Renewal Application for Incidental Harassment Authorization for the Non-Lethal Taking of Marine Mammals Resulting from Pre-Construction High Resolution Geophysical Survey

Nantucket Sound

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Project No. E159-505.1

December 19, 2012

RENEWAL APPLICATION FOR INCIDENTAL HARASSMENT AUTHORIZATION FOR THE NON-LETHAL TAKING OF MARINE MAMMALS RESULTING FROM PRE-CONSTRUCTION HIGH RESOLUTION GEOPHYSICAL SURVEY
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TABLE OF CONTENTS

SECTION **PAGE**

TABLE OF CONTENTS
(CONTINUED)

SECTION **PAGE**

TABLES

FIGURES

APPENDICES

INTRODUCTION

Sections 101(a)(5)(A) and (D) of the Marine Mammal Protection Act (MMPA) (16 U.S.C. 1361 et seq.) direct the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of marine mammals by United States citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region. Cape Wind Associates, LLC (CWA) is submitting this application to the National Marine Fisheries Service (NMFS), a department within the National Oceanic and Atmospheric Association (NOAA), under MMPA section 101(a)(5)(D) to take, by harassment, a small number of marine mammals incidental to CWA's continuation of previously authorized pre-construction High Resolution Geophysical (HRG) survey activities of the Cape Wind Energy Project (Project) area during the summer of 2013

NMFS issued CWA an Incidental Harassment Authorization (IHA) on December 20, 2011 for an HRG survey scope of work developed to satisfy the requirements of the Lease issued to CWA by the Bureau of Ocean Energy Management (BOEM, formerly known as BOEMRE and MMS). Subsequent to the issuance of the IHA, CWA found it necessary to divide the survey into two seasons. The first season of HRG survey was completed during the summer of 2012 and comprised approximately 20% of the entire HRG scope of work previously authorized by NMFS for the 12/20/11 IHA. CWA is submitting this request for extension in order to complete the remaining 80% of the scope of work. The estimated take of marine mammals, provided below, has been modified from the original application to account for the remaining scope of work.

CWA conducted the first season of a High Resolution Geophysical (HRG) survey during the summer of 2012 in accordance with the monitoring and mitigation measures required by CWA's IHA. During the HRG survey, three types of protected species monitoring was conducted:

- Throughout the HRG survey an MMO was posted on board the survey vessel every day to monitor a required 500 meter exclusion zone.
- Once per month (including once prior to the start of the HRG survey work), a site-wide marine mammal monitoring event was conducted whereby a NMFS approved Marine Mammal Observer (MMO) transited the entire Project Area by boat and documented any species present along with pertinent behavioral information.
- Twice per week a second MMO was posted on board the survey vessel to monitor behaviors of any marine mammals in the area beyond the 500 meter exclusion zone.

Over the 28 days, and 459 nautical transect miles of the 2012 HRG survey, zero marine mammal takes occurred and no living marine mammals were sighted. Only one deceased marine mammal was sighted. The marine mammal sighted during the survey was identified as a previously deceased harbor seal (*Phoca vitulina*) by two onboard MMOs and survey equipment was immediately shut down. This information is provided to emphasize that the take estimates presented in Section 5.0 are considered to be highly conservative and are unlikely to be realized during the 2013 survey.

Background

CWA proposes to build, operate, and eventually decommission a wind energy facility off the coast of Massachusetts. CWA originally sought permission from the United States Army Corps of Engineers (USACE) to construct and operate a wind-powered electrical generating facility on Horseshoe Shoal in Nantucket Sound off the coast of Massachusetts. USACE determined that a draft environmental impact statement (DEIS) was required for the Project, which was prepared and made available for public review and comment in November 2004. The document was also prepared to fulfill review requirements under the Massachusetts Environmental Policy Act. Additionally, the document included items identified by the Cape Cod Commission for its review under Developments of Regional Impact that present regional issues or potential impacts to the resources of Cape Cod.

The Energy Policy Act of 2005 modified the federal regulatory authority for alternative energy projects proposed to be sited on the Outer Continental Shelf. The Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE)[1] (of the U.S. Department of the Interior) determined that it would prepare its own environmental impact statement to address its regulations and requirements. BOEMRE issued its DEIS in January 2008 and its Final Environmental Impact Statement (FEIS) on January 19, 2009 for the proposed Cape Wind Project.

The BOEMRE FEIS provides detailed information on the proposed project facilities, construction methods and analysis of potential impacts on marine mammals. The FEIS summarizes data and analysis of potential impacts developed during the lengthy (10+ years) permitting process for the Project that was initiated with the USACE and the Massachusetts Environmental Policy Act office in 2001. Of particular note, FEIS Sections 4.2.6 and 5.3.2.6 focus on potential impacts to marine mammals, including an underwater noise analysis report (Report No. 5.3.2-2). NMFS issued a Biological Opinion, in accordance with Section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.), dated November 13, 2008 (Appendix J of the BOEMRE FEIS), on the effects of the Project on threatened and endangered marine mammal and sea turtle species. At BOEMRE's request, NMFS reinitiated formal consultation under the ESA on July 16, 2010 to address new information on whale sightings outside Nantucket Sound. NMFS issued a new Biological Opinion on December 30, 2010. BOEMRE also prepared two Environmental Assessments, dated April 28, 2010 and April 18, 2011, in conjunction with its Records of Decision that grant a lease to CWA and approve CWA's Construction and Operations Plan, which addressed project-related information that arose after the FEIS was finalized.

Three species of whales (humpback, fin, and North Atlantic right) that were included in the Biological Opinion also fall under the protection of the MMPA. Information pertaining to these whale species in the Biological Opinion is reiterated and referenced in this IHA request. Of particular importance, NMFS's Biological Opinion concluded that the proposed action is not likely to adversely affect any listed whale species (NMFS, 2010).

On October 6, 2010, CWA signed Renewable Energy Lease Number OCS-A 0478 with BOEMRE (BOEMRE, 2010). The lease terms and conditions mandate implementation of specific mitigation, monitoring and reporting measures related to protected marine mammals and sea turtles including a requirement to obtain NMFS authorization prior to commencing activities that could result in the taking of marine mammals under the MMPA. These mitigation measures, which apply to marine mammals protected under both the ESA and the MMPA, are discussed in greater detail below.

A disc with the following project-related documents that are referenced herein was previously submitted to NMFS:

- Bureau of Ocean Energy, Management, Regulation and Enforcement (BOEMRE), 2010. Commercial Lease of Submerged Lands for Renewable Energy Development on the Outer Continental Shelf, No. OCS-A 0478, Herndon, Virginia. October 6, 2010.
- BOEMRE, 2010. Record of Decision – Cape Wind Energy Project, Horseshoe Shoal, Nantucket Sound, April 28, 2010. United States Department of Interior, Minerals Management Service, Washington D.C.
- BOEMRE, 2009. Cape Wind Energy Project Final Environmental Impact Statement. January 2009. United States Department of Interior, Minerals Management Service, Washington D.C.

[1] Secretarial Order 3302 issued June 18, 2010 renamed the Minerals Management Service (MMS) to the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) and Secretarial Order 3299 issued on October 1, 2011 reorganized BOEMRE into the Bureau of Ocean Energy Management (BOEM), the Bureau of Safety and Environmental Enforcement (BSEE), and the Office of Natural Resource Revenue.

- NMFS. 2010. National Marine Fisheries Service Endangered Species Act Section 7 Consultation Biological Opinion – Cape Wind Energy Project. Woods Hole MA: NMFS Northeast Regional Office.

Additional electronic copies of these documents can be provided upon request.

1.0 DESCRIPTION OF THE SPECIFIC ACTIVITY THAT COULD RESULT IN INCIDENTAL TAKING OF MARINE MAMMALS

The proposed action entails the construction of an offshore wind park and associated electrical interconnection facilities located on Horseshoe Shoal in Nantucket Sound, Massachusetts (Figure 1). Prior to construction, CWA is required to conduct a High Resolution Geophysical (HRG) survey, as specified in the mitigation and monitoring requirements for Cultural Resources and Geology in the Environmental Stipulations in Addendum C of the BOEMRE lease, to identify any submerged cultural resources that may be present and to generate additional data describing the geological environment within the survey area (BOEMRE, 2010). As the survey was not completed last season, the survey is anticipated to be completed in 2013. For the purpose of this request for renewal, the second season of the HRG survey is hereby referred to as “the HRG survey”.

The HRG survey consists of remote-sensing data acquisition along predetermined tracklines using a towed instrument package. The survey equipment includes a side scan sonar, magnetometer, shallow-penetration subbottom profiler (chirp), multibeam depth sounder, and a medium-penetration subbottom profiler (boomer). The proposed HRG survey activities will not result in any disturbance to the sea floor.

The previous IHA included geotechnical activities. The entire scope of work for geotechnical activity was completed during the 2012 season and therefore it is not addressed in this renewal.

1.1 High Resolution Geophysical Survey Equipment

The same hydrographic and geophysical equipment utilized during the season 1 HRG surveys will likely be used during season 2 (see Table 1.1). The actual equipment models to be deployed will be determined at a future date following final selection of a survey vendor, therefore comparable model types are presented in the table so that acoustic parameters can be discussed. The frequency, estimated sound pressure levels, and sound propagation distances were obtained from manufacturers and/or publicly available information. The HRG survey equipment to be deployed by CWA is expected to have similar sound power levels and frequencies as survey equipment commonly deployed for such pre-construction survey programs. CWA will ensure that all HRG surveying equipment complies with applicable equipment noise standards of the U.S. Environmental Protection Agency. CWA will also ensure that all equipment shall have noise control devices no less effective than those provided on the original equipment.

Table 1.1 Equipment to be Utilized during High Resolution Geophysical Survey

Survey Task	Sample Equipment Model Type	Frequency (kilohertz)
Multibeam Depth Sounder	R2 Sonic 2024	200, 400 kHz
Side Scan Sonar	EdgeTech 4200-FS	400, 900 kHz
Shallow-Penetration Subbottom Profiler (chirp)	EdgeTech 216S	2-16 kHz
Medium-Penetration Subbottom Profiler (boomer)	AP3000 (dual plate) boomer	0.3-14 kHz

Sound Source Verification monitoring was performed on the shallow- and medium-penetration subbottom profilers during the season 1 survey (Appendix A). Underwater sound was recorded with two Autonomous Multichannel Acoustic Recorders, deployed 100m apart, in the vicinity of the Project Area (water depth ~ 28 feet) The received 90% rms sound pressure levels (SPLs) from the Dual-Plate Boomer and the sub-bottom profiler did not exceed 175 dB re 1 μPa. The loudest source, the Dual-Plate Boomer, produced a received 90% rms SPL of less than 140 dB re 1 μPa at 500 m range (the distance specified for maintaining a monitored exclusion zone). The distance to the 160 dB re 1 μPa rms SPL isopleth was 12 m for the dual plate boomer. The 160 dB isopleth for the shallow-subbottom profiler was 10 meters from the acoustic source.

According to (NMFS, 1998) the hearing threshold for marine mammals is below 200 kHz. Therefore the acoustic impacts from the multibeam depth sounder and side scan sonar are negligible.

1.2 High Resolution Geophysical Survey Design Characteristics

The HRG survey will be conducted within an area extending 1,000 feet beyond the Area of Potential Effect (APE) for offshore archaeological resources as defined by Section 2.1 of the Documentation of Section 106 Finding of Adverse Effect (Revised), issued by BOEMRE in 2010.[2] This area covers the wind turbine generators (WTGs) and inner array cabling locations as well as the area occupied by the interconnecting submarine cable between the wind park and the cable landfall location on the mainland. All totaled, the survey area is approximately 110 square kilometers (km^2) or 42.5 square miles (mi^2).

The purpose of the HRG survey is to identify any submerged cultural resources that may be present and to generate additional data describing the geological environment within the survey area. The HRG survey design is based (in part) on requirements issued by BOEMRE in the project lease and agency guidance for HRG surveys (BOEMRE, 2012). The lease states that CWA shall use a shallow-penetration subbottom profiler (chirp) at 30-meter line spacing for all cultural resource assessments within the survey area. It also states that CWA HRG surveys for geological data collection shall use a medium-penetration subbottom profiler (boomer) operated at 150-meter line spacing. CWA assumes for the purposes of this document that a chirp and a boomer will be deployed and collect data for all aspects of the HRG survey even though the boomer will likely be used less frequently than analyzed in this application. The total length of the trackline to be covered during the Season 2 HRG survey, utilizing Chirp and Boomer, is expected to be approximately 1,853 nautical miles (NM) or 3,432 kilometers (km).

1.3 Survey Vessels

Multiple survey vessels may operate within the survey area during the HRG survey and will each travel at approximately 3 knots during data acquisition and will transit to and from the survey area from port at approximately 15 knots. Survey vessels will acquire data throughout the survey area during the day and terminate survey activities each day before dark, prior to returning to port. Given the slow speeds at which the survey vessels will operate and the requirement that NMFS-approved observers be present, the risk of a vessel collision risk with protected marine mammals is low. This finding is consistent with the finding of “insignificant or discountable” effects on whale and sea turtle collision risk stated in the 2010 NMFS Biological Opinion.

Vessel sounds during the HRG survey will result from propeller cavitations, propeller singing, and propulsion, in addition to flow noise from water dragging across the hull and bubbles breaking in the wake. The dominant sound source from vessels is propeller cavitations; noise intensity associated with vessels is dependent upon size and speed (BOEMRE, 2009). Noise impacts from survey vessels are expected to be comparable to those generated by common and existing vessel traffic in Nantucket Sound.

2.0 DATES, DURATION AND SPECIFIC GEOGRAPHIC REGION OF THE ACTIVITY

2.1 HRG Survey Dates and Duration

The HRG survey program will likely begin in the spring of 2013. As stated above, the survey area includes the entire Wind Turbine Array and 115 kV submarine cable route. The HRG survey vessels will operate during daytime hours only. During the season 1 HRG survey, the survey vessel completed approximately 17 NM of survey track lines per day.

[2] Document available at http://www.boemre.gov/offshore/RenewableEnergy/PDFs/CapeWind/Tripathi/Revised_Findings_Main.pdf

Based on this estimated rate of survey production, for purposes of this application CWA conservatively estimates that the 2013 HRG survey activities will take approximately 109 days. However, if more than one survey vessel is used, the survey duration would be considerably less.

2.2 Specific Geographic Region

As shown in Figure 1, the northernmost WTGs will be approximately 8.4 kilometers (5.2 miles) from the southern shore of Cape Cod (Point Gammon on the mainland); the southernmost part of the Wind Park will be approximately 17.7 kilometers (11 miles) from Nantucket Island (Great Point), and the westernmost WTG will be approximately 8.9 kilometers (5.5 miles) from the island of Martha's Vineyard (Cape Poge).

As described above, the HRG survey will be conducted within an area extending 1,000 feet beyond the APE for offshore archaeological resources. This area covers where the WTGs will be located as well as the submarine cable between the wind park and the cable landfall location on the mainland. All totaled, the survey area is approximately 110 square kilometers (km^2) or 42.5 square miles (mi^2).[3]

3.0 PROFILES OF THE SPECIES OR STOCKS OF MARINE MAMMALS IN THE VICINITY OF THE PROJECT AREA

This section provides a summary of the species and numbers of marine mammals likely to be found within the vicinity of the Project area, and a description of the status, distribution, and seasonal distribution of the affected species or stocks of marine mammals to be potentially affected by the proposed project activities. Primary sources of data for this section are the BOEMRE's FEIS and associated reports. Supplemental data was distilled from current public data sources, namely the 2011 Stock Assessment Reports published by NMFS, and regionally focused scholarly works. CWA conducted aerial avian surveys of the Project area between 2002 and 2004 that provide data on the occurrence and abundance of the seals discussed in this application. The site specific marine mammal observations conducted in 2012 in support of CWA's season 1 HRG survey also provide additional data. These data sources represent the best available scientific documentation of cetacean and pinniped species in Nantucket Sound.

According to the FEIS, the following twelve whale species and four seal species protected under the MMPA occur with varying seasonality in New England waters: humpback whale (*Megaptera novaeangilae*), fin whale(*Balaenoptera physalus*), North Atlantic right whale (*Eubaelena glacialis*), long-finned pilot whale (*Globicephalus melas*), minke whale (*Balaenoptera acutorostrata*), Atlantic white-sided dolphin (*Lagenorhynchus acutus*), striped dolphin (*Stellena coeruleoalba*), common dolphin (*Delphinus delphis*), harbor porpoise (*Phocoena phocoena*), Atlantic spotted dolphin (*Stenella frontalis*), Risso's dolphin (*Grampus griseus*), *Kogia* spp., gray seal (*Halichoerus grypus*), harbor seal (*Phoca vitulina concolor*), harp seal (*Phoca groenlandica*), and hooded seal *(Crystophora cristata*) (BOEMRE, 2009). The fin, humpback and North Atlantic right whales are endangered species under the ESA, and thereby also considered depleted species by definition under the MMPA. The remainder of the species listed is considered to be non-depleted species or stocks under the MMPA.

The status and distribution of the humpback, fin, and North Atlantic right whales are discussed in detail in the FEIS and the NMFS Biological Opinion. Both documents state the small likelihood that federally listed whale species are likely to occur within the Project area during survey activities (NMFS, 2010). The Biological Opinion also contains detailed species profiles and an analysis of the potential effects of HRG survey sounds on ESA-listed whales. NMFS states that it is highly unlikely that any whales will be exposed to injurious or disturbing noise levels given the distances to the 180 dB and 160 dB isopleths produced during the use of the boomer (NMFS, 2010). NMFS also recognizes that any risk of incidental

[3] The survey area is further refined according to information detailed in the BOEMRE Lease from earlier estimates of the survey area as they appear in the FEIS and Biological Opinion.

harassment of whales during the HRG survey will be greatly diminished by the implementation of the 500-meter observation zone included in the monitoring and mitigation measures stipulated in the BOEMRE Lease and included in Section 10.0 of this application. Ultimately, the Biological Opinion resolved that no ESA-listed whales are likely to be exposed to potentially injurious or disturbing levels of noise associated with the HRG surveys.

Only three cetaceans and two pinnipeds known to occur in New England waters have been recorded within the Project area. The minke whale, Atlantic white-sided dolphin, harbor porpoise, gray seal and harbor seal are generally considered to be regular visitors to Nantucket Sound (BOEMRE, 2009). The other cetacean and pinniped species mentioned above are considered uncommon transients to Nantucket Sound, and are not discussed further in this application.

3.1 Whales, Dolphins and Porpoises (Cetaceans)

The three cetaceans observed and recorded with relative frequency in Nantucket Sound and have the potential to appear within the Project area are the minke whale, Atlantic white-sided dolphin, and harbor porpoise. Profiles of these three species of cetacean are presented below.

3.1.1 Minke Whale (*Balaenoptera acutorostrata*)

The minke whale is the third most abundant great whale in the United States Atlantic Exclusive Economic Zone (CeTAP, 1982). These whales occur throughout polar, temperate and tropical waters. This small whale species averages 26 feet for males and 27 feet for females. Schooling fish and copepods comprise much of the minke whale diet. The minke whale is protected under the MMPA, but is not considered a strategic stock (Waring et al., 2011). In the North Atlantic, the minke whale is found from Canada to the Gulf of Mexico, concentrated in New England waters. In the New England area, minke whales are most commonly spotted in the spring and summer months. Pittman et al. (2006) present sightings data suggest minke whales are relatively abundant in the waters around Cape Cod but tend to be observed in waters greater than 40 meters in depth, which are significantly deeper than Nantucket Sound where water depths are less than 20 meters.

The best available abundance estimate, from an August 2006 U.S. aerial survey and a July-August 2007 Canadian survey, for the Gulf of Maine up to the Bay of Fundy and the Gulf of the St. Lawrence is 8,987 individuals (NMFS, 20011a). Bycatch from United States fisheries are causes of anthropogenic mortality for minke whales in United States waters (Waring et al., 2011). Between 2005 and 2009, the United States total annual estimated average human-caused serious injury and mortality rate was 5.9 minke whales per year (Waring et al., 2011). There were 7 minke whale stranding mortalities reported along the United States Atlantic coast in 2006; one of these was in Massachusetts waters (Waring et al., 2011).

3.1.2 Atlantic White-sided Dolphin (*Lagenorhynchus acutus*)

The Atlantic white-sided dolphin is found in temperate and sub-polar water in the North Atlantic (NMFS, 2011b). There is evidence of three distinct stocks: Gulf of Maine, Gulf of St. Lawrence and Labrador Sea (NMFS, 2011b). In the Gulf of Maine, the Atlantic white-sided dolphin frequents waters of the continental shelf and can be seen in intermediate abundance from Georges Bank to the southern Gulf of Maine (NMFS, 2011b). Regional aerial survey data indicate that Atlantic white-sided dolphins favor deep waters and regions such as the Great South Channel. Furthermore, sightings data indicate that white-sided dolphins are rare visitors to Nantucket Sound but may occur throughout the year with the greatest likelihood of occurrence from June to September (BOEMRE, 2009; Pittman et al., 2006; Kenney and Vigness-Raposa, 2009).

Atlantic white-sided dolphins have black coloring on their dorsal side with a yellow stripe on their lower dorsal area. Individuals are known to live up to 22 years (males) and 27 years (females)

(BOEMRE, 2009). Their main diet consists of fish such as herring, mackerel and squid (Minasian and Balcomb, 1984; Leatherwood et al., 1982; Ellis, 1982). This species is protected under the MMPA and was designated as a strategic stock in 2011 (Waring et al., 2011). For the western North Atlantic stock of white-sided dolphins, the best estimate of abundance is 23,390; the minimum population estimate is 19,019 (NMFS, 2011b). The estimated total annual average fishery-related mortality or serious injury to the white-sided dolphin stock between 2005 and 2009 was 245 (NMFS, 2011b). Between 2003 and 2007, there were 245 documented Atlantic white-sided dolphin strandings on the United States Atlantic coast from Maine to South Carolina, with 182 of these strandings in Massachusetts (NMFS, 2011b).

3.1.3 Harbor Porpoise (*Phocoena phocoena*)

There are considered to be four distinct populations of harbor porpoise in the Western Atlantic: the Gulf of Maine/Bay of Fundy, Gulf of St. Lawrence, Newfoundland and Greenland (NMFS, 2011c). Fall and spring months are when this species is most commonly found in the southern Gulf of Maine area. This species is small and rotund, with gray coloring. They reach a maximum length of 6 feet and feed on small fishes (BOEMRE, 2009).

The harbor porpoise is protected under the MMPA and is considered a strategic stock (BOEMRE, 2009). For the Gulf of Maine/Bay of Fundy population, the best estimate for abundance is 89,054 harbor porpoises, from a 2006 survey; the minimum population estimate is 60,970 (NMFS, 2011c). The total annual estimated average human-caused mortality is more than 927 harbor porpoises per year (NMFS, 2011c). Recent reported takes of Gulf of Maine/Bay of Fundy harbor porpoise were reported in the United States Northeast sink gillnet, mid-Atlantic gillnet, Northeast bottom trawl and in the Canadian Bay of Fundy groundfish sink gillnet and herring weir fisheries (NMFS, 2011c). Between 2005 and 2009, 487 harbor porpoise strandings were reported along the United States Atlantic coast and Canadian Atlantic coast; 144 of these strandings were in Massachusetts waters (NMFS, 2011c).

Kenney and Vigness-Raposa (2009) completed an analysis of harbor porpoise sighting, stranding, and bycatch records for the period 1850–2007. This analysis was a part of a larger study of marine mammal and sea turtle distribution across a study area that focused mostly on Rhode Island waters, but also covered Nantucket Sound. They report that harbor porpoises have been observed in Nantucket Sound but mostly in the fall and spring months.

3.2 Seals (Pinnipeds)

Gray seals and harbor seals are observed at known seal congregation or haul out areas located in proximity to Nantucket Sound. Two of these areas – Monomoy Island and Muskeget Island (approximately 23.5 kilometers [12.7 nautical miles] and 13.7 kilometers [7.4 nautical miles], from the proposed Project area, respectively) – are documented as year-round gray seal breeding colonies (Figure 1). Because of the proximity of these congregation areas to the Project area, these two seal species are considered in this IHA application. Species profiles of the gray seal and harbor seal are presented below.

3.2.1 Gray Seal (*Halichoerus grypus*)

Gray seals are relatively large animals that inhabit temperate and sub-arctic waters. Gray seals form three populations in the Atlantic: eastern Canada, northwestern Europe and the Baltic Sea (NMFS, 2011e). In the US, they are found from Maine to Long Island Sound, live on remote, exposed islands, shoals, and unstable sandbars, and are the second most common pinniped along the Atlantic coast of the United States, living as long as 30 to 40 years (BOEMRE, 2009). Gray seals are generally gregarious, but live in loose colonies while breeding. Males reach sexual maturity between 6 and 7 years of age and females at 3 years. Pupping occurs on land or ice from late December through mid-February, and peaks around mid-January. Muskeget Island and Monomoy Island compose the only gray seal breeding colony in the United States, and the southern-most gray seal breeding colony in the world (BOEMRE, 2009).

Available data are insufficient to estimate the size of the entire eastern Canada gray seal population, but estimates are available for portions of the stock for certain time periods (NMFS, 20011e). The eastern Canada population ranges from New England to Labrador, is centered at Sable Island, Nova Scotia, and breeds primarily at Sable Island and on pack ice in the Gulf of St. Lawrence (NMFS, 2009e). The size of the eastern Canada gray seal population was estimated from three surveys: a 1993 survey with a population estimate of 144,000 individuals, a 1997 survey with a population estimate of 195,000 individuals, and a 2004 survey with population estimates ranging between 208,720 and 223,220, depending on the estimation model used by the researchers (NMFS, 2011e; Trzcinski et al., 2005). The 2011 Stock Assessment Report for this species reported that gray seal numbers appear to be increasing in Canadian and U.S. waters (NMFS, 2011e).

Massachusetts waters represent the southernmost gray seal breeding colony in the world, and the only one known in the United States south of the Gulf of Maine (NHESP, 2002). Year-round breeding populations have been identified on Musgeket and Monomoy Islands around the periphery of Nantucket Sound. Gray seals presently use these locations as an area to give birth and raise their pups (Waring et al., 2011).

According to the Massachusetts Natural Heritage & Endangered Species Program (NHESP), gray seals do not have regular seasonal migrations. Generally, there is some adult seal movement north during spring and summer out of Nantucket Sound to the waters of Maine and Canada for pupping, with young individuals observed wandering extensively during their first two years of life, as seen with harbor seals (Waring et al., 2001). Additionally, gray seals are in high abundance in Chatham Harbor and other areas of Lower Cape Cod during the spring and summer months (M. Murray, unpublished data). According to Waring et al. (2011), a small number of gray seals have maintained a winter presence in the Woods Hole region (Vineyard Sound) in recent years.

Gray seal counts from winter/spring surveys in 1998-1999, 1999-2000, and 2002 at Monomoy Island, Muskeget Island, and Tuckernuck Island are summarized in Table 3.2-1 (BOEMRE, 2009). The combined Muskeget and Monomoy colonies were estimated at 2,010 in the spring of 1994 (Rough, 1995). In the spring of 1999, a maximum count of 5,611 was reported for the region between Isles of Shoals, Maine to Woods Hole, Massachusetts (Barlas, 1999). It is not known whether this increase represents population growth or immigration (NMFS, 2011e). An increase in pup sightings in New England may indicate an increased trend in pup production. In January 2002, between 900 and 1,000 pups were counted on Muskeget Island and surrounding shoals (NMFS, 2011e.).

Table 3.2-1 Recent Gray Seal Counts at Muskeget Island, Monomoy Island and Tuckernuck Island

Year	Muskeget Island	Monomoy Island	Tuckernuck Island
1998-1999[1]	3,564	3,322	290
1999-2000[2]	4,751	3,113	461
2002[3]	1,599	16	1,192 (species not determined)

1. Waring, unpublished data
2. Barlas, 1999
3. Wood, 2002

Incidental observations of gray and unidentified seals were recorded during avian aerial surveys conducted by Cape Wind Associates. Between May 2002 and February 2004, CWA conducted 46 aerial avian surveys over Nantucket Sound, with particular focus in the area of the proposed Project.[4] Cape Wind flew surveys with a Cessna-206 floatplane at an altitude of 76 meters (250 feet). The plane maintained an air speed of 90 knots, which was the slowest speed the aircraft could safely fly. The distance flown for each of the aerial surveys was approximately 415 kilometers (258 miles). Birds, and incidental seals, were counted and identified along 16 transects spaced approximately 2,286 meters (7,500 feet) apart. Surveys were flown at different times of the day, at different tides, and in somewhat varying weather, but visibility was good or excellent during every survey (surveys were not conducted in inclement weather or at night). Flights also varied in their starting point and direction of flight.

Cape Wind used two observers, one on either side of the plane. An aluminum rod was attached perpendicular to the wing strut on each side of the plane that delineated the transect boundaries. A clinometer was used to measure the calculated angle for the placement of these aluminum rods. The distances between the plane's float and the aluminum rods were initially verified by flying over the airport at 76 meters (250 feet) using pre-measured 200-meter (656 feet) markers on the ground. The area visible between the float on the plane and the aluminum rod provided each observer with a 200-meter (656 feet) transect width within which all birds or seals at the surface were attempted to be counted. The combined survey width was 400 meters (1,312 feet) resulting in an area surveyed of approximately 168 km^2 (65 mi^2) for each survey. Of this total area covered for each survey, 16.1 km^2 (6.2 mi^2) was within the Project area.

Locations of incidentally observed swimming and hauled out seals were recorded using a global positioning system (GPS) (Figure 2). The approximate number of seals observed in each observation was recorded using numerical bins (e.g. 1-2, 3-10, 11-20, 21-50 animals). Seals were recorded by species when possible, and otherwise were recorded as 'unidentified'. No recorded observations for harbor seals are contained in the 2002-2004 survey data within the Project Area.

During the three years of surveys, approximately 26,873 observations of seals were made. The vast majority of recorded seal observations correspond to sightings made at the three seal congregation areas at Monomoy, Muskeget and Tuckernuck Islands. Observers did record small numbers of seals swimming through the Project area in all three years of the avian aerial survey. The total recorded number of seal observations in the Project area during the three years of surveys was 17, and these represented between 19 to 42 seals. The range reflects the low and high ends of the group size bins. Gray seals constituted approximately 50% of these observations, with the other observations recorded only as unidentified.

3.2.2 Harbor Seal (Phoca vitulina concolor)

The harbor seal, also known as the common seal, is found throughout coastal waters of the Atlantic Ocean and adjoining seas above 30°N (Waring et al., 2011) and is the most abundant pinniped on the east coast of the United States. Harbor seals commonly occur in coastal waters and on coastal islands, ledges, and sandbars above 30°N latitude (BOEMRE, 2009). Harbor seals are seasonal visitors to Massachusetts; breeding and pupping occur through the spring and summer in Maine and Canada. Harbor seals over-winter in Massachusetts, including Nantucket Sound, before returning north in early spring. Some individuals may remain in southern New England year-round (Payne and Selzer, 1989).

[4] In addition to the Cape Wind surveys, Massachusetts Audubon Society (MAS) conducted avian aerial surveys over Nantucket Sound between 2002 and 2006. The MAS surveys contained 396 incidental sightings of seals as opposed to the 26,873 incidental seal sightings recorded during the 2002 – 2004 Cape Wind aerial surveys. The MAS data are not included in the analysis of seals in this application due to differences in survey execution. The Cape Wind data were conservatively chosen because of the greater numbers of incidental sightings.

Overall, since the passing of the MMPA in 1972, the observed count of harbor seals along the New England coast has been increasing (Waring et al., 2011). A 2001 coast-wide aerial survey along the Maine coast, conducted in May/June, included replicate surveys and radio tagged seals to obtain a correction factor for animals not hauled out. The corrected estimate for 2001 is 99,340 (NMFS, 2011f). The 2001 estimate is the most current data available and therefore is used in this IHA application.. The harbor seal ranges seasonally from the Arctic to as far south as Cape Cod and Nantucket Sound. Harbor seals spend the late spring, summer, and early fall between New Hampshire and the Arctic where they breed and care for newly born pups. A general southward movement from the Bay of Fundy to southern New England waters occurs in fall and early winter, mostly consisting of juveniles and sub-adults. Whitman and Payne (1990) have suggested that this age-related dispersal may reflect the higher energy requirements of younger individuals. After over-wintering in southern New England waters, the vast majority of the population migrates in the spring to the northern waters of New Hampshire, Maine, and Canada for pupping season. No pupping areas have been identified in southern New England (BOEMRE, 2009).

The greatest summer concentrations of harbor seals are along the coastal islands and ledges of Maine, but they can occur year round in waters adjacent to Cape Cod and Nantucket Island (Payne and Selzer, 1989). Extensive sand spits on Muskeget Island, Tuckernuck Island, and Skiff Island (west side of Muskeget Channel off Martha's Vineyard) have been identified by the U.S. Fish and Wildlife Service as preferred haul-out points for large numbers of harbor seals. This peripheral area may support larger numbers of fish for seals to prey on, since many species of finfish migrate to deeper waters during their over-wintering periods (BOEMRE, 2009). Harbor seal counts from winter/spring surveys in 1998-1999, 1999-2000, and 2002 at Monomoy Island, Muskeget Island, and Tuckernuck Island in Nantucket Sound (approximately 23.5, 13.7, and 16.9 kilometers [12.7, 7.4, and 9.1 nautical miles], respectively, from the Project area) are summarized in Table 3.2-2 (BOEMRE, 2009).

Table 3.2-2 Recent Harbor Seal Counts at Muskeget Island, Monomoy Island and Tuckernuck Island

Year	Muskeget Island	Monomoy Island	Tuckernuck Island
1998-1999[1]	24	610	272
1999-2000[2]	778	2,154	405

1. Barlas, 1999
2. Waring, unpublished data

Harbor seal abundance estimates for Nantucket Sound are scarce. Barlas (1999) observed harbor seals on Cape Cod from October through April and saw their abundance peak in March, with very few individuals using haul-out sites in Nantucket Sound. Waring (unpublished data, 2002) observed an increased abundance of harbor seals on Muskeget Island, Monomoy Island and Tuckernuck Island in 1999-2000; however, when gray seals are breeding, it is not likely harbor seals will be present on the same sites.

CWA aerial surveys (described above) reported no observations of groups of seals that were identified as harbor seals in the Project area. This may have been due to the smaller harbor seals being less visible or more difficult to identify from the air than gray seals or due to harbor seals not foraging in that area.

3.3 Results from Season 1 of the HRG Survey

CWA conducted the first Season 1 of an HRG survey during the summer of 2012 in accordance with the monitoring and mitigation measures required by CWA's IHA issued by NMFS to CWA on December 20, 2011. During the survey, three types of protected species monitoring were conducted. Once per month (including once prior to the start of survey work), a site-wide monitoring event was conducted whereby an MMO would transit the entire Project Area in a separate vessel and document any species present and behavioral information. During the survey an MMO was posted onboard the survey vessel every day to monitor the 500 meter exclusions zone. Twice per week a second MMO was posted on board the survey vessel to monitor behaviors of any marine mammals in the area beyond the 500 m exclusion zone.

Over the 28 days of the 2012 HRG survey, which accounts for approximately 20% of the entire scope of the originally authorized HRG survey work, zero marine mammal takes occurred and only one deceased marine mammal was sighted. The 2011 IHA allows for the taking of a total of 877 marine mammals by level-B harassment, over the duration of the entire HRG program (see Table 3.3-1).

Table 3.3-1 HRG Survey Marine Mammal Expected Takes vs. Actual Takes (Summer 2012)

Species	2011 Incidental Take Authorization (Level-B Harassment)	2012 Actual Incidental Takes (Level-B Harassment)
Minke Whale	11	0
Atlantic White-sided Dolphin	231	0
Harbor Porpoise	138	0
Gray Seal	398	0
Harbor Seal	99	0

One marine mammal was sighted during the survey and identified as a previously deceased harbor seal (*Phoca vitulina*) by two onboard MMOs, and survey equipment was immediately shut down. The seal was estimated to be deceased for 24-48 hours based on signs of scavenger damage and bloating which suggest moderate decomposition (Pugliares et al. 2007). The two observers onboard concurred that the animal was not injured due to survey activities; however a 60 minute post watch was performed to ensure no other protected species were in the vicinity. In compliance with the BOEM Lease (2010) and IHA (2012) a full report was submitted on July 10, 2012 to the appropriate organizations within 48 hours of the sighting.

In light of the above information, the take estimates presented in Section 5.0 are considered to be highly conservative.

4.0 TYPE AND METHOD OF INCIDENTAL TAKE AUTHORIZATION REQUESTED

CWA requests an IHA pursuant to section 101(a)(5)(D) of the MMPA for incidental take by harassment during its HRG Survey (Level B Harassment). The HRG Survey activities described above have the potential to "take" marine mammals by harassment. "Takes" by harassment may occur if a marine mammal comes within the zones of ensonification of the survey devices described further below. However, the mitigation measures required by the lease significantly reduce the likelihood that the HRG Survey activities will result in the "take" of any marine mammals.

5.0 ESTIMATES OF TAKE BY HARASSMENT

5.1 Summary of Potential Effects from HRG Survey Equipment

Marine mammals are impacted by increased background noise and specific sounds in several ways depending, in part, upon the intensity and frequency of the sound. Richardson et al. (1995) characterize the effects of noise exposure on marine organisms by the following range of physical and behavioral responses:

1. Behavioral reactions
2. Prevention of marine animals from hearing important sounds (masking)
3. Temporary reduction of hearing sensitivity or temporary threshold shift
4. Permanent reduction in hearing sensitivity or permanent threshold shift
5. Non-auditory physiological effects

The hearing thresholds of marine mammals vary.[5] Toothed whales (Odontoceti), baleen whales (Mysticeti), and pinnipeds have different hearing thresholds. Thus, their reaction to survey equipment sounds, for example, may differ. Report No. 5.3.2-2 of the Cape Wind - BOEMRE FEIS provides a discussion of marine mammal species-specific hearing capabilities based in large part on Richardson et al. (1995) and Southall et al. (2007). According to these data, the marine mammals considered in this application could detect two of the seismic survey devices used during the HRG survey: shallow-penetration and medium-penetration sub-bottom profilers (chirp and boomer, respectively). Toothed whales tend to be more sensitive to higher frequency sounds in the 10,000 to 100,000 hertz bandwidths. Pinnipeds are less sensitive to very low frequency sounds and have their lowest hearing thresholds around 10,000 hertz (i.e., where they are most sensitive).

Acoustic Survey Equipment Descriptions

Depth Sounders

A multibeam depth sounder (e.g. R2 Sonic 2024 or similar) will be utilized during the HRG survey. A multibeam depth sounder consists of a transducer array that emits a swath of sound in discrete pulses. Depth sounders produce high-frequency acoustic signals above 200 kHz, which are undetectable by marine mammals. This frequency is beyond any marine mammal species' upper hearing threshold and therefore CWA does not anticipate that any effects on marine mammals will result from operating the multibeam depth sounders during the HRG survey.

Side-Scan Sonar

A side-scan sonar will be used to create seafloor imagery during the HRG survey. A dual-frequency digital side-scan sonar (e.g. EdgeTech 4200 or similar) will be used. The instrument emits a dual frequency sound pulse at 400 kHz and 900 kHz. These frequencies are outside any marine mammal species' hearing range and therefore CWA does not anticipate that any effects on marine mammals will result from the operation of the side scan sonar during the HRG survey.

Sub-bottom Profiler Signals

Two types of sub-bottom profilers may be deployed during the HRG survey. CWA will use a shallow-penetration seismic sub-bottom profiler ("chirp") to provide high resolution data of the upper 15 meters of sea bottom. An Edgetech 216S Series or similar instrument model may be used. The chirp will be towed

[5] The hearing threshold of marine species is the minimum sound level in a one-third octave band that can be perceived by an animal in the absence of significant background noise. The hearing threshold sound level expressed as dB_{ht} represents the sound level above an individuals hearing threshold (e.g., 90 dB_{ht} represents 90 dB above an animal's hearing threshold).

near the center of the survey vessel directly adjacent to the gunwale of the boat, approximately 3 to 5 feet beneath the surface of the water. The frequency range for this instrument is generally 2 kHz to 16 kHz. The estimated sound pressure level at the source for the chirp is 201 dB re 1 □Pa (RMS) at 1 meter with a typical pulse length of 32 milliseconds and a pulse repetition rate of 4 per second.

A medium penetration subbottom profiler (boomer) will be used to obtain deeper resolution of geologic layering that can not be imaged by the chirp. AN AP3000 Dual-Plate Boomer (or similar) will be used. The boomer generates a short duration sound pulse (~330 milliseconds) with broad frequency range (0.5 to 20 kHz). The boomer will be towed by a survey vessel approximately 10 to 15 feet behind the stern at the sea surface.

Sound Source Verification monitoring was performed on the shallow- and medium-penetration subbottom profilers during the Season 1 survey (see Appendix A). Underwater sound was recorded with two Autonomous Multichannel Acoustic Recorders, deployed 100m apart, in the vicinity of the Project Area (water depth ~ 28 feet) The received 90% rms sound pressure levels (SPLs) from the Dual-Plate Boomer and the sub-bottom profiler did not exceed 175 dB re 1 μPa. The loudest source, the Dual-Plate Boomer, produced a received 90% rms SPL of less than 140 dB re 1 μPa at 500 m range (the distance specified for maintaining a monitored exclusion zone). The range to the 160 dB re 1 μPa rms SPL isopleth was 12 m for the dual plate boomer. The 160 dB Isopleth for the shallow-subbottom profiler was 6 meters from the source.

5.2 Basis for Estimating Take by Harassment

CWA followed the guidance of NMFS Office of Protected Resources to estimate the number of potential takes of cetaceans and pinnipeds resulting from the HRG Survey for this application. Take estimates were calculated by multiplying the estimated species density values (n) measured in species (individuals) per square kilometers, by the area of the zone of influence (ZOI)[6] in square kilometers, times the total number of survey days (d = 109) or, **n * ZOI * d**.

The zone of influence was calculated as a function of the distance a survey vessel with deployed boomer travels in one survey day and the area around the boomer where sound levels reach or exceed 160 dB. To estimate the 160 dB ZOI around the boomer, a spatial analysis using ArcGIS® v9.3 was conducted. Using the software's spatial analysis tool, a 160 dB buffer (zone of ensonification) was drawn around the centerline of the HRG survey lines and then a total area within the buffers calculated. Areas where overlap occurred were included only once to estimate the total area of ensonification for one survey day of effort and to calculate the number of individuals potentially exposed to sounds greater than 160 dB.

5.2.1 Cetacean Density Estimates

The estimated density of the minke whales, Atlantic white-sided dolphins, and harbor porpoises have been derived using analytical methods that consider recorded species observations and the associated level of survey effort. Pittman et al. (2006) published a method of an analysis of cetacean distribution for the waters around Cape Cod for NOAA National Centers for Coastal Ocean Science's *An Ecological Characterization of the Stellwagen Bank National Marine Sanctuary Region: Oceanographic, Biogeographic, and Contaminants Assessment*. More recently, Kenney and Vigness-Raposa (2009) applied a similar methodology to determine spatial distribution of marine mammals within the Rhode Island Study Area for the *Rhode Island Ocean Special Area Management Plan*, which included Nantucket Sound. This application refers to these two studies for the purposes of estimating species density in the Cape Wind Project area.

[6] The phrase zone of influence is used as a synonym to zone of ensonification. In this section it describes the area around the sound source (e.g. boomer) where sound levels are greater than 160 dB.

The data used as the basis for estimating species density for this application is sightings per unit effort (SPUE) and was taken from Pittman et al. (2006). As the name suggests, SPUE (or, the relative abundance of species) is derived by using a measure of survey effort and number of individual cetaceans sighted. Species density (animals per km^2) can be computed by dividing the SPUE value by the width of the avian survey track, and numbers of animals can be computed by multiplying the species density by the size of the geographic area in question (km^2). Pittman et al. (2006) selected data from two sources to calculate SPUE: 1) North Atlantic Right Whale Consortium database and, 2) Manomet Bird Observatory database.

SPUE allows for comparison between discrete units of time (i.e. seasons) and space within a project area (Shoop and Kenney, 1992). Both Pittman et al. (2006) and Kenney and Vigness-Raposa (2009) present figures that represent SPUE data in a geo-spatial context. This presentation was accomplished by plotting values on a grid overlying the study areas and then creating contours by interpolating data values to create the appearance of continuity or smoothness across space. Areas represented by these studies include the land masses of Cape Cod, Martha's Vineyard, Nantucket, Block Island and coastal Rhode Island and extend away from shore to deep waters. As a result, gradients or bands of SPUE are illustrated by figures and allow for interpretation of spatial differences within the geographic scope of the study, including Nantucket Sound. SPUE figures are shown for all four seasons, as well as an aggregate "all seasons" illustration. Only Pittman et al. (2006), however, provide numerical SPUE data that could be readily used for estimates of species density and thus applied to potential taking calculations discussed in this application.

Ranges of density values for minke whales, Atlantic white-sided dolphins and harbor porpoises were interpreted from the figures illustrating year-round ("all seasons") SPUE aggregated values in Pittman et al. (2006). Data that was combined as "dolphins and porpoises" is used as an upper bound for harbor porpoise density. The SPUE relative density values are the numerical ranges included in geographical density bands that included the Cape Wind project area, as seen for minke whales, Atlantic white-sided dolphins, and harbor porpoises in Figures 3,4 and 5, respectively.

The species-specific maps in Pittman et al (2006) reveal that minke whales (Figure 3), Atlantic white-sided dolphins (Figure 4) and dolphins and porpoises (Figure 5) are most commonly observed in offshore waters much deeper than Nantucket Sound, east and south of Cape Cod, where prey availability and habitat are better suited. As shown in Table 5.2-1, the range of SPUE values in the bands corresponding or adjacent to the Project area for minke whales, Atlantic white-sided dolphins, and dolphins and porpoises are 0. 1 – 5.9, 0.1 – 131.4, and 0.1 – 78.6 animals per 1,000 kilometers of standardized survey track covered. Compared to the ranges of SPUE values corresponding to waters outside of Nantucket Sound, these values show that the relative density is lower in the Project area than for other more seaward areas. Because of this gradient in density and because the Project area is at the western edge of the density band, the high ends of the above ranges are likely greater than the actual densities in the Project area. In addition, Cape Wind and ESS scientists and engineers surveying in the project area for environmental study efforts and engineering purposes over the 10 year permitting process have not observed these cetacean species. Although this is only anecdotal information, it is consistent with the density assessment included herein.

The SPUE values are converted to an absolute density value by following a methodology published by NMFS.[7] NMFS used 0.4 km (0.25 mi) as a conservative strip width (W) to represent the area viewed on either side of the aerial survey platform. Therefore, the area density (D) of these species in the project area can be obtained by the following formula: $D = SPUE/2W$. The results of these conversions are presented in Table 5.2-1.

[7] "Small Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to Construction and Operation of an LNG Facility Off Massachusetts." 72 Federal Register 92, (May 14, 2007): 27077 – 27091. Print.

Table 5.2-1 Range of Estimated Densities of Minke Whales, Atlantic White-sided Dolphins and Harbor Porpoises in Nantucket Sound

Species	Average Sightings per Unit Effort (SPUE) in Species per 1,000 km of Survey Effort		Density of species [SPUE/2W] – (species/1,000 km^2)	
	Low	*High*	*Low*	*High*
Minke Whales	0.1	5.9	0.13	7.4
Atlantic White-sided Dolphins	0.1	131.4	0.13	164.3
Harbor Porpoises	0.1	78.5	0.13	98.1

5.2.2 Pinniped Density Estimates

Calculations of potential takes of two pinniped species by harassment are based on gray seal density estimates derived from incidental sightings of seals (at sea) within the Project area recorded during project avian surveys (see Section 3.2.1). These incidental sightings constitute the best available data for gray seals transiting Nantucket Sound. While more targeted aerial counts exist of gray and harbor seals observed at known seal congregation areas at Monomoy, Muskeget and Tuckernuck Islands, located around the periphery of Nantucket Sound, there is no comparable survey or count estimating the population of seals swimming *in* Nantucket Sound. Due to the fact that there are no sightings data or population estimates for harbor seals transiting or foraging within Nantucket Sound and harbor seals were not identified in the Cape Wind avian surveys, density estimates for this species were calculated for the purposes of this application based on the ratio of harbor seal to gray seal count data, as discussed below.

5.2.2.1 Gray Seals

Gray seal density was estimated based on the range of incidental sightings recorded during the 2002 – 2004 CWA Aerial Surveys. The recorded range of sightings – 19 to 42 gray seals – was first corrected for aerial survey detection bias because it is assumed that the seals spotted incidental to avian survey work were at the surface and represent only a fraction of the actual number of seals in the area. As previously mentioned, most of these seals observed were foraging for prey in, or transiting, Nantucket Sound. Swimming gray seals are known to be submerged 85% to 90% of the time and exhibit certain diving and foraging behaviors that indicate typical intervals below and at the surface of the water (Thompson and Fedak, 1993). Dependent on their hunting strategy, as determined it is thought by prey availability/selection, seals may dive, swim slowly along the seafloor or pause at a depth for a period of time (square- or U-shaped dive), or, they may dive, and ascend after a brief moment at the bottom (V-shaped dive) (Beck, et al., 2000; Reed, et al., 1994). Scientific measurements of both wild and captive grey seals exhibiting this type of diving behavior indicate that for every minute a seal may spend at the water surface to breathe, it typically spends about 5 minutes underwater (Beck, et al., 2000; Reed, et al., 1994; Thompson and Fedak, 1993).

If we apply the ratio of typical time seals spend underwater to the time spent at the surface (5:1) to the incidental observations of seals within the Project area, then an adjusted gray seal count of 95 to 210 gray seals is obtained for the three-year aerial survey period.

To arrive at a range of density estimates of gray seals for the Project area, the adjusted low and high values of the range of recorded gray seal sightings was divided by the total number of aerial survey days (d = 46) to arrive at estimate ranges of the number of seal sightings recorded per day of aerial survey effort. This value is then divided by the area over the Cape Wind project surveyed during the avian surveys or 16.1 km^2 to arrive at the range of estimated seal densities within the project area or 0.13 to 0.28 seals per km^2.[8]

5.2.2.2 Harbor Seals

Since no population data for harbor seals within the Project area is available, an approximation of species density was calculated by multiplying the gray seal density by the ratio of harbor seal to gray seal sightings. A ratio of harbor seals to gray seals was derived by comparing population count data for the known seal haul-out areas near Nantucket Sound (Muskeget, Monomoy, Tuckernuck Islands). This ratio was arrived at by comparing harbor seal sightings during the same population census years of 1998 – 1999 and 1999 – 2000 (*see* Tables 3.2-1 and 3.2-2 above); for every four (4) gray seals counted there was one (1) harbor seal counted. This 4:1 ratio was applied to the estimated density of gray seals, to arrive at the range of estimated harbor seal densities within the project area or 0.03 to 0.07 seals per km^2.

5.2.3 Estimates of the Number of Species Exposed to Disturbing Levels of Sound (Level B Harassment)

Estimated numbers of species potentially exposed to disturbing levels of sound from the boomer were calculated for minke whales, Atlantic white-sided dolphins, harbor porpoises, gray seals, and harbor seals in the Project area. These estimates were calculated by multiplying the maximum low and high end of the ranges of estimated species density by the boomer (160 dB) ZOI and the number of days of survey operation (d = 109). Table 5.2-2 contains the results of the calculations showing the low and high ends of a range of species exposure estimates. The inclusion of a range of estimates illustrates the broad range of SPUE values in the smoothed density contours of Pittman et al (2005). As set forth in Table 5.2-3, CWA is requesting an incidental harassment authorization based on the highest estimated potential species exposures to potentially disturbing levels of sound from the boomer. No marine species are expected to be exposed to injurious levels of sound in excess of 180 dB during the proposed HRG survey.

Table 5.2-2 Ranges of Conservative Estimates of Potential Takes of Three Cetacean and Two Pinniped Species from the Operation of a Medium-Penetration Subbottom Profiler during the Proposed Cape Wind Pre-Construction Season 2 HRG Survey in Nantucket Sound

	Low Value of Estimated Range	High Value of Estimated Range	Requested Take Authorization
Minke Whale			
Density (species/1,000 km^2)	0.13	7.4	
Estimated Take (number of species)	1	9	**9**
Atlantic White-sided Dolphin			
Density (species/1,000 km^2)	0.13	164.3	
Estimated Take (number of species)	1	185	**185**
Harbor Porpoise			
Density (species/1,000 km^2)	0.13	98.1	
Estimated Take (number of species)	1	110	**110**

[8] The area covered by the avian aerial surveys was calculated by multiplying the aerial survey transect width (400 meters) times the total distance the survey flew over the Cape Wind Project area or 40.25 km, i.e. 0.4 km * 40.25 equals 16.1 km^2.

Gray Seal			
Density (species/km^2)	0.13	0.28	
Estimated Take (number of species)	144	314	**314**
Harbor Seal			
Density (species/km^2)	0.03	0.07	
Estimated Take (number of species)	36	79	**79**

CWA's requested harassment authorization is conservative and precautionary for several reasons:

- The requested cetacean takes are likely overestimated because for each species the highest values of the range of density in each density band are used. Further, the actual densities in the project area are likely lower than the average density in the band because the project area is situated on the western extreme of a gradient in density that increases from west to east. Site specific observations during the 2012 HRG survey monitoring support this conclusion.
- Required mitigation measures, which significantly reduce the likelihood that marine mammal species would be exposed to potentially disturbing sound are not considered. These mitigation measures are set forth in Section 10.0 and briefly summarized here:
    - All surveying equipment will comply with applicable equipment noise standards of the U.S Environmental Protection Agency, and that all equipment shall have noise control devices to the extent practicable, no less effective than those provided on the original equipment.
    - Establishment of a 500-meter-radius exclusion zone around any survey source vessel to be monitored by a NMFS-approved observer for marine mammals (and sea turtles) for 60 minutes prior to commencing or restarting surveys, during surveys, and for 60 minutes after surveys end.
    - Implementation of "ramp up" at the beginning of each survey.

6.0 ANTICIPATED IMPACT OF THE ACTIVITY ON THE SPECIES OR STOCK

In the event that the requested number of cetacean and pinniped species were exposed to sound levels in excess of 160 dB over the 109 days of proposed HRG survey activity, it is likely that these individuals or groups of individuals would avoid the sound source and move away. Thus, the primary anticipated impact from any exposed species can be characterized as temporary behavioral change due to avoidance of the 160 dB area of ensonification. All cetacean and pinniped species in the vicinity of the HRG survey operations would be transient as no breeding, calving, pupping, nursery or haul-out areas coincide with the Project area. Any whales, dolphins, porpoises or seals in the Project area would be foraging for prey or in transit to other waters. The estimated take numbers of minke whales, Atlantic white-sided dolphins, harbor porpoises, gray seals and harbor seals represent 0.10%, 0.79%, 0.12%, 0.14% and 0.08%, of their western North Atlantic populations, respectively. These proportions are based on western North Atlantic population estimates included in the species profiles presented in Section 3.0 above. Hence, negligible impact to these cetacean and pinniped species with respect to their western North Atlantic stocks would be expected over the course of the Project's HRG survey.

7.0 ANTICIPATED IMPACT OF THE ACTIVITY ON THE AVAILABILITY OF THE SPECIES OR STOCKS OF MARINE MAMMALS FOR SUBSISTENCE USES

NOAA Office of Protected Resources defines "subsistence" as the use of marine mammals taken by Alaskan Natives for food, clothing, shelter, heating, transportation, and other uses necessary to maintain the life of the taker or those who depend upon the taker to provide them with such subsistence. There are no traditional subsistence hunting areas in Nantucket Sound. As such, it can be expected that the activity will have no impact on the availability of marine mammal species or stocks for subsistence uses.

8.0 THE ANTICIPATED IMPACT OF THE ACTIVITY UPON THE HABITAT OF THE MARINE MAMMAL POPULATIONS, AND THE LIKELIHOOD OF RESTORATION OF THE AFFECTED HABITAT

There is no anticipated impact on marine mammal habitat from the proposed activities; the equipment deployed during the HRG survey will not come in contact with the seafloor and are not a source of air or water pollution.

9.0 ANTICIPATED IMPACT OF HABITAT LOSS OR MODIFICATION ON MARINE MAMMAL POPULATIONS

There is no anticipated impact on marine mammal habitat from the proposed activities; the equipment deployed during the HRG survey will not come in contact with the seafloor and are not a source of air or water pollution.

10.0 THE AVAILABILITY AND FEASIBILITY (ECONOMIC AND TECHNOLOGICAL), METHODS, AND MANNER OF CONDUCTING SUCH ACTIVITY OR MEANS OF EFFECTING THE LEAST PRACTICABLE IMPACT UPON AFFECTED SPECIES OR STOCK.

Included in the terms and conditions of the BOEMRE lease are required mitigation and monitoring measures designed to minimize the risk of noise and vessel impacts to marine mammals during the HRG survey (BOEMRE, 2010). These measures were initially presented as Appendix G of the FEIS related to marine mammals and sea turtles developed by BOEMRE and as a part of the NMFS ESA Section 7 consultation (NMFS, 2010).

The mitigation and monitoring methods described in the BOEMRE lease terms and conditions, as they relate to protected marine mammals, are included below:

1. CWA shall abide by the following guidelines during all operations:
   - NMFS Northeast Regional Viewing Guidelines (http://www.nmfs.noaa.gov/pr/pdfs/education/viewing_northeast.pdf)
   - BOEMRE Gulf of Mexico Region's Notice to Lessee (NTL) No. 2007-G04 (http://www.gomr.mms.gov/homepg/regulate/regs/ntls/2007NTLs/07-g04.pdf)
   - Marine Trash and Debris Awareness Elimination NTL No. 2007-G03 (http://www.gomr.mms.gov/homepg/regulate/regs/ntls/2007NTLs/07-g03.pdf)
2. CWA shall ensure that all surveying equipment complies with applicable equipment noise standards of the U.S Environmental Protection Agency, and that all equipment shall have noise control devices to the extent practicable, no less effective than those provided on the original equipment.
3. CWA shall establish a 500-meter-radius exclusion zone around any survey source vessel and monitor the zone for marine mammals (and sea turtles) for 60 minutes prior to commencing or restarting surveys, during surveys, and for 60 minutes after surveys end. The exclusion zone shall be free of marine mammals (or sea turtles) for 60 minutes prior to commencing surveys and the sound source shall be shut down immediately should a marine mammal (or sea turtle) enter the zone during surveying. During this time, the zone shall be monitored by a NMFS-approved observer(s) and the zone may not be obscured by fog or poor lighting conditions.
4. CWA shall require a "ramp up" (depending on the technical limitations on the equipment used) at the beginning of each survey in order to allow marine mammals [and sea turtles] to vacate the area prior

to the commencement of activities. Surveys shall not commence at night time or when the exclusion zone cannot be effectively monitored.

5. CWA shall provide a report to BOEMRE and NMFS within 90 days of completion of survey activities that includes a summary of the surveying and monitoring activities and an estimate of the number of marine mammals and sea turtles that may have been taken as a result of survey activities. CWA shall also report to NMFS and BOEMRE, within 24 hours of observation, any observed injury or mortality to a marine mammal or sea turtle. CWA shall transmit to NMFS and BOEMRE, within 48 hours, any significant observations concerning impacts on marine mammals or sea turtles.

Rookery and Mating Ground Concerns

Gray seal rookeries have been identified in Nantucket Sound; however this affected species and other affected stocks are protected under the MMPA and are not to be taken for subsistence uses. The Project will have no adverse impacts on this availability nor would it have direct impacts on the availability of land for use by seals as rookeries.

11.0 THE EFFECT OF THE PROPOSED ACTIVITY ON TRADITIONAL ARCTIC SUBSISTENCE HUNTING AREAS AND/OR THE AVAILABILITY OF A SPECIES OR STOCK OF MARINE MAMMAL FOR ARCTIC SUBSISTENCE USES.

There are no traditional Arctic subsistence hunting areas in Nantucket Sound. As such, it can be expected that the proposed activity will have a negligible impact on the availability of marine mammal species or stocks for subsistence hunting uses.

12.0 NECESSARY MONITORING AND REPORTING THAT WILL RESULT IN INCREASED KNOWLEDGE OF THE SPECIES, THE LEVEL OF TAKING OR IMPACTS ON THE POPULATION OF MARINE MAMMALS AND SUGGESTED MEANS OF MINIMIZING BURDENS BY COORDINATION OF REPORTING REQUIREMENTS.

The CWA-BOEMRE Lease terms and conditions include monitoring and reporting mandates for the Project. BOEMRE incorporated reporting requirements issued by NMFS in its Biological Opinion (2010) that address concerns specific to ESA-listed whales. BOEMRE's notification requirements require agency coordination through a dual reporting mechanism (e.g., reports to both BOEMRE and NMFS) with regard to project activities and marine mammal observations. In recognition of these monitoring and reporting measures as effective means to promote agency coordination and to increase knowledge about protected marine mammals and their potential taking from a project like the Cape Wind Energy Project, CWA proposes to implement several monitoring and reporting measures with respect to all of the marine mammals discussed in this application. These measures are summarized below.

Monitoring

CWA shall establish a 500-meter-radius exclusion zone around any survey source vessel and monitor the zone for marine mammals (and sea turtles) for 60 minutes prior to commencing or restarting surveys, during surveys, and for 60 minutes after surveys end. The exclusion zone shall be free of marine mammals (or sea turtles) for 60 minutes prior to commencing surveys and the sound source shall be shut down immediately should a marine mammal (or sea turtle) enter the zone during surveying. During this time, the zone shall be monitored by a NMFS-approved observer(s)

CWA will provide additional monitoring efforts that will result in increased knowledge of the species. A NMFS-approved protected species observer will be on board the survey vessel for two days for every 14 days of survey activity in order to monitor for marine mammals outside of the exclusion zone using binoculars and any other appropriate equipment to record species, movement, and behavior of any marine mammals in the area. The observer will be positioned to view marine mammal behavior at locations and intervals sufficient for them to extrapolate takes and changes in behavior from the survey activity.

In addition, CWA will send out an additional vessel with a NMFS-approved protected species observer to collect data on presence and behavior of species of concern outside the exclusion zone once per month during the seismic program.

Data Collection and Reporting

The NMFS-approved protected species observer would record data to estimate the numbers of marine mammals present and to document apparent disturbance reactions or lack thereof. Data would be used to estimate numbers of animals potentially ''taken'' by harassment. When a sighting is made, the following information about the sighting would be recorded:

1. Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, and apparent reaction to the acoustic sources or vessel.
2. Time, location relative to the acoustic sources, heading, speed, activity of the vessel (including whether and the level at which acoustic sources are operating), sea state, visibility, and sun glare.

The data listed under (2) would also be recorded at the start and end of each observation watch, and during a watch whenever there is a change in one or more of the variables.

Reporting

CWA shall provide a report to BOEMRE and NMFS within 90 days of completion of survey activities that includes a summary of the surveying and monitoring activities as well as an estimate of the number of marine mammals and sea turtles that may have been taken as a result of survey activities. CWA shall also report to NMFS and BOEMRE, within 24 hours of observation, any observed injury or mortality to a marine mammal or sea turtle. CWA shall transmit to NMFS and BOEMRE, within 48 hours, any significant observations concerning impacts on marine mammals or sea turtles.

13.0 SUGGESTED MEANS OF LEARNING OF, ENCOURAGING, AND COORDINATING RESEARCH OPPORTUNITIES, PLANS, AND ACTIVITIES RELATING TO REDUCING SUCH INCIDENTAL TAKING AND EVALUATING ITS EFFECTS

Other than the monitoring and reporting measures discussed in this application, there is no formal research program targeting marine mammals included in the Project. As mentioned in Section 12.0, marine species sightings data will be collected during the construction phase of the project. In consideration of the fact that Cape Wind will be the first offshore wind park ever installed in the United States, there is great potential for learning more about construction effects on marine mammals in Nantucket Sound, which may provide insights for future projects elsewhere.

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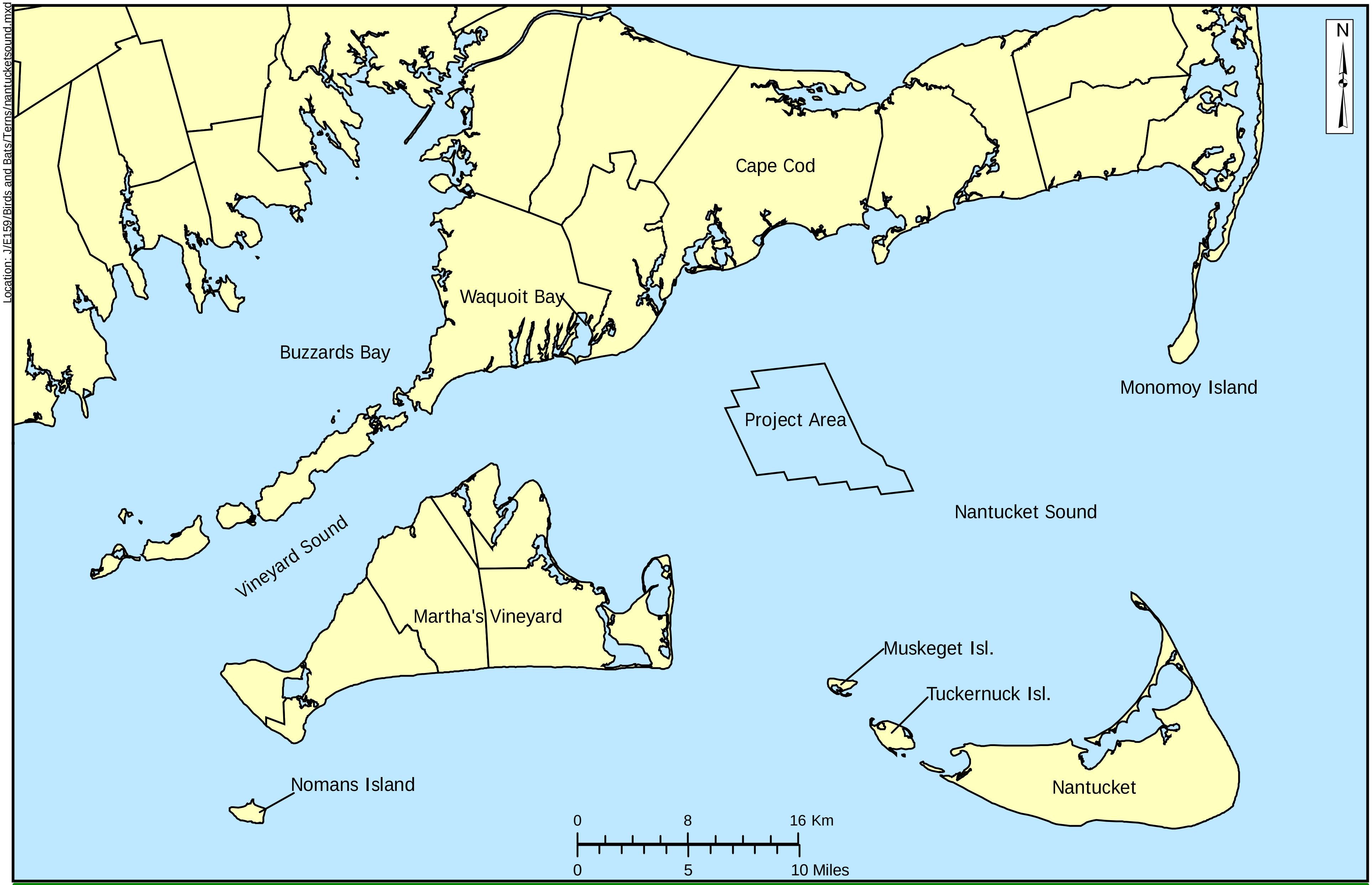
Figures



ESS Group, Inc.
Engineers
Scientists
Consultants

CAPE WIND
Nantucket Sound, Massachusetts

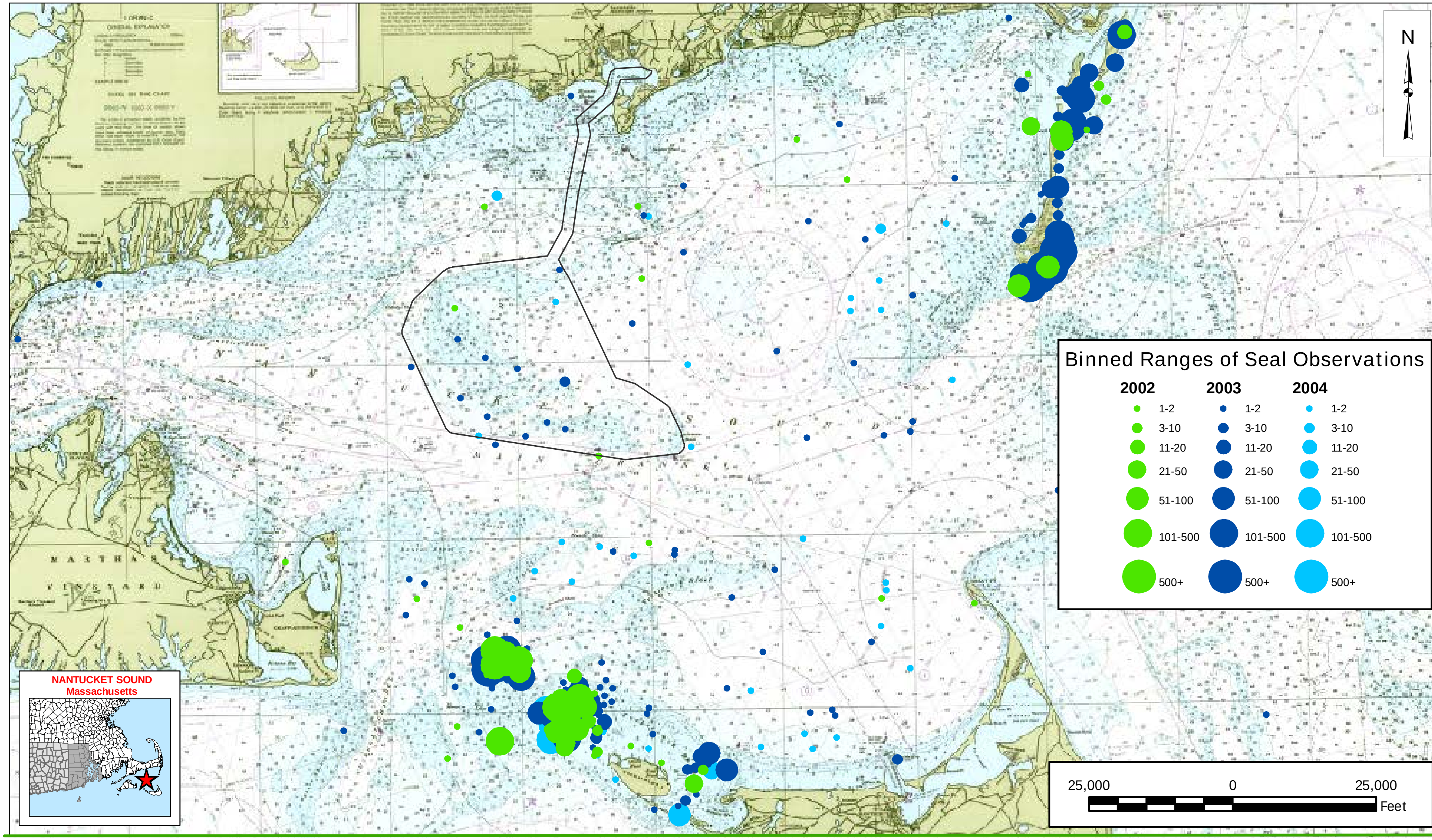
Scale: 1" = 6 miles

Source: 1) MassGIS, Town Boundary

Project Site Locus

Figure 1

Location: G:/GIS-Projects/E159/00-mxd/Seal-2002-2004.mxd



CAPE WIND PROJECT
Nantucket Sound, Massachusetts

Scale: 1" = 25,000'

Source: 1) MassGIS, NOAA Chart (#13237), 1998
2) ESS, Seal Locations, 2002-2004
3) ESS, Area of Ensonification, 2011

—— Anticipated Area of Ensonification

Incidental Seal Observations
2002 - 2004 Cape Wind
Avian Surveys

Figure
2

Figure 3. Relative Abundance of Minke Whales in the Southern Gulf of Maine for All Seasons, with the Associated Relative Density (SPUE) Levels for each of the Five Bands of Density. The band including the Cape Wind Project (superimposed in green) corresponds to the density band from 0.1 to 5.9 animals per 1000 km of standardized track. Adapted from Pittman et al. (2006) Figure 5.3.3.

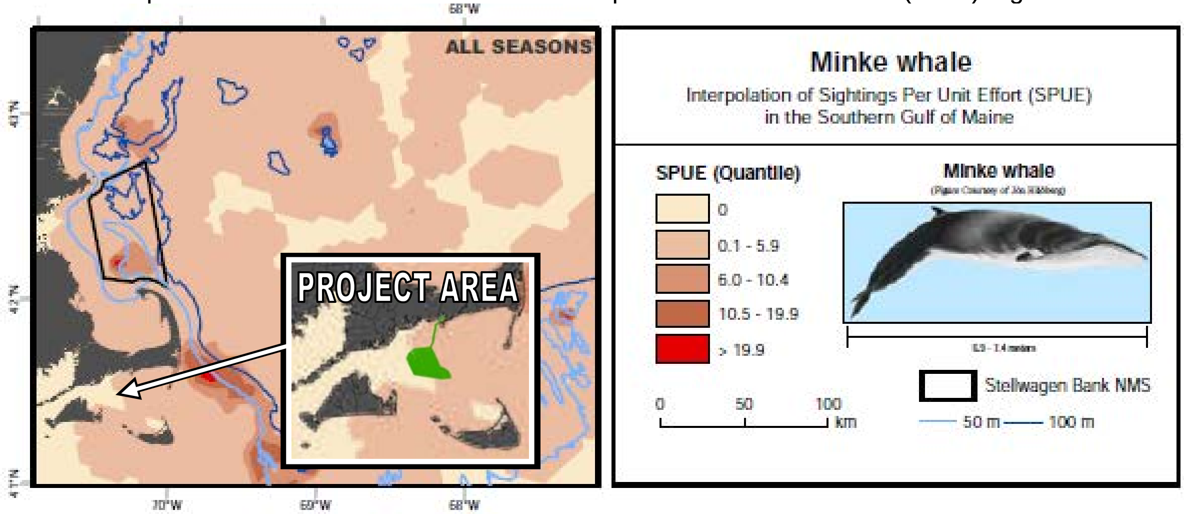


Figure 4. Relative Abundance of Atlantic White-Sided Dolphins in the Southern Gulf of Maine for All Seasons, with the Associated Relative Density (SPUE) Levels for each of the Five Bands of Density. The band including the Cape Wind Project (superimposed in green) corresponds to the zero value density band. In order to be conservative, this application uses the adjacent density band from 0.1 to 131.4 animals per 1000 km of standardized track. Adapted from Pittman et al. (2006) Figure 5.3.7.

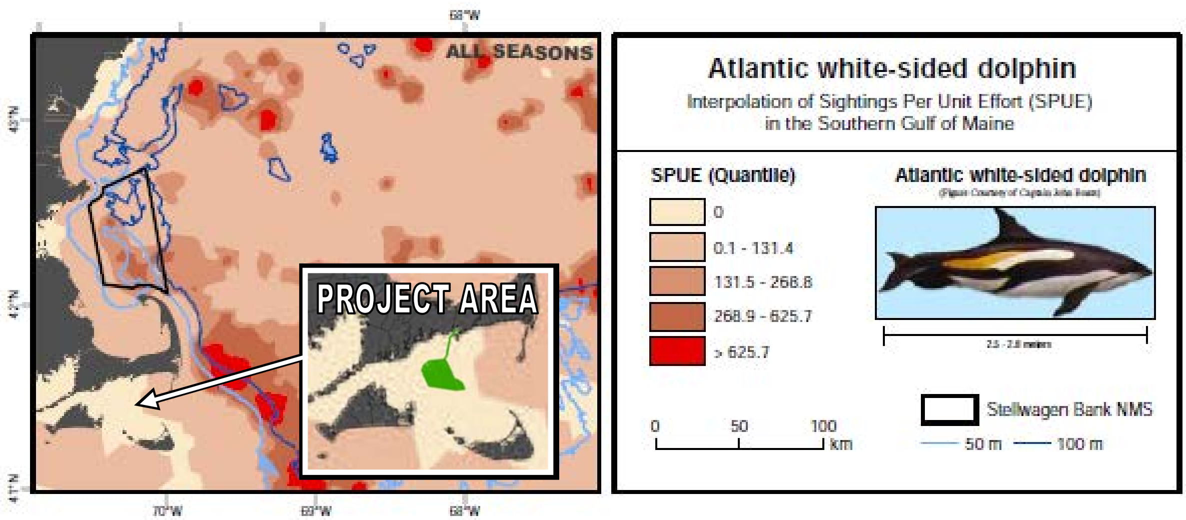
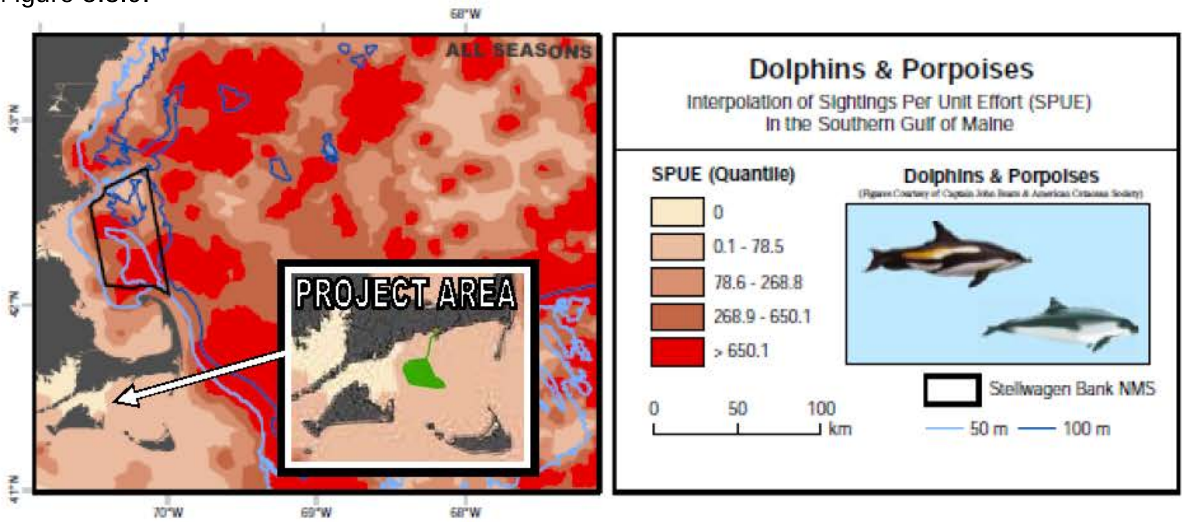


Figure 5. Relative Abundance of Dolphins and Porpoises in the Southern Gulf of Maine for All Seasons, with the Associated Relative Density (SPUE) Levels for each of the Five Bands of Density. The band including the Cape Wind Project (superimposed in green) corresponds to the density band from 0.1 to 78.5 animals per 1000 km of standardized track. Adapted from Pittman et al. (2006) Figure 5.3.9.



Appendix A

JASCO, 2012. Sound Source Verification of Fugro Geotechnical Sources.

Sound Source Verification of Fugro Geotechnical Sources

Final Report: Boomer, Sub-Bottom Profiler, Multibeam Sonar, and the R/V *Taku*

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Contents

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Figures

Tables

1. Introduction

Sound Source Verification (SSV) monitoring was performed by JASCO Applied Sciences for Fugro GeoServices in Nantucket Sound, July 6 and 7, 2012. Acoustic measurements of five sources (Table 1) were performed to determine the noise impact to the surrounding environment. This report presents final sound level results for each source.

Table 1. Sound sources monitored.

Sound Source	Frequency (kHz)	Measurement distance ⊥ to track line (m)
R/V Taku: 32-foot catamaran, 2×225 HP outboards	Broadband	0, 100
AP3000 Dual-Plate Boomer, various input energies	0.3–14	0, 100, 250, 350
X-STAR SB-216S Sub-Bottom Profiler	2–15	0, 100, 250, 350
R2Sonic 2024 Multibeam Sonar	200, 400	0, 100, 250, 350
Single-beam echosounder (vessel depth sounder)	70, 200	0, 100

Fugro used the measurements to verify the ranges to the 160 and 180 dB re 1 µPa isopleths. Their Incidental Harassment Authorization (IHA) stipulated a range of 500 m to avoid harassment of marine mammals. The SSV measurements indicate that the range could be decreased to 15 m.

2. Methods

2.1. Equipment and Survey Test Tracks

Underwater sound was recorded with two Autonomous Multichannel Acoustic Recorders (AMARs, JASCO Applied Sciences). Data were stored in 2.5 min files on internal solid-state flash memory. Each recorder was fitted with a TC4014 omnidirectional hydrophone (RESON; −186 ± 3 dB re 1 V/µPa nominal sensitivity). Acoustic data were recorded continuously with the following settings:

- 16-bits per sample
- 687,500 samples per second
- 16–338,250 Hz useable frequency range

The two AMARs were deployed to the seabed with anchor weights, along with a third anchor weight, each separated by about 100 m of sinking line. A surface float was attached to the third anchor weight for retrieval (Figure 1). AMAR 1 was deployed directly on Test Track A, and AMAR 2 was deployed 100 m from Test Track A (Table 2, Figure 2). Track B was offset 250 m from Track A. Track A was sailed to capture a baseline measurement of the R/V *Taku* sailing at the survey speed of 4 kts. Tracks A and B were sailed for the boomer, at various power settings; the sub-bottom profiler; and the multibeam sonar (Table 3).

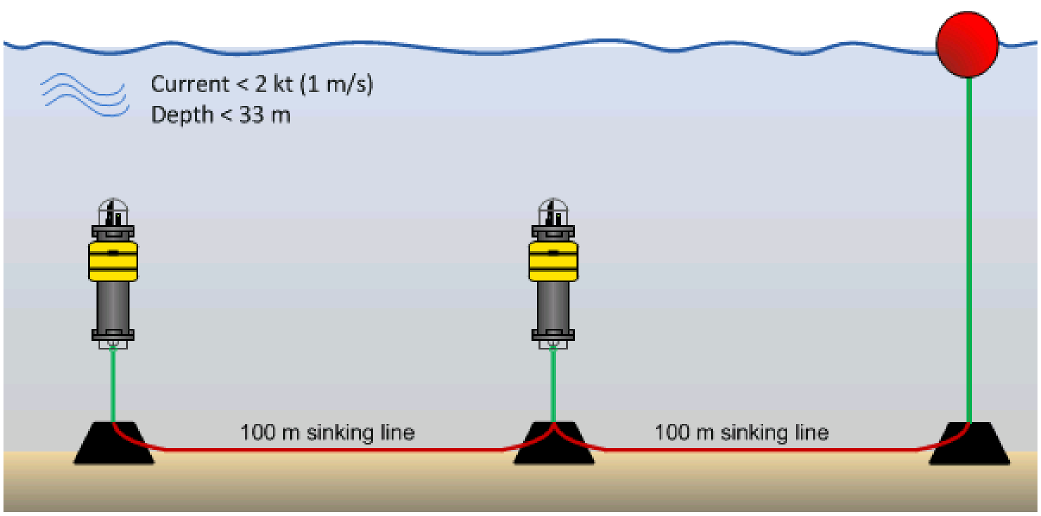

Figure 1. The mooring of two (2) AMARs floating above the seabed with a surface float for retrieval.

Table 2. Details of the AMAR deployments and retrievals in Nantucket Sound for the Sound Source Verifications. Times are in UTC.

Recorder	Deployment (6 Jul)	Latitude	Longitude	Water depth (ft)	Retrieval (7 Jul)
AMAR 1	15:47	41°35.351' N	070°11.353' W	28	17:40
AMAR 2	15:49	41°35.386' N	070°11.293' W	28	17:30

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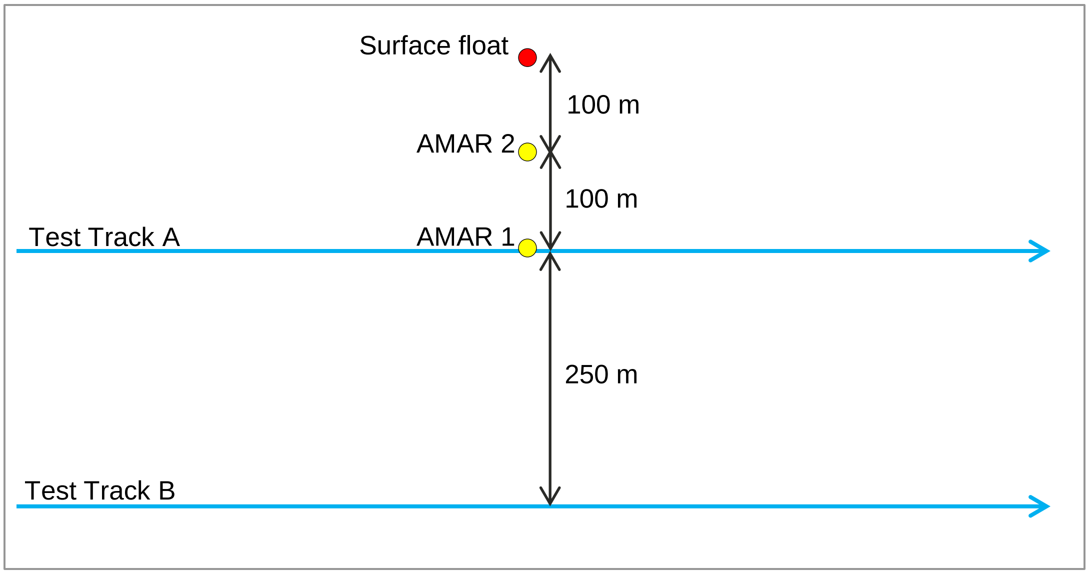

Figure 2. Recorder deployment locations relative to the two Test Track lines. AMAR 1 was deployed directly on Test Track A; AMAR 2, 100 m from Test Track A; and the anchor weight and surface float, 200 m from Test Track A. The Test Tracks included 2 km of approach and departure relative to AMAR 1.

Table 3. Time (UTC) of the start, closest point of approach (CPA), and end of the Test Tracks for each source configuration. All tracks were sailed by the R/V *Taku* at a speed of 4 knots.

Source	Track	Start	CPA	End
6 Jul 2012				
R/V Taku, 4 kts	A	16:20		17:00
Boomer, single plate				
200 J	A	17:20	17:24	17:29
300 J	A	17:33	17:38	17:43
500 J	A	17:46	17:51	17:56
200 J	B	18:03	18:08	18:13
300 J	B	18:15	18:20	18:25
500 J	B	18:28	18:32	18:37
Boomer, dual-plate				
500 J	B	18:47	18:53	18:58
750 J	B	19:00	19:04	19:08
1000 J	B	19:11	19:15	19:21
500 J	A	19:24	19:28	19:32
750 J	A	19:34	19:39	19:45
1000 J	A	19:47	19:51	19:56
7 Jul 2012				
Sub-bottom profiler and multibeam sonar	A	16:47	16:52	16:56
	B	16:58		17:06

2.2. Sound Sources Measured

2.2.1. R/V Taku

The R/V *Taku* is an aluminum-hulled catamaran powered by two 225 Hp outboard motors. Standard equipment aboard the *Taku* includes a generator and a depth sounder operating at 70 and 200 kHz.

VESSEL SPECIFICATIONS:

Length:	36 Feet
Beam:	10.5 Feet'
Draft:	3.5 Feet'
Gross Tons:	15
Net Tons:	8
Fuel Capacity:	1,000 Gallons
Generator:	8 KW Northern Lights
Cabin:	8'x10' Electronics Lab

Figure 3. The geotechnical survey vessel, *R/V Taku* (Zephyr Marine, Ventura, CA).

2.2.2. AP3000 Dual-Plate Boomer

The AP3000 Dual-Plate Boomer (Subsea Systems, Inc., Ventura, CA; Figure 4) was monitored with a maximum of 1000 J of input energy (500 J per shot per plate). One shot was fired per second and the output frequency range was approximately 0.3 to 14 kHz.

Figure 4. The AP3000 Dual-Plate Boomer (Subsea Systems, Inc., Ventura, CA) during deployment from the *R/V Taku* in Nantucket Sound.

2.2.3. X-STAR SB-216S Sub-Bottom Profiler

The X-STAR SB-216S Sub-Bottom Profiler (EdgeTech, Boca Raton, FL; Figure 5) is a high-resolution, wideband, frequency modulated (FM) sub-bottom profiler. The system transmits an FM pulse that is linearly swept over a full spectrum frequency range (for example 2–16 kHz for 20 ms, also called a chirp).

Figure 5. The towfish of the X-STAR SB-216S Sub-Bottom Profiler (EdgeTech, Boca Raton, FL) aboard the *R/V Taku*.

2.2.4. R2Sonic 2024 Multibeam Sonar

The LLC Model 2024 multibeam sonar system (R2Sonic, Santa Barbara, CA) operates at 200 or 400 kHz with 60 kHz bandwidth at either frequency. A total of 256 beams are projected at a 60 Hz ping rate and a power consumption of 50 W.

2.3. Data Analysis

2.3.1. Acoustic Metrics

Underwater sound amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_o = 1 μPa. However, the loudness of impulsive noise, e.g., from seismic sources, is not, in general, proportional to instantaneous acoustic pressure and so several sound level metrics are commonly used to evaluate the loudness of impulsive noise and its effects on marine life.

The zero-to-peak SPL, or peak SPL (L_{pk}, dB re 1 μPa), is the maximum instantaneous sound pressure level in a stated frequency band attained by an impulse, $p(t)$:

$$L_{pk} = 10\log_{10}\left(\frac{\max\left(\left|p^2(t)\right|\right)}{p_o^2}\right) \quad (1)$$

The root-mean square (rms) SPL (L_p, dB re 1 μPa) is the rms pressure level in a stated frequency band over a time window (T, s) containing the pulse:

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$$L_p = 10\log_{10}\left(\frac{1}{T}\frac{\int_T p^2(t)dt}{p_o^2}\right) \quad (2)$$

The rms SPL can be thought as a measure of the average pressure or as the “effective” pressure over the duration of an acoustic event, such as the emission of one acoustic pulse. Because the window length, T, is a divisor, pulses more spread out in time have a lower rms SPL for the same total acoustic energy.

By convention, when computing safety radii, T is often defined as the “90% energy pulse duration”, containing the central 90% (from 5% to 95% of the total) of the cumulative square pressure (or energy) of the pulse, rather than over a fixed time window (Malme et al. 1986, Greene 1997, McCauley et al. 1998). The 90% rms SPL (L_{p90}, dB re 1 µPa) in a stated frequency band is calculated over this 90% energy time window, T_{90}:

$$L_{p90} = 10\log_{10}\left(\frac{1}{T_{90}}\int_{T_{90}} p^2(t)dt \bigg/ p_o^2\right) \quad (3)$$

The SEL (L_E, dB re 1 µPa^2·s) is the time integral of the squared pressure in a stated frequency band over a stated time interval or event. The per-pulse SEL is calculated over the time window containing the entire pulse (i.e., 100% of the acoustic energy), T_{100}:

$$L_E = 10\log_{10}\left(\int_{T_{100}} p^2(t)dt \bigg/ T_o p_o^2\right) \quad (4)$$

where T_o is a reference time interval of 1 s. The per-pulse SEL, with units of dB re 1 µPa·√s, or equivalently dB re 1 µPa^2·s, represents the total acoustic energy delivered over the duration of the acoustic event at a receiver location. It is a measure of sound energy (or exposure) rather than sound pressure, although it is not measured in energy units. The SEL can be a cumulative metric if it is calculated over time periods containing multiple pulses.

Because the 90% rms SPL and SEL are both computed from the integral of square pressure, these metrics are related by a simple expression, which depends only on the duration of the 90% integration time window T_{90}:

$$L_E = L_{p90} + 10\log_{10}(T_{90}) + 0.458 \quad (5)$$

where the 0.458 dB factor accounts for the rms level containing 90% of the total energy from the per-pulse SEL.

2.3.2. Per-Shot Pulse Levels

The loudness or magnitude of each recorded shot from the boomer, sub-bottom profiler, and sonar sources was quantified by computing the three noise metrics described above: peak SPL, 90% rms SPL, and SEL. Each pulse was analyzed as follows:

1. Convert the digital recording units to micropascals (µPa) by applying the hydrophone sensitivity, analogue circuit frequency response, and digital conversion gain.

2. (a) In some cases, apply a high-pass filter (usually ~1 kHz) to remove the low-frequency vessel noise to isolate the targeted sound source signal,

   Or

   (b) Apply a band-pass filter to isolate the targeted sound source from background noise and measurement artifacts (particularly for higher-frequency sonar).
3. Determine the start time of the impulsive pressure signal with an automated power-threshold detector.
4. Compute the peak SPL (symbol L_{pk}) according to Equation 1.
5. Compute the cumulative square pressure over the duration of the pulse.
6. Determine the 90% time window length (T_{90}) and compute the 90% rms SPL (symbol L_{p90}) according to Equation 3.
7. Compute the SEL (symbol L_E) according to Equation 4 over the duration of the pulse.

2.3.3. Ranges to RMS SPL Isopleths

We computed the range to rms SPL isopleths using two methods. If the measured data contained values that included the isopleth value, then the report contains those values. If the data does not include the isopleth value, we computed a linear regression of the measured data in log-log (range – rms SPL) space and used the regression equation to extrapolate the isopleth range.

2.3.4. Continuous Sound Levels

The continuous (non-impulsive) noise produced by the survey vessel was quantified by computing rms SPLs over consecutive 1-second time windows by employing Equation 3 with $T = 1$ s.

2.3.5. Spectral Analysis

The broadband frequency content of each source is presented in three formats: (i) spectrogram, (ii) spectral density over a specified time window, and (iii) 1/3-octave band levels.

For 1/3-octave band analysis of impulsive sources, the sound data were band-pass filtered into several adjacent frequency bins, and the SEL of each bin computed. The acoustics community has adopted standard 1/3-octave band frequencies (more precisely these are 10th decade band frequencies; ISO 266:1975, ANSI/ASA S1.6-1984 R2011) to facilitate comparisons between studies; the central frequency of the ith standard pass-band is:

$$f_{ci} = 10^{i/10}, \quad i = 1, 2, 3, \ldots \tag{6}$$

The bandwidth of each 1/3-octave band is ~23% of the central frequency of the band. Third-octave band analysis was applied to both continuous and impulsive noise sources. The third-octave bands are plotted as a heat-map of range-verus-frequency band.

3. Results

3.1. R/V Taku

JASCO measured a maximum received rms SPL from the R/V *Taku* of 132 dB re 1 µPa for the survey speed of 4 knots (Figure 6). The primary spectral components of the R/V *Taku*'s signature are from power generation and propulsion (Figure 7).

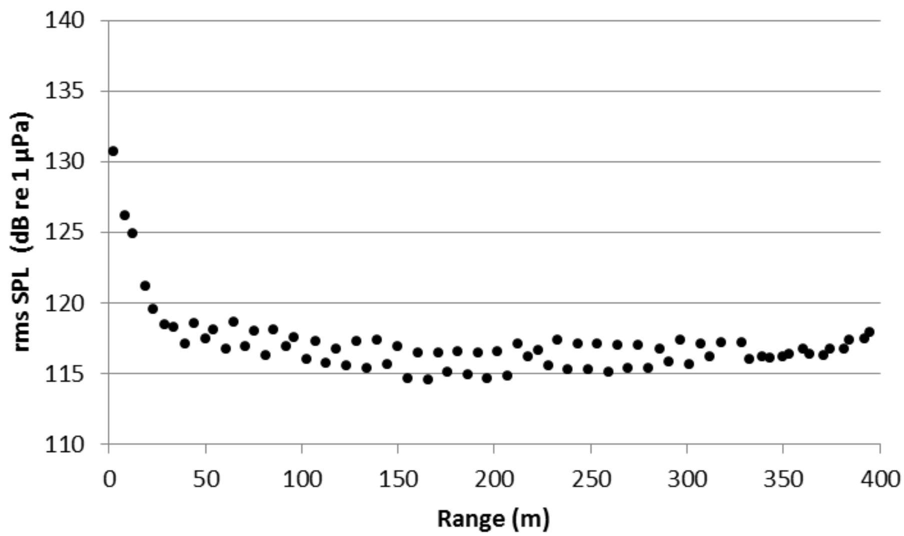

Figure 6. Received sound level with range from the R/V *Taku*.

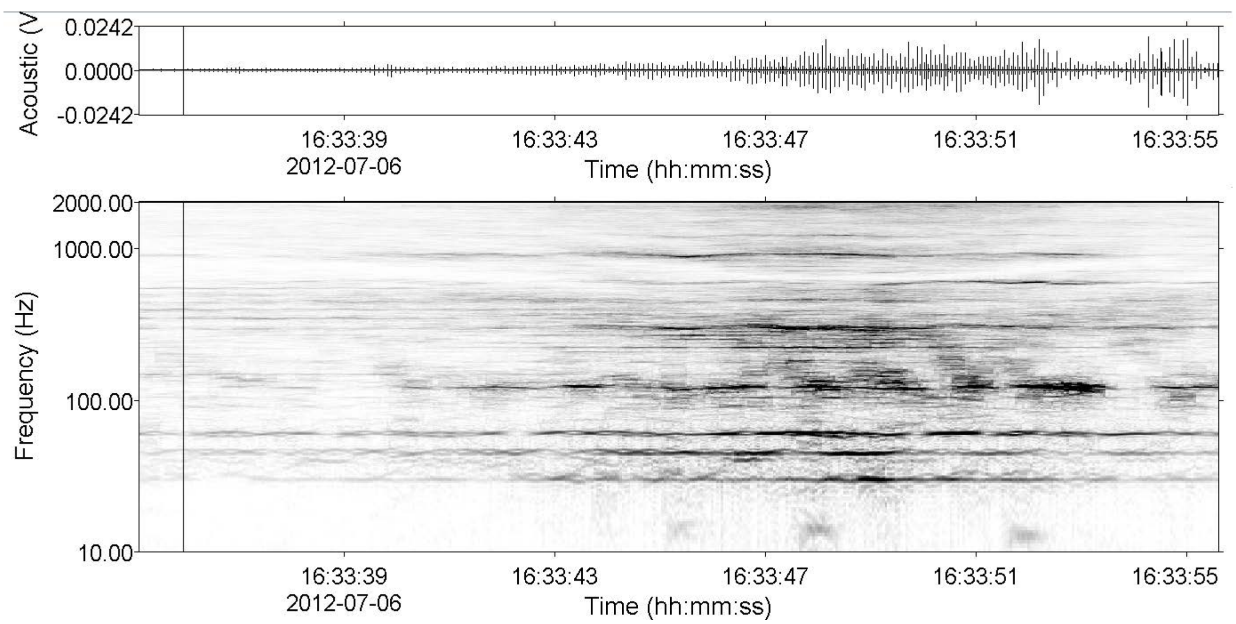

Figure 7. Sample spectrogram of the R/V *Taku* at CPA while traveling 4 knots. In the time series (top), the pulses are from the 70/200 kHz depth sounder. (1048,576 point FFT, 343,750 real data points, 34,375 point advance.)

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The R/V *Taku* has a 70/200 kHz depth sounder that alternates between the two nominal center frequencies. There is significant spectral leakage with this sonar (Figure 8). The received level from the depth sounder varied considerably from pulse to pulse as the *Taku* transited over the recorder (Figure 7, Figure 8, Figure 9). It is unknown if the variability is due to masking of the depth sounder by the vessel and its wake, or if it is from the beam pattern of the transducer. The acoustic data was high pass filtered at 40 kHz before computing the depth sounder received levels. The maximum rms SPL measured for the depth sounder was 167.4 dB re 1 µPa (Figure 10). The cumulative SEL for the 229 pulses measured was 141.5 dB re 1 µPa^{2}s.

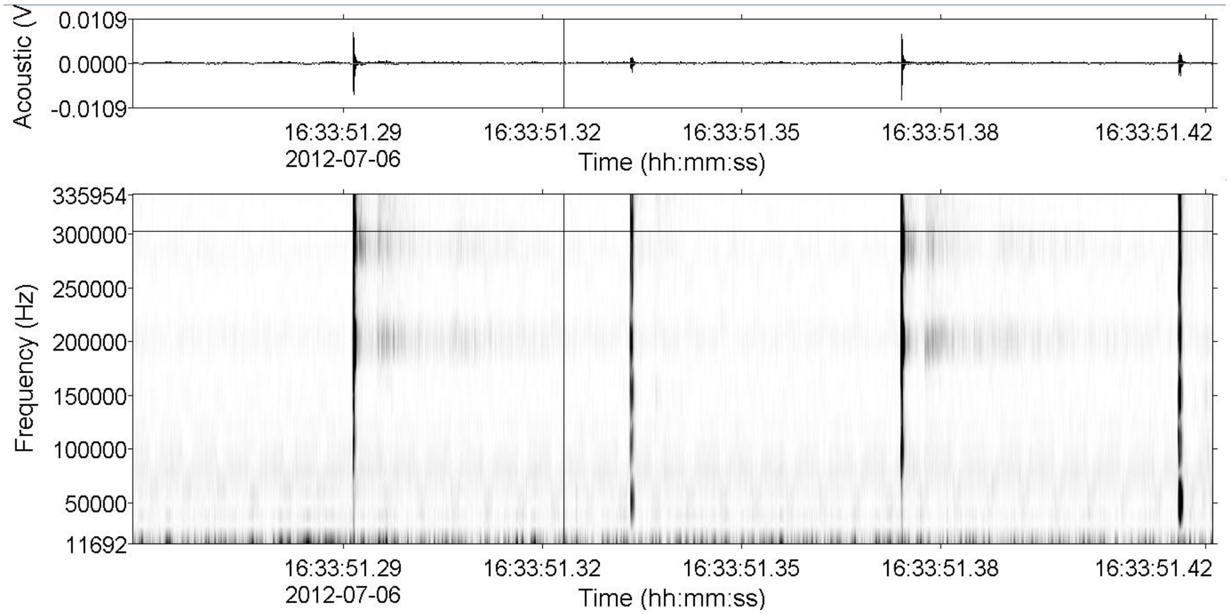

Figure 8. Alternating 70 kHz (2nd and 4th pings) and 200 kHz (1st and 3rd pings) nominal pings from the R/V *Taku*'s depth sounder (4096 point FFT, 34 real data points, 3 point advance, Reisz window).

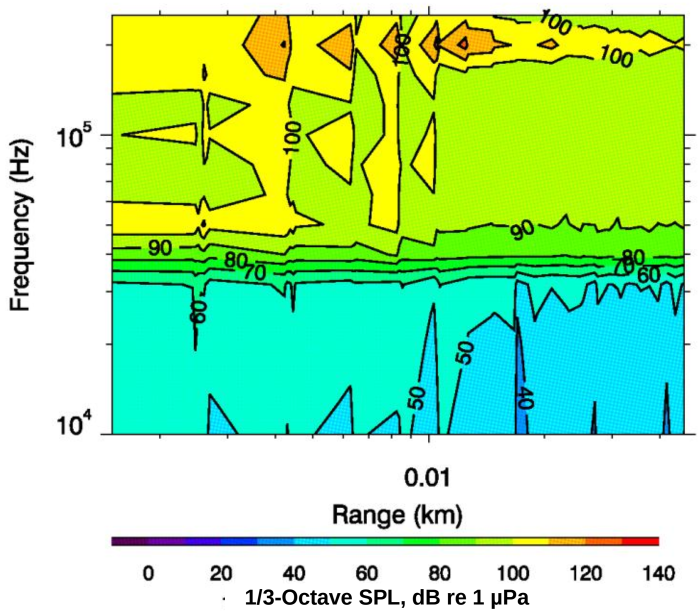

Figure 9. 1/3-octave band SPL versus range for pulses from the 70/200 kHz depth sounder detected during passage of the R/V *Taku* on Track A).

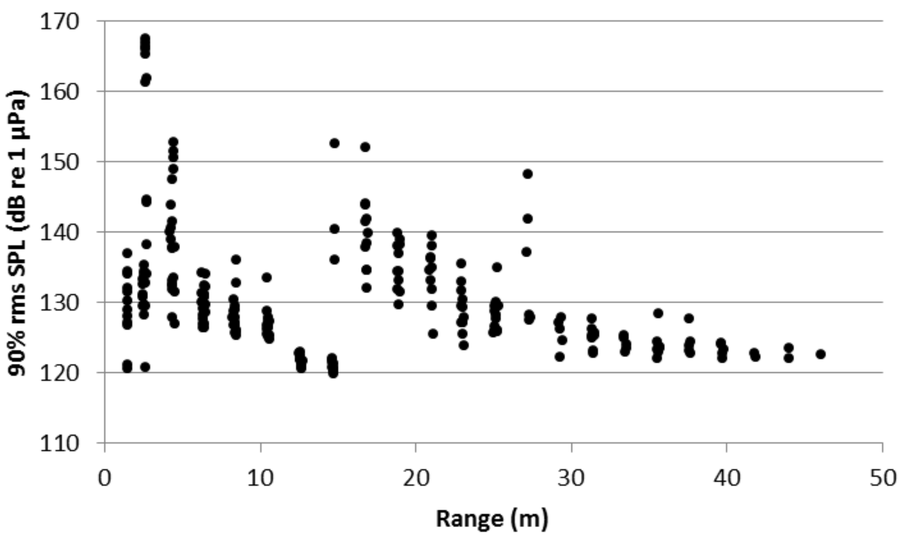

Figure 10. The 90% rms SPL received from the 70/200 kHz depth sounder along Track A.

3.2. AP3000 Dual-Plate Boomer

Six passes were made with different configurations of the AP3000 (Table 3). Analysis of the passes at highest energy levels of 750J (Figure 11, Figure 12) and 1000J (Figure 13, Figure 14) showed that the root-mean-square (rms) sound pressure levels (SPL) never exceeded 180 dB re 1 µPa. The range to the 160 dB re 1 µPa rms SPL isopleth was 12 m (Figure 13). The mean duration of the boomer pulses was 57.9 ms, with a standard deviation of 30.6 ms. The boomer pulses had a frequency range of 100 to 1000 Hz (Figure 15, Figure 16). The cumulative SEL for the 525 pulses measured on Track A at 1000 J (Figure 13) was 161.5 dB re 1 µPa^{2}s. The cumulative sound exposure for the 583 pulses measured on Track B at 1000 J (Figure 14) was 148.4 dB re 1 µPa^{2}s.

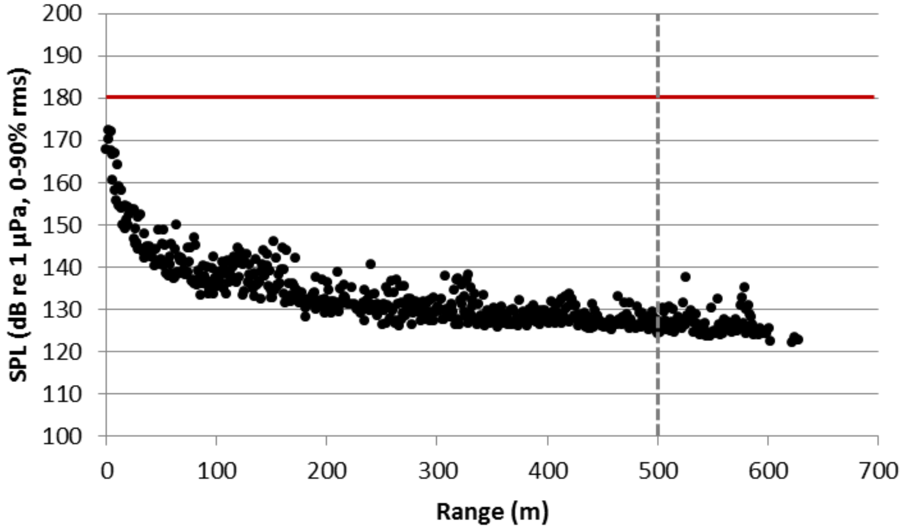

Figure 11. *Dual-Plate Boomer (750 J), Test Track A, AMAR 1*: 90% root-mean-square (rms) sound pressure level (SPL) as a function of range from the AP3000 Dual-Plate Boomer towed by the *R/V Taku*.

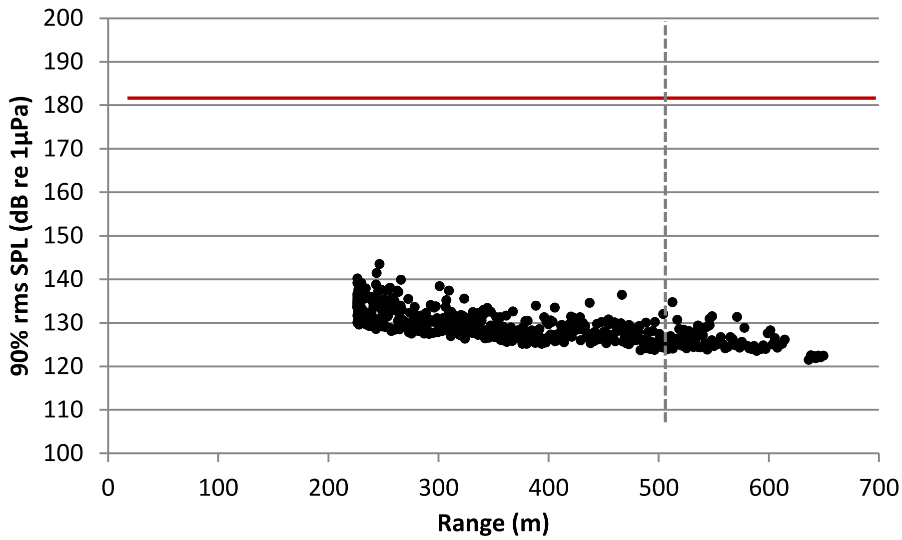

Figure 12. *Dual-Plate Boomer (750 J), Test Track B, AMAR 1*: 90% root-mean-square (rms) sound pressure level (SPL) as a function of range from the AP3000 Dual-Plate Boomer towed by the *R/V Taku*.

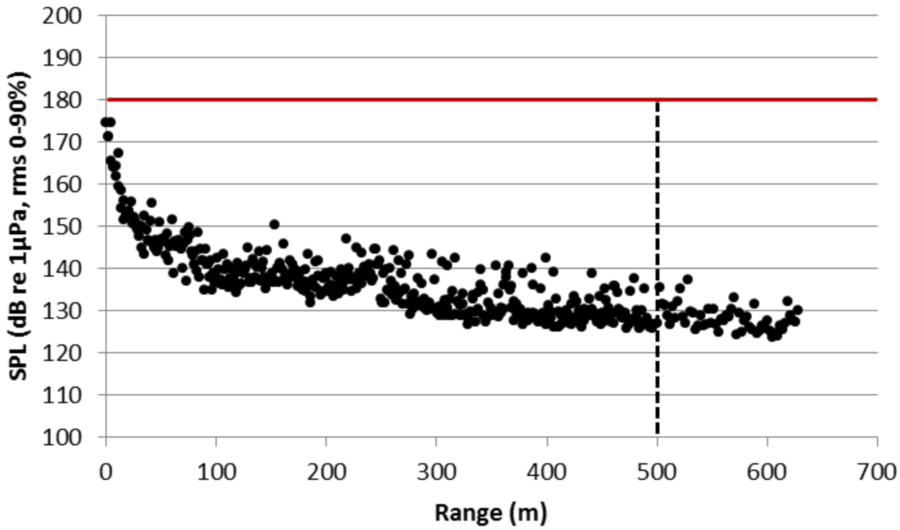

Figure 13. *Dual-Plate Boomer (1000 J) Test Track A, AMAR 1*: 90% root-mean-square (rms) sound pressure level (SPL) as a function of range from the AP3000 Dual-Plate Boomer towed by the *R/V Taku*.

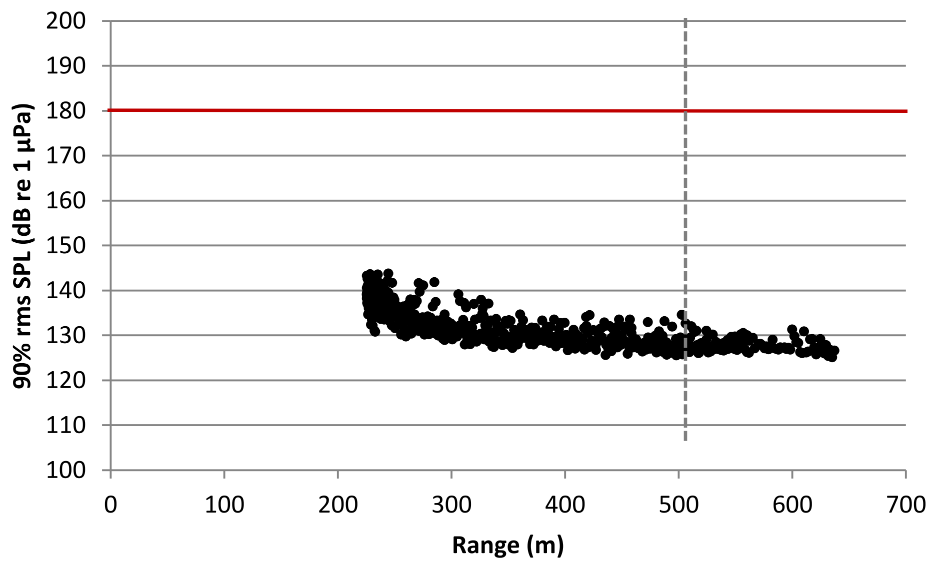

Figure 14. *Dual-Plate Boomer (1000 J) Test Track B, AMAR 1*: 90% root-mean-square (rms) sound pressure level (SPL) as a function of range from the AP3000 Dual-Plate Boomer towed by the *R/V Taku*.

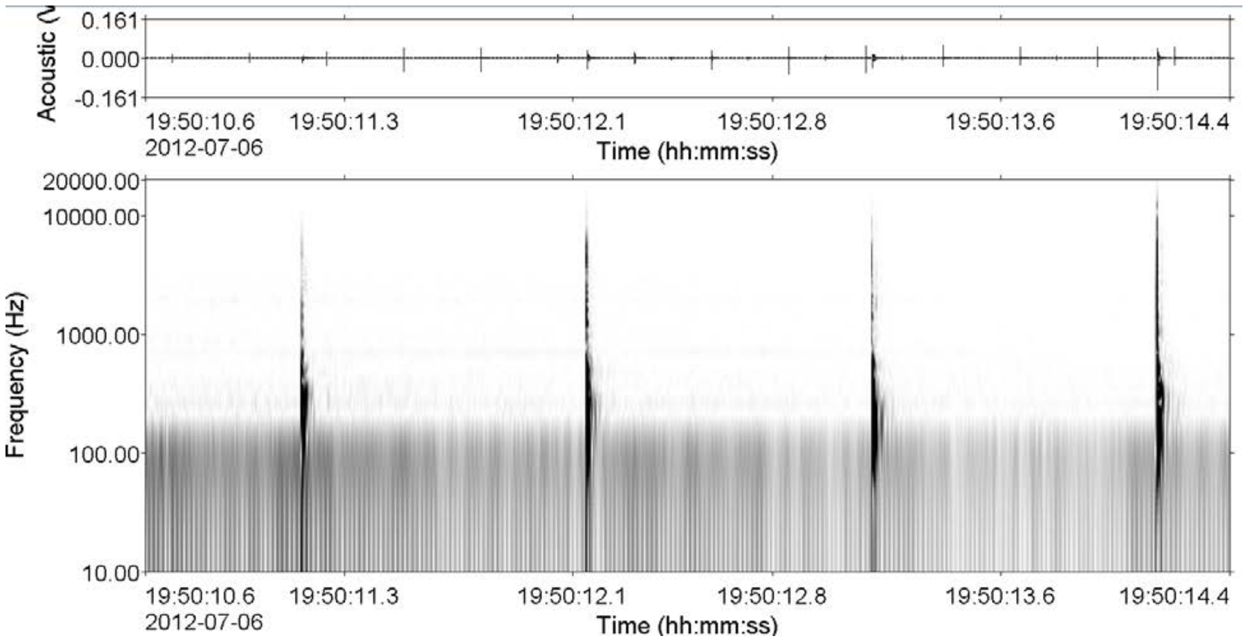

Figure 15. Spectrogram of dual-plate boomer (1000 J) pulses at the closest point of approach on Track A. Most energy is between 100 and 1000 Hz, with some energy at up to 10 kHz. (131,072 point FFT, 7000 data points, 3500 point overlap.)

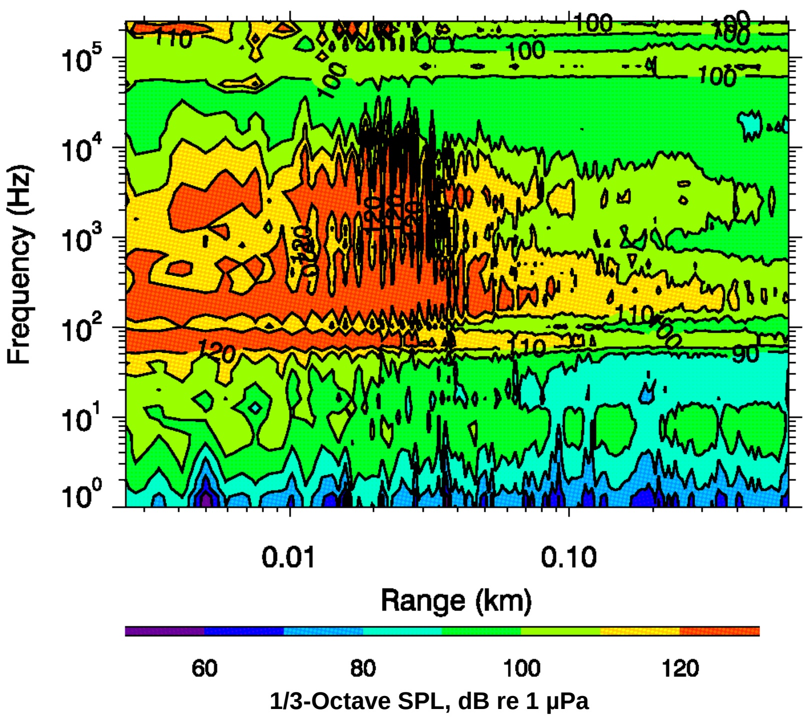

Figure 16. 1/3-octave band SPL versus range for pulses from the dual plate boomer at 1000 J detected during passage of the R/V *Taku* on Track A.

CONFIDENTIAL

3.3. X-STAR SB-216S Sub-Bottom Profiler

The maximum rms SPL measured from the X-Star SB-216S sub-bottom profiler was 173.5 dB re 1 µPa (Figure 17). The maximum received level when the sub-bottom profiler was at least 500 m from the AMARs was 130 dB re 1 µPa. The 160 dB isopleth for the sub-bottom profiler was 6 meters from the sub-bottom profiler (Figure 17). The mean duration of the 90% pulses was 22.1 ms (5.66 ms SD). The total frequency range of the sub-bottom profiler was 2–16 kHz; however, 90% of the energy was between 6 and 13 kHz (Figure 18). The cumulative SEL for the 3187 pulses measured (Figure 17) was 166.6 dB re 1 µPa^{2}s.

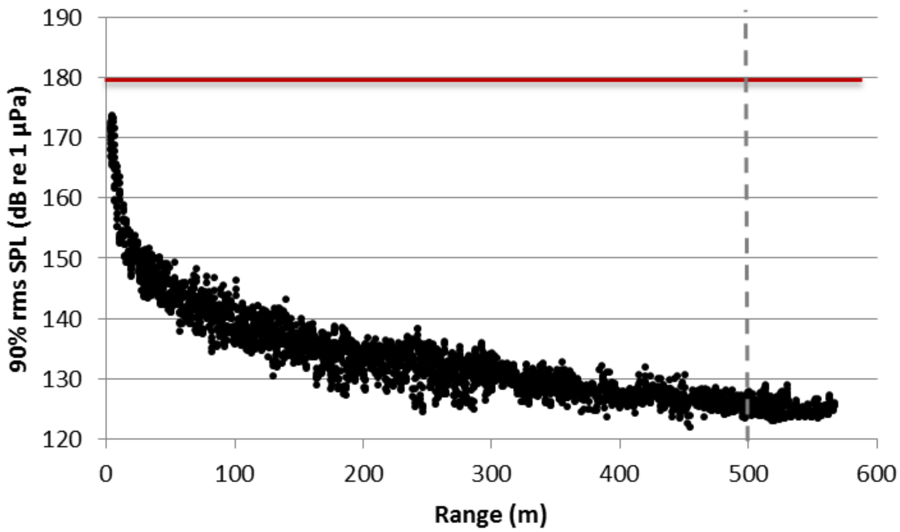

Figure 17. *Sub-Bottom Profiler, Test Track A, AMAR 1*: 90% root-mean-square (rms) sound pressure level (SPL) as a function of range from the X-STAR SB-216S Sub-Bottom Profiler towed by the R/V *Taku*.

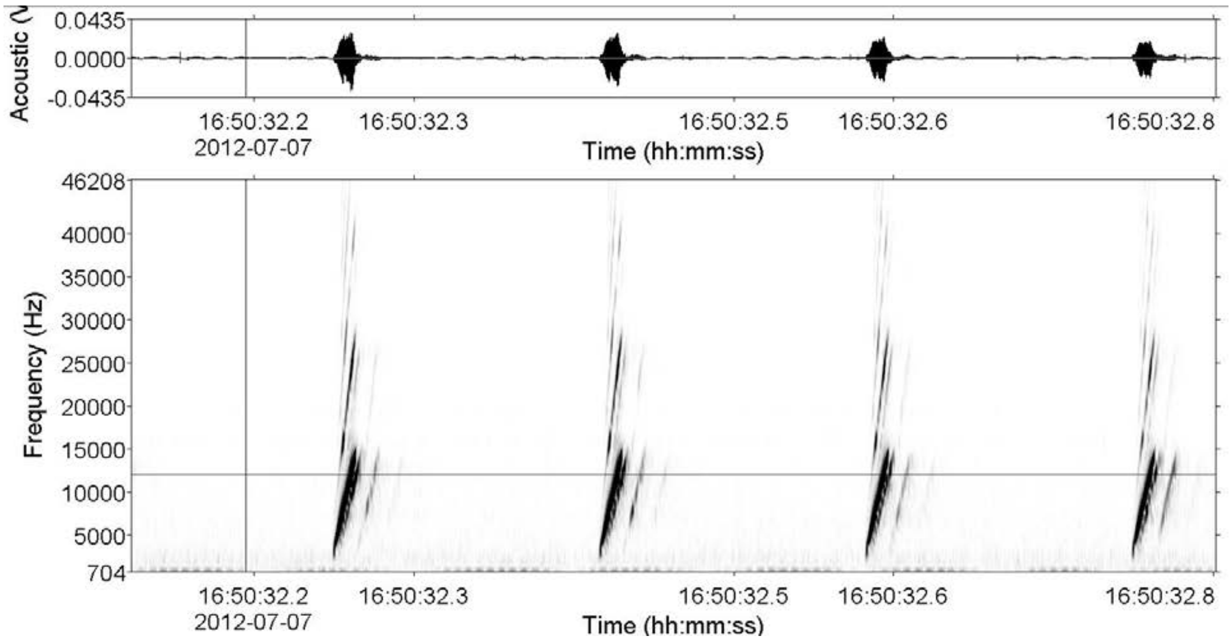

Figure 18. Spectrogram of X-Star SB-216S Sub-Bottom Profiler at closest-point of approach. The centroid frequency of the pulses was approximately 10 kHz, with 90% of the energy between 6 and 13 kHz. Aliased energy is visible above the main pulse. The bottom reflection is visible about 15 ms after the main pulse. (131,072 point FFT, 690 real data points, 345 point overlap.)

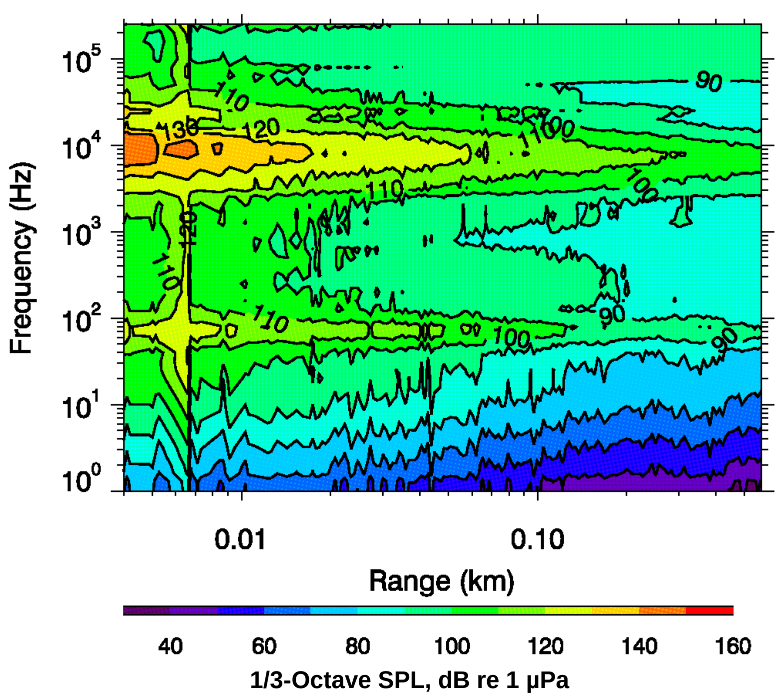

Figure 19. 1/3-octave band SPL versus range for pulses from the SB-216S sub-bottom profiler detected during passage of the R/V *Taku* on Track A.

3.4. R2Sonic 2024 Multibeam Sonar

The R2Sonic 2024 Multibeam Sonar was measured during the same pass as the sub-bottom profiler. The acoustic data was high-pass filtered to remove all energy below 100 kHz in order to analyze only the energy from the multibeam sonar. The multibeam sonar was detected only for 30 s during CPA (Figure 20). The multibeam sonar was operated at 400 kHz, and had significant energy from 260 to 320 kHz when measured with the AMAR (Figure 21, Figure 22). The maximum rms SPL measured was 162 dB re 1 µPa (Figure 23). The average pulse length was 0.11 ms (0.77 ms SD). The cumulative SEL for the 363 pulses measured was 121.5 dB re 1 µPa^{2}s.

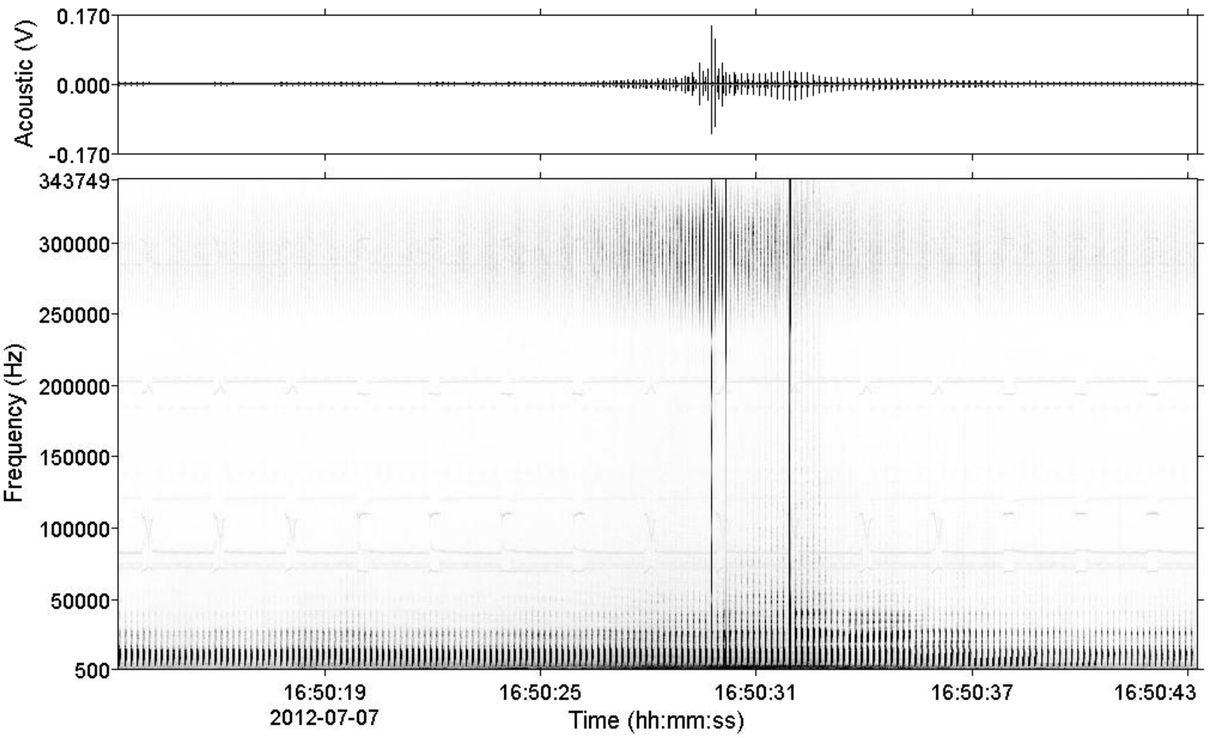

Figure 20. Spectrogram and time series of 30 seconds of data at closest point of approach for the multibeam sonar (250 kHz and above) and the sub-bottom profiler (0–20 kHz). The multibeam sonar is better detected by the AMAR after the R/V *Taku* passes by.

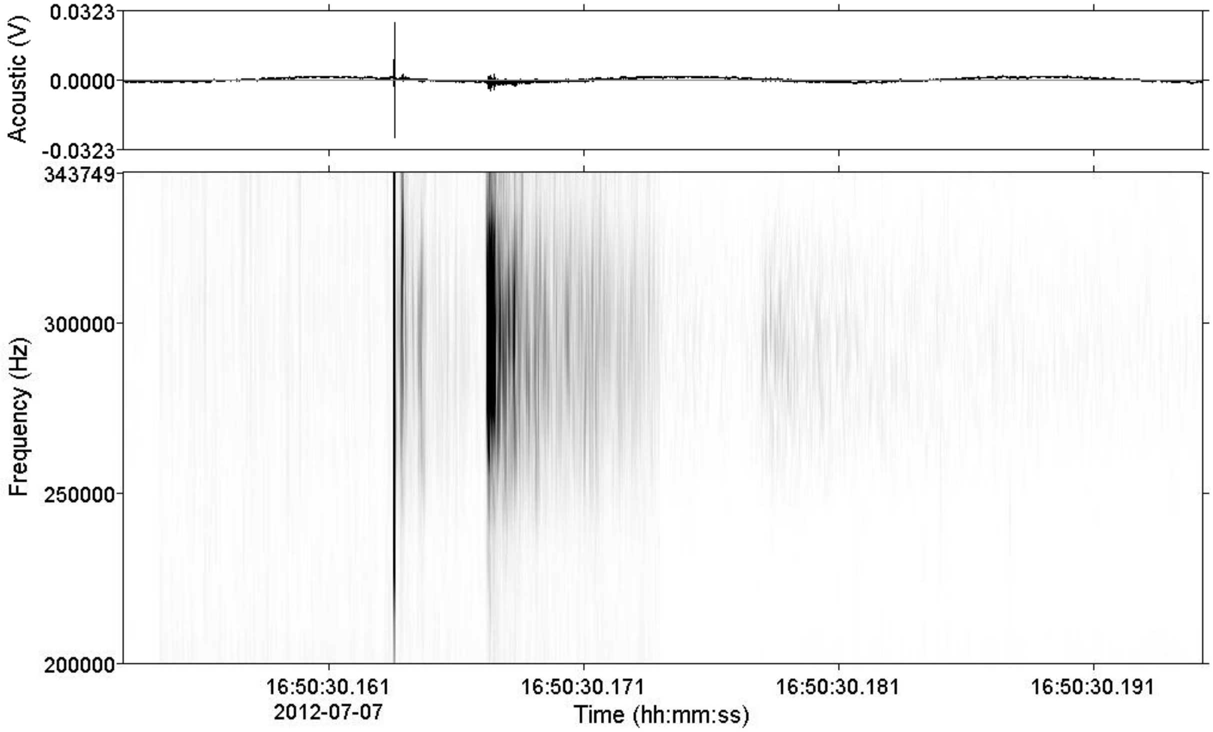

Figure 21. Multibeam sonar main pulse and reverberation (4096 point FFT, 34 real data points, 3 point advance, Reisz window).

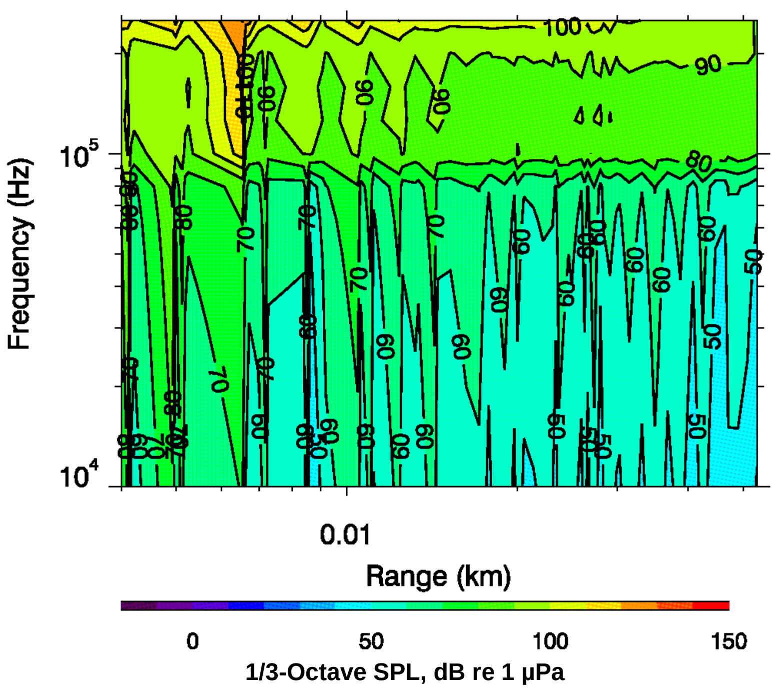

Figure 22. 1/3-octave band SPL statistics for pulses from the R2Sonic 2024 multibeam sonar detected during passage of the R/V *Taku* on Track A.

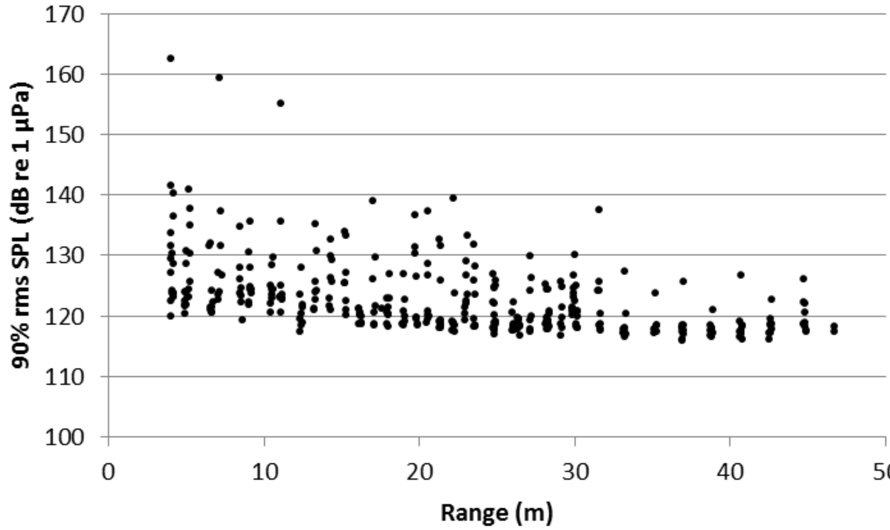

Figure 23. Multibeam sonar, *Test Track A, AMAR 1*: 90% root-mean-square (rms) sound pressure level (SPL) as a function of range from the R2Sonic 2024 Multibeam Sonar towed by the R/V *Taku*. The received level varies at each range, likely depending on whether the AMAR was directly in one of the beams.

4. Discussion

The received 90% rms sound pressure levels (SPLs) did not exceed 175 dB re 1 µPa for any source, even at the closest point of approach (horizontal source-receiver range < 5 m). The dual-plate boomer at an energy setting of 1000 J produced the highest received rms SPL at 174.6 dB re 1 µPa.

The largest range to the 160 dB re 1 µPa isopleth was 12 m, measured for the dual-plate boomer at 1000 J input energy. Extrapolation of the data predicts that the 120 dB re 1 µPa isopleth for the dual-plate boomer at 1000 J is 1632 m.

The sub bottom profiler, which had a much higher ping rate than the boomer, produced the highest cumulative SEL of 166.6 dB re 1 $\mu Pa^2 \cdot s$ (Table 4). With this SEL, the sub-bottom profiler would have to pass over the same location 100 times in a day to accumulate a total exposure of 187 dB re 1 $\mu Pa^2 \cdot s$, the level Southall et al. (2007) specify as the threshold for onset of physiological damage.

Table 4. Summary of SSV results: the horizontal source-receiver range and 90% root-mean-square (rms) sound pressure level (SPL) at the closest point of approach (CPA), the horizontal range from the source to 90% rms SPLs of 160 and 120 dB re 1 µPa, and the cumulative sound exposure level (cSEL) for the entire test track (± 600 m from AMAR 1).

Source	CPA range (m)	90% rms SPL at CPA (dB re 1 µPa)	Range (m) to rms SPL isopleths		cSEL for entire track (dB re 1 $\mu Pa^2 \cdot s$)
			160 dB re 1 µPa	120 dB re 1 µPa	
R/V *Taku*	2	132	--	20	146.3
70/200 kHz Depth Sounder	2	167.4	2	41.5	141.5
1000 J Dual-Plate Boomer	0	174.6	12	1632	161.5
X-Star SB 216S Sub-Bottom Profiler	4	173.5	10	1013	166.6
R2Sonic 2024 Multibeam Sonar	4	162.0	1	32.6	121.5

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