ATLANTIC SHORES offshore wind

Atlantic Shores Offshore Wind Project

Request for the Taking of Marine Mammals Incidental to the Site Characterization of the Atlantic Shores Offshore Wind Farm Lease Area (OCS-A 0499)

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Acronyms and Abbreviations

Atlantic Shores	Atlantic Shores Offshore Wind, LLC
BOEM	Bureau of Ocean Energy Management
CeTAP	Cetacean and Turtles Assessment Program
C.F.R.	Code of Federal Regulations
CPT	cone penetration test
dB	decibel
DMA	Dynamic Management Area
DP	dynamically positioned
DPS	distinct population segments
ECR	Export Cable Route
ESA	Endangered Species Act
ft	feet/foot
GIS	geographic information system
HFC	high-frequency cetaceans
HRG	high-resolution geophysical
Hz	hertz
IHA	Incidental Harassment Authorization
IUCN	World Conservation Union
JASCO	JASCO Applied Sciences
km	kilometer
km^2	square kilometer
km/h	kilometer per hour
kHz	kilohertz
knot	nautical mile per hour
LFC	low-frequency cetaceans
m	meter
MFC	mid-frequency cetaceans
mi	mile
µPa	microPascal
MMPA	Marine Mammal Protection Act
nm	nautical mile
NOAA Fisheries	National Oceanic and Atmospheric Administration, National Marine Fisheries Service
OCS	Outer Continental Shelf
OPW	Otariid pinnipeds in water
PAM	Passive Acoustic Monitoring
PPW	Phocid pinnipeds in water
Project	Atlantic Shores Offshore Wind Project
PSO	Protected Species Observer
PTS	permanent threshold shift
RMS	root mean square
SEL	sound exposure level
SEL_{cum}	cumulative SEL
SL	sound level
SMA	Seasonal Management Area
U.S.C.	United States Code

WEA	Wind Energy Area
WTG	wind turbine generator
ZOI	zone of influence

1. Introduction

Atlantic Shores Offshore Wind, LLC (Atlantic Shores), a 50/50 joint venture between EDF-RE Offshore Development, LLC and Shell New Energies US LLC, is seeking an Incidental Harassment Authorization (IHA) for the Atlantic Shores Offshore Wind Project (Project). The IHA request is pursuant to section 101(a)(5)(D) of the Marine Mammal Protection Act ([MMPA] 16 U.S.C. § 1371(a)(5)(D)) and 50 C.F.R. § 216.107 to allow for the incidental harassment of marine mammals resulting from high-resolution geophysical (HRG) and geotechnical survey investigations off the coasts of New Jersey and New York and in the area of the Commercial Lease of Submerged Lands for Renewable Energy Development on the Outer Continental Shelf OCS-A 0499 (the Lease Area). HRG and geotechnical surveys will take place in three areas including the Lease Area as well as two potential Export Cable Route (ECR) Areas as depicted on Figures 1-1 and 1-2. Atlantic Shores intends to conduct HRG and geotechnical survey campaigns within each of the identified survey areas over a period of up to 12 months. Survey activities are proposed to initiate no earlier than March 1, 2020.

The regulations set forth in Section 101(a)(5) of the MMPA and 50 C.F.R. § 216 Subpart I allow for the incidental taking of marine mammals by a specific activity if the take by such activity is found to have a negligible impact on the species or stock(s) of marine mammals and will not result in an unmitigable adverse impact on the availability of the marine mammal species or stock(s) for certain subsistence uses. In order for the National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA Fisheries) to consider authorizing the taking by U.S. citizens of small numbers of marine mammals incidental to a specified activity (other than commercial fishing), or to make a finding that incidental take is unlikely to occur, a written request must be submitted to NOAA Fisheries' Office of Protected Resources. Such a request is detailed in the following sections.

2. Description of Specified Activity

Atlantic Shores proposes to conduct HRG and geotechnical surveys within the approximately 183,353-acre Lease Area located approximately 18 nautical miles (nm; 21 miles [mi]; 34 kilometers [km])[1] southeast of Atlantic City, New Jersey, as well as along one or more export cables corridors between the Lease Area and New Jersey/New York shorelines. These export cable corridors would be sited within one or both of the ECR Areas defined as (ECR North and ECR South) as depicted on Figure 1-1.

[1] 1 nautical mile = 1.1508 miles; 1 mile = 1.609 kilometers

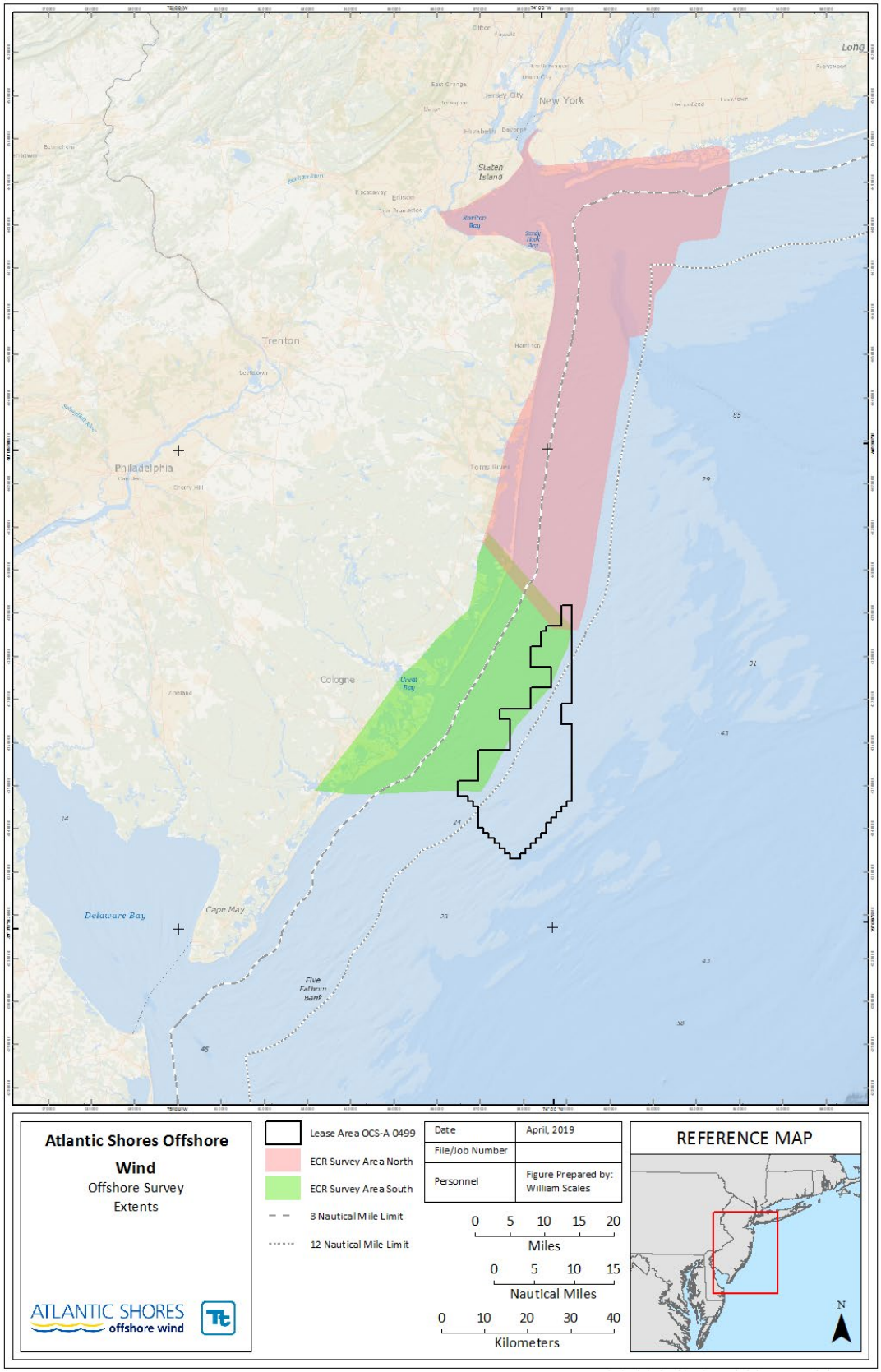

Figure 1-1 Proposed Survey Areas for the Atlantic Shores Offshore Wind Project

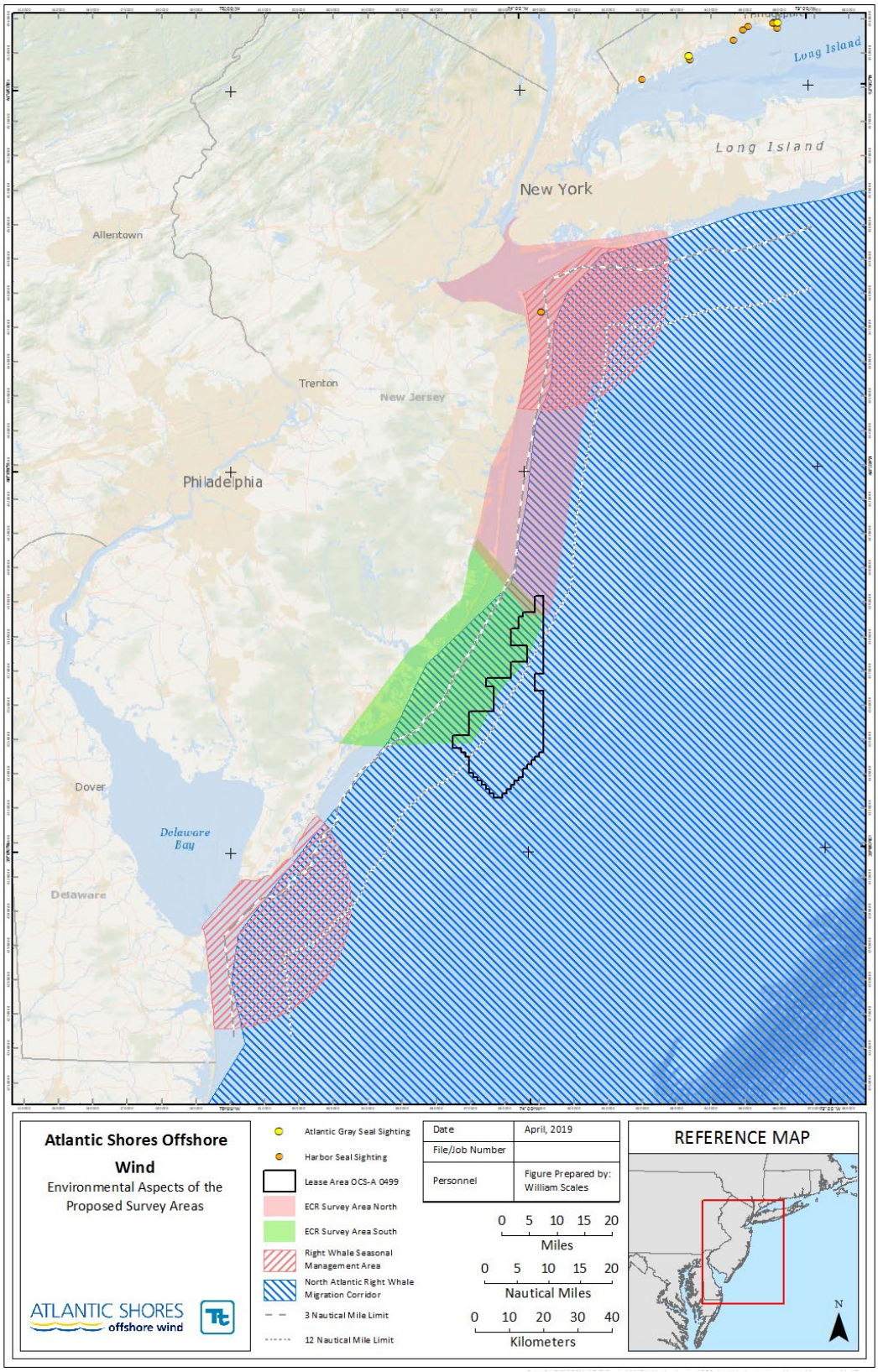

Figure 1-2 Environmental Aspects of the Proposed Survey Areas for the Atlantic Shores Offshore Wind Project

The purpose of the HRG and geotechnical surveys is to:

- Support the preliminary site characterization, siting, and engineering design of offshore Project facilities including wind turbine generators (WTGs), offshore substation(s), and submarine cables within the Lease Area and proposed ECR Areas; and
- Collect the data necessary to support Project review requirements associated with 30 C.F.R. § 585 and the National Environmental Policy Act.

Both NOAA Fisheries and the Bureau of Ocean Energy Management (BOEM) have advised that sound-producing survey equipment operating below 200 kilohertz (kHz) has the potential to cause both Level A and/or Level B acoustic harassment to marine mammals. Under the MMPA, Level A Harassment is statutorily defined as any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild. Level B harassment is defined as any act of pursuit, torment, or annoyance that has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering. The actionable sound pressure levels are not identified in the statute.

Under new NOAA Fisheries (2018a) guidance, Level A harassment is said to occur as a result of exposure to high noise levels and the onset of permanent hearing sensitivity loss, known as a permanent threshold shift (PTS). NOAA Fisheries has defined PTS for five distinct marine mammal hearing groups: Low-frequency (LF) cetaceans (baleen whales), Mid-frequency cetaceans (MFC) (dolphins, toothed whales, beaked whales, bottlenose whales), High-frequency cetaceans (HFC) (true porpoises, Kogia, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* and *L. australis*), Phocid pinnipeds in water (PPW) (true seals), and Otariid pinnipeds in water (OPW) (sea lions and fur seals). PTS levels for each of these hearing groups for both impulsive and non-impulsive noise are defined in Table 2-1.

Table 2-1 M-Weighted PTS Criteria and Functional Hearing Range for Maine Mammals (NOAA Fisheries 2016, 2018a)

Functional Hearing Group	PTS Onset Impulsive	PTS Onset Non-Impulsive	Functional Hearing Range
LFC	219 dB_{peak} and 183 dB SEL_{cum}	199 dB SEL_{cum}	7 Hz to 35 kHz
MFC	230 dB_{peak} and 185 dB SEL_{cum}	198 dB SEL_{cum}	150 Hz to 160 kHz
HFC	202 dB_{peak} and 155 dB SEL_{cum}	173 dB SEL_{cum}	275 Hz to 160 kHz
PPW	218 dB_{peak} and 185 dB SEL_{cum}	201 dB SEL_{cum}	50 Hz to 86 kHz
OPW	232 dB_{peak} and 203 dB SEL_{cum}	219 dB SEL_{cum}	60 Hz to 39 kHz

Notes:
dB – decibel
dB_{peak} – peak decibel
Hz – hertz
kHz – kilohertz
SEL – sound exposure level
SEL_{cum} – cumulative SEL

NOAA Fisheries has defined the threshold level for Level B harassment at 120 dB_{RMS} re 1 microPascal (µPa) for continuous noise and 160 $dB_{RMS90\%}$ re 1 µPa for impulsive and non-continuous pulsed noise.

The following sections provide specific information regarding the HRG and geotechnical survey activities proposed by Atlantic Shores. Each section includes information on the types of activities and associated equipment to be deployed, how the equipment will interact with the surrounding physical and biological environment and which activity may or may not result in the taking of marine mammals per NOAA's established thresholds for Level A and B harassment.

2.1 HRG Survey Activities

The HRG survey activities that have been proposed in each of the identified survey areas will include the following:

- Depth sounding (multibeam depth sounder) to determine water depths and general bottom topography (currently estimated to range from approximately 5 meters [m] to 40 m in depth);
- Magnetic intensity measurements (gradiometer) for detecting local variations in regional magnetic field from geological strata and potential ferrous objects on and below the bottom;
- Seafloor imaging (side scan sonar survey) for seabed sediment classification purposes, to identify natural and man-made acoustic targets resting on the bottom as well as any anomalous features;
- Shallow penetration sub-bottom profiler (pinger/chirp) to map the near surface stratigraphy (top zero to 5 m soils below seabed);
- Medium penetration sub-bottom profiler (chirps/parametric profilers/sparkers) to map deeper subsurface stratigraphy as needed (soils down to 75 m to 100 m below seabed); and
- Grab sampling to validate seabed classification from multibeam echosounder/side scan sonar data.

The HRG survey equipment to be used in each of the identified survey areas will be consistent with the HRG survey equipment used to support other offshore wind development projects along the Atlantic Coast that have been previously approved by both NOAA Fisheries and BOEM. Note that bottom disturbance associated with the HRG activities may include grab sampling to validate the seabed classification obtained from the multibeam echosounder/side scan sonar data. The typical sample size will range between 0.1 m^2 and 0.2 m^2 sample area. This temporary and localized impact is considered negligible and unlikely to affect marine mammal species, their habitat, or prey (see Section 10).

The HRG survey activities will be supported by vessels of sufficient size to accomplish the survey goals in each of the specified survey areas. It is assumed only a single vessel will be operating in each of the identified survey areas during any given campaign.

Atlantic Shores has evaluated a range of possible HRG survey equipment that would be necessary to support seabed assessments across the Lease and ECR Areas during the specified timeframe associated with the proposed activities. This evaluation has been based on both the technical and regulatory requirements for project development as well as the type of survey equipment that has been recently deployed in support of offshore wind projects along the Atlantic Coast. The categories of representative HRG survey equipment that are anticipated for use are presented in Table 2-2. This equipment will either be mounted to or towed behind the survey vessel at a typical survey speed of approximately 3.5 knots (6.5 km) per hour.

Table 2-2 Representative Equipment Specifications

HRG Survey Equipment	Equipment Type	Operating Frequencies Ranges (kHz)	Operational Source Level Ranges (dB_{RMS})	Beamwidth Ranges (degree)	Typical Pulse Durations RMS_{90} (millisec)	Pulse Repetition Rate (Hz)
Single Beam Echosounders	Kongsberg EA 400	38 to 200	222.8 [a]	31	0.3	10
	Teledyne ODOM Echotrac CVM	24	224.6[b]	20	0.3	10
Sparker	Applied Acoustics Dura-Spark 240	0.25 to 5	211.4	180	2.5	1.6
Sub-Bottom Profiler	Edgetech 2000-DSS	2 to 16[c]	178[d]	24[c]	6.3	10
	Edgetech 216	2 to 16[d]	179[d]	17, 20, or 24[d]	10	10
	Edgetech 424	4 to 24[d]	180[e]	71[e]	4	2
	Edgetech 512i	0.5 to 12[d]	180[e]	80[e]	10	10
	Teledyne Benthos Chirp III	2 to 7[f]	197[f]	100[f]	15[i]	10
		10 to 20[f]	205[f]	30[f]	15[i]	10
	Kongsberg GeoPulse	2 to 12	214[g]	30, 40, or 55	16[j]	10
	Innomar SES-2000 Medium-100 Parametric	85 to 115	241[h]	2	2	40
Boomer	Applied Acoustics S-Boom Triple Plate	0.01 to 20	203	80	0.8	3
	Applied Acoustics S-Boom	0.01 to 20	195	98	0.8	3

Notes:

[a]Source Level and beam width is for the 38/200 transducer. EA 400 transducer specifications were obtained from Stale Myklebust (Kongsberg) during a personal conversation on 08-08-2019.

[b]Source levels were not available so the source level was estimated from the arithmetic mean of all Kongsberg EA 400 transducer source levels operating at a similar frequency (18 and 38 kHz).

[c]Operational frequency range provided by Atlantic Shores.

[d]Considered EdgeTech Chirp as a proxy source for levels as the Chirp512i has similar operation settings as the Chirp 2000-DSS tow vehicle. See Table 18 in Crocker and Fratantonio (2016) for source levels for 100% power and 2-12 kHz.

[e]Values from Crocker and Fratantonio (2016) for 100% power and comparable bandwidth.

[f]Source Specifications are for the TTV-170 series Tow Vehicle.

[g]Source levels were obtained during a personal with Mike Bailey (Kongsberg on 07-31-2019).

[h]The specification sheet indicates a peak source level of 247 dB re 1 μPa m (Jens Wunderlich, Innomar, personal communication, 7-18-2019). The average difference between the peak SPL source levels for sub-bottom profilers measured by Crocker and Fratantonio (2016) was 6 dB. We therefore estimate the SPL source level is 240 dB re 1 μPa m.

[i]Assumed pulse duration from 15% duty cycle.

[j]Assumed pulse duration from maximum 32 cycles at 2 kHz.

It is important to note that Atlantic Shores has not finalized its selection of the exact equipment it intends to utilize within any of the survey areas.[2] Instead, Atlantic Shores has included a description of the number and type of equipment that could be deployed and has included information about this equipment and the full range of potential effects to marine mammals and their habitat (see Sections 6 through 11). During each contracting phase, the actual survey equipment to be used will be determined not only by the survey contractor selected but also the data collection requirements of each unique campaign. Given

[2] Atlantic Shores' contracting process has not been completed as of the date of this IHA application.

these stated parameters, the survey equipment that has the potential to result in the take of marine mammals are the subbottom profilers, single beam echosounders, sparkers and boomers (Table 2-2 and Appendices A and B). However, due to the implementation of mitigation and monitoring measures (e.g., established exclusion zones as detailed in Sections 6, 7, and 12) in combination with the behavior of these species (i.e., their transient nature and their ability to move away from the source of potential harassment), it is unlikely that these pieces of equipment will result in the Level A harassment of marine mammals. Therefore, Level A take has not been requested for any marine mammal species. Atlantic Shores is only requesting authorization for the incidental take of small numbers of marine mammals within each of the survey areas by Level B harassment. Estimates of Level B take are further detailed in Section 7.

2.2 Geotechnical Survey Activities

Geotechnical survey activities will include the following:

- Sample boreholes to determine geological and geotechnical characteristics of sediments;
- Deep cone penetration tests (CPTs) to determine stratigraphy and in situ conditions of the deep surface sediments; and
- Shallow CPTs to determine stratigraphy and in situ conditions of the near surface sediments.

Geotechnical investigation activities are anticipated to be conducted from a drill ship equipped with dynamic positioning (DP) thrusters. Impact to the seafloor from this equipment will be limited to the minimal contact of the sampling equipment, and inserted boring and probes, and considered negligible (BOEM 2012).

Field studies conducted off the coast of Virginia (Tetra Tech 2014) to determine the underwater noise produced by borehole drilling and CPTs confirm that these activities (including vibracore sampling) do not result in underwater noise levels that exceed NOAA Fisheries' current Level A and Level B harassment thresholds for marine mammals (NOAA Fisheries 2018b).

In addition, NOAA Fisheries has recently indicated that sound produced through use of DP thrusters is similar to that produced by transiting vessels, and thus, it does not anticipate the need for an MMPA incidental harassment authorization for the use of DP thrusters (NOAA Fisheries 2018b).

Given the recent decisions by NOAA Fisheries concerning the applicability of IHAs for normal operations of vessels and the lack of acoustic impact from geotechnical survey equipment, these activities do not warrant further discussion and no take by Level A or Level B harassment has been requested for the proposed geotechnical activities. Geotechnical survey activities are therefore not further discussed in this application request.

3. Dates, Duration, and Specific Geographic Region

Atlantic Shores is proposing to conduct HRG surveys within three distinct areas including the Lease Area, ECR North and ECR South as depicted on Figure 1-1. The location of the Lease Area, proposed survey activities, and environmental aspects important to the analysis (e.g., pinniped haul outs, critical habitat designated under the Endangered Species Act [ESA], known feeding areas) are depicted in Figure 1-2. HRG surveys are proposed to initiate no earlier than March 1, 2020. The estimated duration of the survey activities is provided in Table 3-1. The total days estimated assume one vessel is actively surveying each

of the identified areas 24 hours per day. The estimated duration to complete survey activities in each survey area do not include weather downtime and assumes activities could occur at any time in a 24-hr day for a period of up to 12 months.

Table 3-1 Summary of Proposed HRG Survey Segments

Survey Segment	Total Duration (Vessel Days) [a]
Lease Area OCS-A 0499	210
Northern ECR Area	80
Southern ECR Area	60
Note: a Estimate is based on total time for one (1) vessel to complete survey activities per area.	

4. Species and Numbers of Marine Mammals

The *Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore New Jersey, Delaware, Maryland, and Virginia Final Environmental Assessment* or "Mid-Atlantic Environmental Assessment" (BOEM 2012) reports 39 species of marine mammals (whales, dolphins, porpoise, and seals) in the Northwest Atlantic OCS region of the mid-Atlantic that are protected by the MMPA, 5 of which are listed under the ESA and are known to be present, at least seasonally, in the Lease Area (see Table 4-1). The status and distribution of these species are discussed in detail in Section 5.

Table 4-1 Marine Mammals Known to Occur in the Marine Waters of the Mid-Atlantic

Common Name	Scientific Name	ESA and MMPA Status	Relative Occurrence in the Region	Estimated Population	Stock	Hearing Range
Toothed Whales (Odontoceti)						
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	N/A	Uncommon	48,819	W. North Atlantic	Mid
Atlantic spotted dolphin	*Stenella frontalis*	N/A	Uncommon	44,715	W. North Atlantic	Mid
Bottlenose dolphin	*Tursiops truncatus*	N/A	Uncommon	77,532	W. North Atlantic, Offshore	Mid
		Strategic [a]	Common	6,639	W. North Atlantic, Northern Migratory Coastal	Mid
Clymene dolphin	*Stenella clymene*	N/A	Not Expected	Unknown	W. North Atlantic	Mid
Pan-tropical spotted dolphin	*Stenella attenuata*	N/A	Rare	3,333	W. North Atlantic	Mid
Risso's dolphin	*Grampus griseus*	N/A	Common	18,250	W. North Atlantic	Mid
Short beaked common dolphin	*Delphinus delphis*	N/A	Common	70,184	W. North Atlantic	Mid
Striped dolphin	*Stenella coeruleoalba*	N/A	Rare	54,807	W. North Atlantic	Mid

Table 4-1 Marine Mammals Known to Occur in the Marine Waters of the Mid-Atlantic

Common Name	Scientific Name	ESA and MMPA Status	Relative Occurrence in the Region	Estimated Population	Stock	Hearing Range
Fraser's dolphin	*Lagenodelphis hosei*	N/A	Rare	Unknown	W. North Atlantic	Mid
Rough-toothed dolphin	*Steno bredanesis*	N/A	Rare	271	W. North Atlantic	Mid
Spinner dolphin	*Stenella longirostris*	N/A	Rare	Unknown	W. North Atlantic	Mid
White-beaked dolphin	*Lagenorhynchus albirostris*	N/A	Rare	2,003	W. North Atlantic	Mid
Harbor porpoise	*Phocoena phocoena*	N/A	Uncommon	79,833	Gulf of Maine/Bay of Fundy	High
Killer whale	*Orcinus orca*	N/A	Rare	Unknown	W. North Atlantic	Mid
Pygmy killer whale	*Feresa attenuata*	N/A	Not Expected	Unknown	W. North Atlantic	Mid
False killer whale	*Pseudorca crassidens*	Strategic	Rare	442	W. North Atlantic	Mid
Northern bottlenose whale	*Hyperoodon ampullatus*	N/A	Not Expected	Unknown	W. North Atlantic	Mid
Long-finned pilot whale	*Globicephala melas*	N/A	Common	5,636	W. North Atlantic	Mid
Short-finned pilot whale	*Globicephala macrorhynchus*	N/A	Rare	21,515	W. North Atlantic	Mid
Sperm whale	*Physeter macrocephalus*	Endangered	Uncommon	2,288	North Atlantic	Mid
Pygmy sperm whale	*Kogia breviceps*	N/A	Rare	3,785 [b]	W. North Atlantic	High
Dwarf sperm whale	*Kogia sima*	N/A	Rare	3,785 [b]	W. North Atlantic	High
Cuvier's beaked whale	*Ziphius cavirostris*	N/A	Rare	6,532	W. North Atlantic	Mid
Blainville's beaked whale	*Mesoplodon densirostris*	N/A	Rare	7,092 [c]	W. North Atlantic	Mid
Gervais' beaked whale	*Mesoplodon europaeus*	N/A	Rare	7,092 [c]	W. North Atlantic	Mid
True's beaked whale	*Mesoplodon mirus*	N/A	Rare	7,092 [c]	W. North Atlantic	Mid
Sowerby's beaked whale	*Mesoplodon bidens*	N/A	Rare	7,092 [c]	W. North Atlantic	Mid
Melon headed whale	*Peponocephala electra*	N/A	Not Expected	Unknown	W. North Atlantic	Mid
Baleen Whales (Mysticeti)						
Minke whale	*Balaenoptera acutorostrata*	N/A	Regular	2,591	Canadian East Coast	Low

Table 4-1 Marine Mammals Known to Occur in the Marine Waters of the Mid-Atlantic

Common Name	Scientific Name	ESA and MMPA Status	Relative Occurrence in the Region	Estimated Population	Stock	Hearing Range
Blue whale*	*Balaenoptera musculus*	Endangered	Uncommon	Unknown	W. North Atlantic	Low
Fin whale	*Balaenoptera physalus*	Endangered	Regular	1,618	W. North Atlantic	Low
Humpback whale	*Megaptera novaeangliae*	N/A	Common	335	Gulf of Maine	Low
North Atlantic right whale	*Eubalaena glacialis*	Endangered	Regular	458	W. North Atlantic	Low
Sei whale	*Balaenoptera borealis*	Endangered	Uncommon	357	Nova Scotia	Low
Bryde's whale	*Balaenoptera edeni*	N/A	Rare	33	Gulf of Mexico	Low
Earless Seals (Phocidae)						
Gray seals*	*Halichoerus grypus*	N/A	Regular	27,131	W. North Atlantic	-
Harbor seals	*Phoca vitulina*	N/A	Regular	75,834	W. North Atlantic	-
Hooded seals	*Cystophora cristata*	N/A	Rare	Unknown	W. North Atlantic	-
Harp seal	*Phoca groenlandica*	N/A	Rare	Unknown	W. North Atlantic	-

Notes:

a A strategic stock is defined as any marine mammal stock: 1) for which the level of direct human-caused mortality exceeds the potential biological removal level; 2) which is declining and likely to be listed as threatened under the ESA; or 3) which is listed as threatened or endangered under the ESA or as depleted under the MMPA (http://www.ncseonline.org/nle/crsreports/biodiversity/biodv-11.cfm).

b This estimate may include both the dwarf and pygmy sperm whales.

c This estimate includes Gervais' and Blainville's beaked whales and undifferentiated *Mesoplodon* spp. beaked whales.

* No occurrence of these species in the survey area. Sources: NJDEP 2010; DoN 2007a

Sources: Hayes et al. 2018; Hayes et al. 2017; Waring et al. 2010, 2011, 2013, 2015; RI Ocean SAMP 2011; Kenney and Vigness-Raposa 2009; NOAA Fisheries 2016, 2018a

5. Affected Species Status and Distribution

As summarized in Section 4, there are up to 39 marine mammal species (whales, dolphins, porpoise, and seals) which are known to be present (some year–round, and some seasonally) in the Northwest Atlantic OCS region. The marine mammal species with the greatest likelihood of occurring in the Survey Areas are listed in Table 4-1.

All 39 marine mammal species identified in Table 4-1 are protected by the MMPA, and some are also listed under the ESA. The five ESA-listed marine mammal species known to be present year-round or seasonally in the waters of the mid-Atlantic are the sperm whale, North Atlantic right whale, fin whale, blue whale, and sei whale. The humpback whale, which may occur year-round, was recently delisted as an endangered species. These large whale species are generally migratory and typically do not spend extended periods of time in a localized area. The waters of the mid-Atlantic (including the survey areas) are primarily used as areas where animals occur seasonally to feed, or as habitat during seasonal

movements between the more northward feeding areas and southern hemisphere breeding grounds typically used by some of the large whale species (though some winter breeding areas exist further offshore vs. in the southerly latitudes). The mid-sized whale species (minke) and large baleen whales, and the sperm whale are present year-round in the continental shelf and slope waters and may occur in the waters of the survey areas though movements will vary with prey availability and other habitat factors. The fin and right whales have the greater potential to occur within the survey areas; however, the sperm, blue, sei, and humpback whales can also occur.

The following subsections provide additional information on the biology, habitat use, abundance, distribution, and the existing threats to the non-endangered or threatened and endangered marine mammals that are both common in the waters of the OCS east of New Jersey and have the likelihood of occurring, at least seasonally, in the survey area. These species include the North Atlantic right whale, humpback whale, fin whale, sei whale, minke whale, long-finned pilot whale, bottlenose dolphin, Atlantic white-sided dolphin, short-beaked common dolphin, Atlantic spotted dolphin, Risso's dolphin, harbor porpoise, and harbor seals.

5.1 Toothed Whales (Odontonceti)

5.1.1 Sperm Whale (*Physeter macrocephalus*) – Endangered

Currently, there is no reliable estimate for the total number of sperm whales worldwide. The best estimate is that there are between 200,000 and 1,500,000 sperm whales, based on extrapolations from only a few areas that have useful estimates (NOAA Fisheries 2006). Estimates show about 1,665 in the northern Gulf of Mexico, 14,000 in the North Atlantic, 80,000 in the North Pacific, and 9,500 in the Antarctic (NOAA Fisheries 2006; Waring et al. 2009). For the North Atlantic, the minimum population size estimate is 1,815 individuals (Hayes et al. 2018).

Sperm whales are highly social, with a basic social unit consisting of 20 to 40 adult females, calves, and some juveniles (Rice 1998; Whitehead 2008). During their prime breeding period and old age, male sperm whales are essentially solitary. Males rejoin or find nursery groups during prime breeding season. While foraging, the whales typically gather in small clusters. Between diving bouts, sperm whales are known to raft together at the surface. Adult males often forage alone. Groups of females may spread out over distances greater than 0.5 nm when foraging. When socializing, they generally gather into larger surface-active groups (Jefferson et al. 2008; Whitehead 2003). In the northern hemisphere, the peak breeding season for sperm whales occurs between March and June, and in the southern hemisphere, the peak breeding season occurs between October and December (NOAA Fisheries 2009).

This species primarily preys on squid and octopus and are also known to prey on fish, such as lumpsuckers and redfish. Although sperm whales are generalists in terms of prey, specialization does appear to occur in a few places. The main sperm whale feeding grounds are correlated with increased primary productivity caused by upwelling.

The sperm whale is thought to have a more extensive distribution than any other marine mammal, except possibly the killer whale. This species is found in polar to tropical waters in all oceans, from approximately 70° N to 70° S (Rice 1998; Whitehead 2003). It ranges throughout all deep oceans of the world, essentially from equatorial zones to the edges of the polar pack ice. In the Atlantic, sperm whales are found throughout the Gulf Stream and North Central Atlantic Gyre. The current abundance estimate for

this species in the North Atlantic is 2,288 individuals (Waring et al. 2016; Hayes et al. 2018). The species is listed as Endangered (Hayes et al. 2018).

Sperm whales show a strong preference for deep waters (Rice 1998; Whitehead 2003). Their distribution is typically associated with waters over the continental shelf break and the continental slope and into deeper waters (Jefferson et al. 2008; Whitehead et al. 1992). Sperm whale concentrations near drop-offs and areas with strong currents and steep topography are correlated with high productivity. These whales occur almost exclusively at the shelf break, regardless of season (NYDOS 2013). Sperm whales are somewhat migratory; however, their migrations are not as specific as seen in most of the baleen whale species. In the North Atlantic, there appears to be a general shift northward during the summer, but there is no clear migration in some temperate areas (Rice 1998; Whitehead 2003).

5.1.2 Long-Finned Pilot Whale (*Globicephala melas*) – Non-Strategic

The long-finned pilot whale is more generally found along the edge of the continental shelf (a depth of 330 to 3,300 feet (ft) [100 to 1,000 m]), choosing areas of high relief or submerged banks in cold or temperate shoreline waters. This species is split between two subspecies: the northern and southern subspecies. The southern subspecies is circumpolar with northern limits of Brazil and South Africa. The northern subspecies, which could be encountered during operation of the Atlantic Shores Offshore Wind Project, ranges from North Carolina to Greenland (Reeves et al. 2002; Wilson and Ruff 1999). In the western North Atlantic, long-finned pilot whales are pelagic, occurring in especially high densities in winter and spring over the continental slope, then moving inshore and onto the shelf in summer and autumn following squid and mackerel populations (Reeves et al. 2002). They frequently travel into the central and northern Georges Bank, Great South Channel, and Gulf of Maine areas during the late spring and remain through early fall (May and October) (CeTAP 1982; Payne and Heinemann 1993). The best population estimate for long-finned pilot whales in the western North Atlantic is 5,636 individuals (Hayes et al. 2018; Waring et al. 2016).

They feed preferentially on squid but will eat fish (e.g., herring) and invertebrates (e.g., octopus, cuttlefish) if squid are not available. They also ingest shrimp (particularly younger whales) and various other fish species occasionally. These whales probably take most of their prey at depths of 600 to 1,650 ft (200 to 500 m), although they can forage deeper if necessary (Reeves et al. 2002). A very social species, long-finned pilot whales travel in pods of roughly 20 individuals while following prey. These small pods are thought to be formed around adult females and their offspring. Behaviors of long-finned pilot whales range from quiet rafting or milling on the surface, to purposeful diving, to bouts of playfulness.

The long-finned pilot whales are subject to bycatch during sink gillnet fishing, pelagic trawling, and pelagic longline fishing. Approximately 215 pilot whales were killed or seriously injured each year by human activities during 1997 to 2001 (Waring et al. 2010). From 2007 through 2011, the total observed fishery-related mortality was 44 individuals (Waring et al. 2014). From 2009 through 2013, the total observed fishery-related mortality was 31 individuals (Waring et al. 2016). From 2010 to 2014, the total annual observed average fishery-related mortality or serious injury is 38 pilot whales (Hayes et al. 2017). Strandings involving hundreds of individuals are not unusual and demonstrate that these large schools have a high degree of social cohesion (Reeves et al. 2002). From 2010 through 2014, 27 long-finned pilot whales and 5 unspecified pilot whales were reported as stranded between Maine and Florida (Hayes et al. 2017). The species is considered “strategic” under the MMPA by NOAA Fisheries because the mean

annual human-cause mortality and serious injury exceeds the Potential Biological Removal (Hayes et al. 2018).

5.1.3 Harbor Porpoise (*Phocoena phocoena*) – Non-Strategic

The harbor porpoise inhabits shallow, coastal waters, often found in bays, estuaries, and harbors. In the western Atlantic, they are found from Cape Hatteras north to Greenland. They are likely to occur frequently in mid-Atlantic waters from fall through spring, reaching their highest densities in spring when migration brings them toward the Gulf of Maine feeding grounds from their wintering areas offshore and in the mid-Atlantic (Kenney and Vigness-Raposa 2009; DoN 2007b). After April, they migrate north toward the Gulf of Maine and Bay of Fundy. Harbor porpoises are the smallest North Atlantic cetacean, measuring at 1.4 to 1.9 m, and feed primarily on fish, but also prey on squid and crustaceans (Reeves and Reed 2003; Kenney and Vigness-Raposa 2009). Sighting records from the 1978 to 1981 Cetacean and Turtle Assessment Program (CeTAP) surveys showed porpoises in spring exhibited highest densities in the southwestern Gulf of Maine in proximity to the Nantucket Shoals and western Georges Bank, with presence throughout the southern New England shelf and Gulf of Maine (CeTAP 1982). While strandings have occurred throughout the south shore of Long Island and coastal Rhode Island, many sightings have occurred offshore in the OCS area (Kenney and Vigness-Raposa 2009). The North Atlantic harbor porpoise population is likely to be over 500,000 (Kenney and Vigness-Raposa 2009). The current population estimate for harbor porpoise for the Gulf of Maine/Bay of Fundy stock is 79,833 (Waring et al. 2016; Hayes et al. 2018). Its hearing is in the high-frequency range (Southall et al. 2007).

The most common threat to the harbor porpoise is from incidental mortality from fishing activities, especially from bottom-set gillnets. It has been demonstrated that the porpoise echolocation system is capable of detecting net fibers, but they either must not have the “system activated” or else they fail to recognize the nets (Reeves et al. 2002). Roughly 307 harbor porpoises are killed by human-related activities in U.S. and Canadian waters each year. In 1999, a Take Reduction Plan to reduce harbor porpoise bycatch in U.S. Atlantic gillnets was implemented. The plan, that pertains to the Gulf of Maine, focuses on sink gillnets and other gillnets that can catch groundfish in New England waters. The ruling implements time and area closures, some of which are complete closures, as well as requiring pingers on multispecies gillnets. In 2001, the harbor porpoise was removed from the candidate species list for the ESA; a review of the biological status of the stock indicated that a classification of “Threatened” was not warranted (Waring et al. 2009). This species has been listed as “non-strategic” because average annual human-related mortality and injury does not exceed the potential biological removal (Waring et al. 2016; Hayes et al. 2018).

5.1.4 Bottlenose Dolphin (*Tursiops truncatus*) – Western North Atlantic Northern Migratory Coastal Stock – Strategic / Western North Atlantic Offshore Stock – Non-Strategic

The bottlenose dolphin is a light- to slate-gray dolphin, roughly 8 to 12 ft (2.4 to 3.7 m) long with a short, stubby beak. Because this species occupies a wide variety of habitats, it is regarded as possibly the most adaptable cetacean (Reeves et al. 2002). It occurs in oceans and peripheral seas at both tropical and temperate latitudes. In North America, bottlenose dolphins are found in surface waters with temperatures ranging from 10 to 32°C (50 to 90°F). Its hearing is in the mid-frequency range (Southall et al. 2007).

There are two distinct bottlenose dolphin morphotypes: migratory coastal and offshore. The Western North Atlantic northern migratory coastal morphotype resides in waters typically less than 65.6 ft (20 m) deep, along the inner continental shelf (within 7.5 km [4.6 mi] of shore), around islands, and is

continuously distributed south of Long Island, New York into the Gulf of Mexico. This Western North Atlantic northern migratory coastal population is subdivided into seven stocks based largely on spatial distribution (Waring et al. 2016). Of these seven coastal stocks, the Western North Atlantic migratory coastal stock is common in the coastal continental shelf waters off the coast of New Jersey (Waring et al. 2016). These animals often move into or reside in bays, estuaries, the lower reaches of rivers, and coastal waters within the approximate 25 m depth isobath north of Cape Hatteras (Reeves et al. 2002; Waring et al. 2016). Common bottlenose dolphins are not listed as threatened or endangered under the ESA, but the Northern Migratory Coastal Stock is a strategic stock due to the depleted listing under the MMPA (Waring et al. 2016).

Generally, the offshore migratory morphotype is found exclusively seaward of 34 km (21 mi) and in waters deeper than 34 m (111.5 ft). The offshore population extends along the entire continental shelf-break from Georges Bank to Florida during the spring and summer months, and has been observed in the Gulf of Maine during the late summer and fall. However, the range of the offshore morphotype south of Cape Hatteras has recently been found to overlap with that of the migratory coastal morphotype, sampled as close as 7.3 km (4.5 mi) from the shore in water depths of 13 m (42.7 ft) (Waring et al. 2016; Hayes et al. 2017). According to the New Jersey Department of Environmental Protection (NJDEP 2010), the bottlenose dolphin is present off the New Jersey coast year-round, and would likely be ubiquitous throughout the survey area. NOAA Fisheries species stock assessment report estimates the population of Western North Atlantic offshore bottlenose dolphin stock at approximately 77,532 individuals and the Western North Atlantic migratory coastal stock at approximately 10,390 individuals (Waring et al. 2016; Hayes et al. 2018).

Bottlenose dolphins feed on a large variety of organisms, depending on their habitat. The coastal, shallow population tends to feed on benthic fish and invertebrates, while deepwater populations consume pelagic or mesopelagic fish such as croakers, sea trout, mackerel, mullet, and squid (Reeves et al. 2002). Bottlenose dolphins appear to be active both during the day and night. Their activities are influenced by the seasons, time of day, tidal state, and physiological factors such as reproductive seasonality (Wells and Scott 2002).

The biggest threat to the population is bycatch because they are frequently caught in fishing gear, gillnets, purse seines, and shrimp trawls (Waring et al. 2016). They have also been adversely impacted by pollution, habitat alteration, boat collisions, and human disturbance, and are subject to bioaccumulation of toxins. Scientists have found a strong correlation between dolphins with elevated levels of polychlorinated biphenyls and illness, indicating certain pollutants may weaken their immune system (ACSonline 2004). Total U.S. fishery-related mortality and serious injury for this stock is less than 10 percent of the calculated potential biological removal and can therefore be considered to be insignificant and approaching the zero mortality and serious injury rate.

5.1.5 Short-Beaked Common Dolphin (*Delphinus delphis*) – Non-Strategic

The short-beaked dolphin is one of the most widely distributed cetaceans and occurs in temperate, tropical, and subtropical regions (Jefferson et al. 2008). Short-beaked dolphins feed on squids and small fish, including species that school in proximity to surface waters as well as mesopelagic species found near the surface at night (World Conservation Union [IUCN] 2010; NatureServe 2010). They have been known to feed on fish escaping from fishermen's nets or fish that are discarded from boats (NOAA 1993). This species is found between Cape Hatteras and Georges Bank from mid-January to May, although they

migrate onto Georges Bank and the Scotian Shelf between mid-summer and fall, where large aggregations occur on Georges Bank in fall (Waring et al. 2007, 2016). These dolphins can gather in schools of hundreds or thousands, although the schools generally consist of smaller groups of 30 or fewer. They are eager bow riders and are active at the surface (Reeves et al. 2002). The short-beaked common dolphin feeds on small schooling fish and squid. While this dolphin species can occupy a variety of habitats, short-beaked common dolphins occur in greatest abundance within a broad band of the northeast edge of Georges Bank in the fall (Kenney and Vigness-Raposa 2009). According to the species stock report, the best population estimate for the Western North Atlantic common dolphin is approximately 70,184 individuals (Hayes et al. 2018). Its hearing is in the mid-frequency range (Southall et al. 2007).

Short-beaked common dolphins can be found either along the 650- to 6,500-ft (200- to 2,000-m) isobaths over the continental shelf and in pelagic waters of the Atlantic and Pacific Oceans. They are present in the Western Atlantic from Newfoundland to Florida. The short-beaked common dolphin is especially common along shelf edges and in areas with sharp bottom relief such as seamounts and escarpments (Reeves et al. 2002). They show a strong affinity for areas with warm, saline surface waters. Off the coast of the eastern United States, they are particularly abundant in continental slope waters from Georges Bank southward to about 35 degrees north (Reeves et al. 2002) and usually inhabit tropical, subtropical, and warm-temperate waters (Waring et al. 2009, 2016).

The short-beaked common dolphin is also subject to bycatch. It has been caught in gillnets, pelagic trawls, and during longline fishery activities. During 2008 to 2012, it was estimated that on average approximately 289 dolphins were killed each year by human activities (Waring et al. 2015). This number increased to 363 dolphins from 2009 to 2013 (Waring et al. 2016), and again from 2010 to 2014 where the number was estimated at 409 dolphins (Hayes et al. 2017), and once more from 2011 to 2015 where the number increased to 437 dolphins (Hayes et al. 2018). This species is also the most common dolphin species to be stranded along the southern New England Coast (Kenney and Vigness-Raposa 2009). Average annual fishery-related mortality and serious injury does not exceed the potential biological removal for this species; therefore, NOAA Fisheries considers this species as “non-strategic” (Waring et al. 2009, 2010, 2015, 2016; Hayes et al. 2018).

5.1.6 Atlantic White-Sided Dolphin (*Lagenorhynchus acutus*) – Non-Strategic

The Atlantic white-sided dolphin is typically found at a depth of 330 ft (100 m) in the cool temperate and subpolar waters of the North Atlantic, generally along the continental shelf between the Gulf Stream and the Labrador current to as far south as North Carolina (Bulloch 1993; Reeves et al. 2002; Jefferson et al. 2008). They are the most abundant dolphin in the Gulf of Maine and the Gulf of St. Lawrence but seem relatively rare along the North Atlantic coast of Nova Scotia (Kenney and Vigness-Raposa 2009).

Atlantic white-sided dolphins range between 8 and 9 ft (2.5 and 2.8 m) in length, with females being approximately 20 centimeters shorter than males (Kenney and Vigness-Raposa 2009). This species is highly social and is commonly seen feeding with fin whales (NOAA 1993). White-sided dolphins feed on a variety of small species, such as herring, hake, smelt, capelin, cod, and squid, with regional and seasonal changes in the species consumed (Kenney and Vigness-Raposa 2009). Sand lance is an important prey species for these dolphins in the Gulf of Maine during the spring. Other fish prey include mackerel, silver hake, herring, smelt, and several other varieties of gadoids (Kenney and Vigness-Raposa 2009). There are seasonal shifts in the distribution of Atlantic white-sided dolphins off the northeastern U.S. coast, with

low abundance in winter between Georges Basin and Jeffrey's Ledge and very high abundance in the Gulf of Maine during spring. During the summer, Atlantic white-sided dolphins are most abundant between Cape Cod and the lower Bay of Fundy. During the fall, the distribution of Atlantic white-sided dolphins is similar to that in the summer, although they are less abundant (DoN 2005). Recent population estimates for Atlantic white-sided dolphins in the Western North Atlantic Ocean places this species at 48,819 individuals (Hayes et al. 2018). This species can be found off the coast of southern New England during all seasons of the year but is usually most numerous in areas farther offshore at depth range of 330 ft (100 m) (Kenney and Vigness-Raposa 2009; Bulloch 1993; Reeves et al. 2002).

The biggest human-induced threat to the Atlantic white-sided dolphin is bycatch, because they are occasionally caught in fishing gillnets and trawling equipment. An estimated average of 328 dolphins each year were killed by fishery-related activities during 2003 to 2007 (Waring et al. 2010). From 2008 through 2012, an estimated annual average of 116 dolphins per year were killed (Waring et al. 2015), and from 2010 through 2014, the estimate decreased to 74 individuals annually (Hayes et al. 2017). This decreased again to 56 dolphins from 2011 to 2015 (Hayes et al. 2018). Average annual fishery-related mortality and serious injury does not exceed the potential biological removal for this species; therefore, NOAA Fisheries considers this species as "non-strategic" (Waring et al. 2011, 2015).

5.1.7 Atlantic Spotted Dolphin (*Stenella frontalis*) – Non-Strategic

There are two species of spotted dolphin in the Atlantic Ocean, the Atlantic spotted dolphin (*Stenella frontalis*) and the pantropical spotted dolphin (*S. attenuata*) (Perrin 1987). In addition, two forms of the Atlantic spotted dolphin exist: one that is large and heavily spotted and usually inhabits the continental shelf, and the other is smaller in size with less spots and occurs in the Atlantic Ocean but is not known to occur in the Gulf of Mexico (Fulling et al. 2003; Mullin and Fulling 2003, 2004; Viricel and Rosel 2014). Where they co-occur, the offshore form of the Atlantic spotted dolphin and the pantropical spotted dolphin can be difficult to differentiate (Waring et al. 2016).

The Atlantic spotted dolphin prefers tropical to warm temperate waters along the continental shelf 10 to 200 m (33 to 650 ft) deep to slope waters greater than 500 m (1,640 ft) deep. It has been suggested that the species may move inshore seasonally during the spring, but data to support this theory are limited (Caldwell and Caldwell 1966; Fritts et al. 1983). The Atlantic spotted dolphin diet consists of a wide variety of fish and squid, as well as benthic invertebrates (Herzing 1997). Its hearing is in the mid-frequency range (Southall et al. 2007). According to the species stock report, the best population estimate for the Atlantic spotted dolphin is approximately 44,715 individuals (Hayes et al. 2018).

No fishing-related mortality of spotted dolphin was reported for 1998 through 2003 (Yeung 1999; Yeung 2001; Garrison 2003; Garrison and Richards 2004). From 2007 through 2011, the estimated mean annual fishery-related mortality and serious injury for this species was 42 Atlantic spotted dolphins (Waring et al. 2016). More recent observer data are not available. The commercial fisheries that interact or potentially interact with the Atlantic spotted dolphin are the pelagic longline fishery and the shrimp trawl fishery (Waring et al. 2016). A total of 16 Atlantic spotted dolphins were reported stranded in the Gulf of Mexico between 2009 and 2013. NOAA Fisheries considers this species as "non-strategic" (Waring et al. 2016).

5.1.8 Risso's Dolphin (*Grampus griseus*) – Non-Strategic

Risso's dolphins are commonly found in the deeper waters of the U.S. east coast continental shelf edge and oceanic waters ranging from Cape Hateras to Georges Bank, mainly during spring, summer and

autumn (CeTAP 1982; Payne et al. 1984). There is currently no information on stock structure of this species for western North Atlantic; therefore, it is not possible to determine if separate stocks exist in the Gulf of Mexico and Atlantic (Hayes et al. 2018). The best estimate of abundance for the stock of Risso's dolphins is 18,250 animals (Hayes et al. 2018; Waring et al. 2014, 2016). There are insufficient data to determine the population trend for this stock.

Risso's dolphins have been subject to bycatch during squid and mackerel trawl activities, pelagic drift gillnet activities, pelagic pair trawl fishery, and mid-Atlantic gillnet fishery (Hayes et al. 2018). Average annual fishery-related mortality and serious injury between 2007 and 2011 was 62 dolphins (Waring et al. 2014). From 2009 to 2013, the average annual fishery-related mortality and serious injury was 54 dolphins (Waring et al. 2016). From 2010 to 2014, the estimated annual average fishery-related mortality or serious injury was 53.6 Risso's dolphins (Hayes et al. 2017). From 2011 to 2015, the estimated annual fishery-related mortality and serious injury was 43.2 dolphins (Hayes et al. 2018). Risso's dolphin strandings have also been observed, and between 2011 and 2015, 26 strandings were recorded along the U.S. Atlantic Coast. NOAA Fisheries does not consider this species as "strategic."

5.2 Baleen Whales (Mysticeti)

5.2.1 North Atlantic Right Whale (*Eubalaena glacialis*) – Endangered

The North Atlantic right whale was listed as a federal endangered species in 1970. The North Atlantic right whale has seen a nominal 2 percent recovery rate since it was listed as a protected species (NOAA 2015). This is a drastic difference from the stock found in the southern hemisphere, which has increased at a rate of 7 to 8 percent (Knowlton and Kraus 2001). Right whales are considered grazers as they swim slowly with their mouths open. They are the slowest swimming whales that reach speeds of up to 10 mi (16 km) per hour. They can dive at least 1,000 ft (300 m) and remain submerged for typically 10 to 15 minutes, feeding on their prey below the surface (ACSonline 2004). Right whales' hearing is in the low-frequency range (Southall et al. 2007).

The right whale is a strongly migratory species that moves annually between high-latitude feeding grounds and low-latitude calving and breeding grounds. The present range of the western North Atlantic right whale population extends from the southeastern United States, which is utilized for wintering and calving, to summer feeding and nursery grounds between New England and the Bay of Fundy and the Gulf of St. Lawrence (Kenney 2002; Waring et al. 2011). The winter distribution of North Atlantic right whales is largely unknown, although offshore surveys have reported 1 to 13 detections annually in northeastern Florida and southeastern Georgia (Waring et al. 2013). A few events of right whale calving have been documented from shallow coastal areas and bays (Kenney 2002). Some evidence provided through acoustic monitoring suggests that not all individuals of the population participate in annual migrations, with a continuous presence of right whales occupying their entire habitat range throughout the year, particularly north of Cape Hatteras (Davis et al. 2017). These data also recognize changes in population distribution throughout the right whale habitat range that could be due to environmental or anthropogenic effects, a response to short-term changes in the environment, or a longer-term shift in the right whale distribution cycle (Davis et al. 2017).

Observations in December 2008 noted congregations of more than 40 individual right whales in the Jordan Basin area of the Gulf of Maine, leading researchers to believe this may be a wintering ground (NOAA 2008). A right whale satellite tracking study within the northeast Atlantic (Baumgartner and Mate 2005) reported that this species often visited waters exhibiting low bottom water temperatures, high

surface salinity, and high surface stratification, most likely for higher food densities. The winter distribution of North Atlantic right whales is largely unknown, although offshore surveys have reported between one and 13 detections annually in northeastern Florida and southeastern Georgia (Waring et al. 2007, 2016). A few documented events of right whale calving have been from shallow coastal areas and bays (Kenney 2002). North Atlantic right whales may be found in feeding grounds within New England waters between February and May, with peak abundance in late March (NOAA Fisheries 2005). While in New England, right whales feed mostly on copepods belonging to the *Calanus* and *Pseudocalanus* genus (Waring et al. 2015).

The North Atlantic right whale was the first species targeted during commercial whaling operations and was the first species to be greatly depleted as a result of whaling operations (Kenney 2002). North Atlantic right whales were hunted in southern New England until the early twentieth century. Shore-based whaling in Long Island involved catches of right whales year-round, with peak catches in spring during the northbound migration from calving grounds off the southeastern United States to feeding grounds in the Gulf of Maine (Kenney and Vigness-Raposa 2009). Abundance estimates for the North Atlantic right whale population vary. From the 2003 United States Atlantic and Gulf of Mexico Marine Mammal Stock Assessments, there were only 291 North Atlantic right whales in existence, which is less than what was reported in the Northern Right Whale Recovery Plan written in 1991 (NOAA Fisheries 1991a; Waring et al. 2004). This is a tremendous difference from pre-exploitation numbers, which are thought to be around 1,000 individuals. When the right whale was finally protected in the 1930s, it is believed that the North Atlantic right whale population was roughly 100 individuals (Waring et al. 2004). In 2015, the Western North Atlantic population size was estimated to be at least 476 individuals (Waring et al. 2016). According to the most current species stock assessment, the best population estimate is 458 individuals (Hayes et al. 2018). Additional information provided by Pace et al. (2017), confirms that the probability that the North Atlantic right whale population has declined since 2010 is 99.99 percent. Data indicate that the number of adult females dropped from 200 in 2010 down to 186 in 2015 while males dropped from 283 to 272 in the same timeframe. Also cause for concern is the confirmed mortality of 17 individuals so far in 2017 alone (NOAA Fisheries 2017; Pace et al. 2017).

Contemporary anthropogenic threats to right whale populations include fishery entanglements and vessel strikes, although habitat loss, pollution, anthropogenic noise, and intense commercial fishing may also negatively impact their populations (Kenney 2002). Entanglements can represent a significant energy expenditure for large whales, leading to injury or death if disentanglement efforts are not successful within a critical time period (van der Hoop et al. 2016, 2017). Such energy expenditures can have significant sublethal impacts to right whales, particularly reproductive females where time for reproduction could be delayed for months or years (van der Hoop et al. 2016). Recovery from entanglements and subsequent energy losses resulting in physiological stress could limit reproductive success and contribute to fluctuations in population growth (van der Hoop et al. 2016). Unfortunately, evidence suggests that recent efforts to reduce entanglement through fishing gear modification have not resulted in decline of frequencies of entanglement or serious injury due to entanglement (Pace et al. 2014). Between 2002 and 2006, a study of marine mammal stranding and human-induced interactions reported that right whales in the western Atlantic were subject to the highest proportion of entanglements (25 of 145 confirmed events) and ship strikes (16 of 43 confirmed occurrences) of any marine mammal studied (Glass et al. 2008). Bycatch of North Atlantic right whale has also been reported in pelagic drift gillnet operations by the Northeast Fisheries Observer Program; however, no mortalities have been reported (Glass et al. 2008). From 2010 through 2014, the minimum rate of annual human-caused mortality and serious injury to this

species from fishing entanglements averaged 5.66 per year, while ship strikes averaged 1.01 whales per year (Hayes et al. 2017). From 2011 through 2015, the minimum rate of annual human-caused mortality and serious injury to this species from fishing entanglements averaged 5.36 per year, while ship strikes averaged 0.81 whale per year (Hayes et al. 2018). Environmental fluctuations and anthropogenic disturbance may be contributing to a decline in overall health of individual North Atlantic right whales that has been occurring for the last three decades (Rolland et al. 2016). The NOAA marine mammal stock assessment for 2015 reports that the low annual reproductive rate of right whales, coupled with small population size, suggests anthropogenic mortality may have a greater impact on population growth rates for the species than for other whales and that any single mortality or serious injury can be considered significant (Waring et al. 2016).

Ship strikes of individuals can impact northern right whales on a population level due to the intrinsically small remnant population that persists in the North Atlantic (Laist et al. 2001). Most ship strikes are fatal to the North Atlantic right whales (Jensen and Silber 2004). Right whales have difficulty maneuvering around boats and spend most of their time at the surface, feeding, resting, mating, and nursing, increasing their vulnerability to collisions. Mariners should assume that North Atlantic right whales will not move out of their way nor will they be easy to detect from the bow of a ship for they are dark in color and maintain a low profile while swimming (see Vessel Strike Avoidance Procedures Section 12.1). To address potential for ship strike, NOAA Fisheries designated the nearshore waters of the mid-Atlantic Bight as the mid-Atlantic U.S. Seasonal Management Area (SMA) for right whales in December 2008. NOAA Fisheries require that all vessels 65 ft (19.8 m) or longer must travel at 10 knots or less within the right whale SMA from November 1 through April 30 when right whales are most likely to pass through these waters (NOAA Fisheries 2010). The most recent stock assessment report noted that studies by van der Hoop et al. (2015) have concluded large whale vessel strike mortalities decreased inside active SMAs but have increased outside inactive SMAs.

Right whales have been observed in or near waters south of New England during all four seasons; however, they are most common in the spring when they are migrating north and in the fall during their southbound migration (Kenney and Vigness-Raposa 2009).

5.2.2 Fin Whale (*Balaenoptera physalus*) – Endangered

The fin whale was listed as federally endangered in 1970. Fin whales' range in the North Atlantic extends from the Gulf of Mexico, Caribbean Sea, and Mediterranean Sea in the south to Greenland, Iceland, and Norway in the north (Jonsgård 1966; Gambell 1985). They are the most commonly sighted large whales in continental shelf waters from the mid-Atlantic coast of the United States to Nova Scotia (Sergeant 1977; Sutcliffe and Brodie 1977; CeTAP 1982; Hain et al. 1992; Waring et al. 2008). Fin whales, much like humpback whales, seem to exhibit habitat fidelity (Waring et al. 2007, 2016; Kenney and Vigness-Raposa 2009). However, fin whales habitat use has shifted in the southern Gulf of Maine, most likely due to changes in the abundance of sand lance and herring, both of which are major prey species along with squid, krill, and copepods (Kenney and Vigness-Raposa 2009). While fin whales typically feed in the Gulf of Maine and the waters surrounding New England, mating and calving (and general wintering) areas are still largely unknown (Waring et al. 2007, 2016). The overall pattern of fin whale movement is complex, consisting of a less obvious north-south pattern of migration than that of right and humpback whales. Based on acoustic recordings from hydrophone arrays, Clark (1995) reported a general southward flow pattern of fin whales in the fall from the Labrador/Newfoundland region, past Bermuda, and into the West Indies. The overall distribution may be based on prey availability, as this species preys opportunistically

on both invertebrates and fish (Watkins et al. 1984). Fin whale abundance off the coast of the northeastern United States is highest between spring and fall, with some individuals remaining during the winter (Hain et al. 1992). Past estimates of fin whale abundance conducted between Georges Bank and the Gulf of St. Lawrence during the feeding season in August 2006 places the western North Atlantic fin whale populations at 2,269 individuals (Waring et al. 2007). More recent estimates indicate the western North Atlantic fin whale population is 1,618 individuals (Waring et al. 2016; Hayes et al. 2018). Fin whales are the second largest living whale species on the planet (Kenney and Vigness-Raposa 2009). The gestation period for fin whales is approximately 11 months, and calve births occur between late fall and winter. Females can give birth every 2 to 3 years.

Present threats to fin whales are similar to other whale species, namely fishery entanglements and vessel strikes. Fin whales seem less likely to become entangled than other whale species. Glass et al. (2008) reported that between 2002 and 2006, fin whales belonging to the Gulf of Maine population were involved in only eight confirmed entanglements with fishery equipment. Furthermore, Nelson et al. (2007) reported that fin whales exhibited a low proportion of entanglements (eight reported events) during their 2001 to 2005 study along the western Atlantic. On the other hand, vessel strikes may be a more serious threat to fin whales. Eight and 10 confirmed vessel strikes with fin whales were reported by Glass et al. (2008) and Nelson et al. (2007), respectively. This level of incidence was similar to that exhibited by the other whales studied. Conversely, a study compiling whale/vessel strike reports from historical accounts, recent whale strandings, and anecdotal records by Laist et al. (2001) reported that of the 11 great whale species studied, fin whales were involved in collisions most frequently (31 in the United States and 16 in France). From 2005 to 2009, the minimum annual rate of mortality for the North Atlantic stock from anthropogenic causes was approximately 2.6 per year (Waring et al. 2011) while from 2009 to 2013, this number has increased to 3.55 per year (Waring et al. 2016), and from 2010 to 2014, this number has increased to 3.8 per year (Hayes et al. 2017). From 2011 to 2015, the average human-caused mortality and serious injury to fin whales has decreased to 2.65 per year (Hayes et al. 2018). Increase in ambient noise has also impacted fin whales, for whales in the Mediterranean have demonstrated at least two different avoidance strategies after being disturbed by tracking vessels (Jahoda et al. 2003).

Fin whales are present in waters south of New England waters during all four seasons. In spring, summer, and fall, the main center of their distribution is in the Great South Channel area to the east of Cape Cod, which is a well-known feeding ground (Kenney and Winn 1986). Winter is the season of lowest overall abundance, but they do not depart the area entirely. Fin whales are the most common large whale encountered in continental shelf waters. The species is listed as endangered due to the depletion of its population from whaling (Reeves et al. 1998). A recovery plan has been written and is available from NOAA Fisheries for review (Waring et al. 2010, 2011).

5.2.3 Sei Whale (*Balaenoptera borealis*) – Endangered

The sei whale is a widespread species in the world's temperate, subpolar, subtropical, and tropical marine waters. NOAA Fisheries considers sei whales occurring from the U.S. East Coast to Cape Breton, Nova Scotia, and east to 42°W as the "Nova Scotia stock" of sei whales (Waring et al. 2016; Hayes et al. 2017). Sei whales occur in deep water characteristic of the continental shelf edge throughout their range (Hain et al. 1985). In the Northwest Atlantic, it is speculated that the whales migrate from south of Cape Cod along the eastern Canadian coast in June and July and return on a southward migration again in September and October (Waring et al. 2014, 2016). The sei whale is most common on Georges Bank and into the Gulf of Maine/Bay of Fundy region during spring and summer, primarily in deeper waters.

Although sei whales may prey on small schooling fish and squid, available information suggests that calanoid copepods and euphausiids are the primary prey of this species (Flinn et al. 2002). Sei whales are occasionally seen feeding in association with right whales in the southern Gulf of Maine and in the Bay of Fundy. However, there is no evidence to demonstrate interspecies competition between these species for food resources. Sei whales reach sexual maturity at 5 to 15 years of age. The calving interval is believed to be 2 to 3 years (Perry et al. 1999).

There is limited information on the stock identity of sei whales in the North Atlantic (Hayes et al. 2017). The best abundance estimate for the Nova Scotia stock of sei whales is 357; however, this estimate must be considered low and limited given the known range of the sei whale (Hayes et al. 2018; Waring et al. 2014, 2016). There are insufficient data to determine trends of the Nova Scotian sei whale population. From 2007 to 2011, the minimum annual rate of confirmed human-caused serious injury and mortality to Nova Scotian sei whales was 1.0 (Waring et al. 2014). From 2009 to 2013, this mortality rate was estimated 0.4 (Waring et al. 2016). From 2010 through 2014, the minimum annual rate of human-caused mortality and serious injury was 0.8 (Hayes et al. 2017), and from 2011–2015 this rate remained the same (Hayes et al. 2018). This species is listed as endangered under the ESA and is designated as depleted under the MMPA. A final recovery plan for the sei whale was published in 2011 (NOAA Fisheries 2011).

5.2.4 Humpback Whale (*Megaptera novaeangliae*) – Non-Strategic for Gulf of Maine Stock/West Indies Distinct Population Segment

The humpback whale was listed as endangered in 1970 due to population decrease resulting from overharvesting. In September 2016, NOAA Fisheries revised the ESA listing for the humpback whale to identify 14 distinct population segments (DPSs) based on breeding populations: West Indies, Cape Verde Islands/Northwest Africa, Hawaii, Mexico, Central America, Brazil, Gabon/Southwest Africa, Southeast Africa/Madagascar, West Australia; East Australia, Oceania, Southeastern Pacific, and Arabian Sea (81 FR 62259[3]). Under this new final rule, humpback whales are considered endangered in the Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, and Arabian Sea DPSs and are considered threatened in the Mexico DPS. For all the remaining DPSs, including the West Indies DPS, to which humpback whales along the east coast of the United States belong, humpback whales are no longer listed as endangered or threatened. As part of the West Indies DPS, the Gulf of Maine stock is no longer listed as strategic (Hayes et al. 2018). Humpback whales feed on small prey that is often found in large concentrations, including krill and fish such as herring and sand lance (Waring et al. 2007; Kenney and Vigness-Raposa 2009). Humpback whales are thought to feed mainly while migrating and in summer feeding areas; little feeding is known to occur in their wintering grounds. Humpbacks feed over the continental shelf in the North Atlantic between New Jersey and Greenland, consuming roughly 95 percent small schooling fish and 5 percent zooplankton (i.e., krill), and they will migrate throughout their summer habitat to locate prey (Kenney and Winn 1986). They swim below the thermocline to pursue their prey, so even though the surface temperatures might be warm, they are frequently swimming in cold water (NOAA Fisheries 1991b). Humpback whales from all of the North Atlantic migrate to the Caribbean in winter, where calves are born between January and March (Blaylock et al. 1995).

[3] Volume 81, Federal Register, Number 174, Thursday, September 8, 2016, pp 62260-62320.

Humpback whales exhibit consistent fidelity to feeding areas within the northern hemisphere (Stevick et al. 2006). There are six subpopulations of humpback whales that feed in six different areas during spring, summer and fall. These feeding populations can be found in the Gulf of Maine, the Gulf of St. Lawrence, Newfoundland/Labrador, western Greenland, Iceland, and Norway (Waring et al. 2016). The highest abundance for humpback whales is distributed primarily along a relatively narrow corridor following the 328-ft (100-m) isobath across the southern Gulf of Maine from the northwestern slope of Georges Bank, south to the Great South Channel, and northward alongside Cape Cod to Stellwagen Bank and Jeffreys Ledge. In winter, whales from waters off New England, Canada, Greenland, Iceland, and Norway migrate to mate and calve primarily in the West Indies (including the Antilles, the Dominican Republic, the Virgin Islands and Puerto Rico), where spatial and genetic mixing among these groups occurs (Waring et al. 2015). While migrating, humpback whales utilize the mid-Atlantic as a migration pathway between calving/mating grounds to the south and feeding grounds in the north (Waring et al. 2007). Since 1989, observations of juvenile humpbacks in the mid-Atlantic have been increasing during the winter months, peaking January through March (Swingle et al. 1993). Biologists theorize that non-reproductive animals may be establishing a winter feeding range in the mid-Atlantic since they are not participating in reproductive behavior in the Caribbean. Swingle et al. (1993) identified a shift in distribution of juvenile humpback whales in the nearshore waters of Virginia, primarily in winter months.

Humpback whales were hunted as early as the seventeenth century, with most whaling operations having occurred in the nineteenth century (Kenney and Vigness-Raposa 2009). Before whaling activities, it was thought that the abundance of whales in the North Atlantic stock was in excess of 15,000 (Nowak 2002). By 1932, commercial hunting within the North Atlantic may have reduced the humpback whale population to as little as 700 individuals (Breiwick et al. 1983). Humpback whales were commercially exploited by whalers throughout their whole range until they were protected in the North Atlantic in 1955 by the International Whaling Commission ban. Humpback whaling ended worldwide in 1966 (NatureServe 2010). Contemporary anthropogenic threats to humpback whales include fishery entanglements and vessel strikes. Glass et al. (2008) reported that between 2002 and 2006, humpback whales belonging to the Gulf of Maine population were involved in 77 confirmed entanglements with fishery equipment and 9 confirmed ship strikes. Humpback whales that were entangled exhibited the highest number of serious injury events of the six species of whale studied by Glass et al. (2008). A whale mortality and serious injury study conducted by Nelson et al. (2007) reported that the minimum annual rate of anthropogenic mortality and serious injury to humpback whales occupying the Gulf of Maine was 4.2 individuals per year. During this study period, humpback whales were involved in 70 reported entanglements and 12 vessel strikes and were the most common dead species reported. This number has increased to 9 animals per year between 2009 and 2013 (Waring et al. 2016). From 2011 to 2015, the average annual rate of human-caused mortality and serious injury is 8.25 humpback whales from the Gulf of Maine stock (Hayes et al. 2018). The humpback whale population within the North Atlantic has been estimated to include approximately 11,570 individuals (Waring et al. 2015, 2016). Through photographic population estimates, humpback whales within the Gulf of Maine (the only region where these whales summer in the United States) have been estimated to consist of 600 individuals in 1979 (NOAA Fisheries 1991b). According to the latest species stock assessment report, the best estimate of abundance for the Gulf of Maine stock of humpback whales is 335 individuals (Hayes et al. 2018).

5.2.5 Minke Whale (*Balaenoptera acutorostrata*) – Non-Strategic

Minke whales are among the most widely distributed of all the baleen whales. They occur in the North Atlantic and North Pacific, from tropical to polar waters. Common minke whales range between 20 and

30 ft (6 and 9 m) long (with maximum lengths of 30 to 33 ft [9 to 10 m]) and are the smallest of the North Atlantic baleen whales (Jefferson et al. 1993; Wynne and Schwartz 1999; Kenney and Vigness-Raposa 2009). The primary prey species for minke whales are most likely sand lance, clupeids, gadoids, and mackerel (Kenney and Vigness-Raposa 2009). These whales basically feed below the surface of the water, and calves are usually not seen in adult feeding areas. Minke whales are almost absent from OCS waters off the western Atlantic in winter; however, they are common in the fall and abundant in spring and summer (CeTAP 1982; Kenney and Vigness-Raposa 2009). In the 2015 stock assessment, the estimate for minke whales in the Canadian East Coast stock was 20,741 (Waring et al. 2016). This population estimate substantially decreased to 2,591 individuals in the most recent stock assessment because estimates older than 8 years were excluded from the newest estimate (Hayes et al. 2018). This new estimate should not be interpreted as a decline in abundance of this stock, as previous estimates are not directly comparable (Hayes et al. 2017). Minke whales have been observed south of New England during all four seasons; however, widespread abundance is highest in spring through fall (Waring et al. 2016). Their hearing is in the low-frequency range (Southall et al. 2007).

As is typical of the baleen whales, minke whales are usually seen either alone or in small groups, although large aggregations sometimes occur in feeding areas (Reeves et al. 2002). Minke populations are often segregated by sex, age, or reproductive condition. Known for their curiosity, minke whales often approach boats.

Minke whales are impacted by ship strikes and bycatch from bottom trawls, lobster trap/pot, gillnet, and purse seine fisheries. From 2008 to 2012, the minimum annual rate of mortality for the North Atlantic stock from anthropogenic causes was approximately 9.9 per year (Waring et al. 2015), while from 2010 to 2014 this decreased to 8.25 per year (Hayes et al. 2017). This number increased to 9.15 minke whales from 2011 to 2015 (Hayes et al. 2018). In addition, hunting for minke whales continues today by Norway in the northeastern North Atlantic and by Japan in the North Pacific and Antarctic (Reeves et al. 2002). International trade in the species is currently banned. The best recent abundance estimate for the Canadian East Coast stock is 2,591 (Hayes et al. 2018). Average annual fishery-related mortality and serious injury does not exceed the potential biological removal for this species; therefore, NOAA Fisheries considers this species as “non-strategic” (Waring et al. 2010, 2011, 2015, 2016; Hayes et al. 2018).

5.3 Earless Seals (Phocidae)

5.3.1 Harbor Seal (*Phoca vitulina*) – Non-Strategic

Harbor seals are the most abundant seals in eastern United States waters and are commonly found in all nearshore waters of the Atlantic Ocean and adjoining seas above northern Florida; however, their “normal” range is probably only south to New Jersey. While harbor seals occur year-round north of Cape Cod, they only occur during winter migration, typically September through May, south of Cape Cod (Southern New England to New Jersey) (Hayes et al. 2017; Waring et al. 2015; Kenney and Vigness-Raposa 2009). During the summer, most harbor seals can be found north of New York, within the coastal waters of central and northern Maine, as well as the Bay of Fundy (DoN 2005). Harbor seals are relatively small pinnipeds, with adults ranging between 1.7 and 1.9 m in length, with females being slightly smaller than males (Jefferson et al. 1993; Wynne and Schwartz 1999; Kenney and Vigness-Raposa 2009). Their hearing ranges from 100 hertz (Hz) to 12 kHz (Southall et al. 2007).

Harbor seals prey upon small to medium-sized fish, followed by octopus and squid, and lastly by shrimp and crabs (Kenney and Vigness-Raposa 2009). Fish eaten by harbor seals include commercially

important species such as mackerel, herring, cod, hake, smelt, shad, sardines, anchovy, capelin, salmon, rockfish, sculpins, sand lance, trout, and flounders (Kenney and Vigness-Raposa 2009). They spend about 85 percent of the day diving, and much of the diving is presumed to be active foraging in the water column or on the seabed. They dive to depths of about 30 to 500 ft (10 to 150 m), depending on location. Harbor seals forage in a variety of marine habitats, including deep fjords, coastal lagoons and estuaries, and high-energy, rocky coastal areas. They may also forage at the mouths of freshwater rivers and streams, occasionally traveling several hundred miles upstream (Reeves et al. 2002). They haul out on sandy and pebble beaches, intertidal rocks and ledges, and sandbars, and occasionally on ice floes in bays near calving glaciers.

Except for a strong bond between mothers and pups, harbor seals are generally intolerant of close contact with other seals. Nonetheless, they are gregarious, especially during the molting season, which occurs between spring and autumn, depending on geographic location. They may haul out to molt at a tide bar, sandy or cobble beach, or exposed intertidal reef. During this haul out period, they spend most of their time sleeping, scratching, yawning, and scanning for potential predators such as humans, foxes, coyotes, bears, and raptors (Reeves et al. 2002). In late autumn and winter, harbor seals may be at sea continuously for several weeks or more, presumably feeding to recover body mass lost during the reproductive and molting seasons and to fatten up for the next breeding season (Reeves et al. 2002).

Historically, these seals have been hunted for several hundred to several thousand years. Harbor seals are still killed legally in Canada, Norway, and the United Kingdom to protect fish farms or local fisheries (Reeves et al. 2002). From 2006 to 2010, the average rate of mortality for the Western North Atlantic harbor seal stock from anthropogenic causes was approximately 337 per year (Waring et al. 2013) and that number has increased from 2009 through 2013 to 420 per year (Waring et al. 2016), but has decreased from 2010 through 2014 to 389 per year (Hayes et al. 2017) and again decreased from 2011 to 2015 to 368 per year (Hayes et al. 2018). From 2011 to 2015, the total human-caused mortality and serious injury estimate decreased to 368 per year. Currently, the best population estimate for harbor seals is approximately 75,834 for the Western North Atlantic stock (Hayes et al. 2018). Average annual fishery-related mortality and serious injury does not exceed the potential biological removal for this species; therefore, NOAA Fisheries considers this species as “non-strategic” (Waring et al. 2016; Hayes et al. 2018).

5.3.2 Gray Seal (*Halichoerus grypus*) – Non-Strategic

The gray seal occurs in cold temperate to sub-arctic waters in the North Atlantic, and is partitioned into three major populations occurring in eastern Canada, northwestern Europe, and the Baltic Sea (Jefferson et al. 2008; Kenney and Vigness-Raposa 2009). The western North Atlantic stock is considered to be the same population as the one found in eastern Canada, and ranges between New England and Labrador (Waring et al. 2007). As exhibited in harbor seal populations, gray seals occur most often in the waters off of Maine during winter and spring, and spend summer and fall off northern Maine and in Canadian waters (DoN 2005). Gray seals exhibit sexual dimorphism, with adult males reaching 7.5 ft (2.3 m) long and females reaching 6.6 ft (2.0 m) (Jefferson et al. 1993; Wynne and Schwartz 1999; Kenney and Vigness-Raposa 2009). The gray seal is primarily found in coastal waters and forages in OCS regions (Lesage and Hammill 2001).

Gray seals are gregarious, gathering to breed, molt, and rest in groups of several hundred or more at island coasts and beaches or on land-fast ice and pack-ice floes. They are thought to be solitary when feeding and telemetry data indicates that some seals may forage seasonally in waters close to colonies,

while others may migrate long distances from their breeding areas to feed in pelagic waters between the breeding and molting seasons (Reeves et al. 2002). Gray seals molt in late spring or early summer and may spend several weeks ashore during this time. When feeding, most seals remain within 45 mi (72 km) of their haulout sites. Gray seals feed on numerous fish species and cephalopods (Kenney and Vigness-Raposa 2009). Gray seal scat samples from Muskeget Island, Massachusetts, included species such as sand lance, skates, flounder, silver hake, and gadids (Kenney and Vigness-Raposa 2009).

Gray seals form colonies on rocky island or mainland beaches, though some seals give birth in sea caves or on sea ice, especially in the Baltic Sea. Gray seals prefer haulout and breeding sites that are surrounded by rough seas and riptides where boating is hazardous. Pupping colonies have been identified at Muskeget Island (Nantucket Sound), Monomoy National Wildlife Refuge, and in eastern Maine (Rough 1995). Total western Atlantic gray seal population estimates are not currently available (Hayes et al. 2017). However, the gray seal colony of Massachusetts has more than 5,600 seals total and there are more than 1,700 individuals in Maine (Waring et al. 2007). This species has been reported with greater frequency in waters south of Cape Cod in recent years, likely due to a population rebound in southern New England and the mid-Atlantic (Kenney and Vigness-Raposa 2009); however, most gray seals present are juveniles dispersing in the spring. The only consistent haul-out locations within the vicinity of the Lease Area are along the sandy shoals around Monomoy and Nantucket in Massachusetts (Kenney and Vigness-Raposa 2009).

The biggest threats to gray seals are entanglements in gillnets or plastic debris (Waring et al. 2004). From 2006 to 2010, the total estimated human-caused mortality to gray seals was approximately 5,253 per year, which includes the removal of nuisance animals in Canada (Waring et al. 2015). For the period 2011 through 2015, the average annual mortality estimate decreased to 5,207 gray seals per year (Hayes et al. 2018). Average annual fishery-related mortality and serious injury does not exceed the potential biological removal for this species; therefore, NOAA Fisheries considers this species as “non-strategic” (Waring et al. 2015; Hayes et al. 2018).

6. Type of Incidental Take Authorization Requested

Atlantic Shores is requesting authorization for incidental take by Level B harassment of small numbers of marine mammals resulting from the operation of HRG equipment within each of the identified survey areas. The request is based on the following:

- The projected HRG survey activities as described in Section 2;
- The projected survey schedule as described in Section 3;
- Then evaluation of the “maximum” acoustic footprint associated with the range of potential sound-producing equipment available on the market that could be deployed within the survey areas; and
- The mitigation and monitoring measures proposed in Section 12.

To support the determination of the type of potential take that could result from the operation of the range of HRG survey equipment operating below 200 kHz available for deployment throughout the survey period, Atlantic Shores worked with JASCO Applied Sciences (JASCO) to estimate the maximum horizontal distance to the Level A and B marine mammal acoustic harassment thresholds for impulsive noise (see Appendices A and B). Results of this assessment are provided in Tables 6-1 and 6-2, respectively.

Table 6-1 Maximum Distances to Level A Thresholds by Equipment Type Operating Below 200kHz

Equipment	Level A Horizontal Impact Distance (m)				
	LFC	MFC	HFC	PPW	OPW
Sub-bottom Profiler	1	<1	60	1	<1
Single Beam Echosounder	<1	<1	220	<1	<1
Sparker	<1	2	9	<1	<1
Boomer	<1	<1	38	<1	<1

Table 6-2 Maximum Distances to Level B 160 $dB_{RMS90\%}$ Thresholds by Equipment Type Operating Below 200kHz

Equipment	Lateral Distance (m)
Sparker	372
Subbotom Profiler	231
Single Beam Echosounder	172
Boomer	97

As evidenced in Table 6-1, the maximum distance to the Level A harassment threshold for all marine mammal hearing groups, except for the HFC, is discountable. However, due to the suite of mitigation and monitoring measures presented in Section 12, no Level A take by HFC is anticipated. Furthermore, NOAA Fisheries has acknowledged in comments to the Marine Mammal Commission for previously issued IHAs (dated July 24, 2018 [NOAA Fisheries 2018b]) that harbor porpoise, the species that is at greatest risk of Level A harassment, display profound and sustained avoidance behavior to sound produced by high frequency sourcs greater than 140 dB re 1 µPa (Barlow 1988; Palka and Hammond 2001; Dyndo et al. 2015).

Moreover, it is unlikely that the sound sources resulting in the maximum possible impact as presented in Tables 6-1 and 6-2 will be used over the entire duration of the 12-month survey period in the identified survey areas. As such, the assessment included herein is based on conservative assumptions and provides a cautious approach to predicting active survey operations and their potential impact on marine mammal species.

7. Take Estimates for Marine Mammals

Atlantic Shores seeks authorization for potential take of small numbers of marine mammals by Level B harassment in the specified geographic region where the proposed activities will occur (Figure 1-1). Anticipated impacts to marine mammals from the proposed survey activities will be associated with noise propagation from the use of specific HRG survey equipment contracted to meet the goals of the survey campaigns conducted over the 12-month period. The following sections present Atlantic Shores' basis for estimating take and associated request for take related to the type of commercially available equipment and the projected level of HRG surveys.

7.1 Basis for Estimating Numbers of Marine Mammals that Might be Taken by Harassment

As stated in Section 2, Atlantic Shores proposes to conduct a range of HRG surveys throughout a 12-month period in three distinct survey areas including the Lease Area, ECR North and ECR South, as

depicted on Figure 1-1. To provide flexibility in the design, selection, and execution of each survey campaign (including choice of equipment) and to maximize protection of marine mammals from survey activities, Atlantic Shores used the following maximum (or upper-end) parameters to estimate the potential for take:

- Maximum number of days of survey that could occur over a 12-month period in each of the identified survey areas;
- Maximum distance each vessel could travel per 24-hour period in each of the identified survey areas;
- Maximum ensonified area (zone of influence [ZOI]) from the equipment listed in Table 6-2; and
- Maximum marine mammal densities for any given season that a survey could occur.

The following sections provide additional details on how each of these parameters have been applied to calculate the maximum ZOI associated with the planned survey activities in each survey area, along with estimates and associated requests for take.

7.2 Calculation of Maximum ZOI

The ZOI is the maximum ensonified area around the sound source over a 24-hour period. The following formula for a mobile source was used to calculate the ZOI:

$$\textit{Mobile Source ZOI} = (\textit{Distance/day} \times 2r) + \pi r^2$$

Where:

Distance/day = the maximum distance a survey vessel could travel in a 24-hour period;

r = the maximum radial distance from a given sound source to the NOAA Level A or Level B harassment thresholds.

For the purpose of the Atlantic Shores HRG surveys, the total *distance/day* has been estimated to be approximately 52.8 mi (85.0 km) in each identified survey area (see Table 7-1). This estimated distance per day has taken into consideration not only the line-kilometers per day achieved during Atlantic Shores' 2019 HRG Reconnaisance Survey but also data inputs from pervious offshore wind and oil and gas surveys performed by members of the Altantic Shores Geoscience Teams.

To calculate a conservative ZOI, Atlantic Shores applied the maximum radial distance (*"r"*) for any category and type of HRG survey equipment considered in its assessment to the mobile source ZOI calculation. Based on the analysis conducted by JASCO (Appendix B), the maximum calculated distance to the Level B harassment threshold for any category and type of HRG survey equipment that could be operated is the sparker at 1,221 ft (372 m; Table 6-2). As such, the ZOI for the subbottom profiler was applied as the maximum assumption.

Results of the maximum mobile source ZOI calculations are provided in Table 7-1.

Table 7-1 HRG Survey Area Distances and Maximum ZOIs

Survey Area	Number of Active Survey Days	Survey distances per day (km)	Calculated ZOI per day (km^2)
Lease Area	210	85	63.675

Table 7-1 HRG Survey Area Distances and Maximum ZOIs

Survey Area	Number of Active Survey Days	Survey distances per day (km)	Calculated ZOI per day (km^2)
ECR North	80		
ECR South	60		

It should be noted that the maximum ZOI calculation for mobile sources results in an overly conservative ZOI because of the following assumptions: (1) the subbottom profiler that produces the largest Level B ZOI would be used during all survey campaigns in each survey area; and (2) once an area along a survey trackline is ensonified by the sound source, the area will remain ensonified at a level that could result in Level B acoustic take throughout the entire 24-hour period. However, the only time survey activities could result in take by acoustic harassment is if a marine mammal enters directly into the area of ensonification.

7.3 Estimate of Numbers of Marine Mammals that Might be Taken by Harassment

Estimates of take are computed according to the following formula as provided by NOAA (Personal Communication, November 24, 2015):

$$Estimated\ Take = D \times ZOI \times (d).$$

Where:

D = average highest marine mammal species density (number per m^2)
ZOI = maximum ensonified (as calculated in Section 7.0 and summarized in Table 7-1)
d = number of days (as summarized in Table 7-1)

The data used as the basis for estimating species density "*D*" for the survey areas were derived from data provided by Duke University's Marine Geospatial Ecology Lab and the Marine-life Data and Analysis Team. This dataset is a compilation of the best available marine mammal data (1994-2018) and was prepared in a collaboration between Duke University, Northeast Regional Planning Body, University of North Carolina, the Virginia Aquarium and Marine Science Center, and NOAA (Roberts et al. 2016a; Curtice et al. 2018). Recently, these data have been updated with new modeling results and include density estimates for pinnipeds (Roberts et al. 2016b, 2017, 2018). Pinniped density data (as presented in Roberts et al. 2016b, 2017, 2018) were used to estimate pinniped densities within the identified survey areas. For bottlenose dolphin densities, Roberts et al. (2016b, 2017, 2018) does not differentiate by individual stock. Given the northern migratory coastal stock propensity to be found shallower than the 20 m depth isobath between Assateague, Virginia and Long Island, New York (Reeves et al. 2002; Hayes et al. 2018), the survey areas ECR North and South were roughly divided along the 20 m depth isobath, which roughly corresponds to the 10-fathom contour on NOAA navigation charts. The Lease Area is located within depths exceeding 20 m, where the northern migratory coastal stock would be unlikely. Roughly 33 percent of ECR North and South are 20 m or less in depth. Therefore, to account for the potential for mixed stocks within ECR North and South, 33 percent of the estimated take calculation for bottlenose dolphins will be applied to the northern migratory coastal stock and the remaining applied to the western North Atlantic offshore stock. Bottlenose dolphin densities within the Lease Area have been considered part of the offshore stock only. For pinnipeds, because the seasonality of, and habitat use by, gray seals roughly overlaps with harbor seals, the same estimated abundance has been applied to both gray and harbor seals. Pinniped density data (as presented in Roberts et al. 2016b; 2017; 2018) were used to estimate pinniped numbers presented in Table 7-2. These data, as presented by Roberts et al. (2016b; 2017; 2018) do not differentiate between pinnipend species.

To determine seasonal densities of marine mammal species in each of the survey areas, density data from Roberts et al. (2016b, 2017, 2018) were mapped within the boundary of the each survey area using geographic information systems (GIS). For each survey area, the densities as reported by Roberts et al. (2016b, 2017, 2018), were averaged by season (spring, summer, fall and winter). To support the most conservative estimates of take over a 12-month period, Atlantic Shores applied the maximum average seasonal density values for each marine mammal to the calculation. The seasonal densities by survey area are provided in Appendix C. Maximum densities used to support the calculations of take are presented in bold. Table 7-2 provides a summary of total take inclusive of all survey areas. It should be noted that calculations do not take into account whether a single animal is harassed multiple times or whether each exposure is a different animal. Therefore, the numbers summarized in Table 7-2 are the maximum estimates for animals that may be harassed during the HRG surveys (i.e., Atlantic Shores assumes that each exposure event is a different animal).

While Table 7-2 provides estimates of take over the entire Project schedule, it is unlikely that all HRG equipment will be in operation for the entire duration. However, to provide maximum operational flexibility, this analysis is based on the assumption that the sound source that could result in the largest Level B ZOI (subbottom profiler) would be utilized for the entire duration and in all locations. At this time, Atlantic Shores has not made a final decision regarding the specific type of HRG survey equipment it intends to employ and it is unlikely that the equipment resulting in the maximum-case ZOI would be used during all survey campaigns in each survey area. As such, the calculated take represents an overly conservative number. In addition, as noted in Section 12.8, for delphinoid cetaceans or pinnipeds, HRG survey equipment can continue operating if the individuals voluntarily approach the vessel (e.g., to bow ride) when the sound sources are at full operating power. Therefore, the determination of “voluntary” approach will effectively reduce the numbers and percent population affected for delphinoid cetaceans or pinnipeds, far below estimated values.

As noted in Table 7-2, requested take estimates were adjusted to account for typical group size for Risso’s and Atlantic spotted dolphins. For Risso’s and Atlantic spotted dolphins, despite the fact that the total number of estimated takes is unlikely to actually occur due to the very restrictive mitigation measures (e.g., shutdown/power-down if an animal enters the Level B harassment isopleths), NOAA Fisheries’ is typically of the opinion that some Level B takes would still occur due to the nature and duration of the survey activities within the harassment zones and potential to take Risso’s and Atlantic spotted dolphins should be included (NOAA 2018). Takes have been added for Risso’s dolphin for a total of 30 authorized takes by Level B harassment. Takes of Atlantic spotted dolphin, while unlikely, have been added for a total of 50 takes by Level B harassment, ensuring the number of takes authorized is at least equal to the average group size. In the instance of the North Atlantic right whale and ESA-listed marine mammals Atlantic Shores is committed to establishing exclusion zone(s) for each survey that are consistent with the maximum radial distance to the Level B harassment isopleth for the specific suite of equipment to be deployed as defined in Appendices A and B. This strategy will ensure no take or harm to these species during any survey campaign (see Section 12.4). For this reason, Level B take has been adjusted to zero individuals for these species.

Table 7-2 Total Maximum Marine Mammal Density and Total Estimated Level B Harassment Take Numbers

Species		Lease Area		Northern ECR Corridor		Southern ECR Corridor		Total Estimated Takes	
		Maximum Seasonal Density [a] (No./100 km²)	Calculated Take (No.)	Maximum Seasonal Density [a] (No./100 km²)	Calculated Take (No.)	Maximum Seasonal Density [a] (No./100 km²)	Calculated Take (No.)	Adjusted Take Authorization (No.)	Percent of Population
North Atlantic right whale		0.087	11.697	0.068	3.467	0.073	2.781	**0 [c]**	**0.000**
Humpback whale		0.076	10.162	0.082	4.166	0.103	3.931	**18**	**5.450**
Fin whale		0.100	13.379	0.080	4.068	0.057	2.177	**0 [c]**	**0.000**
Sei whale		0.004	0.533	0.004	0.219	0.002	0.067	**0 [c]**	**0.000**
Minke whale		0.055	7.368	0.017	0.861	0.019	0.724	**9**	**0.346**
Sperm whale		0.013	1.755	0.005	0.244	0.003	0.126	**0 [c]**	**0.000**
Long-finned pilot whale		0.036	4.797	0.012	0.629	0.009	0.352	**6**	**0.103**
Bottlenose dolphin	*N. Coastal Migratory*	-	-	21.675	364.364	58.524	737.845	**1,102**	**16.602**
	Offshore	21.752	2,908.610	21.675	728.729	58.524	1,475.690	**5,113**	**6.595**
Short beaked common dolphin		3.120	417.206	1.644	83.735	1.114	42.570	**544**	**0.774**
Atlantic white-sided dolphin		0.487	65.133	0.213	10.855	0.152	5.811	**82**	**0.168**
Atlantic spotted dolphin		0.076	10.186	0.059	2.982	0.021	0.787	**50 [d]**	**0.112**
Risso's Dolphin		0.010	1.372	0.001	0.061	0.002	0.073	**30 [d]**	**0.164**
Harbor porpoise		2.904	15.487	7.357	15.487	2.209	84.377	**847**	**0.020**
Harbor seal [b]		4.918	657.668	9.737	496.009	6.539	249.838	**1,404**	**1.851**
Gray seal [b]		4.918	657.668	9.737	496.009	6.539	249.838	**1,404**	**0.402**

Notes:
a Cetacean density values from Duke University (Roberts et al. 2016b, 2017, 2018).
b Pinniped density values from Duke University (Roberts et al. 2016, 2017, 2018) reported as "seals" and not species-specific.
c Exclusion zone exceeds Level B isopleth; take adjusted to 0 given mitigation to prevent take.
d The number of authorized takes (Level B harassment only) for these species has been increased from the estimated take to mean group size. Source for Atlantic spotted dolphin group size estimate is: Jefferson et al. (2008). Source for Risso's dolphin group size estimate is: Baird et al. (1991).

8. Anticipated Impacts of the Activity

In order for NOAA Fisheries to authorize the incidental take of marine mammals, it must determine that harassment resulting from proposed activities will have a negligible impact on marine mammal species or stocks. In 50 C.F.R. § 216.103, NOAA Fisheries defines negligible impact to mean "an impact resulting from a specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stocks [of marine mammals] through effects on annual rates of recruitment or survival." Based upon best available data regarding the marine mammal species or stocks (including density, status, and distribution) that are likely to occur in the survey areas, Atlantic Shores concludes that exposure to marine mammal species and stocks during marine site characterization surveys would result in short-term minimal effects and would not affect the overall annual recruitment or survival for the following reasons:

- As detailed in Sections 2.1 and 2.2, potential acoustic exposures from survey activities are within the non-injurious behavioral effects zone (Level B harassment);
- The potential for take as estimated in Section 7.3 represents a highly conservative estimate of harassment based upon typical HRG survey scenarios utilizing an overly conservative ZOI; and
- The protective measures as described in Section 12 are designed to avoid and/or minimize the potential for interactions with and exposure to marine mammals.

Marine mammals are mobile free-ranging animals and have the capacity to exit an area when noise-producing survey activities are initiated. Based on the conservative take estimations, survey activities may disturb more than one individual for some species (mainly dolphins), but in conjunction with other aforementioned factors we conclude the short-term HRG survey activities are not expected to result in population-level effects and that individuals will return to normal behavioral patterns after activities have ceased or after the animal has left the area under survey.

9. Anticipated Impacts on Subsistence Uses

There are no traditional subsistence hunting areas in the Survey Area.

10. Anticipated Impacts on Habitat

As summarized in Section 2.1, bottom disturbance associated with the HRG activities will be limited to grab samples to support the validation of seabed classifications obtained from the multibeam echosounder/side scan sonar data.

The temporary and localized impact of the ZOI associated with sound emitted from various HRG equipment in relation to the comparatively vast area of surrounding open ocean, would result in negligible effects to marine mammals. Impact on prey species is expected to be limited to avoidance of the area around the HRG survey activities and short-term changes in behavior. Such impacts are not expected to result in population-level effects on prey species (BOEM 2012). Individuals disturbed by a survey would likely return to normal behavioral patterns after the survey has ceased or after the animal has left the survey area. Because of the limited immediate area of ensonification and duration of individual HRG surveys, few fish may be expected in most cases to be present within the survey areas (BOEM 2012).

Impact on marine mammal habitat from these activities will be negligible.

11. Anticipated Effects of Habitat Impacts on Marine Mammals

As stated in Section 10, the effects to marine mammals from loss or modification of habitat from the proposed survey activities will be insignificant and discountable.

12. Mitigation and Monitoring Measures to Protect Marine Mammals and Their Habitat

The mitigation and monitoring measures presented in this section represent Atlantic Shores' baseline commitment to ensure the protection of marine mammals during HRG survey activities. The mitigation procedures outlined in this section are based on minimum requirements set forth in Atlantic Shores' Renewable Energy Lease No. OCS-A 0499 as well as protocols and procedures that have been successfully implemented and resulted in no take of marine mammals for similar offshore projects and previously approved by NOAA Fisheries (Bay State Wind 2018; Garden State Offshore Energy 2018; ESS 2013; Dominion 2013, 2014).

12.1 Survey Specific Protected Species Mitigation Plans

As activities in each of the survey areas are refined and survey contractors selected, Atlantic Shores will commit to providing survey-specific Protected Species Mitigation and Monitoring Plans to NOAA Fisheries for review and approval prior to the mobilization of each survey. Information in these survey-specific plan(s) will include, but is not be limited to, the following:

- Detailed list of HRG survey equipment operating at or below 200kHz to be deployed during the survey(s).
- Confirmation of the maximum distances to the NOAA acoustic harassment thresholds associated with any HRG survey equipment operating at or below 200kHz. This will be performed using sound source verification and/or modeling to set the extent of any exclusions and/or monitoring zones necessary to support the specified survey activity (see also Section 12.4).
- Details of the specific daytime and nighttime monitoring strategies and equipment to be employed to ensure mitigation measures will be successfully implemented through the duration of each survey.

Atlantic Shores commits to providing survey-specific plans a minimum of 90-days prior to the start of individual surveys. This process also aligns with Atlantic Shores' Lease requirements.

12.2 Vessel Strike Avoidance Procedures

Atlantic Shores will ensure that vessel operators and crew maintain a vigilant watch for cetaceans and pinnipeds. Survey vessel crew members responsible for navigation duties will receive site-specific training on marine mammal sighting/reporting and vessel strike avoidance measures. Vessel strike avoidance measures will include, but are not limited to, the following, except under extraordinary circumstances when complying with these requirements would put the safety of the vessel or crew at risk:

- All vessel operators and crew will maintain vigilant watch for cetaceans and pinnipeds and slow down or stop their vessel to avoid striking these protected species.
- All vessel operators will comply with 10 knot (less than 18.5 km per hour [km/h]) speed restrictions in any Dynamic Management Area (DMA). In addition, all vessels 65 ft or greater

operating from November 1 through July 31 will operate at speeds of 10 knots (less than 18.5 km/h) or less.

- All vessel operators will reduce vessel speed to 10 knots or less when mother/calf pairs, pods, or larger assemblages of non-delphinoid cetaceans are observed near an underway vessel.
- All survey vessels will maintain a separation distance of 500 m or greater from any sighted North Atlantic right whale.
- If underway, vessels will steer a course away from any sited North Atlantic right whale at 10 knots (less than 18.5 km/h) or less until the 500-m minimum separation distance has been established. If a North Atlantic right whale is sited in a vessel's path, or within 100 m to an underway vessel, the underway vessel must reduce speed and shift the engine to neutral. Engines will not be engaged until the North Atlantic right whale has moved outside of the vessel's path and beyond 100 m. If stationary, the vessel will not engage engines until the North Atlantic right whale has moved beyond 100 m.
- All vessels will maintain a separation distance of 100 m or greater from any sighted non-delphinoid cetacean. If sighted, the vessel underway will reduce speed and shift the engine to neutral, and will not engage the engines until the non-delphinoid cetacean has moved outside of the vessel's path and beyond 100 m. If a survey vessel is stationary, the vessel will not engage engines until the non-delphinoid cetacean has moved out of the vessel's path and beyond 100 m.
- Any vessel underway remain parallel to a sighted delphinoid cetacean's course whenever possible and avoid excessive speed or abrupt changes in direction. Any vessel underway reduces vessel speed to 10 knots or less when pods (including mother/calf pairs) or large assemblages of delphinoid cetaceans are observed.
- All vessels underway will not divert to approach any delphinoid cetacean or pinniped. Any vessel underway will avoid excessive speed or abrupt changes in direction to avoid injury to the sighted delphinoid cetacean or pinniped.

A crew training program will be provided to NOAA Fisheries for review and approval prior to the start of surveys. Confirmation of the training and understanding of the requirements will be documented on a training course log sheet. Signing the log sheet will certify that the crew members understand and will comply with the necessary requirements throughout the survey event.

12.3 Seasonal Operating Requirements

Throughout all survey operations, Atlantic Shores will monitor NOAA Fisheries North Atlantic right whale reporting systems for the presence of North Atlantic right whales throughout survey operations. If NOAA Fisheries should establish a DMA in the Lease Area or cable route corridor(s), survey vessels will abide by established restrictions. While the proposed survey activities will occur outside of established SMA located off of Delaware Bay, the survey area ECR North does overlap with the SMA located off of Raritan Bay. If surveys in ECR North occur within this SMA between November 1 through July 31, Atlantic Shores will ensure compliance with the requisite speed restrictions.

12.4 Exclusion and Monitoring Zone Implementation

As noted above, Atlantic Shores will commit to providing survey-specific Protected Species Mitigation and Monitoring Plans to NOAA Fisheries for review and approval prior to the mobilization of each survey.

These survey-specific plans will be informed by the actual equipment to be deployed. To support the establishment of exclusion and/or monitoring zones, Atlantic Shores will rely on the analyses provided in Appendices A and B and/or the results of sound source verification. Any sound source verification activities will be conducted in coordination and collaboration with NOAA Fisheries. Confirmation of the equipment and the associated zone(s) including as appripriat the results of the sound source verification will be provided in the respective survey-specific Protected Species Mitigation and Monitoring Plans.

In the instance of the North Atlantic right whale and ESA-listed marine mammals Atlantic Shores is committed to establishing exclusion zone(s) for each survey that are consistent with the maximum radial distance to the Level B harassment isopleth for the specific suite of equipment to be deployed to ensure no take or harm to these species.

12.5 Visual Monitoring Program

Visual monitoring of the established exclusion zones and monitoring zones will be performed by qualified and NOAA Fisheries–approved Protected Species Observers (PSOs). Qualifications for PSOs will include direct field experience on a marine mammal observation vessel and/or aerial surveys in the Atlantic Ocean/Gulf of Mexico. PSOs aboard each survey vessel will be staffed to sufficiently cover the day and/or nighttime observation requirements of the surveys being executed. PSOs will also be staffed to ensure that no one monitor will work more than 4 consecutive hours without a 2-hour break or longer than 12 hours during any 24-hour period. Atlantic Shores will provide resumes of all proposed PSOs (including alternates) to NOAA Fisheries for review and approval prior to the start of survey operations.

As stated previously, Atlantic Shores will provide a survey-specific Protected Species Mitigation and Monitoring Plan for NOAA Fisheries' review and approval prior to the mobilization of each survey. However, at a minimum the following procedures will be followed:

- PSOs will begin observation of the exclusion zones and monitoring zone during all HRG survey operations. Observations of the zones will continue throughout the survey activity and/or while equipment operating below 200 kHz are in use. The PSOs will be responsible for visually monitoring and identifying marine mammals approaching or entering the established zones during survey activities. It will be the responsibility of a Lead PSO on duty to communicate the presence of marine mammals as well as to communicate and enforce the action(s) that are necessary to ensure mitigation and monitoring requirements are implemented as appropriate.
- PSOs will be equipped with binoculars and will have the ability to estimate distances to marine mammals located in proximity to their respective exclusion zones and monitoring zone using range finders. Reticulated binoculars will also be available to PSOs for use as appropriate based on conditions and visibility to support the siting and monitoring of marine species. Digital single-lens reflex camera equipment will be used to record sightings and verify species identification. During night operations, night-vision equipment will be used. The specifications for any night-vision equipment will be provided to NOAA Fisheries for review and approval prior to use in the field as part of the survey-specific Protected Species Mitigation and Monitoring Plan(s).
- Observations will take place from the highest available vantage point on all the survey vessels. General 360-degree scanning will occur during the monitoring periods, and target scanning by the PSO will occur when alerted of a marine mammal presence.

As part of the monitoring program, PSOs will record all sightings beyond the established monitoring and exclusion zones, as far as they can see. Data on all PSO observations will be recorded based on standard PSO collection requirements. This will include dates and locations of construction operations; time of observation, location and weather; details of the sightings (e.g., species, age classification [if known], numbers, behavior); and details of any observed behavioral disturbances or injury/mortality. The data sheet will be provided to NOAA Fisheries for review and approval prior to the start of survey activities. In addition, prior to initiation of survey work, all crew members will undergo environmental training, a component of which will focus on the procedures for sighting and protection of marine mammals and sea turtles. A briefing will also be conducted between the survey supervisors and crews, the PSOs, and Atlantic Shores. The purpose of the briefing will be to establish responsibilities of each party, define the chains of command, discuss communication procedures, provide an overview of monitoring purposes, and review operational procedures.

12.6 Passive Acoustic Monitoring

Depending on the scope, location, duration, and equipment to deployed, Passive Acoustic Monitoring (PAM) may be implemented to support HRG survey activities at night and/or during periods of reduced visibility, such as fog, to support the monitoring of the established exclusion zones and/or monitoring zones.

All PAM operations will be performed by qualified and NOAA Fisheries–approved PAM Operators. Qualifications for a PAM Operator will include completion of a PAM training course as well as direct field experience on a marine mammal observation vessel in the Atlantic Ocean/Gulf of Mexico. PAM Operators aboard each survey vessel will be staffed to sufficiently cover the observation requirements of the surveys being executed. PAM Operators will also be staffed to ensure that no one monitor works more than 4 consecutive hours without a 2-hour break or longer than 12 hours during any 24-hour period. Atlantic Shores will provide resumes of all proposed PAM Operators (including alternates) to NOAA Fisheries for review and approval prior to the start of survey operations.

As stated previously, Atlantic Shores will provide a survey-specific Protected Species Mitigation and Monitoring Plan for NOAA Fisheries' review and approval that will provide the details of the PAM operation and equipment prior to the mobilization of each survey. However, at a minimum, the following procedures will be followed:

- PAM to be utilized during nighttime and periods of reduced visibility such as fog will initiate no less than 60 minutes prior to the initiation of the sound sources operating below 200 kHz and continuing until source operations cease for a significant duration.
- PAM operator will acoustically monitor, detect, and identify marine mammals and determine distance to source to support the appropriate implementation of mitigation procedures.
- The PAM operators will be in a suitable location that will not interfere with navigation or the operation of the vessel. The location will provide the PAM operator a comfortable, ergonomic position to monitor the PAM system. The PAM Operator will monitor from a location that allows for a quick exchange of communication to the source operator in case of a need for shut-down or delay.

All acoustic detections will be will be recorded as part of the PSO data logs as described in Section 12.5.

12.7 Pre-Clearance of the Exclusion Zones

Atlantic Shores will implement a 60-minute clearance period of the established exclusion zones prior to the initiation of ramp-up (Section 12.8). During this period the exclusion zones will be monitored by the PSOs, using the appropriate visual technology for a 60-minute period. Ramp up may not be initiated if any marine mammal(s) is within its respective exclusion zone. If a marine mammal is observed within an exclusion zone during the pre-clearance period, ramp-up of HRG survey equipment that operates below 200 kHz may not begin until the animal(s) has been observed exiting its respective exclusion zone or until an additional time period has elapsed with no further sighting (i.e., 15 minutes for small odontocetes and 30 minutes for all other marine mammal species).

12.8 Ramp-Up Procedures

Where technically feasible, a ramp-up procedure will be used for HRG survey equipment capable of adjusting energy levels at the start or re-start of HRG survey activities. A ramp-up procedure will be used at the beginning of HRG survey activities in order to provide additional protection to marine mammals near the Survey Area by allowing them to vacate the area prior to the commencement of survey equipment use. The ramp-up procedure will not be initiated during periods of inclement conditions or if the exclusion zones cannot be adequately monitored by the PSOs, using the appropriate visual technology for a 60-minute period.

A ramp-up would begin with the powering up of the smallest acoustic HRG equipment at its lowest practical power output appropriate for the survey.

Ramp-up activities will be delayed if a marine mammal(s) enters its respective exclusion zone. Ramp-up will continue if the animal has been observed exiting its respective exclusion zone or until an additional time period has elapsed with no further sighting (i.e., 15 minutes for small odontocetes and 30 minutes for all other marine mammal species).

12.9 Shut-Down and Power-Down Procedures

An immediate shut-down of the HRG survey equipment operating below 180 kHz will be required if a marine mammal is sighted at or within its respective exclusion zone (NOAA, Personal Communication, August 8, 2019). The vessel operator must comply immediately with any call for shut-down by the designated Lead PSO. Any disagreement between the Lead PSO and vessel operator should be discussed only after shut-down has occurred. Subsequent restart of the survey equipment can be initiated if the animal has been observed exiting its respective exclusion zone within 20 minutes of the shut-down or until an additional time period has elapsed with no further sighting (i.e., 15 minutes for small odontocetes and 30 minutes for all other marine mammal species).

If a delphinoid cetacean or pinniped is detected at or within the exclusion zone, HRG survey equipment can continue operating if the delphinoid cetacean or pinniped voluntarily approach the vessel (e.g., to bow ride) when the sound sources are at full operating power. The determination of whether the animal has “voluntarily” approached will be made by the PSO on watch after a minimum of 10 minutes of observation that the delphinoid cetacean or pinniped is approaching the vessel or towed equipment at a speed and vector that indicates voluntary approach to bow-ride or chase towed equipment.

If the acoustic source is shut down for reasons other than mitigation (e.g., mechanical difficulty) for less than 20 minutes, it may be activated again without ramp-up, if PSOs have maintained constant

observation and no detections of any marine mammal have occurred within the respective exclusion zones.

If the acoustic source is shut down for a period longer than 20 minutes and PSOs have maintained constant observation, then ramp-up procedures will be initiated as described in Section 12.8.

13. Mitigation Measures to Protect Subsistence Uses – Arctic Plan of Cooperation

Potential impacts to species or stocks of marine mammals will be limited to individuals of marine mammal species located in the northeast region of the United States and will not affect Arctic marine mammals. Given that the Project is not located in Arctic waters, the activities associated with Atlantic Shores' marine characterization surveys will not have an adverse effect on the availability of marine mammals for subsistence uses allowable under the MMPA.

14. Monitoring and Reporting

14.1 Monitoring

Visual monitoring protocols are described in Section 12.

14.2 Reporting

Atlantic Shores will provide the following reports as necessary during survey activities:

- Atlantic Shores will contact NOAA Fisheries within 24 hours of the commencement of survey activities and again within 24 hours of the completion of the activity;
- Atlantic Shores will report any observed injury or mortality in accordance with NOAA Fisheries' standard reporting guidelines; and
- Within 90 days after completion of survey activities, a draft technical report will be provided to NOAA Fisheries that fully documents the methods and monitoring protocols, summarizes the data recorded during monitoring, estimates the number of listed marine mammals that may have been taken during survey activities, and provides an interpretation of the results and effectiveness of all monitoring tasks. Any recommendations made by NOAA Fisheries shall be addressed in the final report prior to acceptance by NOAA Fisheries.

15. Suggested Means of Coordination Research

All marine mammal data collected by Atlantic Shores during marine characterization survey activities will be provided to NOAA Fisheries, BOEM, and other interested government agencies, and be made available upon request to educational institutions and environmental groups. These organizations could use the data collected during this period to study ways to reduce incidental taking and evaluate its effects.

All hydroacoustic data and resulting transmission loss rates collected during field verification of the safety and/or exclusion zones by Atlantic Shores during HRG surveys will be provided to NOAA Fisheries, BOEM, and other interested government agencies, and be made available upon request to educational institutions and environmental groups. These organizations could use the data collected during this period to study ways to reduce incidental taking from survey activities and evaluate its effects.

16. List of Preparers

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Appendix A

Distances to Acoustic Thresholds Corresponding to Level A Injury for High Resolution Geophysical Sources

Distances to Acoustic Thresholds corresponding to Level A Injury for High Resolution Geophysical Sources

Atlantic Shores HRG

Submitted to:
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APPENDIX A. EQUIPMENT SPECIFICATION REFERENCE SHEETS A-1

1. Methods

This section describes the methods used to estimate the horizontal distances to the National Marine Fisheries Service (NMFS) injury criteria (Table 1). Sources that operate with a repetition rate greater than 10 Hz were assessed with the non-impulsive (intermittent) source criteria; sources with a repetition rate equal to or less than 10 Hz were assessed with the impulsive source criteria.

Table 1. Peak pressure level (PK, dB re 1 µPa) and sound exposure level (SEL, dB re 1 µPa^2·s) thresholds for injury (PTS onset) for marine mammals for impulsive and non-impulsive sound sources (NMFS 2018).

Functional hearing group	Impulsive source		Non-impulsive (intermittent) source
	PK	Weighted SEL_{24h}	Weighted SEL_{24h}
Low-frequency cetaceans (LFC)	219	183	199
Mid-frequency cetaceans (MFC)	230	185	198
High-frequency cetaceans (HFC)	202	155	173
Phocid pinnipeds in water (PPW)	218	185	201
Otariid pinnipeds in water (OPW)	232	203	219

NMFS provides a spreadsheet to calculate these distances, but it is not designed for high-resolution geophysical survey sources. The spreadsheet does not consider seawater absorption or beam patterns, both of which can substantially influence received sound levels. In order to account for these effects, we model sound levels using Equations 1–9, as follows.

The sonar equation is used to calculate the received sound pressure level:

$$SPL(r) = SL - PL(r), \tag{1}$$

where *SPL* is the sound pressure level (dB re 1 µPa), *r* is the distance from the source (m), *SL* is the source level (dB re 1 µPa m), and *PL* is the propagation loss as a function of distance. Propagation loss is calculated using:

$$PL(r) = 20\log_{10}\left(\frac{r}{1\,m}\right)\ \mathrm{dB} + \alpha(f)\cdot r/1000, \tag{2}$$

where $\alpha(f)$ is the absorption coefficient (dB/km) and f is frequency (kHz). The absorption coefficient is approximated by discarding the boric acid term from Ainslie (2010; p29; eq 2.2):

$$\alpha(f) \approx 0.000339f^2 + 48.5f^2/(75.6^2 + f^2)\,. \tag{3}$$

When a range of frequencies is produced by a source, we use the lowest frequency for determining the absorption coefficient.

The source level is either its in-beam value (for angles within the -3 dB beamwidth) or a single representative out-of-beam value. This representative value is estimated by first calculating upper and lower bounds and then taking the average of these. We assume the beam pattern $b(u)$ is that of an unshaded circular transducer:

$$b(u) = (2\ J_1(u)/u)^2, \tag{4}$$

where $J_1(u)$ is a first order Bessel function of the first kind, whose argument is a function of off-axis angle θ and beam width (full width at half maximum) $\delta\theta$

$$u = u_0\frac{\sin\theta}{\sin\frac{\delta\theta}{2}}, \tag{5}$$

where $u_0 = 1.614$.

For the upper limit we choose the highest sidelobe level of the beam pattern, given by (Ainslie 2010; p265; Table 6.2)

$$B_{\max} = -17.6 \text{ dB}. \tag{6}$$

For the lower limit we consider the asymptotic behaviour of the beam pattern in the horizontal direction

$$J_1(u) \sim \sqrt{\frac{2}{\pi u}} \cos\left(u - \frac{3\pi}{4}\right), \tag{7}$$

where

$$u = \frac{u_0}{\sin\frac{\delta\theta}{2}}. \tag{8}$$

In this way we obtain the lower limit as

$$B_{\min} = 10 \log_{10}\left(\frac{8}{\pi\, u_0^3} \sin^3 \frac{\delta\theta}{2}\right) \text{dB}. \tag{9}$$

The out-of-beam source level is found by adding the arithmetic mean of $B_{\min}$ and $B_{\max}$ to the in-beam source level.

For broad beam sources (beam widths larger than 90°), we assumed the source was omnidirectional. For intermediate beam sources (beam widths between 36° and 90°), we interpolated the correction between the two methods. The resulting correction as a function of beam width is shown in Figure 1.

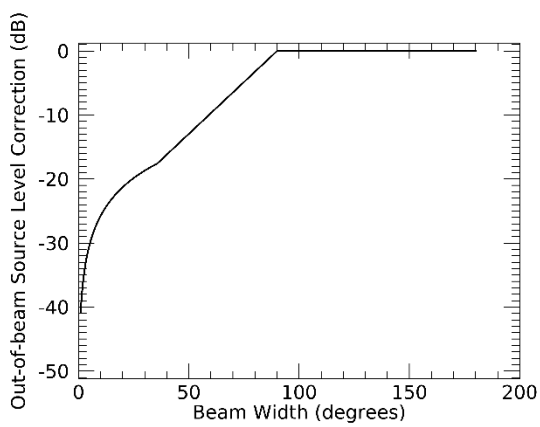

Figure 1. Correction for calculating out-of-beam source level (i.e., in the horizontal direction) from in-beam source level, as a function of source beam width.

Separate sound levels were calculated using the in-beam source level at the angle corresponding to the - 3 dB half-width and the out-of-beam source level in the horizontal direction. The higher of the two sound levels was then selected for assessing impact distance.

Distances to peak thresholds were calculated using the peak source level and applying propagation loss from Equation 2. Peak levels were assessed for both in-beam and out-of-beam levels (the latter was assessed using the out-of-beam source level correction described previously).

For the weighted SEL thresholds, we performed the following steps:

1. Calculated weighted broadband source levels by assuming a flat spectrum between the source minimum and maximum frequency, weighted the spectrum according to the marine mammal hearing group weighting function (NMFS 2018), and summed across frequency.
2. Modeled propagation loss as a function of oblique range using Equation 2.
3. Modeled per-pulse SEL for a stationary receiver at a fixed distance off a straight survey line, using a vessel transit speed of 3.5 knots and source-specific pulse length and repetition rate. The off-line distance is referred to as the closest point of approach (CPA) and was performed for CPA distances between 1 m and 10 km. The survey line length was modeled as 10 km long (analysis showed longer survey lines increased SEL by a negligible amount). SEL is calculated as $SPL + 10\log_{10}\frac{T}{1\,s}\ \mathrm{dB}$, where T is the pulse duration. For equipment where SEL was known, we used SEL directly in the calculations and provide the corresponding pulse duration in Section 2. Both in-beam and out-of-beam levels were included in the SEL calculation as per the described method above.
4. Calculated the SEL for each survey line to produce curves of weighted SEL as a function of CPA distance.
5. Used the curves from Step 4 to estimate the CPA distance to the impact criteria.

This method accounts for the hearing sensitivity of the marine mammal group, seawater absorption, and beam width for downwards-facing transducers.

2. Sources

The following subsections describe the source characteristics of HRG equipment that operates at and below 200 kHz ([BOEM] Bureau of Ocean Energy Management 2014). The horizontal impact distance to the Level A injury criteria (Table 1) was computed for each source by applying the methods from Section 1. We used the following conservative assumptions when calculating impact distances:

- For sources that operate at different levels (power settings) we used the maximum source level provided in Crocker and Fratantonio 2016 or manufacturer specifications.
- For sources that operate with different beam widths, we used the maximum beam width.
- We use the lowest frequency of the source when calculating the absorption coefficient.

BOEM Guidelines for providing Geophysical, Geotechnical, and Geohazard Information Pursuant to 30 CFR Part 585 (DoI and BOEM 2015) recommends that side scan sonar systems operate between 200 and 600 kHz and the BOEM Guidelines for Providing Archaeological and Historic Property Information Pursuant to 30 CFR Part 585 (DoI and BOEM 2017) recommends that side scan sonar systems operate at 500 kHz or greater; therefore no side scan sonars systems below 200 kHz will be used during Atlantic Shores HRG survey activities.

Atlantic Shores may use the following multibeam echosounders for HRG survey activities: Reson SeaBat 7101, and R2Sonic Sonic 2020. The Reson multibeam operates at 240 kHz (Appendix A.1) and the R2Sonic multibeam operates between 200 and 400 kHz (Appendix A.2). The distances to sound level thresholds are not assessed in this document because they will be operated at frequencies above 200 kHz.

2.1. Sparker

Atlantic Shores has indicated they may use the following sparker sources: Geo-Source 200, Geo-Source 400 – 2 kJ Ultra Hi-Res Sparker system with dual 400 tip Geo Source, Geo-Source 600, Geo-Source 800, Applied Acoustics Dura-Spark 240, Applied Acoustics Dura-Spark 400, and SIG ELC 820. The source levels for several of these sources are not listed in Crocker and Fratantonio (2016).

The Applied Acoustics Dura-Spark 240 had the highest interpolated source level, so we used that source as representative for sparker sources. The frequency range was estimated from the 3 dB bandwidth reported in Crocker and Fratantonio (2016). Based on sparker operations currently taking place within the Atlantic Shores Lease Area, the operating energy necessary to meet BOEM's guidelines has not exceeded 800 J. This sparker operating energy is also consistent with other offshore wind HRG surveys along the Atlantic. As such, the 800 J energy level is assumed in the horizontal impact distance calculation. The 800 J source levels were calculated by interpolating the Crocker and Fratantonio (2016) measurements. Pulse duration was calculated from source level and energy source level. Repetition rate was provided by Atlantic Shores.

Table 2. Sparker source specifications.

Equipment	Frequency (kHz)	Source Level (dB re 1 µPa m)	Peak Source Level (dB re 1 µPa m)	Energy source level (dB re 1 µPa^{2}s m^2)	Beam Width[a] (°)	Pulse Duration (ms)	Repetition Rate (Hz)
Applied Acoustics Dura-Spark 240	0.25 – 5	211.4	221.4	184.0	180	1.8	0.4

[a]Multi-tip sparkers are typically activated simultaneously to direct energy downwards and so they should have a downwards-oriented directivity pattern. We have not been able to find published directivity information for sparkers so have conservatively assumed sparker sources are omnidirectional. This assumption will likely lead to a larger estimated horizontal impact distance than would be expected during operation.

2.2. Sub-bottom Profiler

Table 3 list the sub-bottom profilers that Atlantic Shores may use for surveying and their acoustic characteristics. The average difference between the peak and SPL source levels for sub-bottom profilers measured by Crocker and Fratantonio (2016) was 6 dB. Unless otherwise noted, we have estimated the peak source level by adding 6 dB to the source level, and source SEL was calculated from pulse duration and source level. When pulse repetition rates were unknown, we assumed they were 10 Hz and assessed the sources with the impulsive criteria (Table 1).

Table 3. Sub-bottom profiler source specifications.

Equipment	Frequency (kHz)	Source Level (dB re 1 µPa m)	Peak Source Level (dB re 1 µPa m)	Energy source level (dB re 1 µPa²s m²)	Beam Width[a] (°)	Pulse Duration (ms)[h]	Repetition Rate (Hz)
Edgetech 2000-DSS	2 – 16[a]	178[b]	182[b]	151[b]	65[b]	6.3	10[j]
Edgetech 216	2 – 16[a]	179[b]	184[b]	159[b]	65[b]	10	10
Edgetech 424	4 – 24[a]	180[c]	187[c]	156[c]	71[c]	4	2[i]
Edgetech 512i	0.5 – 12[a]	180[c]	186[c]	160[c]	80[c]	10	10
Teledyne Benthos Chirp III	2 – 7[a,d]	197[d]	203	unknown	100[d]	unknown	10
	10 – 20[d]	205[d]	211	unknown	30[d]	unknown	10
Kongsberg GeoPulse	2 – 12[e]	214[e]	220	unknown	30, 40, or 55[e]	unknown	10
Innomar SES-2000 Medium-100 parametric	85 – 115[f]	241[f,g]	247[f]	214	2[f]	0.07 – 2[f]	40[f]

[a]Provided by Atlantic Shores as operational frequency range.
[b]Considered EdgeTech Chirp 512i as a proxy for source levels as the Chirp 512i has similar operation settings as the Chirp 2000-DSS tow vehicle (Appendix A.6). See Table 18 in source for levels Crocker and Fratantonio (2016) for 100% power and 2-12kHz.
[c]Values from Crocker and Fratantonio (2016) for 100% power and comparable bandwidth.
[d]Source specifications are for the TTV-170 Series Tow Vehicle. This tow vehicle is designed for shallow water (< 600 m depth) surveying. See Appendix A.7.
[e]Mike Bailey (Kongsberg), personal communication, 2019-07-31, Appendix A.4.
[f]Appendix A.5
[g]The specification sheet indicates a peak source level of 247 dB re 1 µPa m (Jens Wunderlich, Innomar, personal communication, 2019-07-18). The average difference between the peak and SPL source levels for sub-bottom profilers measured by Crocker and Fratantonio (2016) was 6 dB. We therefore estimate the SPL source level is 241 dB re 1 µPa m.
[h]Pulse duration was calculated from energy source level and source level unless indicated otherwise.
[i]Provided by Atlantic Shores as an operating parameter.

2.3. Single Beam Echosounder

Pulse duration was calculated from energy source level and source level. We assumed pulse repetition rates were 10 Hz and assessed the sources with the impulsive criteria (Table 1).

Table 4. Single beam echosounder source specifications.

Equipment	Frequency (kHz)	Source Level (dB re 1 µPa m)	Peak Source Level (dB re 1 µPa m)	Energy source level (dB re 1 µPa²s m²)	Beam Width[a] (°)	Pulse Duration (ms)	Repetition Rate (Hz)
Kongsberg EA 400	38[a]	222.8[a]	226.3[c]	186.8[d]	31[a]	0.3	10
Teledyne ODOM Echotrac CVM	24[b]	224.6[b]	228.1[c]	188.6[d]	20[b]	0.3	10

[a]Source level and beam width is for the 38/200 transducer. This transducer, when operating at 38 kHz, has the largest horizontal impact distance (Atlantic Shores has indicated they will not be operating the Kongsberg EA 400 with a transducer that operates below 38 kHz). EA 400 transducer specifications are tabulated in Appendix A.3 and were obtained from Ståle Myklebust (Kongsberg), personal conversation, 2019-08-08.
[b]Atlantic Shores has indicated they will use a 24 kHz transducer with the ODOM Echotrac CVM. Appendix A.8 shows the corresponding beam width. Source levels were not available so we have estimated the source level from the arithmetic mean of all Kongsberg EA 400 transducer source levels (Appendix A.3) operating at a similar frequency (18 and 38 kHz).
[c]Peak source levels for single beam echosounders were, on average, 3.5 dB higher than source levels (Crocker and Fratantonio 2016) . We estimated the peak source level by adding 3.5 dB to the source level.
[d]Energy source level for single beam echosounders were, on average, 36 dB lower than source levels (Crocker and Fratantonio 2016) . We estimated energy source level by subtracting 36 dB from the source level.

2.4. Boomer

Pulse duration was calculated from energy source level and source level. Atlantic Shores has indicated they will use these sources with a 3 Hz repetition rate. We have assessed these sources with the impulsive criteria (Table 1).

Table 5. Boomer source specifications.

Equipment	Frequency (kHz)	Source Level (dB re 1 µPa m)	Peak Source Level (dB re 1 µPa m)	Energy source level (dB re 1 µPa²s m²)	Beam Width[a] (°)	Pulse Duration (ms)	Repetition Rate (Hz)
Applied Acoustics S-Boom Triple Plate	0.01 – 20[a]	203[a]	211[a]	172[a]	80[a]	0.8	3
Applied Acoustics S-Boom	0.01 – 20[a]	195[a]	204[a]	164[a]	98[a]	0.8	3

[a] Crocker and Fratantonio (2016)

3. Distances

The following tables list the geophysical survey sources and the horizontal impact distances to the Level A criteria that were obtained by applying the methods from Section 1 with the source parameters in Section 2. The Innomar sub-bottom profiler was assessed based on the intermittent SEL thresholds because of the relatively high repetition rate (40 Hz); all other sources were assessed with the impulsive SEL thresholds.

3.1. Sparker

Equipment	Level A horizontal impact distance (m)				
	LFC	MFC	HFC	PPW	OPW
Applied Acoustics Dura-Spark 240	1	<1	9	1	<1

3.2. Sub-bottom Profiler

Equipment	Level A horizontal impact distance (m)				
	LFC	MFC	HFC	PPW	OPW
Edgetech 2000-DSS	<1	<1	<1	<1	<1
Edgetech 216	<1	<1	<1	<1	<1
Edgetech 424	<1	<1	<1	<1	<1
Edgetech 512i	<1	<1	3	<1	<1
Teledyne Benthos Chirp III	*	*	*	*	*
Kongsberg GeoPulse	*	*	*	*	*
Innomar SES-2000 Medium-100 parametric	<1	<1	60	<1	<1

*Unable to compute distance due to unavailable source parameters (see Section 2).

3.3. Single Beam Echosounder

Equipment	Level A horizontal impact distance (m)				
	LFC	MFC	HFC [a]	PPW	OPW
Kongsberg EA 400	<1	2	213	<1	<1
Teledyne ODOM Echotrac CVM	<1	1	220	<1	<1

[a] Level A impact distances are larger than the corresponding level B impact distances (19 m and 16 m) because the level A criterion for PTS is based on cumulative SEL, whereas the level B criterion is for SPL, which is not accumulated. The accumulation of sound exposure for multiple pulses means that the risk threshold for PTS is exceeded at relatively long range, even though the levels at these ranges are not high enough to exceed risk thresholds for behavioral disturbance.

3.4. Boomer

Equipment	Level A horizontal impact distance (m)				
	LFC	MFC	HFC	PPW	OPW
Applied Acoustics S-Boom Triple Plate	<1	<1	38	<1	<1
Applied Acoustics S-Boom	<1	<1	13	<1	<1

4. Summary

The table below lists the equipment that was associated with the largest horizontal impact distance for each equipment type.

Equipment	System	Level A horizontal impact distance (m)				
		LFC	MFC	HFC	PPW	OPW
Sparker	Applied Acoustics Dura-Spark 240	1	<1	9	1	<1
Sub-bottom Profiler[a]	Innomar SES-2000 Medium-100 parametric	<1	<1	60	<1	<1
Single Beam Echosounder	Kongsberg EA 400 / Teledyne ODOM Echotrac CVM[b]	<1	2	220	<1	<1
Boomer	Applied Acoustics S-Boom Triple Plate	<1	<1	38	<1	<1

[a]Not all sub-bottom profilers could be assessed because some source parameters were unavailable (see Sections 2.2 and 3.2).
[b]The MFC distance is for the Kongsberg EA 400 and the HFC distance is for the Teledyne ODOM Echotrac CVM.

We note that the methods used here are approximate and likely conservative. A rigorous propagation loss model coupled with a full beam pattern and spectral source model would result in more accurate results. Assessing the accuracy of either method requires sound field measurements.

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[DoI] Department of the Interior (U.S.) and [BOEM] Bureau of Ocean Energy Management, Office of Renewable Energy Programs. 2017. *Guidelines for Providing Archaeological and Historic Property Information Pursuant to 30 CFR Part 585*. 23 p. https://www.boem.gov/Guidelines_for_Providing_Archaeological_and_Historic_Property_Information_Pursuant_to_30CFR585/.

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Appendix A. Equipment Specification Reference Sheets

A.1. Reason SeaBat 7101

SeaBat® 7101

Teledyne RESON

PLD13773-7

SeaBat® 7101

Multibeam Echosounder

Since its release in 1996 the SeaBat 8101 has gained a formidable reputation for performance, reliability and robustness. The new SeaBat 7101 multibeam echosounder brings to the forefront the advanced technology utilised across the range of SeaBat 7000 series multibeam systems. This combination of the well-proven 8101 sonar head and new 7000 series signal processing and data handling provides the ultimate in performance through an easy upgrade path.

A bathymetric sonar operating at 240kHz fitted with either a stick (St) or Extended Range (ER) projector, the 7101 measures up to 511 discrete soundings equally spaced across the wide 150° swath. This sounding density combined with realtime roll stabilisation, high accuracy and robust bottom detect provides maximum performance and efficiency in all acoustic environments. Optional, unique 210° coverage option for extremely shallow water or vertical structure surveys.

The SeaBat 7101 transducer is depth rated to 100m and is suitable for installation on ROVs and surface vessels where the high ping rate provides very high efficiency by meeting international survey standards even at high vessel speeds.

The SeaBat 7101 is available as a Composite variant which includes all sensors and software required to conduct a full hydrographic survey, or as a 7101-Flow variant with an incorporated sensor. Both variants are available with a standard or extended range projector in titanium.

FEATURES

SWATH
150° swath coverage providing up to 7.5 x water depth swath coverage. Optional 210° swath

FREQUENCY
240kHz operating frequency provides seamless coverage from 0.5m to 500m max depth (Using ER)

HIGH SPEED
High ping rate allows high speed operations without comprising data density

IHO
Compliant with IHO SP44 Ed 5 over entire depth range

DATA
Bathmetry, sidescan, snippets & water column data available over gigabit ethernet

ROLL STABILISATION
Realtime roll stabilisation maximizes usable swath width

WATER COLUMN
Up to 511 beams in selectable modes optimises operations for any survey type

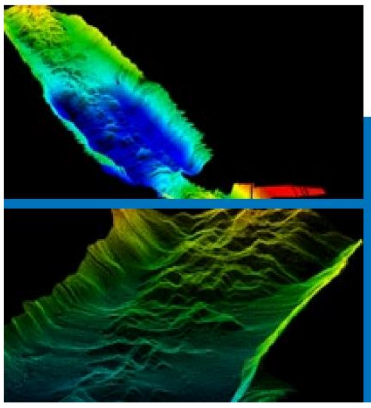
TELEDYNE RESON
Everywhereyoulook™

SeaBat® 7101

Teledyne RESON SeaBat® 7101

SEABAT 7101 SYSTEM SPECIFICATIONS

Frequency	240 kHz
Along-track transmit bandwidth	1,5°
Across-track receive beamwidth	1,8°
Max ping rate	40Hz
Pulse length	21µsec to 225 µsec
Number of beams	Up to 511 beams in selectable mode
Max swath angle	150° (210° optional)
Typical depth	0.5m to 300m (St), 0.5m to 475m (ER)
Max depth	350m (St), 500m (ER)
Depth resolution	12,5 mm
Data interface	Bathmetry, sidescan & snippets. 7K data format. Gigabit Ethernet
Power requirement	110/220 VAC, 50/60 Hz, 500W max
Head to processor cable length	25m
Depth rating	100m
Seabat 7101 composite	7101-Composite is a full hydrographic survey system based on the 7101 and the Applanix Wavemaster. All required sensors including sound velocity and software is provided.
Seabat 7101 flow	7101-Flow is a specialised version of the 7101 specifically for surveys in sheltered areas such as dams, rivers, lakes, harbours where the effects of motion are limited. The systems consists of a standard 7101 with a motion sensor incorporated inside the sonar head enclosure. The 7101-Flow is available with integrated PDS2000 software, sound velocity and position/heading sensors.



WHY CHOOSE A SEABAT 7101?

- Ideal for underwater vehicles or rapid deployment onto survey craft
- Flexible upgrade options for increased efficiency
- Wide swath coverage of 150° to a maximum range of 500m to reduce survey time
- Easy upgrade from SeaBat 8101
- Optional 210° swath
- Water column data

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A.2. R2Sonic Sonic 2020

R2 SONIC
OUR VISION IS SOUND™

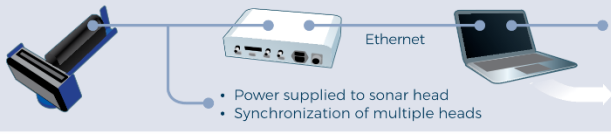
Multibeam Echosounder Specifications

We apply our technical expertise and experience as surveyors to serve you: Our portfolio is elegantly simple while technologically advanced and user-friendly. **Beamwidth** and **depth range** are the 2 main characteristics that differentiate each of those MultiBeam EchoSounders (MBES). All options can be implemented on all products, except for the option to operate at 90kHz/100kHz that is exclusive to the Sonic 2026 (at the expense of the UHR option). This provides **high flexibility** to end-users to upgrade their equipment **remotely**. These options go beyond just opting for a longer cable; they all bring extra capabilities and functionalities, allowing even the entry level sonar to benefit from advanced operating modes. **Additionally, the firmware of all 4 MBES can be upgraded remotely.**

Standard Features for all R2Sonic MBES

SONIC 2020

Extra Light & Compact!



- Ultra High Density (UHD): 1024 soundings per ping
- Selectable operating frequencies 'on-the-fly' in steps of 1Hz
- Ability to rotate the swath sector 'on-the-fly'
- Free firmware updates can be done remotely by end users
- Low power consumption for the performance delivered
- Light & compact
- Training delivered by experts
- Options upgradable remotely
- Embedded processor / controller in the sonar head that enables fast and powerful computation at low power (no separate topside processor)
- 3-year warranty
- All R2Sonic MBES exceed IHO-S44 Special Order, when installed following the instructions from the Manual and used with the I2NS and the Sound Velocity Sensor offered by R2Sonic

Only R2Sonic does it...

- Multispectral mode: survey with up to 5 frequencies in 1 pass and with 1 MBES. **Saves Time & Money!**
- Increased true sounding density with UHD → **It Provides Accurate and Truthful Resolution***
- **Smallest Beamwidth Available!** Down to **0.3° x 0.6°**
- Clean and small data files which reduces processing time and **Saves Time & Money!**
- Ability to upgrade options remotely
- Free firmware updates
- Optional 6-year warranty, which **minimizes risk** on investment
- 24/7 technical support via email and phone wherever you are in the world
- Express and high quality repairs, performed by the team that engineered the systems

Options

- Ultra High Resolution (UHR): beamwidth down to 0.3° x 0.6°
- Multimode
  - Pipeline mode: 2 frequencies, requiring UHR (700kHz)
  - Multispectral mode: ability to survey with up to 5 different frequencies in one pass and with one system
- TruePix™: provides highly compact water column imagery and backscatter
- Raw water column data output
- Robo™: automated operation
- On-site training (theory class & hands-on demo)
- 6-year warranty
- 4000m and 6000m immersion depth rating
- Mounting hardware & assemblies, including Dual Head for Sonic 2020
- Antifouling coating protection
- Switchable Forward Looking Sonar Imagery
- I2NS™ (Integrated Inertial Navigation System): 3 types available that provide different accuracy for roll / pitch and heading
  Please consult specification sheet for more information on the I2NS™
- Software available: HYPACK®, QINSy™, SonarWiz 7, Fledermaus GeoCoder
- Sound Velocity Sensors available

Quick Mobilization

Easy to Pack | Easy to Maneuver | Easy to Check-In

Sonic Series store easily in Peli™ Case, for increased mobility

US Patent 10,132,924

*Please consult the "Making Concepts Simple" booklet for clarification on technical terms / concepts.

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MADE IN USA

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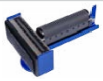
Technical Specifications

Multibeam Echosounders



	Sonic 2020	Sonic 2022	Sonic 2024	Sonic 2026
Applications	Entry level hydrography Very small vessels Small ASV and AUV	Construction Dredging Autonomous Surface Vehicle (ASV) Offshore O&G (pipeline)	Autonomous Surface Vehicle (ASV) Construction Dredging Offshore O&G (pipeline) Offshore WindFarm (cable, towers)	Advanced hydrography Research Seafloor characterization Autonomous Underwater Vehicle (AUV) Remote Operated underwater Vehicle (ROV)
Selectable Frequencies	200kHz - 400kHz. Optional 700kHz	170 - 450kHz. Optional 700kHz		170 - 450kHz. Optional 90kHz and 100kHz
Minimum frequency increase	1Hz			
Beamwidth, across track and along track	1° x 1° at 700kHz (optional) 2° x 2° at 400kHz 4° x 4° at 200kHz	0.6° x 0.6° at 700kHz (optional) 0.9° x 0.9° at 450kHz 2° x 2° at 200kHz	0.3° x 0.6° at 700kHz (optional) 0.45° x 0.9° at 450kHz 1° x 2° at 200kHz	0.45° x 0.45° at 450kHz 1° x 1° at 200kHz 2° x 2° at 90kHz & 100kHz (optional)
Number of soundings	Up to 1024 soundings per ping			
Max speed (vessel)	11.1 knots for full coverage (*)			
Near-field focusing*	Yes			
Roll stabilized beams	Yes			
Pitch stabilized beams	Yes	No		Yes
ROBO™ Automated Operation	Yes Auto Power, pulse width, rangeTrac™, GateTrac™, SlopeTrac™			
Saturation monitor	Yes			
Selectable Swath Sector *(also referred as Max Coverage)*	10° to 130° User selectable in real-time	10° to 160° User selectable in real-time		
Sounding Patterns	Equiangular Equidistant single / double / quad modes Ultra High Density (UHD)			
Sounding Depth	up to 200m+	up to 400m+		up to 800m+
Pulse Length	15µs - 1ms			15µs - 2ms
Pulse Type	Shaped CW			
Ping rate	up to 60Hz			
Bandwidth	up to 60kHz			
Immersion Depth	100m Optional 4000m		100m Optional 4000m & 6000m	100m Optional 4000m
	FLS projectors are rated 4000m	FLS projectors are rated 3000m		FLS projectors are rated 4000m
Bottom Detect Resolution	3mm			
Operating Temperature	-10°C to 40°C	-10°C to 50°C		
Storage Temperature	-30°C to 55°C			
Electrical Interface				
Mains	90-260VAC, 45-65Hz			
Power consumption	20W avg	35W avg	50W avg	100W avg
Uplink/downlink	10/100/1000Base-T Ethernet			
Sync in, Sync out	TTL			
Deck cable length	15m, optional 25m and 50m			
Mechanical				
Sonar Dimension (Sonic 2020)	140 x 161 x 133.5 mm			
Sonar Mass (Sonic 2020)	4.4kg			
Receiver Dim (LWD)		276 x 109 x 190 mm	480 x 109 x 190 mm	
Receiver Mass		7.7kg	12.9kg	
Projector Dim (LWD)		273 x 108 x 86 mm		480 x 109 x 196 mm
Projector Mass		3.3kg		13.4kg
Sonar Interface Module Dim (LWH)	280 x 170 x 60 mm			
Sonar Interface Module Mass	2.4kg			

(*) The speed of the survey is primarily limited by the installation of the MBES.

Specification Sheet 2019 version 1.3 subject to change without notice

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A.3. Specifications for Kongsberg EA 400 Transducers

Single Beam

The table below shows the Source Level (SL) for all Single beam transducers.
Some abbreviations for this list: (For combi transducers the lowest frequency is first)

SL: Source Level in dB (re 1µpa per 1m)
TP: Transmit Power (Max) (in Watts)
BW: Band Width (in degrees), If not circular Longitudinal first.
TR: Transmit Response in dB (re 1µpa per V)
RS: Receive Response in dB (re 1V per µpa)

System	SL	TP	BW	TR	RS
12Khz 12-16/60 18+1 Element	221,8	2000	16	171	-168,5
12Khz 12-16/60 1 Wide Element	197,8	100	60	142	-168,5
15Khz (15-17 Airmar)	228,4	4000	17	165	-175
18Khz (18/11)	225,8	2000	11 ±2	176 ±2	-168 ±2
38Khz (38/7)	230,1	2000	7	182,5 ±2	-170,5 ±2
38Khz (38/9)	225,6	1500	9	177	-171
38/200Khz (Combi W)	222,8 /220,7	400 /250	31	164 /155	-184 / -197
38/200Khz (Combi C and D)	218,8 / 226,3	1000	13/21 and 7	170 /178	-178 / -185
50Khz (50/7)	228,8	2000	7	177,5	-173
50Khz (50/18)	214,8	500	18 ±3	207 ±2	-181 ±2
50/200 Khz (Combi C and D)	221 / 227	1000	10/16 and 7	172 / 178	-179 / -185
120Khz (120-25)	227,8	1000	10 ±2	176,5 ±2	-183 ±2
120Khz (SideScan)	223,3	1000	1,9/55	?	?
200Khz (200 7F)	226,3	1000	7 ±1	180 ±2	-185 ±2
200Khz (200 7G)	226,3	1000	7 ±1	215 ±2 re 1 µpa per A	-185 ±2
200Khz (200 9G)	221,6	500	9	175 ±2	-169 ±2
200Khz (200 28E)	228	1500	7 ±1	180 ±2	-185 ±2
200Khz (200-35E)	235,8	2000	3 ±0.5	186,5	-177
200Khz (Side Scan)	226,8	1000	0,5/49	182 ±2	-167 ±2
500Khz (500-3G)	231,4	500	3	186 ±2	-189 ±2
500Khz (SideScan)	230,8	1000	0,35 / 60	179	-196

DRAFT

A.4. Kongsberg GeoPulse Sub-bottom Profiler

GEOPULSE

KONGSBERG

Feb 14

PINGER SUB-BOTTOM PROFILER

GeoPulse is pinger sub-bottom profiler system. Its proven success is due to its reliability, ruggedness, ease of operation and flexibility. Sub-Seabed structures are delineated using reflexions from a selectable single frequency multi-cycle high power signal, which is transmitted from an over-the-side, towed or hull mounted platform. The signal is processed in the compact deck unit.

System Components
The system comprises the deck unit (Transmitter Model 5430A and Receiver Model 5210A) and a four transducer array (Models T135) in a tow-fish (Model 136), over the side-mount assembly (Model 132) or a bespoke hull mount arrangement, which can be configured to hold up to 16 transducers.

Transmitter
The compact unit controls the transmitted signal. The output power is continuously adjustable up to 10 kW with a selectable frequency from 2 to 12 kHz. The pulse length is selected by number of cycles to improve penetration and reduce ringing effects. The transmit repetition rate can be controlled externally or internally.

Receiver
The Receiver allows the operator to apply gain up to 100 dB to the received signal. This can be done manually as well as using automatic algorithms including bottom tracking TVG (time variant gain) and AGC (automatic gain control). The processed signal can be output on a wide range of storage and printing media.

Transducer deployment options
Over-The-Side-Mount (Model 132)
The assembly was designed for small boat operation at lower speeds. The transducers are mounted on a plate at the end of a vertical, gimballed staff. The staff, in turn, is supported by a mounting pad, which can be fastened to either the deck of the boat, or to an athwart-ships timber.
Towed Transducer Vehicle (Model 136A)
The Model 136A fish is the industry standard of the GeoAcoustics profiling systems. It has logged more survey kilometres and more pipeline
crossings than any other profiling vehicle in the world. Its design allows for stable, noise-free towing in high seas and at speeds up to 12 knots.
The rugged galvanised body and fibreglass cowling, provides protection and will stand up to the punishment encountered in harsh marine environments.
Hull mounting
The transducers are mounted in a bespoke sea-chest arrangements. Up to 16 transducers are supported for deep water operations producing a narrower beam.

FEATURES

- Selectable transmit frequency 2 to 12 kHz
- Over-the-side, towed or hull mounted deployment
- Reliable, proven, easy to use
- Good penetration and resolution

OPTIONS

- Combined with side scan sonar
- Third party acquisition system integration
- Range of tow cables and winches

TECHNICAL SPECIFICATIONS

Transmitter Model 5430A

- Output: 10kW with 0.75% duty cycle, continuously adjustable.
- 2 to 12kHz, continuously adjustable.
- Short circuit proof.
- Impedance matched.
- Pulse Cycles: 1, 2, 4, 8, 16 or 32 cycles of the frequency selected. The transmitted output pulse will be phase coherent within 22.5°.
- Key:
- External: 2 to 12 V pulse, either + or – leading edge triggered.
- Max width 50 ms to eliminate double triggering. Transformer isolated.
- Internal: Set by internal potentiometer, 1 to 10 pps, uncalibrated.
- Output to Receiver Transformer isolated. or Third Party Acquisition System: Frequency response flat
- Processor: between approximately 1 kHz and 20 kHz.
- Two modes of operation:
  - A: Flat gain –0 dB gain
  - B: Short range TVG -20 dB (10:1) of attenuation during transmit pulse and a –20 dB to 0 dB ramp within 15ms after end of transmit signal.
- Power: 115/230 VAC ± 10%, 47 to 63 Hz, 220 W maximum.
- Auxiliary Power: IEC connector, unfused, 6 A maximum.
- Environmental: Operational: -5 to 50°C,Storage: -15 to 85°C
- Dimensions: 45.7 cm (L) x 43 cm (W) x 13 cm (H)
- Weight: 18 kg

Receiver Model 5210A

- Amplifier: Differential common mode rejection:
- 100 dB at 60 Hz. Sensitivity 30 µV RMS in, produces 1V RMS out at 90 dB total gain with TVG.
- Signal to noise: 20 dB at 100 dB gain 1 kHz centre frequency and 1 kHz bandwidth.
- Coarse gain: 40 dB maximum
- Fine gain: 0 – 30 dB in 3 dB increments
- Filter: Low pass and high pass, active type, maximally flat, 24 dB/octave minimum roll-off, 0 gain, 0.02 kHz to 15 kHz adjustable in ½ octave increments.
- Knobs interlock to prevent overlap.
- TVG: Dynamic range: 30 dB
- Rate: approximately flat to 30 dB in 14 ms.
- Manual delay: vernier adjust from 1 to 14 ms with multiplier of x 1, x 10, x 100 and internal select of x 1000
- AGC: Attack adjustable from 330 µs to 330 ms.
- Decay: adjustable from 330 µs to 330 ms.
- Range: 20 dB
- Power: 115/230 VAC ± 10% (internal switch selectable), 47 to 63 Hz, 45 W maximum
- Environmental:
  - Operational: -5 to 50° C,
  - Storage: -15 to 85°C
- Dimensions: 45.7 cm (L), x 43 cm (W), x 17.8 cm (H)
- Weight: 12kg

Over-the-side mount assembly (Model 132B)

- Beam width (4 Transducers):
  - 55° at 3.5kHz.
  - 40° at 5.0kHz.
  - 30° at 7.0kHz
- Source level: 214dB re 1µPa/1M
- Dimensions: 70 cm (L) x 52 cm (W) x 46 cm (H)
- Mounting Staff:
- One section 183 cm, two sections 360 cm
- Weight: 120 kg

Tow-fish (Model 136A)

- Beam width (4 Transducers):
  - 55° at 3.5kHz.
  - 40° at 5.0kHz.
  - 30° at 7.0kHz
- Source level: 214dB re 1µPa/1M
- Dimensions: 156 cm (L) x 46 cm (W) x 46 cm (H)
- Weight: 125 kg

Hull mount

- 2 x 2 (4), 3 x 3 (9) and 4 x 4 (16) transducer arrays available
- Bespoke sea chest deployment

Specifications subject to change without any further notice.

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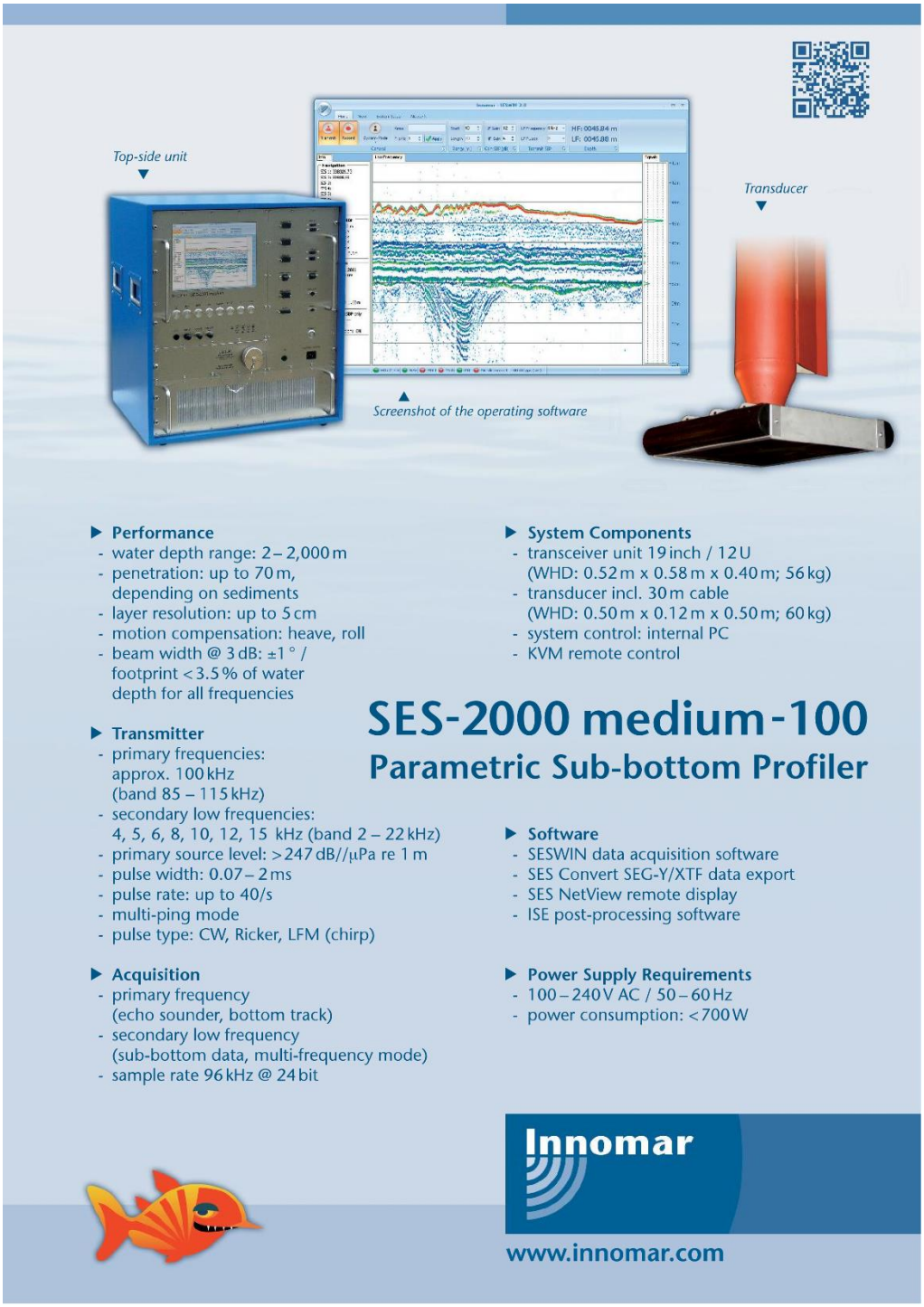
A.5. Innomar Sub-bottom Profiler



A.6. Edgetech Sub-bottom Profilers

2.1.2 Processor Unit Specs

The specifications for the Processing Unit within the rack mount topside are shown in TABLE 2-2.

SPECIFICATION	VALUE
Mother Board	Intel I7 6700 Quad Core 3.4GHz. 8 MB Cache
Sonar Interface	Sonar Interface board (Tiger board) composed of carrier board, Acquisition board, and Sonar board
Memory	8 GB DDR4 RAM
Hard Drives	500 GB minimum (operating system) 1 TB minimum (Removable Drive [Hot Swappable])
DVD-R/W drive	10x4x32 minimum speed
Operating system	Windows 7 64 Bit
Application software	DISCOVER Sub-Bottom
Display	High resolution 23-inch flat panel LCD monitor
Keyboard	High impact industrial
Trackball	High impact industrial
I/O ports	(4) RS-232 Front: (2) Ethernet Ports (2) USB2 Rear: (2) USB2 (2) USB3 (2) USB3.1
Analog input	16-bit resolution, 200 kHz max sampling rate
Analog Output	16-bit resolution, 200 kHz max sampling rate
Pulse type	Full Spectrum CHIRP FM
Pulse length	5-100 ms, depending on tow vehicle and application
Bandwidth	0.5-15 kHz, depending on tow vehicle and application
Trigger in	TTL negative edge triggered
Trigger out	TTL negative edge triggered, 5ms ling pulse minimum
Sampling rate	20, 25, 40, or 50 kHz, depending on the transmit upper frequency
Acoustic power	212 dB re1 NPa @ 1 meter peak (approx.) at center frequency
Input voltage	120-220 VAC, 50/60 Hz, auto sense

Table 2-2: 3200-XS Topside Processor Specs

2.1.3 Power Amplifier

The specifications for the Power Amplifier are show in TABLE 2-5, TABLE 2-4, and TABLE 2-5.

2.1.3.1 Power Output

SPECIFICATION	VALUE
2-ohm Dual (*per channel*)	20 mS BURST: 4,700 W 20 Hz – 20 kHz: 2,800 W 1 kHz: 2,800 W
4-ohm Dual (*per channel*)	3,500 W
8-ohm Dual (*per channel*)	1,500 W
4-ohm Bridge	5,600 W
8-ohm Bridge	6,000 W

Table 2-3: Power Amplifier Specs: Power Output

EdgeTech

2000 SERIES

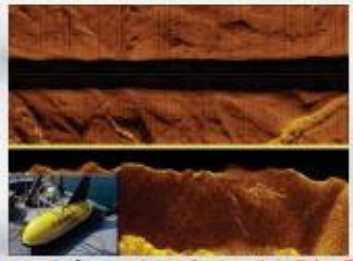
COMBINED SIDE SCAN SONAR & SUB-BOTTOM PROFILING SYSTEM

KEY SPECIFICATIONS

SIDE SCAN SONAR		
Frequency (dual simultaneous CHIRP)	100/400 kHz	300/600 kHz
Operating Range	100 kHz: 500 meters/side 400 kHz: 150 meters/side	300 kHz: 230 meters/side 600 kHz: 120 meters/side
Beam Width (2-way) & Along Track Resolution	100 kHz: 1.08 deg or 1.90 m @ 100 m 400 kHz: 0.56 deg or 0.96 m @100 m	300 kHz: 0.6 deg or 1.0 m @ 100 m 600 kHz: 0.26 deg 0.45 m @ 100 m
Across Track Resolution	100 kHz: 6.3 cm 400 kHz: 1.8 cm	300 kHz: 2.8 cm 600 kHz: 1.4 cm

SUB-BOTTOM PROFILER	2000-CSS	2000-DSS	2000-TVD
Frequency Band	500 Hz - 12 kHz	2-16 kHz	1-10 kHz
Resolution	8-20 cm	6-10 cm	9-25 cm
Penetration in coarse sand	20m	6m	20m
Penetration in clay	200m	80m	200m
TOWFISH	**2000-CSS**	**2000-DSS**	**2000-TVD**
Length	160 cm (63")	145 cm (57")	226 cm (89")
Width	124 cm (49")	74 cm (30")	81 cm (32")
Height	47 cm (18.5")	84 cm (33")	55 cm (22")
Weight in Air	232 kg (510 lbs.)	145 kg (320 lbs.)	250 kg (550 lbs.)
Maximum Water Depth	300m	2,000m	3000m

TOPSIDE PROCESSOR	
Hardware	Standard 19" rack
Operating System	Windows XP
Display	Dual 22" high resolution flat panel monitors
Archive	DVD-R/W and/or LAN connection
File Format	Native JSF or XTF for side scan, SEG-Y for sub-bottom
Output	Ethernet
Power Input	90 to 132 VAC and 180 to 260 VAC, Auto voltage detect and switching, 47-63 Hz



For more information please visit EdgeTech.com

info@EdgeTech.com | USA 1.508.291.0057

2-7

SPECIFICATION	SB-424 VALUE	SB-216S VALUE	SB-512i VALUE
Frequency range	4-24 kHz	2-16 kHz	0.5-12 kHz
Pulse type	FM	FM	FM & WB (wide band)
Pulse bandwidth/pulse length	4-24 kHz/10 ms 4-20 kHz/10 ms 4-16 kHz/10 ms	2-15 kHz/20 ms 2-12 kHz/20 ms 2-10 kHz/20 ms	0.5-8.0 kHz/5 ms FM 0.5-2.7 kHz/40 ms WB 0.5-6.0 kHz/20 ms WB 0.5-4.5 kHz/50 ms FM 0.5–6.0 kHz/9 ms FM 0.5–6.0 kHz/18 ms FM 0.5–7.2 kHz/30 ms FM 0.7–12.0 kHz/20 ms FM 2.0–12.0 kHz/20 ms FM
Calibration:	Gaussian-shaped pulse spectrum	Gaussian-shaped pulse spectrum	Gaussian- and rectangular-shaped pulse spectrum
Vertical resolution[a]	4 cm (4–24 kHz) 6 cm (4–20 kHz) 8 cm (4–16 kHz)	6 cm (2–15 kHz) 8 cm (2–12 kHz) 10 cm (2–10 kHz)	19 cm (1–5.0 kHz) 12 cm (1.5–7.5 kHz) 8 cm (2–12 kHz)
Penetration in course and calcareous sand[b]	2 m (typ)	6 m (typ)	30 m (typ)
Penetration in soft clay[b]	40 m	80 m	250 m
Beam width	16°, 4–24 kHz 19°, 4–20 kHz 23°, 4–16 kHz	17°, 2–15 kHz 20°, 2–12 kHz 24°, 2–10 kHz	41°, 0.5–5 kHz 32°, 1–6 kHz 24°, 1.5–7.5 kHz 16°, 2–12 kHz
Optimum tow vehicle pitch/roll[c]	<7°, 4–24 kHz <8°, 4–20 kHz <10°, 4–16 kHz	<7°, 2–15 kHz <8°, 2–12 kHz <10°, 2–10 kHz	<16°, 0.5–5 kHz <13°, 1–6 kHz <10°, 2–8 kHz <8°, 2–10 kHz <7°, 2–12 kHz
Optimum tow height	3-5m above sea floor	3-5 m above sea floor	3-5 m above sea floor
Transmitters	1	1	2
Receive arrays	2	2	4
Output power	2000 W	2000W	2000 W
Tow vehicle size	77 cm (30 in.) L 50 cm (20 in.) W 34 cm (13 in.) H	105 cm (41 in.) 67 cm (26 in.) W 46 cm (18 in.) H	158 cm (62 in.) L 134 cm (53 in.) W 46 cm (18 in.) H
Shipping container size	91 cm (36 in.) L 66 cm (26 in.) W 64 cm (25 in.) H	117 cm (46 in.) L 79 cm (31 in.) W 61 cm (24 in.) H	173 cm (68 in.) L 137 cm (54 in.) W 71 cm (28 in.) H
Weight in air	35 kg (78 lb)	72 kg (160 lb)	186 kg (410 lb)
Shipping weight	110 kg (243 lb)	162 kg (357 lb)	356 kg (783 lb)
Tow cable requirements	3 shield-twisted wire pairs	3 shield-twisted wire pairs	3 shield-twisted wire pairs
Depth rating	300 m (984 ft) max	300 m (984 ft) max	300 m (984 ft) max

Table 2-6: Tow Vehicle Specifications

A.7. Teledyne Benthos Chirp III

TTV-170 Series Tow Vehicle

The TTV-170 Series Tow Vehicle is designed for use on small boats in relatively shallow water. The TTV-172 is configured with a low frequency transducer, a high frequency transducer and two hydrophone arrays. The TTV-171 is configured for single frequency operation with the low frequency transducer and the hydrophone arrays.

Physical Characteristics

Construction:	Two-part fiberglass shell with 6061 aluminum tow body
Dimensions:	94 cm (37 in.) long and 32.4 cm (12.7 in.) by 43.4 cm (17.1 in.) in cross section
Weight in air (TTV-172):	75 lb (34 kg)
Weight in water (TTV-172):	45 lb (20 kg)
Tether system:	Either of two Industry-standard multi-conductor cables: Teledyne Benthos TWC-602, Kevlar reinforced, with three twisted/shielded pairs and three conductors—for use with separate steel tow cable, or Teledyne Benthos TWC-601, Rochester 301301 double-armored, with three coaxial pairs and three single conductors—for use with winch and slip rings
Operating depth:	600 meters
Towing speed:	1 to 6 knots operational

Low Frequency Sonar

Transmitter transducer:	Teledyne Benthos AT-471 low frequency transducer

Power output:	400 watts, 15% duty cycle at 3.5 kHz for 197 dB re 1 μPa @ 1 m nominal, 4 kw maximum at reduced duty cycle
Frequency range:	Sweeps in the 2 kHz to 7 kHz band
Transducer radiation:	100° conical

High Frequency Sonar

Transmitter transducer:	Teledyne Benthos AT-14F7C high frequency transducer
Power output:	90 watts, 15% duty cycle at 17 kHz for 205 dB re 1 μPa @ 1 m nominal, 4 kw maximum at reduced duty cycle
Frequency range:	Sweeps in the 10 kHz to 20 kHz band
Transducer radiation:	30° conical

Sonar Receiver

Receiver hydrophone:	Two 8-element hydrophone arrays
Frequency band:	2 kHz to 100 kHz

TTV-290 Series Tow Vehicle

The TTV-290 Series Tow Vehicle is designed for use in deep water. The TTV-292 is configured with four low frequency transducers, a high frequency transducer and a hydrophone array. The TTV-291 is configured for single frequency operation with the four low frequency transducers and the hydrophone array.

Physical Characteristics

Construction:	Two-part aluminum reinforced fiberglass
Dimensions:	208.7 cm (82 in.) long and 38.4 cm (15.1 in.) by 53.3 cm (21.0 in.) in cross section
Weight in air (TTV-292):	330 lb (150 kg)

A.8. ODOM Echotrac CVM

The following specifications were obtained from http://www.teledynemarine.com/odom-transducers?BrandID=15

Teledyne Odom have a wide range of echo sounder transducers to meet almost every need.

SINGLE FREQUENCY TRANSDUCERS

Model	Configuration	Housing model	Weight	Frequency	Beam width	Application
SMBB200-9	Stem Mount (stainless steel)	SS510	1.5 kg	200 kHz	9°	Hydro Survey
SMBB200-3	Stem Mount (stainless steel)	SS549	4.6 kg	200 kHz	3°	Hydro Survey
SMSW200-4a	Stem Mount	SS538	2.1 kg	200 kHz	4°	Very Shallow Hydro Survey
SM1000-1.7	Stem Mount	SS546	4.6 kg	1000 kHz	1.7°	Hydro Survey
FMBB200-9	Flange Mount (Atlas)	M194	.5 kg	200 kHz	9°	Hydro Survey
HM100-8	Hull Mount (stainless steel)	SS216	10.0 kg	100 kHz	8°	Hydro Survey
HM40-19	Hull Mount (stainless steel)	SS216	10.0 kg	40 kHz	19°	Hydro Survey
TM33-19	Tank Mount (Atlas)	M194	9.5 kg	33 kHz	19°	Hydro Survey
TM33-19-NAV	Tank Mount (with underwater connector	M192NAV	9.5 kg transducer 23.0 kg housing	33 kHz	19°	Hydro Survey
HM10-17	Hull Mount (seal cast)	M187-1	114.0 kg	10 kHz	17°	Deep Survey
TM200-3	Tank Mount (Atlas)	M192	9.0 kg	200 kHz	3°	Hydro Survey
TH24-20SAW	Thru Hull (stainless steel window)	CS234/229	51.0 kg	24 kHz	20°	Hydro Survey
TM28-18-NAV	Thru Hull (urethane window)	M192NAV	9.5 kg transducer 23.0 kg housing	28 kHz	18°	Hydro Survey
HM24-10	Hull Mount (round urethane)	93-190	40.0 kg	24 kHz	10°	Deep Survey
TM24-20	Tank Mount (Atlas)	M192-2	10.0 kg	24 kHz	20°	Hydro Survey

Model	Configuration	Housing model	Weight	Frequency	Beam width	Application
TM24-20	Tank Mount (with underwater connector)	M192	9.0 kg	200 kHz	3°	Hydro Survey

DUAL FREQUENCY TRANSDUCERS

Model	Configuration	Housing Model	Weight	Frequency	Beam Width	Application
THP200/24-4/20	Tank, Hull or Pole Mount	M108	14.5 kg	200-24 kHz	4° 20°	Hydro Survey
OTSBB200/33-5/23	Over the Side (sealcast)	M177-2	6.5 kg	200-33 kHz	5° 23°	Hydro Survey
OTSBB200/24-4/20	Over the Side (sealcast)	M42	14.5 kg	200-24 kHz	4° 20°	Hydro Survey
HM210/12-8/20	Hull Mount (seal cast)	T196	40.0 kg	210-12 kHz	8° 20°	Shallow, Sub-Bottom, Deep Survey
HMBB200/24-4/20	Hull Mount (seal cast)	M175-2	21.0 kg	200-24 kHz	4° 20°	Hydro Survey
HM200/12-9/25x32	Hull Mount (seal cast)	M176-3	28.0 kg	200-12 kHz	9° 25x32°	Deep Survey
HM200/12-8/20	Hull Mount	T197	40.0 kg	200-12 kHz	8° 20°	Shallow, Sub-Bottom, Deep Survey

SIDE LOOKING TRANSDUCERS

Model	Configuration	Housing Model	Weight	Frequency	Beam Width	Application
SS200-0.7x50	Side Scan	SS82	10.5 kg	200 kHz	50°	Shallow Recon
SS340-0.5x50	Side Scan	SS134	6.0 kg	340 kHz	50°	Shallow Recon

WIDE BANDWIDTH TRANSDUCERS

Model	Configuration	Housing Model	Weight	Frequency	Beam Width	Application
HMBB12-20	Hull Mount (round urethane)	M74-2	74.5 kg	12 kHz	20°	Deep Survey
HM15-17	Hull Mount (round urethane)	M74	44.0 kg	15 kHz	17°	Hydro Survey

Appendix B

Distances to Acoustic Thresholds Corresponding to Level B Harassment for High Resolution Geophysical Sources

Distances to Acoustic Thresholds corresponding to Level B Harassment for High Resolution Geophysical Sources

Atlantic Shores

Submitted to:

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Disclaimer:

The results presented herein are relevant within the specific context described in this report. They could be misinterpreted if not considered in the light of all the information contained in this report. Accordingly, if information from this report is used in documents released to the public or to regulatory bodies, such documents must clearly cite the original report, which shall be made readily available to the recipients in integral and unedited form.

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APPENDIX A. EQUIPMENT SPECIFICATION REFERENCE SHEETS A-1

1. Methods

This section describes the methods used to estimate the horizontal distance to the root-mean-square sound pressure level (SPL) 160 dB re 1 µPa isopleth for the purposes of estimating Level B harassment. We use the methods specified in the Interim Recommendation for Sound Source Level and Propagation Analysis for High Resolution Geophysical (HRG) Sources (NOAA July 22, 2019), with modifications to use a more accurate seawater absorption formula and a method to account for energy emitted outside of the primary beam of the source. The method is described below.

The sonar equation is first used to calculate the in-beam distance at which 160 dB re 1 µPa is reached:

$$SPL(r) = SL - PL(r), \tag{1}$$

where *RL* is the sound pressure level (dB re 1 µPa), *r* is the in-beam range (m), *SL* is the in-beam source level (dB re 1 µPa m), and *PL* is the propagation loss as a function of distance. Propagation loss is calculated using:

$$PL(r) = 20\mathrm{Log}_{10}(r) + \alpha(f) \cdot r/1000, \tag{2}$$

where α is the absorption coefficient (dB/km) and *f* is frequency (kHz). The absorption coefficient is approximated by discarding the boric acid term from Ainslie (2010; p29; eq 2.2):

$$\alpha(f) \approx 0.000339f^2 + 48.5f^2/(75.6^2 + f^2)\,. \tag{3}$$

When a range of frequencies is produced by a source, we use the lowest frequency for determining the absorption coefficient.

For pulses of duration less than 100 ms, the source level is calculated over the pulse duration. The source level is also shown using an averaging time of 100 ms, the latter chosen to represent a typical integration time for marine mammal hearing ([COL] Consortium for Ocean Leadership 2018).

For a downwards-pointing source with a beamwidth less than 180°, the horizontal impact distance (*R*) is calculated from the in-beam range using:

$$R = r \cdot \sin\left(\frac{\delta\theta}{2}\right), \tag{4}$$

where $\delta\theta$ is the -3 dB beamwidth.

To account for energy emitted outside of the primary beam of the source, we estimate a single representative out-of-beam source level and propagate the sound horizontally. For narrow-beam sources (up to 36° beam width) the representative source level is estimated by first calculating upper and lower bounds and then taking the average of these. We assume the beam pattern $b(u)$ is that of an unshaded circular transducer:

$$b(u) = (2\ J_1(u)/u)^2, \tag{5}$$

where $J_1(u)$ is a first order Bessel function of the first kind, whose argument is a function of off-axis angle θ and beam width (full width at half maximum) $\delta\theta$

$$u = u_0 \frac{\sin\theta}{\sin\frac{\delta\theta}{2}}, \tag{6}$$

where $u_0 = 1.614$.

For the upper limit we choose the highest sidelobe level of the beam pattern, given by (Ainslie 2010; p265; Table 6.2)

$$B_{\max} = -17.6\ \mathrm{dB}. \tag{7}$$

For the lower limit we consider the asymptotic behaviour of the beam pattern in the horizontal direction

$$J_1(u) \sim \sqrt{\frac{2}{\pi u}} \cos\left(u - \frac{3\pi}{4}\right), \tag{8}$$

where

$$u = \frac{u_0}{\sin\frac{\delta\theta}{2}}. \tag{9}$$

In this way we obtain the lower limit as

$$B_{\min} = 10 \log_{10}\left(\frac{8}{\pi\, u_0^3} \sin^3 \frac{\delta\theta}{2}\right) \text{dB}. \tag{10}$$

The out-of-beam source level is found by adding the arithmetic mean of $B_{\min}$ and $B_{\max}$ to the in-beam source level.

For broad beam sources (beam widths larger than 90°), we assumed the source was omnidirectional. For intermediate beam sources (beam widths between 36° and 90°), we interpolated the correction between the two methods. The resulting correction as a function of beam width is shown in Figure 1.

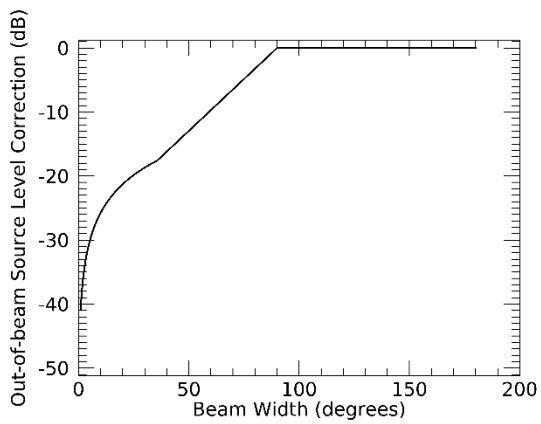

Figure 1. Correction for calculating out-of-beam source level (i.e., in the horizontal direction) from in-beam source level, as a function of source beam width.

Separate sound levels were calculated using the in-beam source level at the angle corresponding to the - 3 dB half-width and the out-of-beam source level in the horizontal direction. The higher of the two sound levels was then selected for assessing impact distance.

Both the pulse duration and 100 ms averaged source levels were used to compute two different horizontal impact distances for each source. These two distances were provided to show the effect of using a 100 ms averaging time as recommended by COL (2018). However, at the request of NMFS, the distances corresponding to the pulse duration averaged source levels were used in the summary section.

2. Sources and Distances to Threshold

The following subsections describe the source characteristics of HRG equipment that operates at and below 200 kHz ([BOEM] Bureau of Ocean Energy Management 2014). The horizontal impact distance to the Level B harassment threshold (160 dB re 1 μPa) was computed for each source by applying the methods from Section 1. We used the following conservative assumptions when calculating impact distances:

- For sources that operate with different beam widths, we used the maximum beam width.

- We use the lowest frequency of the source when calculating the absorption coefficient.

BOEM Guidelines for providing Geophysical, Geotechnical, and Geohazard Information Pursuant to 30 CFR Part 585 (DoI and BOEM 2015) recommends that side scan sonar systems operate between 200 and 600 kHz and the BOEM Guidelines for Providing Archaeological and Historic Property Information Pursuant to 30 CFR Part 585 (DoI and BOEM 2017) recommends that side scan sonar systems operate at 500kHz or greater; therefore no side scan sonars systems below 200 kHz are planned to be used to support Atlantic Shores HRG survey activities.

Atlantic Shores may use the following multibeam echosounders for HRG survey activities: Reson SeaBat 7101, and R2Sonic Sonic 2020. The Reson multibeam operates at 240 kHz (Appendix A.1) and the R2Sonic multibeam operates between 200 and 400 kHz (Appendix A.2). The distances to sound level thresholds are not assessed in this document because they will be operated at frequencies above 200 kHz.

2.1. Sparker

Atlantic Shores has indicated they may use the following sparker sources: Geo-Source 200, Geo-Source 400 – 2 kJ Ultra Hi-Res Sparker system with dual 400 tip Geo Source, Geo-Source 600, Geo-Source 800, Applied Acoustics Dura-Spark 240, Applied Acoustics Dura-Spark 400, and SIG ELC 820. The source levels for several of these sources are not listed in Crocker and Fratantonio (2016).

The Applied Acoustics Dura-Spark 240 had the highest interpolated source level, so we used that source as representative for sparker sources. The frequency range was estimated from the 3 dB bandwidth reported in Crocker and Fratantonio (2016). Based on sparker operations currently taking place within the Atlantic Shores Lease Area, the operating energy necessary to meet BOEM's guidelines has not exceeded 800 J. This sparker operating energy is also consistent with other offshore wind HRG surveys along the Atlantic. As such, the 800 J energy level is assumed in the horizontal impact distance calculation. The 800 J source levels were calculated by interpolating the Crocker and Fratantonio (2016) measurements.

Table 1. Sparker specifications and Level B horizontal impact distance.

Equipment	Frequency (kHz)	Source Level (dB re 1 µPa m)	Beam Width (°)[a]	Pulse duration (ms)	Repetition rate (Hz)	Level B Horizontal Impact Distance using Source Level (m)	Adjusted source level for 100 ms averaging time (dB re 1 µPa m)	Level B Horizontal Impact Distance using Adjusted Source Level (m)
Applied Acoustics Dura-Spark 240	0.25 – 5	211.4	180	1.8	0.4	372	194.0	50

[a]Multi-tip sparkers are typically activated simultaneously to direct energy downwards and so they should have a downwards-oriented directivity pattern. We have not been able to find published directivity information for sparkers so have conservatively assumed sparker sources are omnidirectional. This assumption will likely lead to a larger estimated horizontal impact distance than would be expected during operation.

2.2. Sub-Bottom Profiler

Table 2 lists the sub-bottom profilers that are planned for Atlantic Shores HRG surveys, their associated specifications, and the Level B horizontal impact distances. Impact distances for sources with unknown pulse durations were calculated from the source level since the adjusted source level was also unknown.

Table 2. Sub-bottom profiler specifications and Level B horizontal impact distances.

Equipment	Frequency (kHz)	Source Level (dB re 1 µPa m)	Beam Width (°)	Pulse duration (ms)	Repetition rate (Hz)	Level B Horizontal Impact Distance using Source Level (m)	Adjusted source level for 100 ms averaging time (dB re 1 µPa m)	Level B Horizontal Impact Distance using Adjusted Source Level (m)
Edgetech 2000-DSS	2 – 16[a]	178[b]	65[b]	6.3	10	4	166.0	1
Edgetech 216	2 – 16[b]	179[b]	65[b]	10	10	5	169.0	2
Edgetech 424	4 – 24[b]	180[c]	71[c]	4	2	6	166.0	1
Edgetech 512i	0.5 – 12[b]	180[c]	80[c]	10	10	7	170.0	2
Teledyne Benthos Chirp III	2 – 7[d]	197[d]	100[d]	15[h]	10	71	188.8	28
	10 – 20[d]	205[d]	30[d]	15[h]	10	45	196.8	18
Kongsberg GeoPulse[e]	2 – 12	214[e]	30, 40, or 55	16[i]	10	231	206.0	92
Innomar SES-2000 Medium-100 parametric	85 – 115[f]	241[f,g]	2[f]	2	40	116	230.0	42

[a]Provided by Atlantic Shores as operational frequency range.
[b]Considered EdgeTech Chirp 512i as a proxy for source levels as the Chrip512i has similar operation settings as the Chirp 2000-DSS tow vehicle (Appendix A.6). See Table 18 in source for levels Crocker and Fratantonio (2016) for 100% power and 2-12kHz.
[c]Values from Crocker and Fratantonio (2016) for 100% power and comparable bandwidth.
[d]Source specifications are for the TTV-170 Series Tow Vehicle. This tow vehicle is designed for shallow water (< 600 m depth) surveying. See Appendix A.7.
[e]Mike Bailey (Kongsberg), personal communication, 2019-07-31, Appendix A.4.
[f]Appendix A.5
[g]The specification sheet indicates a peak source level of 247 dB re 1 µPa m (Jens Wunderlich, Innomar, personal communication, 2019-07-18). The average difference between the peak and SPL source levels for sub-bottom profilers measured by Crocker and Fratantonio (2016) was 6 dB. We therefore estimate the SPL source level is 241 dB re 1 µPa m.
[h]Assumed pulse duration from 15% duty cycle (Appendix A.7).
[i]Assumed pulse duration from maximum 32 cycles at 2 kHz (Appendix A.4).

2.3. Single Beam Echosounder

Table 3 lists the single beam echosounders that are planned for Atlantic Shores HRG surveys, their associated specifications, and the Level B horizontal impact distances.

Table 3. Single beam echosounder specifications and Level B horizontal impact distances.

Equipment	Frequency (kHz)	Source Level (dB re 1 µPa m)	Beam Width (°)	Pulse duration (ms)	Repetition rate (Hz)	Level B Horizontal Impact Distance using Source Level (m)	Adjusted source level for 100 ms averaging time (dB re 1 µPa m)	Level B Horizontal Impact Distance using Adjusted Source Level (m)
Kongsberg EA 400[a]	38 – 200	222.8	31	0.3	10	172	197.6	19
Teledyne ODOM Echotrac CVM[b]	24	224.6	20	0.3	10	173	199.4	16

[a]Source level and beam width is for the 38/200 transducer. This transducer has the largest Level B horizontal impact distance (Atlantic Shores has indicated they will not be operating the Kongsberg EA 400 with a transducer that operates below 38 kHz). EA 400 transducer specifications are tabulated in Appendix A.3 and were obtained from Ståle Myklebust (Kongsberg), personal conversation, 2019-08-08.
[b]Atlantic Shores has indicated they will use a 24 kHz transducer with the ODOM Echotrac CVM. Appendix A.8 shows the corresponding beam width. Source levels were not available so we have estimated the source level from the arithmetic mean of all Kongsberg EA 400 transducer source levels (Appendix A.3) operating at a similar frequency (18 and 38 kHz).

2.4. Boomer

Table 4 lists the boomers that are planned for Atlantic Shores HRG surveys, their associated specifications, and the Level B horizontal impact distance. Source specifications were obtained from Crocker and Fratantonio (2016).

Table 4. Boomer specifications and Level B horizontal impact distances.

Equipment	Frequency (kHz)	Source Level (dB re 1 µPa m)	Beam Width (°)	Pulse duration (ms)	Repetition rate (Hz)	Level B Horizontal Impact Distance using Source Level (m)	Adjusted source level for 100 ms averaging time (dB re 1 µPa m)	Level B Horizontal Impact Distance using Adjusted Source Level (m)
Applied Acoustics S-Boom Triple Plate	0.01 – 20	203	80	0.8	3	97	182.0	9
Applied Acoustics S-Boom	0.01 – 20	195	98	0.8	3	56	174.0	5

3. Summary

For each equipment type, we compiled the equipment that produced the largest horizontal impact distance using the source levels averaged over the pulse duration. Table 5 lists the equipment and horizontal impact distances.

Table 5. Summary of Level B horizontal impact distances for different equipment types.

Equipment Type	Equipment with Largest Level B Horizontal Impact Distance	Level B Horizontal Impact Distance (m)
Sparker	Applied Acoustics Dura-Spark 240	372
Sub-Bottom Profiler	Kongsberg GeoPulse	231
Single Beam Echosounder	Kongsberg EA 400	173
Boomer	Applied Acoustics S-Boom Triple Plate	97

We note that the methods used here are approximate and likely conservative. A rigorous propagation loss model coupled with a full beam pattern and spectral source model would result in more accurate results. Assessing the accuracy of either method requires sound field measurements.

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Appendix A. Equipment Specification Reference Sheets

A.1. Reson SeaBat 7101

SeaBat® 7101

Teledyne RESON

PLD13773-7

SeaBat® 7101

Multibeam Echosounder

Since its release in 1996 the SeaBat 8101 has gained a formidable reputation for performance, reliability and robustness. The new SeaBat 7101 multibeam echosounder brings to the forefront the advanced technology utilised across the range of SeaBat 7000 series multibeam systems. This combination of the well-proven 8101 sonar head and new 7000 series signal processing and data handling provides the ultimate in performance through an easy upgrade path.

A bathymetric sonar operating at 240kHz fitted with either a stick (St) or Extended Range (ER) projector, the 7101 measures up to 511 discrete soundings equally spaced across the wide 150° swath. This sounding density combined with realtime roll stabilisation, high accuracy and robust bottom detect provides maximum performance and efficiency in all acoustic environments. Optional, unique 210° coverage option for extremely shallow water or vertical structure surveys.

The SeaBat 7101 transducer is depth rated to 100m and is suitable for installation on ROVs and surface vessels where the high ping rate provides very high efficiency by meeting international survey standards even at high vessel speeds.

The SeaBat 7101 is available as a Composite variant which includes all sensors and software required to conduct a full hydrographic survey, or as a 7101-Flow variant with an incorporated sensor. Both variants are available with a standard or extended range projector in titanium.

FEATURES

SWATH
150° swath coverage providing up to 7.5 x water depth swath coverage. Optional 210° swath

FREQUENCY
240kHz operating frequency provides seamless coverage from 0.5m to 500m max depth (Using ER)

HIGH SPEED
High ping rate allows high speed operations without comprising data density

IHO
Compliant with IHO SP44 Ed 5 over entire depth range

DATA
Bathmetry, sidescan, snippets & water column data available over gigabit ethernet

ROLL STABILISATION
Realtime roll stabilisation maximizes usable swath width

WATER COLUMN
Up to 511 beams in selectable modes optimises operations for any survey type

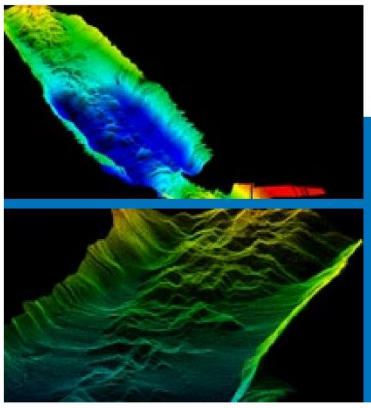
TELEDYNE RESON
Everywhereyoulook™

SeaBat® 7101

Teledyne RESON SeaBat® 7101

SEABAT 7101 SYSTEM SPECIFICATIONS

Frequency	240 kHz
Along-track transmit bandwidth	1,5°
Across-track receive beamwidth	1,8°
Max ping rate	40Hz
Pulse length	21µsec to 225 µsec
Number of beams	Up to 511 beams in selectable mode
Max swath angle	150° (210° optional)
Typical depth	0.5m to 300m (St), 0.5m to 475m (ER)
Max depth	350m (St), 500m (ER)
Depth resolution	12,5 mm
Data interface	Bathmetry, sidescan & snippets. 7K data format. Gigabit Ethernet
Power requirement	110/220 VAC, 50/60 Hz, 500W max
Head to processor cable length	25m
Depth rating	100m
Seabat 7101 composite	7101-Composite is a full hydrographic survey system based on the 7101 and the Applanix Wavemaster. All required sensors including sound velocity and software is provided.
Seabat 7101 flow	7101-Flow is a specialised version of the 7101 specifically for surveys in sheltered areas such as dams, rivers, lakes, harbours where the effects of motion are limited. The systems consists of a standard 7101 with a motion sensor incorporated inside the sonar head enclosure. The 7101-Flow is available with integrated PDS2000 software, sound velocity and position/heading sensors.



WHY CHOOSE A SEABAT 7101?

- Ideal for underwater vehicles or rapid deployment onto survey craft
- Flexible upgrade options for increased efficiency
- Wide swath coverage of 150° to a maximum range of 500m to reduce survey time
- Easy upgrade from SeaBat 8101
- Optional 210° swath
- Water column data

For more details visit www.reson.com or contact your local Teledyne RESON Office. Teledyne RESON reserves the right to change specifications without notice. 2012©Teledyne RESON

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Everywhereyoulook™

A.2. R2Sonic Sonic 2020

R2 SONIC
OUR VISION IS SOUND™

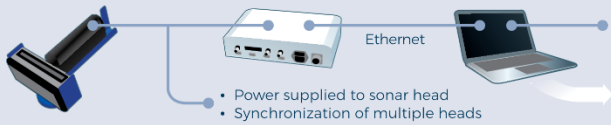
Multibeam Echosounder Specifications

We apply our technical expertise and experience as surveyors to serve you: Our portfolio is elegantly simple while technologically advanced and user-friendly. **Beamwidth** and **depth range** are the 2 main characteristics that differentiate each of those MultiBeam EchoSounders (MBES). All options can be implemented on all products, except for the option to operate at 90kHz/100kHz that is exclusive to the Sonic 2026 (at the expense of the UHR option). This provides **high flexibility** to end-users to upgrade their equipment **remotely**. These options go beyond just opting for a longer cable; they all bring extra capabilities and functionalities, allowing even the entry level sonar to benefit from advanced operating modes. **Additionally, the firmware of all 4 MBES can be upgraded remotely.**

Standard Features for all R2Sonic MBES

SONIC 2020

Extra Light & Compact!



User-friendly, simple and easy to learn controller interface

Clean and small data files which require minimum data processing time

- Ultra High Density (UHD): 1024 soundings per ping
- Selectable operating frequencies 'on-the-fly' in steps of 1Hz
- Ability to rotate the swath sector 'on-the-fly'
- Free firmware updates can be done remotely by end users
- Low power consumption for the performance delivered
- Light & compact
- Training delivered by experts
- Options upgradable remotely
- Embedded processor / controller in the sonar head that enables fast and powerful computation at low power (no separate topside processor)
- 3-year warranty
- All R2Sonic MBES exceed IHO-S44 Special Order, when installed following the instructions from the Manual and used with the I2NS and the Sound Velocity Sensor offered by R2Sonic

Only R2Sonic does it...

- Multispectral mode: survey with up to 5 frequencies in 1 pass and with 1 MBES. **Saves Time & Money!**
- Increased true sounding density with UHD → **It Provides Accurate and Truthful Resolution***
- **Smallest Beamwidth Available!** Down to **0.3° x 0.6°**
- Clean and small data files which reduces processing time and **Saves Time & Money!**
- Ability to upgrade options remotely
- Free firmware updates
- Optional 6-year warranty, which **minimizes risk** on investment
- 24/7 technical support via email and phone wherever you are in the world
- Express and high quality repairs, performed by the team that engineered the systems

Options

- Ultra High Resolution (UHR): beamwidth down to 0.3° x 0.6°
- Multimode
  - Pipeline mode: 2 frequencies, requiring UHR (700kHz)
  - Multispectral mode: ability to survey with up to 5 different frequencies in one pass and with one system
- TruePix™: provides highly compact water column imagery and backscatter
- Raw water column data output
- Robo™: automated operation
- On-site training (theory class & hands-on demo)
- 6-year warranty
- 4000m and 6000m immersion depth rating
- Mounting hardware & assemblies, including Dual Head for Sonic 2020
- Antifouling coating protection
- Switchable Forward Looking Sonar Imagery
- I2NS™ (Integrated Inertial Navigation System): 3 types available that provide different accuracy for roll / pitch and heading
  Please consult specification sheet for more information on the I2NS™
- Software available: HYPACK®, QINSy™, SonarWiz 7, Fledermaus GeoCoder
- Sound Velocity Sensors available

Quick Mobilization

Easy to Pack | Easy to Maneuver | Easy to Check-In

Sonic Series store easily in Peli™ Case, for increased mobility

US Patent 10,132,924

*Please consult the "Making Concepts Simple" booklet for clarification on technical terms / concepts.

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Technical Specifications

Multibeam Echosounders

	Sonic 2020	Sonic 2022	Sonic 2024	Sonic 2026
Applications	Entry level hydrography Very small vessels Small ASV and AUV	Construction Dredging Autonomous Surface Vehicle (ASV) Offshore O&G (pipeline)	Autonomous Surface Vehicle (ASV) Construction Dredging Offshore O&G (pipeline) Offshore WindFarm (cable, towers)	Advanced hydrography Research Seafloor characterization Autonomous Underwater Vehicle (AUV) Remote Operated underwater Vehicle (ROV)
Selectable Frequencies	200kHz - 400kHz. Optional 700kHz	170 - 450kHz. Optional 700kHz		170 - 450kHz. Optional 90kHz and 100kHz
Minimum frequency increase	1Hz			
Beamwidth, across track and along track	1° x 1° at 700kHz (optional) 2° x 2° at 400kHz 4° x 4° at 200kHz	0.6° x 0.6° at 700kHz (optional) 0.9° x 0.9° at 450kHz 2° x 2° at 200kHz	0.3° x 0.6° at 700kHz (optional) 0.45° x 0.9° at 450kHz 1° x 2° at 200kHz	0.45° x 0.45° at 450kHz 1° x 1° at 200kHz 2° x 2° at 90kHz & 100kHz (optional)
Number of soundings	Up to 1024 soundings per ping			
Max speed (vessel)	11.1 knots for full coverage (*)			
Near-field focusing*	Yes			
Roll stabilized beams	Yes			
Pitch stabilized beams	Yes	No		Yes
ROBO™ Automated Operation	Yes Auto Power, pulse width, rangeTrac™, GateTrac™, SlopeTrac™			
Saturation monitor	Yes			
Selectable Swath Sector *(also referred as Max Coverage)*	10° to 130° User selectable in real-time	10° to 160° User selectable in real-time		
Sounding Patterns	Equiangular Equidistant single / double / quad modes Ultra High Density (UHD)			
Sounding Depth	up to 200m+	up to 400m+		up to 800m+
Pulse Length	15µs - 1ms			15µs - 2ms
Pulse Type	Shaped CW			
Ping rate	up to 60Hz			
Bandwidth	up to 60kHz			
Immersion Depth	100m Optional 4000m		100m Optional 4000m & 6000m	100m Optional 4000m
	FLS projectors are rated 4000m	FLS projectors are rated 3000m		FLS projectors are rated 4000m
Bottom Detect Resolution	3mm			
Operating Temperature	-10°C to 40°C	-10°C to 50°C		
Storage Temperature	-30°C to 55°C			
Electrical Interface				
Mains	90-260VAC, 45-65Hz			
Power consumption	20W avg	35W avg	50W avg	100W avg
Uplink/downlink	10/100/1000Base-T Ethernet			
Sync in, Sync out	TTL			
Deck cable length	15m, optional 25m and 50m			
Mechanical				
Sonar Dimension (Sonic 2020)	140 x 161 x 133.5 mm			
Sonar Mass (Sonic 2020)	4.4kg			
Receiver Dim (LWD)		276 x 109 x 190 mm	480 x 109 x 190 mm	
Receiver Mass		7.7kg	12.9kg	
Projector Dim (LWD)		273 x 108 x 86 mm		480 x 109 x 196 mm
Projector Mass		3.3kg		13.4kg
Sonar Interface Module Dim (LWH)	280 x 170 x 60 mm			
Sonar Interface Module Mass	2.4kg			

(*) The speed of the survey is primarily limited by the installation of the MBES.

Specification Sheet 2019 version 1.3 subject to change without notice

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A.3. Specifications for Kongsberg EA 400 Transducers

Single Beam

The table below shows the Source Level (SL) for all Single beam transducers.
Some abbreviations for this list: (For combi transducers the lowest frequency is first)

SL: Source Level in dB (re 1µpa per 1m)
TP: Transmit Power (Max) (in Watts)
BW: Band Width (in degrees), If not circular Longitudinal first.
TR: Transmit Response in dB (re 1µpa per V)
RS: Receive Response in dB (re 1V per µpa)

System	SL	TP	BW	TR	RS
12Khz 12-16/60 18+1 Element	221,8	2000	16	171	-168,5
12Khz 12-16/60 1 Wide Element	197,8	100	60	142	-168,5
15Khz (15-17 Airmar)	228,4	4000	17	165	-175
18Khz (18/11)	225,8	2000	11 ±2	176 ±2	-168 ±2
38Khz (38/7)	230,1	2000	7	182,5 ±2	-170,5 ±2
38Khz (38/9)	225,6	1500	9	177	-171
38/200Khz (Combi W)	222,8 /220,7	400 /250	31	164 /155	-184 / -197
38/200Khz (Combi C and D)	218,8 / 226,3	1000	13/21 and 7	170 /178	-178 / -185
50Khz (50/7)	228,8	2000	7	177,5	-173
50Khz (50/18)	214,8	500	18 ±3	207 ±2	-181 ±2
50/200 Khz (Combi C and D)	221 / 227	1000	10/16 and 7	172 / 178	-179 / -185
120Khz (120-25)	227,8	1000	10 ±2	176,5 ±2	-183 ±2
120Khz (SideScan)	223,3	1000	1,9/55	?	?
200Khz (200 7F)	226,3	1000	7 ±1	180 ±2	-185 ±2
200Khz (200 7G)	226,3	1000	7 ±1	215 ±2 re 1 µpa per A	-185 ±2
200Khz (200 9G)	221,6	500	9	175 ±2	-169 ±2
200Khz (200 28E)	228	1500	7 ±1	180 ±2	-185 ±2
200Khz (200-35E)	235,8	2000	3 ±0.5	186,5	-177
200Khz (Side Scan)	226,8	1000	0,5/49	182 ±2	-167 ±2
500Khz (500-3G)	231,4	500	3	186 ±2	-189 ±2
500Khz (SideScan)	230,8	1000	0,35 / 60	179	-196

DRAFT

A.4. Kongsberg GeoPulse Sub-bottom Profiler

GEOPULSE

KONGSBERG

Feb 14

PINGER SUB-BOTTOM PROFILER

GeoPulse is pinger sub-bottom profiler system. Its proven success is due to its reliability, ruggedness, ease of operation and flexibility. Sub-Seabed structures are delineated using reflexions from a selectable single frequency multi-cycle high power signal, which is transmitted from an over-the-side, towed or hull mounted platform. The signal is processed in the compact deck unit.

System Components
The system comprises the deck unit (Transmitter Model 5430A and Receiver Model 5210A) and a four transducer array (Models T135) in a tow-fish (Model 136), over the side-mount assembly (Model 132) or a bespoke hull mount arrangement, which can be configured to hold up to 16 transducers.

Transmitter
The compact unit controls the transmitted signal. The output power is continuously adjustable up to 10 kW with a selectable frequency from 2 to 12 kHz. The pulse length is selected by number of cycles to improve penetration and reduce ringing effects. The transmit repetition rate can be controlled externally or internally.

Receiver
The Receiver allows the operator to apply gain up to 100 dB to the received signal. This can be done manually as well as using automatic algorithms including bottom tracking TVG (time variant gain) and AGC (automatic gain control). The processed signal can be output on a wide range of storage and printing media.

Transducer deployment options
Over-The-Side-Mount (Model 132)
The assembly was designed for small boat operation at lower speeds. The transducers are mounted on a plate at the end of a vertical, gimballed staff. The staff, in turn, is supported by a mounting pad, which can be fastened to either the deck of the boat, or to an athwart-ships timber.
Towed Transducer Vehicle (Model 136A)
The Model 136A fish is the industry standard of the GeoAcoustics profiling systems. It has logged more survey kilometres and more pipeline
crossings than any other profiling vehicle in the world. Its design allows for stable, noise-free towing in high seas and at speeds up to 12 knots.
The rugged galvanised body and fibreglass cowling, provides protection and will stand up to the punishment encountered in harsh marine environments.
Hull mounting
The transducers are mounted in a bespoke sea-chest arrangements. Up to 16 transducers are supported for deep water operations producing a narrower beam.

FEATURES

- Selectable transmit frequency 2 to 12 kHz
- Over-the-side, towed or hull mounted deployment
- Reliable, proven, easy to use
- Good penetration and resolution

OPTIONS

- Combined with side scan sonar
- Third party acquisition system integration
- Range of tow cables and winches

TECHNICAL SPECIFICATIONS

Transmitter Model 5430A

- Output: 10kW with 0.75% duty cycle, continuously adjustable.
- 2 to 12kHz, continuously adjustable.
- Short circuit proof.
- Impedance matched.
- Pulse Cycles: 1, 2, 4, 8, 16 or 32 cycles of the frequency selected. The transmitted output pulse will be phase coherent within 22.5°.
- Key:
- External: 2 to 12 V pulse, either + or – leading edge triggered.
- Max width 50 ms to eliminate double triggering. Transformer isolated.
- Internal: Set by internal potentiometer, 1 to 10 pps, uncalibrated.
- Output to Receiver Transformer isolated. or Third Party Acquisition System: Frequency response flat
- Processor: between approximately 1 kHz and 20 kHz.
- Two modes of operation:
  - A: Flat gain –0 dB gain
  - B: Short range TVG -20 dB (10:1) of attenuation during transmit pulse and a –20 dB to 0 dB ramp within 15ms after end of transmit signal.
- Power: 115/230 VAC ± 10%, 47 to 63 Hz, 220 W maximum.
- Auxiliary Power: IEC connector, unfused, 6 A maximum.
- Environmental: Operational: -5 to 50°C,Storage: -15 to 85°C
- Dimensions: 45.7 cm (L) x 43 cm (W) x 13 cm (H)
- Weight: 18 kg

Receiver Model 5210A

- Amplifier: Differential common mode rejection:
- 100 dB at 60 Hz. Sensitivity 30 µV RMS in, produces 1V RMS out at 90 dB total gain with TVG.
- Signal to noise: 20 dB at 100 dB gain 1 kHz centre frequency and 1 kHz bandwidth.
- Coarse gain: 40 dB maximum
- Fine gain: 0 – 30 dB in 3 dB increments
- Filter: Low pass and high pass, active type, maximally flat, 24 dB/octave minimum roll-off, 0 gain, 0.02 kHz to 15 kHz adjustable in ½ octave increments.
- Knobs interlock to prevent overlap.
- TVG: Dynamic range: 30 dB
- Rate: approximately flat to 30 dB in 14 ms.
- Manual delay: vernier adjust from 1 to 14 ms with multiplier of x 1, x 10, x 100 and internal select of x 1000
- AGC: Attack adjustable from 330 µs to 330 ms.
- Decay: adjustable from 330 µs to 330 ms.
- Range: 20 dB
- Power: 115/230 VAC ± 10% (internal switch selectable), 47 to 63 Hz, 45 W maximum
- Environmental:
  - Operational: -5 to 50° C,
  - Storage: -15 to 85°C
- Dimensions: 45.7 cm (L), x 43 cm (W), x 17.8 cm (H)
- Weight: 12kg

Over-the-side mount assembly (Model 132B)

- Beam width (4 Transducers):
  - 55° at 3.5kHz.
  - 40° at 5.0kHz.
  - 30° at 7.0kHz
- Source level: 214dB re 1µPa/1M
- Dimensions: 70 cm (L) x 52 cm (W) x 46 cm (H)
- Mounting Staff:
- One section 183 cm, two sections 360 cm
- Weight: 120 kg

Tow-fish (Model 136A)

- Beam width (4 Transducers):
  - 55° at 3.5kHz.
  - 40° at 5.0kHz.
  - 30° at 7.0kHz
- Source level: 214dB re 1µPa/1M
- Dimensions: 156 cm (L) x 46 cm (W) x 46 cm (H)
- Weight: 125 kg

Hull mount

- 2 x 2 (4), 3 x 3 (9) and 4 x 4 (16) transducer arrays available
- Bespoke sea chest deployment

Specifications subject to change without any further notice.

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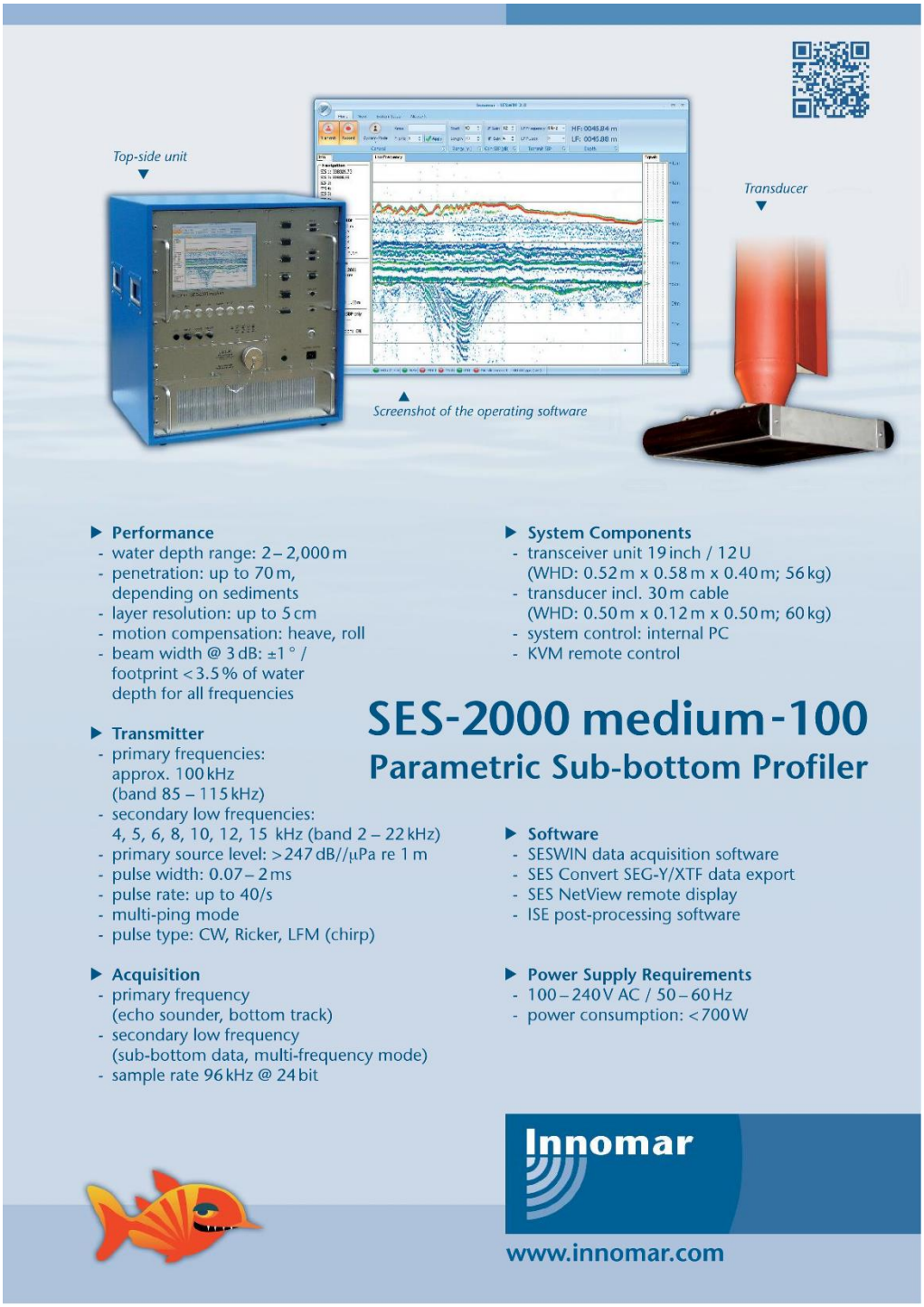
A.5. Innomar Sub-bottom Profiler



A.6. Edgetech Sub-bottom Profilers

2.1.2 Processor Unit Specs

The specifications for the Processing Unit within the rack mount topside are shown in TABLE 2-2.

SPECIFICATION	VALUE
Mother Board	Intel I7 6700 Quad Core 3.4GHz. 8 MB Cache
Sonar Interface	Sonar Interface board (Tiger board) composed of carrier board, Acquisition board, and Sonar board
Memory	8 GB DDR4 RAM
Hard Drives	500 GB minimum (operating system) 1 TB minimum (Removable Drive [Hot Swappable])
DVD-R/W drive	10x4x32 minimum speed
Operating system	Windows 7 64 Bit
Application software	DISCOVER Sub-Bottom
Display	High resolution 23-inch flat panel LCD monitor
Keyboard	High impact industrial
Trackball	High impact industrial
I/O ports	(4) RS-232 Front: (2) Ethernet Ports (2) USB2 Rear: (2) USB2 (2) USB3 (2) USB3.1
Analog input	16-bit resolution, 200 kHz max sampling rate
Analog Output	16-bit resolution, 200 kHz max sampling rate
Pulse type	Full Spectrum CHIRP FM
Pulse length	5-100 ms, depending on tow vehicle and application
Bandwidth	0.5-15 kHz, depending on tow vehicle and application
Trigger in	TTL negative edge triggered
Trigger out	TTL negative edge triggered, 5ms ling pulse minimum
Sampling rate	20, 25, 40, or 50 kHz, depending on the transmit upper frequency
Acoustic power	212 dB re1 NPa @ 1 meter peak (approx.) at center frequency
Input voltage	120-220 VAC, 50/60 Hz, auto sense

Table 2-2: 3200-XS Topside Processor Specs

2.1.3 Power Amplifier

The specifications for the Power Amplifier are show in TABLE 2-5, TABLE 2-4, and TABLE 2-5.

2.1.3.1 Power Output

SPECIFICATION	VALUE
2-ohm Dual (*per channel*)	20 mS BURST: 4,700 W 20 Hz – 20 kHz: 2,800 W 1 kHz: 2,800 W
4-ohm Dual (*per channel*)	3,500 W
8-ohm Dual (*per channel*)	1,500 W
4-ohm Bridge	5,600 W
8-ohm Bridge	6,000 W

Table 2-3: Power Amplifier Specs: Power Output

2-7

SPECIFICATION	SB-424 VALUE	SB-216S VALUE	SB-512i VALUE
Frequency range	4-24 kHz	2-16 kHz	0.5-12 kHz
Pulse type	FM	FM	FM & WB (wide band)
Pulse bandwidth/pulse length	4-24 kHz/10 ms 4-20 kHz/10 ms 4-16 kHz/10 ms	2-15 kHz/20 ms 2-12 kHz/20 ms 2-10 kHz/20 ms	0.5-8.0 kHz/5 ms FM 0.5-2.7 kHz/40 ms WB 0.5-6.0 kHz/20 ms WB 0.5-4.5 kHz/50 ms FM 0.5–6.0 kHz/9 ms FM 0.5–6.0 kHz/18 ms FM 0.5–7.2 kHz/30 ms FM 0.7–12.0 kHz/20 ms FM 2.0–12.0 kHz/20 ms FM
Calibration:	Gaussian-shaped pulse spectrum	Gaussian-shaped pulse spectrum	Gaussian- and rectangular-shaped pulse spectrum
Vertical resolution[a]	4 cm (4–24 kHz) 6 cm (4–20 kHz) 8 cm (4–16 kHz)	6 cm (2–15 kHz) 8 cm (2–12 kHz) 10 cm (2–10 kHz)	19 cm (1–5.0 kHz) 12 cm (1.5–7.5 kHz) 8 cm (2–12 kHz)
Penetration in course and calcareous sand[b]	2 m (typ)	6 m (typ)	30 m (typ)
Penetration in soft clay[b]	40 m	80 m	250 m
Beam width	16°, 4–24 kHz 19°, 4–20 kHz 23°, 4–16 kHz	17°, 2–15 kHz 20°, 2–12 kHz 24°, 2–10 kHz	41°, 0.5–5 kHz 32°, 1–6 kHz 24°, 1.5–7.5 kHz 16°, 2–12 kHz
Optimum tow vehicle pitch/roll[c]	<7°, 4–24 kHz <8°, 4–20 kHz <10°, 4–16 kHz	<7°, 2–15 kHz <8°, 2–12 kHz <10°, 2–10 kHz	<16°, 0.5–5 kHz <13°, 1–6 kHz <10°, 2–8 kHz <8°, 2–10 kHz <7°, 2–12 kHz
Optimum tow height	3-5m above sea floor	3-5 m above sea floor	3-5 m above sea floor
Transmitters	1	1	2
Receive arrays	2	2	4
Output power	2000 W	2000W	2000 W
Tow vehicle size	77 cm (30 in.) L 50 cm (20 in.) W 34 cm (13 in.) H	105 cm (41 in.) 67 cm (26 in.) W 46 cm (18 in.) H	158 cm (62 in.) L 134 cm (53 in.) W 46 cm (18 in.) H
Shipping container size	91 cm (36 in.) L 66 cm (26 in.) W 64 cm (25 in.) H	117 cm (46 in.) L 79 cm (31 in.) W 61 cm (24 in.) H	173 cm (68 in.) L 137 cm (54 in.) W 71 cm (28 in.) H
Weight in air	35 kg (78 lb)	72 kg (160 lb)	186 kg (410 lb)
Shipping weight	110 kg (243 lb)	162 kg (357 lb)	356 kg (783 lb)
Tow cable requirements	3 shield-twisted wire pairs	3 shield-twisted wire pairs	3 shield-twisted wire pairs
Depth rating	300 m (984 ft) max	300 m (984 ft) max	300 m (984 ft) max

Table 2-6: Tow Vehicle Specifications

A.7. Teledyne Benthos Chirp III

TTV-170 Series Tow Vehicle

The TTV-170 Series Tow Vehicle is designed for use on small boats in relatively shallow water. The TTV-172 is configured with a low frequency transducer, a high frequency transducer and two hydrophone arrays. The TTV-171 is configured for single frequency operation with the low frequency transducer and the hydrophone arrays.

Physical Characteristics

Construction:	Two-part fiberglass shell with 6061 aluminum tow body
Dimensions:	94 cm (37 in.) long and 32.4 cm (12.7 in.) by 43.4 cm (17.1 in.) in cross section
Weight in air (TTV-172):	75 lb (34 kg)
Weight in water (TTV-172):	45 lb (20 kg)
Tether system:	Either of two Industry-standard multi-conductor cables: Teledyne Benthos TWC-602, Kevlar reinforced, with three twisted/shielded pairs and three conductors—for use with separate steel tow cable, or Teledyne Benthos TWC-601, Rochester 301301 double-armored, with three coaxial pairs and three single conductors—for use with winch and slip rings
Operating depth:	600 meters
Towing speed:	1 to 6 knots operational

Low Frequency Sonar

Transmitter transducer:	Teledyne Benthos AT-471 low frequency transducer

Power output:	400 watts, 15% duty cycle at 3.5 kHz for 197 dB re 1 μPa @ 1 m nominal, 4 kw maximum at reduced duty cycle
Frequency range:	Sweeps in the 2 kHz to 7 kHz band
Transducer radiation:	100° conical

High Frequency Sonar

Transmitter transducer:	Teledyne Benthos AT-14F7C high frequency transducer
Power output:	90 watts, 15% duty cycle at 17 kHz for 205 dB re 1 μPa @ 1 m nominal, 4 kw maximum at reduced duty cycle
Frequency range:	Sweeps in the 10 kHz to 20 kHz band
Transducer radiation:	30° conical

Sonar Receiver

Receiver hydrophone:	Two 8-element hydrophone arrays
Frequency band:	2 kHz to 100 kHz

TTV-290 Series Tow Vehicle

The TTV-290 Series Tow Vehicle is designed for use in deep water. The TTV-292 is configured with four low frequency transducers, a high frequency transducer and a hydrophone array. The TTV-291 is configured for single frequency operation with the four low frequency transducers and the hydrophone array.

Physical Characteristics

Construction:	Two-part aluminum reinforced fiberglass
Dimensions:	208.7 cm (82 in.) long and 38.4 cm (15.1 in.) by 53.3 cm (21.0 in.) in cross section
Weight in air (TTV-292):	330 lb (150 kg)

A.8. ODOM Echotrac CVM

Teledyne Odom have a wide range of echo sounder transducers to meet almost every need.

SINGLE FREQUENCY TRANSDUCERS

Model	Configuration	Housing model	Weight	Frequency	Beam width	Application
SMBB200-9	Stem Mount (stainless steel)	SS510	1.5 kg	200 kHz	9°	Hydro Survey
SMBB200-3	Stem Mount (stainless steel)	SS549	4.6 kg	200 kHz	3°	Hydro Survey
SMSW200-4a	Stem Mount	SS538	2.1 kg	200 kHz	4°	Very Shallow Hydro Survey
SM1000-1.7	Stem Mount	SS546	4.6 kg	1000 kHz	1.7°	Hydro Survey
FMBB200-9	Flange Mount (Atlas)	M194	.5 kg	200 kHz	9°	Hydro Survey
HM100-8	Hull Mount (stainless steel)	SS216	10.0 kg	100 kHz	8°	Hydro Survey
HM40-19	Hull Mount (stainless steel)	SS216	10.0 kg	40 kHz	19°	Hydro Survey
TM33-19	Tank Mount (Atlas)	M194	9.5 kg	33 kHz	19°	Hydro Survey
TM33-19-NAV	Tank Mount (with underwater connector	M192NAV	9.5 kg transducer 23.0 kg housing	33 kHz	19°	Hydro Survey
HM10-17	Hull Mount (seal cast)	M187-1	114.0 kg	10 kHz	17°	Deep Survey
TM200-3	Tank Mount (Atlas)	M192	9.0 kg	200 kHz	3°	Hydro Survey
TH24-20SAW	Thru Hull (stainless steel window)	CS234/229	51.0 kg	24 kHz	20°	Hydro Survey
TM28-18-NAV	Thru Hull (urethane window)	M192NAV	9.5 kg transducer 23.0 kg housing	28 kHz	18°	Hydro Survey
HM24-10	Hull Mount (round urethane)	93-190	40.0 kg	24 kHz	10°	Deep Survey
TM24-20	Tank Mount (Atlas)	M192-2	10.0 kg	24 kHz	20°	Hydro Survey

Model	Configuration	Housing model	Weight	Frequency	Beam width	Application
TM24-20	Tank Mount (with underwater connector)	M192	9.0 kg	200 kHz	3°	Hydro Survey

DUAL FREQUENCY TRANSDUCERS

Model	Configuration	Housing Model	Weight	Frequency	Beam Width	Application
THP200/24-4/20	Tank, Hull or Pole Mount	M108	14.5 kg	200-24 kHz	4° 20°	Hydro Survey
OTSBB200/33-5/23	Over the Side (sealcast)	M177-2	6.5 kg	200-33 kHz	5° 23°	Hydro Survey
OTSBB200/24-4/20	Over the Side (sealcast)	M42	14.5 kg	200-24 kHz	4° 20°	Hydro Survey
HM210/12-8/20	Hull Mount (seal cast)	T196	40.0 kg	210-12 kHz	8° 20°	Shallow, Sub-Bottom, Deep Survey
HMBB200/24-4/20	Hull Mount (seal cast)	M175-2	21.0 kg	200-24 kHz	4° 20°	Hydro Survey
HM200/12-9/25x32	Hull Mount (seal cast)	M176-3	28.0 kg	200-12 kHz	9° 25x32°	Deep Survey
HM200/12-8/20	Hull Mount	T197	40.0 kg	200-12 kHz	8° 20°	Shallow, Sub-Bottom, Deep Survey

SIDE LOOKING TRANSDUCERS

Model	Configuration	Housing Model	Weight	Frequency	Beam Width	Application
SS200-0.7x50	Side Scan	SS82	10.5 kg	200 kHz	50°	Shallow Recon
SS340-0.5x50	Side Scan	SS134	6.0 kg	340 kHz	50°	Shallow Recon

WIDE BANDWIDTH TRANSDUCERS

Model	Configuration	Housing Model	Weight	Frequency	Beam Width	Application
HMBB12-20	Hull Mount (round urethane)	M74-2	74.5 kg	12 kHz	20°	Deep Survey
HM15-17	Hull Mount (round urethane)	M74	44.0 kg	15 kHz	17°	Hydro Survey

Appendix C

Marine Mammal Seasonal Densities

Table B-1 Lease Area – Marine Mammal Seasonal Densities

Species		Winter Density [a/] (No./100 km²)	Spring Density [a/] (No./100 km²)	Summer Density [a/] (No./100 km²)	Fall Density [a/] (No./100 km²)
North Atlantic right whale		**0.087** [c/]	0.060	0.008	0.006
Humpback whale		**0.076**	0.027	0.011	0.024
Fin whale		0.058	**0.100**	**0.100**	0.094
Sei whale		0.001	**0.004**	0.000	0.001
Minke whale		0.019	**0.055**	0.016	0.012
Sperm whale		0.000	0.002	**0.013**	0.008
Long-finned pilot whale		0.036	0.036	0.036	0.036
Bottlenose dolphin	*N. Coastal Migratory*	-	-	-	-
	Offshore	1.508	2.776	**21.752**	9.125
Short beaked common dolphin		**3.120**	1.156	1.622	2.636
Atlantic white-sided dolphin		0.197	**0.487**	0.151	0.200
Atlantic spotted dolphin		0.003	0.009	**0.076**	0.060
Risso's Dolphin		0.002	0.001	**0.010**	0.003
Harbor porpoise		**2.904**	2.132	0.018	0.683
Harbor seal [b/]		**4.918**	2.125	0.132	0.181

Table B-2 ECR North – Marine Mammal Seasonal Densities

Species		Winter Density [a] (No./100 km²)	Spring Density [a] (No./100 km²)	Summer Density [a] (No./100 km²)	Fall Density [a] (No./100 km²)
North Atlantic right whale		**0.068**	0.056	0.008	0.006
Humpback whale		**0.082**	0.031	0.011	0.046
Fin whale		0.057	**0.080**	0.063	0.078
Sei whale		0.000	**0.004**	0.000	0.000
Minke whale		0.010	**0.017**	0.003	0.003
Sperm whale		0.001	0.004	0.003	**0.005**
Long-finned pilot whale		0.012	0.012	0.012	0.012
Bottlenose dolphin	*N. Coastal Migratory*	1.565	3.291	**21.675**	7.773
	Offshore	1.565	3.291	**21.675**	7.773
Short beaked common dolphin		1.370	0.330	0.522	**1.644**
Atlantic white-sided dolphin		0.127	**0.213**	0.089	0.131
Atlantic spotted dolphin		0.001	0.002	**0.059**	0.022
Risso's Dolphin		0.000	0.000	**0.001**	**0.001**
Harbor porpoise		**7.357**	1.965	0.059	1.488
Harbor seal [b]		**9.737**	4.616	0.247	0.316

Table B-3 ECR South – Marine Mammal Seasonal Densities

Species		Winter Density [a] (No./100 km²)	Spring Density [a] (No./100 km²)	Summer Density [a] (No./100 km²)	Fall Density [a] (No./100 km²)
North Atlantic right whale		**0.073**	0.055	0.007	0.006
Humpback whale		**0.103**	0.019	0.005	0.015
Fin whale		0.034	0.055	0.052	**0.057**
Sei whale		0.000	**0.002**	0.000	0.000
Minke whale		0.008	**0.019**	0.004	0.004
Sperm whale		0.000	0.001	**0.003**	**0.003**
Long-finned pilot whale		0.009	0.009	0.009	0.009
Bottlenose dolphin	*N. Coastal Migratory*	3.650	7.806	**58.524**	22.994
	Offshore	3.650	7.806	**58.524**	22.994
Short beaked common dolphin		0.819	0.405	0.635	**1.114**
Atlantic white-sided dolphin		0.063	**0.152**	0.048	0.065
Atlantic spotted dolphin		0.000	0.001	**0.021**	0.014
Risso's Dolphin		0.000	0.000	**0.002**	0.001
Harbor porpoise		**2.209**	0.787	0.013	0.767
Harbor seal [b]		**6.539**	2.445	0.477	0.673