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Cetacean and Sea Turtle Observations in the Remote Mid-Atlantic (NW) Ocean

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Abstract

Due to its remoteness, little is known about the occurrence and abundance of cetaceans and sea turtles in the pelagic mid-Atlantic Ocean. Data on cetacean and sea turtle occurrence and distribution were collected by dedicated biological observers to address U.S. monitoring and mitigation requirements associated with a vessel-based academic geophysical survey in international waters in the northwestern and mid-Atlantic Ocean from 14 June through 16 July 2018. A total of 6,949 km (503 h) of visual observations occurred while surveying north from Bermuda and ending in Woods Hole, Massachusetts. A total of 928 cetaceans representing at least 14 species and 15 sea turtles representing three species were observed. The most frequently observed cetacean species was the Atlantic white-sided dolphin (*Lagenorhynchus acutus*) (340 individuals; 37%) followed by the short-beaked common dolphin (*Delphinus delphis*) (286 individuals; 31%) and pilot whales (*Globicephala* spp.) (95 individuals; 10%). These sighting data also included an extralimital sighting of a sperm whale (*Physeter macrocephalus*) calf at 43.44° N latitude and 36.85° W longitude, and extralimital sightings of Atlantic white-sided dolphins below 38° N latitude. Loggerhead sea turtles (*Caretta caretta*) were seen most frequently (6 individuals). This study addresses a data gap in documented occurrence and lack of occurrence of cetaceans and sea turtles over a large pelagic area in the northwestern Atlantic Ocean during summer.

Key Words: cetaceans, sperm whale, *Physeter macrocephalus*, Atlantic white-sided dolphin, *Lagenorhynchus acutus*, geophysical, Bermuda, pelagic

Introduction

Cetacean occurrence, distribution, and abundance have been extensively studied near coastal regions of the western and eastern North Atlantic Ocean, including near islands (e.g., Lawson & Gosselin, 2009; Hayes et al., 2019). However, there are far fewer studies in the pelagic waters of the mid-Atlantic, particularly visual surveys, due to its remoteness and, thus, associated logistical access challenges. The limited studies have focused on visual observations from the Mid-Atlantic Ridge region (e.g., Doksæter et al., 2008; Waring et al., 2008). An exception is the Azores where extensive long-term studies have been undertaken, presumably due to the accessibility of these islands and the relatively high density of cetaceans associated with the high site-specific biological productivity related to island upwelling and currents (e.g., Silva et al., 2014; Hartman et al., 2015; Schmiing et al., 2015). Studies have also been conducted around Bermuda but have tended to focus on cetacean behavior rather than documentation of sightings (e.g., Hamilton et al., 1997; Klatsky et al., 2007). In comparison, studies and data are scant from deep offshore waters. Even less information is reported for sea turtles. Most studies on sea turtles in the North Atlantic have focused over the continental shelf regarding nesting and bycatch in fisheries (Plotkin & Spotila, 2002; Murray, 2009). In addition, juvenile green sea turtles (*Chelonia mydas*) are known to feed on seagrasses around Bermuda (Fourqurean et al., 2010). Past cetacean surveys from pelagic mid-Atlantic Ocean waters did not report sea turtle sightings.

During June and July of 2018, vessel-based visual observations for cetaceans and sea turtles were conducted during all daylight hours in the northwestern Atlantic Ocean, including the oligotrophic gyre of the Sargasso Sea (Arenovski et al., 1995; Sigel et al., 1999; Wong & Whitehead,

2014). These observations were required by the U.S. National Marine Fisheries Service (NMFS) to provide monitoring and mitigation to reduce the potential impacts from exposure to underwater sound on these species during an academic geophysical survey conducted by the Scripps Institution of Oceanography (SIO; San Diego, CA, USA). Mitigation measures to reduce exposure of cetaceans to underwater noise included shutting down the sound sources when animals were detected within an NMFS-specified shut-down distance, turning the vessel away from sightings to reduce the potential for strike, and enumerating the number of animals exposed to sounds within NMFS-regulated distances. During the cruise, a great deal of cetacean and sea turtle occurrence data were collected opportunistically along the predetermined geophysical survey routes in a little studied region of the Atlantic using standardized data collection protocol. Results reported herein help address the data gaps on these species from pelagic North Atlantic waters given the scarcity of data.

Methods

Project Overview

SIO conducted a low-energy academic marine seismic survey from the 83.5 m R/V *Atlantis* during the study period 14 June through 16 July 2018 in international waters between 33.5° and 53.5° N latitude and 37° and 49° W longitude (Figure 1). The purpose of this project was to gather data to support a potential future International Ocean Discovery Program (IODP) focused on examining regional seismic stratigraphy and providing seismic images to characterize changing sediment distributions from deep water production changes (see NMFS, 2018a). To achieve this, low-energy, high-resolution multi-channel seismic (MCS) profiles were made of the proposed study areas using a towed pair of 45 in^3 Generator Injector (GI) airguns with a total discharge volume of approximately 90 in^3 along predetermined survey lines. Airgun dominant frequency components were 0 to 188 Hz, employed at shot intervals of 9.72 s (2-m airgun separation survey) and 12.15 s (8-m airgun separation survey). Due to the nature of towing equipment, vessel speeds were faster during non-seismic transit (0 to 13 kts) than seismic periods (3 to 10 kts).

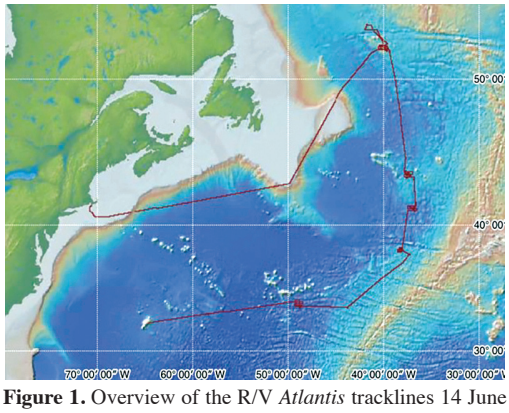

Figure 1. Overview of the R/V *Atlantis* tracklines 14 June through 16 July 2018. Start point was Bermuda.

The vessel mobilized in Bermuda and demobilized in Woods Hole, Massachusetts (Figure 1). Water depths ranged from 1,800 to over 5,000 m. Smultea Sciences, LLC conducted monitoring and mitigation for protected cetacean and sea turtle species following regulations issued by the Incidental Harassment Authorization (IHA) granted by NMFS (2018a, 2018b). Environmental data and vessel activity were collected every 30 min during Protected Species Observer (PSO) watch periods or whenever conditions changed. Sea surface temperature (SST) was measured by devices onboard, and PSOs recorded the SST every 30 min while on watch.

Cetacean and Sea Turtle Observations

Three NMFS-approved PSOs watched for cetaceans and sea turtles using the naked eye, reticle binoculars (Fujinon 7 × 50; Fujinon, Cypress, CA, USA), and/or big-eye binoculars (Fujinon 25 × 150). During the 30 min before and after sunrise/sunset, when natural light was limited, PSOs performed observations using handheld night vision devices (ITT Night Vision Goggles, Gen 3 AN/PVS-7D [F5001 Series]; ITT Industries, Stamford, CT, USA). The captain and crew were also instructed to keep watch for marine mammals and sea turtles for vessel strike avoidance and to immediately inform the PSOs of any such opportunistic sightings which were confirmed by the PSO when possible.

Prior to mobilization, PSOs were trained on specific project details and requirements, including species identification characteristics, behavior, and expected occurrence of local protected species inhabiting the general survey area (i.e., northwestern Atlantic Ocean). Species identification guides and references were always available at the PSO station on the vessel. Visual monitoring occurred during all daylight hours and 30 min before and after local sunrise/sunset. Following designated rotations, one or more PSOs monitored the surrounding waters for cetaceans and sea turtles and recorded all sightings onto a laptop using *Mysticetus*™ software (www.mysticetus.com). For each sighting, the species, identification reliability, number of individuals (low count, high count, and best estimate), vessel activity, and behavior

Table 1. Data parameters recorded as required by the Incidental Harassment Authorization (IHA) permit issued by the National Marine Fisheries Service

Data parameter	Description of data
Effort and vessel activity data	Date, time, airgun activity (i.e., whether seismic equipment was/was not active), array volume, Beaufort sea state, visibility, glare, and cloud cover, as well as the location, speed, and activity of the vessel. These data were recorded at least every 30 min when a sighting occurred or when conditions changed significantly.
Seismic period	Any time airguns were operating (on), including notations regarding ramp-up (use of seismic equipment was initiated and ramped-up at the start of survey activities beginning with the lowest acoustic output, starting with one seismic array followed by a second > 5 min after the first) and mitigation activities.
Non-seismic period	When no airguns were operational (off), data were recorded that included transit locations and times when magnetometer or sonar equipment (multibeam echosounder, side-scan sonar, sub-bottom profiler) were operational.
Sighting data	When cetaceans or sea turtles were sighted, data were recorded regarding date, time, species, the total number of individuals, number of calves (< 1/3 the length of the closely accompanying adult)/juveniles, bearing of the sighting relative to the heading of the R/V *Atlantis*, direction of movement relative to the vessel, initial distance from the vessel, closest observed point of approach to the airgun array location, behavior state when sighted, secondary behavior, pace (i.e., animal's swim speed), vessel position, water depth, number and location of other vessels within a 5 km radius, and the time that mitigation measures were requested and implemented (if necessary).

were recorded (Table 1; see Smultea et al., 2018, for detailed behavior definitions). Observations occurred while airguns were operating (seismic period) and when the airguns were not operating (non-seismic periods, including transit to/from port and between survey sites) except for during inclement weather (Beaufort sea state > 5).

PSOs monitored primarily from the mid-level deck (approximately 10.4 m above sea level [ASL]) or from the ship's bridge (approximately 12.8 m ASL). Distance to sightings was determined by PSOs entering binocular reticle or estimated distance (in meters) into a laptop running *Mysticetus*™ along with the estimated bearing (in degrees) of the sighting from the observer. The *Mysticetus*™ program automatically converted reticles to distance considering specific observer eye height above sea level (including deck height) by applying trigonometry and corrections for curvature of the earth. Individual PSO eye heights and deck heights were measured prior to the survey during mobilization. *Mysticetus*™ then was used to automatically and immediately plot sighting locations on a bathymetric chart displayed on the PSO laptop. During non-seismic periods (e.g., transit), observations were focused toward the front of the bridge and to either side of the bow (180° arc). During seismic periods, observers monitored around the entire vessel (360°). Data were collected on sightings, parameters required by the IHA (Table 1), and supplemental data (the supplemental data table for this article is available in the "Supplemental Material" section of the *Aquatic Mammals* website). Effort and vessel activity data were recorded every 30 min or whenever conditions changed.

To minimize the potential for exposure to underwater sounds associated with geophysical operations, standard and conservative seismic survey-related mitigation measures were implemented for all protected species approaching, entering, or within designated safety zone distances during airgun operations as required by the IHA. This included implementing an exclusion zone (EZ) of < 100 m around the seismic equipment and a conservative buffer zone of 100 to 500 m radius when airguns were active. Airgun power-down or shutdown procedures were implemented when a cetacean or sea turtle was sighted within or approaching applicable zones. Shutdown procedures were also required for sightings of a large whale with a calf, where a "calf" was defined as an animal less than two-thirds the body size of an adult and observed to be in close association with an adult, at any distance (NMFS, 2018b).

Results

Effort

From 14 June to 16 July, the R/V *Atlantis* covered 10,657 km of tracks, during which PSOs conducted observations for 6,949 km for a total of 503 h during the 32-d survey (Table 2). They were on watch during all daylight periods except

Table 2. Monitoring effort (h) and vessel trackline (km) completed while the Protected Species Observers (PSOs) were monitoring during different vessel states.

Description	Hours	Kilometers
Operations (Airguns ON)	258	3,262
Ramp up (Airguns ON)	3	27
Underway/transit/other (Airguns OFF)	242	3,660
Total	503	6,949

for inclement weather for an average of 15.3 h daily (SE 2.2 h). Airguns were on for roughly half (52%) of the observation hours (Figure 2).

Sightings

PSOs recorded a total of 120 sighting events (i.e., groups of animals), comprising an estimated 928 (98%) individual cetaceans and 15 (2%) sea turtles. This included 17 sightings made by the captain or crew, representing 14% of the total 120 sighting events, nine of which were then confirmed by the PSO on watch. No pinnipeds were confirmed during the survey. Groups were defined as individuals belonging to the same species that remained together and interacted with one another (i.e., traveling or foraging together; Acevedo-Gutiérrez, 2002). Of the 120 sighting events, 32% (n = 303) of all individuals were seen when seismic equipment was off (e.g., underway/in transit or deploying equipment prior to turning on the equipment); the remaining 68% (n = 641) of individuals were observed when seismic equipment was being operated (Table 3).

The number of sightings (number of groups observed) decreased with increasing distance from the vessel, ranging from 1 to 7,000 m, with the median sighting distance being 400 m (Figure 2). Average initial sighting distance was farther when airguns were on (n = 82; 1,659.5 to 1,914.75 m; median 700 m) vs when they were off (n = 40; 593.42 to 1,354.91 m; median 62.5 m). Sea turtles were not detected as far from the vessel (initial sighting 1 to 500 m; median 20 m) as dolphins (initial sighting 1 to 7,000 m; median 200 m), non-delphinid odontocetes (initial sighting 120 to 7,000 m; median 600 m), and whales (initial sighting 15 to 7,000 m; median 2,000 m) (Figure 3).

The overall sighting rate (number of initial sightings per 1,000 PSO effort hours) for all cetaceans and sea turtles was 242.5 (Table 3). Dolphins (i.e., delphinids) had the highest sighting rate (125.4) followed by mysticete whales (49.8), sea turtles (29.8), non-delphinid odontocetes (27.8), and unidentified cetaceans (9.5).

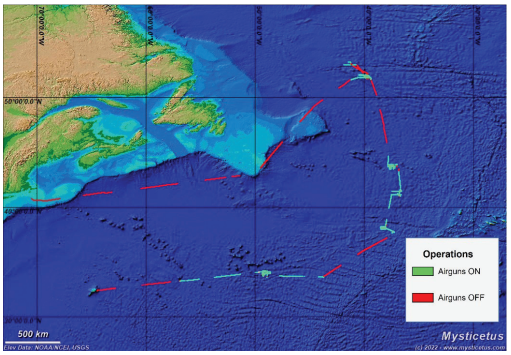

Figure 2. Vessel tracklines from 14 June to 16 July 2018 when PSOs were on watch indicating when the airguns were on or off. Gaps in the trackline indicate times when PSOs were off effort (i.e., non-daylight hours).

Odontocetes

The only non-delphinid odontocetes confirmed to species were the sperm whale (*Physeter macrocephalus*) and True's beaked whale (*Mesoplodon mirus*), comprising 4.6% (n = 43) of all individual odontocetes sighted (Table 3). Delphinids were the most sighted taxonomic grouping, comprising 90% (n = 848) of all individual animals sighted and representing the top five most observed species overall (Table 3). The Atlantic white-sided dolphin (*Lagenorhynchus acutus*) was the most frequently seen delphinid species, comprising 36% of all individuals and 40% of all delphinids sighted. They were followed by short-beaked common dolphins (*Delphinus delphis*; 30% of all individuals and 34% of all delphinids sighted), pilot whales (*Globicephala* spp.; 10% of all individuals and 11% of all delphinids sighted), Atlantic spotted dolphins (*Stenella frontalis*; 7% of all individuals and 8% of all delphinids sighted), and unidentified dolphins or porpoises (5% of all individuals and 6% of all delphinids sighted).

Non-delphinid odontocete group sizes ranged from one to eight with a mean of 3 (SE 2.5). The maximum non-delphinid odontocete group size was eight sperm whales, all of which were juvenile-sized. One sperm whale calf was also seen in a mother–calf pair. True's beaked whales were

Table 3. Estimated number, group size, sighting rate (number of individuals initially detected per 1,000 observation effort hours), and water depth of cetaceans and sea turtles by species, including when airguns were on and off. Species are listed in alphabetical order by taxonomic group. NA = sample size too small to calculate standard error (SE) or sightings not identified to species. Note that any discrepancy in totals is due to rounding.

		Airguns ON			Airguns OFF			Total					Mean water depth (m)	SE
Species	Scientific name	Number sightings	Number individuals	Sighting rate	Number sightings	Number individuals	Sighting rate	Number sightings	Number individuals	Sighting rate	Mean group size	SE		
Mysticetes														
Blue whale	*Balaenoptera musculus*	3	3	11.5	0	0	NA	3	3	6.0	3.0	1.00	4,368	63.4
Fin whale	*B. physalus*	0	0	NA	1	1	4.1	1	1	2.0	1.0	NA	4,269	NA
Minke whale	*B. acutorostrata*	0	0	NA	1	1	4.1	1	1	2.0	1.0	NA	56	NA
Sei whale	*B. borealis*	1	1	3.8	0	0	NA	1	1	2.0	1.0	NA	3,671	NA
Unid. whale	NA	18	25	69.0	1	2	4.1	19	27	37.8	1.5	0.84	NA	NA
Odontocetes														
Sperm whale	*Physeter macrocephalus*	11	31	42.1	2	8	8.3	13	39	25.8	2.9	2.63	3,851	48.7
True's beaked whale	*Mesoplodon mirus*	0	0	NA	1	4	4.1	1	4	2.0	4.0	NA	3,993	NA
Delphinids														
Atlantic spotted dolphin	*Stenella frontalis*	5	54	19.2	2	11	8.3	7	65	13.9	9.3	6.32	4,345	340.0
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	8	218	30.7	3	122	12.4	11	340	21.9	30.6	39.91	4,099	450.6
Pilot whale spp.	*Globicephala* spp.	2	67	7.7	4	28	16.5	6	95	11.9	15.3	15.38	3,848	557.7
Risso's dolphin	*Grampus griseus*	1	9	3.8	0	0	NA	1	9	2.0	9.0	NA	3,983	NA
Short-beaked common dolphin	*Delphinus delphis*	18	200	69.0	8	86	33.1	26	286	51.7	10.7	10.89	4,036	845.8
White-beaked dolphin	*L. albirostris*	0	0	NA	1	5	4.1	1	5	2.0	5.0	NA	3,315	NA
Unid. dolphin/porpoise	NA	6	25	23.0	5	23	20.7	11	48	21.9	4.8	3.58	NA	NA
Sea turtles														
Green turtle	*Chelonia mydas*	2	2	7.7	0	0	NA	2	2	4.0	1.0	0.00	3,654	186.7
Leatherback turtle	*Dermochelys coriacea*	0	0	NA	2	2	8.3	2	2	4.0	1.0	0.00	62	6.0
Loggerhead turtle	*Caretta caretta*	3	3	11.5	3	3	12.4	6	6	11.9	1.0	0.00	3,930	298.5
Unid. sea turtle	NA	1	1	3.8	4	4	16.5	5	5	9.9	1.0	0.00	NA	NA
Unidentified cetacean														
Unid. cetacean	NA	3	2	11.5	2	2	8.3	5	5	9.9	1.0	0.00	NA	NA
Totals		82	641	314.2	40	302	165.3	122	943	242.5	7.7	15.61		

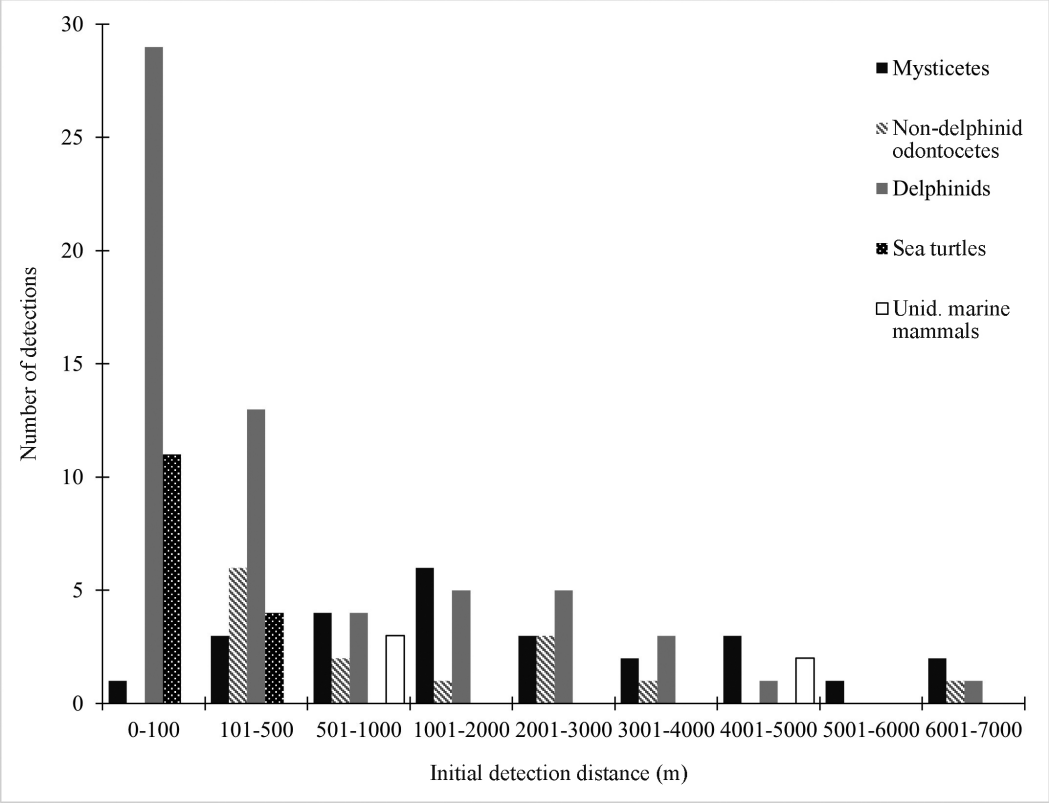

Figure 3. Number of mysticetes (n = 25), non-delphinid odontocetes (n = 14), delphinids (n = 61), sea turtles (n = 15), and unidentified cetaceans (n = 5) by initial sighting distance.

only observed once. Non-delphinid odontocetes were observed over water depths between 2,966 and 4,299 m (mean 3,826 m; SE 434 m). Delphinid group sizes ranged from one to 125 individuals with a mean of 13.5 (SE 20.2). Atlantic white-sided dolphins had the largest mean group size (30.6; n = 11), which was at least double that of all other delphinids (Table 3). White-beaked (*Lagenorhynchus albirostris*) and Risso's (*Grampus griseus*) dolphins were only observed once, whereas all other dolphin species were seen throughout the voyage (Figure 4). Four delphinid species (Atlantic white-sided dolphins, Atlantic spotted dolphins, short-beaked common dolphins, and pilot whales) had groups that contained at least one calf (n = 11; 21% of all groups). Delphinids were observed over water depths between 73 and 4,937 m (mean 3,977 m; SE 734 m). The largest concentrations of all odontocetes occurred between 40° and 50° N latitude and 35° and 40° W longitude (68% of sightings; 71% of non-delphinid odontocetes; 67% of delphinid sightings) (Figure 4B). Water depth between 40° and 50° N latitude and 35° and 40° W longitude was 4,156 m on average (SE 188 m).

Behavior state was documented among 64 of the total 66 confirmed odontocete species sightings and involved eight species (Table 4). The majority of observed behavior states among odontocetes consisted of surface-active travel (73%), followed by bowriding (13%), travel (8%), and surface-active mill (5%). Behavior state was most commonly observed for the short-beaked common dolphin (n = 25 sightings), followed by the sperm whale (n = 13 sightings), Atlantic white-sided dolphin (n = 11 sightings), and Atlantic spotted dolphin (n = 7 sightings), corresponding with the highest numbers of overall sightings of these species (Table 3).

Mysticetes

Mysticete whales comprised 3.5% (n = 33) of all individual animals sighted (Table 3). The most sighted species were unidentified whale species (76%), followed by blue whales (*Balaenoptera musculus*; 12%) (Figure 5A). Of the unidentified whales, 68% (n = 13) were only spotted by their blow.

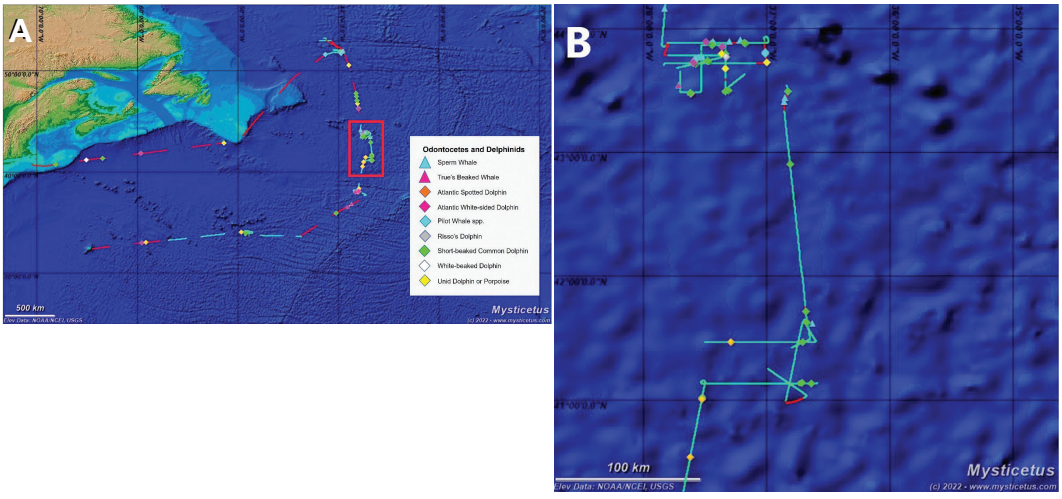

Figure 4. (A) Map of odontocete sighting locations in the North Atlantic Ocean from 14 June to 16 July 2018. Area in the red box is enlarged in (B). Tracklines shown with airguns on (green segments) and off (red segments).

Table 4. Behavior states by species of cetacean and sea turtle for those groups sighted where behavior state and species were documented. See Table 3 for scientific species names. Species are listed in alphabetical order by taxonomic group.

Species	Bowride	Surface-active travel	Rest	Travel	Surface-active mill	Mill	Total
Mysticetes							
Blue whale	0	0	0	1	0	0	1
Fin whale	0	1	0	0	0	0	1
Minke whale	0	0	0	1	0	0	1
Sei whale	0	0	0	1	0	0	1
Odontocetes							
Sperm whale	0	10	1	1	0	0	12
True's beaked whale	0	1	0	0	0	0	1
Delphinids							
Atlantic spotted dolphin	1	3	0	3	0	0	7
Atlantic white-sided dolphin	1	9	0	0	1	0	11
Pilot whale spp.	0	5	0	0	1	0	6
Risso's dolphin	0	1	0	0	0	0	1
Short-beaked common dolphin	6	17	0	1	1	0	25
White-beaked dolphin	0	1	0	0	0	0	1
Sea turtles							
Green turtle	0	0	2	0	0	0	2
Leatherback turtle	0	1	0	0	0	1	2
Loggerhead turtle	0	0	2	0	2	2	6
Total	8	49	5	8	5	3	78

Mysticete group size ranged from one to four with a mean of 1.4 (SE 0.7). Seventy-six percent of all whale sightings ($n = 19$) consisted of a solitary whale. No mysticetes were seen with calves. Whales were observed over water depths between 56 and 4,452 m (mean 3,952 m; SE 866 m). The first whale was seen 4 d into the voyage (18 June), over 1,506 km northeast of the survey start location in Bermuda (Figure 5A). Most whales (72% of sightings) were seen between 40° and 50° N latitude and 35° and 40° W longitude, like odontocetes (Figure 5B).

Behavior state was documented among all six of the confirmed mysticete sightings representing four species, with 75% engaged in travel and 25% in surface-active travel (Table 4).

Sea Turtles

A total of three sea turtle species were documented, representing 2% ($n = 15$) of all individual animals sighted. Loggerhead turtles (*Caretta caretta*) were the most common, comprising 40% of all individual sea turtles ($n = 6$). Unidentified sea turtles were the second-most common type of turtle sighting, followed by green and leatherback (*Dermochelys coriacea*) turtles (Figure 6A).

All sea turtles were solitary. Two sea turtles (one green and one loggerhead; 13% of sightings) were small for their species and deemed to be juveniles. One loggerhead sighting was accompanied by about 18 small (approximately 0.3 m long) ocean sunfish (*Mola mola*) swimming

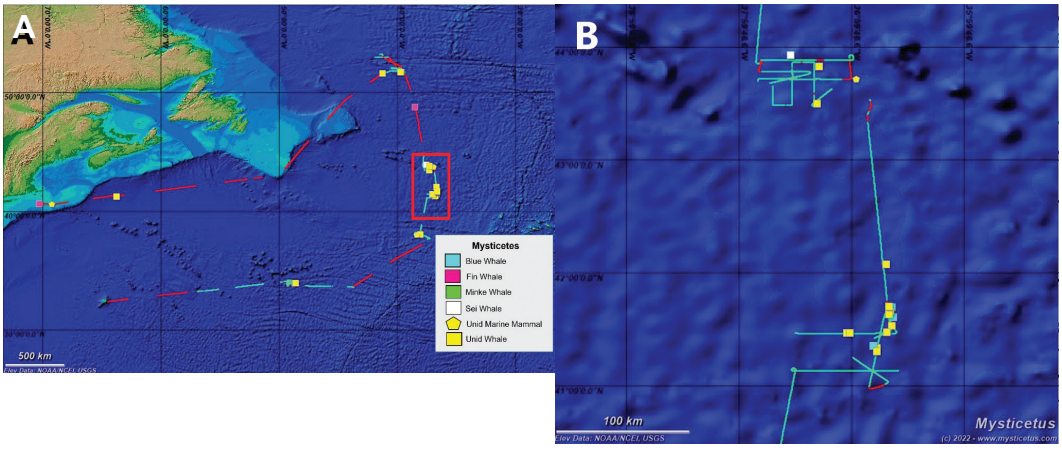

Figure 5. (A) Map of mysticete, unidentified whale, and unidentified cetacean sighting locations in the North Atlantic Ocean from 14 June to 16 July 2018. Area in the red box is enlarged in (B). Tracklines shown with airguns on (green segments) and off (red segments).

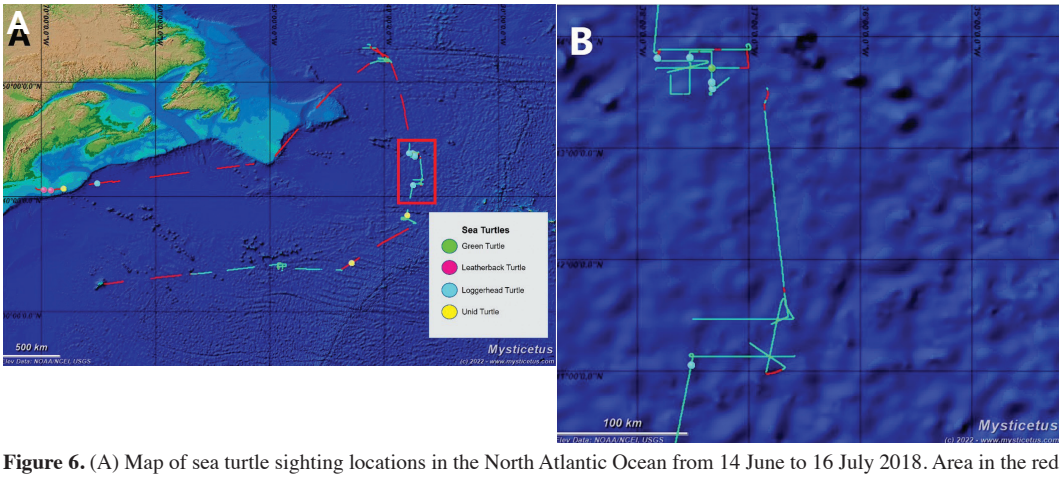

Figure 6. (A) Map of sea turtle sighting locations in the North Atlantic Ocean from 14 June to 16 July 2018. Area in the red box is enlarged in (B). Tracklines shown with airguns on (green segments) and off (red segments).

around it. Sea turtles were observed over water depths between 56 and 4,292 m (mean 3,145 m; SE 1,546 m). The first sea turtle sighting occurred 1 wk into the voyage (22 June), approximately 4,263 km northeast from the Bermuda survey start. Sea turtle sightings were more spread out than cetacean sightings except for a small cluster ($n = 8$) around 43° N latitude and 37° W longitude (Figure 6B).

Behavior state was documented for all of the 10 confirmed sea turtle species sightings, with most (40%) engaged in rest followed by 30% mill, 20% surface-active mill, and the remaining 10% ($n = 1$) surface-active travel (Table 4).

Unidentified Cetaceans

Unidentified cetaceans comprised 0.5% ($n = 5$) of all individual animals sighted. All unidentified cetaceans were solitary. Four of the sightings consisted of a splash, but a determination could not be made of whether they were mysticetes or odontocetes. The final unidentified cetacean was a 2 to 3 m long oblong shape floating on the surface with birds hovering over it and was possibly deceased. Unidentified cetaceans were observed between 700 to 5,000 m from the vessel (mean 2,440 m; SE 1,896 m).

Unidentified cetaceans were observed over water depths between 61 and 4,130 m (mean 3,159 m; SE 1,556 m). The first whale (unidentified species) was seen 7 d into the voyage (25 June), over 1,500 km northeast of the survey start location in Bermuda (Figure 5A). Most unidentified cetaceans (60% of sightings) were seen between 40° and 50° N latitude and 35° and 40° W longitude, like odontocetes, mysticetes, and sea turtles (Figure 5B).

Discussion

Prior to this study, very few surveys in pelagic waters of the northwestern Atlantic Ocean have systematically recorded cetaceans and especially sea turtles. Twelve cetacean species (six delphinids and six whales) and three sea turtle species were observed on this survey. Prior to our survey, the relative occurrence for all cetaceans we saw was noted as uncommon by NMFS, except for the True's beaked whale, which was considered rare as there are few sightings of recorded Mesoplodont beaked whales in the survey area (NMFS, 2018a). The most commonly seen cetaceans (in descending order of individuals) were Atlantic white-sided dolphins, short-beaked common dolphins, pilot whales, Atlantic spotted dolphins, and sperm whales, consistent with available literature (e.g., Doksæter et al., 2008; Waring et al., 2008; Silva et al., 2014; NMFS, 2018a; Hayes et al., 2019). Unidentified animals were relatively common (8.5% of all individuals) on this voyage, which was attributed to the vessel's dedication to the overarching academic geophysical survey goals that did not facilitate maneuvering the vessel to follow sightings. Therefore, animals at a distance were more challenging to identify than those who surfaced near the vessel.

No protected species were observed on the first day of the voyages in the Sargasso Sea, a generally oligotrophic gyre in the northwestern Atlantic Ocean (Arenovski et al., 1995; Sigel et al., 1999; Wong & Whitehead, 2014) bordered in the north by the Gulf Stream and in the south by the Antilles Current. This area is traditionally thought to be low in nutrients, except for the northern border where the Gulf Stream creates mesoscale eddies that create areas of higher productivity (Sigel et al., 1999; Wong & Whitehead, 2014). While nutrient concentrations were not measured in this survey, traveling through an area of generally low nutrients may have contributed to the lack of sightings over the first few survey days.

The occurrence of most of our sightings was consistent with the species' typical distribution and water depth ranges (Jefferson et al., 2015). Two species (Atlantic spotted dolphin and Risso's dolphin) were seen further offshore than their typical reported range but were still within a reasonable secondary range. Studies indicate that delphinids showed less preference for specific bottom depths while in pelagic (> 1,000 m) waters compared to coastal waters (Baumgartner et al., 2001; Doksæter et al., 2008). The survey occurred in a region of the North Atlantic where both the long-finned (*Globicephala melas*) and short-finned (*Globicephala macrorhynchus*) pilot whales are distributed (Jefferson et al., 2015). At sea, the two pilot whale subspecies are often difficult to differentiate (Rone & Pace, 2011; Jefferson et al., 2015; Thorne et al., 2017), especially without the aid of a camera. This survey did not have a camera available, and the vessel could not approach animals, so for the purpose of this study, pilot whale subspecies were not identified. We observed pilot whales over depths of 3,003 to 4,569 m, similar to studies along the Mid-Atlantic Ridge (Waring et al., 2008), near the Azores (Silva et al., 2014) and the Ligurian Sea (Azzelino et al., 2008). In all these studies, including ours, these species demonstrate pelagic preferences, consistently occurring in water over 1,000 m deep. Short-finned pilot whale studies in the coastal North Atlantic have reported the highest density along the 1,000-m isobath (Stepanuk et al., 2018), while studies in the Pacific have found short-finned pilot whales in waters up to

9,661 m depth (Hill et al., 2019). We observed Atlantic spotted dolphins over much deeper water depths (mean 4,347 m; SE 364 m) than the shallower, continental shelf and slope waters (20 to 220 m) within 250 to 350 km of the coast typically reported for this species (Griffin & Griffin, 2003; Braulik & Jefferson, 2018). However, deeper oceanic waters are considered a secondary range (Jefferson et al., 2015). This apparent contrast in habitat preference may be attributable to two separate ecotypes of Atlantic spotted dolphins—one that occurs exclusively on the continental shelf and one that occurs in deeper waters offshore and around oceanic islands (up to 2,000 m isobath) (Jefferson & Schiro, 1997; Braulik & Jefferson, 2018). Our single sighting of a Risso's dolphin occurred over much deeper waters (3,983 m) than their reported preference for shallower continental slope waters in the North Atlantic and Ligurian Sea (depth 200 to 2,000 m; Baumgartner et al., 2001; Azzellino et al., 2008), although they have been observed in deep pelagic water in relatively low concentrations as well (Jefferson et al., 2015).

Sightings of note included sperm whales and Atlantic white-sided dolphins. Sperm whales can be found from the tropics to the poles, but typically only males travel above 40° N latitude in the Atlantic Ocean (Gosho et al., 1984). This is because females and young whales are more temperature-limited than the males (Jefferson et al., 2015). All our sperm whale sightings occurred north of 43° N latitude, including juveniles and a mother–calf pair at 43.44° N latitude. While females have been seen as far north as 54° N latitude (Gosho et al., 1984), this sighting of a female and young sperm whales occurred on the outer edge of their known limit. Our most northerly sperm whale sightings were two individuals and a group of three between 51.88° and 51.93° N latitude, although sex was not determined. Atlantic white-sided dolphins were observed from 33° to 41° N latitude, which was quite south of the expected southern limit (about 38° N latitude) for this temperate and subarctic dwelling species in the western Atlantic (Reeves et al., 1999; Doksæter et al., 2008; Jefferson et al., 2015). Our deep-water sightings (mean 4,099 m; SE 473 m) were outside their typical preference for deeper waters of the outer continental shelf and slope (Jefferson et al., 2015).

We observed a relatively dense cluster of delphinids, whales, and sea turtles (73 sightings constituting 61% of all survey sightings) between 40° to 45° N latitude and 36° to 38° W longitude over the course of 3 d from 28 to 30 June 2018 (Figures 4b, 5b, & 6b). The majority of all delphinids (54%; n = 34), whales (77%; n = 30), and sea turtles (60%; n = 9) seen during the study occurred within this area on these 3 d. All three unidentified cetacean sightings also occurred in this region. The reason this area was an apparent cetacean and sea turtle hotspot is unknown. We hypothesize that this concentration of sightings may have been related to localized oceanographic conditions. The Beaufort sea state ranged from 0 to 4 over the 3 d in this region, and visible sighting distance ranged from 3 to 10 km; however, these conditions were similar to those encountered for much of the trip and did not likely contribute to an increase in sightings. Depth ranged from 3,510 to 4,473 m, and slope ranged from 0.14° to 2.73°. This region is near the Gulf Stream and is characterized by many dynamic, localized swirling eddies, including during our observations in 2018 (Earth Null School, 2018). During the study period, this region experienced moderately lower temperatures of around 17°C SST (compared to an average of approximately 19° to 21°C SST typical for this period and region) as polar and more tropical waters mixed in this area (Climate Reanalyzer, 2023). These conditions may have resulted in biologically productive waters associated with localized gyres and currents contributing to upwelling and/or intermixing of waters conducive to foraging. The behavior states of delphinids in this region were bow riding, milling, and medium-fast traveling and included breaching and foraging/feeding behavioral events. Short-beaked common dolphins, long-finned pilot whales, and Atlantic white-sided dolphins were observed chasing or feeding on fish. Birds were observed flying above the dolphins and resting on the water. Although the species of fish being preyed on were unknown, dolphins were seen feeding on a bait ball with fish roughly 15.24 to 20.32 cm in length.

The behavior states of baleen whales in this region consisted of rest/slow travel and medium-fast traveling. Although baleen whales were not observed to be feeding at the surface, many were observed to be diving, which could indicate feeding below the surface. The behavior states of sea turtles observed were milling and rest/slow travel. One of the sea turtles was accompanied by a small ocean sunfish as described above. While not all animals were observed feeding, it is likely that animals were drawn to this area by good foraging opportunities.

Cetacean sighting rates were significantly higher during seismic vs non-seismic periods. The reasons for this are unclear and are outside the scope of this article. Although PSO effort was comparable between seismic periods (3,289 km; 261 h) and non-seismic periods (3,660 km; 242 h), the sighting rate (number of initial sightings per 1,000 PSO effort hours) during seismic periods was nearly double that of non-seismic periods. However, most of the non-seismic

periods took place during transit when the vessel was moving faster (0 to 13 kts) than seismic periods (3 to 10 kts) and PSOs focused their attention forward of the vessel for strike avoidance, which likely contributed to lower sighting rates. Effects of seismic surveys on cetaceans have been well studied for over 30 y (e.g., Mate et al., 1994; Richardson et al., 1998; Gordon et al., 2003). Though short-term behavioral responses have been documented for some species and individuals (e.g., movement away and changes in respiration, vocalization rates, and behavior), injury and adverse long-term population consequences have not been demonstrated (e.g., Dunlop et al., 2015; Kavanagh et al., 2019; Southall et al., 2019). Potential seismic impacts on sea turtles are much less understood as they have not been the focus of most noise surveys (Nelms et al., 2015). Sea turtle hearing overlaps with the sound emitted by airguns, although hearing damage to turtles is unknown (Lavender et al., 2014). Due in part to this lack of knowledge, only three countries (U.S., Brazil, and Canada) have mitigation measures for seismic exploration that includes sea turtles (Nelms et al., 2015). Regardless, mitigation measures involving delayed starts, ramp-ups, and shutdowns were implemented whenever any of these species were observed in or about to enter the mitigation zones.

Despite the limited ability to gather unbiased occurrence data during a seismic survey, our findings present new information on cetacean and sea turtle occurrence and distribution in little-studied remote pelagic waters of the Atlantic Ocean during summer. Such data are considered useful for assessing future potential changes, including those related to anthropogenic activities and global warming.

Note: A supplemental data table for this article is available in the "Supplemental Material" section of the *Aquatic Mammals* website: https://www.aquaticmammalsjournal.org/index.php?option=com_content&view=article&id=10&Itemid=147.

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