Request for an Incidental Harassment Authorization (IHA) under the Marine Mammal Protection Act

TDI-Brooks / ONE East Coast Multibeam Bathymetry Program

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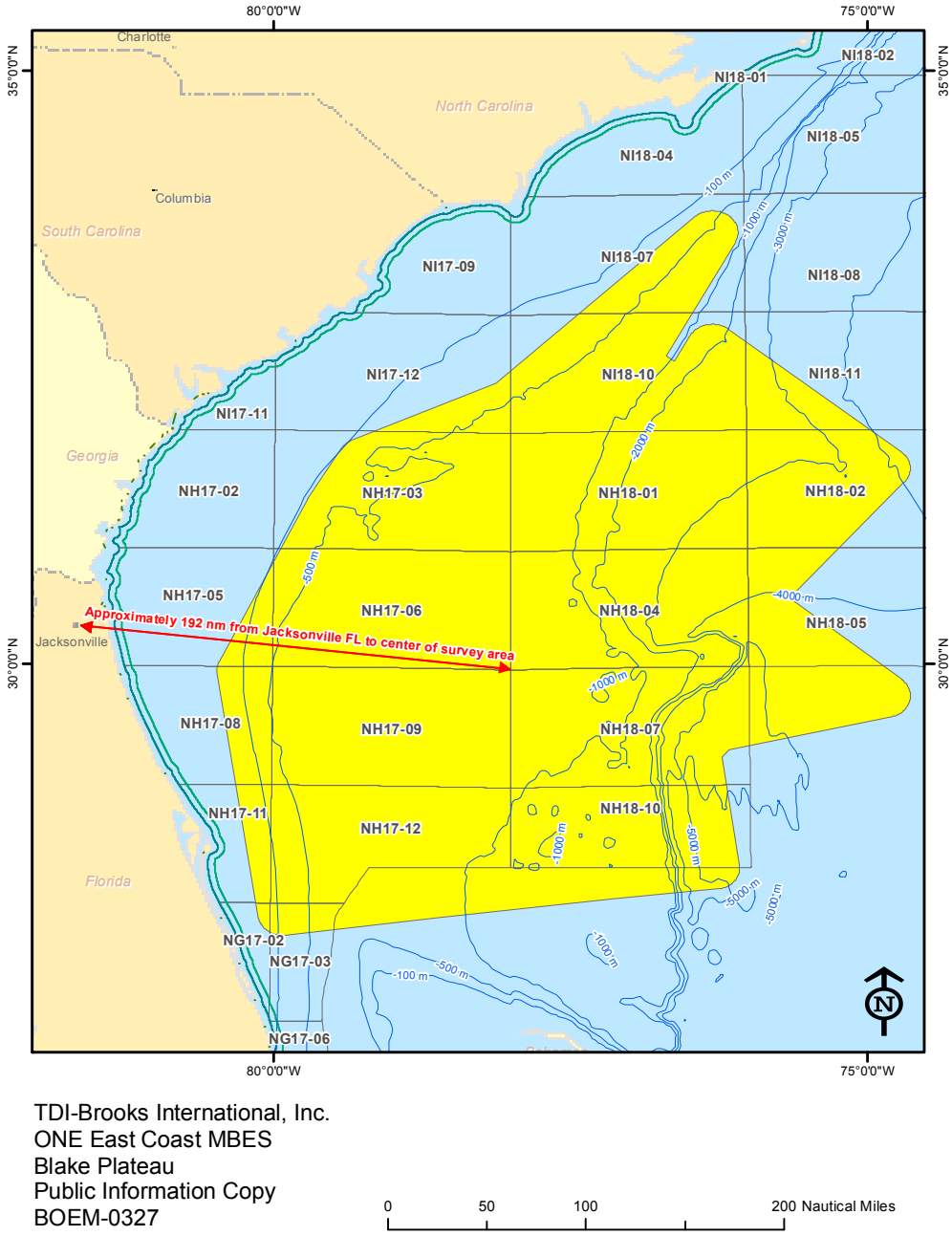
Section 1. Description of Activities

TDI-Brooks / ONE East Coast MBES program will conduct a regional multibeam (bathymetry, backscatter, water column) and sub-bottom profiler acquisition program over an area of approximately 90,434 square miles stretching from the east coast of Florida to North Carolina (see Figure 1). Processed MBES and sub-bottom data will be evaluated for the presence of hydrocarbon seepage. Water depths for the survey area will range from approximately 100m to over 5,000m.

Figure 1 shows the proposed survey area for permitting through BOEM. The expected survey line spacing varies from 2.25km in shallow water to 4.5km in deeper water (the majority of the proposed survey will be run at 4.5km spacing). See shapefile 'Blake_Plateau_v2_buff.shp' for the proposed survey permit area.

Attached to this submission are spec sheets for the Kongsberg EM122 MBES and sub-bottom profiler systems that are expected to be used for the proposed survey, as well as vessel specs for the Teknik Perdana and the TDI-Brooks R/V Gyre. It is possible that other vessels of opportunity could be utilized instead of (or in addition to) the Teknik Peranda or Gyre for this program. Only MBES systems capable of operating in water depths > 500m would be considered for use on this survey, nominally operating at 100 kHz or less (such as the Kongsberg EM710). The Kongsberg EM302 (30kHz) would also be suitable for the majority of the survey area. However, the current plan is to use the Teknik Perdana and / or R/V Gyre for the entire program so long as they are available for use during the planned survey period.



TDI-Brooks International, Inc.
ONE East Coast MBES
Blake Plateau
Public Information Copy
BOEM-0327

0 50 100 200 Nautical Miles

Figure 1 - Proposed MBES survey areas

The planned survey is expected to be conducted using the TL GeoHydrographics *M/V TEKNIK PERDANA* and / or the TDI-Brooks *R/V Gyre* (see figure 2 and 3). Both are multi-use research vessels outfitted with state-of-the art survey equipment; including Kongsberg multibeam and various sub-bottom profiler systems utilizing Masa TR1075 transducers. The *Gyre* is currently equipped with an EM1002 mid-water multibeam system, this would be upgraded to either an EM122 or EM302 for this program.

Figure 2 - TL Geohydrographics *M/V TEKNIK PERDANA*

Figure 3 - TDI-Brooks *R/V Gyre*

It is expected that normal survey operations will occur on a 24 hour per day basis. The Perdana and Gyre each have a survey endurance of at least 30 days.

The actions listed in section 1.1 and 1.2 are those field activities that might affect marine mammals or other sensitive species - actions that produce underwater sound or involve a moving vessel.

1.1 Regional survey with multibeam and sub-bottom sonars

The proposed east coast survey program will be conducted using a Kongsberg EM122 multibeam echosounder and sub-bottom profiler, which use projected sound waves to find and identify objects in the water column, to determine water depth, characterize bottom surface type, and resolve sub-surface sediment layers and structures. During the survey the vessel(s) will run a pre-determined survey grid to insonify (or visualize) the seafloor bottom / sub-bottom and ensure full coverage of the seafloor within the survey area.

The EM122 multibeam system uses two orthogonal hull-mounted transducer arrays, one to transmit a fan-shaped lobe of acoustic energy that is narrow (1 degree) along track, and one to receive the acoustic energy reflected back from the seafloor via multiple fan-shaped lobes that are narrow across-track. The intersection of the area insonified by the fan-shaped transmit energy, and each of the fan-shaped receive lobes is a 'beam'. The system calculates the location of each 'beam' on the seafloor by knowing the location, orientation and position of the transmit array at the time of transmit; measuring the two way travel time; knowning the location, orientation and position of the receive array at the time the energy returns; and correcting for refraction in the water column.

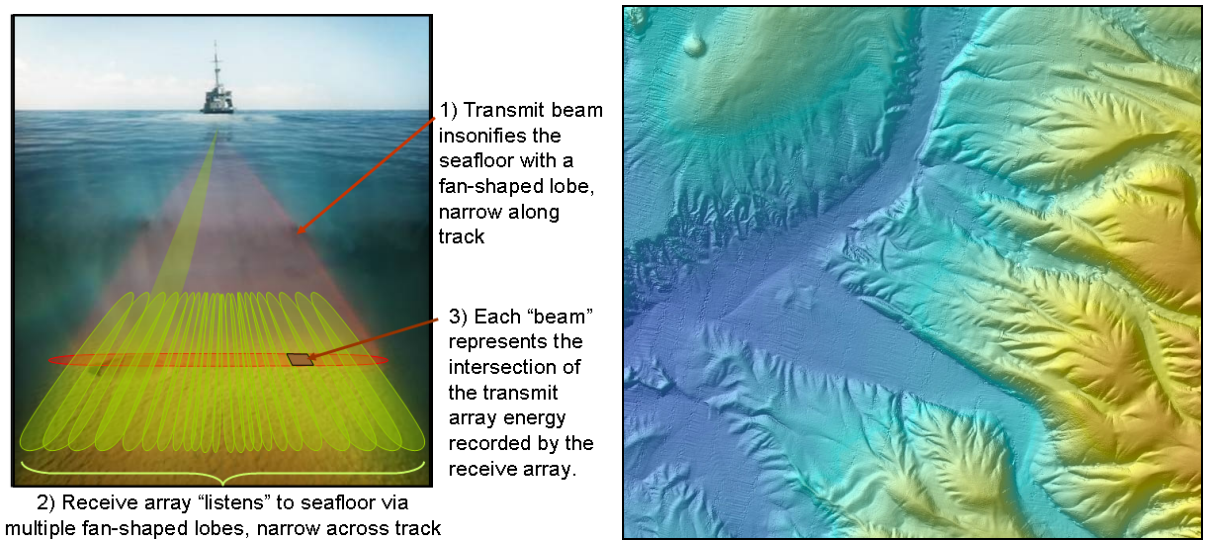


Figure 4 - MBES operation and example of processed data

Multibeam echosounders transmit acoustic energy in a fan-shaped pattern that is very narrow (1 degree) along-track, and in frequencies ranging in the tens to hundreds of kilohertz. Choice of operating frequency for a multibeam echosounder is primarily dictated by water depth and the required resolution of the survey. Echosounders that transmit sound in the tens of kilohertz can travel a longer distance in the water (increased range) but have a lower resolution and are less precise. Echosounders that transit sound in the hundreds of kilohertz

cannot travel longer distances in water but achieve a higher resolution and are more precise.

The majority of the proposed East Coast survey program is in deep to very deep water (> 5,000m) and is primarily aimed at identifying relatively large features. As a result, the low frequency Kongsberg EM122, which transmits at a nominal 12kHz, is an ideal system for these water depths and required resolution.

For sub-bottom sonar, sound energy transmitted to the seafloor is reflected off the boundaries between layers of different densities and/or different acoustic velocities. The first boundary is between the water and the seafloor itself. As layers of clay, sand and various other sediments succeed each other, they create interfaces that reflect sound. It is the energy reflected from these boundaries that the system uses to build the image.

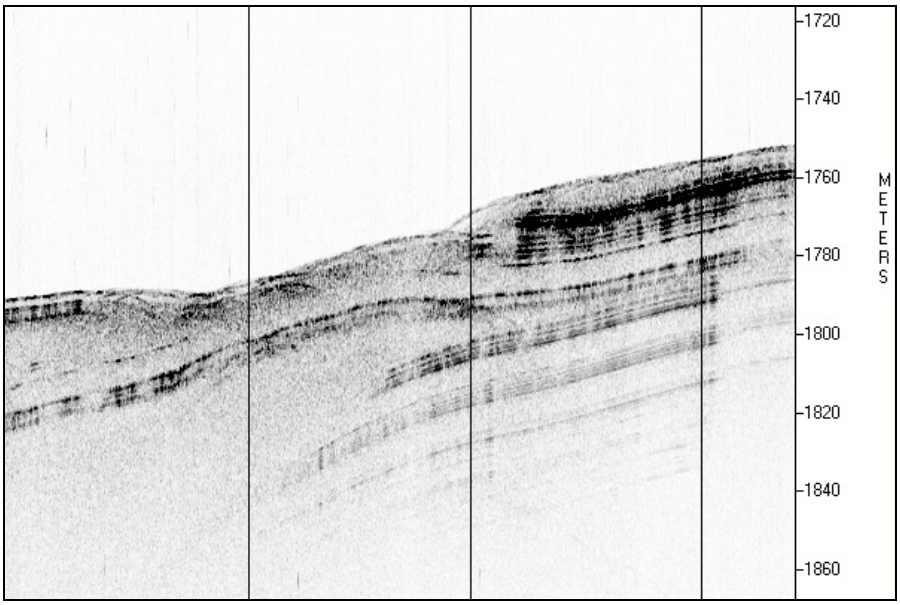


Figure 5 - Example of sub-bottom profiler data

A 4x4 array of sub-bottom transducers are permanently installed on the vessels in a hull-mounted, acoustically transparent sea-chest (see Figure 6). The transducers perform both transmit and receive functions, and operate in the 2 – 10 kHz range.

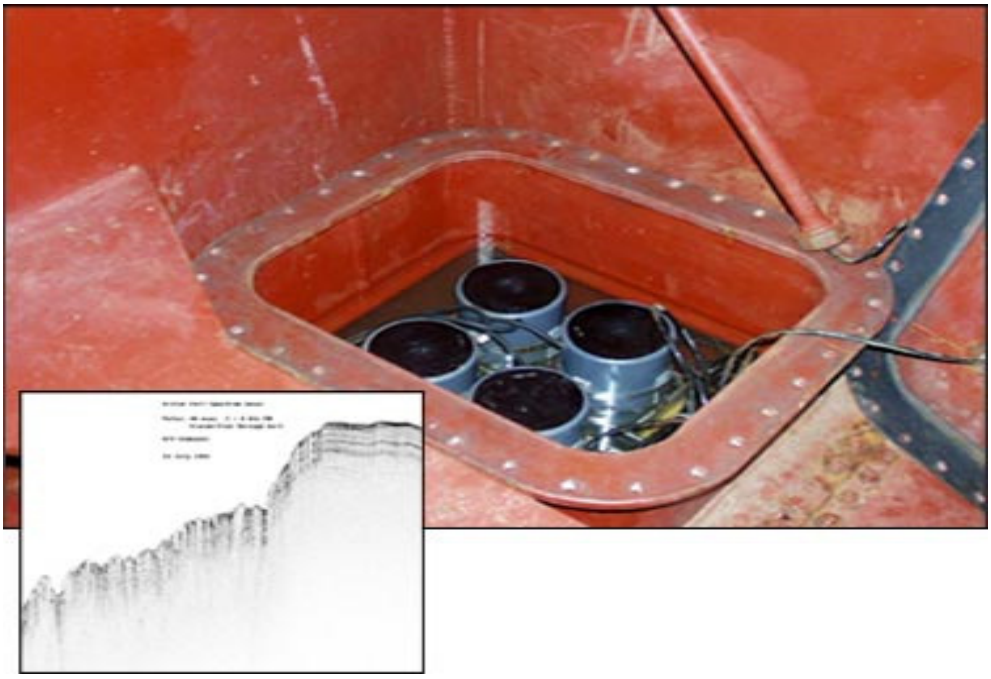


Figure 6 - Example of sub-bottom profiler transducer installation

See the attachments section at the end of this document for details on expected MBES sound levels and spec sheets for the proposed MBES and sub-bottom systems.

1.2 Sound Speed Data Collection

The speed of sound in sea water is roughly 1500 meters/second. However the speed of sound can vary with changes in temperature, salinity and pressure. These variations can drastically change the way sound travels through water, as changes in sound speed between bodies of water, either vertically in the water column or horizontally across the ocean, cause the trajectory of sound waves to bend due to refraction. Accurate measurement of the water column velocity profile reduces the errors due to refraction, and accurate knowledge of the water column's absorption coefficient results in better backscatter data.

Water column properties vary spatially and temporally, and so frequent measurements to determine sound velocity, spread throughout the survey area, are required to get the best possible multibeam data. At regular intervals a 'CTD' or "Conductivity, Temperature and Depth" instrument (Figure 7) – is lowered from the stationary vessel, down through the water column to the seafloor and back. Data is generally recorded every 1m through the water column and is used to derive a model of the sound velocity though the water column for that location and time. This sound velocity 'profile' is then input into the multibeam acquisition system. An alternative method for acquiring water column data utilizes XBTs, Expendable Bathy-Thermographs, or XSVs, Expendable Sound Velocity, measuring probes.

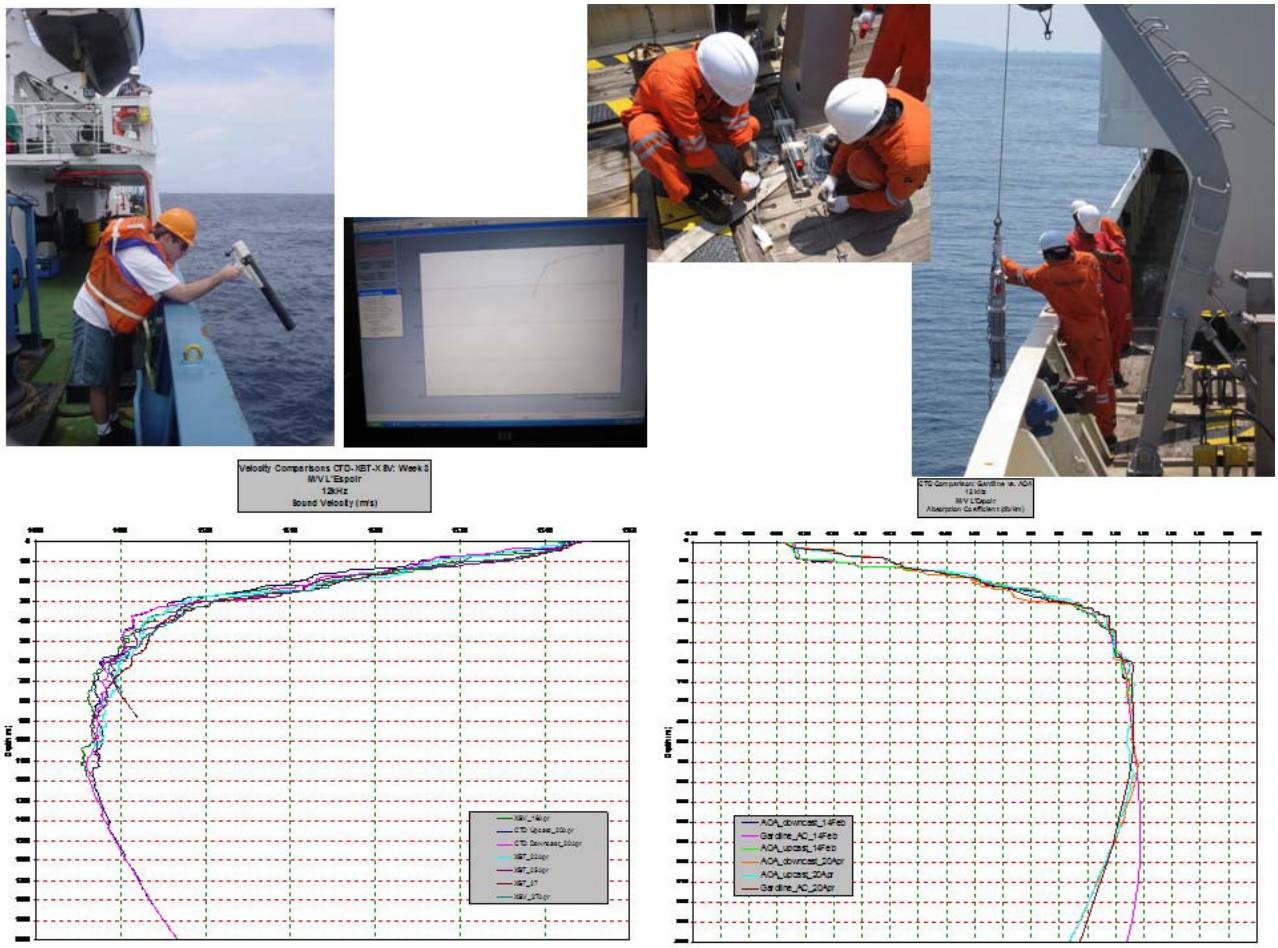


Figure 7 - Example of speed of sound measurements with CTD and XSV / XBT

Section 2. Duration and Location

TDI / ONE will conduct the survey with the more northerly waters mapped during the summer months, and the more southerly waters mapped during the winter months. As such, the actual survey activity and geographical region will vary with season and the timing of the start of survey activities. Survey activities will be conducted using hull-mounted equipment only – no towed instruments will be used. Surveying will be conducted at typically 9-10 knots. TDI / ONE anticipate that approximately 40-45,000 square kilometers of seafloor will be surveyed in each 30 day leg.

Section 3: Species and Numbers of Marine Mammals

Table 1 - The species and numbers of marine mammals likely to be found within the activity area.

Species (Scientific name)	Habitat range	Occurrence/seasonality within survey area	Regional SAR abundance estimates	Endangered Species Act status
North Atlantic right whale (Eubalaena glacialis)	coastal and shelf	uncommom; most likely found during spring, fall, winter	455	listed
humpback whale (Megaptera novaengliae)	nearshore, banks, pelagic	rare/unlikely; may be found year-round	823	listed
minke whale (Balaenoptera acutorostrata)	coastal	unlikely; may be found year-round	20741	not listed
Sei whale (Balaenoptera borealis)	offshore	rare; may be found year-round	357	listed
fin whale (Balaenoptera physalus)	slope, pelagic	uncommon; may be found year-round	3522	listed
blue whale (Balaenoptera musculus)	shelf, pelagic	rare to unlikely; may be found year-round	440 (c)	listed
sperm whale (Physeter macrocephalus)	pelagic	common; may be found year-round	2288	listed
pygmy sperm whale (Kogia breviceps)	off shelf	uncommon; may be found year-round	3785	not listed
dwarf sperm whale (Kogia sima)	off shelf	uncommon; may be found year-round	3785	not listed
Cuvier's beaked whale (Ziphius cavirostris)	pelagic	uncommon; may be found year-round	6532	not listed
True's beaked whale (Mesoplodon mirus)	pelagic	rare; may be found year-round	7,092 (d)	not listed
Gervais' beaked whale (Mesoplodon europaeus)	pelagic	uncommon; may be found year-round	7,092 (d)	not listed
Sowerby's beaked whale (Mesoplodon bidens)	pelagic	uncommon; may be found year-round	7,092 (d)	not listed

Blainville's beaked whale (Mesoplodon densirostris)	pelagic	uncommon; may be found year-round	7,092 (d)	not listed
rough-toothed dolphin (Steno bredanensis)	pelagic	uncommon; may be found year-round	271	not listed
bottlenose dolphin (Tursiops truncatus)	coastal, offshore	uncommon; may be found year-round	77,532 (b)	not listed
Pantropical spotted dolphin (Stenella attenuata)	pelagic	common; may be found year-round	3333	not listed
Atlantic spotted dolphin (*Stenella frontalis*)	shlef, slope, pelagic	common; may be found year-round	44715	not listed
spinner dolphin (*Stenella longirostris*)	coastal, pelagic	rare; may be found year-round	unknown	not listed
striped dolphin (*Stenella coeruleoalba*)	off shelf	common; may be found year-round	5,4807	not listed
Clymene dolphin (*Stenella clymene*)	pelagic	uncommon; may be found year-round	unknown	not listed
short-beaked common dolphin (*Delphinus delphis*)	shelf, pelagic	rare; may be found year-round	17,3486	not listed
Fraser's dolphin (*Lagenodelphis hosei*)	pelagic	rare; may be found year-round	unknown	not listed
Risso's dolphin (*Grampus griseus)*	shelf, pelagic	common; may be found year-round	18250	not listed
melon-headed whale (P*eponocephala electra*)	shelf and slope	rare; may be found year-round	unknown	not listed
false killer whale (*Pseudorca crassidens*)	pelagic	rare; may be found year-round	unknown	not listed
pygmy killer whale (*Feresa attenuata*)	pelagic	rare; may be found year-round	unknown	not listed
killer whale (*Orcinus orca*)	coastal	rare; may be found year-round	unknown	not listed
long-finned pilot whale (*Globicephala melas*)	pelagic	common; may be found year-round	26535	not listed

short-finned pilot whale (*Globicephala macrorhynchus*)	pelagic	common; may be found year-round	21515	not listed
notes	a. Jefferson, 2008 estimate for the North Atlantic	b. Western North Atlantic offshore	c. SAR 2013 minimum estimate	d. best estimate for all beaked whales of this genus SAR2013

Section 4: Affected Species Status and Distribution

Marine Mammals

Right whales (*Eubalaena glacialis)*
The North Atlantic right whale occurs primarily along the continental shelf waters off the eastern U.S. and Canada, from Florida to Nova Scotia (Winn et al. 1986; Jefferson et al. 2008). This species generally inhabits waters more inshore than those of this proposed survey. There are five well-known habitats in the northwest Atlantic used annually by right whales (Winn et al. 1986; NMFS 2005). These include the winter calving grounds in coastal waters of the southeastern U.S. (Florida/Georgia); spring feeding grounds in the Great South Channel (east of Cape Cod); late winter/spring feeding grounds and nursery grounds in Massachusetts Bay and Cape Cod Bay; summer/fall feeding and nursery grounds in the Bay of Fundy; and summer/fall feeding grounds on the Nova Scotian Shelf.

A general north-south seasonal migration of the North Atlantic population occurs between feeding and calving areas, but right whales could be seen anywhere off the Atlantic U.S. throughout the year (Gaskin 1982). The migration route between the Cape Cod summer feeding grounds and the Georgia/Florida winter calving grounds, known as the mid-Atlantic corridor, does not include high use areas, but the whales clearly move through these waters regularly year-round (Reeves and Mitchell 1986; Winn et al. 1986; Kenney et al. 2001; Reeves 2001; Knowlton et al. 2002; Whitt et al. 2013).

Knowlton et al. (2002) analyzed survey data, satellite tag data, whale strandings, and opportunistic sightings along state waters of the mid-Atlantic migratory corridor from the border of Georgia/South Carolina to south of New England, between the years 1974 to 2002 and found that the majority of sightings (94%) along the migration corridor were within 56 km of shore, and more than half (64%) were within 18.5 km of shore. Water depth preference was for shallow waters; 80% of all sightings were in depths <27 m, and 93% were in depths <45 m (Knowlton et al. 2002). These depth preferences of the right whale are much shallower than our proposed survey area, which should limit any encounters between our ship(s) and right whales. Most sightings farther than 56 km from shore occurred at the northern end of the corridor, off New York and south of New England, well outside of our survey area.

North of Cape Hatteras, most sightings were reported for March–April; south of Cape Hatteras, most sightings occurred during February–April (Knowlton et al., 2002). Similarly, sighting data analyzed by Winn et al. (1986) dating back to 1965 showed that the occurrence of North Atlantic right whales in the Cape Hatteras region peaked in March; in the mid-Atlantic area, it peaked in April. Beaudin and Ring (2002) found that between 1974 and 2002 right whales only occurred off the coasts of Virginia and North Carolina during fall, winter, and spring; there were no sightings for July–September. Right whale sighting data mapped by DoN (2008a,b) showed the greatest occurrence off Virginia and North Carolina during the winter (December–April), with many fewer sightings during spring and fall.

Between 2005 and 2013, the Interactive North Atlantic Right Whale Sighting Map showed 30 sightings in the shelf waters off Virginia and North Carolina. Only one sighting was seaward of the shelf off Virginia (NEFSC 2013). Over the past year of 2014, there were well over 100 sightings of right whales made south of Maryland through the Florida coast. The only sightings that occurred off the shelf, however, were made at the very northern extent of the proposed survey area (NEFSC, 2014).

Humpback whales (*Megaptera novaengliae)*

Humpback whales are generally considered a coastal species. However, they often traverse deep pelagic areas while migrating (Calambokidis et al. 2001). Along the Western North Atlantic summer, the greatest concentrations of humpback whales occur in the southern Gulf of Maine and east of Cape Cod, with a few sightings ranging south to North Carolina (Clapham et al. 1993; DoN 2005). The distribution in the fall is similar, but sightings are fewer. Off Virginia and North Carolina, most sightings mapped by DoN (2008a,b) were during the winter, mostly nearshore. During the spring, most sightings were made along the shelf break or in deep, offshore water. During CETAP surveys, three sightings of humpbacks where made off Virginia: one each during spring, fall, and winter (CETAP 1982). Wiley et al. (1995) reported that 38 humpback whale strandings occurred during 1985-1992 in the U.S. mid-Atlantic and southeastern states. Most of these strandings, particularly along the Virginia and North Carolina coasts, were of sexually immature individuals; the small size of many of these whales strongly suggested that they had only recently separated from their mothers. Wiley et al. (1995) concluded that these areas were becoming an increasingly important habitat for juvenile humpback whales and that anthropogenic factors may negatively impact whales in this area.

Minke (*Balaenoptera acutorostrata)*

Minke whales are common off the U.S. east coast over continental shelf waters, especially off New England during spring and summer (CETAP 1982; DoN 2005). Sightings off Virginia and North Carolina are less common than near New England; 15 sightings were mapped by DoN (2008a,b), most in winter and spring with 1 in summer and 1 in fall, and most on the shelf or near the shelf break. There are ~17 OBIS sighting records of minke whales for the shelf waters off Virginia and North Carolina and another two sightings in deep offshore waters (IOC 2013); half of the sightings were made during spring and summer CETAP surveys (CETAP 1982).

Sei whale (*Balaenoptera borealis)*
Sei whales are generally distributed throughout offshore waters, and along the North American Atlantic coast, generally inhabit areas north of Cape Hatteras. They likely will not be encountered during this survey given that very few sightings off of Virginia and North Carolina have been recorded. All of these sightings occurred during winter and spring north of Cape Hatteras (DoN, 2008a). There were only two OBIS sightings of sei whales off of North Carolina (IOC 2013), including one in deep offshore water that was made during a CETAP survey in 1980 and one on the shelf (CETAP 1982).

Although known to eat fish, sei whales (like right whales) are mainly planktivorous, feeding primarily on euphausiids and copepods (Flinn et al. 2002). A review of prey preferences by Horwood (1987) revealed that in the North Atlantic sei whales prefer copepods over all other prey species. In Nova Scotia, stomach samples from captured sei whales showed a clear preference for copepods between June and October, and a preference for euphausiids in May and November (Mitchell 1975).

Fin whales (*Balaenoptera physalus)*
Fin whales are common in waters of the U. S. Atlantic Exclusive Economic Zone (EEZ), principally from Cape Hatteras northward. In this region fin whales are the dominant large cetacean species during all seasons, having the largest standing stock, the largest food requirements, and therefore the largest influence on ecosystem processes of any cetacean species (Hain et al. 1992; Kenney et al. 1997).

The occurrence of fin whales off Virginia and North Carolina appears to be highest during winter and spring, with more sightings close to shore during winter and farther offshore, mostly on the outer shelf and along the shelf break, during spring; only a few sightings were made in summer and fall (DoN 2008a,b). There are ~100 OBIS sightings of fin whales in and near the proposed survey area off Virginia and North Carolina, mainly in shelf waters (IOC 2013); some of these sightings were made during the CETAP surveys (CETAP 1982). Three fin whale sightings were made near the shelf break off Virginia and North Carolina on NEFSC and SEFSC summer surveys during 1995–2011 (Waring et al. 2013).

Blue whales *(Balaenoptera musculus)*
Blue whales are relatively rare off the U.S. Atlantic coast (Wenzel et al., 1988; Waring et al. 2010). Two offshore sightings of blue whales during spring were reported off the mid-Atlantic coast: one off the coast of North Carolina and the other off
Virginia (IOC 2013). DoN (2008a) also reported one blue whale sighting in deep water off North Carolina during spring.

Beaked whales (*genus Mesoplodon)*

Mesoplodon beaked whales are difficult to distinguish at sea. A survey conducted between June-August 2011 estimated an abundance for the entire genus in waters between central Virginia and central Florida at 1,570 (CV=0.65) (Waring et al., 2013). The majority of sightings occurred along the continental shelf break with generally lower sighting rates over the continental slope.

Sowerby's beaked whale (Mesoplodon bidens) prefers deep, cold temperate waters (NOAA Fisheries OPR 2012m). Blainville's beaked whale (Mesoplodon densirostris) prefers deep, offshore waters spanning from tropical to temperate areas (NOAA Fisheries OPR 2012n). Gervais' beaked whales (Mesoplodon europaeus) prefer deep, warm temperate tropical and sub-tropical waters (NOAA Fisheries OPR 2012o). True's beaked whale (Mesoplodon mires) prefers deeper, warm, temperate waters in the western North Atlantic Ocean (NOAA Fisheries OPR 2012p).

Sperm whales (*Physeter macrocephalus)*

The distribution of the sperm whale in the U.S. Exclusive Economic Zone (EEZ) occurs on the continental shelf edge, over the continental slope, and into mid-ocean regions. Waring et al. (2013) suggested that this offshore distribution is more commonly associated with the Gulf Stream edge and other features. In the northwest Atlantic, the sperm whale generally occurs in deep water along the continental shelf break from Virginia to Georges Bank, and along the northern edge of the Gulf Stream (Waring et al. 2001). Shelf edge, oceanic waters, seamounts, and canyon shelf edges are also predicted habitats of sperm whales in the Northwest Atlantic (Waring et al. 2001). Off the eastern U.S. coast, they are also known to concentrate in regions with well-developed temperature gradients, such as along the edges of the Gulf Stream and warm core rings, which may aggregate their primary prey, squid (Jaquet 1996).

Sperm whales occur in deep, offshore waters of Virginia and North Carolina throughout the year, on the shelf, along the shelf break, and offshore; the lowest number of sightings was in fall (DoN 2008a,b). There are several hundred OBIS records of sperm whales in deep waters off Virginia and North Carolina (IOC 2013), and numerous sightings were reported on and seaward of the shelf break during CETAP surveys (CETAP 1982) and during summer NEFSC and SEFSC surveys between 1998 and 2011 (Waring et al. 2013).

Dwarf and Pygmy Sperm whales (*Kogia sima and K. breviceps)*

Dwarf sperm whales (K. sima) and pygmy sperm whales (K. breviceps) are difficult to differentiate at sea (Caldwell and Caldwell 1989, Wursig et al. 2000), and sightings of either species are often categorized as Kogia sp. Diagnostic morphological characters have been useful in distinguishing the two Kogia species (Barros and Duffield 2003), thus enabling researchers to use stranding data in distributional and ecological studies. Specifically, the distance from the snout to the center of the blowhole in proportion to the animal's total length, as well as the height of the dorsal fin in proportion to the animal's total length, can be used to differentiate between the two Kogia species when such measurements are obtainable (Barros and Duffield 2003; Handley 1966).

The dwarf sperm whale (Kogia sima) is distributed worldwide in temperate to tropical waters (Caldwell and Caldwell 1989; McAlpine 2002). Sightings of these animals in the western North

Atlantic occur in oceanic waters (Mullin and Fulling 2003; NMFS unpublished data). Stranding records exist from Florida to Maine (Willis and Baird 1998).

The pygmy sperm whale (Kogia breviceps) is distributed worldwide in temperate to tropical waters (Caldwell and Caldwell 1989; McAlpine 2002). Sightings of these animals in the western North Atlantic occur within oceanic waters (Mullin and Fulling 2003; SEFSC unpublished data). Stranding records exist from Florida to Maine (Willis and Baird 1998).

Between 2006 and 2010, 127 pygmy and 32 dwarf sperm whale strandings were recorded from Maine to Puerto Rico, mostly off the southeastern coast. Eleven strandings of Kogia spp. were reported for Virginia and 48 for North Carolina (Waring et al. 2013). There are eight OBIS sightings of pygmy or dwarf sperm whales in offshore waters off Virginia and North Carolina (IOC 2013). DoN (2008a,b) mapped 22 sightings of Kogia spp. off Virginia and North Carolina, most in winter and spring with 2 in summer and 1 in fall, and most near the shelf break or offshore. Several sightings of Kogia sp. (either pygmy or dwarf sperm whales) were also reported by DoN (2008a) and Waring et al. (2013) in deep, offshore waters off Virginia and North Carolina during summer months.

Cuvier's beak whale *(Ziphius cavirostris)*

The distribution of Cuvier's beaked whales is poorly known, and (like most beaked whale information) is based mainly on stranding records (Leatherwood et al. 1976). Strandings have been reported from Nova Scotia along the eastern U.S. coast south to Florida, around the Gulf of Mexico, and within the Caribbean (Leatherwood et al. 1976; CETAP 1982; Heyning 1989; Houston 1990; MacLeod et al. 2006; Jefferson et al. 2008). Stock structure in the North Atlantic is unknown.

Cuvier's beaked whale sightings occur primarily along the continental shelf edge in the Mid-Atlantic region off the northeast U.S. coast (CETAP 1982; Waring et al. 1992; Waring et al. 2001; Hamazaki 2002; Palka 2006). Most sightings were in late spring or summer. Off North Carolina, there are have been at least 14 sightings of Cuvier's beaked whales (DoN 2008a,b), most along the shelf break or offshore. Several sightings were made along the shelf break off North Carolina in the spring and summer during the 1978–1982 CETAP surveys (CETAP 1982). Palka (2012) reported one Cuvier's beaked whale sighting in deep offshore waters off Virginia during June–August 2011 surveys. There are four and nine OBIS sighting records of Cuvier's beaked whale in offshore waters off Virginia and North Carolina (IOC 2013).

Pilot whale (*Globicephala melas; G. macrorhynchus)*

There are two species of pilot whales, the long-finned pilot whale, Globicephala melas, and the short-finned pilot whale, G. macrorhynchus. These species are very difficult to differentiate at sea, which has hampered efforts to assess their distributions independently. Undifferentiated pilot whales (Globicephala sp.) in the western North Atlantic occur primarily near the continental shelf break ranging from Florida to the Nova Scotia Shelf (Mullin and Fulling 2003). Long-finned and short-finned pilot whales overlap spatially along the mid-Atlantic shelf break between

New Jersey and the southern flank of Georges Bank (Payne and Heinemann 1993; NMFS unpublished data). Long-finned pilot whales have occasionally been observed stranded as far south as South Carolina, and short-finned pilot whales have occasionally been observed stranded as far north as Massachusetts. The latitudinal ranges of the two species therefore remain uncertain, although south of Cape Hatteras, most pilot whale sightings are expected to be short-finned pilot whales, while north of ~42°N most pilot whale sightings are expected to be long-finned pilot whales.

An abundance estimate of 16,946 (CV=0.43) Globicephala sp. was generated from a shipboard survey conducted concurrently (June-August 2011) in waters between central Virginia and central Florida. This shipboard survey included shelf-break and inner continental slope waters deeper than the 50-m depth contour within the U.S. EEZ.

Melon-headed whales (*Peponocephala electra)*
Melon-headed whales prefer deep waters of tropical areas. There are few sightings near the study area, however there is a recognized stock of the western North Atlantic. Relatively little is known about this stock. This species is found in large groups and feed primarily on squids, fishes, and some crustaceans (NOAA Fisheries OPR 2012)

Short beaked common dolphin (*Delphinus delphis)*
In the North Atlantic, common dolphins occur over the continental shelf between the 100-2000m isobaths and over prominent underwater topography and east to the mid-Atlantic Ridge (29°W) (Doksaeter et al. 2008; Waring et al. 2008). The species is less common south of Cape Hatteras, although groups of North Atlantic common dolphin [ISN'T A GROUP OF DOLPHIN CALLED A POD, NOT A "SCHOOL"?? I CHANGED THIS TO "GROUPS" TO BE CONSISTENT WITH THE TEXT ON CLYMENE DOLPHIN.] have been reported as far south as the Georgia/South Carolina border (32°N) (Jefferson et al. 2009). In waters off the northeastern USA coast, common dolphins are distributed along the continental shelf between the 100-2000-m isobaths and are associated with Gulf Stream features (CETAP 1982; Selzer and Payne 1988; Waring et al. 1992; Hamazaki 2002). They occur from Cape Hatteras northeast to Georges Bank (35° to 42°N) during mid-January to May (Hain et al. 1981; CETAP 1982; Payne et al.1984). Common dolphins move onto Georges Bank, Gulf of Maine, and the Scotian Shelf from mid-summer to autumn. Selzer and Payne (1988) reported very large aggregations (greater than 3,000 animals) on Georges Bank in autumn.

Atlantic spotted dolphin (*Stenella frontalis)*
Atlantic spotted dolphins are distributed in tropical and warm temperate waters of the western North Atlantic (Leatherwood et al. 1976). Their distribution ranges from southern New England, south through the Gulf of Mexico and the Caribbean to Venezuela (Leatherwood et al. 1976; Perrin et al. 1994). Atlantic spotted dolphins regularly occur in continental shelf waters south of Cape Hatteras and in continental shelf edge and continental slope waters north of this region (Payne et al. 1984; Mullin and Fulling 2003). Sightings have also been made along the north wall of the Gulf Stream and warm-core ring features (Waring et al. 1992).

The Atlantic spotted dolphin occurs in two ecotypes, which may be distinct sub-species (Perrin et al. 1987, 1994; Rice 1998): the large, heavily spotted form that inhabits the continental shelf

and is usually found inside or near the 200 m isobath; and the smaller, less spotted island and offshore form which occurs in the Atlantic Ocean (Fulling et al. 2003; Mullin and Fulling 2004). The offshore ecotype of the Atlantic spotted dolphin and the pantropical spotted dolphin can be difficult to differentiate at sea.

Pantropical spotted dolphin (*Stenella attenuata)*
The pantropical spotted dolphin has a global distribution within tropical and sub-tropical waters (Perrin et al., 1987; Perrin and Hohn 1994). Sightings during surveys in the Atlantic have been concentrated in the slope waters north of Cape Hatteras while in waters south of Cape Hatteras sightings are recorded over the Blake Plateau and in deeper offshore waters of the mid-Atlantic (Maze-Foley and Mullin 2006). Waring et al. (2010) reported one sighting off North Carolina and one off South Carolina during NEFSC and SEFSC surveys in the summer during 1998–2004. OBIS sighting records list 91 records for pantropical spotted dolphins in waters off Virginia and North Carolina, mostly within shelf waters (IOC 2013).

Striped dolphin (*Stenella coeruleoalba)*
The striped dolphin is distributed worldwide in warm-temperate to tropical seas (Archer and Perrin 1997; Archer 2009). Striped dolphins are found in the western North Atlantic from Nova Scotia south to at least Jamaica and in the Gulf of Mexico. Striped dolphins appear to prefer continental slope waters offshore to the Gulf Stream (Leatherwood et al. 1976; Perrin et al. 1994; Schmidly 1981). There is very little information concerning striped dolphin stock structure in the western North Atlantic (Archer and Perrin 1997).

Striped dolphins inhabit the waters off the mid-Atlantic coast, near Virginia and North Carolina, year-round. These animals are especially likely to be found along the shelf break and deep, offshore waters (IOC 2013).

Rough-toothed dolphins (*Steno bredanensis)*
Rough-toothed dolphins are distributed worldwide in the Atlantic, Pacific and Indian Oceans, The generally prefer warm temperate, subtropical, or tropical waters. Their range includes water depths from shallow and nearshore waters to oceanic areas (West et al. 2011). Along the U.S. East Coast, rough-toothed dolphins occur in oceanic waters at depths greater than 1,000 m. Sightings of rough-toothed dolphins along the East Coast of the U.S. are much less common than in the Gulf of Mexico (CETAP 1982; NMFS 1999; Mullin and Fulling 2003).

In the western North Atlantic, five rough-toothed dolphins that were rehabilitated and released with satellite tags demonstrated a variety of ranging patterns (Wells et al. 2008). All tagged rough-toothed dolphins moved through a large range of water depths that were on average greater than 100 m. (Wells and Gannon 2005).

Clymene dolphin (*Stenella clymene)*
The Clymene dolphin is endemic to tropical and sub-tropical waters of the Atlantic (Jefferson and Curry 2003). Clymene dolphins have been commonly sighted in the Gulf of Mexico since 1990 (Mullin et al. 1994; Fertl et al. 2003). Four Clymene dolphin groups were sighted during

summer 1998 in the western North Atlantic (Mullin and Fulling 2003), and two groups were sighted in the same general area during a 1999 survey (NMFS 1999). Two groups of Clymene dolphins were sighted during summer 2011 in the western North Atlantic, with one group in the same general area off North Carolina as the 1998 and 1999 sightings, and the other group off Florida over the Blake Plateau (NMFS unpublished data). These sightings in conjunction with stranding records (Fertl et al. 2003) indicate that this species routinely occurs in the western North Atlantic. The western North Atlantic population is being considered a separate stock for management purposes, although there is currently no information to differentiate this stock from the northern Gulf of Mexico stock(s).

Spinner dolphin (*Stenella longirostris)*

Spinner dolphins are distributed in oceanic and coastal tropical waters (Leatherwood et al. 1976). Spinners are generally believed to be an offshore, deep-water species (Schmidly 1981; Perrin and Gilpatrick 1994). Its distribution within the Atlantic is very poorly known. In the western North Atlantic, these dolphins occur in deep water along most of the U.S. coast south to the West Indies and Venezuela, including the Gulf of Mexico. Spinner dolphin sightings have occurred almost exclusively in deeper (>2,000 m) oceanic waters (CETAP 1982; Waring et al. 1992; NMFS unpublished data) off the northeast U.S. coast, but there was one recent sighting during summer 2011 in oceanic waters off North Carolina. Stranding records exist from North Carolina, South Carolina, Florida and Puerto Rico in the Atlantic, and in Texas, Alabama and Florida in the Gulf of Mexico.

Bottlenose (*Tursiops truncatus)*

There are two morphologically and genetically distinct common bottlenose dolphin morphotypes (Duffield et al. 1983; Duffield 1986; Mead and Potter 1995; Rosel et al. 2009) described as the coastal and offshore forms. Both inhabit waters in the western North Atlantic Ocean (Hersh and Duffield 1990; Mead and Potter 1995; Curry and Smith 1997; Rosel et al. 2009) along the U.S. Atlantic coast. The two morphotypes are genetically distinct based upon both mitochondrial and nuclear markers (Hoelzel et al. 1998; Rosel et al. 2009). The offshore form is distributed primarily along the outer continental shelf and continental slope in the Northwest Atlantic Ocean from Georges Bank (CETAP 1982; Kenney 1990) to the Florida Keys, where dolphins with characteristics of the offshore type have stranded. An abundance estimate of 50,766 (CV=0.55) offshore bottlenose dolphins was generated from a shipboard survey conducted concurrently (June-August 2011) in waters between central Virginia and central Florida. This shipboard survey included shelf-break and inner continental slope waters deeper than the 50-m depth contour within the U.S. EEZ. An abundance estimate of 26,766 (CV=0.52) offshore bottlenose dolphins was generated from the same survey for the area between central Virginia and central Florida (Waring et al., 2013).

Turtle Species

Green Sea Turtle (*Chelonia mydas)*

The green turtle is globally distributed and generally found in tropical and subtropical waters along continental coasts and islands between 30° North and 30° South. Within the U.S. Atlantic and Gulf of Mexico waters, green turtles are found in inshore and nearshore waters from Texas to Massachusetts, the U.S. Virgin Islands, and Puerto Rico.

Adult females travel hundreds to thousands of kilometers while migrating between foraging areas and mainland or island nesting beaches. Hatchlings swim to offshore areas, where they are believed to live for several years, feeding close to the surface on a variety of pelagic plants and animals. Juveniles leave the pelagic habitat for nearshore foraging grounds after reaching a certain, unknown size (NOAA Fisheries OPR, 2014r).

Hawksbill (*Erethochelys imbricata)*

Hawksbill turtles are most commonly associated with coral reef habitat, however they use different habitats at different stages of their life cycle.

Juvenile hawksbills likely occupy the pelagic ocean environment. They shelter within floating algal mats and drift lines of flotsam and jetsam in the Atlantic Ocean (NOAA Fisheries OPR, 2014s).

Kemp's Ridley (*Lepidochelys kempii)*

Kemp's ridleys are distributed throughout the Gulf of Mexico and U.S. Atlantic seaboard, from Florida to New England.

Hatchlings inhabit a much different environment than their adult counterparts. Similar to many sea turtle species, Kemp's Ridleys likely utilize an open ocean developmental stage. Some hatchlings remain in currents within the Gulf of Mexico while others may be swept out of the Gulf, around Florida, and into the Atlantic Ocean by the Gulf Stream.

Juveniles may associate with floating sargassum seaweed where they can rest, forage, and hide from predators. Sub-adults return to neritic zones of the Gulf of Mexico or northwestern Atlantic Ocean to feed and develop until they reach adulthood (NOAA Fisheries OPR, 2014t).

Loggerhead Turtle (*Caretta caretta)*

Loggerheads live throughout the world's oceans, they can be found in temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans. Loggerheads are the most abundant species of sea turtle found in U.S. coastal waters.

The predominate foraging areas for western North Atlantic adult loggerheads are found throughout the relatively shallow continental shelf waters of the U.S., Bahamas, Cuba, and the

Yucatán Peninsula, Mexico. A portion of the population utilizes migratory routes along the continental shelf, while other routes involve crossing oceanic waters to and from the Bahamas, Cuba, and the Yucatán Peninsula. Seasonal migrations of adult loggerheads along the mid- and southeast U.S. coasts are also known to occur.

Nesting during summer months occurs primarily in the subtropics. Although the major nesting concentrations in the U.S. are found from North Carolina through southwest Florida, minimal nesting occurs outside of this range westward to Texas and northward to Virginia. Adult loggerheads are known to make extensive migrations between foraging areas and nesting beaches. During non-nesting years, adult females from U.S. beaches are distributed in waters off the eastern U.S. and throughout the Gulf of Mexico, Bahamas, Greater Antilles, and Yucatán (NOAA Fisheries OPR, 2014u).

Section 5: Type of Incidental Take Requested

The survey operations discussed have the potential to "take" marine mammals by harassment. Sounds will be generated by the multibeam echosounder, sub-bottom profiler, and by general vessel operations. "Takes" by harassment could result when marine mammals near the ship are exposed to sounds generated by the acoustic sources. The effects will vary with species, the behavior of the animals at the time of exposure, and the actual received level of the sound. Based on the planned survey activities and mitigation measures, no serious injury to any marine mammals is expected, and no lethal takes are anticipated.

Section 6: Number of Marine Mammals that could be taken by "Harassment"

The number of marine mammals that could be exposed to acoustic levels defined by NMFS as capable of producing TTS were determined from density estimates provided by the NMFS stock assessment of the north Atlantic for 2013 and the model results of the OBIS-SERDP. These density estimates utilize data gathered in high density coastal areas, inshore of planned survey activities, however they are the most representative data of our survey area available.

The width of the MBES beam where sound intensity reaches at least 180dB was multiplied by the length of each survey line to calculate a total ensonified area. This area was multiplied by the density of each species to estimate the number of takes. All takes were rounded to the nearest whole number.

Survey activities will be conducted year-round, so density estimates in some cases have been averaged across seasons. Since surveys have not yet been planned for a particular season and may be weather dependent, take estimates were made for the entire anticipated population. Given the intermittent nature of sound produced and the directional nature of the beam that will reduce the actual volume of water ensonified, we believe these take estimates represent an over-

estimate of animals that will actually be exposed to acoustic threshold levels. These “take” estimates also do not take into account proposed mitigation procedures.

Table 2 - Take Estimates

Species	Estimated Number of Takes
North Atlantic right whale	1
atlantic spotted dolphin	175
beaked whales	4
bottlenose dolpohin	161
clymene	19
common dolphin	105
Gomex false killer	3
fin	1
frasers dolphin	2
humpback	2
killer whale	2

melon headed whale	12
minke	0
pantropical spotted dolphin	40
pilot whales	89
pygmey killer whale	1
Risso's dolphin	54
rough-toothed dolphin	1
sei whale	7
striped dolphin	147
spinner dolphin	33
sperm whale	11
Kogia sp	2

Section 7: Potential Effects of Multibeam Echosounder and Sub-Bottom Profiler on Marine Mammals

Permanent and Temporary threshold shifts (PTS and TTS)

The PEIS (Final Programmatic Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) for Marine Seismic Research funded by the National Science Foundation or Conducted by the U.S. Geological Survey (June 2011) concluded that the operation of MBESs and SBPs is unlikely to impact odontocetes, mysticetes, or pinnipeds because the short (millisecond) and intermittent (one ping every few seconds) and narrow, downward-directed nature of both acoustic sources would result in no more than one or two brief pinging exposures of any individual animal, due to the movement and speed of the survey vessel. Lurton and DeRuiter (2011) had similar findings but do suggest that behavioral responses and temporary responses are not well known or documented.

Au and Hastings (2008) found that sound from echosounders used during regular hydrographic survey operations could lead to behavioral changes in marine mammals that might affect migration, feeding, breeding, and the ability to avoid predators. The narrow and highly directional beams of these sounds will limit the range at which they are heard. Additionally, the sounds are produced intermittently, every few seconds, and the ship will continue to move through an area at approximately 10 knots, limiting the TTS sound levels in any one area to just a few minutes. Given the timing of the sounds generated by the MBES, masking of communicative or echolocation sounds produced by cetaceans should occur very rarely and potentially interfere only briefly with normal behavior of the animals.

The MBES system utilized for this study will produce sound at a level that only just barely exceeds the proposed NMFS guidelines PTS threshold for high-frequency cetaceans using the peak sound metric. This PTS level will only exist within about 10m of the transducer head which is mounted to the bottom of the hull and is approximately 6m below the sea surface. Using the cumulative sound energy metric, the MBES will likely produce sounds exceeding the proposed PTS guidelines no more than 1000m from the transducer head for all types of cetaceans. Given that the MBES will sound a “ping” every several seconds for a pulse length of a fraction of a second (2, 5, 8 or 15milliseconds), it is very unlikely that a cetacean will pass under this section of the MBES beam. Depending on water depth, the pulse width will vary from 2 to 15 milliseconds; we anticipate that the most commonly used pulse width will be 8 milliseconds. The EM122 1° transmit beamwidth system has a source level of 242 db, which decays rapidly to 211 db 1m from the transducer head. The pressure level further decays to 205 db 10m from the transducer head, 195db 100m from the transducer head (where the 1° fan-shaped transmit beam is only 1.75m wide). The power level reduces to 180db 1000m from the transducer head. The time between pings will vary with water depth and swath width, as the system “waits” for the outermost beam’s ping energy to return from second-to-most-recent ping. For water depths of 400m, the ping repetition rate may be on the order of 1 second. At 1000m, the system will ping approximately every 2 to 2.5 seconds. In 3000m, the ping repetition rate will be approximately every 3 seconds. For the more widely spaced lines in deeper water, the system may ping every 5 to 6 seconds. Utilizing this proposed method of operation and additional mitigation procedures, we do not anticipate any level A harassment to occur.

While the MBES sound levels may be capable of producing a temporary threshold shift in cetacean hearing, exposure to these sound levels is unlikely. The ship will survey continuously at approximately 10 knots. Distance between survey lines will be approximately 2.25km to 4.5km. Given the highly directional nature of the beam, intermittent pings of sound, and the continuous

movement of the ship away from any particular area, we do not anticipate that any one animal will be exposed to more than one or two pings, which will reduce the threat of cumulative effects. The NMFS proposed guidelines indicate that TTS peak sound for low and mid frequency cetaceans is 198 dB. This 198dB pressure level of the MBES will occur at less than 100m from the transducer head. The along-track swath of water/seafloor ensonified by the MBES is approximately 2-5m 100m from the transducer head. At 1000m from the transducer head where sound levels may reach 180dB, the MBES swath of sound is still just 17.5m wide. The pressure level will also decrease with angle away from straight down for the flat array proposed for the survey, so that at 45° the pressure level will be 3db lower than straight down, 8db lower at a take-off angle of 60°, and 16 db lower at 70° (e.g.: the power level at 70° will be 179db 100m from the transducer array, where the along-track beam width will be 5.1m). Given this very small volume of water which may be ensonified at levels capable of inducing TTS in cetaceans, the acoustic harassment of marine mammals from this survey should be very minimal.

Section 8: Anticipated Impacts on Subsistence Uses

Not Applicable, no subsistence hunts of protected species in the area.

Section 9: Anticipated Impacts on Habitat

The proposed survey should have negligible impact on the marine habitat. The ship will follow all MARPOL regulation and best practices. There is no direct sampling anticipated during the survey.

Most fish species do not hear well above 1kHz (Au and Hastings, 2008), which is well below the operating frequency of the planned MBES. Therefore, the MBES should have no impact on the prey items of marine mammals within the study region.

Section 10: Anticipated Effects of Habitat Impacts on Marine Mammals

The ship will survey at about 10 knots. Survey lines are spaced approximately 2.25 to 4.5km apart. Even if avoidance behavior by cetaceans is detected in relation to the ship, the ship should move itself well away from any cetaceans each day. We do not anticipate survey activities will displace cetaceans from their normal ranging patterns. The constant movement of the ship will not restrict animal movement in any way or prohibit their movement.

Section 11: Mitigation Measures

Mitigation Procedures

Trained Protected Species Observers (PSOs) will be utilized to provide visual observation of waters surrounding the survey ship during, preceding, and following survey operations. PSOs will keep watch prior to the use of the MBES in order to ensure the area surrounding the ship, including the exclusion zone (EZ), is clear of any protected species. Observers will continue to keep watch during operation of the MBES and alert MBES operators of any protected species that enter the survey area. PSOs will instruct MBES operators to shut down the gear, should protected species approach the vessel in a manner that suggests they may enter the exclusion zone. Since the entirety of water where sound levels may exceed levels capable of inducing threshold shifts in cetaceans will be below the sea surface, PSOs with experience observing marine mammals in the field will be employed to gauge whether observed cetaceans are likely to enter the exclusion zone. Cetaceans that pass well forward or astern of the ship will not pass within the MBES beam and actual exclusion zones, however cetaceans diving abeam of the transducer head or diving below the path of the ship could enter the exclusion zone. Observers will carefully record the behavior of cetaceans in relation to the ship and its activities. PSOs will be expected to ask for an immediate shutdown of survey equipment, or to divert the ship's course away from marine mammals, should any erratic or suspicious behavior on the part of cetaceans that might indicate harassment or injury be observed. Should animals display attraction to the ship in a way manner that may expose them to prolonged acoustic disturbance, the MBES may be shut down until the marine mammals clear the immediate exclusion zone.

Observers will rotate at least every other three hours in order to avoid visual fatigue. Observers will maintain a watch through daylight hours and during any time when the MBES needs to be re-started following a shut-down.

During nighttime and other times when visibility is obscured, the MBES system will continue to operate, in order to continue to deter animals from entering the exclusion zone. The operational noise of the instrument acts in and of itself a deterrent to animals. Continuous operation of the instrument is a mitigation measure and should include ship turns or other times when data may not be collected. Should the instrument be shut down for any length of time, observers should monitor the exclusion zone for thirty minutes prior to a soft-start of the instrument. Soft-start or start-up of the multibeam by first utilizing lower sound pressure levels will alert any unseen and nearby animals of the acoustic source before full power is utilized. This acoustic disturbance will aid in moving animals away from the sound source.

For a power-down situation, the MBES will not be started up again until:

- the animal has been visually confirmed to have left the EZ. In the case of turtles, the vessel has moved outside the EZ.
- or, the ship and associated EZ has cleared the area where the animals were last seen.

<u>North Atlantic Right whales</u>

Very few right whales are anticipated within the survey area. However, the North Atlantic right whale is considered critically endangered, and special care will be taken to avoid harassment of this species. Ship speed will not exceed 10 knots when right whales are observed within the area. Additionally, mother-calf pairs will be avoided.

Section 12: Arctic Plan of Cooperation

Not applicable, proposed survey will not occur in Alaskan waters north of 60° North latitude.

Section 13: Monitoring and Reporting

While conducting observations, observers should record observing conditions, current ship operations, and maintain a daily log. When a sighting of a protected species is made, observers should note:

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 survey vessel, sighting cue, apparent reaction to the MBES or vessel (e.g., none, avoidance, approach, paralleling, etc.), and behavioral pace.
2. The closest approach of the animals to the survey vessel will be noted for each sighting. The number of sightings in which animals entered the EZ will be tallied. The behavior of these animals in relation to those which did not enter the EZ will be especially valuable information.
3. Time, location, heading, speed, activity of the vessel, sea state, visibility, and sun glare.The data listed under (2) will 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.

Section 14: Suggested Means of Coordination

As part of the required US Governmental permitting processing, TDI-Brooks / ONE will be also be submitting an application for geophysical exploration through Bureau of Ocean Energy Management (BOEM). As part of this process, BOEM will inform all state and federal agencies within our area of operations about our proposed activities and facilitate communication / information sharing between all parties.

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Attachments - Technical Note from Kongsberg regarding Multibeam sound levels, proposed equipment and vessel spec sheets

EM Technical Note

Date: **September 20, 2005**
Author: **Erik Hammerstad**

Subject: Sound Levels from Kongsberg Multibeams

The power output level of an echo sounder is normally specified by giving its source level in dB relative to 1 μPa at a distance of 1 m from the transmit transducer. However this is really a measure of the pressure level of the output sound wave and is only directly applicable in the farfield. The intensity (power per unit area) of a sound wave can be found from the pressure level by the relation $I = p^2/\rho c$ where ρ is the water density and c the speed of sound. The quantity ρc is the acoustic impedance of water and for sea water is nominally taken to be 1.5×10^6 kg/m^2s. Thus a pressure level in sea water of 1 μPa is nominally equal to an energy intensity of 0.667×10^{-18} W/m^2, and a pressure level of for example 210 dB corresponds to an intensity of 667 W/m^2.

In the farfield the pressure level of a sound wave will fall off with the square of the distance, this because of spherical spreading of the wave, and the wave will be further attenuated due to absorption loss. In the nearfield the pressure level will be nominally constant as there is no spreading. If the transmit transducer generating the sound wave is rectangular, there will be a transition region in which the pressure will fall of proportionally to the distance due to cylindrical spreading in the direction parallel to the shortest side of the transducer. It may be noted that in the nearfield the pressure level will have large variations, with peaks up to about twice the nominal level and also deep nulls, this effect will however be ignored in this note.

The source level is given by $SL = 170.8 + 10\lg P_{Ac} + DI$. P_{Ac} is the acoustic power which is typically half the electric power applied to the transmit transducer. DI is the transducer's directivity index which for a rectangular flat transducer can be approximated by $DI = 46.2 - 10\lg \theta_x \theta_y$ where θ_x and θ_y are the transmit beamwidths in degrees along and across respectively. The relation between beamwidth and transducer array length, L, depends upon the applied shading and the number of elements in the array, typically it would be $\theta = 65\lambda/L$ where λ is the wavelength. The nearfield limit is conventionally given by $R = L^2/\lambda$.

To derive the pressure levels in the nearfield from the source level of an echo sounder one must first calculate the pressure level at the largest farfield limit assuming spherical spreading from the 1 meter reference level used in defining the source level. From the largest to the smallest nearfield limit the pressure level will increase linearly with distance, and

from the smallest nearfield limit in to the transducer level the pressure level will be constant.

If the source level of the echo sounder is not known, but both beamwidths or transducer array lengths or even just area are, the maximum possible pressure level may still to a good degree be estimated. Then one has to rely upon the fact that there is a maximum acoustic power intensity that can be applied to a transducer in the order of 2-5 W/cm^2 to avoid cavitation (lowest number is typical at say 12 kHz, highest at say 100 kHz). With shading being applied in one direction the power will be reduced to about 50-60%, and for both directions to about 30%.

The calculations outlined above are for the on-axis direction (usually straight down). Off-axis the pressure level will fall rapidly for a narrow beam (alongtrack for a multibeam echo sounder), the level will be 20 dB down at a little more than twice the beamwidth. Acrosstrack, the pressure level will typically be 20 dB down for angles of more than 75-80° of the vertical for flat arrays. At for example 45° the closest nearfield distance will be half that of on-axis, leading to a 3 dB reduction in pressure level for distances larger than the nearfield distance on-axis. At 60° the nearfield distance will be reduced by another factor of two, and taking into account the usual level reduction at large beam angles also, the pressure level would typically be down about 8 dB compared to on-axis. At 70° the level will be about 16 dB down due a further halving of the nearfield distance and the beam pattern drop-off. For multibeams which use sectorized transmission such as most current Kongsberg systems, beam defocusing is applied in the central sector(s) in shallow waters which implies that the nearfield will be shortened and the drop-off in pressure level starts earlier. For curved transducers the nearfield limit and the pressure level will stay fairly constant across the whole angular coverage angle.

Sonars may be transmitting horizontally and with a sound speed profile where the sound speed lessens toward the surface the spreading will cylindrical even in the farfield due to ducting causing a sound channel at the surface. For multibeam echo sounders this is usually not the case, except for tilted systems such as with the dual head EM 3002.

The following table shows the relevant parameters for the currently available Kongsberg multibeam echo sounders. For each model the alongtrack (transmit) beamwidth, the source level in dB re 1μPa at 1 meter, calculated nearfield distances and pressure levels in dB re 1 μPa at the nearfield distances are provided. The effect of absorption loss is not included in this table.

System	SL	NF1	PL@NF1	NF2	PL@NF2
SBP 120 3°	230	0.8m	209	140m	187
SBP 120 6°	224	0.8m	209	35m	193
SBP 120 12°	218	0.8m	209	9m	199
EM 122 0.5°	245	2.8m	208	1840m	180
EM 120/122 1°	242	2.8m	211	460m	189
EM 120/122 2°	236	2.8m	211	115m	195
EM 302 0.5°	241	1m	212	720m	186
EM 300/302 1°	237	1m	214	180m	192
EM 300/302 2°	231	1m	214	45m	198
EM 710 0.5°	232	0.3m	213	220m	185
EM 710 1°	228	0.3m	215	55m	193
EM 710 2°	222	0.3m	215	14m	199
EM 1002 (3°)	225	3.2m	210	10m	205
EM 2000 (1.5°)	218	0.8m	208	12m	196
EM 3002 (1.5°)	216	0.01m	227	7m	199

In the next table the pressure levels at a set of fixed distances are given and also the range at which the pressure level is 180 dB re 1 μPa. Note that the figures are worst case, i.e. on-axis and with no defocusing. Note also that in this table absorption loss has been taken into account, but not in the former, using absorption coefficients of 0.2 dB/km at 4 kHz, 1 dB/km at 12 kHz, 6 dB/km at 30 kHz, 30 dB/km at 100 kHz, 50 dB/km at 200 kHz and 70 dB/km at 300 kHz.

System	PL@1m	PL@10m	PL@100m	PL@1000m	R@180dB
SBP 120 3°	208	198	188	170	310m
SBP 120 6°	208	198	184	164	160m
SBP 120 12°	208	198	178	158	80m
EM 122 0.5°	208	202	192	181	1100m
EM 120/122 1°	211	205	195	180	1000m
EM 120/122 2°	211	205	195	174	550m
EM 302 0.5°	212	202	193	171	600m
EM 300/302 1°	214	204	193	165	400m
EM 300/302 2°	214	204	190	159	250m
EM 710 0.5°	208	197	182	112	120m
EM 710 1°	210	199	182	108	110m
EM 710 2°	210	199	176	102	75m
EM 1002 (3°)	210	204	179	105	90m
EM 2000 (1.5°)	207	196	168	NA	45m
EM 3002 (1.5°)	207	194	162	NA	35m

M/V TEKNIK PERDANA

VESSEL SPECIFICATIONS

Name:	MV Teknik Perdana
Owner:	TL Geohydrographics
Operator:	TL Geohydrographics
Type:	MBES Survey
Port of Registration:	Panama
Flag:	Panama
Class:	NKK., NS* MNS* Class C (Ice strengthening)
Call Sign:	H3RN
IMO:	735 3999
MMSI	35211 6000
Year Built/Rebuilt:	Keel laid 1973/1994/2000

Length overall:	86.95 Meters
Breadth:	13.40 Meters
Draught, loaded:	5.26 meters + Transducer = 6.90 Meters
Tonnage:	2270 tons (gross tonnage)
Cruising Speed:	15 knots
Endurance MBES:	60 days
Main Engine:	Mitsubishi 3746.65 HP
Gearbox	N/A
Propulsion:	2833.66KW
Rudder:	KaMeWA S-17
Steering:	KaMeWA S-17
Bow Thruster	1 x 500 HP Electrically driven forward tunnel thruster
Electrical power:	Daihatsu 3 x 600 KVA
Emergency generator	Batteries
Fuel capacity:	550 m^3 ^{90}% Full
Fresh water capacity:	326.44 m3
Fresh water generator:	17 m^3/day
Sewage treatment plant	Taikokika WS-1-15
Incinerator	Volcano VTV-25B
Crane (made, type & capacity):	Palfinger 2.0 tons Forward Crane 2.0 Tons Aft Crane HIAB 0.6 Tons
Winch:	2 CDP
Hydraulic power pack:	
Accommodation:	55 persons
Galley stores (how many, capacity):	Full crew 60 Days
Mess (how many, capacity):	Officer Room 12 Crew 14
Day room:	Officer 18, Crew 12 + Lounge 14
Air condition:	Yes

Auto Pilot:	Yokogawa PT 200
GPS:	Trimble. On the bridge Furuno, JRC & Garmin
Differential GPS receiver:	Fugro Starfix
Radar no.: 1	JRC JMA-800 S-Band
Radar no.: 2	JRC JMA-800 X-band
Radar no.: 3	Nil
Gyro no.: 1	Yokogawa CMZ 300 X
Gyro no.: 2	Yokogawa CMZ 300 X
Speed log:	Using GPS
VHF direction finder	Nil
Wind sensor:	Koshin
Nav. Echo Sounder:	JRC JFE -582
Navtex:	JRC NCR-300A
Weather fax:	JRC JAX-90

Survey Equipment

Positioning	1x Star Fix Ultra Differential Global Positioning System (DGPS). Antenna and cabling
(Back-up)	1x Star Fix Ultra Differential Global Positioning System (DGPS). Antenna and cabling.
On-line Navigation	1x Data acquisition QC package c/w computer running QPS QinSy interfaced to the positioning system, TLGH computer, echo sounder, gyro, plotter and printer
Gyro	2x TSS Meridian Gyro
Singlebeam Echo sounder	1x Simrad EA 600 at 12kHz, 38kHz and 200kHz 1x Simrad EA 600 topside recorder

Multibeam Echo sounders	1x Kongsberg EM 1002 (water depth < 100meters), 1x Kongsberg EM 122 (water depth > 1000meters), Seatex Sepath 330+ with MRU 5+ 1x Kongsberg Neptune Processing System
CTD Probe	2x Valeport CTD 606 7.5kW Winch, with 6000meters Amsteel 12-strand blue rope
Acoustic Probes	Sippicaan Hand Held Launcher XBT T5 and XSV 02 probes
Sub-bottom Profiler	1x *SES Digital Sub Bottom Profiler* 1x Massa TR1075 4X4 Hull Mounted SBP Array 1x *CODA DA2000* Recorder

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The R/V Gyre

The R/V GYRE is a multi-use vessel suited for a wide variety of oceanographic research duties. The Gyre is equipped with satellite communications (voice, fax, and email), differential GPS, geophysical survey gear (USBL positioning, bathymetry, SSS, magnetometer, etc) and large a-frames with high-speed winches for coring or geotechnical work. The Gyre is also outfitted with a suite state-of-the-art equipment for environmental studies (CTD, ADCP, Mocness zooplankton sampling system, etc.

Basic Specifications

- LENGTH OA: 182 ft - 55.47 m
- BEAM: 36 ft - 10.97 m
- FREEBOARD TO WORKING DECK: 1.4 m
- MAX. DRAFT: 12 ft - 4 m
- TONNAGE (LONG TONS): 292 gross, 197 net, 946 displacement.
- SPEED: Maximum, 11.5 knots; cruising, 9.5
- FUEL CAPACITY: 86,000 gallons (278 m3)
- WATER CAPACITY: 8,600 gallons
- EVAPORATORS: 2 Maxims, 60 GPH, (6 m3/day)
- CLEAN WATER: Uncontaminated sea water available in lab
- RANGE, NOMINAL: 8,000 miles
- ENDURANCE: 21 days nominal, 35 days
- COMPLEMENT: Scientists/technicians 23, crew 14

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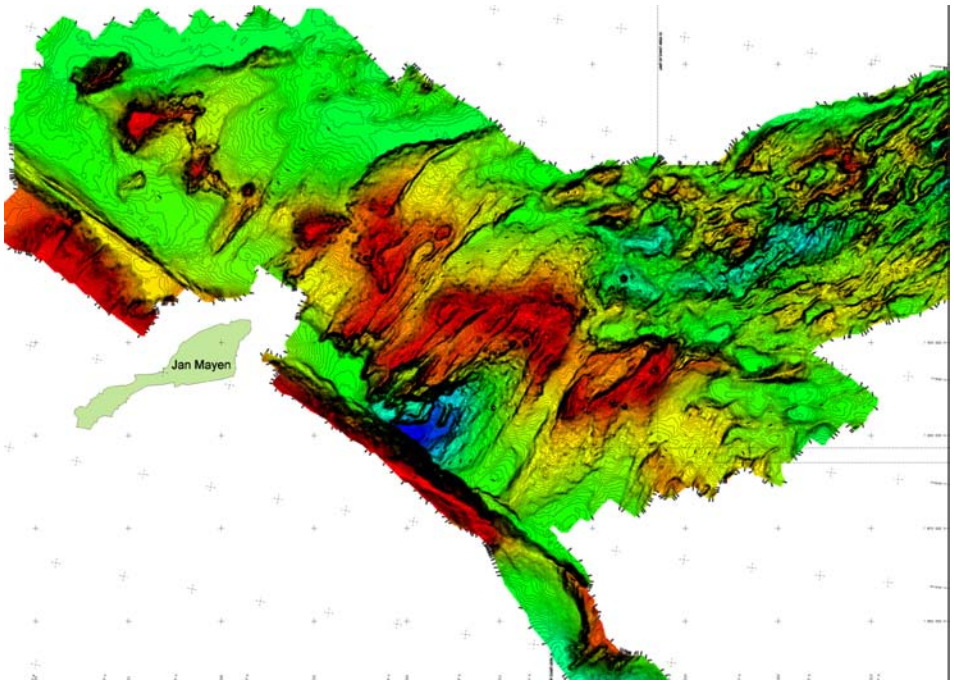
EM 122

12 kHz multibeam echo sounder

KONGSBERG

- **Depth range from 20 to 11000 m**
- **Swath width up to 6 times water depth/30 km**
- **Focused beams for transmission and reception**
- **High density and multiping modes for increased resolution**
- **Up to 864 soundings per ping**
- **Yaw, pitch and roll stabilization**
- **High accuracy**
- **Seabed image (sidescan) data display and recording**
- **Water column data display and recording**
- **Modular design, beamwidths 0.5 to 4 degrees**
- **Dual and triple frequency versions possible**
- **Integrated subbottom profiler available**
- **Mammal protection**



The EM 122 12 kHz multibeam echo sounder is designed to perform seabed mapping – bathymetry and seabed imagery- to full ocean depth with an unsurpassed resolution, coverage and accuracy. It represents a major improvement from previous models by offering significantly larger swath width, improved data density, and greatly improved resolution. Beam focusing is applied both during reception and transmission.

EM 122 is equipped with a function to reduce the transmission power in order to avoid hurting mammals if they are close by.

The system has up to 288 beams/432 soundings per swath with pointing angles automatically adjusted according to achievable coverage or operator defined limits. In multiping mode, 2 swaths are generated per ping cycle, with up to 864 soundings. The beam spacing is equidistant or equiangular.

In high density mode more than one sounding can be produced per beam, such that the horizontal resolution is increased and is almost constant over the whole swath.

EM 122 uses both CW pulses and FM sweep pulses with pulse compression on reception, in order to increase the maximum useful swath width.

The transmit fan is split in several individual sectors, with independent active steering, according to accomplish compensation for the vessel movements: yaw, roll and pitch.

With multi-ping (two swaths per ping) the transmit fan is duplicated and transmitted with a small difference in alongtrack tilt. The applied tilt takes into account depth, coverage and vessel speed to give a constant sounding separation alongtrack.

The EM 122 transducers are modular linear arrays in a Mills cross configuration with separate units for transmit and receive. The projector array is available as 0.5, 1,2, or 4 degree resolution, while the receive array is available as 1,2, or 4 degrees.

The receive transducer is wideband. In conjunction with a separate low frequency transmit transducer, the EM 122 may optionally be able to deliver sub-bottom profiling capabilities with a very narrow beamwidth. This system is known as the SBP 120 Sub-Bottom Profiler.

Dual or triple frequency versions can be obtained by integration with other EM multibeams at 30, 100 or 300 kHz.

EM 122 performance data

Operating frequency ..... 12 kHz
Depth range ..... 20-11000 m
Swath width ..... 6 x Depth, to approx 30 km
Pulse forms ..... CW and FM chirp
Swath profiles per ping ..... 1 or 2
Motion compensation:
- Yaw ..... ± 10 degrees
- Pitch ..... ± 10 degrees
- Roll ..... ± 15 degrees
Sounding pattern ..... Equi-distant on bottom/equiangular
Depth resolution of soundings ..... 1 cm
High resolution mode ..... High Density processing
Sidelobe suppression ..... - 25 dB
Suppression of sounding artefacts ..... 9 frequency coded transmit sectors
Beam focusing ..... On transmit (per sector) and on reception (dynamic)
Beamforming method ..... Time delay
Gain control ..... Automatic
Swath width control ..... Manual or automatic, all soundings intact even with reduced swath width
Seabed imagery/sidescan sonar image ..... Standard
Water column display ..... Standard
Mammal protection ..... Standard
Multi frequency operation ..... Yes, by integration with EM 3002, EM 710 and/or EM 302
Sub bottom profiling ..... Yes, by integration with SBP 120

Versions of EM 122

System version	0.5 x 1	1 x 1	1 x 2	2 x 2	2 x 4	4 x 4
Transmit array [deg]	150 x 0.5	150 x 1	150 x 1	150 x 2	150 x 2	150 x 4
Receive array [deg]	1 x 30	1 x 30	2 x 30	2 x 30	4 x 30	4 x 30
No of beams/swath	288	288	288	288	144	144
Max no of soundings/swath	432	432	432	432	216	216
Max no of swaths per ping	2	2	2	1	1	1
Max no of soundings/ping	864	864	864	432	216	216

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KONGSBERG

GENERATIONS AHEAD IN SONAR & ULTRASONIC TECHNOLOGY

Massa TR-1075
Sub-Bottom Profiling Transducers

The Massa Model TR-1075 Family consists of rugged high-power underwater transducers designed to operate in the 2.5 to 10 KHz frequency range. They are ideal for use in bottom mapping and sub-bottom profiling applications.

The transducers are designed to be driven with a maximum input power of 600 Watts using up to a 30% duty cycle, or 200 Watts maximum for continuous operation. In shallow water, the maximum output is cavitation limited. Minimum water depths of approximately 30 and 100 feet are recommended for input power of 200 and 600 Watts respectively to avoid cavitation.

All of the transducers in the family utilize the same resonant structure containing a circular piston for the radiating source that is ½ wavelength in diameter at 4 KHz. The transducers are designed to be bolted directly through their 4-corner integral shock mounts to a simple frame structure. This modular design allows the transducers to easily be assembled into arrays to achieve any desired beam pattern and source level. Each transducer is terminated with a Massa C1F2 Female Underwater Connector and has a locking ring included. Mating C1M2 Male Connectors can be purchased separately.

The TR-1075E consists of the basic resonator with no electrical tuning. Its nominal frequency of resonance is 3.5 KHz. Massa has fabricated TR-1075 Transducers with a wide variety of different internal tuning networks. They have included transformers to produce different output impedance magnitudes. Transducers have been made with both series and parallel tuning to produce a nominal phase angle of 0 at different frequencies. A separate inductor is required for series tuning, while the inductance of the primary windings of the transformer is used for parallel tuning.

In some cases, damping resistors have been connected across the transducer to lower its Q, which allows the use of a short tone burst excitation pulse with reduced sensitivity for operation when very close to the sea floor. These transducers can be driven with greater input power because some of the energy is dissipated by the resistor. Massa can customize a tuning network to meet any requirement, but one of the standard models will usually meet the needs of most customers.

FEATURES

- High Power
  - Up to 600 Watts @ 30% Duty Cycle
  - Up to 200 Watts CW
- Broadband
  - 2.5 to 10 kHz
- MaximumOperating Depth is 2,000 ft.
- True Piston Radiating Source
  - 1/2 Wavelength Diameter at 4 kHz
  - 80° Conical Beam Angle
- Module Design
  - Shock Mounted
  - Easily Assembled into Arrays
- Weight is 25 lbs.
- Terminated with Proven Reliable C1F2 Underwater Connector
- Mates to Massa C1M2 Underwater Connector

APPLICATIONS

- Sub-Bottom Profiling
- Bottom Mapping

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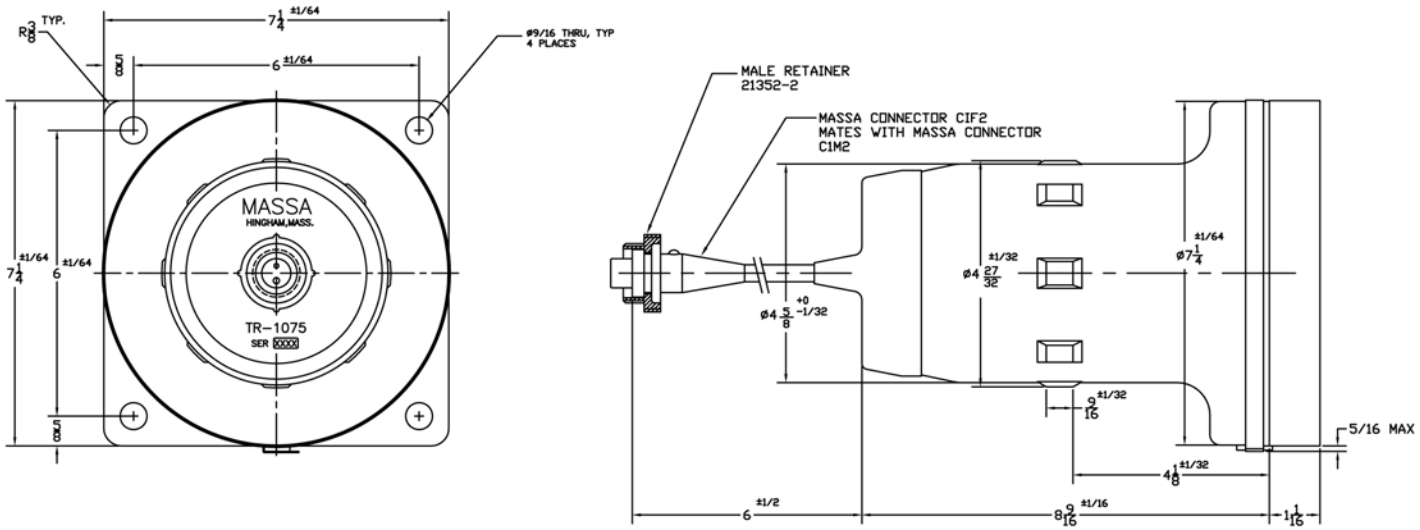
Massa TR-1075 Data



TR-1075 Transducer Family Outline Drawing
(Dimensions in Inches)

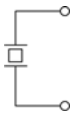
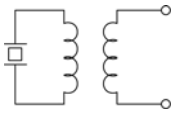
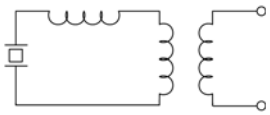
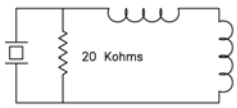
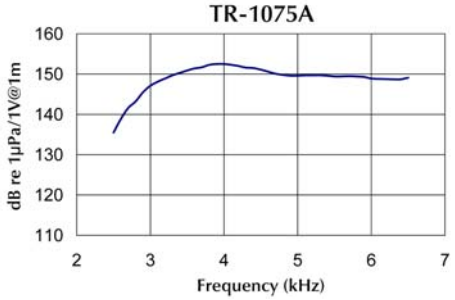
Transducer Model Number	Frequency Tuned for 0° Phase *(nominal)*	Impedance Magnitude *(nominal)*	Power Rating % Duty Cycle	Tuning Circuit
TR-1075E	No Tuning	4,500 Ohms @ 3.5 kHz	600 Watts @ 30% 200 Watts @ 100%	No Tuning 
TR-1075A	4 kHz	100 Ohms @ 4 kHz	600 Watts @ 30% 200 Watts @ 100%	Parallel 
TR-1075H	3.5 kHz	200 Ohms @ 3.5 kHz	600 Watts @ 30% 200 Watts @100%	Series 
TR-1075D	3.5 kHz	200 Ohms @ 3.5 kHz	1,000 Watts @ 30% 335 Watts @ 100%	Series with Shunt Resistor 

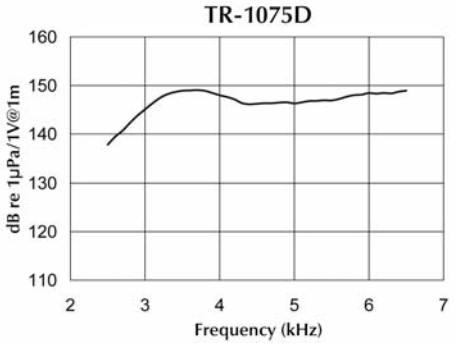
Chart Showing the Tuning Circuits for the Standard Models of the TR-1075 Transducer Family

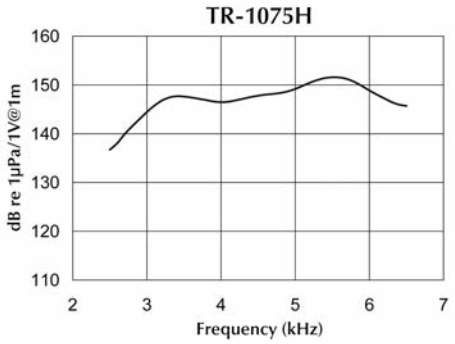
All Specifications subject to change without notice.

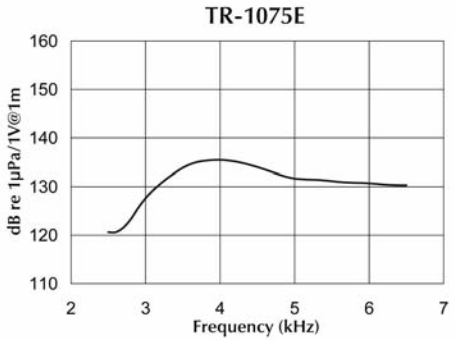
Massa TR-1075 Nominal Response Curves

Transmitting Voltage Responses

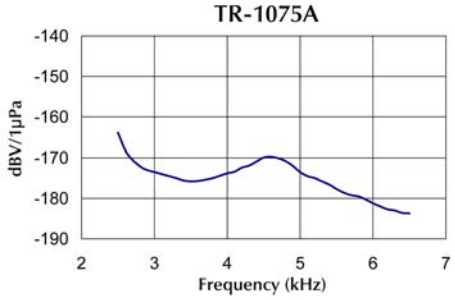


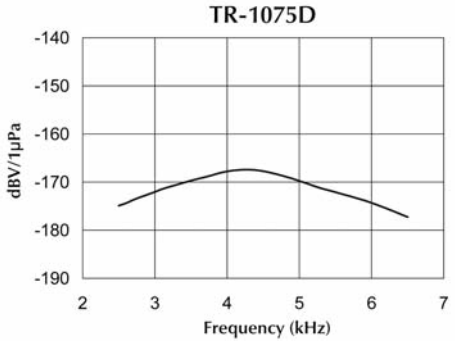


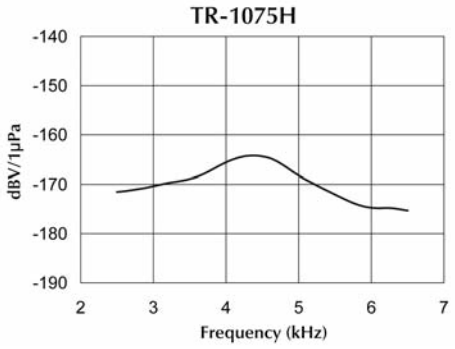


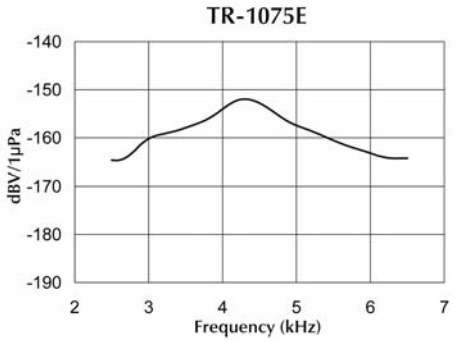


Receiving Voltage Sensitivities

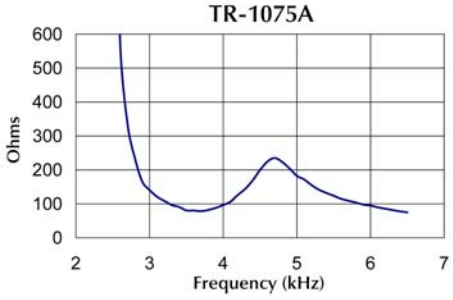


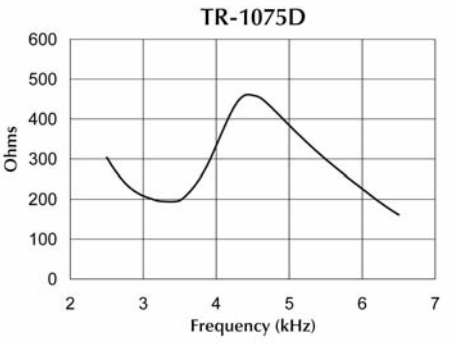


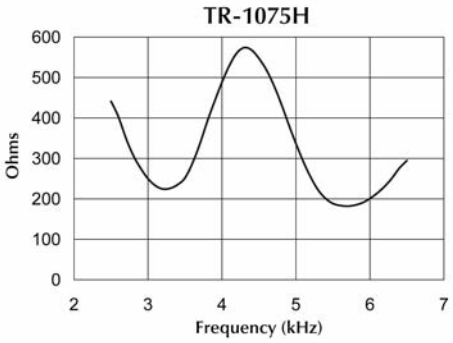


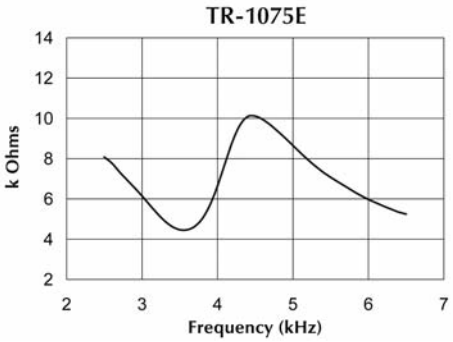


Impedance Magnitudes









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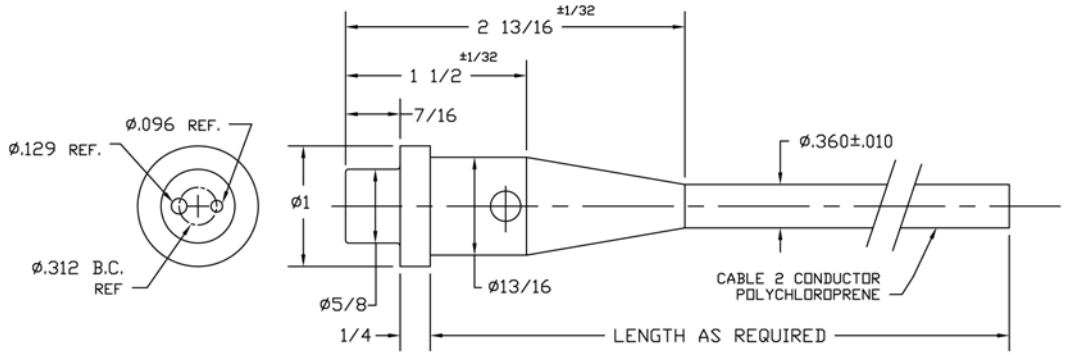
Massa C1M2/C1F2 Underwater Connectors

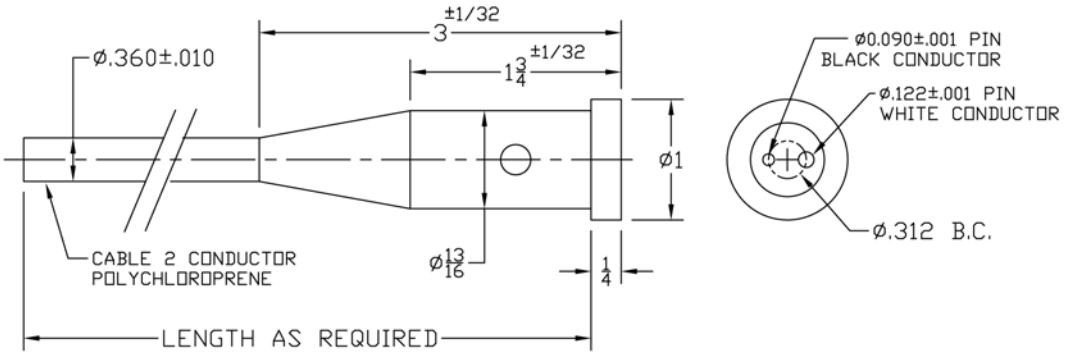
Photograph of C1M2 and C1F2 Connectors with Retaining Rings

Massa C1M2 male and C1F2 female 2-conductor in-line Underwater Connectors were developed for the oceanographic community to provide highly reliable underwater connection. Massa has manufactured and sold over 100,000 connector pairs, and some have been successfully used for over 20 years in the ocean. There has never been a failure of a connector reported to Massa.

Massa typically supplies transducers with C1F2 Female Connectors attached. C1M2 Male Connectors can be purchased separately to complete the mating connection. The standard C1M2 is attached to a 5 foot cable with a retaining ring included, but connectors can be fabricated with any length of cable required.



Outline Drawing of a C1M2 Male Connector for Mating to Massa Underwater Transducers
(without retaining ring)



Outline Drawing of a C1F2 Female Connector Supplied on Massa Underwater Transducers
(without retaining ring)

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