2017
Annual Report of a Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in US waters of the Western North Atlantic Ocean – AMAPPS II

Black Capped Petrel (*Pterodroma hasitata*). Photo taken by Glen Davis.

Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543

Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami, FL 33149

Contents

1 Overview of 2017

1.1 Background

The Atlantic Marine Assessment Program for Protected Species (AMAPPS) is a comprehensive multi-agency research program in the US Atlantic Ocean, from Maine to the Florida Keys. Its aims are to assess the abundance, distribution, ecology, and behavior of marine mammals, sea turtles, and seabirds throughout the US Atlantic and to place them in an ecosystem context. This information can then provide spatially explicit information in a format that can be used when making marine resource management decisions and will provide enhanced data to managers and other users by addressing data gaps that are needed to support conservation initiatives mandated under the Marine Mammal Protection Act (MMPA), Endangered Species Act (ESA), National Environmental Policy Act (NEPA) and Migratory Bird Treaty Act (MBTA).

To conduct this work NOAA's National Marine Fisheries Service (NMFS) currently has inter-agency agreements with the Bureau of Ocean Energy Management (BOEM) and the US Navy. The 2017 products of these inter-agency agreements are being developed by NMFS's Northeast Fisheries Science Center (NEFSC) and Southeast Fisheries Science Center (SEFSC).

Because of the broad nature and importance of the AMAPPS work, AMAPPS has evolved beyond the above agencies into larger collaborative programs involving researchers from a variety of domestic and international organizations. These collaborative efforts have the benefit of increasing the amount of funds and personnel for field and analytical work.

This report documents the work conducted by NMFS during 2017.

1.2 Summary of 2017 Activities

During 2017 under the AMAPPS program, NMFS conducted field studies to collect cetacean, sea turtle, seal, and sea bird seasonal distribution, abundance and biological data (Table 1.1). In addition, NMFS staff continued to analyze past and present data collected under AMAPPS I and II (Table 1.2). Recently published papers are listed in Table 1.3 and recent presentations are listed in Table 1.4. A summary of the 2017 projects follows, with more details in the following chapters.

1.2.1 Field Activities

During 17 April – 15 July 2017, the NEFSC and SEFSC conducted two aerial line transect abundance surveys covering US Atlantic waters from Florida to Maine, from the coastline to shelf break at about the 2000 m depth contour. The surveys using NOAA Twin Otter airplanes targeted marine mammals and sea turtles (Figure 1.1; Table 1.5). In total the two planes completed about 19,200 km of on-effort track lines. The observers detected about 750 groups of cetaceans consisting of about 8300 individuals for 15 positively identified species and about 1150 groups consisting of about 1400 individual sea turtles from 5 species. The most frequently detected dolphins included: common bottlenose dolphins (*Tursiops truncatus*) ranging from about 30°N – 44°N on the continental shelf and shelf break; common dolphins (*Delphinus delphis*) ranging from 36°N – 43°N in deep shelf break waters (in contrast to the summer coastal distribution); and harbor porpoises (*Phocoena phocoena*) mostly in the northern Gulf of Maine.

The most frequently detected large whales were minke whales (*Balaenoptera acutorostrata*) and humpback whales (*Megaptera novaeangliae*) who both ranged from 38°N – 44°N. Of interest are the groups of Northern bottlenose whales (*Hyperoodon ampullatus*) and beaked whales (Ziphiidae) found off Nova Scotia in waters about 2000 m deep and the additional beaked whales off Cape Hatteras in waters deeper than 250 m. The most frequently detected turtle species was the loggerhead turtle (*Caretta caretta*), with about 530 individuals that ranged from 30°N – 41°N mostly in waters on the continental shelf with large aggregations off Georgia/northern Florida, North Carolina/Virginia, and Long Island, NY. All visual line-transect data have been or will be archived in the NEFSC Oracle data base and submitted to the publically available OBIS-SEAMAP website. More information is found in Chapters 2 and 3.

During May, June, October and November 2017, visual detection data of seabirds, marine mammals, turtles, and large pelagic fish were collected during three non-marine mammal cruises in 2017: a spring Ecosystem Monitoring (EcoMon) cruise, a Bluefin Tuna Slope Sea cruise, and a fall EcoMon cruise. A fourth summer EcoMon cruise was scheduled but was canceled due to emergency ship repairs. The 300 m strip transect methodology was used to collect the data by one or two on-effort observers when the ship was travelling between collection stations during daylight hours. During these three cruises about 2050 km were surveyed and nearly 9000 birds were detected from 63 seabird species and 24 land bird species. In addition, there were detections of 74 whales of 7 species that were killer whale sized and larger; 174 dolphins and pilot whales, 3 harbor porpoises and 13 sea turtles. All strip-transect data are archived in the NEFSC Oracle data base and submitted to the USFWS Seabird Compendium who will also submit it to the publically available OBIS-SEAMAP website. More information is found in Chapter 4.

During 14 – 19 April 2017, the National Science Foundation ship *R/V Endeavor* operated by the University of Rhode Island (URI) conducted a Rhode Island Endeavor Program (RIEP) research cruise intended to explore marine mammal distribution relative to prey layers and physical oceanography while also deploying instrumentation examining carbon export to the deep sea. The cruise ran transects for sighting marine mammals (detected 51 groups), deployed 9 bongo nets and 10 CTD deployments, gathered 64 hours of active acoustic data on prey layers using a tow body equipped with 38 and 120 kHz EK60 echosounders, and collected 12 hours of passive acoustic data, which included humpback and sei whale calls. In addition underway physical oceanographic data were recorded, and a few instruments to assess carbon export to the deep sea were tested. A contractor (funded with AMAPPS funds) and a NEFSC federal staff member, who is also a doctoral graduate student at URI, participated in the research cruise by running the marine mammal, zooplankton, and active acoustic portions of the cruise. All visual line-transect data have been or will be archived in the NEFSC Oracle data base and submitted to the publically available OBIS-SEAMAP website. More information is found in Chapter 5.

During 6 – 19 July 2017, NEFSC and partners conducted a cetacean and turtle cruise aboard the NOAA Ship *Henry B. Bigelow* on the shelf and shelf break waters off of the Northeast United States and Canada. The cruise accomplished objectives related to loggerhead sea turtle ecology, maintenance (exchange) of fixed acoustic recording devices, and distribution of zooplankton, turtles and cetaceans. Five loggerhead turtles were equipped with satellite data loggers to collect location and depth profile data. Morphometric measures and tissue samples were also collected from these five turtles. High-frequency acoustic recording packages (HARPS) at three locations were retrieved and re-deployed. The HARPS are used to record vocalizing cetaceans and other species (See Chapter 9 for more details). While transiting these waters, distribution data on about 2500 animals across 25 taxonomic groups of cetaceans and turtles were collected using line transect methods. In addition, physical and biological oceanographic data such as temperature, depth, salinity, and plankton – including larval bluefin tuna (*Thunnus thynnus*) were collected at sampling stations (using 56 CTD casts, 14 bongo and 13 neuston nets for tuna and 21 neuston nets equipped with cameras for gelatinous zooplankton), while underway (using an EK60 and Acoustic Doppler Current Profiler) and via 3 drifters deployed from the ship and tracked for up to February 2018. More information is found in Chapter 6.

During 8 – 18 September 2017, on the UNOLS vessel *R/V Hugh R. Sharp* NEFSC conducted a survey for beaked whales in the western North Atlantic, focusing primarily on the Georges Bank region. The scientific crew included a visual observation team scanning for marine mammals and sea turtles using line-transect and focal-follow methods, a single observer scanning for sea birds using strip transect methods, and an acoustic team monitoring a towed hydrophone array. In addition, small boat work was conducted, when conditions were feasible, to collect identification photographs, water samples for eDNA testing, and to attempt deployment of suction cup tags on beaked whales. Approximately 800 km of track line were surveyed by the marine mammal visual team and 570 km surveyed by the seabird team. The passive acoustic team surveyed approximately 2053 km (including both daytime and nighttime recording effort) and collected over 167 hours of passive acoustic data. In total, the teams detected about 160 groups (1259 individuals) of cetaceans, 1 loggerhead sea turtle, and 259 groups (417 individuals) of birds. Beaked whales were the most commonly sighted cetacean taxa, followed by pilot whales (*Globicephala spp.*). Three CTD casts were conducted in areas where beaked whales were presumed to be foraging (based on dive times and the occurrence of echolocation clicks). Active acoustic (EK60) data were collected during one night to map prey distribution in an area associated with beaked whale foraging activity. In addition, 14 water samples were collected from several groups of Cuvier's (*Ziphius cavirostris)* and True's (*Mesoplodon mirus*) beaked whales for eDNA testing. More information is found in Chapter 7.

During 18 October 2017 – 04 January 2018, the NEFSC and SEFSC conducted two aerial line transect abundance surveys covering US Atlantic waters from Florida to Maine, from the coastline to shelf break at about the 2000 m depth contour (Figure 1.1). The surveys using NOAA Twin Otter airplanes targeted marine mammals and sea turtles. The cruise reports will be included in next year's annual report.

1.2.2 Analyses

The AMAPPS I final report was completed during 2017 (Palka et al. 2017; Table 1.3). This document reported on analyses that were completed and in progress and were on all the topics covered by AMAPPS. In particular, within Palka et al. (2017) seasonal spatially-explicit density distribution maps for 18 species or species groups were reported in Chapter 5 and Appendices 1-2, offshore seabird distribution research is in Chapter 6 and Appendix 3, coastal seabird distribution research is in Chapter 7 and Appendix 4, passive acoustic research is in Chapter 8, marine turtle tagging research is in Chapter 9, seal research is in Chapter 10, and ecosystem research is in Chapter 11 and Appendix 5.

One of the AMAPPS objectives is to assess the population size of surveyed species at regional scales and develop models and associated tools to translate these survey data into seasonal, spatially-explicit density estimates incorporating habitat characteristics. To achieve these objectives, work in 2017 related to the finalization of the AMAPPS I report and preparations for the 2018 analyses of all of the AMAPPS 2010 – 2017 abundance survey data using the generalized additive model (GAM) and Bayesian hierarchical model frameworks. This involved error-checked and archived the recently collected shipboard and aerial abundance survey data; collating, processing and error-checking the environmental habitat variables for the entire time series; streamlining the scripts to input, output and process the data; and generalizing the GAM and Bayesian hierarchical analytical methods to be more flexible and robust. The methods and resulting models from the 2010 – 2013 data were also presented at several meetings (Chavez-Rosales et al. 2017; Palka and Warden M 2017; Sigourney et al. 2017; Table 1.4), will be published in peer-reviewed journal articles and will be available on a public website. The 2017 work on the model that integrates visual line transect and passive acoustic data to estimate a dive time adjusted abundance estimate for sperm whales (*Physeter macrocephalus*) included improving the structure of the model to account for individual animal heterogeneity and modifying the method to make it more flexible. During 2017 collaborations were initiated to expand the analysis of dive time pattern data to estimate availability correction factors by including other dive data derived from DTAGs. In addition a new project was initiated to compare the results from the AMAPPS visual surveys to the results from hi-definition photographic surveys conducted over waters off New York. More information is found in Chapter 8.

The goal of the AMAPPS-related work conducted by the Northeast and Southeast Fisheries Science Center’s passive acoustic groups is to collect acoustic data that complement visual-based analyses of animal occurrence and abundance, particularly for species that are difficult to detect visually, or in times of year and regions where visual surveys are not conducted. In 2017, the ongoing primary analyses involve the following. One, document migratory pathways of baleen whales along the eastern seaboard continental shelf and shelf break. Two, improve abundance estimates for sperm whales by evaluating methodologies for acoustic abundance estimation and by integrating visual and acoustic data to better document distribution and evaluate availability bias. And in addition, three, quantify acoustic detection rates and acoustic characterization of beaked whales recorded on towed hydrophone arrays, with the goals of comparing to visual detection rates and compiling sufficient data for acoustic abundance estimation for these taxa (Cholewiak et al. 2017; DeAngelis et al. 2017; Tables 1.3 and 1.4). Development is also continuing on the Tethys acoustic database in collaboration with scientists from San Diego State University, the Scripps Institution of Oceanography and the NOAA Science Centers. Also collaborates are continuing with colleagues to conduct further work on acoustics of odontocete species, where grant proposals were submitted to continue work on acoustic classification and group size estimation for delphinid species. More information is found in Chapter 9.

In 2017 to advance research on turtle distribution, abundance, dive patterns and habitat use, loggerhead turtles from less studied areas were tagged during several collaborative field projects. Other field work focused on leatherback turtles. Two leatherback turtles from nesting beaches in Florida were tagged. In addition, beaches on North Carolina were explored to determine where to conduct more leatherback tagging in 2018. Previously collected loggerhead turtle tag data were used in a recently published peer-reviewed paper that explored various statistical models as applied to loggerhead turtle satellite telemetry data to estimate utilization distribution maps (Winton et al. 2017; 2018; Tables 1.3 and 1.4). These data showed the overall predicted densities were greatest in the shelf waters along the US Atlantic coast from Florida to North Carolina. In particular the Mid-Atlantic Bight was an important summer foraging habitat. Methodologies to estimate distribution maps are continuing to be developed by adding sightings and bycatch data to the tag data. More information is found in Chapter 10.

To gain a better understanding of the underlying processes that may drive the distribution and abundance of predators, such as marine mammals, sea turtles, and sea birds, the relationships between hydrographic characteristics of the water column and distributions of lower trophic level organisms, such as fish and plankton, are being compared relative to the distribution patterns of the protected species. During 2017, the processing of the physical and biological oceanographic data collected during the 2016 NOAA ship *Henry B. Bigelow* cruises were nearly completed and those collected in 2017 were initiated. More information is found in Chapter 11.

Table 1.1. General information on the AMAPPS NMFS 2017 field data collection projects: the project name (NMFS principal investigating center), platforms used, dates and general location of the field study, and the chapter within this document where more information on the project can be found.

2017 field collection projects	Platform(s)	Dates in 2017	Location	Chapter
Spring abundance survey (SEFSC)	NOAA Twin Otter airplane	17 Apr – 20 May	Continental shelf waters from New Jersey to Florida	2
Spring abundance survey (NEFSC)	NOAA Twin Otter airplane	6 Jun – 15 Jul	Continental shelf waters from New Jersey to Maine	3
Spring seabird survey (NEFSC)	NOAA ship *Gordon Gunter*	16 – 25 May 31 May – 7 Jun	Continental shelf waters from Maine to North Carolina	4
Summer seabird survey (NEFSC)	NOAA ship *Gordon Gunter*	9 – 23 Jun	Continental slope and deeper waters from New Jersey to North Carolina and shelf waters from North Carolina to Florida	4
Fall seabird survey (NEFSC)	NOAA ship *Gordon Gunter*	31 Oct – 10 Nov	Continental shelf waters from Massachusetts to Virginia	4
Spring marine mammal educational survey (NEFSC)	R/V *Endeavor*	14 – 19 Apr	Continental shelf and slope waters south of Rhode Island	5
Loggerhead turtle tagging (NEFSC)	NOAA ship *Henry B. Bigelow*	6 – 19 Jul	Continental shelf and slope waters from Canada to Virginia	6
Beaked whale survey (NEFSC)	R/V *Hugh R. Sharp*	8 – 18 Sept	Continental shelf, slope and deeper waters on the southern edge of Georges Bank	7
Fall abundance survey (SEFSC)	NOAA Twin Otter airplane	18 Oct – 20 Nov	Continental shelf waters from New Jersey to Florida	N/A
Fall abundance survey (NEFSC)	NOAA Twin Otter airplane	20 Nov – 04 Jan	Continental shelf waters from New Jersey to Maine	N/A

Table 1.2. A brief description of the purpose of the AMAPPS National Marine Fisheries Service analysis projects that occurred during 2016 and the appendix where more information can be found.

2016 analysis projects	Purpose	Chapter
Spatially- and temporally-explicit density models and abundance estimates	Improve Bayesian hierarchical and generalized additive models to quantify relationship between marine mammals and sea turtles and habitat	8
Estimate abundance and trends	Using visual data from AMAPPS and previous surveys estimate abundance of the coastal morphotype of bottlenose dolphins and the short-finned pilot whale	8
Process new abundance data	Process and check quality of abundance survey data and associated habitat covariate data	8
Develop availability correction factors	Initiate collaborations with researchers that have previously collected DTAG data to extract the dive time pattern information needed for the correction factors	8
Compare visual and hi-def surveys	Initiate collaboration with Normandeau Associates	8
Acoustic and visual abundance estimate of sperm whales	Estimate sperm whale abundance by integrating passive acoustic and visual sightings shipboard data	8 & 9
Acoustic only abundance estimate of sperm whales	Estimate abundance of sperm whales using only acoustic data using several analytical methods	9
East Coast Migratory Corridor 2.0 project	Document migratory pathways of baleen whales along the eastern seaboard continental shelf and shelf break	9
Acoustic characteristics of beaked whales	Document depths of acoustic detections, distinguish species-specific characteristics, and effects of active acoustics on detection rates	9
Archive data	Archive sightings, passive acoustic, tag and ecosystem data	8, 9, 10, 11
Collect tag data on turtles	To document distribution and ecology of loggerhead and leatherback turtles, equip them with satellite tags	10
Estimate density distributions of tagged loggerhead turtles	Estimate spatial- and temporal- distributions of loggerhead turtle densities using tag, sightings and bycatch data	10
Process and compare EK60 active acoustic backscatter, VPR and net tow data	Process active acoustic backscatter data (represents middle level trophic level taxa), and plankton/fish data collected from VPR and net tows so they can be compared to distributions of marine mammals, sea turtles and sea birds	11

Table 1.3. List of recently published manuscripts on AMAPPS projects

Cholewiak D, DeAngelis AI, Palka D, Corkeron P, Van Parijs SM 2017. Beaked whales demonstrate a marked acoustic response to the use of shipboard echosounders. Royal Society Open Science: 170940.

DeAngelis AI, Valtierra R, Van Parijs SM, Cholewiak D. 2017. Using multipath reflections to obtain dive depths of beaked whales from a towed hydrophone array. The Journal of the Acoustical Society of America 142(2): 1078-1087.

Garrison LP, Barry K, Hoggard W. 2017. The abundance of coastal morphotype bottlenose dolphins on the U.S. east coast: 2002-2016. Southeast Fisheries Science Center, Protected Resources and Biodiversity Division, 75 Virginia Beach Dr., Miami, FL 33140. PRBD Contribution # PRBD-2017-01, 37 pp.

Palka DL, Chavez-Rosales S, Josephson E, Cholewiak D, Haas HL, Garrison L, Jones M, Sigourney D, Waring G (retired), Jech M, Broughton E, Soldevilla M, Davis G, DeAngelis A, Sasso CR, Winton MV, Smolowitz RJ, Fay G, LaBrecque E, Leiness JB, Dettlof M, Warden M, Murray K, Orphanides C. 2017. Atlantic Marine Assessment Program for Protected Species: 2010- 2014. US Dept. of the Interior, Bureau of Ocean Energy Management, Atlantic OCS Region, Washington, DC. OCS Study BOEM 2017-071. 211 pp.

Patel SH, Dodge KL, Haas HL, Smolowitz, RJ. 2016. Videography Reveals In-Water Behavior of Loggerhead Turtles (*Caretta caretta*) at a Foraging Ground. Front. Mar. Sci, 3, 254.

Winton MV, Fay G, Haas HL, Arendt M, Barco S, James M, Sasso C, Smolowitz R. 2018. Estimating the distribution and relative density of tagged loggerhead sea turtles in the western North Atlantic from satellite telemetry data using geostatistical mixed effects models. Mar Ecol Prog Ser 586: 217-232.

Table 1.4. List of recent presentations on AMAPPS projects

Chavez-Rosales S, Palka D, Josephson E. 2017. Environmental predictors of habitat suitability and cetacean occurrence in the western North Atlantic Ocean. Poster presented at Biennial Conference on the Biology of Marine Mammals, Halifax, NS October 2017.

Chavez-Rosales, S. 2017. Atlantic Marine Assessment Program for Protected Species. Talk presented at "Oceanos :WHOI en Español e Português", Woods Hole, MA September 2017.

Chavez-Rosales, S and Sigourney, D. 2017. Habitat Density Models for Cetaceans in the Atlantic: A Brief Overview of the AMAPPS Modeling Efforts. Talk presented at the Density Modeling (DenMod) workshop, Halifax, NS October 2017.

Cholewiak D, DeAngelis AI, Palka D, Corkeron P, Van Parijs SM. 2017. Beaked whales demonstrate a marked acoustic response to the use of shipboard echosounders. Talk presented at Biennial Conference on the Biology of Marine Mammals, Halifax, NS October 2017.

DeAngelis AI, Palka D, Van Parijs SM, Cholewiak D. 2017. Is it truly True's? First description of True's beaked whale clicks. Talk presented at Biennial Conference on the Biology of Marine Mammals, Halifax, NS October 2017.

Palka DL, Warden M. 2017. Accounting for availability bias in line transect abundance estimates. Poster presented at Biennial Conference on the Biology of Marine Mammals, Halifax, NS October 2017.

Palka DL. 2017. Atlantic Marine Assessment Program for Protected Species. Presented to the "Best Management Practices Workshop for Atlantic Offshore Wind Facilities and Marine Protected Species", Silver Spring, MD March 2017.

Sigourney D, Chavez-Rosales S, Palka D, Lance Garrison L, Josephson E. 2017. Fitting a species distribution model to line transect data of fin whales in the western Atlantic using a Bayesian hierarchical framework: Implications for uncertainty. Poster presented at Biennial Conference on the Biology of Marine Mammals, Halifax, NS October 2017.

Winton M, Fay G, Haas H, Arendt M, Barco S, James M, Sasso C, Smolowitz R. 2017. Estimating loggerhead sea turtle densities from satellite telemetry data using geostatistical mixed models. Talk presented at the Southern New England Chapter of the American Fisheries Society.

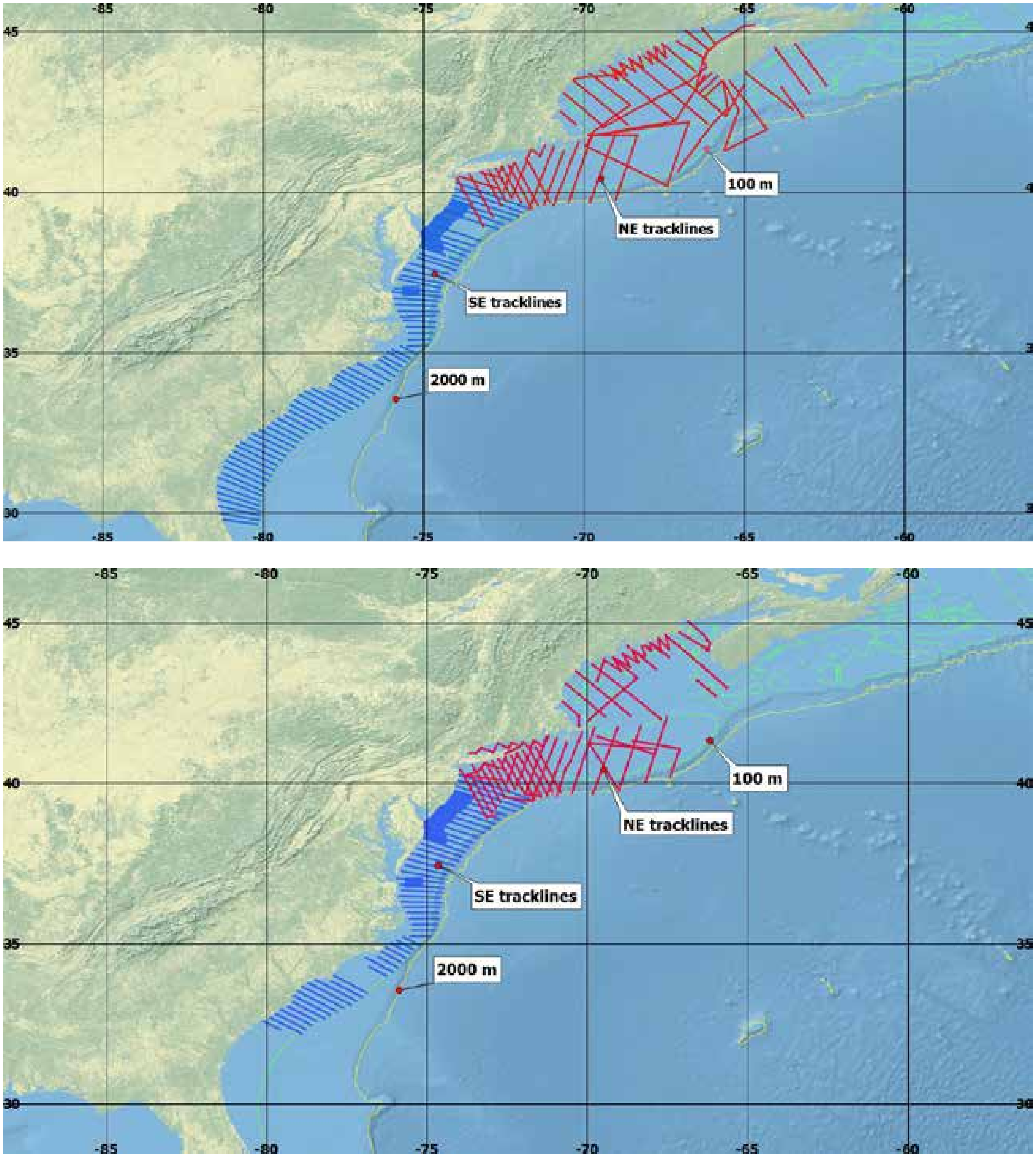
VanParijs S. 2017. Atlantic passive acoustic monitoring of soundscapes. Presented to the "Best Management Practices Workshop for Atlantic Offshore Wind Facilities and Marine Protected Species", Silver Spring, MD March 2017.

Yang T, Haas HL, Smolowitz R, Patel S, James M, Williard A. 2016. Baseline blood biochemical values for the Northwest Atlantic population of loggerhead sea turtles. Poster presented at the International Sea Turtle Symposium.

Table 1.5 Detected species during the SEFSC and NEFSC abundance aerial surveys, 17 April – 15 July 2017 and preliminary number of groups and individuals per species.

Species		Detections	
		Groups	Individuals
Atlantic spotted dolphin	*Stenella frontalis*	19	302
Common bottlenose dolphin	*Tursiops truncatus*	146	1224
Common dolphin	*Delphinus delphis*	171	5048
Common or white-sided dolphin	-	16	53
Bottlenose/Spotted dolphin	-	11	40
Striped dolphin	*Stenella coeruleoalba*	2	58
Risso's dolphin	*Grampus griseus*	19	155
White-sided dolphin	*Lagenorhynchus acutus*	43	367
Harbor porpoise	*Phocoena phocoena*	120	182
Cuvier's beaked whale	*Ziphius cavirostris*	3	5
Fin whale	*Balaenoptera physalus*	13	14
Fin or sei whale	*B. physalus or B. borealis*	6	6
Humpback whale	*Megaptera novaeangliae*	34	44
Northern bottlenose whale	*Hyperoodon ampullatus*	2	13
Minke whale	*B. acutorostrata*	34	37
Pilot whale spp	*Globicephaia spp*	21	176
Sei whale	*B. borealis*	1	1
Sperm whale	*Physeter macrocephalus*	2	2
Unid beaked whale	*Ziphiidae*	4	13
Unid dolphin	*Delphinidae*	57	565
Unid large whale	*Mysticeti*	17	21
TOTAL CETACEANS	-	741	8326
Leatherback turtle	*Dermochelys coriacea*	57	59
Loggerhead turtle	*Caretta caretta*	465	531
Kemp’s ridley turtle	*Lepidochelys kempii*	22	22
Green turtle	*Chelonia mydas*	15	15
Hawksbill turtle	*Eretmochelys imbricata*	1	1
Unid hardshell turtle	-	596	748
TOTAL TURTLES	-	1156	1376

Figure 1.1. Track lines completed during the spring 17 April – 15 July 2017 (top) and 18 October – 04 January 2018 (bottom) AMAPPS aerial surveys conducted by the Northeast and Southeast Fisheries Science Centers.



2 Southern leg of aerial abundance survey during April – May 2017: Southeast Fisheries Science Center

Lance P. Garrison[1], Kevin Barry[2], Laura Aichinger Dias[1, 3]

[1]Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami FL 33149
[2]Southeast Fisheries Science Center, 3209 Frederic St., Pascagoula, MS 39567
[3]Cooperative Institute for Marine and Atmospheric Studies, 4600 Rickenbacker Causeway, Miami FL 33149

2.1 Summary

As part of the AMAPPS program, the Southeast Fisheries Science Center conducted aerial surveys of continental shelf and slope waters (up to the 2,000 m isobath) along the US east coast from New Jersey to Florida. The survey was conducted during 2017 between 17 April and 20 May aboard a NOAA Twin Otter aircraft at an altitude of 600 feet (183 m) and a speed of 110 knots. Survey tracklines were oriented perpendicular to the shoreline and latitudinally spaced 20 km apart. "Fine-scale" tracklines were surveyed closer to the shores of NJ, DE and VA over renewable energy leasing areas. The survey was designed for analysis using Distance sampling and a two-team (independent observer) approach to correct for perception bias in resulting abundance estimates. A total of 9,690.7 km of trackline were surveyed on-effort. Cetacean records totaled 241 sightings from at least 9 different species (not including unidentified taxa). Nearly 60% of the sightings were of common bottlenose dolphins, followed by common dolphins and Atlantic spotted dolphins. Sea turtles totaled 992 sightings of five different species, although nearly 60% of the sightings were of turtles classified as "Hardshell". The data collected during this survey will be analyzed to estimate the abundance and spatial distribution of cetaceans and turtles along the US east coast.

2.2 Objectives

The goal of the survey was to conduct line-transect surveys using the Distance sampling approach to estimate the abundance and spatial distribution of cetaceans and turtles in waters over the continental shelf and slope (shoreline to 2,000 m isobath) of the eastern USA.

2.3 Cruise Period and Area

This survey was conducted during 17 April – 20 May, 2017. The study area extended from New Jersey to northern Florida. Between New Jersey and Cape Hatteras (NC) the survey was flown from the coast line up to the 2,000 m depth contour; south of Cape Hatteras to northern Florida, the survey area covered most of the continental shelf (up to the 250 m isobath) (Figure 2.1).

2.4 Methods

The survey was conducted aboard a DeHavilland Twin Otter DHC-6 flying at an altitude of 183m (600 ft) above the water surface and a speed of approximately 200 kph (110 knots). Surveys were typically flown only when wind speeds were less than 20 knots or approximately sea state 4 or less on the Beaufort scale. The survey was conducted along tracklines oriented perpendicular to the shoreline and spaced latitudinally at approximately 20 km intervals starting at a random point (Figure 2.1). In the waters offshore of NJ, DE and VA, fine-scale tracklines spaced 5 km apart were flown over "wind lease areas" (Figure 2.1).

To conduct the survey, two pilots and two teams (team 1/forward and team 2/aft) of three marine mammal observers each were onboard the airplane. Both teams operated independently to implement the independent observer approach to correct for visibility bias (Laake and Borchers 2004). The forward team (Team 1) consisted of two observers stationed in bubble windows on the left and right side of the airplane and an associated data recorder. The bubble windows allowed downward visibility including the trackline. The aft team (Team 2) consisted of a belly observer looking straight down through a belly port window, an observer stationed on the right side of the aircraft observing through a bubble window, and a dedicated data recorder. The side bubble window observer was stationed in a large "vista" window that provided trackline visibility while the belly observer can see approximately 35 degrees on either side of the trackline. Therefore, the aft team had limited visibility of the left side of the aircraft. The two observer teams operated on independent intercom channels so that they were not able to cue one another to sightings.

Data were entered by each team's data recorder onto a laptop computer running data acquisition software that recorded GPS location, environmental conditions entered by the observer team (e.g., sea state, glare, sun penetration, visibility, etc.) and effort information.

During on effort periods (e.g., level flight at survey altitude and speed), observers searched visually from the trackline (0˚) to approximately 60˚ above vertical. When a turtle, mammal, or other organism was observed, the observer waited until it was perpendicular to the aircraft and then measured the angle to the organism (or the center of the group) using a digital inclinometer. The belly observer only reported the interval for the sighting based on markings on the window. Fish species were recorded opportunistically.

Sea turtle sightings were recorded independently, without communication, by each team. For cetacean sightings, if the sighting was made initially by the forward team, they waited until it was aft of the airplane to allow the aft team an opportunity to observe the group before notifying the pilots to circle over the sighting. Once both teams had the opportunity to observe the group, the observers asked the pilots to break effort and circle the sighting. The aircraft circled over the majority of the cetacean groups sighted to verify species identification and group sizes and to take photographs. The data recorders indicated at the time of the sighting whether or not the group was recorded by one or both teams.

Post survey, the turtle data were reviewed to identify duplicate sightings by the two teams based upon time, location, and position relative to the trackline.

2.5 Results

The survey was conducted 17 April - 20 May 2017 with 17 survey-days. A total of 9,690.7 km of trackline were surveyed on effort along 100 tracklines (Table 2.1, Figure 2.1). The average sea state during the survey was 2.6 on the Beaufort scale (Table 2.1, Figure 2.1).

A total of 241 cetacean sightings including 3,987 individuals were recorded (Table 2.2, Figure 2.2-2.3). The primary species observed was common bottlenose dolphins (*Tursiops truncatus*) with 142 sightings and 1,212 individuals, followed by common dolphins (*Delphinus delphis*) with 26 sightings and 2,068 individuals and Atlantic spotted dolphins (*Stenella frontalis*) with 19 sightings and 302 individuals (Table 2.2, Figure 2.2). Eleven sightings of confirmed baleen whales were recorded including 5 common minke whales (*Balaenoptera acutorostrata*), 4 fin whales (*Balaenoptera physalus*) and 2 humpback whales (*Megaptera novaeangliae*) (Table 2.2, Figure 2.3).

There were a total of 992 unique sightings of sea turtles for a total of 1,210 individuals (Table 2.3, Figure 2.4). Loggerhead turtles (*Caretta caretta*) were the most commonly identified species with 337 sightings, followed by leatherback (*Dermochelys coriacea*) with 50 sightings and Kemp's ridley (*Lepidochelys kempii*) with 20 sightings. Green turtles (*Chelonia mydas*) accounted for 10 sightings and one Hawksbill turtle (*Eretmochelys imbricata*) was recorded. Unidentified hardshell accounted for nearly 60% of all the sightings (Table 2.3). Sea turtle sightings were mostly recorded off the coast of VA / NC and GA / FL (Figure 2.4).

Opportunistic fish species sighted included primarily unidentified sharks, hammerhead sharks (*Sphyrnidae* spp.) and ocean sunfish (*Mola mola*) (Figure 2.5).

2.6 Disposition of Data

All data collected during the aerial survey are archived and managed at the Southeast Fisheries Science Center (SEFSC), Miami, FL. The final audited version is also archived in the Northeast Fisheries Science Center (NEFSC) ORACLE database. The line transect data are available online on the OBIS-SEAMAP website.

2.7 Permits

The SEFSC was authorized to conduct marine mammal research activities during the survey under Permit No. 14450-04 issued to the SEFSC by the National Marine Fisheries Service (NMFS).

2.8 Acknowledgements

The funds for this project came from the Bureau of Ocean Energy Management (BOEM) and the US Navy through the respective Interagency Agreements for the AMAPPS project. Flight time and other aircraft costs were funded by NOAA Aircraft Operations Center. Staff time was provided by the NOAA Fisheries Service, Southeast Fisheries Science Center and NOAA Aircraft Operations Center. We would also like to thank the airplane's crew and observers that were involved in collecting these data.

2.9 References Cited

Laake JL, Borchers DL. 2004. Methods for incomplete detection at distance zero. In: Advanced Distance Sampling. Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., and Thomas, L. (eds.). Oxford University Press, 411 pp.

Table 2.1. Daily summary of effort and sightings during SE AMAPPS aerial survey spring 2017

Date	Effort (km)	Number of cetacean sightings	Number of turtle sightings	Average sea state
04/17/17	799.7	23	0	2.8
04/18/17	507.3	7	1	2.9
04/20/17	487.7	17	0	2.3
04/23/17	1083.8	19	1	2.7
04/27/17	195.4	2	0	2.7
04/28/17	217.9	11	74	2.4
04/30/17	914.8	25	102	3.0
05/03/17	936.8	39	394	2.7
05/08/17	750.2	14	19	2.6
05/09/17	464.0	5	12	2.9
05/10/17	371.6	6	18	2.1
05/12/17	419.2	8	22	2.5
05/14/17	466.3	8	22	2.5
05/15/17	786.1	27	110	2.5
05/16/17	279.5	10	60	1.7
05/19/17	789.2	19	106	3.0
05/20/17	221.2	1	51	2.4
TOTAL	9690.7	241	992	2.6

Table 2.2. Summary of cetacean sightings during SE AMAPPS aerial survey spring 2017

Species	Number of sightings	Number of animals
Atlantic spotted dolphin	19	302
Bottlenose dolphin	142	1212
Bottlenose/Spotted dolphin	11	40
Common dolphin	26	2068
Cuvier's beaked whale	2	4
Fin whale	4	5
Humpback whale	2	2
Minke whale	5	7
Pilot whales	4	95
Risso's dolphin	11	75
Unid. Baleen Whale	1	1
Unid. dolphin	10	161
Unid. large whale	1	1
Unid. odontocete	1	12
Unid. small whale	2	2
TOTAL	241	3987

Table 2.3 Summary of sea turtle sightings during SE AMAPPS aerial survey spring 2017

Species	Number of sightings	Number of animals
Green Turtle	10	10
Hardshell	574	726
Hawksbill	1	1
Kemp's Ridley	20	20
Leatherback	50	52
Loggerhead	337	401
TOTAL	992	1210

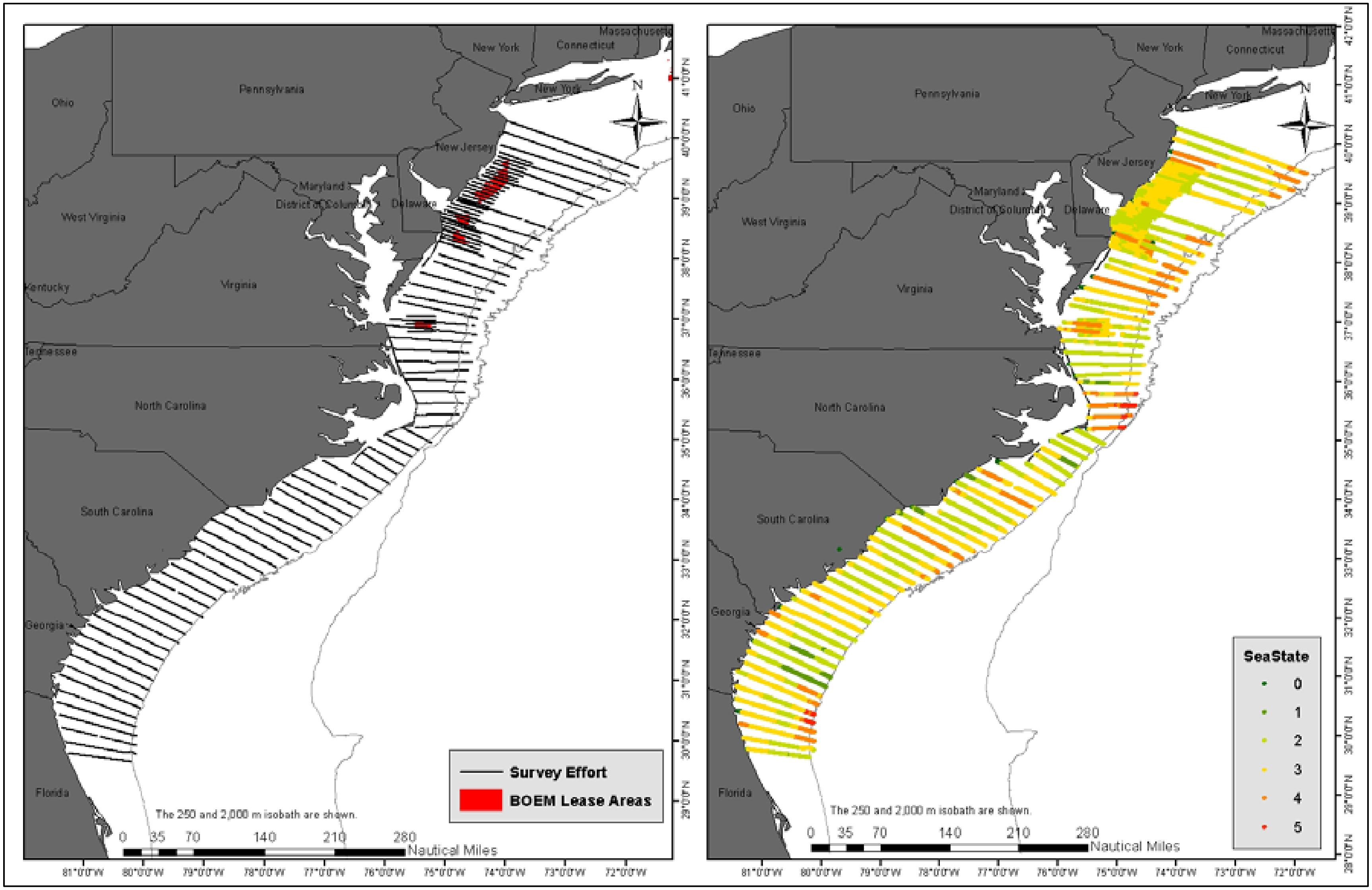


Figure 2.1 Effort tracklines, renewable energy areas and sea state during SE AMAPPS aerial survey spring 2017

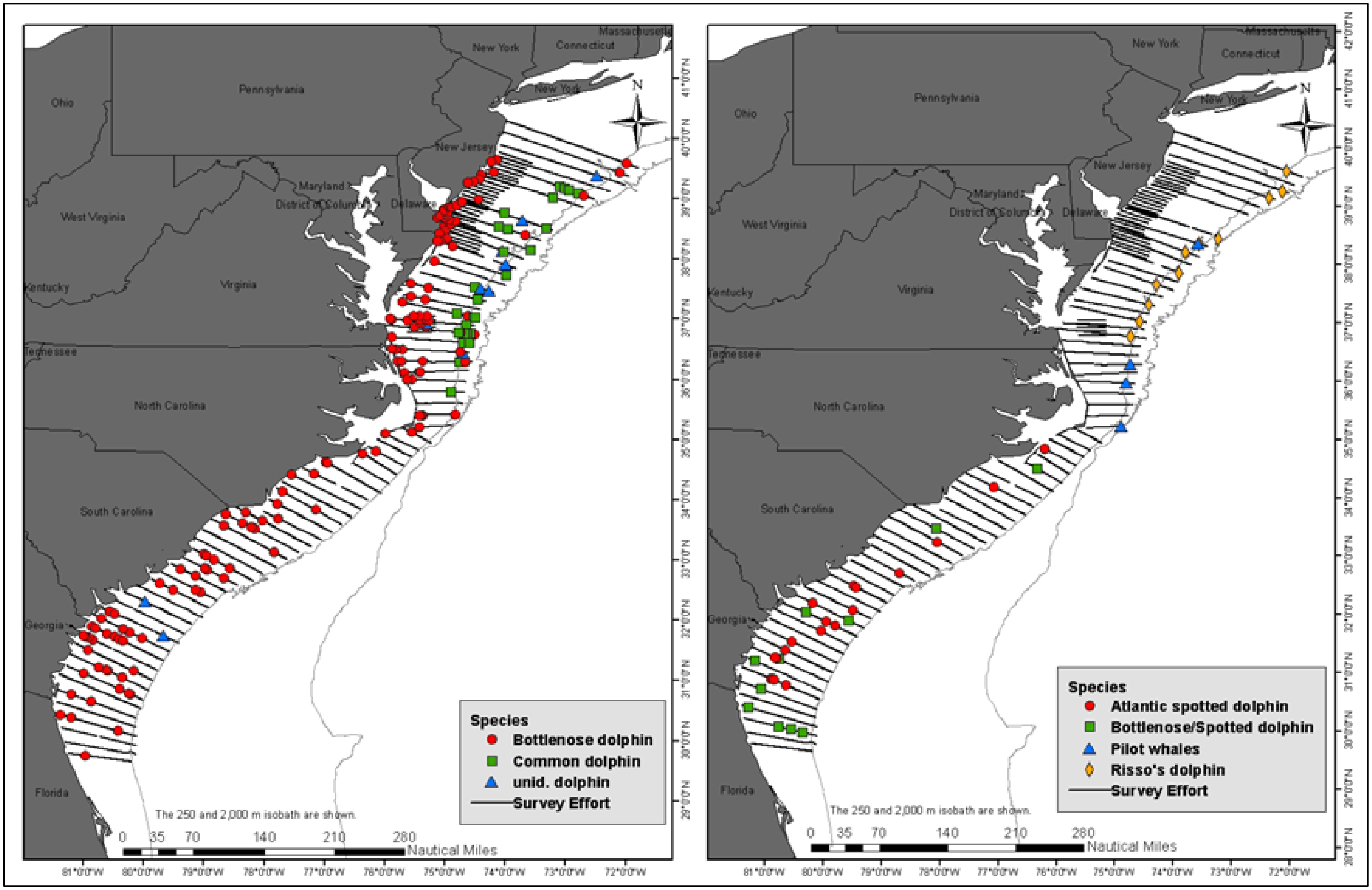


Figure 2.1 Delphinid sightings during SE AMAPPS aerial survey spring 2017

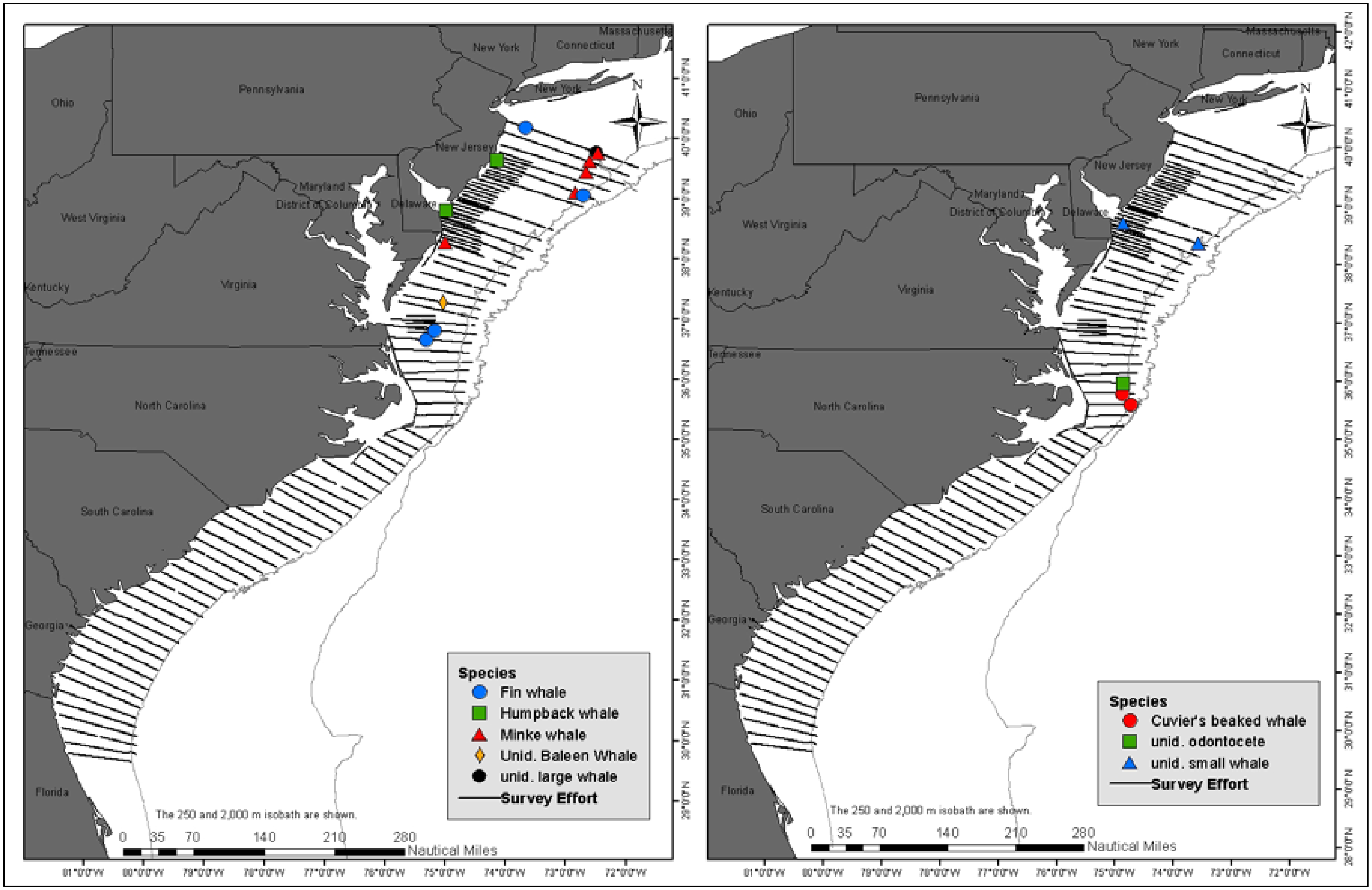


Figure 2.2 Baleen, beaked and unidentified cetaceans sightings during SE AMAPPS aerial survey spring 2017

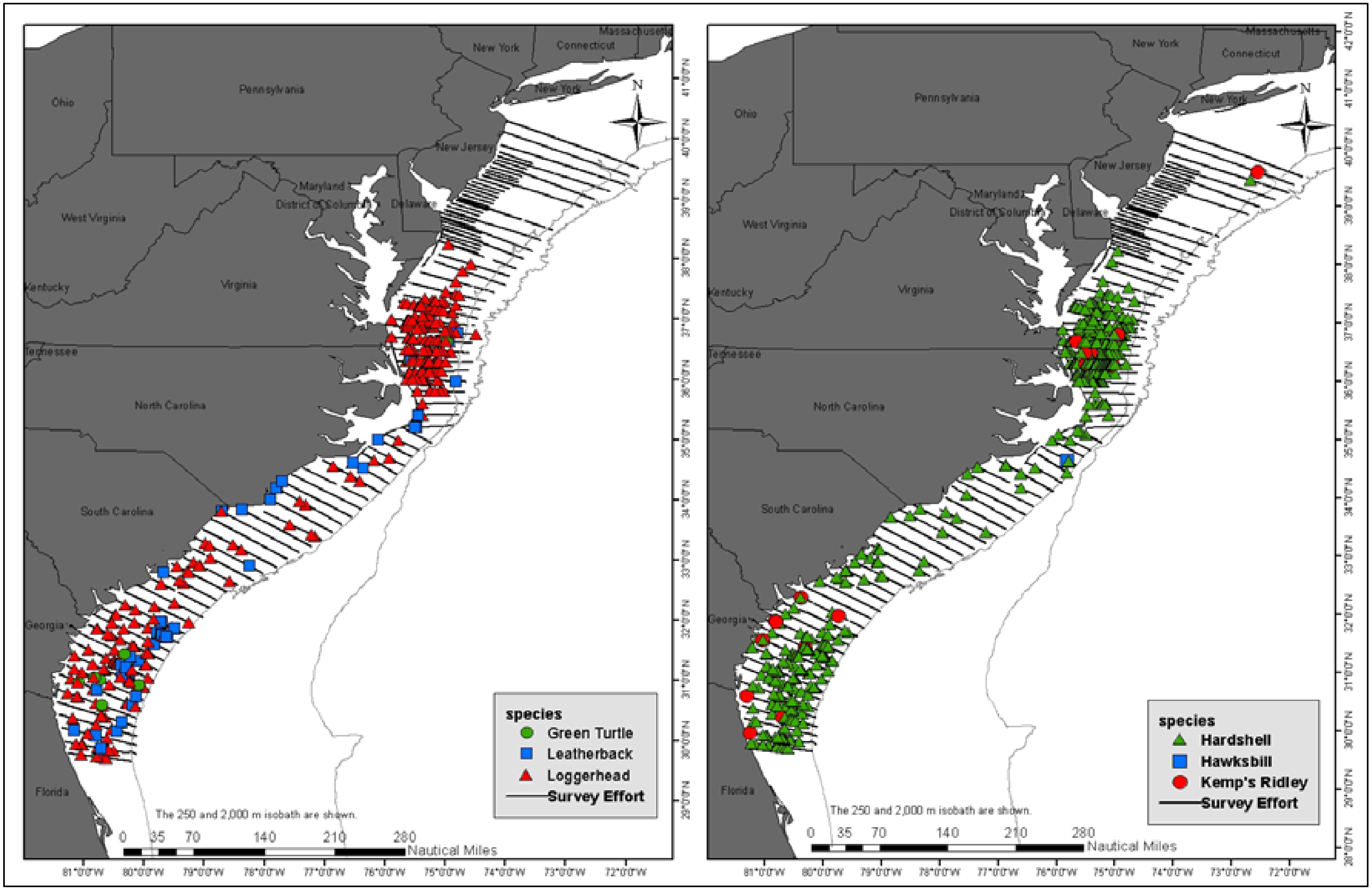


Figure 2.3 Sea turtle sightings during SE AMAPPS aerial survey spring 2017

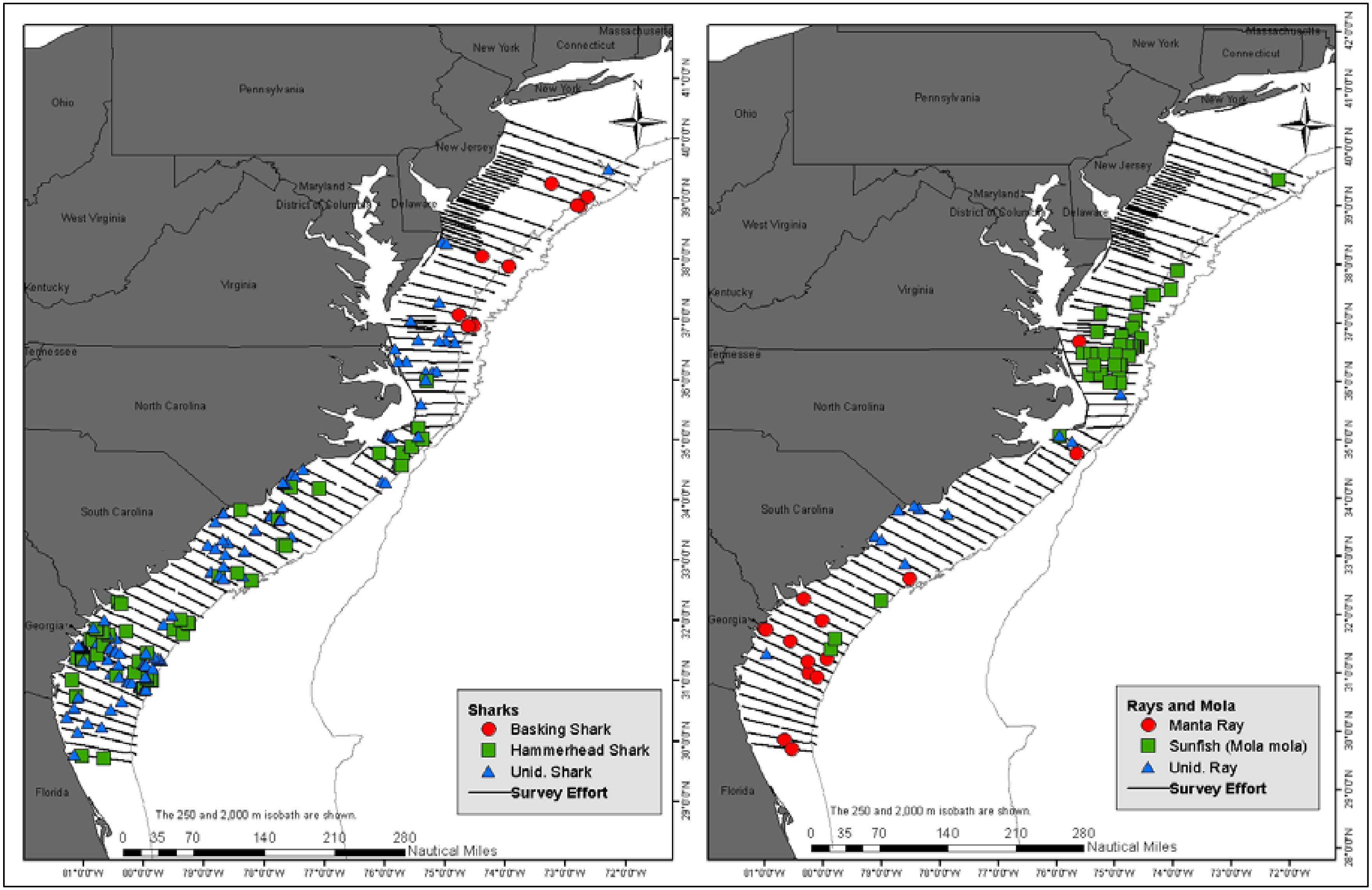


Figure 2.4 Opportunistic fish sightings during SE AMAPPS aerial survey spring 2017

3 Northern leg of aerial abundance survey during 6 June – 15 July 2017: Northeast Fisheries Science Center

Debra L. Palka

Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543

3.1 Summary

During 6 June 2017 – 15 July 2017, the Northeast Fisheries Science Center (NEFSC) conducted aerial abundance surveys targeting marine mammals and sea turtles. The southwestern extent was New Jersey and the northeastern extent was off of Halifax, Nova Scotia, Canada. This survey covered waters from the coast line to about the 2000 m depth contour with a higher coverage over the New York State Offshore Planning Area. This survey coordinated with the SE aerial survey south of this study area in US waters. Track lines were flown 183 m (600 ft) above the water surface, at about 200 kph (110 knots). The two-independent team methodology was used to collect data. In Beaufort sea states of six and less, about 9,479 km of on-effort track lines were surveyed, where 95% of this effort was in Beaufort 3 and below. The front team detected 5415 individual cetaceans from 352 groups. The back team detected 1919 individual cetaceans from 210 groups. This was from 16 species or species groups. Common dolphins (*Delphinus delphis*) were the most frequently detected species. The most common large whales were humpback whales (*Megaptera novaeangliae*) and minke whales (*Balaenoptera acutorostrata*). Over 400 turtles from 4 species and 1 species group were detected, where most were loggerhead turtles (*Caretta caretta*). In addition, seals, basking sharks (*Cetorhinus maximus*), ocean sunfish (*Mola mola*) and a variety of other sharks were also detected.

3.2 Objectives

The objectives of these aerial flights were to collect the data needed to estimate abundance of cetaceans and turtles in the study area, and to investigate how the animal's distribution and abundance relate to their physical and biological ecosystem.

3.3 Cruise Period and Area

This survey was conducted during 6 June 2017 – 15 July 2017. The study area extended from New Jersey to the waters south of Halifax, Nova Scotia, Canada, from the coast line to about the 2000 m depth contour (Figure 3.1). An associated aerial survey was conducted in US waters from New Jersey and south.

The proposed track lines cover the entire region using a broad scale strategy providing an overall spatial coverage. In addition the New York State Offshore Planning Area was surveyed at a higher coverage level.

3.4 Methods

The aerial surveys were conducted on a DeHavilland Twin Otter DHC-6 aircraft over Atlantic Ocean waters off the east coast of the U.S. and Canada. Track lines were flown 183 m (600 ft) above the water surface, at about 200 kph (110 knots), when Beaufort sea state conditions were six and below, and when there was at least two miles of visibility.

When a cetacean, seal, turtle, sunfish, or basking shark was observed the following data were collected:

- Time animal passed perpendicular to the observer;
- Species identification;
- Species identification confidence level (certain, probable, not sure);
- Best estimate of the group size;
- Angle of declination between the track line and location of the animal group when it passed abeam (measured to the nearest one degree by inclinometers or marks on the windows, where 0º is straight down);
- Cue (animal, splash, blow, footprint, birds, vessel/gear, windrows, disturbance, or other);
- Swim direction (0º indicates animal was swimming parallel to the track line in the same direction the plane was flying, 90º indicates animal was swimming perpendicular to the track line and towards the right, etc.);
- If the animal appeared to react to the plane (yes or no);
- If a turtle was initially detected above or below the surface, and;
- Comments, if any.

Other fish species were also recorded opportunistically. Species identifications were recorded to the lowest taxonomic level possible.

At the beginning of each leg, and when conditions changed the following effort data were collected:

- Initials of person in the pilot seats and observation stations;
- Beaufort sea state (recorded to one decimal place);
- Water turbidity (clear, moderately clear, turbid very turbid, and unknown);
- Percent cloud cover (0-100%);
- Angle glare swath started and ended at (0-359º), where 0º was the track line in the direction of flight and 90º was directly abeam to the right side of the track line;
- Magnitude of glare (none, slight, moderate, and excessive); and
- Subjective overall quality of viewing conditions (excellent, good, moderate, fair, and poor).

In addition, the location of the plane was recorded every two seconds with a GPS that was attached to the data entry program. Sightings and effort data were collected by a computer program called VOR.exe, version 8.75 originally created by Phil Lovell and Lex Hiby.

To help correct for perception bias, data were collected to estimate the parameter *g(0)*, the probability of detecting a group on the track line. This was accomplished by using the two independent team data collection method (Laake and Borchers 2004). In addition, the approximate area that a species can be detected was determined, when possible by the front team. This was accomplished by recording the time a group was initially seen and then also collected the time and angle of declination of that same group when it was perpendicular to the observers position. The initial time a group was seen was identified in the sightings data by a species identification of “FRST”.

Onboard, in addition to two pilots, were six scientists who were divided into two teams. One team, the primary forward team, consisted of a recorder and two observers viewing through the two forward right and left bubble windows. The other team, the independent back team, consisted of one observer viewing through the back belly window, one observer viewing from the right back visa window, and a recorder. The two observer teams operated on independent intercom channels so that they were not able to cue one another to sightings.

The belly window observer was limited to approximately a 30º view on both sides of the track line. The bubble window and back side visa window observers searched from straight down to the horizon, with a concentration on waters between straight down (0º) and about 50º up from straight down.

When at the end of track lines or about every 30 – 40 minutes, scientists rotated between the observations positions. When both teams could not identify the species of a group that was within about 60º of the track line and there was a high chance that the group could be relocated or the species was thought to have been a right whale then sighting effort was broke off, and the plane returned to the group to confirm the species identification and group size. The marine mammal and turtle data were reviewed after the flights to identify duplicate sightings that were made by the two teams based upon time, location, and position relative to the track line.

3.5 Results

The observers and pilots who collected these data are listed in Table 3.1.

Ten of the 40 possible flight days had sufficiently good weather to conduct the survey and 5 of the possible flight days at the end of the time period were not flown because the 88 flight hours were used. During the on-effort portions of the flights about 9,479 km of track lines were covered, where about 95% of the track lines were surveyed in Beaufort 3 and less (Table 3.2).

On the on-effort portions of the track lines, 1895 and 4527 individual cetaceans from at least 14 species within 278 and 511 groups were detected by the back and/or front teams, respectively (Table 3.3). The locations of sightings seen on the on- and off-effort transect legs, by species, are displayed in Figures 3.2 – 3.8, where dolphins and porpoises are in Figure 3.2 – 3.4, whales in Figure 3.5 – 3.7. Fish species locations are depicted in Figures 3.9 – 3.12, turtles in Figures 3.13 – 3.14 and seals are in Figure 3.15.

The most commonly detected species were the common dolphin (*Delphinus delphis*) and white-sided dolphin (*Lagenorhynchus acutus*). The common dolphins were seen mostly in waters on Georges Bank and the shelf break from New Jersey to Halifax, Nova Scotia. In contract, most of the white-sided dolphins were north in the Gulf of Maine and on the northern edged of Georges Bank. Harbor porpoises (*Phocoena phocoena*) were also prevalent, but in contract to their summer restricted distribution, at this time of the year they were more spread out for New Jersey to Canada. Risso’s dolphins (*Grampus griseus*), beaked whales (*Ziphiidae*), Northern bottlenose dolphins (*Hyperoodon ampullatus*) and sperm whales (*Physeter macrocephalus*) were located on the deeper portion of the shelf edge.

About 165 sea turtles were detected, which is much less than seen during the latter part of the summer (July – August), where most were loggerhead turtles and unidentified hardshell turtles, and a handful of Kemp's ridley turtles (*Lepidochelys kempii*) and green turtles (*Chelonia mydas*) that were located south of Long Island on the continental shelf. In contrast most of the detected leatherback turtles (*Dermochelys coriacea*) were on the Scotian Shelf, south of Nova Scotia.

In addition, about 140 seals were seen spread out from Cape Cod, along the coast of Maine and Nova Scotia and a few on Georges Bank.

Four species of sharks were identified (basking sharks (*Cetorhinus maximus*; Figure 3.9), blue sharks (*Prionace glauca*), great white sharks (*Carcharodon carcharias*) and hammerhead sharks (*Sphyrnidae spp*), along with many other unidentified sharks (Figure A11). Ocean sunfish (*Mola mola*; Figure 3.10) and rays (Figure 3.12) were also identified.

3.6 Disposition of Data

All data collected during this survey will be maintained by the Protected Species Branch at NEFSC in Woods Hole, MA and are available from the NEFSC's Oracle database. The line transect data are available on OBIS-SEAMAP.

3.7 Permits

NEFSC was authorized to conduct these research activities during this survey under US Permit No. 17355 issued to the NEFSC by the NMFS Office of Protected Resources. The NOAA aircraft was granted diplomatic overflight clearance in Canadian airspace with the Overflight Clearance number 0052-US-2017-05-TC. The Species at Risk Management Division of the Canadian Fisheries and Oceans concluded a permit under SARA was not needed.

3.8 Acknowledgments

Funds for this project came from the Bureau of Ocean Energy Management (BOEM) and the US Navy through the respective Interagency Agreements for the AMAPPS project. Flight time and other aircraft costs were funded by NOAA Aircraft Operations Center (AOC). Staff time was also provided by the NOAA Fisheries Service, NEFSC and NOAA AOC. We would like to thank the pilots and observers involved in collecting these data for their efforts and dedication to this project.

3.9 References Cited

Laake JL, Borchers DL. 2004. Methods for incomplete detection at distance zero, In: Advanced distance sampling, edited by S. T. Buckland, D. R. Andersen, K. P. Burnham, J. L. Laake, and L. Thomas, pp. 108–189, Oxford University Press, New York.

Table 3.1 List of observers and pilots that participated in the June-July 2017 Northeast AMAPPS aerial survey

Name	Affiliation
	OBSERVERS
Corey Accardo	Integrated Statistics, Inc, Woods Hole, MA
Roxanne Carter	Integrated Statistics, Inc, Woods Hole, MA
Robert DiGiovanni	Integrated Statistics, Inc, Woods Hole, MA
Jen Gatzke	Integrated Statistics, Inc, Woods Hole, MA
Rachel Hardee	Integrated Statistics, Inc, Woods Hole, MA
Richard Holt	Integrated Statistics, Inc, Woods Hole, MA
Nicolas Metheny	Integrated Statistics, Inc, Woods Hole, MA
Karen Vale	Integrated Statistics, Inc, Woods Hole, MA
Christin Khan	Northeast Fisheries Science Center, Woods Hole, MA
Debra Palka	Northeast Fisheries Science Center, Woods Hole, MA
	PILOTS
Adam Ruckman	NOAA Aircraft Operations Center, Tampa, FL
Michael Marino	NOAA Aircraft Operations Center, Tampa, FL

Table 3.2 Length of on-effort track lines (in km) surveyed by Beaufort sea state.

	Beaufort sea state						
	0	**1**	**2**	**3**	**4**	**5**	**TOTAL**
Track length (km)	0	1490.3	3837.9	3631.3	448.1	71.1	9,478.7
% of total	0	15.72	40.49	38.31	4.73	0.75	100

Table 3.3 Number of groups and individuals of cetaceans detected on-effort by the front and back teams. Some of the groups seen by the back team were also seen by the front team.

Species		Number of groups		Number of individuals	
		Back	Front	Back	Front
Common bottlenose dolphin	*Tursiops truncatus*	3	4	6	12
Common dolphin	*Delphinus delphis*	76	145	1,394	2,980
Common or white-sided dolphin	-	10	16	27	53
Striped dolphin	*Stenella coeruleoalba*	-	2	-	58
Risso's dolphin	*Grampus griseus*	4	8	12	80
White-sided dolphin	*Lagenorhynchus acutus*	26	43	150	367
Harbor porpoise	*Phocoena phocoena*	69	120	88	182
Cuvier's beaked whale	*Ziphius cavirostris*	1	1	1	1
Fin whale	*Balaenoptera physalus*	1	9	1	9
Fin or sei whale	*B. physalus or B. borealis*	1	6	2	6
Humpback whale	*Megaptera novaeangliae*	28	32	37	42
Northern bottlenose whale	*Hyperoodon ampullatus*	2	2	6	13
Minke whale	*B. acutorostrata*	16	29	18	30
Pilot whale spp	*Globicephaia spp*	4	17	10	81
Sei whale	*B. borealis*	-	1	-	1
Sperm whale	*Physeter macrocephalus*	1	2	1	2
Unid beaked whale	*Ziphiidae*	1	3	7	6
Unid dolphin	*Delphinidae*	22	47	102	404
Unid large whale	*Mysticeti*	7	13	7	17
TOTAL CETACEANS		278	511	1,895	4,527

Table 3.4. Number of groups and individuals of other species detected on-effort by the front and back teams. Some of the groups seen by the back team were also seen by the front team.

Species		Number of groups		Number of individuals	
		Back	**Front**	**Back**	**Front**
Leatherback turtle	*Dermochelys coriacea*	4	7	4	7
Loggerhead turtle	*Caretta caretta*	80	128	81	130
Kemp's ridley turtle	*Lepidochelys kempii*	2	2	2	2
Green turtle	*Chelonia mydas*	5	4	5	4
Unid hardshell turtle	-	16	22	16	22
Basking shark	*Cetorhinus maximus*	112	220	120	236
Blue shark	*Prionace glauca*	20	18	26	18
Great white shark	*Carcharodon carcharias*	1	2	1	2
Hammerhead shark	*Sphyrnidae* spp.	1	8	2	8
Chilean devil ray	*Mobula tarapacana*	1	2	1	2
Manta ray	*Cephalopterus manta*	1	-	1	-
Ocean sunfish	*Mola mola*	300	587	350	721
Tuna	-	1	2	8	28
Unid ray	-	1	4	1	5
Unid shark	-	35	50	36	54
Gray seal	*Halichoerus grypus*	8	11	8	11
Unid seal	Pinnipedia	41	79	80	125
TOTAL SPECIES		907	1,657	2,637	5,902

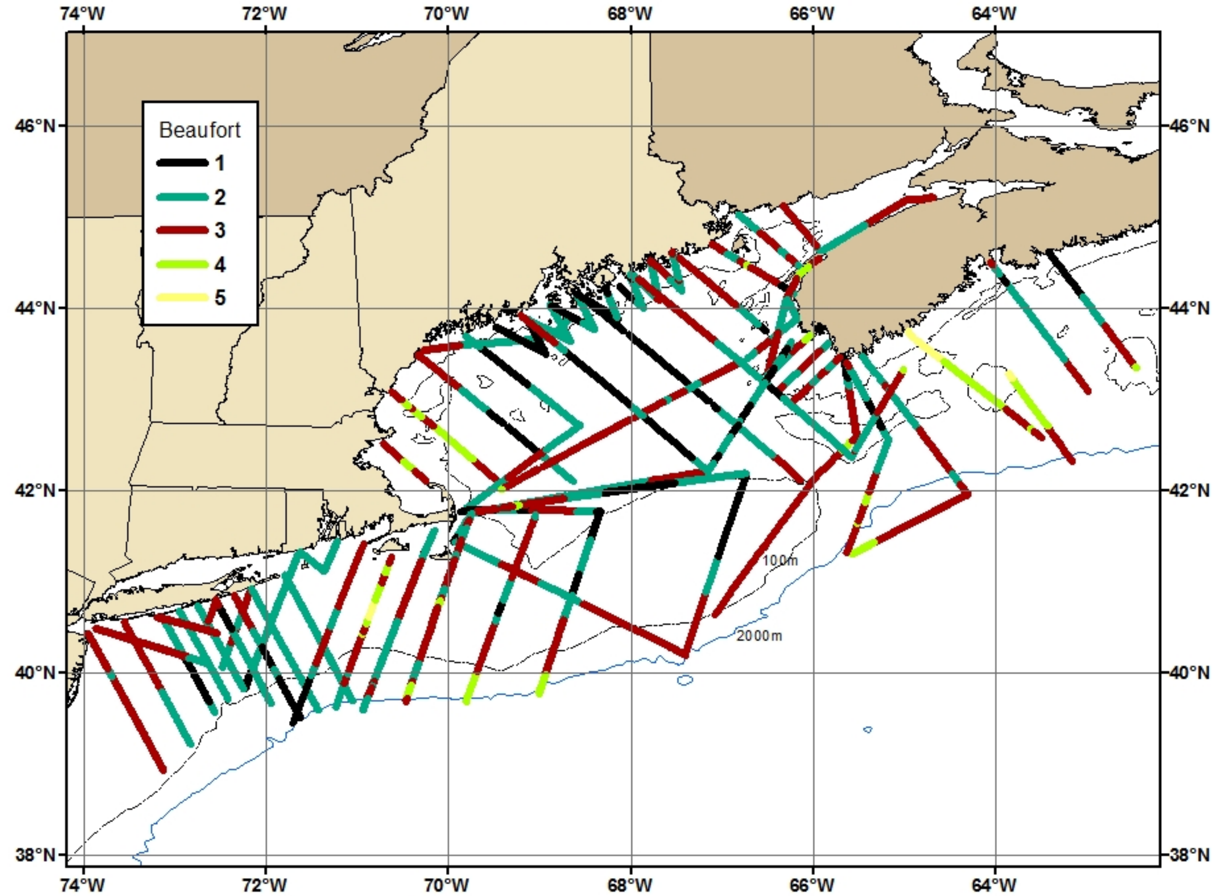


Figure 3.1. Completed on-effort track lines by Beaufort sea state. The 100 m and 2000 m depth contours are also shown

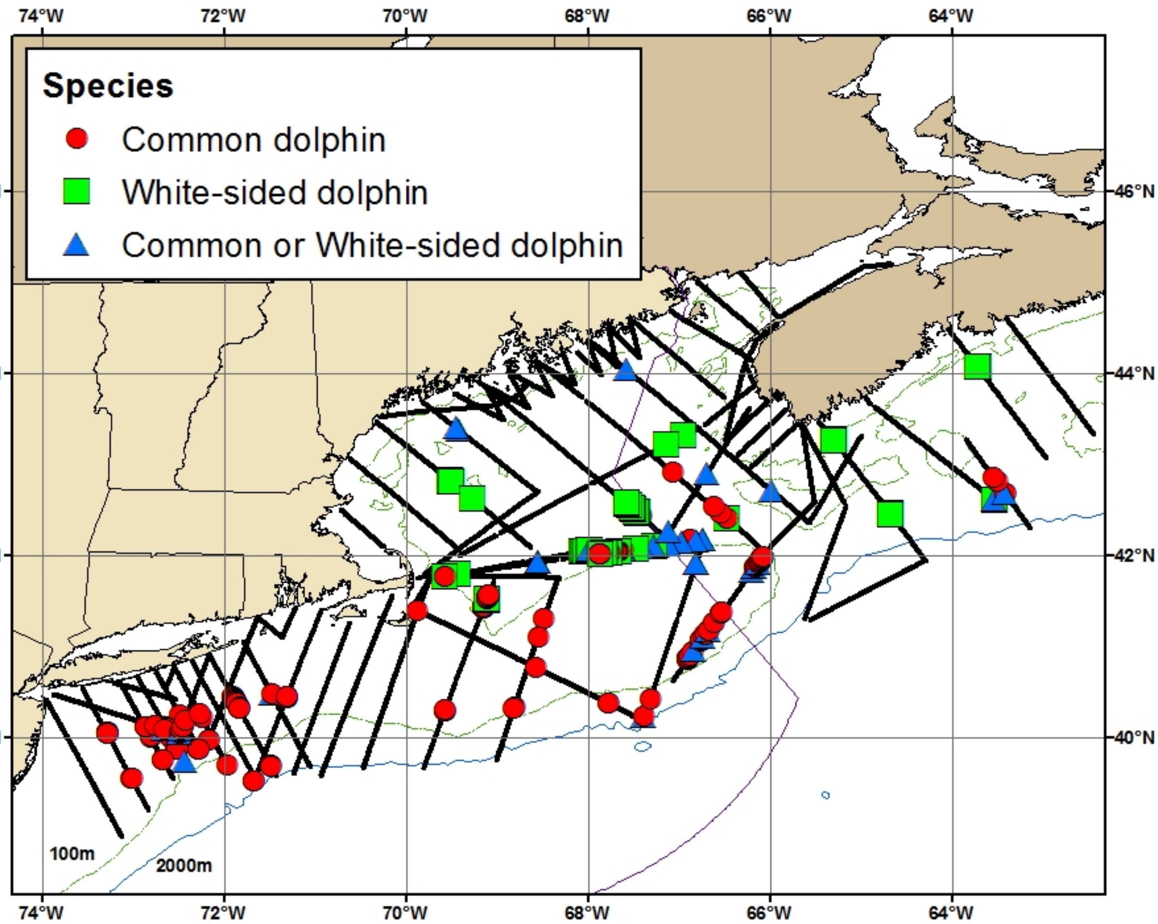


Figure 3.2. Locations of common dolphins (*Delphinus delphis*) and white-sided dolphins (*Lagenorhynchus acutus*) detected by either the front or back team.

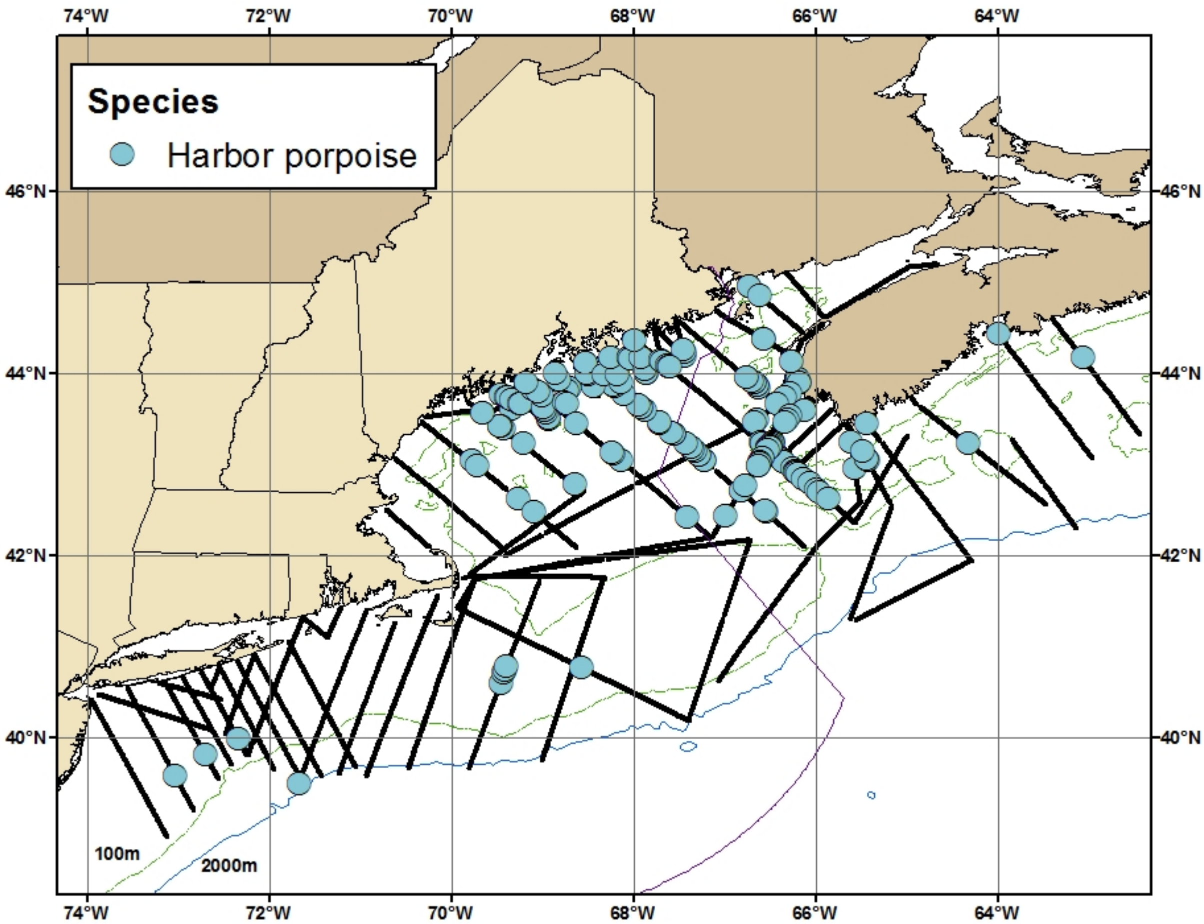


Figure 3.3. Locations of harbor porpoises (*Phocoena phocoena*) detected by either the front or back team.

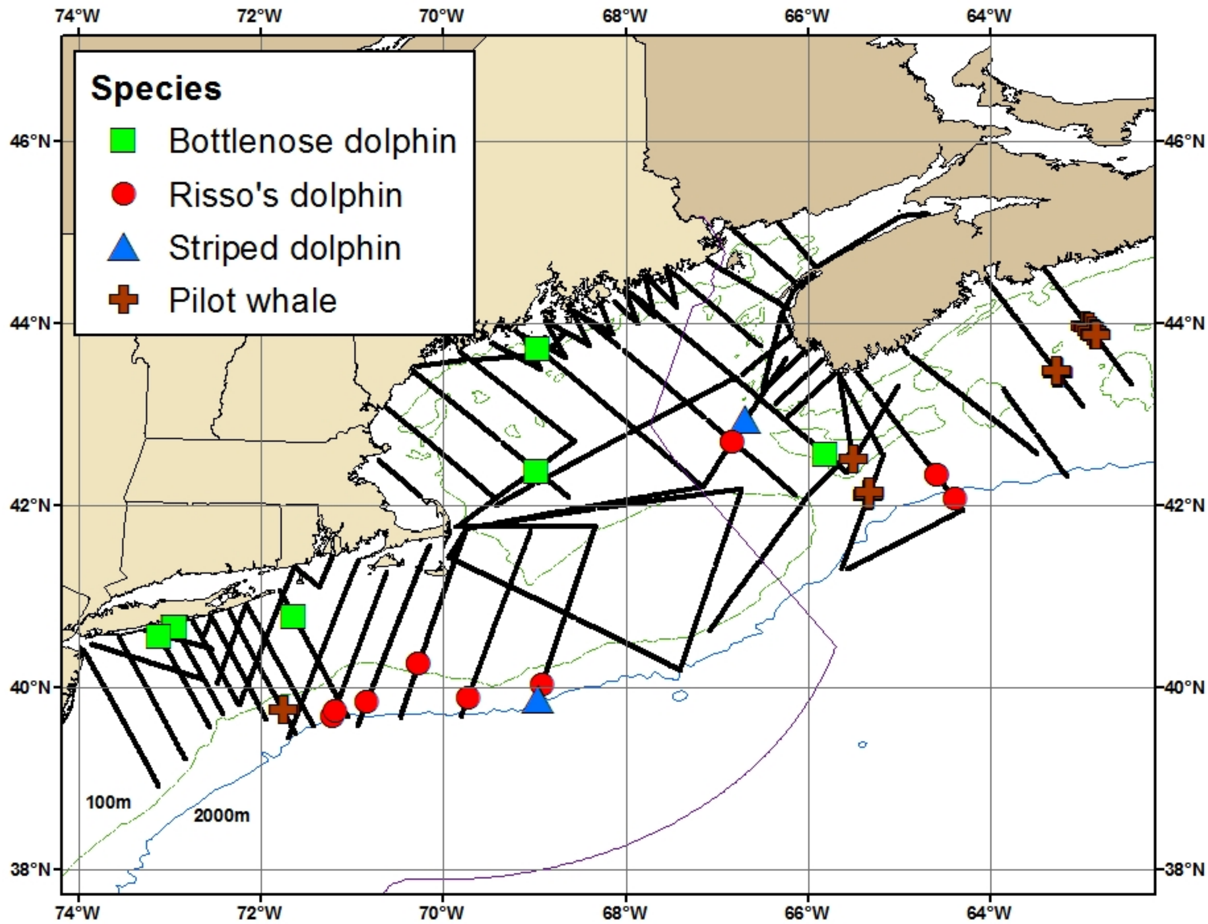


Figure 3.4. Locations of common bottlenose dolphins (*Tursiops truncatus*), Risso's dolphins (*Grampus griseus*), striped dolphins (*Stenella coeruleoalba*) and pilot whales (*Globicephaia spp*) detected by either the front or back team

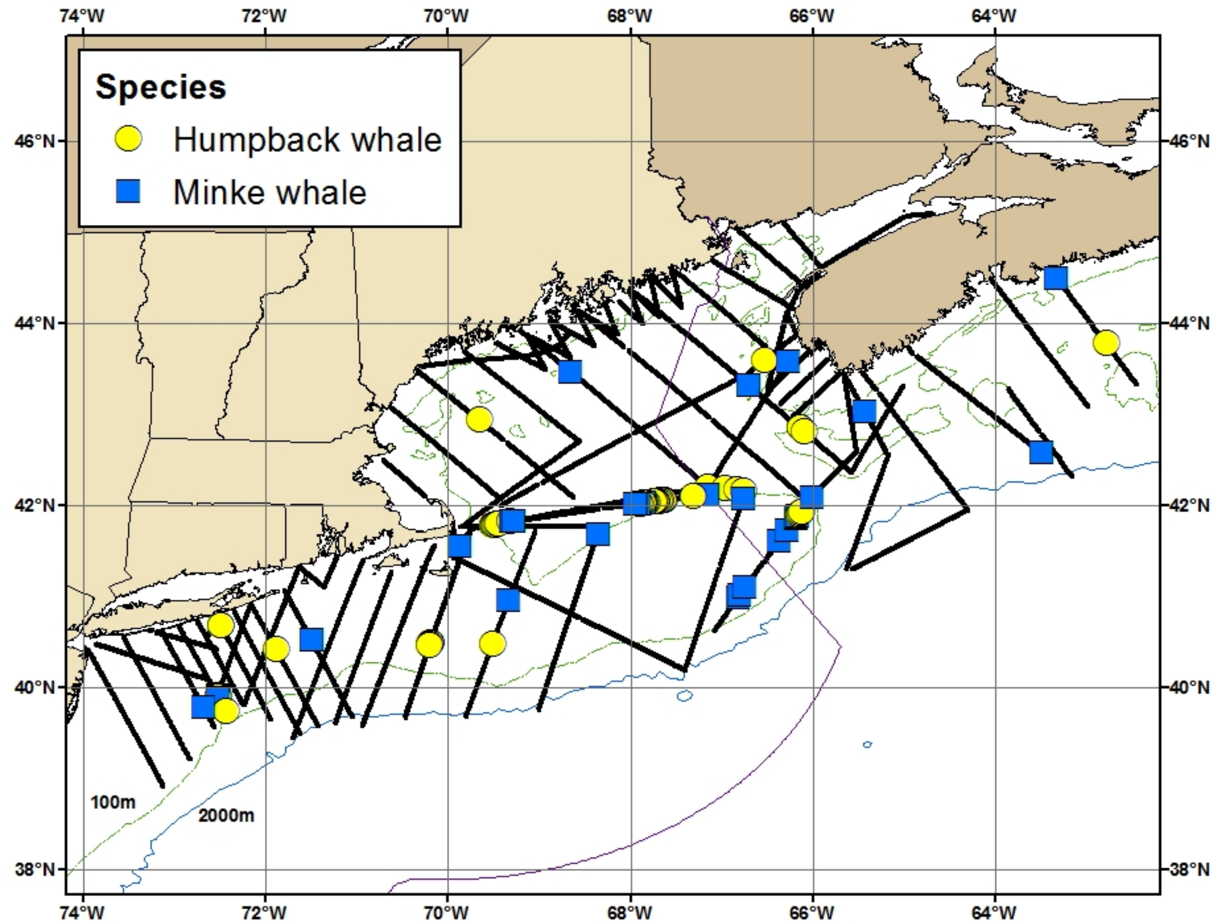


Figure 3.5. Locations of humpback whales (*Megaptera novaeangliae*), and minke whales (*Balaenoptera acutorostrata*) detected by either the front or back team

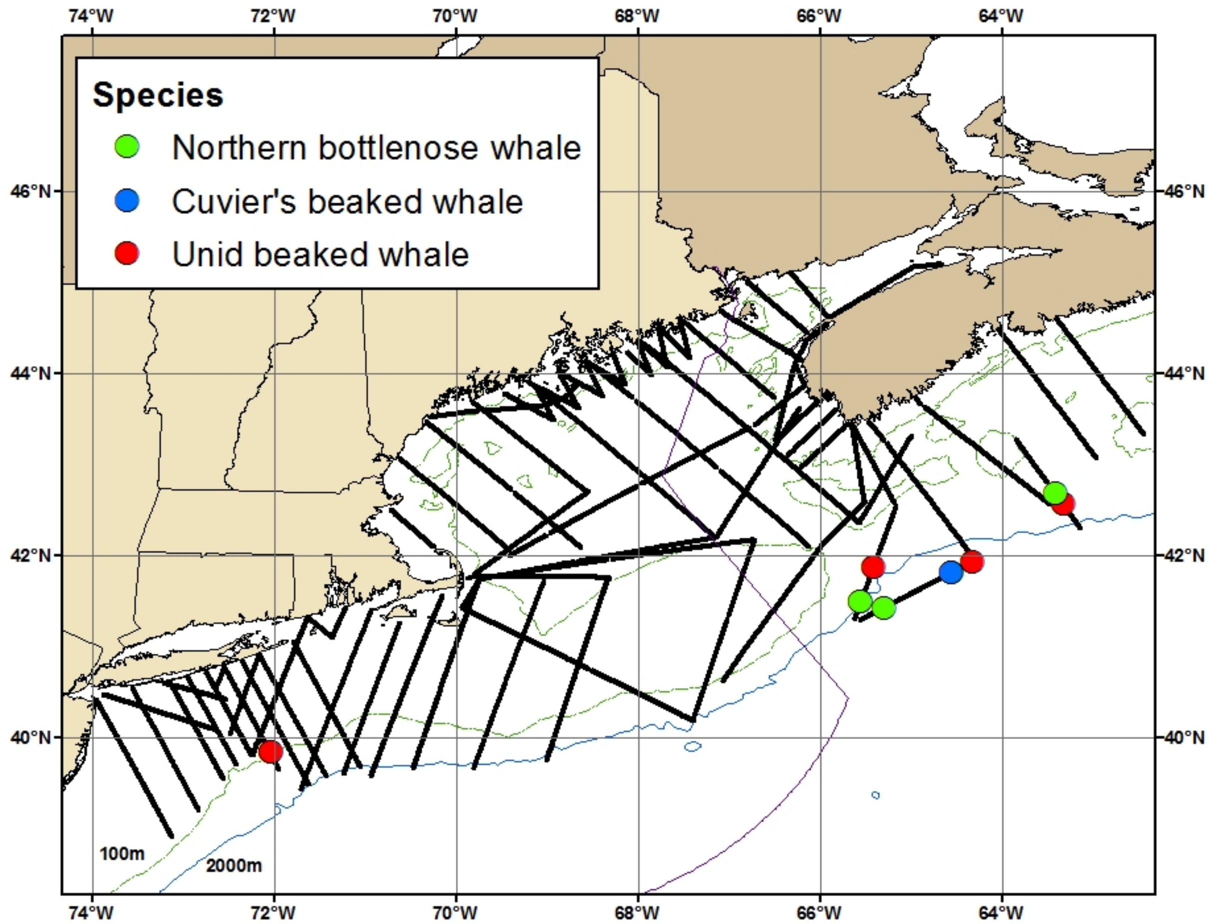


Figure 3.6. Locations of Northern bottlenose whales (*Hyperoodon ampullatus*), Cuvier's beaked whales (*Ziphius cavirostris*) and unidentified beaked whales (*Ziphiidae*) detected by either the front or back team.

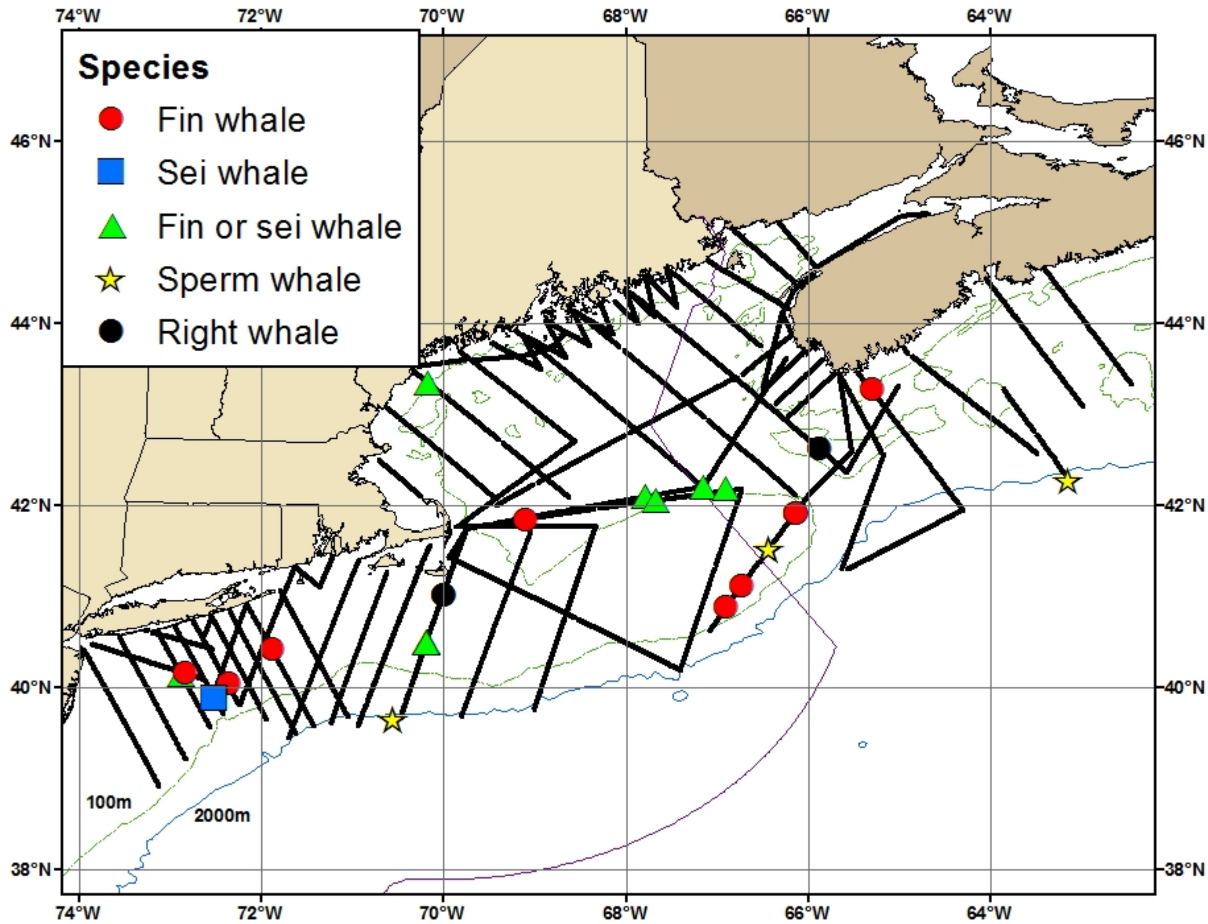


Figure 3.7. Locations of fin whales (*Balaenoptera physalus*), sei whales (*B. borealis*), fin or sei whales, sperm whales (*Physeter macrocephalus*), and right whales (*Eubalaena glacialis*) detected by either the front or back team.

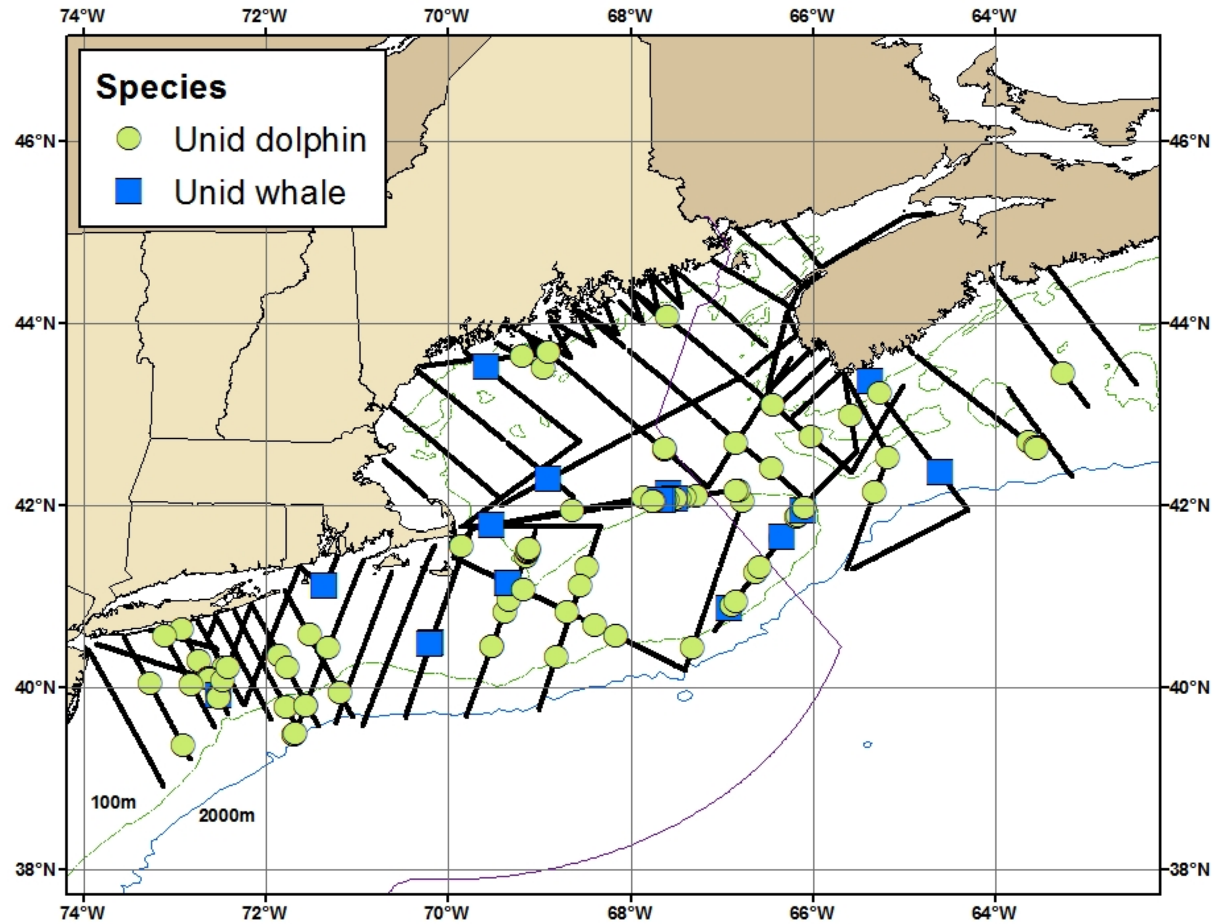


Figure 3.8. Locations of unidentified dolphins and whales detected by either the front or back team.

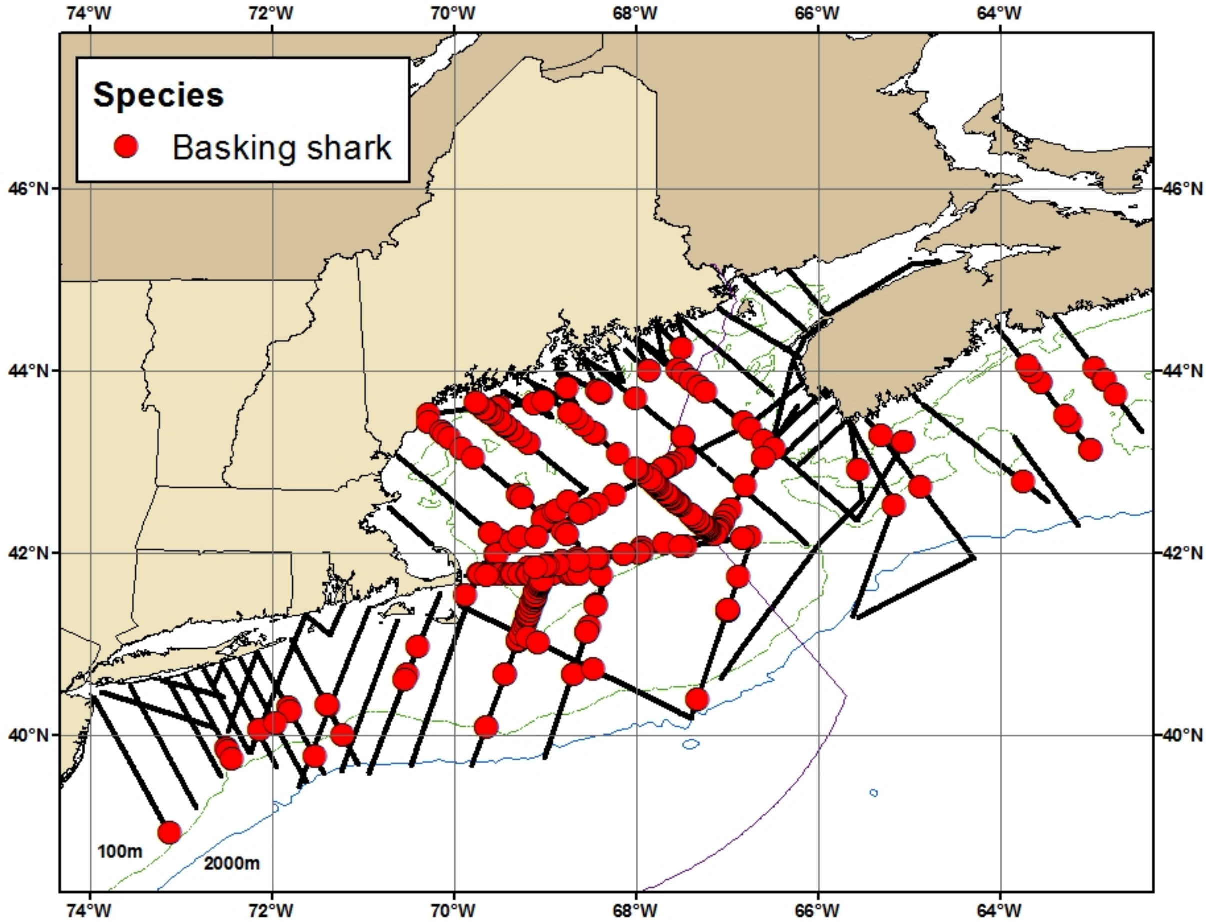


Figure 3.9. Locations of basking sharks (*Cetorhinus maximus*) detected by either the front or back team.

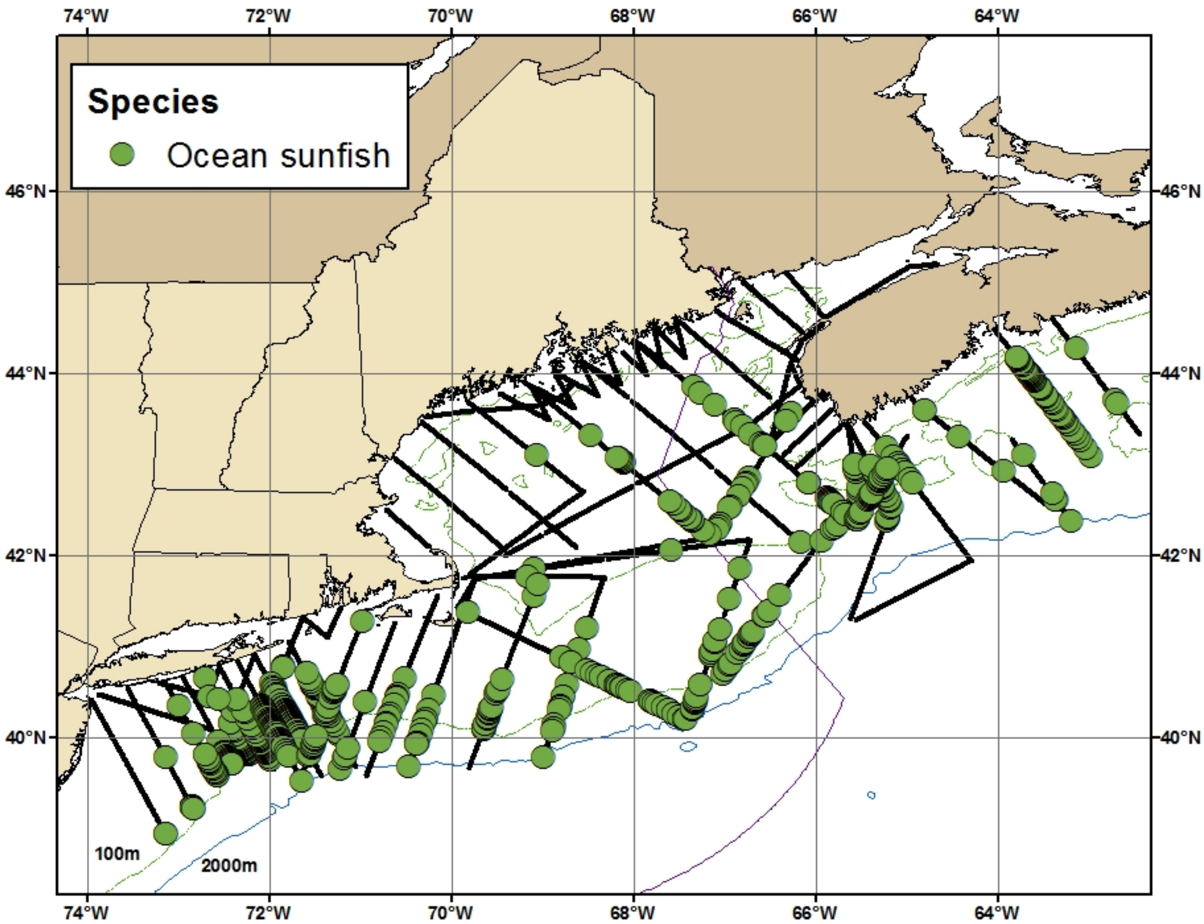


Figure 3.10. Locations of ocean sunfish (*Mola mola*) detected by either the front or back team.

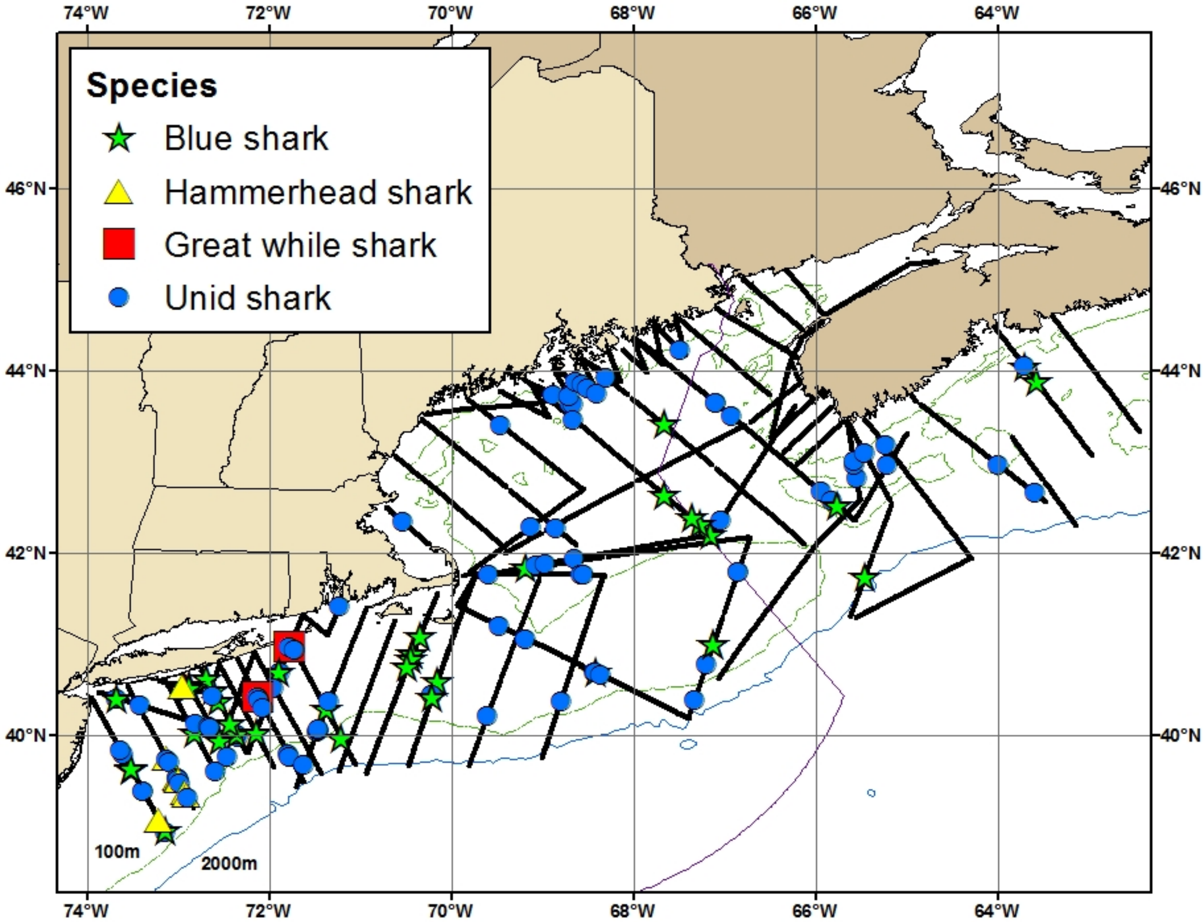


Figure 3.11. Locations of blue sharks (*Prionace glauca*), hammerhead sharks (*Sphyrnidae* spp.), great white sharks (*Carcharodon carcharias*) and unidentified sharks detected by either the front or back team.

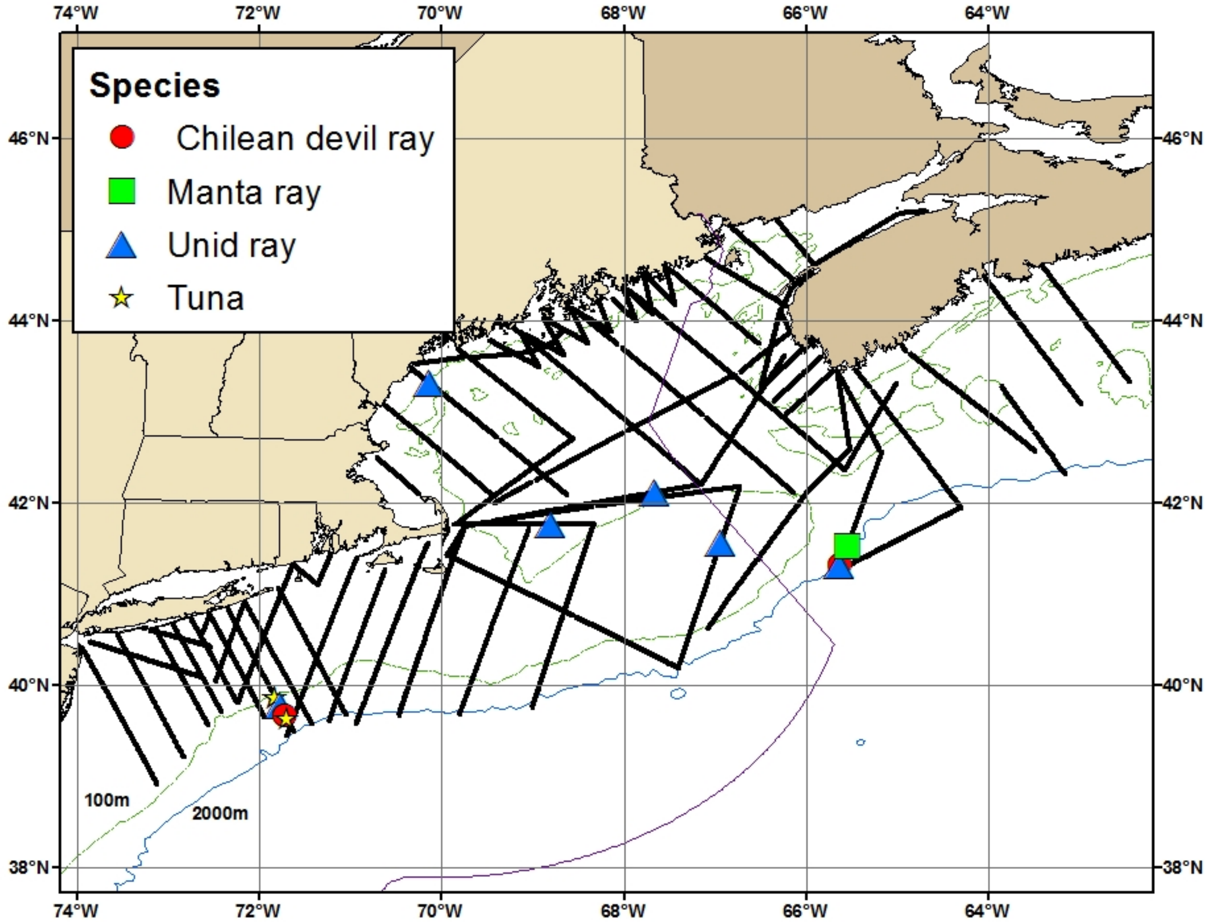


Figure 3.12. Locations of Chilean devil rays (*Mobula tarapacana*), manta rays (*Cephalopterus manta*), unidentified rays and tuna detected by either the front or back team.

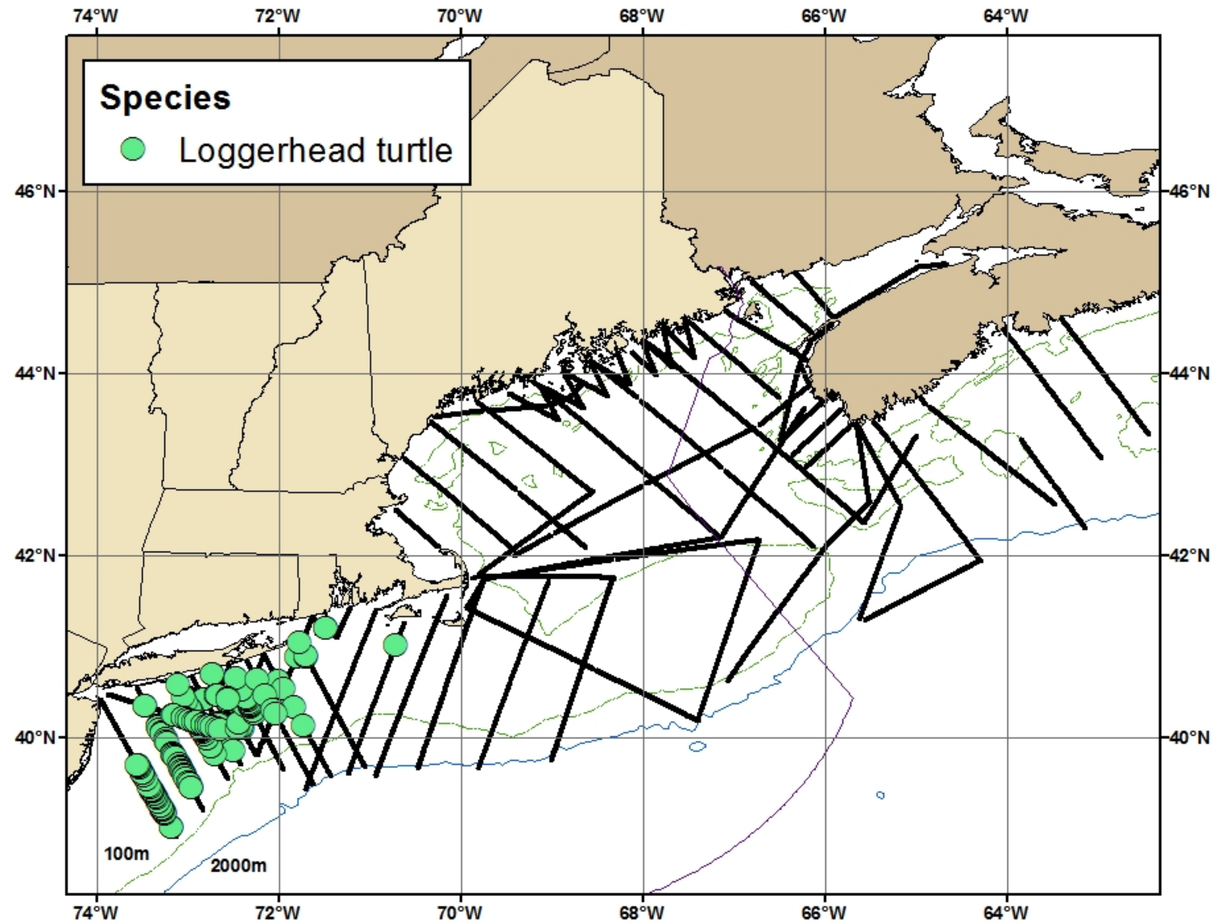


Figure 3.13. Locations of loggerhead turtles (*Caretta caretta*) detected by either the front or back team.

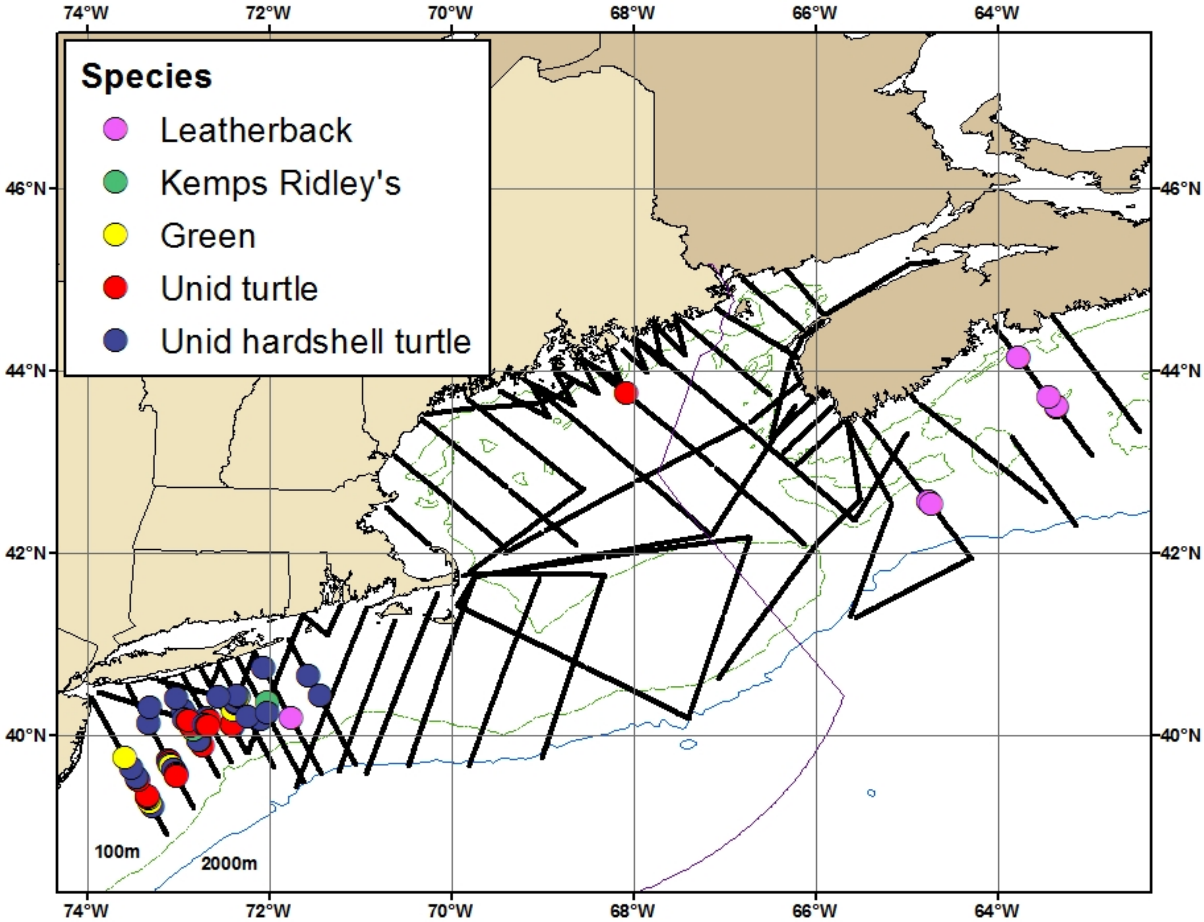


Figure 3.14. Locations of leatherback turtles (*Dermochelys coriacea*), Kemps Ridley's turtles (*Lepidochelys kempii*), green turtles (*Chelonia mydas*), and unidentified turtles detected by either the front or back team.

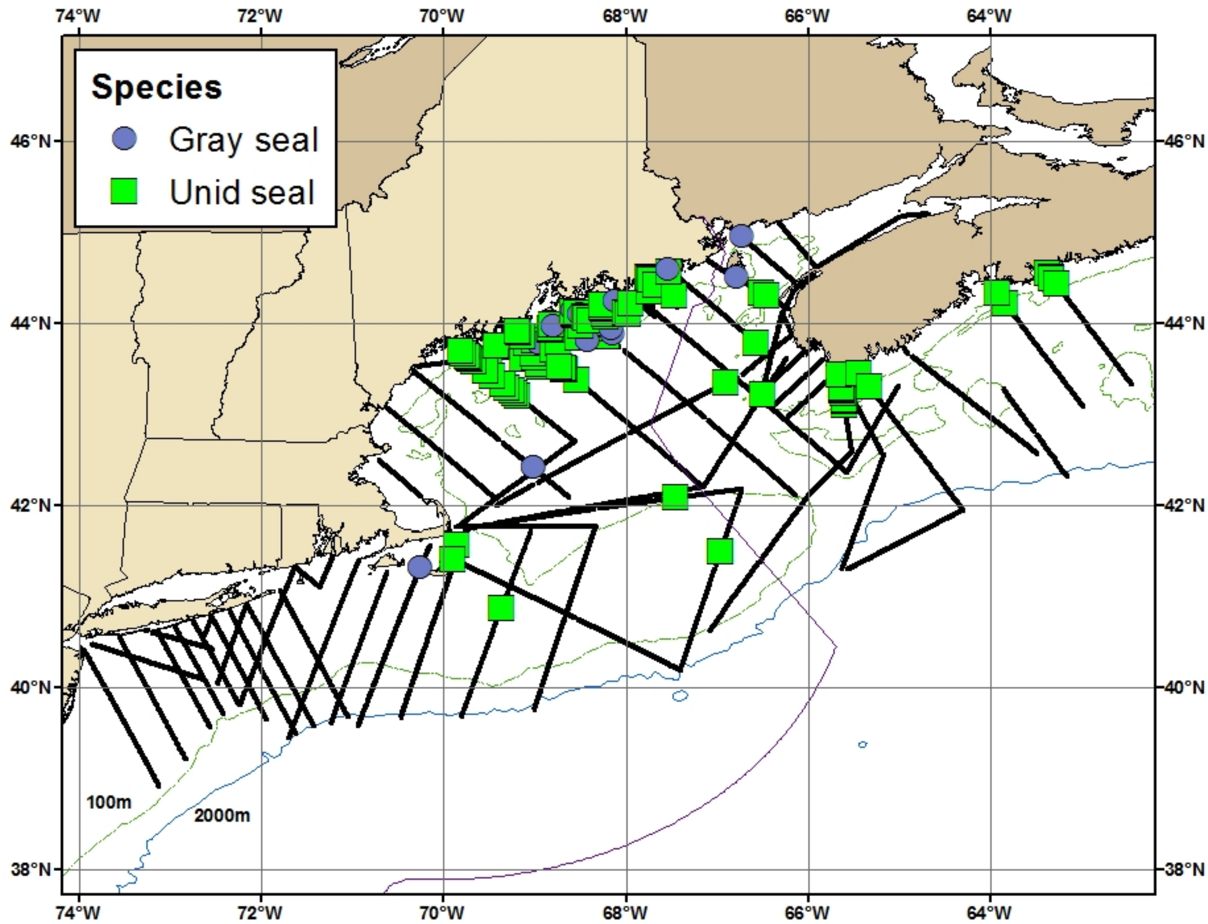


Figure 3.15. Locations of gray seals (*Halichoerus grypus*) and unidentified seals detected by either the front or back team.

4 At-sea monitoring of the distributions of pelagic seabirds in the Northeast US Shelf Ecosystem: Northeast Fisheries Science Center

Harvey J. Walsh[1], Nicholas Metheny[2], Timothy White[3], and Glen Davis[2]

[1] Northeast Fisheries Science Center, 28 Tarzwell Dr, Narragansett RI 02882
[2] Integrated Statistics, Inc., 16 Sumner St., Woods Hole, MA 02543
[3] BOEM, Environmental Studies Program

4.1 Summary

Visual detection data of seabirds, marine mammals, turtles, and large pelagic fish were collected during three surveys in 2017; a spring Ecosystem Monitoring (EcoMon) cruise (Figure 4.1, GU1701), a Bluefin Tuna Slope Sea survey (Figure 4.2, GU1702), and a fall EcoMon (Figure 4.3, GU1706). A fourth summer EcoMon survey was scheduled but was canceled due to emergency ship repairs.

4.2 Objective

The goal of this at-sea monitoring program is to provide comprehensive visual surveys of seabirds, marine mammals, turtles, large pelagic fish, and marine debris in the Northeast US shelf ecosystem while piggy-backing on NMFS shipboard cruises that are dedicated to non-marine mammal studies.

4.3 Methods and Results

The protocol used during the surveys is based on a standardized 300 m strip transect survey, like that used by various agencies in North America and Europe (Anon 2011, Ballance 2011; Tasker 2004) and on the dedicated marine mammal abundance shipboard surveys under the AMAPPS project.

Cruise reports for the three 2017 cruises, GU1701, GU1702, and GU1706 are provided as Appendices 4-I, 4-II and 4-III.

4.4 Disposition of Data

The visual census data from each cruise is maintained in an Oracle Database at NEFSC and distributed to the Seabird Compendium.

4.5 Acknowledgements

We acknowledge the officers and crew of the NOAA Ship *Gordon Gunter* for great ship support. This project was funded by the U.S. Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program, Washington, DC, through an Inter-Agency Agreement with the National Marine Fisheries Service as the Atlantic Marine Assessment Program for Protected Species (AMAPPS); and by the Northeast Fisheries Science Center.

4.6 References Cited

Anonymous. 2011 Seabird Survey Instruction Protocol. Seabird distribution and abundance, Summer 2011. NOAA RV Henry B. Bigelow. Northeast Fisheries Science Center.

Ballance LT. 2011. Seabird Survey Instruction Manual, PICEAS 2011. Ecosystems Studies Program Southwest Fisheries Science Center, La Jolla, California.

Tasker ML, Hope Jones P, Dixon T, Blake BF. 1984. Counting seabirds at sea from ships; a review of methods employed and a suggestion for a standardized approach. Auk 101: 567 – 577.

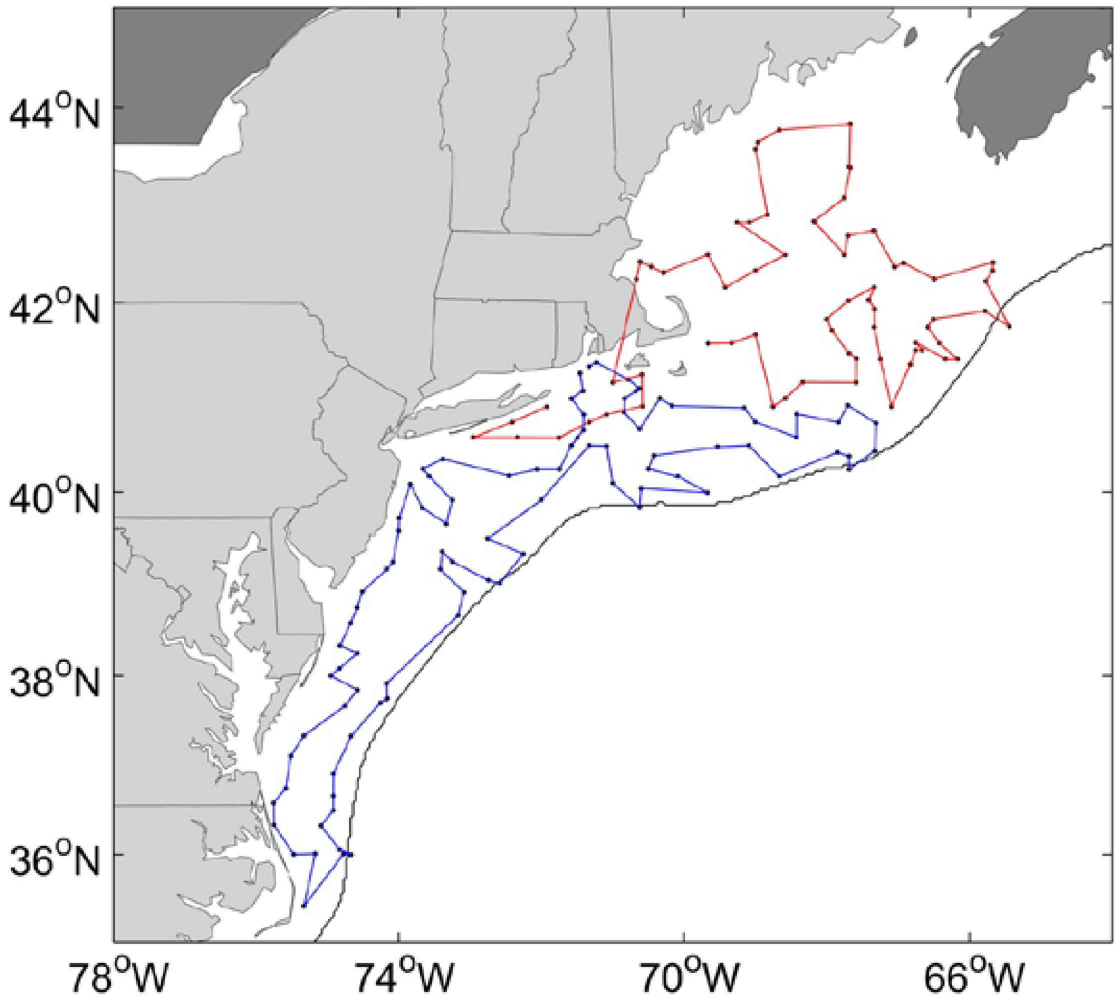


Figure 4.1. Cruise tracks of legs 1 (blue line) and 2 (red line) of spring Ecosystem Monitoring cruise GU1701. Leg 1 sailed from 16-25 May 2017 and leg 2 sailed from 31 May-7 June 2017. The black dots show locations where the ship stopped to conduct plankton and hydrographic sampling. The Black line indicates the 1000 m isobath.

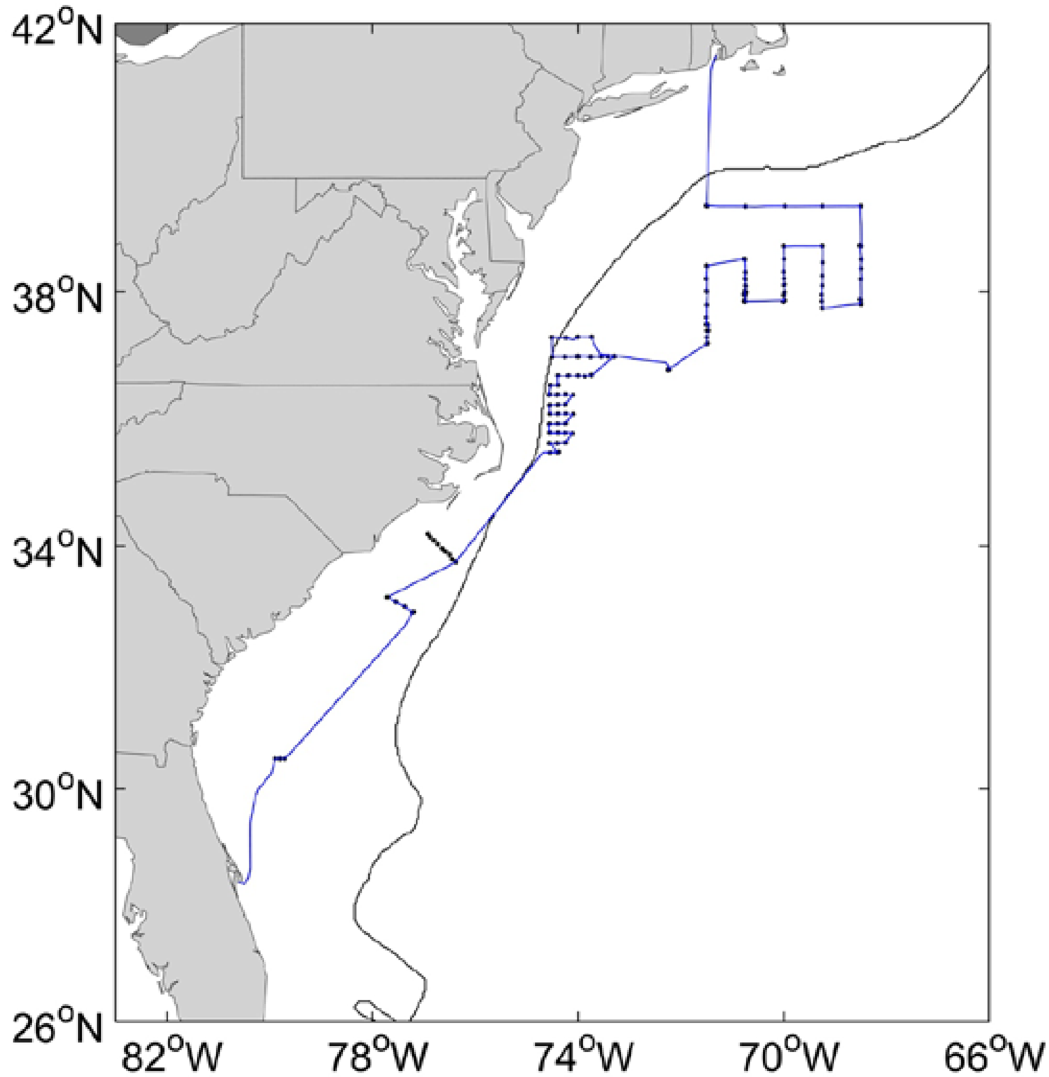


Figure 4.2. Cruise track of Bluefin Tuna Slope Sea cruise GU1702. The cruise sailed from 9-23 June 2017. The black dots show locations where the ship stopped to conduct plankton and hydrographic sampling. The Black line indicates the 1000 m isobath.

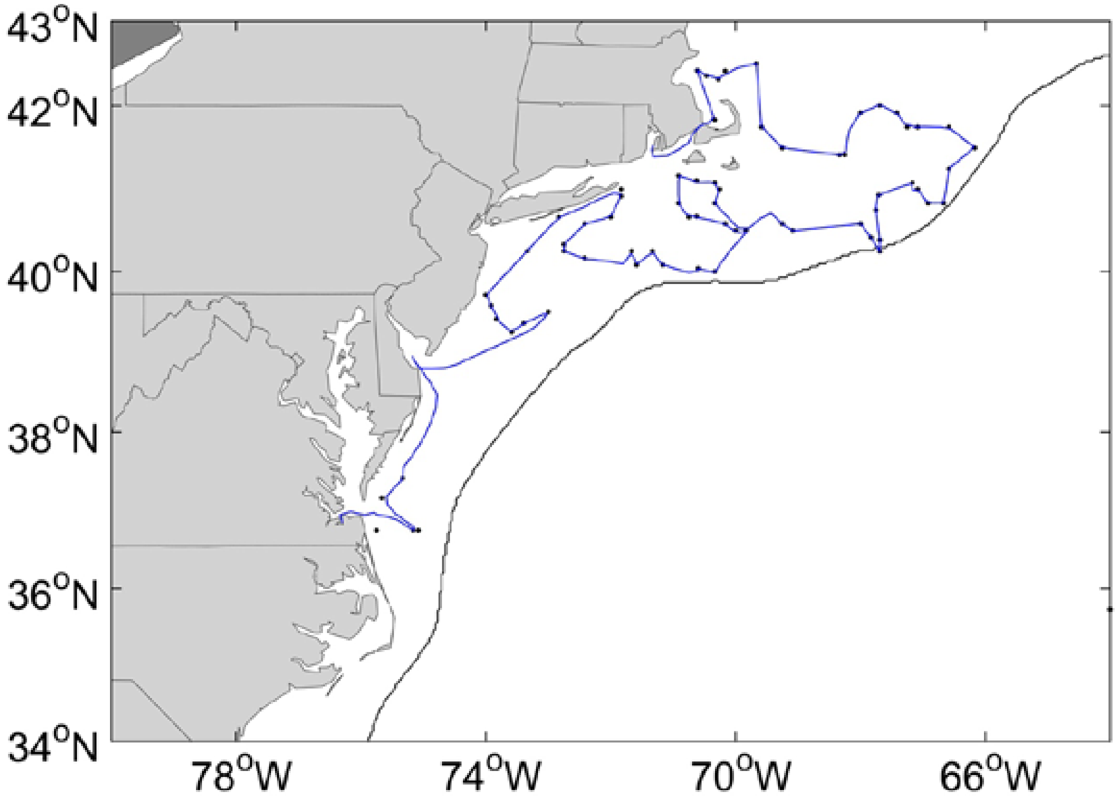


Figure 4.3. Cruise track (blue line) of fall Ecosystem Monitoring cruise GU1706, which sailed from 31 October – 10 November 2017. The black dots show locations where the ship stopped to conduct plankton and hydrographic sampling. The Black line indicates the 1000 m isobath.

4.7 Appendix 4-I: GU1701 Seabird Survey Report

Nicholas Metheny
Integrated Statistics, 16 Sumner St, Woods Hole, MA, 02543

Marine Species Observers: Nicholas Metheny and Glen Davis

4.7.1 Objective

The primary goal was to gather data on the abundance and distribution of seabirds as a part of longer term monitoring efforts for these far-ranging apex predators. Our secondary objective was to also collect data, when possible, on the abundance and distribution of other marine megafauna including, marine mammals, sea turtles, sharks, and other large pelagic fishes.

Collecting this data in conjunction with other biological data and abiotic factors may help understand possible changes occurring in the marine ecosystem in the Northwest Atlantic.

4.7.2 Cruise Period and Area

This cruise was conducted on the NOAA ship *Gordon Gunter* in two legs, where Leg 1 was 16 – 26 May 2017 and Leg 2 was 30 May – 7 June 2017. The area surveyed was on the continental shelf from Maine to North Carolina (Figure 4.1).

4.7.3 Methods

The protocol used for this survey is based on a standardized 300 m strip transect survey, one that is used by various agencies in North America and Europe (e.g., Anon 2011, Ballance 2011; Tasker 2004) and by the seabird observers on abundance surveys conducted under AMAPPS.

The survey strip is 300 m wide, with observers collecting data on all seabirds within that strip, from the bow to 90 degrees to either the port or the starboard side (depending on where the better viewing conditions are). Observations can be made in seas up to a Beaufort 7, in light rain, fog, and ship speeds between 8-12 knots (below 8 knots, the data becomes questionable to use for abundance estimates).

Surveys were conducted on the flying bridge (13.7 m) of the NOAA ship *Gordon Gunter* when possible. However, if limited visibility necessitated the use of the foghorn, then observation were made from the bridge wings (10.97 m) on either side of the wheelhouse.

The software used to collect survey data was, SeeBird version 4.3.7. This program extracts GPS coordinates and time from the ship's navigation system through a NMEA data feed connected to the data collection computer. Thus, each observation was associated with the location of the ship (latitude and longitude), a time stamp, and the ship's course. However, when observations were made from the bridge wings, a GPS puck was used to replace the ship's navigation feed.

The standard data collected for observations included: species, distance to sighting, number of individuals in the group, associated species, behavior, flight direction, flight height, and if possible or applicable, age, sex, and plumage status. Furthermore, a sub-module of SeeBird allows for the collection of data on seabird flocks that fall outside the survey zone. For the purposes of this cruise a flock was deemed an aggregation of seven birds or more. For flocks the following data were recorded: latitude and longitude of ship's position, time, bearing, reticle distance, species composition and number, associations, behavior, age, and sex. While SeeBird was not specifically designed to collect data on other marine megafauna, other such observations were also recorded anytime an animal was seen, both inside and outside of the 300 m searching zone.

During surveys, individual observers took two-hour shifts, to prevent observer fatigue. Observers utilized binoculars (10x42 or 8x42) for general scanning purposes within the survey strip. However, if an animal proved elusive a pair of 20x60 Zeiss imaged-stabilized binoculars were used to attain positive identifications. To aide in approximating distance, observers used custom made range finders based on height above water and the observer's personal body measurements (Heinemann 1981).

4.7.4 Results

4.7.4.1 Seabird Sightings

Over the course of the two legs of the cruise approximately 500 km were surveyed. A total of 3,856 birds were observed on survey, within an additional 1,269 birds observed over a total of 36 detected flocks; a total of 46 species of birds were identified (Table 4.1). Average bird densities were 2.29 birds/km^2, ranging from 0 birds/km^2 to 44 birds/km^2. The highest densities of birds occurred in the vicinity of the mid-Atlantic shelf break, east of Cape May, NJ.

4.7.4.2 Marine Mammal, Sea Turtle, and Large Fishes Sighting

A total of 67 whales were seen, with five species of whale positively identified among them. Of these, eight whales were Northern right whales (*Eubaleana glacialis*) in a concentrated area that triggered a Dynamic Management Area (DMA) that was active until June 1st.

Dolphins numbered 338, with four species of dolphin positively identified; approximately 85% of dolphins sighted were common dolphins (*Delphinus delphis*).

A total of 12 sea turtles were sighted, composed of leatherbacks (*Dermochelys coriacea*) and loggerheads (*Caretta caretta*); with one unidentified sea turtle.

For large fishes, basking sharks (*Cetorhinus maximus*) and sunfish (*Mola mola*) each species tallied eight individuals, with an additional one unidentified shark.

4.7.5 References Cited

Anonymous. 2011 Seabird Survey Instruction Protocol. Seabird distribution and abundance, Summer 2011. NOAA RV Henry B. Bigelow. Northeast Fisheries Science Center.

Ballance LT. 2011. Seabird Survey Instruction Manual, PICEAS 2011. Ecosystems Studies Program Southwest Fisheries Science Center, La Jolla, California.

Heinemann D. 1981. A range finder for pelagic bird censusing. Journal of Wildlife Management 45:489-493.

Tasker M, Hope Jones P, Dixon T, Blake BF. 1984. Counting seabirds at sea from ships; a review of methods employed and a suggestion for a standardized approach. Auk 101: 567 – 577.

Table 4.1. List of birds detected during the GU1701 survey.

Common Bird Name	Scientific Name	Number Observed in Zone	Number Observed in Flock*	Total Observed
Atlantic Puffin	*Fratercula arctica*	18		18
Black Guillemote	*Cepphus grylle*	1		1
Dovekie	*Alle alle*	2		2
Common Murre	*Uria aalge*	1		1
Razorbill	*Alca torda*	5		5
Unidentified Alcid	-	3		3
Common Loon	*Gavia immer*	48	8 (1)	56
Red-throated Loon	*Gavia stellata*	2		2
Common Eider	*Somateria mollissima*	5		5
Audubon Shearwater	*Puffinus lherminieri*	1		1
Cory's Shearwater	*Calonectris borealis*	13		13
Great Shearwater	*Puffinus gravis*	403	209 (12)	612
Sooty Shearwater	*Ardenna grisea*	563	151 (5)	714
Manx Shearwater	*Puffinus puffinus*	17	33 (2)	50
Unidentified Shearwater	-	4		4
Wilson's Storm Petrel	*Oceanites oceanicus*	999	539 (13)	1538
Leach's Storm Petrel	*Leach's Storm Petrel*	156		156
Unidentified Storm Petrel	-	7		7
Northern Fulmar	*Fulmarus glacialis*	331	37 (2)	368
Arctic Tern	*Sterna paradisaea*	44		44
Common Tern	*Sterna hirundo*	138	25 (2)	163
Roseate Tern	*Sterna dougallii*	13		13
Royal Tern	*Thalasseus maximus*	9		9
Least Tern	*Sternula antillarum*	11		11
Unidentified Tern	-	2	111 (5)	113
Great Black-backed Gull	*Larus marinus*	170		170
Herring Gull	*Larus argentatus*	268	139 (4)	407
Laughing Gull	*Leucophaeus atricilla*	29	1 (1)	30
Lesser Blaack-backed Gull	*Larus fuscus*	2		2
Black-legged Kittiwake	*Rissa tridactyla*	2		2
Sabine's Gull	*Xema sabini*	1		1
Unidentified Large Gull	-	1		1
Parasitic Jaeger	*Stercorarius parasiticus*	3		3
Pomarine Jaeger	*Stercorarius pomarinus*	3	2 (1)	5
Unidentified Jaeger	-	1	3 (1)	4
South Polar Skua	*Stercorarius maccormicki*	12		12
Unidentified Skua	-	3		3
Double Crested Comorant	*Phalacrocorax auritus*	24	38 (1)	62
Northern Gannet	*Morus bassanus*	241		241
Red Phalarope	*Phalaropus fulicarius*	208		208
Red-necked Phalarope	*Phalaropus lobatus*	39		39

Common Bird Name	Scientific Name	Number Observed in Zone	Number Observed in Flock*	Total Observed
Unidentified Phalarope	-	2		2
Ruddy Turnstone	*Arenaria interpres*	4		4
Sanderling	*Calidris alba*	5		5
Semipalmated Sandpiper	*Calidris pusilla*	1		1
Unidentified Sandpiper	-	24		24
American Oystercatcher	*Haematopus palliatus*	3		3
Unidentified Shorebird	-	3		3
Great Egret	*Ardea alba*	1		1
Barn Swallow	*Hirundo rustica*	3		3
Chimney Swift	*Chaetura pelagica*	1		1
Cedar Waxwing	*Bombycilla cedrorum*	1		1
Common Yellowthroat	*Geothlypis trichas*	1		1
Northern Parula	*Setophaga americana*	1		1
Purple Martin	*Progne subis*	2		2
Osprey	*Pandion haliaetus*	1		1

Table 4.2. List of other marine mammals, sea turtles, and fishes detected during the GU1701 survey.

Common Name	Scientific Name	Number Observed
Fin Whale	*Balaenoptera physalus*	14
Sei Whale	*Balaenoptera borealis*	2
Fin/Sei Whale	*B. physalus or borealis*	5
Humpback Whale	*Megaptera novaeangliae*	13
Minke Whale	*Balaenoptera acutorostrata*	1
Northern Right Whale	*Eubalaena glacialis*	8
Unidentified Whale	-	24
Risso's Dolphin	*Grampus griseus*	16
Common Dolphin	*Delphinus delphis*	288
Atlantic Spotted Dolphin	*Stenella frontalis*	14
Bottlenose Dolphin	*Tursiops truncatus*	13
Unidentified Dolphin	-	7
Leatherback Sea Turtle	*Dermochelys coriacea*	1
Loggerhead Sea Turtle	*Caretta caretta*	10
Unidentified Sea Turtle	-	1
Ocean Sunfish	*Mola mola*	8
Basking Shark	*Cetorhinus maximus*	8
Unidentified Shark	-	2

4.8 Appendix 4-II: GU1702 Seabird Survey Report.

Tim White[1] and Glen Davis[2]
[1] Bureau of Ocean Energy Management, 45600 Woodland Rd. Sterling, VA 20166
[2]Integrated Statistics, 16 Sumner St, Woods Hole, MA, 02543

Seabird Observers: Glen Davis and Timothy White

4.8.1 Objective

In June 2017, the NOAA ship *Gordon Gunter* surveyed transects along the Gulf Stream to gather information about tuna spawning, while collecting data (abiotic and biotic) that helps describe and quantify ecological conditions. Much of the area visited, had been little-investigated/sampled, especially for seabirds. Our observer team's task was to observe as much as possible, to gather data on the abundance and distribution of seabirds as a part of longer term monitoring efforts for these far-ranging marine fauna. In addition, observation data were collected, whenever possible, for other marine megafauna including, marine mammals, sea turtles, sharks, and other large pelagic fishes.

4.8.2 Cruise Period and Area

This cruise was conducted during 9 – 22 June 2017 on the NOAA ship *Gordon Gunter* and covered the continental slope and deeper waters from New Jersey to North Carolina, in addition to shelf waters from North Carolina to Florida (Figure 4.2).

4.8.3 Methods

The protocol used for this survey is based on a standardized 300 meter strip transect survey, one that is used by various agencies in North America and Europe (Ballance 2011; Tasker 2004) and by the seabird observers on AMAPPS dedicated abundance surveys.

For this survey, we elected to effectively double the 300 meter strip to a 600 m x 300 m rectangle by employing two observers simultaneously watching in front of the ship, with observers collecting data on all seabirds within their strip quadrant, from the bow to 90 degrees to either the port or the starboard side, and communicating about flying birds from one quadrant to the other to prevent over-counting. When observers were at meals or taking a break, only a single 300 m strip transect was surveyed (typically selected to minimize glare).

Observations can made in seas up to a Beaufort 7, in light rain, fog, and ship speeds between 8-12 knots. During rain, the strip transect reverts to 300 m and observations are made from the ship's bridge by one observer watching in a 90 degree quadrant from 315-45 degrees. Surveys were conducted on the ship's flying bridge at an elevation of 13.7 meters. When there was fog or rain the bridge deck was the observation platform at 10.97 m.

The software used to collect survey data was, SeeBird version 4.3.7. The survey laptop (Panasonic Toughbook) was equipped with GPS, and was time-synched with the ship's GPS time. All of the ship's recorded sea data could be linked to the observation timestamps. The standard data collected for observations included: species, distance, number of individuals, association, behavior, flight direction, flight height, and if possible or applicable, age, sex, and plumage status.

Observers scanned the 300 m quadrant naked eye and also frequently through binoculars (10x50 or 8x42) to detect birds. At-sea experience and a systematic observation approach made it possible for the observers to maximize the effort of their detections. A Canon 7D with 400mm 5.6 camera setup was used to document and identify as much as possible, and a 20x60 Zeiss imaged-stabilized binocular was also sometimes used to attain positive identifications. Observers used custom-made range finders (marked, unsharpened pencils) based on the height of the observation platform and body height and arm measurements, to aide in distance estimation (Heinemann 1981).

4.8.4 Results

4.8.4.1 Seabird sightings

We traversed the thermocline edges of the Gulf Stream from over 400 nautical miles east of southern Delaware to just south of Cape Hatteras. A total of 1,448 individual seabirds (1,364 with 300 meters) were observed along this transect route (see Table 4.3; Figures 4.4 – 4.7). The species that are most specifically tied to this geographic feature were seen throughout the survey, with 231 Cory Shearwater, 189 Audubon's Shearwater, 122 Band-rumped Storm-Petrels, and 58 of the endangered Black-capped Petrel. Of the petrel, also know as Diablotín, all sightings were of the "light-faced" form, and mostly at the start of their wing molts. Three Trinidade Petrels were recorded during the time the ship was the furthest east along the Gulf Stream and farthest from shore. The Beaufort was 5-7 for these sightings and detection of marine birdlife was difficult at best. These heavier winds and seas may have hampered further detections of this species, most notably.

There was also the presence of a northbound passage and arrival of other seabird species. The most abundant species, Great Shearwater (534), and a few others were mostly observed flying north. Many Wilson's (490) and most Leach's Storm-Petrel (36) were also heading north. The molt was limited to absent on most of these and presumably upon arrival to better feeding grounds for them their molt will begin in force.

One Snowy Egret was the only non-seabird sighting. South Polar Skua, Pomarine Jaeger (both northbound migrants), White-tailed Tropicbird, Brown Booby, and various terns like Arctic, Sooty, and Bridled Terns were also of interest in occurrence.

4.8.4.2 Marine Mammals and All Other Fauna

Although the survey protocol (Gjerdrum et al. 2012) used for the seabird surveys was not designed for marine mammals, turtles or large fish, these observations were also recorded. See Table 4.4 for a summary of marine mammal observations. The offshore transient killer whale (*Orcinus orca*; Figure 4.8) group of three individuals was particularly rare. The pilot whales were probably short-finned pilot whale (*Globicephala macrorhynchus*) based on photos and range.

One loggerhead sea turtle was observed, as well as a handful of ocean sunfish. While close to the continental shelf, many scalloped hammerhead, and some mahi mahi and blackfin tuna were observed. Seven species of flying fish were also encountered and recorded.

4.8.5 Acknowledgements

Thanks to the officers and crew of the NOAA ship *Gordon Gunter* and NOAA, BOEM, and Integrated Statistics.

4.8.6 References Cited

Ballance LT. 2011. Seabird Survey Instruction Manual, PICEAS 2011. Ecosystems Studies Program Southwest Fisheries Science Center, La Jolla, California.

Heinemann D. 1981. A range finder for pelagic bird censusing. Journal of Wildlife Management 45: 489-493.

Tasker ML, Hope Jones P, Dixon T, Blake BF. 1984. Counting seabirds at sea from ships; a review of methods employed and a suggestion for a standardized approach. Auk 101: 567 – 577.

Table 4.3. List of seabird species sighted during seabird surveys on board the NOAA ship *Gordon Gunter* during oceanographic surveys from 10 – 22 June 2017.

Species	Latin	Total number within 300m	Total number observed
South Polar Skua	*Stercorarius maccormicki*	1	2
Pomarine Jaeger	*Stercorarius pomarinus*	2	2
Herring Gull	*Larus argentatus*	3	4
Sooty Tern	*Onychoprion fuscatus*	0	3
Bridled Tern	*Onychoprion anaethetus*	0	3
Common Tern	*Sterna hirundo*	2	2
Arctic Tern	*Sterna paradiasaea*	0	1
Common/Arctic sp.	*Sterna hirundo/paradiasaea*	0	3
Royal Tern	*Thalasseus maximus*	3	3
White-tailed Tropicbird	*Phaethon lepturus*	1	1
Trinidad Petrel	*Pterodroma arminjoniana*	2	3
Black-capped Petrel	*Pterodroma hasitata*	51	58
Pterodroma sp.	*Pterodroma sp.*	0	1
Cory’s Shearwater	*Calonectris diomedea*	170	231
Sooty Shearwater	*Ardenna grisea*	4	6
Great Shearwater	*Ardenna gravis*	393	534
large shearwater sp.	*Calonectris/Ardenna sp.*	0	26
Manx Shearwater	*Puffinus puffinus*	2	2
Audubon’s Shearwater	*Puffinus Iherminieri*	166	189
Wilson’s Storm-Petrel	*Oceanites oceanicus*	386	490
Leach’s Storm-Petrel	*Oceanoodroma leucorhoa*	28	36
Band-rumped Storm-Petrel	*Oceanoodroma castro*	102	122
Leach’s/Band-rumped sp.	*Oceanoodroma*	10	18
storm-petrel sp.	*Hydrobatidae sp.*	16	82
Brown Booby	*Sula leucogaster*	2	2
Northern Gannet	*Morus bassanus*	1	1
Double-crested Cormorant	*Phalacrocorax auritus*	1	1
TOTAL		1346	1826

Table 4.4. List of marine mammal species sighted during seabird surveys on board the NOAA ship *Gordon Gunter* during oceanographic surveys from 10 – 22 June 2017.

Species	Latin	Total number observed	Comments
Sperm whale	*Physeter macrocephalus*	2	One adult and one juvenile; separate sightings.
Common dolphin	*Delphinus delphis*	7	A small group in the colder water.
Pilot whale sp.	*Globicephala sp.*	24	On two days; close to Continental Shelf.
Killer whale	*Orcinus orca*	3	Including one adult male; high seas: 37.812, -68.563.
Pantropical spotted dolphin	*Stenella attenuata*	25	Four small groups on one day.
Striped dolphin	*Stenella coeruleoalba*	251	Far offshore; on two days; one group of 170.
Atlantic spotted dolphin	*Stenella frontalis*	73	Closer to Continental Shelf; on four days; one group up to 45.
Spotted dolphin sp.	*Stenella attenuata/frontalis*	19	Too poor looks to confirm identification.
Common bottlenose dolphin	*Tursiops truncatus*	186	Widespread; on six days; often near fishing ops.

Figure 4.4 Black capped Petrel (*Pterodroma hasitata*). Photo credit: Glen Davis.

Figure 4.5 Great Shearwater (*Ardenna gravis*). Photo credit: Glen Davis.

Figure 4.6 Trinidade Petrel (*Pterodroma arminjoniana*). Photo credit: Glen Davis.

Figure 4.7 Brown Booby (*Sula leucogaster*). Photo credit: Glen Davis.

Figure 4.8 Killer whale (*Orcinus orca*). Photo credit: Glen Davis.

4.9 Appendix 4.III: GU1706 Seabird Survey Report.

Nicholas Metheny
Integrated Statistics, Inc., 16 Sumner St, Woods Hole, MA, 02543

Marine Species Observers: Nicholas Metheny and John Loch

4.9.1 Objectives

The primary goal of conducting seabird surveys aboard the NOAA ship *Gordon Gunter* in Oct./Nov. 2017 was to gather data on the abundance and distribution of seabirds as a part of longer term monitoring efforts for these far-ranging apex predators. Our secondary objective in conducting these surveys was to also collect data, when possible, on the abundance and distribution of other marine megafauna including, marine mammals, sea turtles, sharks, and other large pelagic fishes.

Collecting this data in conjunction with other biological data and abiotic factors will help better complete our "picture" of possible changes occurring in the marine ecosystem in the Northwest Atlantic from the mid-Atlantic to the Bay of Fundy.

4.9.2 Cruise Period and Area

This cruise was conducted during 31 October – 10 November 2017 on the NOAA ship *Gordon Gunter* and covered the continental shelf waters from Massachusetts to Virginia (Figure 4.3).

4.9.3 Methods

From an observation station on the flying bridge, about 13.7 m above the sea surface, two observers, working solo on a two-hour rotation, conducted a visual daylight survey for seabirds during approximately 0730 – 1730. Seabird observation effort employed a modified 300 m strip and line-transect methodology. Data on seabird distribution and abundance were collected by identifying and enumerating all birds seen within a 300 m arc on one side of the bow while the ship was underway. Seabird observers maintained a visual unaided eye watch of the 300 m survey strip, with frequent scans of the perimeter using hand-held binoculars for cryptic and/or hard to detect species. Binoculars were used for distant scanning and to confirm identification. Ship-following species were counted once and subsequently carefully monitored to prevent re-counts. All birds, including non-marine species, such as raptors, doves, and Passerines, were recorded.

Operational limits are higher for seabird surveys compared to other survey protocols. As a result, seabird survey effort was possible in sea states up to and including a low Beaufort 8. Seabird survey effort was suspended, however, if the ship's speed over ground fell below six knots. In limited visibility conditions (i.e. fog) in which the fog horn on the flying bridge was activated, observations were made from the bridge deck (about 10.97m above sea surface) and the computer's internal GPS was used.

All data were entered in real time into a Panasonic Toughbook laptop running *Seebird* (vers 4.3.7), a data collection program developed at the Southwest Fisheries Science Center. The software was linked to the ship's navigation system via a serial cable. The following data were collected for each sighting: species identification, number of birds within a group, distance between the observer and the group, angle between the track line and the line of sight to the group, behavior, flight direction, flight height, age, sex and, if possible, molt condition. The sighting record received a corresponding time and GPS fix once the observer accepted the record and the software wrote it to disk. *Seebird* also added a time and location fix every five minutes. *Seebird* incorporates a time synchronization feature to ensure the computer clock matches the GPS clock to assist with post-processing of the seabird data with the ship's SCS data. All data underwent a quality assurance and data integrity check each evening and saved to disk and to an external backup dataset.

4.9.4 Results

Seabird survey effort was conducted on at least parts of 10 out of 10 sea-days covering roughly 1,150 km. Nomenclature of species identifications followed that reported in The Clements Checklist of Birds of the World. 6th edition, Cornell University Press 2007, with electronic updates to 2016.

A summary of the 2,015 birds seen while on effort (including flocks seen in zone 4) broken down by species is presented in Table 4.5. This survey recorded 45 species of birds and 9 unidentified species groups (e.g., unidentified shearwater, unidentified storm-petrel or unidentified shore bird). Six species comprised 77% of the total birds seen. In declining order of abundance these were: Black Scoter (*Melanitta americana*), Great Shearwater *(Puffinus gravis)*, Herring Gull (*Larus argentatus*), Northern Gannet (*Morus bassanus*), Double-crested Cormorant (*Phalacrocorax auritus*), and Bonaparte's Gull (*Chroicocephalus philadelphia*).

A majority of Scoter and Double-crested Cormorant sightings were seen as flocks close to shore, and in the case of the cormorants, most of their number being counted near Delaware Bay and near the entrance of Norfolk, Virginia. Atlantic Puffins were seen mostly offshore around George's Banks, whereas the lone Razorbill and Dovekie were seen further inshore, the Razorbill near Boston, and the Dovekie near Long Island. Of further note, all the Wilson's Storm-petrels were seen on the transit to Norfolk, Virginia on the last day of the cruise, where as a Leach's Storm-petrel (and probable Leach's denoted as unidentified storm-petrel) were sighted along the continental shelf around 540 km east of the New Jersey shoreline. Also of note were one (possibly two) late season South Polar Skuas sighted far off shore East of Cape Cod.

A diversity of non-marine avian species were sighted on this cruise including American Robin (*Turdus migratorius*), Brown-headed Cowbird (*Molothrus ater*), Chipping Sparrow (*Spizella passerina*), Dark-eyed Junco (*Junco hyemalis*), Great Blue Heron (*Ardea herodias*), Gray Catbird (*Dumetella carolinensis*), Osprey (*Pandion haliaetus*), Red-wing Black Bird (*Agelaius phoeniceus*), Sanderling (*Calidris alba*), Scarlet Tanager (*Piranga olivacea*), Snow Bunting (*Plectrophenax nivalis*), Song Sparrow (*Melospiza melodia*), Wood Duck (*Aix sponsa*), White-throated Sparrow (*Zonotrichia albicollis*), and Yellow-rumped Warbler (*Setophaga coronata*); most of these sighting likely due to the last of the fall migrants along the Atlantic Flyway.

A summary of non-avian marine species seen is presented in Table 4.6. This survey encountered 5 species of marine mammals, 1 species of sea turtle, and 3 kinds of marine fishes. The loggerhead sea turtle, humpback whale, and harbor porpoise were all seen on the transit in to Norfolk, Virginia.

Table 4.5. Number of groups and individual birds detected during GU1706

Name	Scientific Name	Number of Groups	Number of Individuals	Relative Number of Individuals (rounded)
American Robin	*Turdus migratorius*	1	1	0.0005
Atlantic Puffin	*Fratercula arctica*	5	5	0.0025
Brown-headed Cowbird	*Molothrus ater*	1	1	0.0005
Black-legged Kittiwake	*Rissa tridactyla*	40	48	0.0239
Black Scoter	*Melanitta americana*	24	391	0.195
Bonaparte's Gull	*Chroicocephalus philadelphia*	31	150	0.0758
Brown Pelican	*Pelecanus occidentalis*	2	11	0.0055
Chipping Sparrow	*Spizella passerina*	1	1	0.0005
Common Eider	*Somateria mollissima*	3	13	0.0065
Common Loon	*Gavia immer*	15	21	0.0105
Cory's Shearwater	*Calonetrics diomedea*	8	12	0.006
Double-crested Cormorant	*Phalacrocorax auritus*	4	187	0.0933
Dark-eyed Junco	*Junco hyemalis*	2	4	0.002
Dovekie	*Alle alle*	1	1	0.0005
European Starling	*Sturnus vulgaris*	1	1	0.0005
Great Black-backed Gull	*Larus mainus*	56	75	0.0374
Great Blue Heron	*Ardea herodias*	1	3	0.0015
Gray Catbird	*Dumetella carolinensis*	1	1	0.0005
Great Shearwater	*Puffinus gravis*	136	350	0.1746
Herring Gull	*Larus argentatus*	166	266	0.1327
Laughing Gull	*Larus atricilla*	5	8	0.004
Leach's Storm-petrel	*Oceanodroma leucorhoa*	1	1	0.0005
Manx Shearwater	*Puffinus puffinus*	3	4	0.002
Marsh Wren	*Cistothorus palustris*	1	1	0.0005
Northern Fulmar	*Fulmarus glacialis*	57	71	0.0354
Northern Gannet	*Morus bassanus*	169	199	0.0993
Osprey	*Pandion haliaetus*	1	1	0.0005
Parasitic Jaeger	*Stercorarius parasiticus*	2	2	0.001
Passerine	*N/A*	6	7	0.0035
Pomarine Jaeger	*Stercorarius pomarinus*	4	4	0.002
Razorbill	*Alca torda*	1	1	0.0005
Ring-billed Gull	*Lars delawarensis*	5	6	0.003
Red-throated Loon	*Gavia stellata*	3	15	0.0075
Red-wing Black Bird	*Agelaius phoeniceus*	1	1	0.0005
Sanderling	*Calidris alba*	2	6	0.003
Scarlet Tanager	*Piranga olivacea*	1	1	0.0005
Shorebird Sp	*N/A*	1	1	0.0005
Snow Bunting	*Plectrophenax nivalis*	2	2	0.001
Sooty Shearwater	*Puffinus griseus*	1	1	0.0005
Song Sparrow	*Melospiza melodia*	1	1	0.0005
South Polar Skua	*Stercorarius maccormicki*	1	1	0.0005
Surf Scoter	*Melanitta perspicillata*	8	20	0.01
Unid Alcid	*N/A*	2	2	0.001
Unid Dolphin	*N/A*	3	10	0.005
Unid Jaeger	*Stercorarius sp*	6	6	0.003

Name	Scientific Name	Number of Groups	Number of Individuals	Relative Number of Individuals (rounded)
Unid Phalarope	*Phalaropus sp*	3	20	0.01
Unid Shearwater	*Puffinus sp*	2	2	0.001
Unid Skua	*Stercorarius sp*	1	1	0.0005
Unid Storm-petrel	*N/A*	1	2	0.001
Wilson's Storm-petrel	*Oceanites oceanicus*	3	5	0.0025
Wood Duck	*Aix sponsa*	1	1	0.0005
White-throated Sparrow	*Zonotrichia albicollis*	1	1	0.0005
White-winged Scoter	*Melanitta fusca*	14	56	0.0279
Yellow-rumped Warbler	*Setophaga coronata*	1	1	0.0005
TOTAL		813	2003	1

Table 4.6 Number of groups and individual of non-avian marine species dectected during GU1706

Name	Scientific Name	Number of Groups	Number of Individuals
Short-Beaked Common Dolphin	*Delphinus delphis*	15	126
Humpback Whale	*Megaptera novaeangliae*	1	2
Bottlenose Dolphin	*Tursiops truncatus*	2	5
Pilot Whale Sp	*Globicephla sp*	1	10
Harbor Porpoise	*Phocoena phocoena*	1	3
Loggerhead Turtle	*Caretta caretta*	1	1
Tuna Sp	*Thunnus sp*	2	*
Shark Sp	*N/A*	2	2
Ocean Sunfish	*Mola mola*	3	3

*No accurate estimate for either school of tuna given.

5 Pilot Study Linking Biological and Physical Oceanography to Marine Mammal Sightings: University of Rhode Island, 14 – 19 April 2017

Christopher Orphanides

Northeast Fisheries Science Center, 166 Water St, Woods Hole, MA 02543

5.1 Summary

During April 14-19, 2017, the National Science Foundation ship *R/V Endeavor* operated by the University of Rhode Island (URI) conducted a Rhode Island Endeavor Program (RIEP) research cruise intended to explore marine mammal distribution relative to prey layers and physical oceanography while also deploying instrumentation examining carbon export to the deep sea. The protocols employed during this pilot study could be applied to potential future AMAPPS studies aimed at high resolution sampling to discern processes influencing marine mammal distribution in energy development regions. AMAPPS contributed contractor funds for one observer. The cruise ran transects for sighting marine mammals, deployed bongo nets and CTDs, gathered active acoustic data on prey layers using a tow body equipped with 38 and 120 kHz EK60 echosounders, collected passive acoustic data on humpback and sei whale calls, recorded underway physical oceanographic data, and tested a few instruments to assess carbon export to the deep sea. The 51 recorded marine mammal sightings data from this cruise will be audited then added to the AMAPPS Oracle database. The echosounding data are currently being analyzed, and the zooplankton samples have been preserved and will be sent to Poland for processing identification and quantity.

5.2 Objectives

The RIEP is designed to provide URI researchers and Rhode Island's educator's access to the scientific research and educational capabilities of an ocean-going research vessel. This particular research cruise was designed as the centerpiece of an undergraduate honors science class in which the undergraduate students participated in data collection while at sea and shared their experiences using telepresence via the URI Graduate School of Oceanography (GSO) Inner Space Center. The cruise's marine mammal focus was chosen because of the potential for students to experience multiple types of oceanographic sampling that examine the linkages between several trophic levels. While a primary focus of this cruise was education, it was important that the students were collecting real data that contributes to a research objective. Sightings data collected will be added to the AMAPPS Oracle database and the research on marine mammal distribution relative to prey layers and physical oceanography could lay the groundwork for future AMAPPS studies. The protocols developed during this pilot study could provide potential methods used for high resolution sampling of a future AMAPPS process study conducted in regions of interest such as potential energy development regions.

5.3 Cruise Period and Area

The cruise was conducted during April 14-19, 2017 on the *R/V Endeavor*. The study area was continental shelf and shelf edge south of Narragansett Bay, Rhode Island (Figure 5.1).

5.4 Methods

The data collection plan was to simultaneously record sightings of marine mammals and collect both physical and biological data from the water column while underway. This creates a unique dataset allowing for the exploration of physical and biological linkages defining water column habitat for marine mammals and their prey. The cruise ran transects for sighting marine mammals, deployed bongo nets and CTDs, gathered active acoustic data on prey layers using a tow body equipped with 38 and 120 kHz EK60 echosounders, collected passive acoustic data on humpback and sei whale calls, recorded underway physical oceanographic data, and tested a few instruments to assess carbon export to the deep sea.

A contractor (funded with AMAPPS funds) and a NEFSC federal staff member, who is also a doctoral graduate student at GSO, participated in the research cruise by running the marine mammal, zooplankton, and active acoustic portions of the cruise. The original plan for the cruise was to run marine mammal transects along the shelf break, similar to those conducted for AMAPPS shipboard abundance surveys. Then while underway and conducting standard marine mammal observations, researchers collected information on prey layers using a tow body equipped with EK60 echosounders and simultaneously collected physical oceanographic data using a CTD (Conductivity Temperature Depth sensor) deployed in a tow-yo motion using a winch from a UCTD (Underway CTD). To tow the echosounders and the CTD, the ship ran at roughly 4 kts, in contrast to the usual AMAPPS abundance protocol of traveling at about 10 kts.

5.5 Results

In summary, as a pilot study we accomplished a lot in this 6 day survey. We detected 51 marine mammal sightings (Figure 5.1), deployed 10 CTD and 9 bongo nets. We recorded 22 minutes of data from the underway CTD until it broke. In addition we recorded 64 hours of EK60 data and 12 hours of passive acoustic data from a buoy.

In detail, the cruise embarked on this plan and followed it for roughly two and half days before the seas picked up, which limited marine mammal sighting ability. During this time the UCTD system broke down and the experimental carbon export instruments did not function as planned. We then changed course and headed towards the mid-shelf where there were calmer seas and a better chance to observe the typically larger marine mammals thought to be occupying this area (Figure 5.1). We began our mid-shelf transect where we had sighted a number of marine mammals a few days prior while transiting to the shelf break. We progressed from the mid-shelf towards a passive acoustic buoy near Noman's Land Island where there were recent right whale acoustic detections. We deployed the active acoustics and progressed at roughly 4 kts. Several marine mammals were observed, and we sampled the water column with stationary CTDs and bongo nets at multiple stations along the transect line. Overnight we traversed back along the transect line towards the location where we started the previous day.

During the second day of surveying the mid-shelf, we encountered an aggregation of whales at first light, which were primarily sei and humpback whales. A passive acoustics buoy was rigged and deployed on a float with a GPS in an attempt to record sei whale calls, and we decided to do higher resolution sampling in this region to assess the biological and physical characteristics that may have led to this aggregation. Later that day the float was retrieved, and we prepared to head back to shore, concluding the short cruise.

The sightings data from this cruise will be audited then added to the AMAPPS Oracle database. The echosounding data are currently being analyzed, and the zooplankton samples have been preserved and will be sent to Poland for processing identification and quantity.

A second 6-day RIEP cruise, also associated with a URI undergraduate honors science class, is currently being planned for April 2018 that will build off our experience with the April 2017 cruise. Given the short nature of the cruise and our experience last year, we hope to choose one research area prior to the cruise based on predicted weather and sightings information and stay in this region for the duration of the cruise. Two research areas under consideration are the shelf break region explored in the 2017 cruise, or south of Martha's Vineyard in or near regions targeted for potential wind energy development. The region south of Martha's Vineyard is also a region of interest for North Atlantic right whales, as they have recently been found to use this region all year, with potential higher concentrations during the early spring or late winter.

5.6 Disposition of Data

All visual and passive acoustic data collected will be maintained by the Protected Species Branch at the Northeast Fisheries Science Center (NEFSC) in Woods Hole, MA. Visual sightings data will be archived in the NEFSC's Oracle database and later submitted to OBIS SEAMAP.

All active acoustic data are archived at the NEFSC and at NOAA's National Center for Environmental Information (NCEI) facility in Boulder, CO. The data will be publically available when they are archived at NCEI.

All plankton samples collected will be maintained by the Oceans and Climate Branch at the NEFSC in Narragansett RI. Plankton samples in ethanol will be sent to Poland for identification. After identification and enumeration are complete plankton data can be accessed through the NEFSC's Oracle database.

5.7 Permits

The marine mammal research activities were authorized to be conducted under US Permit No. 17355 issued to the NEFSC by the NMFS Office of Protected Resources.

5.8 Acknowledgements

Most of the funds for this project came from the University of Rhode Island. AMAPPS funds were used for one observer. These funds are from the Bureau of Ocean Energy Management (BOEM) and the US Navy through the respective Interagency Agreements for the AMAPPS project. Staff time for the NMFS federal employee was provided by the NOAA Fisheries Service, NEFSC. We would like to thank the crew of the *R/V Endeavor*, the University of Rhode Island students and instructors that were involved in planning and collecting these data for their efforts and dedication to this project.

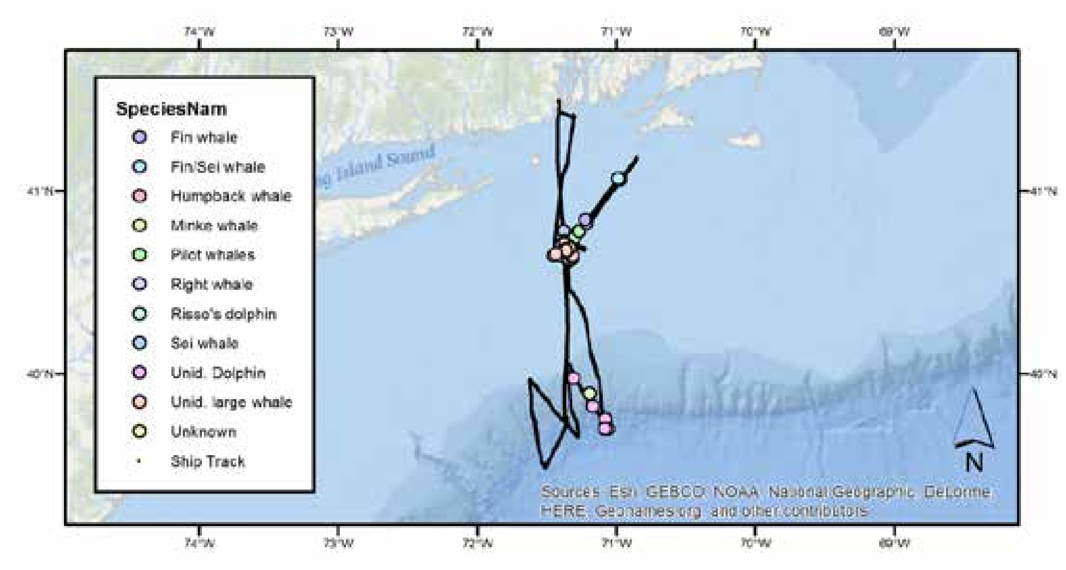


Figure 5.1. Cruise track and 51 recorded marine mammal sightings on EN595 (April 14 – 19, 2017). Additional harbor porpoise, pilot whales, and sei whales were observed in route to the first station but not recorded.

6 Turtle tagging cruise 6 – 19 July 2017: Northeast Fisheries Science Center

Heather Haas[1] (with contributions from Elizabeth Broughton[1] and other cruise participants)

[1]Northeast Fisheries Science Center, 166 Water St, Woods Hole, MA 02543

6.1 Summary

From July 6 to July 19, 2017, the Northeast Fisheries Science Center (NEFSC) and partners conducted a Cetacean and Turtle cruise aboard the NOAA Ship *Henry B. Bigelow* (Figure 6.1). This survey occurred in shelf and shelf break waters off of the Northeast United States and Canada. The southwestern extent was the shelf waters off of New Jersey and the northeastern extent was Canadian waters near the Northeast Channel. The cruise accomplished objectives related to loggerhead sea turtle ecology, maintenance (exchange) of fixed acoustic recording devices, and zooplankton, turtle, and cetacean distribution. We deployed 5 satellite related data loggers to collect information on loggerhead sea turtles. We retrieved and re-deployed acoustic devices at three locations. We collected temperature, depth, and salinity, and documented the distribution of zooplankton, turtles, and cetaceans. Throughout the cruise, we documented 2521 animals across 25 taxonomic groups.

6.2 Objectives

The cruise accomplished 4 main objectives:

1) Locate and capture loggerhead sea turtles. Collect loggerhead morphometric data (length, width, body depth, weight, tail length), tissue samples (e.g., blood, skin, parasites); and apply tags (Passive Integrated Transponders, Inconel, and satellite linked data loggers) to loggerhead turtles.
2) Retrieve and re-deploy high-frequency acoustic recording packages (HARPS) at three sites.
3) Collect oceanographic data related to temperature, salinity, and zooplankton distribution; including conducting a transect line into a large warm core ring.
4) Opportunistically collect information on the distribution and occurrence of cetacean and sea turtle species sighted during the survey.

6.3 Cruise Period and Area

The total cruise period was scheduled as Leg 1 July 5 to 20, 2017 and Leg 2 July 24 to August 9, 2017 with a preceding period of small boat operations June 26 to 29, 2017. To maximize time for small boat training and operations prior to the cruise, the July 5 sea day was transferred to July 30 resulting in the final Leg 1 cruise dates set to July 6 to 20. Due to engine problems, Leg 1 returned on July 19 and Leg 2 was cancelled.

From July 6 to July 19, 2017, the Northeast Fisheries Science Center (NEFSC) and partners conducted a Cetacean and Turtle cruise aboard the NOAA Ship *Henry B. Bigelow*. This survey occurred in shelf and shelf break waters off of the Northeast United States and Canada. The southwestern extent was the shelf waters off of New Jersey and the northeastern extent was Canadian waters near the Northeast Channel. There were no port calls.

6.4 Methods

Cruise participants are listed in Table 6.1, and the primary daily daytime cruise priorities are listed in Table 6.2.

6.4.1 Sea Turtle Tagging

The visual surveys were conducted from the fly bridge, using naked eye, standard and imaged stabilized binoculars, as well as two sets of "big eye" binoculars (25 x150). Visual surveys typically began at 0730 and lasted until the capture boat could no longer be safely deployed and retrieved (which would occur at dusk or with increasing sea conditions). Track lines and vessel speed were selected and adjusted to optimize sightings conditions. Vessel speed typically ranged from 4 knots to 9 knots during visual surveys.

When a turtle was spotted and was a good candidate for capture, the work boat was deployed if it was not already in the water. The work boat was staffed with three science party (one Operator-in-Charge and two crew). The work boat approached the turtles and a scientist attempted capture with a large dip net. The netted turtle was then carefully brought alongside the work boat and lifted on board. The work boat then returned alongside the NOAA ship *Henry B. Bigelow*, and the turtle was transferred into a square net to be lifted aboard. Upon transfer of the turtle to the larger vessel, the turtle was sampled according to ESA Permit #16556, which is largely consistent with NOAA Technical Memorandum NMFS-SEFSC-579, except that the ESA permit also authorizes cloacal lavage. All turtles were fitted with a Sea Mammal Research Unit satellite relayed data logger and released back into the water.

6.4.2 HARP

The retrieval and redeployment of the high-frequency acoustic recording packages was completed according to standard operating procedures of the NEFSC's Protected Species Branch's Passive Acoustic group.

6.4.3 Oceanographic Data

We collected oceanographic data related to temperature, salinity, and zooplankton distribution. Most of the oceanographic sampling occurred at night. One long transect through a warm core ring was completed, and some daylight hours were devoted to accomplishing this objective. Our primary sampling equipment was a 1m x 2m neuston net with a CTD towed from a single wire. At most stations, two tows were conducted; the first tow ran from the surface to 25-m depths in a tow-yo fashion, while the second tow was targeted to a specific depth with a high concentration of plankton based on multibeam sonar readings. A camera system, which included a pair of GoPro cameras in deep-water housings and Fix Neo dive lights, was attached to the neuston net frame to collect video data of the zooplankton being captured in the net. At stations that were possible locations for bluefin tuna larvae, a standard Bongo tow was also performed. Additional details are provided below.

6.4.4 Hydrographic and Plankton Data

The ship's SCS logger system continuously recorded oceanographic data from the ship's sensors. A SEACAT 19+ Conductivity, Temperature, and Depth Profiler (CTD) was used to measure water column conductivity, temperature and depth. The CTD was mounted on a 322 conducting core cable above all net samplers allowing the operator to see a real time display of the instrument depth and water column temperature, salinity, density and sound speed on a computer monitor in the ship's dry lab. Once per day a vertical profile was done with the CTD with a Niskin bottle attached to the wire above the CTD. The Niskin bottle was used to collect a water sample used to calibrate the conductivity sensor of the CTD. The calculated sound speeds from the vertical profiles were also used for the daily calibration of the active acoustic sensors.

During the night when the turtle survey was off-effort, physical and biological sampling of the water column was conducted employing a combination of underway and station-based sampling. The goal was to sample for two types of zooplankton: larval bluefin tuna (*Thunnus thynnus*) and gelatinous zooplankton.

Sampling equipment included:

- EK60 multi-frequency echosounder for plankton, micronekton, and fish distribution
- ADCP (Acoustic Doppler Current Profiler) for currents, synchronized to the EK60 to minimize interference
- CTDs for hydrography
- 1x2m modified neuston frame with Go-Pro cameras, Star Oddi temperature sampler, and 333µ mesh net
- 61cm bongo with 333µ mesh nets

6.4.5 Bluefin Tuna Sampling

Plankton sampling was conducted in areas with temperatures above 22°C and salinities above 32psu to target bluefin tuna. Of special interest was the area inside of a large warm core ring. To compare sample densities to standardized plankton tows conducted by the NEFSC and SEFSC, a tow was conducted to 200 m depth using a 61 cm bongo with 333 µ mesh nets using standard ECOMON protocols. One net was preserved in 5% formalin and the other was preserved in 85% ethanol. A second plankton tow was conducted using a 1x2 m neuston net with 333 µ mesh and the frame modified with the addition of weights and a flowmeter. The net was tow-yo'ed at 1 knot SOW between the surface and 25 m depth for at least 10 minutes. Samples were preserved in 85% ethanol. To prevent the ethanol from becoming too diluted by water drawn from the plankton by osmosis, all ethanol samples had the ethanol drained and replaced after 24 hrs.

While the second tow was being conducted the ethanol preserved bongo net was sorted at-sea utilizing a stereomicroscope looking for bluefin tuna larvae. Through a partnership with a graduate student at WHOI and NEFSC's Jim Manning, if more than 2 larvae were present, 3 drifters with a drogue at 15 m depth was deployed simultaneously to create a triangular pattern to study the transportation of larvae.

6.4.6 Gelatinous Zooplankton Sampling

In areas near the shelf break or canyons, zooplankton tows were conducted to sample gelatinous zooplankton. Tows were conducted using the 1x2 m neuston frame targeting a specific layer seen on the EK60 echosounder. The net was kept in the target layer for 10-15 minutes before being brought to the surface. Samples were sorted onboard then preserved in 10% formalin and seawater.

6.4.7 Acoustic Sampling

Active acoustic data were collected during the survey to characterize spatial distributions of potential prey and investigate relationships among predator (marine mammals), prey, and oceanography. Active acoustic data were collected with the multi-frequency (18, 38, 70, 120, and 200 kHz) scientific EK60 echo sounders and split-beam transducers mounted downward-looking on the retractable keel. Data were collected to 3000 m, regardless of bottom depth. The ping interval was set to 2 pings per second, but actual ping rate will be slower due to two-way travel time and signal processing requirements of the EK60. The EK60 was synchronized to the ES60 on the bridge, the Acoustic Doppler Current Profiler (ADCP), and Simrad ME70 multibeam to alleviate acoustic interference among acoustic instruments. At daily intervals throughout the survey, EK60 data were recorded in passive mode to assist with noise removal post-processing procedures. Survey speeds for underway acoustic data collection were 10 knots or less.

Active acoustic data were collected continuously but with the EK60 in passive mode on every other day during daytime operations. Active acoustic data were only collected every other day during daylight so that impacts of active acoustics on marine mammal sightings by observers can be investigated. Acoustic data in active mode were collected continuously during nighttime operations.

The EK60's were calibrated using a standard target method at the Newport Naval Anchorage. A 38.1-mm tungsten carbide with 6% cobalt binder sphere was suspended at about 20 m range from the transducers and was used to calibrate all frequencies. A wireless calibration system, consisting of three remotely controlled downriggers, and automated software were used to initially position the target under the split-beam transducers and the software automatically moved the sphere throughout the acoustic beams. The data were collected and then the Simrad Lobe program was used during data playback for each EK60 individually.

6.4.8 Marine animal sightings

The collection of information on the distribution and occurrence of cetacean and sea turtle species was modelled after the system used in the AMAPPS shipboard line transect surveys, but with two major points of difference. First, the transects and effort (including number of people sighting at one time) were designed to be optimal rather than standard. Second, because the sightings data were second in priority to turtle capture, and because the sightings data was not collected with the intention of being analyzed with line transect survey methodology, a truncated set of variables were collected. Species identifications were recorded to the lowest taxonomic level possible. Sightings data were only recorded when the sightings computer was on the fly bridge, typically when it was not raining and when the vessel was going survey speed.

When a cetacean, seal, turtle, or large fish was observed the following data were collected opportunistically:

- Time animal was sighted observer
- Species identification
- Species identification confidence level (certain, probable, not sure)
- Best estimate of the group size
- Cue (animal, splash, blow, footprint, birds, vessel/gear, windrows, disturbance, or other)
- Behavior.

6.5 Results

6.5.1 Sea Turtle Tagging

We located, captured, and satellite tagged five loggerhead sea turtles. The identification number, size, and tag information is shown in Table 6.3.

6.5.2 HARP

We retrieved and re-deployed high-frequency acoustic recording packages (HARPS) at three sites (HARP 1, HARP 2, and HARP 3, in Figure 6.3).

6.5.3 Oceanographic Data

We collected oceanographic data related to temperature, salinity, and zooplankton distribution; including a transect line into a large warm core ring (Figure 6.4). We obtained images of some gelatinous zooplankton as it was going in the neuston net and after it was removed from the cod end of the net (Figure 6.5). A set of 3 oceanographic drifters were deployed into the warm core ring and tracked for 4 weeks. Summaries are provided below and more details are found in Chapter 11.

6.5.4 CTD

A total of 56 SEACAT 19+ CTD casts were conducted and 5 water samples for conductivity calibrations were collected. Oceanographic traces looked noisy so a different 19+ was used for the second half of the cruise. It was determined nothing was wrong with either instrument. Towing in water with strong oceanographic features creates noisy raw data. Data will be smoothed during processing. Interesting profiles included Gulf Steam eddies, shelf slope fronts, canyon fronts, and tidal intrusions. A seven station transect was conducted from the edge to the center of the warm core ring.

6.5.5 Bluefin Tuna Sampling

A total of 13 1x2 m neuston and 14 61 cm bongo tows were conducted including 5 stations within the warm core ring. Shipboard processing showed the presence of bluefin tuna larva at two of the warm core ring stations. Samples were returned to the NEFSC Narragansett lab where all ichtyoplankton will be removed and identified. Any bluefin tuna larvae found will have otoliths removed to determine age, stomach contents analyzed, and identifications confirmed by DNA analysis.

Three drifters were launched into the warm core ring at 12:30 am on 11 July EDT and have been successfully transmitting (Figure 3). Current drifter data can be found online.

The drifters are expected to transmit for about 3 months before the batteries are depleted.

6.5.6 Gelatinous Zooplankton Sampling

A total of 21 1x2m neuston tows were conducted for gelatinous zooplankton sampling. Individuals of the salp species *Salpa aspera* were preserved in ethanol from three stations. These were collected for Ann Bucklin of the University of Connecticut and will be used in a NSF study of salp genomics/transcriptomics and to help construct a DNA barcode protocol for salps.

6.5.7 Marine Animal Sightings

We collected information on the distribution and occurrence of cetacean, sea turtle, and other marine species sighted during the survey. We identified over 2,500 animals (Table 6.4 and Figures 6.6 – 6.10). The most commonly detected species were dolphins, with the common dolphin (*Delphinus delphis*) the most numerous. We were able to sight more than a dozen beaked whales (Cuvier's and Sowerby's plus unidentified Mesoplondant and Ziphiid).

6.6 Disposition of Data

The cetacean and turtle sightings data collected during this survey will be maintained by the Protected Species Branch at NEFSC in Woods Hole, MA and are available from the NEFSC's Oracle database. Similarly, the behavioral data that will be relayed in the coming months will also be maintained in an Oracle Database overseen by NEFSC's Data Management Systems Division.

All hydrographic data collected will be maintained by the Fishery Oceanography Branch at the NEFSC in Woods Hole, MA. Hydrographic data can be accessed through the Oceanographic FTP website or the NEFSC's Oracle database.

All bongo plankton samples collected will be maintained by the Fishery Oceanography Branch at the NEFSC in Narragansett RI. Bongo samples preserved in formalin will be sent to Poland for identification. Bongo and Neuston samples preserved in ethanol will be processed by Oceans and Climate Branch staff. Plankton data can be accessed through the NEFSC's Oracle database.

All neuston samples preserved in formalin will be maintained or disposed of by Stony Brook University.

All Go-Pro camera data will be maintained and processed by the Coonamessett Farm Foundation. Data is available by request only.

6.7 Permits

The turtle handling and sampling was authorized under ESA #16556. We had corresponding SARA authority (through Dr. James, DFO-MAR-2017-08), however no turtle sampling occurred under the Canadian authority because no turtles were sighted in Canadian waters. Similarly, we had United States (Permit No 17355) and Canadian (DFO-MAR-2016-02) permits to sample mammals (particularly North Atlantic Right Whales), however we did not have the opportunity, so no work occurred under the mammal permits. The mammals that were sighted and photographed on this cruise were incidental encounters, and we never approached a mammal to photograph it. Because we followed the regional viewing guidelines for marine mammals, no mammal permit was invoked to cover our research.

6.8 Acknowledgements

This study was funded in part by the U.S. Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program, Washington, DC (through Inter-Agency Agreement Number M14PG00005 with the National Marine Fisheries Service in association with the Atlantic Marine Assessment Program for Protected Species), the Northeast Fisheries Science Center, the Atlantic Sea Scallop Research Set Aside, and Fisheries and Oceans Canada. The funding for the drifters was from the WHOI Ocean Life Institute, and the drifters were provided through the NEFSC drifter program run by Jim Manning. This cruise was a true collaborative effort with guest scientists contributing to the cruise mission in critical and fundamental ways. Without the skills and devotion of the guest scientists, this cruise could not have happened. I also wish to thank the crew of the NOAA Ship *Henry B. Bigelow* for their work throughout the cruise, LTJG Michael Ball for his extra devotion to protected species work, and especially Steven Wigely for his excellent mentoring on small boat operations.

6.9 References Cited

National Marine Fisheries Service Southeast Fisheries Science Center. 2008. Sea Turtle Research Techniques Manual. NOAA Technical Memorandum NMFS-SEFSC-579, 92 p.

Table 6.1. List of the science party aboard NOAA Ship *Henry B. Bigelow* for HB17-04 Leg 1. HAB=Hours above base.

Name (Last, First)	Affiliation	Percent of hours supported with AMAPPS funds
Haas, Heather	Northeast Fisheries Science Center	HAB ~10
Blair, Hannah	Stony Brook University	0
Broughton, Elisabeth	Northeast Fisheries Science Center	HAB ~40
Cassandra Fries	Stony Brook University	0
Christina Hernandez	Woods Hole Oceanographic Institute	0
Conger, Lisa	Northeast Fisheries Science Center	HAB ~40
Crowe, Leah	Integrated Statistics	100
James, Michael*	Fisheries and Oceans Canada	0
Matzen, Eric	Integrated Statistics	100
Milliken, Henry	Northeast Fisheries Science Center	HAB ~10
Patel, Samir	Coonamessett Farm Foundation	0
Seimens, Liese	Coonamessett Farm Foundation	0
Warren, Joe	Stony Brook University	0

*Michael James was a foreign participant.

Table 6.2. Primary daily daylight operations on HB17-04 Leg 1.

Date	Cruise Operation
July 6	Initial meetings, Practice Launch and Recovery underway, Transit.
July 7	Retrieve HARP 2, Deploy new HARP 2, Turtle Survey (no turtle sightings).
July 8	Retrieve HARP 1, Deploy new HARP 1, start oceanographic transect through warm core ring.
July 9	Visual Survey (no turtle sightings).
July 10	Visual Survey (no turtle sightings).
July 11	Visual Survey (no turtle sightings).
July 12	Transit.
July 13	Visual Survey (4 tags deployed).
July 14	Visual Survey (no tags deployed).
July 15	Visual Survey (1 tag deployed).
July 16	Transit to HARP 3, Retrieve HARP 3, Deploy new HARP 3, Continue transit east.
July 17	Visual survey until 11am, rest of day on engine issues.
July 18	Begin transit home on one engine.
July 19	Continue transit home, arrive in port.
July 20	In port due to engine issues.

Table 6.3. Size and tag information for each loggerhead turtle brought on board the NOAA ship *Henry B. Bigelow*.

Turtle ID	CCL standard	PTT	L flipper tag	R flipper tag
2017.20	98.5	139040	MMJ121	MMJ120
2017.21	102.5	149447	MMJ123	MMJ122
2017.22	94.1	172191	MMJ125	MMJ124
2017.23	77.2	172179	EEZ787	EEZ786
2017.24	71.3	172181	MMJ202	MMJ201

Turtle ID is the consecutive number assigned to all turtles captured in collaborative tagging. CCL Standard is the curved carapace length from notch to tip in centimeters. PTT is the Argos identification number for the platform transmitter terminal. L and R flipper tag is the identification of the left and right (respectively) tags that were applied during the cruise. We did not observe any pre-existing tags on the captured turtles.

Table 6.4. Draft list of species observed with "probable" and "certain" species identifications.

Taxa	Number
Basking shark	1
Bottlenose dolphin	71
Bottlenose/Spotted dolphin	10
Common dolphin	1678
Common/White-sided dolphin	90
Cuvier's beaked whale	3
Fin whale	24
Fin/Sei whale	12
Humpback whale	16
Ray	4
Marlin spp	1
Minke whale	9
Mola mola (sunfish)	16
Pilot whales	77
Risso's dolphin	132
Sowerby's beaked whale	5
Sperm whale	15
Striped dolphin	15
Tuna sp	10
Turtle, leatherback	3
Turtle, loggerhead	8
Unid. Dolphin	309
Unid. Mesoplondant	3
Unid. Shark	6
Unid. Ziphiid	3
TOTAL	2521

Several of the unidentified species will be assigned a species code upon inspection of the text notes and photographs, and total numbers may shift slightly when the follow-up sightings data is reviewed.

Figure 6.1 The NOAA ship *Henry B. Bigelow*

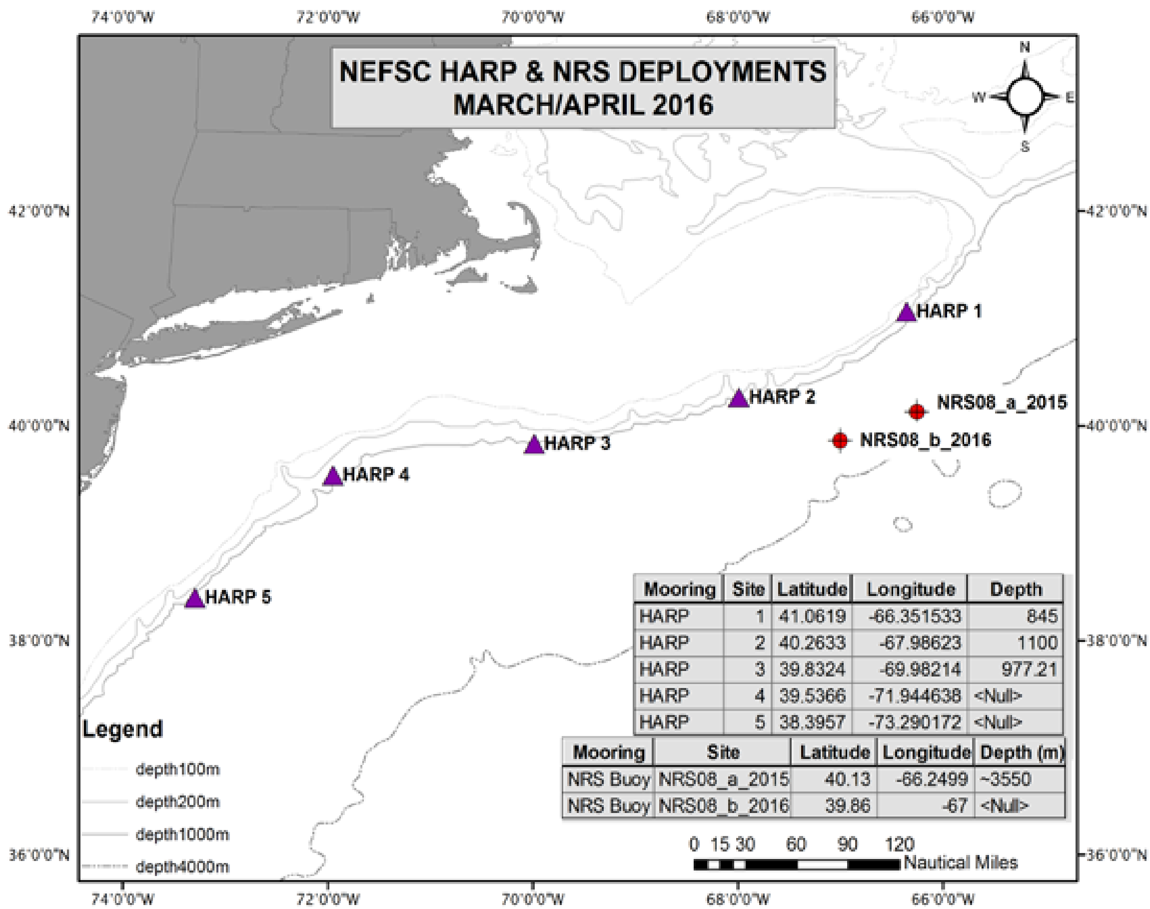


Figure 6.2. Map of acoustic recorder locations as of April 2016. Recorders at sites HARP 1, 2, 3 were recovered and re-deployed during HB17-04 leg 1.

Figure 6.3. Photographs of the three HARP exchanges. At each of the HARP sites, one unit was recovered, and a different unit was deployed. (Photo credit H Haas)

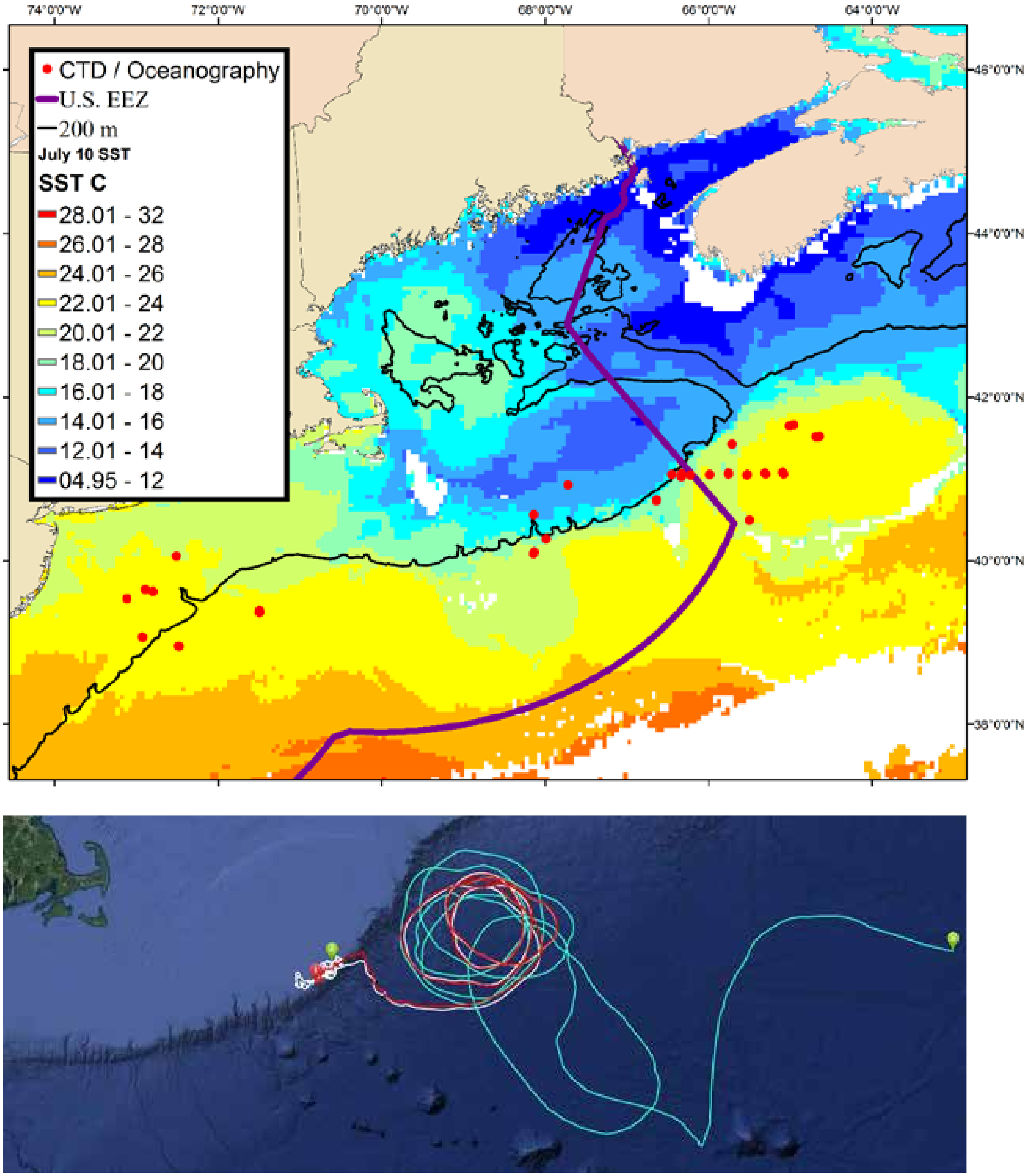


Figure 6.4. Top panel shows locations of oceanographic sampling (red dots) overlaid on sea surface temperature map from July 10, 2017. Bottom panel shows drifter tracks from release to August 16, 2017.

Figure 6.5. Images of salps, potential turtle prey. The top photograph (photo credit J Warren) is magnified so that prey within the salp is visible. The bottom photograph (photo credit L Seimens) is unmagnified and shows a salp chain as it entered the plankton net, before it got broken apart by forces within the net.

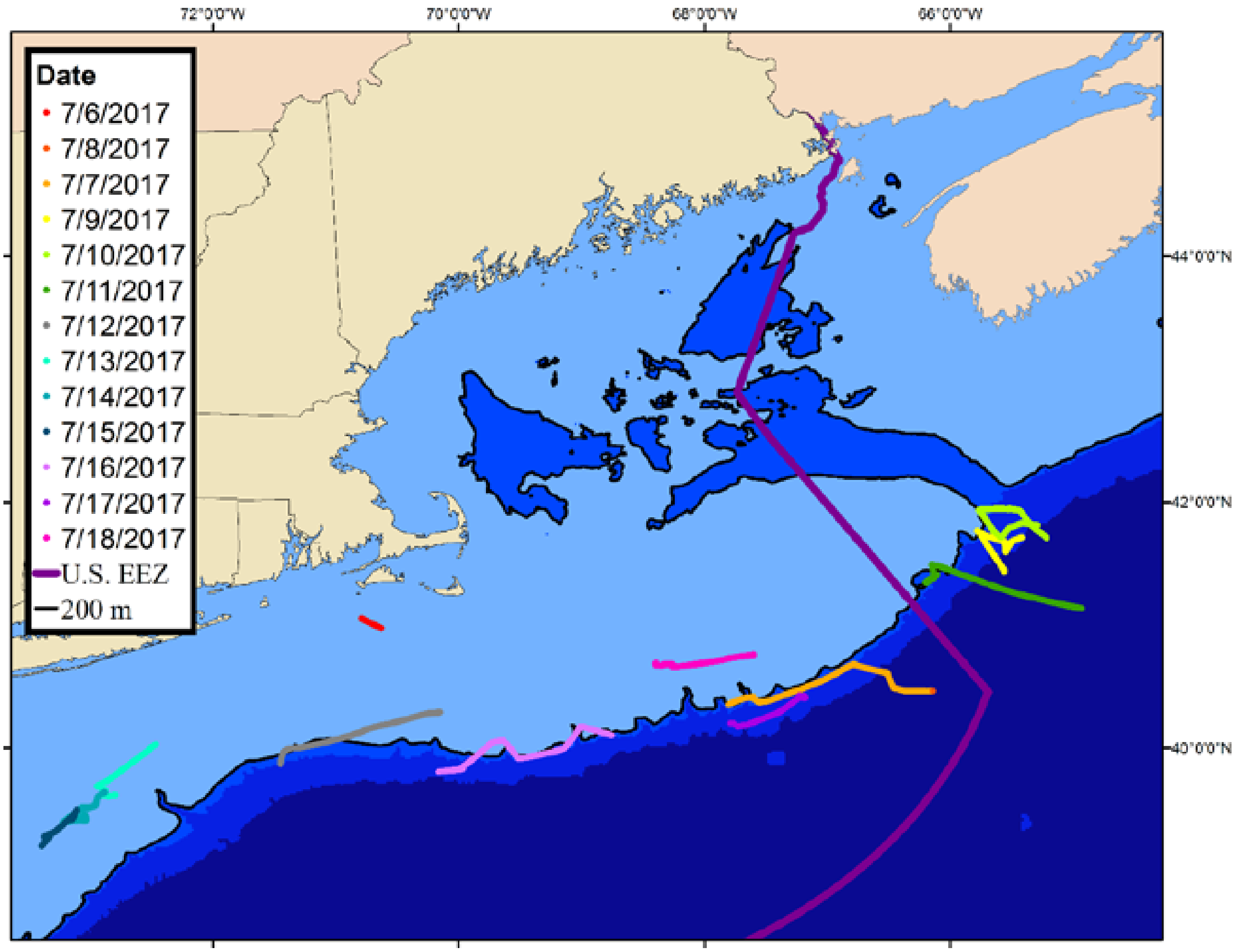


Figure 6.6. Daily track lines showing the locations for which there was a dedicated visual observation team.

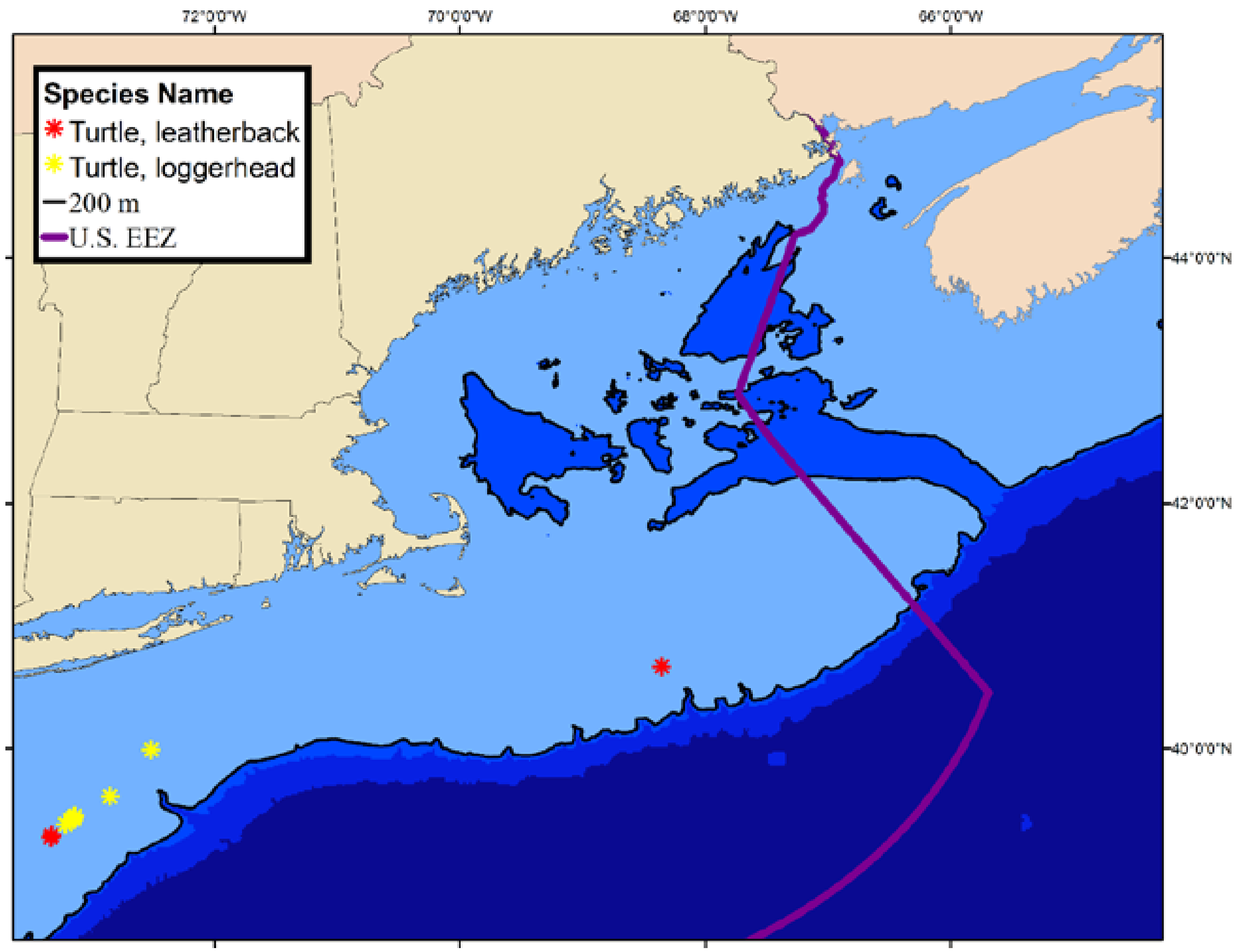


Figure 6.7. Locations of turtles sighted during HB17-04.

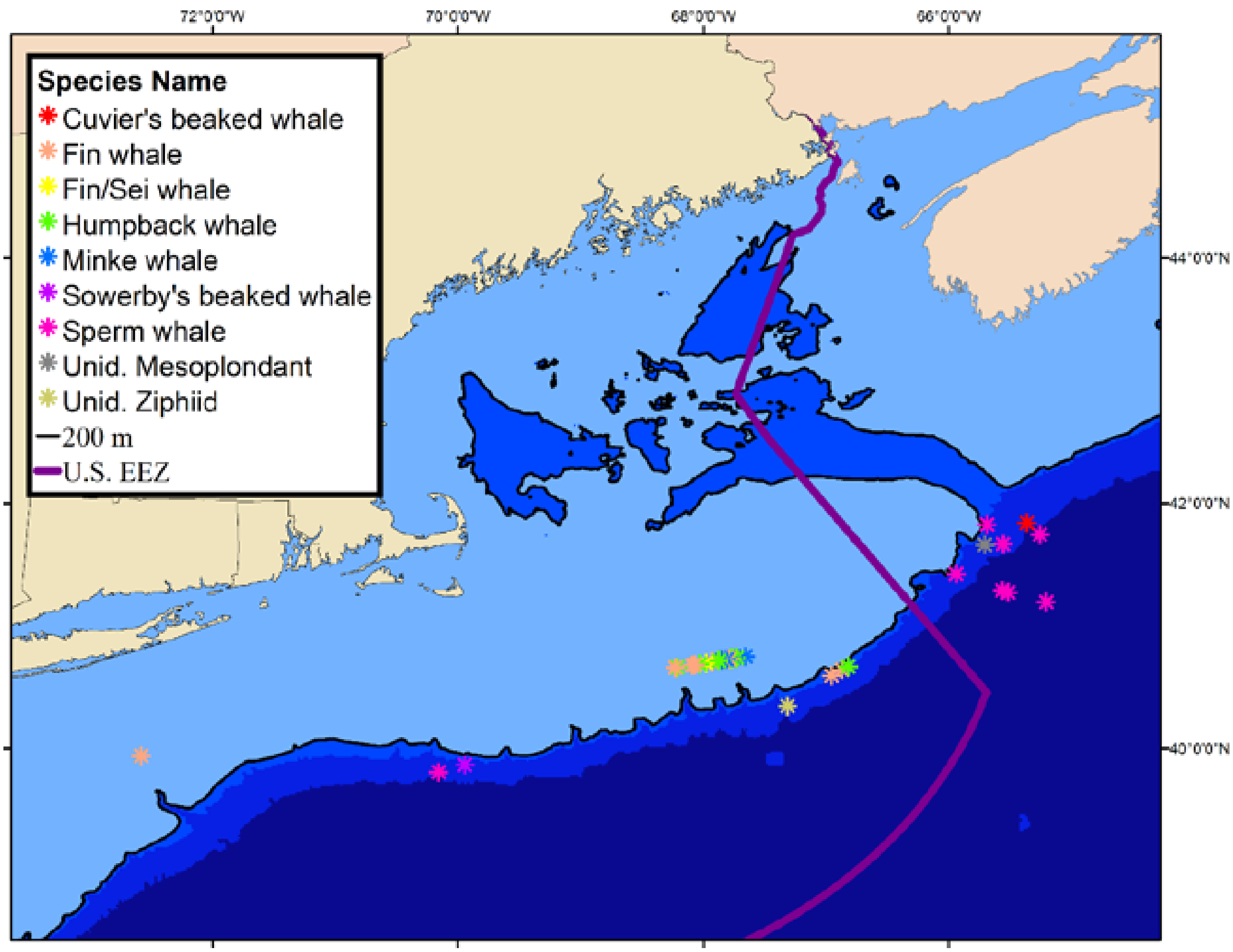


Figure 6.8. Preliminary locations of whales sighted during HB17-04.

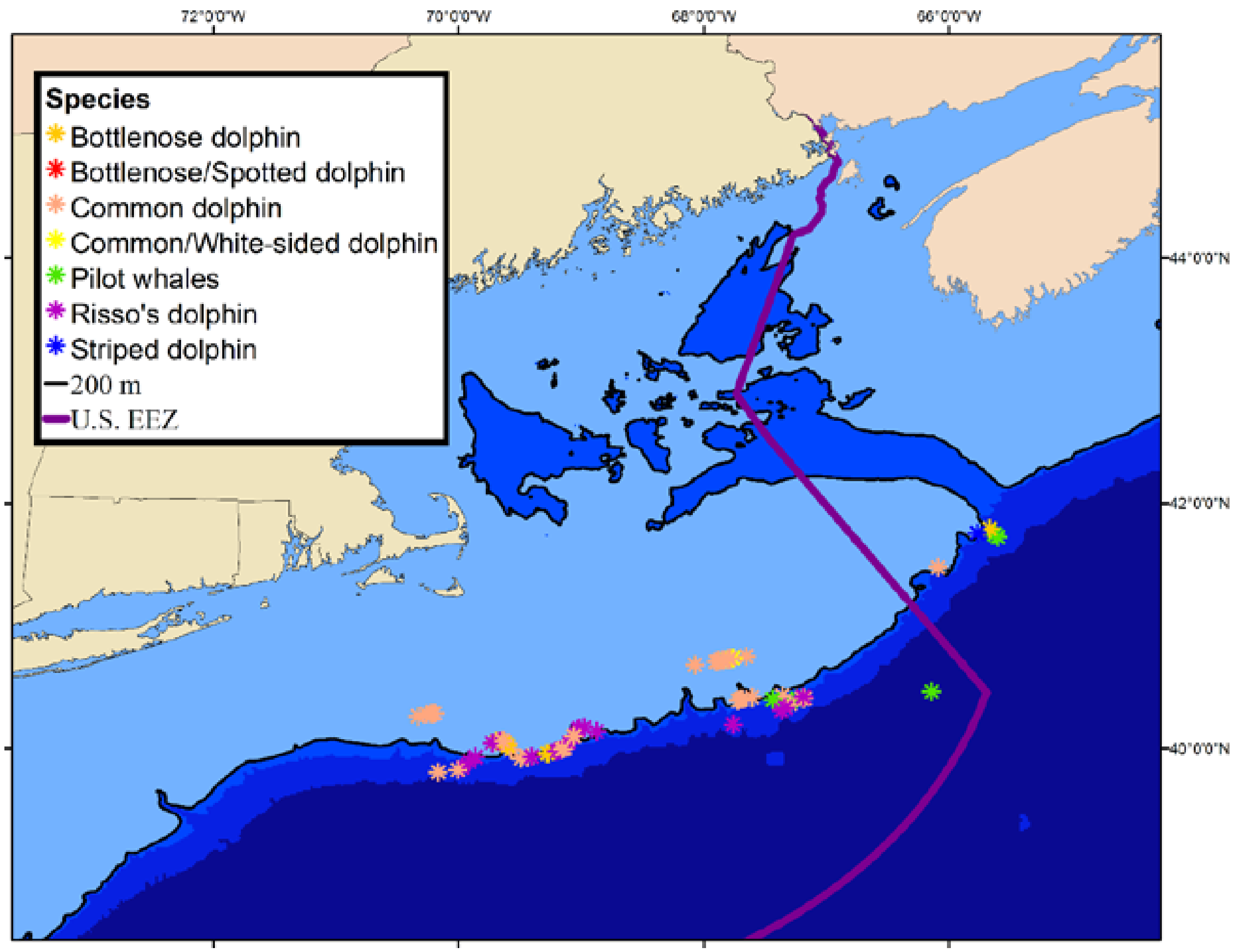


Figure 6.9. Preliminary locations of dolphins sighted during HB17-04.

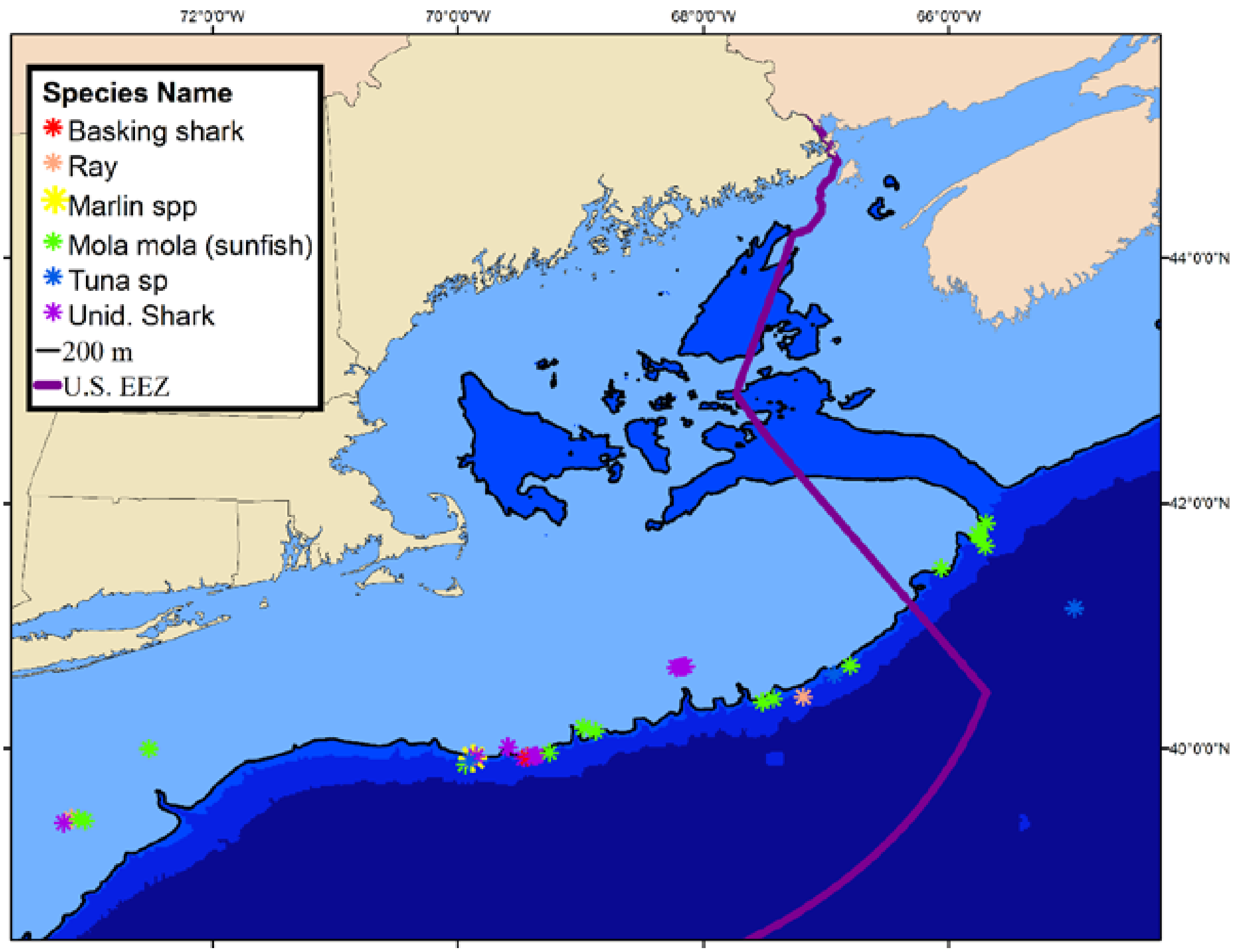


Figure 6.10. Preliminary locations of fish sighted during HB17-04.

7 Shipboard Beaked Whale Survey 8 – 18 September 2017: Northeast Fisheries Science Center

Danielle Cholewiak[1], Annamaria DeAngelis[2], Joy Stanistreet[2], Nicholas Metheny[2]

[1]Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543
[2]Integrated Statistics, 16 Sumner Street, Woods Hole, MA 02543

7.1 Summary

In September, the Northeast Fisheries Science Center conducted a 10-day survey for beaked whales in the western North Atlantic, focusing primarily on the Georges Bank region. This survey was originally scheduled for July-August 2017, and was scheduled to take place on the NOAA ship *Henry Bigelow*. However, due to the necessity of unexpected repairs on the *Bigelow*, the survey was postponed until September and was conducted instead on the UNOLS vessel the R/V *Hugh R. Sharp*. Nine scientists participated in the survey. The ship and crew departed from Lewes, DE on 8 September, and returned into Woods Hole, MA, ahead of Tropical Storm Jose, the morning of 18 September.

The scientific crew included a visual observation team scanning for marine mammals and sea turtles using line-transect sampling techniques, a single observer targeting sea birds using strip transect sampling techniques, and an acoustic team monitoring a towed hydrophone array. In addition, small boat work was conducted when conditions were feasible to collect identification photographs, water samples for eDNA testing, and to attempt deployment of suction cup tags on beaked whales. Survey design was considered "exploratory" or "focal follow", depending on activity. Survey tracklines were covered at a speed of approximately 13 -15 km/hr (7 – 8 kts) during exploratory phases, and were much slower when collecting focal follow data.

Approximately 800 km of trackline were surveyed by the marine mammal visual team, with 570 km of effort also targeted for seabirds. The passive acoustic team surveyed approximately 2053 km (including both daytime and nighttime recording effort), collecting over 167 hours of passive acoustic data. An estimated 160 groups of cetaceans were sighted (1259 individuals), 1 loggerhead sea turtle, and 259 groups (417 individuals) of birds. Beaked whales were the most commonly sighted cetacean taxa, followed by pilot whales (*Globicephala spp.*). Passive acoustic data will be post-processed; preliminary results are included here. Three CTD casts were conducted in areas where beaked whales were presumed to be foraging (based on dive times and the occurrence of echolocation clicks), and active acoustic (EK60) data were collected during one night to map prey distribution in an area associated with beaked whale foraging activity. In addition, 14 water samples were collected from several groups of Cuvier's (*Ziphius cavirostris)* and True's (*Mesoplodon mirus*) beaked whales for eDNA testing.

7.2 Objectives

The main objectives of this survey were to: 1) Locate and document occurrence of Mesoplodon beaked whales (*Mesoplodon spp*) in the region of Georges Bank, including waters of the Northeast Canyons and Seamounts Marine National Monument; 2) collect information on the distribution and occurrence of all cetacean and sea turtle species sighted during the survey; 3) collect passive acoustic recordings, identification photographs, biopsy samples, and deploy suction-cup digital recording tags (DTAGs) on beaked whales, if possible; 4) collect water samples for eDNA testing in the vicinity of beaked whales; 5) collect oceanographic data (using CTDs) and EK60 data on prey layers in areas with documented foraging activity

7.3 Cruise Period and Area

The survey was conducted on the UNOLS vessel the *Hugh R. Sharp*, out of Lewes, Delaware. The survey period was scheduled for 7 – 19 September 2017, though the ship actually departed on September 8th and returned into Woods Hole on September 18th due to the approach of Tropical Storm Jose. The primary target region included the shelf break and offshore waters of Georges Bank, from approximately 38° – 42° N and 66° – 70° W , but surveying was conducted for several days during the transit from Lewes, DE to the Georges Bank region.

7.4 Methods

The design for this survey was "exploratory", during periods in which the team was searching for beaked whales, and "focal follow", when groups were sighted that warranted dedicated focal-follow effort. Typical survey speeds were 13 -15 km/hr (7 – 8 kts) during exploratory phases, but reduced to 3-4 km/hr (~2 kts) during focal follow phases. The number of visual observers varied depending on survey phase and weather conditions; see below for more information. Nine scientists participated in the survey (Table 7.1; Figure 7.1).

7.4.1 Visual Marine Mammal – Turtle Sighting Team

Visual surveys were conducted during daylight hours (approximately 0630-1900 ET), and in all sea states when rain was not present. Data on all marine mammal and sea turtle sightings were collected by a single observation team, operating from stations located on flying bridge, 13.9 m above the sea surface. The observation team was typically comprised of three observers at a time during exploratory phases. Two observers utilized 25x150-power binoculars, to scan from the bow of the ship to 90° port or starboard. A third observer scanned the trackline region using naked eye and handheld 7x50 binoculars, and recorded data on all sightings of marine mammals, turtles or large fishes (i.e. tuna). While in exploratory search mode, observers rotated through their positions every 30 minutes, and then had a break of at least 30 minutes. When conditions were good, additional observers often assisted in survey effort. However, when Beaufort conditions exceeded a sea state 5 (as was common for the first week of surveying), observer effort was frequently reduced to one person.

Sightings data were recorded onto laptop computers with the custom-built software package VisSurv-NE (version 6), which was initially developed by L. Garrison and customized by D. Palka. The following information was collected: 1) The observer recording the sighting; 2) Time of the sighting to the nearest second; 3) Species composition of the group; 4) Radial distance to the group, estimated by reticles when using binoculars; 5) Bearing between the line of sight to the group and the ship's track line; measured by a polarus mounted at the base of the binoculars; 6) Best estimate of group size; 7) Swim direction; 8) Number of calves; 9) Initial sighting cue; 10) Initial behavior of the group, and 11) Any comments on unusual markings or behavior. The location of the ship (latitude and longitude) was recorded using the ship's GPS every 12 seconds, and every time a sighting entry was made into VisSurv-NE. At times when it was not possible to positively identify a species, the ship broke from the survey tracklines to head in the direction of the sighting, until species composition was verified.

In addition, effort and environmental condition data were recorded every time there was a noticeable change in environmental state or when observers rotated. Environmental data included: apparent Beaufort sea state when scanning ahead of the ship, horizon clarity, swell height and direction relative to the ship's direction of travel, percentage of the survey area covered with glare, and magnitude of the glare within that region.

On good weather days, when beaked whales were sighted and the decision was made to initiate focal follow data collection, observer effort changed substantially. Typically, ship speed was slowed to 3-4 km/hr, the seabird observer joined the mammal team to augment visual data collection, and effort was made by all available observers to track, photograph, and collect data on target beaked whale groups, while still recording sightings of additional cetacean groups in the area. In this mode, observers rotated on an as-needed basis, and there were frequently more than three observers' on-effort at a time.

7.4.2 Small Boat Operations

An NEFSC rigid-hulled inflatable was deployed when sea states were low enough that it was considered feasible to approach and follow groups of beaked whales. A team of 3 – 4 personnel were deployed with each small boat launch, while the remaining observers continued to track cetacean groups and direct the small boat. At times, one or both members of the passive acoustic team joined the visual observers (depending on whether the acoustic array had been recovered). When small boat operations were underway, the team of visual observers remained on the flying bridge and in visual and radio contact with the small boat team at all times. The small boat approached beaked whale groups to collect identification photographs, water samples for eDNA testing, and to attempt to deploy digital suction-cup recording tags (DTAGs). Identification photographs were collected with a Canon D6 equipped with a 100 – 300 mm lens.

7.4.3 Tagging

Suction-cup tagging using DTAGs was planned in collaboration with scientists at the Woods Hole Oceanographic Institution (WHOI). Two DTAGv3, including suction cups and releases, were prepared for deployment during this project. Prior to departure from the dock, the *R/V Sharp* was equipped with a 4-element Yagi antenna, handheld Yagi antennae, and VHF tracking equipment. Tag reception range was tested and confirmed both while the ship was at dock, and in open water upon the ship's departure from Lewes. Tags were to be deployed using a handheld, carbon fiber pole, by an experienced tag operator. Tag deployments were planned for 4 – 12 hrs.

7.4.4 eDNA Sampling

Paired water samples for eDNA testing were collected in 1L bottles on either side of the small boat, in the flukeprint of an animal upon a dive. Water samples were maintained in a cooler with frozen ice pack during daytime operations, and were transferred back to the ship for refrigerator storage either at midday or end of day. Once back aboard the ship, each 1L bottle, or paired samples (2L total) were filtered through 0.4 µM filters, and were stored in Longmire's buffer for later analyses.

7.4.5 Visual Seabird Sighting Team

From an observation station on the flying bridge, a single observer, working approximately two five-hour shifts, conducted a visual daylight survey for seabirds during approximately 0630 – 1830h ET, with a one hour break at lunchtime; and a half-hour break at dinnertime. Seabird observation effort employed a modified 300 m strip and line-transect methodology. Data on seabird distribution and abundance were collected by identifying and enumerating all birds seen within a 300 m arc on one side of the bow while the ship was underway. The seabird observer maintained a visual unaided eye watch of the 300 m survey strip, with frequent scans of the perimeter using hand-held binoculars for cryptic and/or hard to detect species. Binoculars were used for distant scanning and to confirm identification. Ship-following species were counted once and subsequently carefully monitored to prevent re-counts. All birds, including non-marine species, such as raptors, doves, and Passerines, were recorded.

Operational limits are higher for seabird surveys compared to visual marine mammal and sea turtle surveys. As a result, seabird survey effort was possible in sea states up to and including a low Beaufort 8. Seabird survey effort was suspended, however, if the ship's speed over ground fell below six knots. Due to the unique objective, survey speed (6 – 7.5 kts), and the split effort between surveying for seabirds and surveying for marine mammals required of the seabird observer, off-effort sightings were incorporated into survey effort and summary chart.

All data were entered in real time into a Panasonic Toughbook laptop running *Seebird (vers 4.3.7)*, a data collection program developed at the Southwest Fisheries Science Center. The software was linked to the internal GPS of the Toughbook, for course over ground and heading. The following data were collected for each sighting: species identification, number of birds within a group, distance between the observer and the group, angle between the track line and the line of sight to the group, behavior, flight direction, flight height, age, sex and, if possible, molt condition. The sighting record received a corresponding time and GPS fix once the observer accepted the record and the software wrote it to disk. *Seebird* also added a time and location fix every 5 minutes. *Seebird* incorporates a time synchronization feature to ensure the computer clock matches the GPS clock to assist with post-processing of the seabird data. All data underwent a quality assurance and data integrity check each evening and saved to disk and to an external backup dataset.

7.4.6 Passive Acoustic Detection Team

The passive acoustic team consisted primarily of 2 people who operated the system in 1 – 2 hr shifts, with assistance from the chief scientist on several days. The hydrophone array was deployed for up to 24 hr/day during exploratory survey mode, with periodic retrievals to check on array status. During focal follow survey mode, the array was sometimes recovered to facilitate maneuverability of the vessel. The array was also recovered for each small boat launch and recovery, but was typically redeployed during focal follows. The acoustic team monitored the array during all daytime hours (0600-1900 ET). In areas of high beaked whale density, real-time monitoring was extended to cover approximately 0400 – 2200h. The array recorded passive acoustic data but was not monitored in real-time for the remainder of the nighttime deployments.

The hydrophone array was comprised of two modular, oil-filled sections, separated by 30 m of cable, towed 300m behind the ship. The array was comprised of 8 hydrophones, including HTI 96-min, Reson TC 4014, and APC International 42-1021 elements, as well as a depth sensor

(Keller America, PA7FLE). Acoustic data were routed to a custom-built Acoustic Recording System that encompassed all signal conditioning, including A/D conversion, filtering, and gain. Data were filtered at 1000 Hz, and variable gain between 20 – 40 dB was added depending on the relative levels of signal and noise. The recording system incorporated two National Instruments soundcards (NI USB-6356). One soundcard sampled six channels (APC and HTI) at 192 kHz, the other sampled two channels at 500 kHz (HTI and Reson), all at a resolution of 16 bits. Digitized acoustic data were recorded directly onto laptop and desktop computer hard drives using the software program Pamguard, which also recorded simultaneous GPS data, continuous depth data, and allowed manual entry of corresponding notes. Two channels of analog data were also routed to an external RME Fireface 400 soundcard and a separate desktop computer, specifically for the purpose of real-time detection and tracking of vocal animals using Pamguard. Whenever possible, vocally-active groups that were acoustically tracked were matched with visual detections in real-time, for assignment of unambiguous species classification. Frequent communication was established between the acoustic team and the visual team situated on the flying bridge to facilitate this process.

7.4.7 Oceanographic and Environmental Sampling

The ship's surface mapping system (SMS) collected data every ten minutes on the ship's position, wind speed and direction (relative and true), air temperature, pressure and humidity, sea surface temperature, salinity, and fluorescence. A SEACAT 19+ Conductivity, Temperature, and Depth Profiler (CTD) was used to measure water column conductivity, temperature and depth at sites where beaked whale foraging behavior was thought to being occurring. CTD casts were conducted down to 800 – 1000 m depth at these locations.

Active acoustic data were collected during the course of one night, using a Simrad EK60 38 kHz split-beam echosounder to characterize spatial distributions of potential prey and investigate relationships among predator (marine mammals), prey, and oceanography. Data were collected to 500 m with a ping interval of 1.5 s. Transducer depth was 4.1 m.

7.5 Results

The *R/V Sharp* departed Lewes, DE around midday on 8 September, and began transiting out to the shelf break. During that afternoon, the science team conducted training exercises, including both visual data collection as well as small boat operations. Overall, the survey covered approximately 2145 km, including both daytime visual survey effort, as well as nighttime effort where only passive or active acoustic data were collected (Figure 7.2).

7.5.1 Visual Marine Mammal – Turtle Sighting Team

The visual marine mammal team surveyed approximately 800 km during daylight hours over the course of the survey. From September 9 – 17, total visual survey effort comprised 101.5h, for an average of 10.9 hr/day. Approximately 72 h were spent in exploratory mode across all survey days. Focal follow data were collected on 4 days, during 14 – 17 September 2017, for a total of 30 hrs. The weather conditions at the start of the survey were generally poor, but improved over the course of the week. About 40% of surveying was conducted in Beaufort sea states 2 or less; the rest was conducted in Beaufort sea states 3 – 5 (Table 7.2).

Eleven species of cetaceans were encountered during the survey, including both Cuvier's and True's beaked whales (Tables 7.3 and 7.4). Beaked whales were encountered most often, with approximately 61 groups comprising over 180 individuals (Figure 7.3). Of these, about twice as many Cuvier's were sighted as True's beaked whales (Table 7.3). True's beaked whales were visually identified based on several distinguishing characteristics (described in deSoto et al. 2017): 1) pale coloration of the melon, extending over the top of the head forward of the eye (Figure 7.4); 2) lack of dark pigmentation along the spine ("dorsal stripe"), and 3) lack of dark vertical striping along the flank of the body. The latter two features are thought to be characteristic of Gervais' beaked whales (*Mesoplodon europaeus*). In addition to 25 beaked whale groups that were visually identified to species, another 36 groups were sighted but not identified to species. Note that these estimates may include some duplicate sightings.

Among delphinids and other species, pilot whales were the most frequently encountered group type, though common dolphins and striped dolphins were the most numerically abundant (Table 7.4). Only one baleen whale was sighted, a humpback whale outside of Lewes, DE. An additional 21 cetacean groups were not identified to species (Tables 7.3 and 7.4). The visual team also recorded a number of fishes and sharks, and one sea turtle (Table 7.4). Figures 7.2 and 7.4 show the distribution of cetacean sightings.

7.5.2 Small Boat Team

The NEFSC RHIB was launched on 5 survey days. The first day, a practice launch and recovery was conducted after departing from the dock in Lewes, DE, and the RHIB was used to test detection range for the DTAGs. Subsequently, the RHIB was not deployed until weather conditions permitted.

The deployment of DTAGs on True's beaked whales was attempted during good weather periods on two days, but groups did not allow for close approach of the RHIB. Water samples were collected for eDNA testing in the vicinity of beaked whale groups on three days (Table 7.5). A total of 14 filtered samples were available for testing. Some of these samples represent duplicates, either collected at the same time, or during subsequent dives of the same group of individuals. Visual species identification for two groups was uncertain (either *M. mirus* or *Z. cavirostris*); other groups were definitively identified based on visual characteristics.

7.5.3 Visual Seabird Sighting Team

Seabird survey effort was conducted on at least parts of 7 out of 11 sea-days covering roughly 570 km. Nomenclature of species identifications followed that reported in The Clements Checklist of Birds of the World. 6th edition, Cornell University Press 2007, with electronic updates to 2016.

A summary of the 374 birds seen while surveying (on and off effort) broken down by species is presented in Table 7.6. Distribution maps of these sightings are shown in Figure 7.6. This survey recorded 27 species of birds and 9 unidentified species groups (e.g., unidentified shearwater, unidentified storm-petrel or unidentified shore bird). Four species comprised approximately 71% of the total birds seen. In declining order of abundance these were: Wilson's Storm-Petrel *(Oceanites oceanicus),* Leach's Storm-Petrel *(Oceanodroma leucorhoa),* Great Shearwater *(Puffinus gravis),* and Manx Shearwater (*Puffinus puffinus).*

With this survey being conducted in mid-September out on the shelf break, canyons, and sea mounts in the Northeast, there has not been much data collected on occurrence or distribution of bird species in these areas, thus why off-effort sightings were included in the summary table.

Given the proximity to traditionally pelagic productive areas (shelf break, canyons, and sea mounts), it is no surprise to see Wilson's Storm Petrels and Leach's Storm Petrels in such high abundance relative to other seabirds, especially when considering migration movement at this time of year. It would seem that Audubon's Shearwater (*Puffinus lherminieri*) had mostly vacated the areas surveyed this September, leaving Manx Shearwaters (*Puffinus puffinus*) as the sole small shearwater observed. This also would seem to be true for the relative abundance of Cory's Shearwaters (*Calonetrics diomedea*) compared to Great Shearwaters (*Puffinus gravis*); both species being very abundant during the height of summer, but this September Great Shearwaters being observed nearly four times more often than Cory's Shearwaters. Sooty Shearwaters (*Puffinus griseus*), not being found in abundance on offshore surveys during the summer months, were similarly sparse in September. Long-tailed Jaegers (*Stercorarius longicaudus*), usually not seen during the height of summer, were seen in the form of dispersing juveniles; whereas Parasitic Jaegers (*Stercorarius parasiticus*) and Pomarine Jaegers (*Stercorarius pomarinus*) were observed to be a mix of immature and adult birds. Furthermore, sightings of tropical and sub-tropical species, specifically Black-capped Petrels *(Pterodroma hasitata)* and White-faced Storm-Petrels *(Pelagodroma marina*), were likely linked to offshore warm water still found in quantity during the September cruise.

A diversity of non-marine bird species were observed including American Golden Plover (*Pluvialis dominica*), Black-bellied Plover (*Pluvialis squatarola*), Cedar Waxwing (*Bombycilla cedrorum*), Common Yellowthroat (*Geothlypis trichas*), Duck sp., Great Crested Flycatcher (*Myiarchus crinitus*), Mourning Dove (*Zenaida macroura*), Northern Flicker (*Colaptes auratus*), Ovenbird (*Seiurus aurocapilla*), Passerines, Plover sp., Red Phalarope (*Phalaropus fulicarius*), Red-necked Phalarope (*Phalaropus lobatus*), Sanderlings (*Calidris alba*), Sandpiper sp., and Shorebird sp; most of these sighting due to fall migration along the Atlantic Flyway.

7.5.4 Passive Acoustic Detection Team

Over the course of the survey, acoustic monitoring effort was conducted on 9 survey days, with a total of 120.5 hrs of monitored recording time. Recordings were monitored in real-time by an acoustic technician over a total distance of 1,471 km along survey tracklines and during beaked whale focal follows (Table 7.7). This total includes daytime survey effort during concurrent visual survey operations as well as nighttime acoustic-only effort. During the last four days of this survey, most of the monitored survey time was spent at slow ship speeds or while the ship was nearly stationary while beaked whale groups were being tracked. An additional 46.8 hrs of unmonitored acoustic data were collected at night, covering a distance of 582 km. Un-monitored night recordings span a relatively large distance traveled with respect to time, as the ship generally traveled at a constant higher speed of 8 knots along uninterrupted tracklines during these periods. Due to technical issues, an additional 4.6 hrs of recordings were lost, however, acoustic binary data were collected during that time, which can be used in post-processing to extract and classify beaked whale clicks.

Real-time monitoring resulted in 86 acoustic detections of beaked whales (Figure 7.7, Table 7.8). All beaked whale detections occurred in the northernmost part of the survey area, most of which were near or within the Northeast Canyons and Seamounts Marine National Monument (Figure

7.8). Beaked whale detections were acoustically classified in real time as either Cuvier's beaked whale (*Ziphius cavirostris*) or True's/Gervais' beaked whale. It is likely that most or all detections in the latter category were clicks produced by True's beaked whale (*Mesoplodon mirus*), however, potential similarities between the clicks produced by True's and Gervais' beaked whales (*M. europaeus*) necessitate post-processing of the data to confirm the species identity of these detections. Beaked whales were detected on seven survey days, with detections of both species groups on each day. In total, there were 56 detections of click trains from Cuvier's beaked whales and 30 detections of click trains from True's/Gervais' beaked whales. Post-processing of passive acoustic data will be conducted to extract beaked whale detections during unmonitored recording periods and any detections that were missed during real-time monitoring. A detailed analysis of the acoustic characteristics of beaked whale clicks will be performed to assign species classifications to the True's/Gervais' detections.

The focus of real-time acoustic monitoring on this survey was to detect and localize beaked whales; other vocally-active odontocetes were also recorded, but only opportunistically noted in real-time. Sperm whales were acoustically detected on six survey days. Delphinid encounters occurred on all nine survey days, and were generally not classified to species, except where detections clearly corresponded to simultaneous visual detections, such as when animals approached the bow and passed alongside the ship and hydrophone array. Delphinid species represented in the data include bottlenose dolphins, common dolphins, Atlantic spotted dolphins, striped dolphins, Risso's dolphins, and pilot whales.

7.5.5 Oceanographic and Environmental Sampling

CTD casts were conducted at one site on each of three days: 12, 14 and 15 September (Figure 7.9). Casts were conducted down to 800 – 1000 m depth. During the evening of 16 September, active acoustic data were collected with the 38 kHz Ek60 for approximately nine hours (00:46-09:31 GMT). Trackline coverage was planned such that data were collected throughout the region where potential beaked whale foraging activity was taking place (Figure 7.9). The echogram (Figure 7.10) shows a dense mesopelagic layer from approximately 100 – 400 m depth.

7.6 Disposition of Data

All visual, passive acoustic, and associated data will be maintained by the Protected Species Branch at the Northeast Fisheries Science Center (NEFSC) in Woods Hole, MA. Visual sightings data will be archived in the NEFSC's Oracle database and submitted to OBIS SEAMAP for public access.

Active acoustic data are archived at the NEFSC and at NOAA's National Center for environmental Information (NCEI) facility in Boulder, CO. The data will be publically available when they are archived at NCEI.

Table 7.1. Scientific team participating in data collection aboard the *R/V Hugh R. Sharp*.

Name	Title	Institution
Danielle Cholewiak	Chief Scientist	NOAA NMFS NEFSC
Dee Allen	Mammal Observer	Marine Mammal Commission
Salvatore Cerchio	Mammal Observer	Integrated Statistics, Woods Hole, MA
Lisa Conger	Mammal Observer	NOAA NMFS NEFSC
Annamaria DeAngelis	Passive Acoustics	Integrated Statistics, Woods Hole, MA
Leigh Hickmott	Mammal Observer	Integrated Statistics, Woods Hole, MA
Nick Metheny	Seabird/Mammal Observer	Integrated Statistics, Woods Hole, MA
Joy Stanistreet	Passive Acoustics	Integrated Statistics, Woods Hole, MA
Christopher Tremblay	Mammal Observer	Integrated Statistics, Woods Hole, MA

Table 7.2. Visual survey effort categorized by Beaufort sea state. Exploratory effort was conducted when surveying pre-determined tracklines while searching for beaked whales; focal follow data collection was conducted in good weather conditions with specific beaked whale groups.

Beaufort Sea State	Exploratory Survey (hrs)	Focal Follow (hrs)	Total Hours
0	0		
1	5.0	25.0*	40.2
2	11.2		
3	10.3	4.6	15.0
4	22.8	0	22.8
5	22.6	0	22.6

*Represents number of hours in sea states of Beaufort 2 or less.

Table 7.3. Number of beaked whale groups sighted by the visual team. Note that there may be some duplicates of groups included in these numbers.

Species	Scientific name	Number of groups	Number of individuals
Cuvier's beaked whale	*Ziphius cavirostris*	17	59
True's beaked whale	*Mesoplodon mirus*	8	32
Unid. beaked whale	*Ziphiidae*	21	42
Unid. mesoplodont	*Mesoplodon spp.*	15	55
TOTAL		61	188

Table 7.4. Number of cetaceans (other than beaked whales), turtles, fishes and sharks sighted by the visual team.

Species	Scientific name	Number of groups	Number of individuals
Atlantic spotted dolphin	*Stenella frontalis*	3	25
Bottlenose dolphin	*Tursiops truncatus*	8	54
Common dolphin	*Delphinus delphis*	6	245
Pilot whale, spp.	*Globicephala spp.*	27	126
Risso's dolphin	*Grampus griseus*	5	63
Striped dolphin	*Stenella coeruloealba*	8	317
Sperm whale	*Physeter macrocephalus*	4	5
Humpback whale	*Megaptera novaeangliae*	1	1
Kogia, spp.	*Kogia spp.*	11	13
Pygmy sperm whale	*Kogia breviceps*	1	2
Loggerhead turtle	*Caretta caretta*	1	1
Basking shark	*Cetorhinus maximus*	1	1
Mola mola (sunfish)	*Mola mola*	1	1
Tuna	*Scombridae*	1	10
Unid. Cetacean	--	3	3
Unid. Dolphin	--	14	215
Unid. Large dolphin	--	1	0
Unid. Small whale	--	2	2
Unid. Odontocete	--	1	0
Fish, jellyfish, shark	--	3	0
Shark spp.	--	5	4
Unknown	--	11	15
TOTAL		118	1103

Table 7.5. Summary of water samples collected for eDNA testing. Water samples were collected near where animals dove. All samples were collected in the vicinity of beaked whales; in some cases species assignment was uncertain.

Date	Time (ET)	Group #	Filter Label	Species	Species ID Confidence
15-Sep-17	12:57	12	17-09-15_01	*M. mirus*	probable
15-Sep-17	12:57	12	17-09-15_02	*M. mirus*	probable
15-Sep-17	16:22	15	17-09-15_03	*Z. cavirostris*	probable
15-Sep-17	16:22	15	17-09-15_04	*Z. cavirostris*	probable
15-Sep-17	16:58	15	17-09-15_05	*Z. cavirostris*	probable
15-Sep-17	16:58	15	17-09-15_06	*Z. cavirostris*	probable
16-Sep-17	10:29	13	17-09-16_01/02	*M. mirus*	certain
16-Sep-17	11:13	13	17-09-16_03	*M. mirus*	certain
16-Sep-17	11:13	13	17-09-16_04	*M. mirus*	certain
16-Sep-17	11:32	13	17-09-16_05/06	*M. mirus*	certain
16-Sep-17	14:18	22	17-09-16_07/08	*M. mirus*	certain
16-Sep-17	15:30	22	17-09-16_09/10	*M. mirus*	certain
16-Sep-17	16:27	22	17-09-16_11/12	*M. mirus*	certain
17-Sep-17	12:43	13	17-09-17-01/02	*Z. cavirostris*	certain

Table 7.6. Number of groups and individual birds detected by the seabird team.

Name	Scientific Name	Number of Groups	Number of Individuals	Relative Number of Individuals
American Golden Plover	*Pluvialis dominica*	1	1	0.002
American Redstart	*Setophaga ruticilla*	1	1	0.002
Black-Bellied Plover	*Pluvialis squatarola*	3	4	0.001
Black-capped Petrel	*Pterodrom hasitata*	3	3	0.007
Bonaparte's Gull	*Chroicocephalus philadelphia*	1	1	0.002
Cedar Waxwing	*Bombycilla cedrorum*	3	3	0.007
Cory's Shearwater	*Calonetrics diomedea*	7	7	0.017
Common Tern	*Sterna hirundo*	3	3	0.007
Common Yellowthroat	*Geothlypis trichas*	1	1	0.002
Duck species	*n/a*	1	5	0.012
Great Black-backed Gull	*Larus mainus*	1	1	0.002
Great Crested Flycatcher	*Myiarchus crinitus*	1	1	0.002
Great Shearwater	*Puffinus gravis*	33	37	0.089
Herring Gull	*Larus argentatus*	7	9	0.022
Lesser Black-backed Gull	*Larus fuscus*	5	5	0.012
Leach's Storm Petrel	*Oceanodroma leucorhoa*	28	30	0.072
Long-tailed Jaeger	*Stercorarius longicaudus*	2	3	0.007
Manx Shearwater	*Puffinus puffinus*	20	23	0.055
Mourning Dove	*Zenaida macroura*	1	1	0.002
Northern Flicker	*Colaptes auratus*	2	2	0.005
Ovenbird	*Seiurus aurocapilla*	1	1	0.002
Parasitic Jaeger	*Stercorarius parasiticus*	5	7	0.017
Passerines	*n/a*	8	13	0.031
Plover species	*n/a*	3	3	0.007
Pomarine Jaeger	*Stercorarius pomarinus*	3	3	0.007
Red Phalarope	*Phalaropus fulicarius*	1	5	0.012
Red-necked Phalarope	*Phalaropus lobatus*	1	1	0.002
Sanderling	*Calidris alba*	3	3	0.007
Shorebird species	*n/a*	3	5	0.012
Sooty Shearwater	*Puffinus griseus*	1	1	0.002
Unidentified Phalarope	*n/a*	2	3	0.007
Unidentified Sandpiper	*n/a*	2	5	0.012
Unidentified Shearwater	*n/a*	1	1	0.002
Unidentified Storm-petrel	*n/a*	3	3	0.007
Unidentified Tern	*n/a*	1	4	0.01
White-faced Storm Petrel	*Pelgaodroma marina*	8	8	0.019
Wilson's Storm-Petrel	*Oceanites oceanicus*	89	210	0.504
TOTAL		259	417	1

Table 7.7. Summary of passive acoustic recording effort during the HRS-1701 survey.

Activity	TOTAL
Days with towed array effort	9
Monitored towed array recording (hrs)	120.5
Unmonitored towed array recording (hrs)	46.8
Monitored towed array track line distance covered (km)	1471
Unmonitored towed array track line distance covered (km)	582

Table 7.8. Summary of real-time beaked whale detections during the HRS-1701 survey. An acoustic detection may represent one animal or groups of animals.

Species	Number of acoustic detections
Cuvier's beaked whale	56
True's/Gervais' beaked whale	30
TOTAL	86

Figure 7.1. Scientists onboard the beaked whale survey.

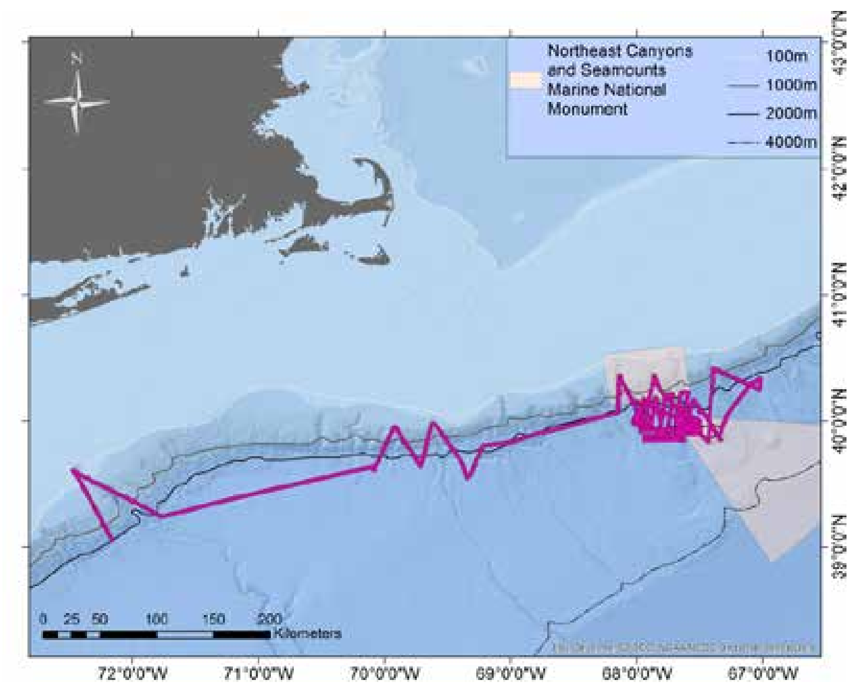


Figure 7.2. Survey tracklines covered by the *R/V Hugh R. Sharp* from 9 – 17 September 2017, including both daytime and nighttime effort. Daytime effort included visual and passive acoustic data collection; night effort included only passive acoustic data collection. The straight tracks between canyon areas were transited at night. The Northeast Canyons and Seamounts Marine National Monument is shown in pink.

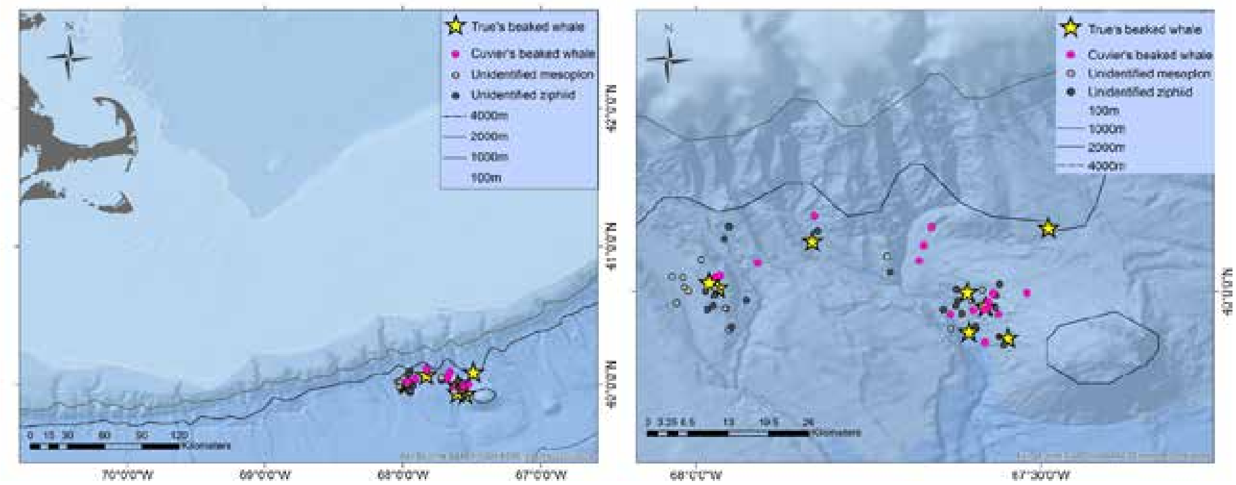


Figure 7.3. Visual sightings of beaked whales in the Georges Bank/ Bear Seamount region, including True's (*Mesoplodon mirus*) and Cuvier's (*Ziphius cavirostris*) beaked whales, as well as beaked whale sightings unidentified to species. The right panel is zoomed into the same data.

Figure 7.4. Photograph of True's beaked whale (*Mesoplodon mirus*) taken on 16 September 2017, showing pale melon, lack of defined dorsal stripe, and lack of vertical striping on body. Photo credit: S. Cerchio.

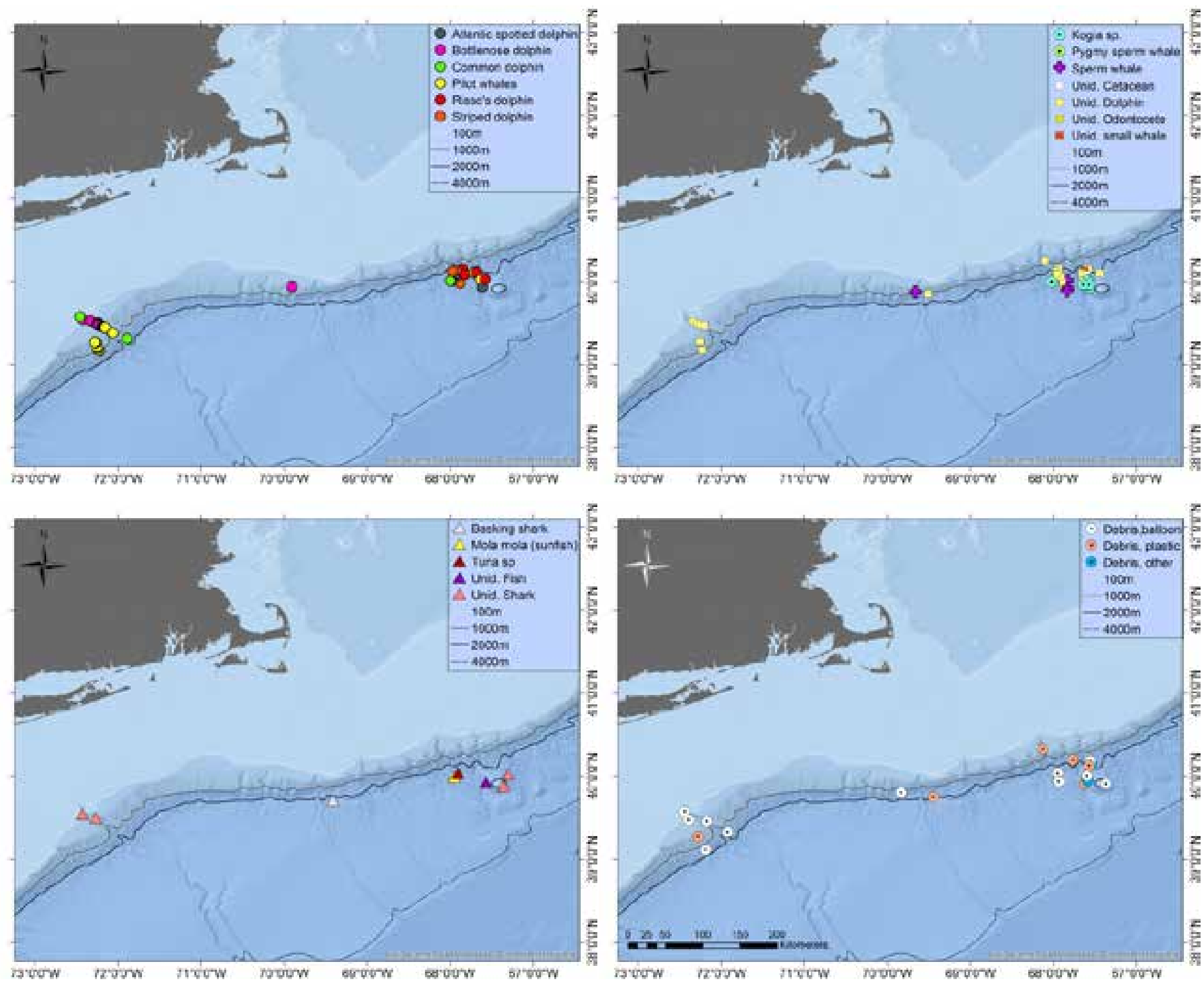


Figure 7.5. Visual sightings of cetaceans (top left and right), fishes and sharks (bottom left) and debris (bottom right).

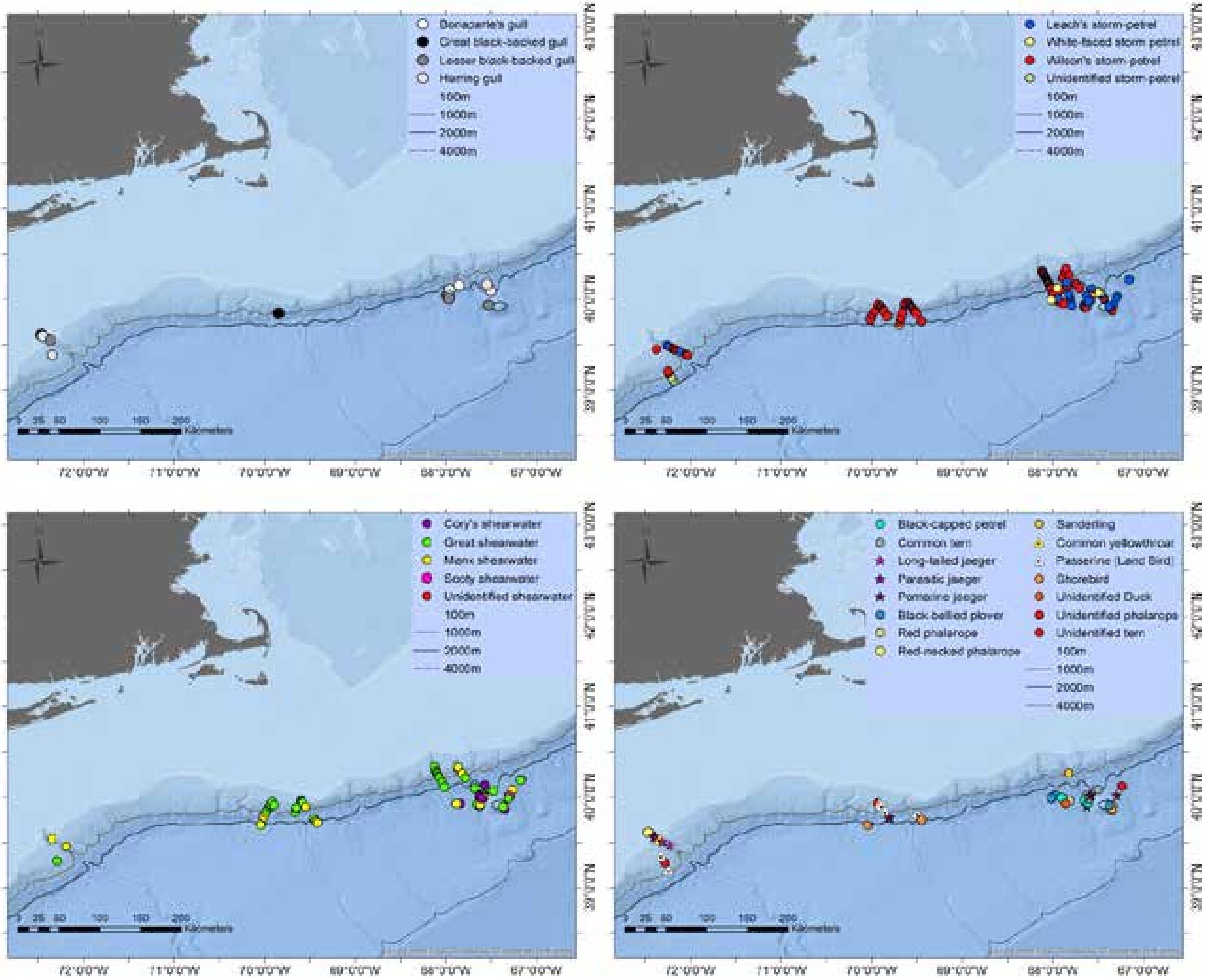


Figure 7.6. Visual sightings of seabirds. Top panels show locations of gulls (left) and storm-petrels (right). Bottom panels show shearwaters (left) and all other birds sighted (right). Survey tracklines are shown in pink but include nighttime transits between regions as well as daytime effort.

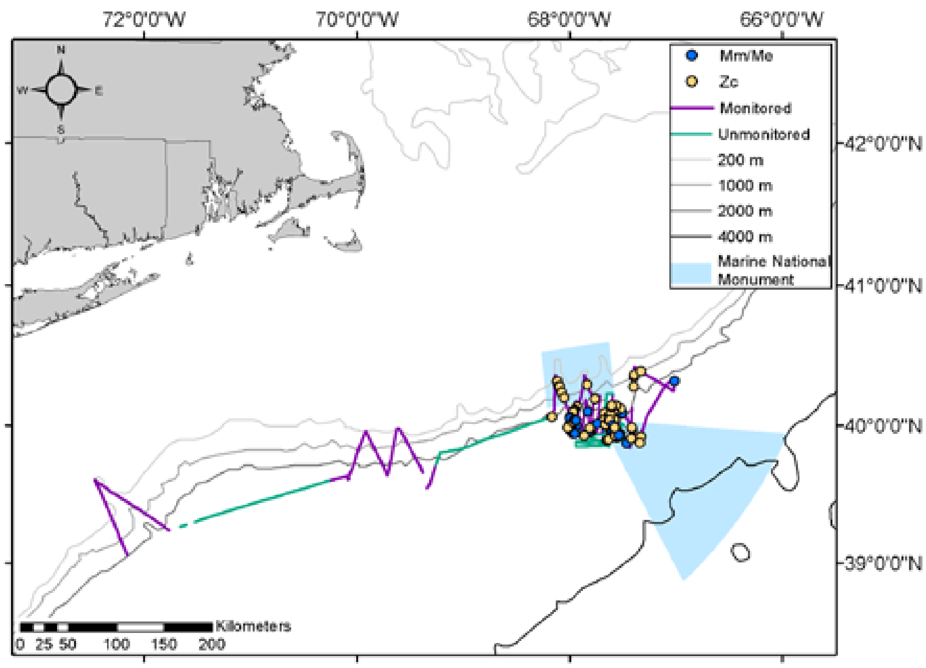


Figure 7.7. Acoustic recording effort and location of the *R/V Hugh R. Sharp* during acoustic detections of vocally-active beaked whale groups. Purple tracklines denote times when the array was monitored and green when the array was unmonitored. The Northeast Canyons and Seamounts Marine National Monument is shown in blue.

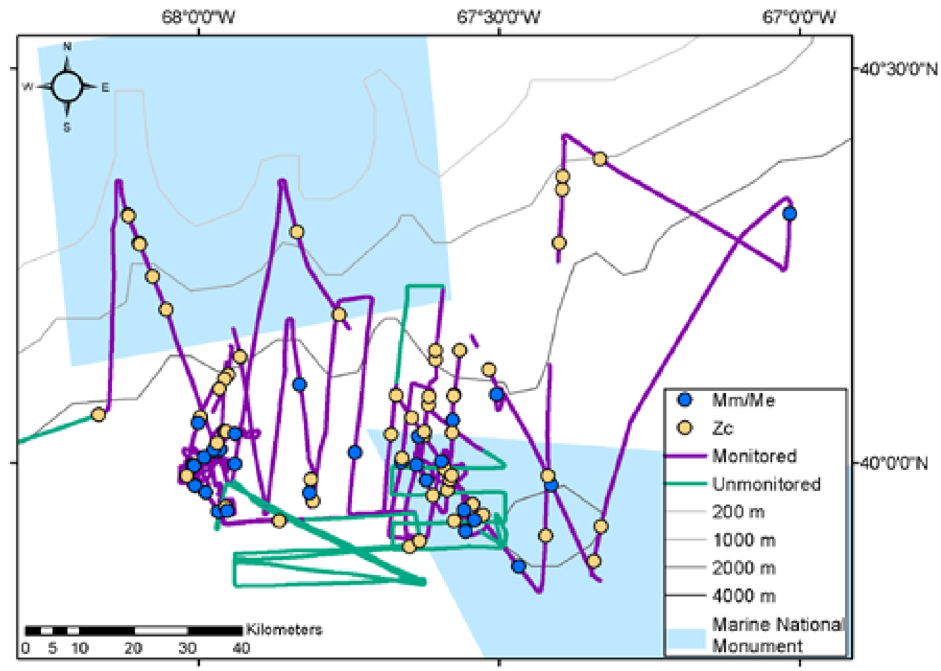


Figure 7.8. Detailed view of the acoustic recording effort and location of the *R/V Hugh R. Sharp* as well as beaked whale detections near the Northeast Canyons and Seamounts Marine National Monument.

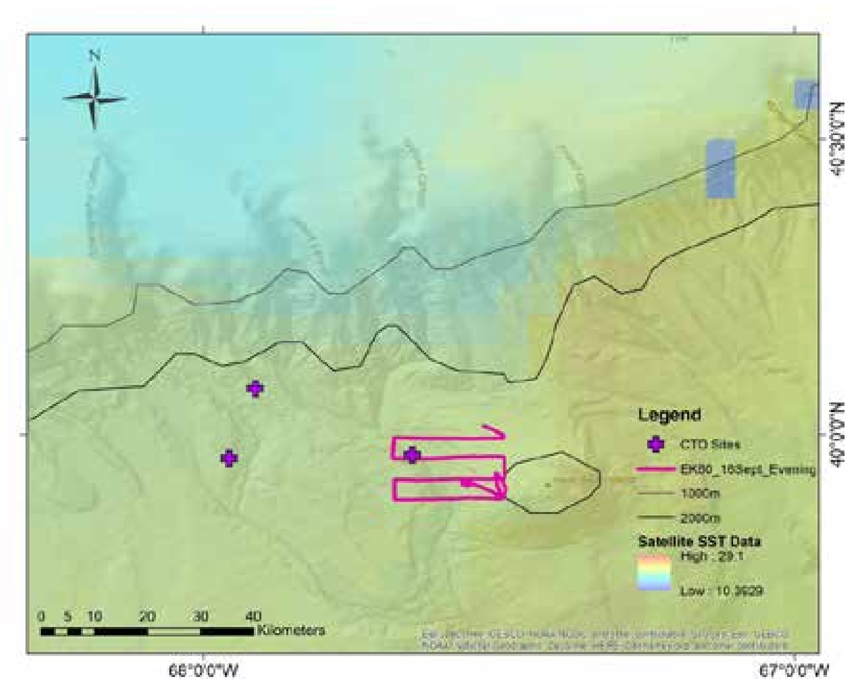


Figure 7.9. Map showing locations of three CTD deployments (purple crosses), and the track line coverage for the EK60 data collection on 16-17 September. EK60 data were collected for approximately 92 km. A 3-day composite of SST data centered on 8 September is overlaid on the background, showing surface temperatures of 22 – 23ºC across the region where the EK60 data were collected.

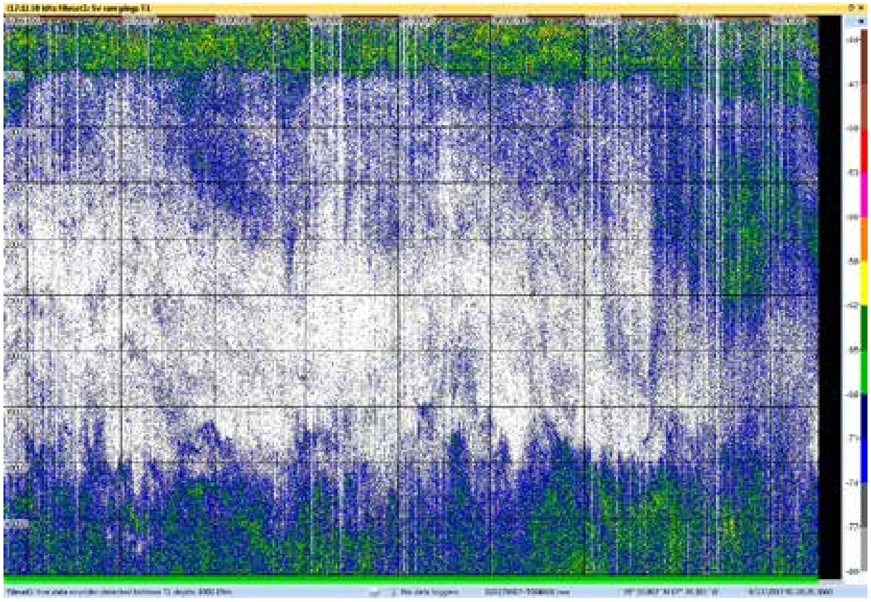


Figure 7.10. A 38 kHz echogram spanning approximately 9 hours. These data were collected in the vicinity of Bear Seamount (see Figure 6) from 16-17 September 2017. The echogram shows the acoustic backscattering patterns of the mesopelagic layer, down to 400 m. The timing of this data collection did not capture the diel migration of fishes and plankton in the water column.

8 Progress on Research Related to Density and Abundance Estimation: Northeast and Southeast Fisheries Science Centers

Debra L. Palka[1], Samuel Chavez-Rosales[2], Douglas Sigourney[2], Elizabeth Josephson[2], Lance P. Garrison[3], Laura A. Dias[4]

[1]Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543
[2]Integrated Statistics, Inc., 16 Sumner Street, Woods Hole, MA 02543
[3]Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami FL 33149
[4]Cooperative Institute for Marine and Atmospheric Studies, 4600 Rickenbacker Causeway, Miami FL 33149

8.1 Summary

One of the AMAPPS objectives is to assess the population size of surveyed species at regional scales and develop models and associated tools to translate these survey data into seasonal, spatially explicit density estimates incorporating habitat characteristics. To achieve these objectives work in 2017 related to the finalization of the AMAPPS I report and preparations for the 2018 analyses of all of the AMAPPS 2010 – 2017 abundance survey data using the generalized additive model (GAM) and Bayesian hierarchical model frameworks. This involved error-checked and archived the recently collected shipboard and aerial abundance survey data; collating, processing and error-checking the environmental habitat variables for the entire time series; streamlining the scripts to input, output and process the data; and generalizing the GAM and Bayesian hierarchical analytical methods to be more flexible and robust. The methods and resulting models from the 2010 – 2013 data were presented at several meetings and was published in the AMAPPS I report (Palka et al. 2017). In addition, the methods and results will be published in peer-reviewed journal articles (Chavez-Resales et al. (in review) and Sigourney et al. (in review)) and available on a public website (in review). The 2017 work on the model that integrates visual line transect and passive acoustic data to estimate a dive time adjusted abundance estimate for sperm whales included improving the structure of the model to account for individual animal heterogeneity and modifying the method to make it more flexible. During 2017 collaborations were initiated to expand the analysis of dive time pattern data to estimate availability correction factors by including other dive data derived from DTAGs. In addition a new project was initiated to compare the results from the AMAPPS visual surveys to the results from hi-definition photographic surveys conducted over waters off New York.

8.2 Objectives

The objective of AMAPPS II that was addressed in this chapter is: "Assess the population size of surveyed species at regional scales; and develop models and associated tools to translate these survey data into seasonal, spatially explicit density estimates incorporating habitat characteristics". This can only be achieved by addressing several of the other AMAPPS objectives that relate to (1) collecting broad-scale and fine-scale data over multiple years on the seasonal distribution and abundance of marine mammals (cetaceans and pinnipeds), sea turtles, and sea birds using fixed passive acoustic monitoring and direct aerial and shipboard surveys of U.S. Atlantic Ocean waters and (2) conducting tagging studies of protected species to develop corrections for availability bias in the abundance survey data.

8.3 Survey Data

During 2017 the abundance survey data collected during the NEFSC shipboard and aerial surveys that were conducted during 2016 and up to July 2017 were error-checked, archived in the Oracle data base and sent to OBIS-SEAMAP. For the SEFSC, data collected during aerial surveys between 2014 and 2017 and a shipboard survey in 2016 are currently being audited and prepared for archive at OBIS-SEAMAP.

In addition, the loggerhead turtle data from 2010 – 2013 were provided to Megan Winton of University of Massachusetts, Dartmouth to be included in her Phase II modeling project of loggerhead distribution using data collected from satellite tags, survey data and bycatch data (see Chapter 10 for more details).

8.4 Environmental Data

During 2017 collection of dynamic variables for the years 2014 – 2015 was completed. However after a thorough analysis it was determined that the scale of some of the variables differed considerably from the data collected for 2010 – 2013. This was probably due to changes of the sensors and/or algorithms from the data source. Consequently, a new set of dynamic variable data was collected for the years 2010 – 2016. Then during 2017 we began the interpolation process, updating the seasonal data sets, and data checking the new dynamic environmental variables. This process is scheduled to be completed in spring 2018.

8.5 Generalized Additive Modeling (GAM) Framework

During 2017 the NEFSC aerial circle-back surveys for summer 2010 and winter 2011 were re-analyzed with DISTANCE. Information for fin whales, sei whales and minke whales is now ready to be incorporated into the GAM modeling framework. In addition, a DISTANCE preliminary analysis for loggerhead turtles from NEFSC and SEFSC data from 2010 – 2013 was completed.

The robustness of the 2010 – 2013 GAM models was investigated in two ways. The first way involved the species bottlenose dolphins, common dolphins, fin whales, Risso's dolphins, humpback whales, sperm whales and pilot whales. The 2010 – 2013 model parameters were applied to the spring 2014 environmental data, and then the resulting predicted density models were compared with the actual spring 2014 AMAPPS sighting locations and reported in the AMAPPS I final report (Palka et al. 2017). The second way involved the common dolphin data. The 2010 – 2013 model parameters (for the only covariate sea surface temperature) was applied to the 2004 summer sea surface temperature and then the resulting predicted density map was compared to the locations of the summer 2004 NEFSC sightings (Figure 6.1). In addition, the resulting predicted 2004 abundance estimate was compared to the abundance estimate reported in the 2005 SAR which was derived from only the 2004 summer line transect data (Table 7.1). The predicted density model showed good correlation with the sightings data and the predicted abundance estimate was within 4% of the 2005 estimate, which is not statistically different. This indicates that for this species the density-habitat model appears to be robust to inter-annual changes.

Using the 2010 – 2013 cetacean models the environmental predictors of habitat suitability and cetacean occurrence in the western North Atlantic Ocean were documented in Chavez-Rosales et al. (in review), presented in a poster at the Society of Marine Mammal Science Conference in Halifax, Nova Scotia in October 2017 (Chavez-Rosales et al. 2017) and presented as talks during the DenMod Workshop held in October 2017 (Chavez-Rosales and Sigourney 2017) and the Woods Hole Oceanographic Institution's "Oceanos: WHOI en Español e Português" held in September 2017 (Chavez-Rosales 2017).

8.6 Bayesian Hierarchical Model

Work on the Bayesian hierarchical framework in 2017 focused on incorporating GAMs into the framework and directly comparing the output to results from the conventional 2-step GAM approach as described above. Results showed that density estimates and predicted spatial distributions were similar between the two methods. However estimates of uncertainty under the Bayesian approach were considerably higher as the Bayesian method directly propagates the uncertainty from the detection function. The new Bayesian hierarchical version was applied to data on fin whales and was summarized in a manuscript that will be submitted to a peer reviewed journal (Sigourney et al. in review). The methods and results were also presented at the Society of Marine Mammal Conference in Halifax, Nova Scotia (Sigourney et al. 2017) in October 2017 and presented at the Density Modeling (DenMod) meeting in October 2017 (Chavez-Rosales and Sigourney 2017).

8.7 Integrating Passive Acoustic and Line Transect Data

The 2017 work on the model that integrates line transect and passive acoustic data to estimate a dive time adjusted abundance estimate for sperm whales, included improving the structure of the model to account for individual animal heterogeneity and modifying the method to make it more flexible. The original hidden Markov model approach previously outlined was modified to adopt a more conventional capture mark-recapture framework. The updated method was tested with simulated data. In addition, sperm whale data from the AMAPPS 2013 shipboard surveys was summarized and used as input into the model. A description of the processing of the acoustic data are in Chapter 10. A preliminary estimate of sperm whale abundance from the line transect and passive acoustic was about 3200 sperm whales. This is comparable with the sperm whale abundance estimate of 2600 (which is an availability bias correction of the 1593 estimated by Palka (2012) using the 2011 AMAPPS line transect only data). In addition, the coefficient of variation (CV) of the abundance estimate from this method was 0.12 which is lower than the CV of 0.42 reported by Palka (2012) indicating considerably higher precision. Finally, the estimate of availability bias was similar to an independent estimate calculated from tag data using the method of Laake et al. (1997) (see Figure 9.2).

Results from both simulations and real data have been summarized in a draft report and circulated to a review committee. A meeting was held in October 2017 with the committee and results and methods were discussed. In addition, the method was presented at a mini-symposium in Seattle in March 2018. Several helpful suggestions were offered by the review committee and participants of the mini-symposium and are currently being explored in a simulation framework.

8.8 Abundance for Bottlenose Dolphins and Short-finned Pilot Whales

Survey data from the summer 2010, summer 2011, and summer 2016 AMAPPS aerial surveys were combined with past aerial surveys to update abundance estimates and evaluate population trends in coastal bottlenose dolphin stocks between Florida and New Jersey. For each survey, data were post-stratified to match the defined boundaries of the five coastal bottlenose dolphin stocks along the US east coast. Due to the overlap between the coastal and offshore morphotypes of bottlenose dolphins in continental shelf waters, a logistic regression model was developed using genetic data from biopsy samples to predict the probability that a given group was from the coastal morphotype based upon location and environmental predictors. The data for each survey were analyzed using Distance analysis integrated with the outcome from the logistic regression model to develop population estimates for each stock for 2002, 2004, 2010, 2011 and 2016. The results demonstrated a significant coast-wide decline in population size between 2011 and 2016. The coast-wide estimate during 2011 was 41,456 (CV=0.30) while the estimate during 2016 was 19,470 (CV=0.23). This decline corresponds to the period of a large coast wide unusual mortality event during 2013 – 2015. Due to high inter-annual variability, uncertainty in stock boundaries, and high uncertainty in estimates for individual stocks, no significant differences could be identified for individual stocks. The updated abundance estimates and trend analyses were included in the 2017 MMPA Stock Assessment Reports. Additional detail is provided in Garrison et al. (2017).

Abundance estimates for the western North Atlantic stock of short-finned pilot whales were updated for the 2018 MMPA stock assessment reports using data collected during the summer 2016 southeast and northeast AMAPPS vessel surveys. Short-finned pilot whales are of significant interest to NMFS managers due to frequent interactions with the pelagic longline fishery and the associated Pelagic Longline Take Reduction plan that has been in place since 2008. The last abundance estimate for the stock was developed in 2011, also using data from the AMAPPS program. One challenge for these estimates is the spatial overlap between the long-finned and short-finned pilot whale stocks, particularly in the waters along the shelf break of Southern New England in the area covered by the NEC AMAPPS vessel surveys. To address this overlap, pilot whale biopsy samples collected during 1998-2007 were used to develop a logistic regression model to predict the probability that a vessel sighting was of short-finned vs. long-finned pilot whales based upon location, water temperature, and month (Garrison and Rosel, 2017). This model was applied to the summer 2016 data and integrated with Distance analysis to estimate short-finned pilot whale abundance in U.S. waters. The resulting abundance estimate for 2016 was 28,924 (CV = 0.24), which was higher than (but not significantly different from) the estimate from 2011 (Garrison and Palka, in review). The updated abundance estimate and associated Potential Biological Removal value was included in the draft 2018 MMPA stock assessment report.

8.9 Database and Website Development

Scripts have been developed in R to make data uploads to Oracle easier and better documented. Similarly, R scripts have been written to output data from the database in various formats, including formatting the bird sightings data for submission to the Seabird Compendium Database, formatting mammal and turtle sightings data for submission to OBIS, and outputting the shipboard and aerial data in a format that can be analyzed using DISTANCE. R scripts that generate maps of density-habitat model results have also been created to simplify that process.

In addition, the draft website that displays the interactive habitat-density seasonal distribution maps was improved to be easier to use and run faster and was rewritten to be compliant with security and Section 508 requirements.

8.10 Availability Bias Correction Factor

Previously, dive time data from tagged cetaceans were used to estimate availability correction factors to the perception bias-corrected density estimates (Palka and Warden 2017). During 2017, contacts were initiated with other researchers that have dive time pattern data derived from tagged cetaceans. The plan is to examine these data to estimate average dive and surface times that can be used to improve the availability correction factors and to report these results in a peer-reviewed paper (Palka et al. in prep).

8.11 Compare Visual Survey to Hi-Definition Photographic Survey Data

In 2017 a new collaborative project was initiated with Julia Willmott and Michell Vukovich from Normandeau Associates, Inc.. The goal is to compare the results from the AMAPPS visual and Normandeau hi-definition photographic aerial surveys that are targeting cetacean, seals and sea turtles.

8.12 Acknowledgements

We would like to thank David Chevrier for the NEFSC for his work on creating the website that will be displaying the density maps. We would also like to thank the crews of the NOAA ships *Henry B. Bigelow* and *Gordon Gunter*, and the science teams who participated in the data collection on AMAPPS surveys. This work was partially supported by the Bureau of Ocean Energy Management (BOEM) and the US Navy through Interagency Agreements for AMAPPS, as well as by the NOAA Fisheries.

8.13 References Cited

Chavez-Rosales S. 2017. Atlantic Marine Assessment Program for Protected Species. Presented at "Oceanos: WHOI en Español e Português" September 2017. https://www.whoi.edu/page.do?pid=17315&tid=7342&cid=256549

Chavez-Rosales S, Palka D., Garrison L, Josephson E. (in review) Environmental predictors of habitat suitability and cetacean occurrence in waters of the northeastern coast of United States.

Chavez-Rosales S, Palka D, Garrison L, Josephson E. 2017. Environmental predictors of habitat suitability and cetacean occurrence in the western North Atlantic Ocean. Poster presented at the SMM 2017Biennial Conference in Halifax October 2017.

Chavez-Rosales, S and Sigourney D. 2017. Habitat Density Models for Cetaceans in the Atlantic: A Brief Overview of the AMAPPS Modeling Efforts. Talk presented at DenMod workshop October 2017.

Garrison LP, Barry K, Hoggard W. 2017. The abundance of coastal morphotype bottlenose dolphins on the U.S. east coast: 2002-2016. Southeast Fisheries Science Center, Protected Resources and Biodiversity Division, 75 Virginia Beach Dr., Miami, FL 33140. PRBD Contribution # PRBD-2017-01, 37 pp.

Garrison LP, Palka D. (in review). Abundance of short-finned pilot whales along the U.S. east coast from summer 2016 vessel surveys.Southeast Fisheries Science Center, Protected Resources and Biodiversity Division, 75 Virginia Beach Dr. Miami, FL 33140. PRBD Contribution # PRBD-2018-XX, 17 pp.

Garrison LP, Rosel PE. 2017. Partitioning short-finned and long-finned pilot whale bycatch estimates using habitat and genetic information. Southeast Fisheries Science Center, Protected Resources and Biodiversity Division, 75 Virginia Beach Dr., Miami, FL 33140. PRBD Contribution # PRBD-2016-17, 24 pp.

Laake JL, Calambokidis J, Osmek SD, Rugh DJ. 1997. Probability of detecting harbor porpoise from aerial surveys: Estimating g(0). Journal of Wildlife Management 61(1):63-75.

Palka D. 2012. Cetacean abundance estimates in US northwestern Atlantic Ocean waters from summer 2011 line transect survey. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 12-29; 37 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

Palka DL, Chavez-Rosales S, Josephson E, Cholewiak D, Haas HL, Garrison L, Jones M, Sigourney D, Waring G (retired), Jech M, Broughton E, Soldevilla M, Davis G, DeAngelis A, Sasso CR, Winton MV, Smolowitz RJ, Fay G, LaBrecque E, Leiness JB, Dettlof M, Warden M, Murray K, Orphanides C. 2017. Atlantic Marine Assessment Program for Protected Species: 2010- 2014. US Dept. of the Interior, Bureau of Ocean Energy Management, Atlantic OCS Region, Washington, DC. OCS Study BOEM-2017-071. 211 pp.

Palka D, Warden M. 2017. Accounting for availability bias in line transect abundance estimates. Poster presented at Biennial Conference on the Biology of Marine Mammals, Oct 2017.

Palka D, Warden M, plus other data owners (in prep). Estimating availability bias correction factors from tagged cetaceans.

Sigourney D, Chavez-Rosales S, Palka D, Lance Garrison L, Josephson E. 2017. Fitting a species distribution model to line transect data of fin whales (*Balaenoptera physalus*) in the western Atlantic using a Bayesian hierarchical framework: Implications for uncertainty. Talk at Biennial Conference on the Biology of Marine Mammals, Oct 2017.

Sigourney D, Chavez-Rosales S, Garrison L, Josephson E, Palka D. (in review). Development of a species distribution model for fin whales (*Balaenoptera physalus*) within a Bayesian hierarchical framework: Implications for quantifying and communicating uncertainty.

Table 8.1. Comparison of common dolphin abundance estimates between the Stock Assessment Report (SAR 2005) and the 2010 – 2013 habitat model when applied to 2004 habitat data.

Source	Season	Year	N_{best}	CV
SAR 2005	Jun-Aug	2004	120,743	0.23
Habitat model	Jun-Aug*	2004	126,009	0.10

*2010-2013 model, prediction using the 2004 environmental data

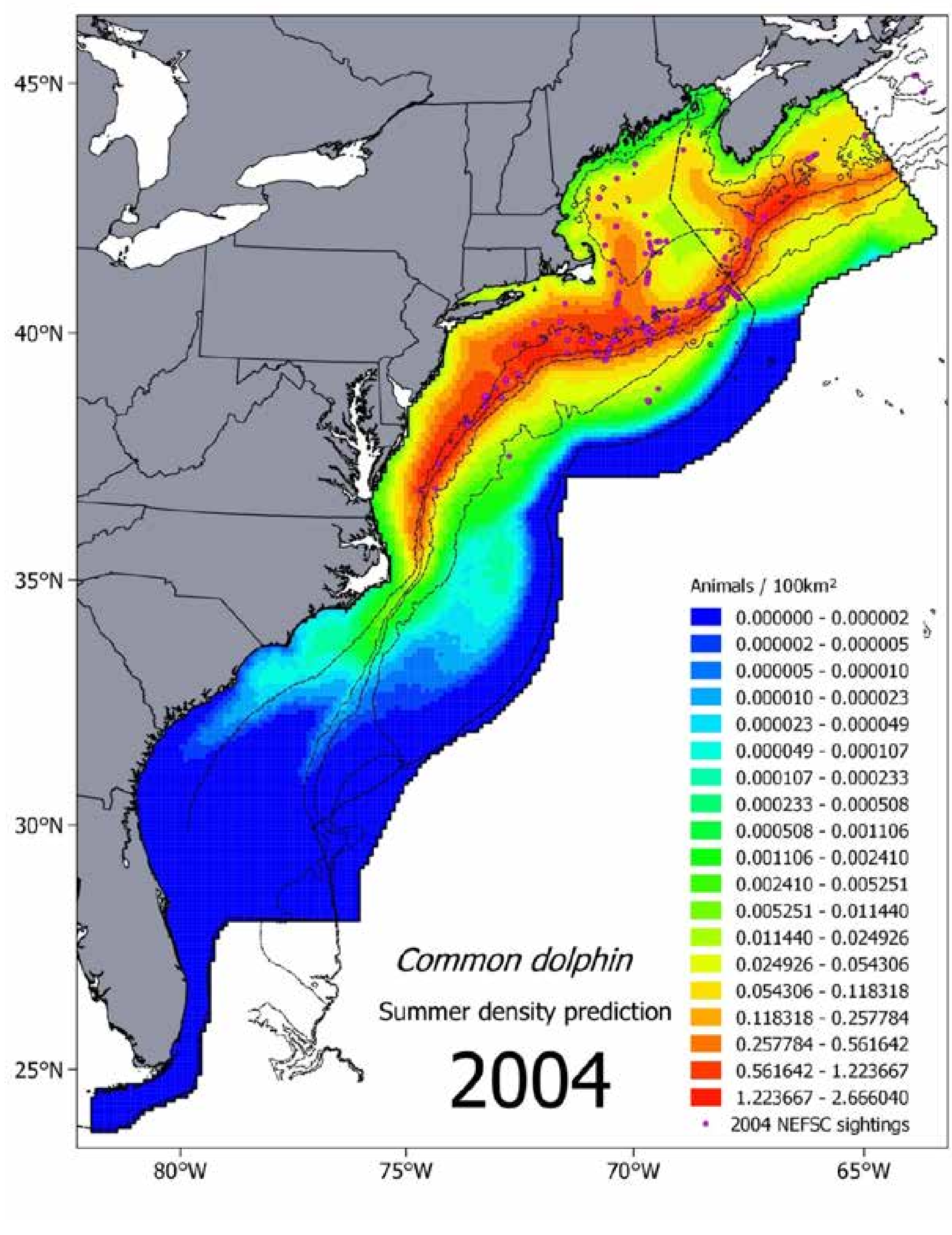


Figure 8.1. Common dolphin 2010 – 2013 model predictions using the 2004 habitat data.

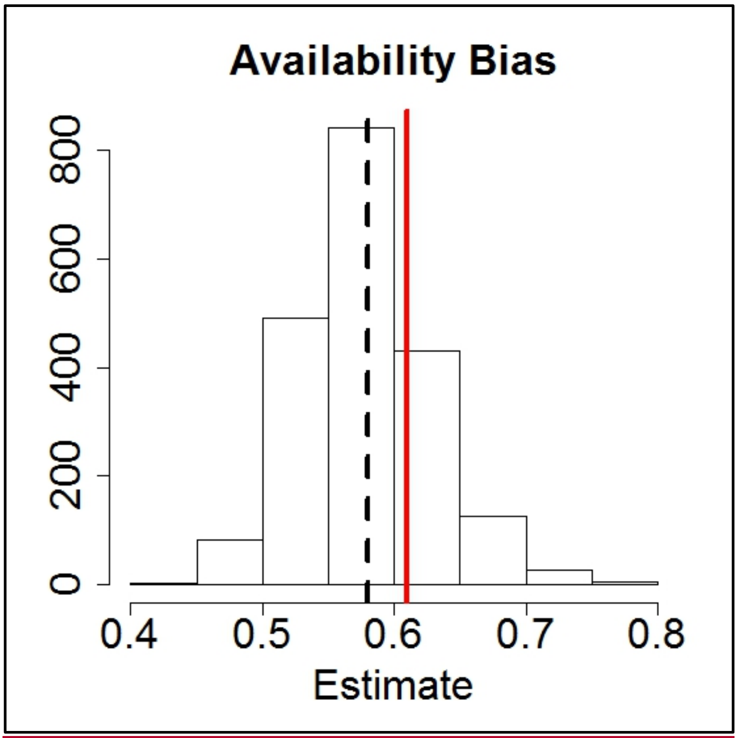


Figure 8.2. Posterior distribution of availability bias for sperm whales calculated from the 2013 AMAPPS shipboard data using the acoustic and visual data integration model. The black dashed line indicates the model's posterior median estimate and the solid red line represents an independent estimate of availability bias for sperm whales that was derived from dive pattern data collected from tag-equipped sperm whales (Palka and Warden in prep).

9 Progress on Passive Acoustic Data Collection and Analyses: Northeast and Southeast Fisheries Science Centers

Danielle Cholewiak[1] and Melissa Soldevilla[2]

[1]Northeast Fisheries Science Center, 166 Water Street, Woods Hole, MA 02543
[2]Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami FL 33149

9.1 Summary

The goal of the AMAPPS-related work conducted by the Northeast and Southeast Fisheries Science Center's passive acoustic groups is to collect acoustic data that complement visual-based analyses of animal occurrence and abundance, particularly for species that are difficult to detect by visual observation, or in times of year and regions where visual surveys are not conducted. In 2017, there were several ongoing primary analyses involving bottom-mounted recorder data and towed hydrophone array data collected during AMAPPS surveys. These are: (1) documenting migratory pathways of baleen whales along the eastern seaboard continental shelf and shelf break, (2) improving abundance estimates for sperm whales (*Physeter macrocephalus*) by evaluating methodologies for acoustic abundance estimation, and by integrating visual and acoustic data to better document distribution and evaluate availability bias; (3) quantifying acoustic detection rates and acoustic characterization of beaked whales recorded on towed hydrophone arrays, with the goals of comparing to visual detection rates and compiling sufficient data for acoustic abundance estimation for these taxa. In addition, development is continuing on the Tethys acoustic database in collaboration with scientists from San Diego State University, Scripps Institution of Oceanography and the NOAA Science Centers. Also collaboration with colleagues to conduct further work on odontocete species continued as well, with grant proposals submitted to continue work on acoustic classification and group size estimation for delphinid species.

9.2 Background and Objectives

Passive acoustic technologies have become a critical component of marine mammal monitoring, contributing information about the spatial and temporal occurrence, distribution, and acoustic behavior for a variety of species. Some species, such as beaked whales, have low visual detection rates (Barlow *et al.* 2005); while even more reliably sighted species cannot be detected visually at night or when conditions are poor. Data collected from acoustic studies provide important new insights about species occurrence, including abundance estimation for species that are often poorly detected visually (e.g., Marques *et al.* 2009), presence of species in regions that are difficult to otherwise survey (e.g., Moore *et al.* 2012), and the response of individuals to anthropogenic activities that produce underwater sound (e.g., Castellote *et al.* 2012). Archival recorders, gliders, and towed hydrophone arrays offer the opportunity to collect data on cetacean occurrence and distribution that complements traditional visual survey methodologies.

The goals of the passive acoustic groups at the Northeast and Southeast Fisheries Science Centers include improving our understanding of cetacean acoustic ecology, so that we may improve abundance estimation and develop more effective monitoring and management strategies where needed.

The main objectives of incorporating passive acoustic data into AMAPPS include:

- Improve our understanding of the spatial and temporal distribution and relative abundance of baleen whales in the western North Atlantic using bottom-mounted archival recorders; and
- Improve abundance estimates of odontocetes in the western North Atlantic using acoustic data collected from towed hydrophone arrays, particularly for sperm whales, beaked whales, and delphinids;
- Evaluate the efficacy of towed hydrophone array and archival recorder data collection with comparison to traditional visual data collection to determine where data from these different platforms may be integrated.

9.3 Data Collection

9.3.1 Bottom-mounted Recorder Data

Five lines of MARUs (Marine Autonomous Recording Units, Cornell University, Bioacoustics Research Program), sampling at 2 kHz, were deployed along the US eastern seaboard off the coasts of Rhode Island, North Carolina, South Carolina, and Georgia (Figure 9.1) for approximately 6 months at time. These deployments are part of a large-scale project to monitor baleen whale migratory movements along the US east coast that started in 2015. A total of 27 MARUs were deployed in December 2016 – January 2017 of which 24 were successfully recovered in May – July 2017. Re-deployment of 27 units took place in May – July 2017, with recoveries initiated in November 2017.

In addition, eight HARPs (High-frequency Acoustic Recording Packages, Scripps Institution of Oceanography), sampling at 200 kHz, are deployed along the shelf break (Figure 9.1) for one year at time. These deployments are part of a study to monitor the acoustic ecology of deep water habitats, including the presence of baleen whales and odontocetes. One full year of data were collected from 2016 – 2017. In June –July 2017, all 8 units were recovered and redeployed.

9.3.2 Towed Hydrophone Array Data

Towed hydrophone array data collected in conjunction with the NEFSC shipboard cetacean abundance survey from June – August 2016 were analyzed in 2017 (Figure 9.2). Details on field data collection can be found in the NEFSC/SEFSC 2016 report (Report of a Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in US Waters of the Western North Atlantic Ocean - AMAPPS II). New field data collected in September 2017 (Chapter 7 in this report) will be analyzed in 2018.

9.4 Database Development

The Tethys acoustic database, developed in collaboration with scientists from San Diego State University, the Scripps Institution of Oceanography and the other NOAA Science Centers utilizes standardized formats for archival of metadata associated with our acoustic data collection and analyses, including AMAPPS data. Tethys is currently being used to archive the metadata associated with the deployments of AMAPPS bottom-mounted recorders, as well as metadata associated with analyses of baleen whale detections. Development of Tethys is continuing to increase functionality, with the goal of incorporating additional recorder platforms, including towed array data.

9.5 Data Analysis Methods

Processing of passive acoustic data took place using a variety of software packages. Bottom-mounted recorder data were reviewed for baleen whale acoustic activity using custom-written software, the Low-Frequency Detection Classification System (LFDCS, Baumgartner et al., 2013). Towed hydrophone array data were analyzed using Pamguard (version 1.15.10, Gillespie et al. 2008), Audacity®, as well as custom-written Matlab scripts. Abundance estimation was conducted using the software package DISTANCE. Visual and aural reviews of spectrograms and extraction of delphinid whistles were conducted using the software packages Raven (version 1.5, Bioacoustics Research Program 2011) and Xbat (Figueroa and Robbins 2008), executed in Matlab.

9.6 Analysis Results

9.6.1 Baleen Whale Occurrence along the Eastern Seaboard

Five lines of MARUs have been deployed along the US eastern seaboard (Figure 9.1) since October 2015. Data from November 2015 – June 2017 were processed using the Low Frequency Detection and Classification System (LFDCS, Baumgartner & Mussoline 2011). Calls of North Atlantic right whales and sei whales, as well as song units of humpback whales, fin whales, and blue whales were detected and classified. Analyses in 2017 focused on determining daily presence of North Atlantic right whales, based on the occurrence of up-calls. Right whales were considered present on any given day if 3 or more up-calls were detected. Total number of recording days varied by site, depending on deployment timing, equipment performance, and interactions between human activities (e.g. trawling) and recording units. However, combined results from these three deployments indicate consistent seasonal presence of right whales in the region south of Cape Cod. One site in this region contained evidence of right whale presence on 472/523 days; that is, over 90% of the recording days. With the exception of the winter period, when right whales were detected on all five lines, detections were generally sparse south of Cape Hatteras in spring, summer and fall seasons. Figure 9.3 shows the number of detection days per season, per recorder site. This work builds on a study by Davis et al. (2017) of North Atlantic right whale distribution, and highlights their use of habitats across the continental shelf.

Analyses are ongoing and have been expanded to include additional species. Acoustic data from 2006 – 2016 were scanned to identify patterns in humpback whale song structure. Prevalent song units that were considered good candidates for the LFDCS automated detection system were identified, and the LFDCS call library was expanded to include song units spanning this 11-year period. Figure 9.4 shows a short example of one theme from the North Atlantic humpback whale song recorded in 2016. Analyses are underway to quantify the efficacy of the automated detector for this species.

9.6.2 Acoustic Abundance Estimates of Sperm Whales

Based on consultations with colleagues, analyses were initiated to estimate the acoustic abundance of sperm whales using point-transect methodology. Previous analyses had been conducted to estimate abundance using the traditional line-transect approach, which treats acoustic localizations of animals as though they are on a two-dimensional plane. However, for deep diving animals such as sperm whales, this approach may overestimate the horizontal distance to animals that are close to the ship but at considerable depth. Point transect methodology, in contrast, utilizes the radial distance to a detected animal, rather than the horizontal distance. For towed hydrophone array data, localization of animals in 2-D generates a slant range, similar to the radial distance. The actual horizontal distance to the animal can only be obtained if the individual is localized in 3-D, which is not always possible. Therefore, this methodology may prove to produce more accurate estimates of acoustic abundance given typical towed array data. Analyses are ongoing.

In addition, analysis efforts continued on the topic of combining visual sightings and acoustic detections of sperm whales to improve abundance estimation and understanding of sperm whale distributions. Modeling efforts continue to focus on data collected during the NEFSC 2013 summer shipboard survey. Acoustic databases were converted from Microsoft Access to SQL to maintain cohesion with the acoustical software package Pamguard. Matlab routines were customized to extract details on sperm whale echolocation events, including the time, bearing and radial distances to all clicks. Model development by D. Sigourney of the AMAPPS team is described in Chapter 9.

9.6.3 Acoustic Detections of Beaked Whales (family: Ziphiidae)

The manuscript on using multipath reflections to determine the depths of beaked whales using a towed hydrophone array was published in the Journal of the Acoustical Society of America (DeAngelis et al. 2017a). Vocalizing Cuvier's beaked whales (*Ziphius cavirostris*) were found on average at 1158 m $\pm$ 287 m and Gervais'/True's beaked whales (*Mesoplodon europaeus/Mesoplodon mirus*) at 870 m $\pm$ 151 m (Figure 9.5). In addition, the classification of Mesoplodon species was revised based on the preliminary analysis of the 2016 survey data further described below. Also, the manuscript on the effects of shipboard echosounders on the detection rates of beaked whales was published in Royal Society Open Science (Cholewiak et al. 2017a). Acoustic detection rates of beaked whales were found to decrease significantly when shipboard echosounders were operating in active mode.

Post-processing of the NEFSC 2016 shipboard abundance survey data was completed using the software package Pamguard. Analysis steps included running the Pamguard click detector (pre-filter: 16-90 kHz; trigger filter: 20-90 kHz; threshold 10 dB) over all sound files, and reviewing detections to identify putative beaked whale events following a set of established criteria. During the 2016 survey, there were three encounters with True's beaked whales in which passive acoustic and visual data were collected. This represents the first time passive acoustic data were collected in the presences of positively identified True's beaked whale. Preliminary results suggest that the echolocation clicks produced by True's beaked whales are characterized by a peak frequency of 46 kHz, -10 dB frequency of 37 kHz, and an inter-click-interval of 0.17 s (Figure 9.6). These echolocation clicks have similar spectral characteristics to those of Gervais' beaked whales (Figure 9.7), which creates a challenge for distinguishing between the two species in the broader AMAPPS datasets. Further analyses are planned to determine which spectral and temporal characteristics may be most reliable in acoustically distinguishing between these two species. The characterization of echolocation clicks recorded in the presence of True's beaked whales was presented at the 22nd Biennial Society for Marine Mammology Conference on the Biology of Marine Mammals in October 2017 (DeAngelis et al. 2017b), and was submitted as a manuscript to the Journal of the Acoustical Society of America.

A total of 119 positive detections of beaked whales were found in the 2016 NEFSC dataset, comprising of Cuvier's (n= 70), Sowerby's (n= 5), Gervais'/True's (n= 44); there were also 28 probable and 32 possible detections of beaked whales (Table 9.1). Additional detections during times when the ship was "on chase" for visual sightings or acoustic detections are listed in Table 9.2. Similarly to results from the AMAPPS survey in 2013, beaked whale detections were significantly lower during the 2016 survey when the EK60 echosounders were operating (Cholewiak et al. 2017a, b). In 2016, there were a total of 159 beaked whale acoustic detections when echosounders were in passive mode, and 20 beaked whale detections when echosounders were in active mode (Table 9.3).

9.7 Acknowledgements

Genevieve Davis, Annamaria DeAngelis and Sarah Weiss contributed to the acoustic analyses included in this report. We would like to thank the crews of the NOAA ships *Henry B. Bigelow* and *Gordon Gunter*, and the science teams who participated in visual and acoustic data collection on AMAPPS surveys. We thank Eric Matzen and Heather Haas for support in the field deployment of the three northern HARP recorders. We thank colleagues at Cornell University and Scripps Institution of Oceanography for assistance in data collection (deployment and recovery of MARUs and HARPs, respectively), data extraction and analyses. This work was partially supported by the Bureau of Ocean Energy Management (BOEM) and the US Navy through Interagency Agreements for AMAPPS, as well as by the Navy's Living Marine Resources Program and NOAA Fisheries.

9.8 References Cited

Barlow J, Ferguson M, Perrin W, Balance L, Gerrodette T, Joyce G, MacLeod C, Mullin K, Palka D, Waring G.. 2005. Abundance and densities of beaked and bottlenose whales (family Ziphiidae). J. Cet. Res. Manag. 7:263-270.

Baumann-Pickering S , McDonald M, Simonis AE, Solsona Berga A, Merkens KPB, Oleson EM, Roch M, Wiggins SM, Rankin S, Yack TM, Hildebrand J. 2013. Species-specific beaked whale echolocation signals, J. Acous. Soc. Amer. 134, 2293-2301.

Baumgartner M, Fratantoni D, Hurst T, Brown M, Cole T, Van Pajis S, Johnson M. 2013. Real-time reporting of baleen whale passive acoustic detections from ocean gliders. J. Acous. Soc. Amer. 134:1814-1823

Baumgartner MF, Mussoline SE. 2011. A generalized baleen whale call detection and classification system. J. Acous. Soc. Amer. 129: 2889-2902.

Bioacoustics Research Program 2011. Raven Pro: Interactive Sound Analysis Software (Version 1.4) [Computer software]. Ithaca, NY: The Cornell Lab of Ornithology.

Castellote M, Clark CW, Lammers MO. 2012. Acoustic and behavioural changes by fin whales (*Balaenoptera physalus*) in response to shipping and airgun noise. Biological Conservation 147. 115–122.

Cholewiak D, Baumann-Pickering S, Van Parijs SM. 2013. Description of sounds associated with Sowerby's beaked whales (*Mesoplodon bidens*) in the western North Atlantic Ocean. J. Acous. Soc. Amer. 134(5): 3905-3912.

Cholewiak D, DeAngelis AI, Palka D, Corkeron PJ, Van Parijs SM. 2017a. Beaked whales demonstrate a marked acoustic response to the use of shipboard echosounders.R. Soc. Open Sci. 4: 170940. http://dx.doi.org/10.1098/rsos.170940.

Cholewiak D, DeAngelis AI, Palka D, Corkeron P, Van Parijs SM. 2017b. Beaked whales demonstrate a marked acoustic response to the use of shipboard echosounders. 22nd Biennial Conference on the Biology of Marine Mammals, Halifax, NS, October 2017.

Davis GE, Baumgartner MF, Bonnell JM, Bell J, Berchok C, Thornton JB, Brault S, Buchanan G, Charif RA, Cholewiak D, Clark CW, Corkeron P, Delarue J, Dudzinski K, Hatch L, Hildebrand J, Hodge L, Klinck H, Kraus S, Martin B, Mellinger DK, Moors-Murphy H, Nieukirk S, Nowacek DP, Parks S, Read AJ, Rice AN, Risch D, Sirovic A, Soldevilla M, Stafford K, Stanistreet JE, Summers E, Todd S, Warde A, Van Parijs SM. 2017. Long-term passive acoustic recordings track the changing distribution of North Atlantic right whales (*Eubalaena glacialis*) from 2004 to 2014. Scientific Reports, 7: 13460.

DeAngelis AI, Valtierra R, Van Parijs SM, Cholewiak D. 2017a. Using multipath reflections to obtain dive depths of beaked whales from a towed hydrophone array. The Journal of the Acoustical Society of America 142(2): 1078-1087.

DeAngelis AI, Palka D, Van Parijs SM, Cholewiak D. 2017b. Is it truly True's? First description of True's beaked whale clicks. 22nd Biennial Conference on the Biology of Marine Mammals, Halifax, NS, October 2017.

Figueroa HK, Robbins M. 2008. “XBAT: An Open-Source Extensible Platform for Bioacoustic Research and Monitoring,” In K.-H. Frommolt, R. Bardeli, and M. Clausen (Eds.), Computational bioacoustics for assessing biodiversity (Bundesamt für Naturschutz, Bonn), pp. 143–155.

Gillespie D, Gordon J, McHugh R, Mclaren D, Mellinger D, Redmond P. 2008. PAMGUARD: semiautomated, open source software for real-time acoustic detection and localisation of cetaceans. Proc Inst Acoust 30(5).

Marques T, Thomas L, Ward J, DiMarzio J, Tyack, P. 2009. Estimating cetacean population density using fixed passive acoustic sensors: an example with Blainville’s beaked whales. Journal of the Acoustical Society of America, 125: 1982-1994.

Moore SE, Stafford KM, Mellinger D, Berchok C, Wiig Ø, Kovacs KM, Lydersen C. 2011. Comparing marine mammal acoustic habitats in Atlantic and Pacific sectors of the High Arctic: year-long records from Fram Strait and the Chukchi Plateau. Polar Biology 35, 475–480.

Northeast Fisheries Science Center (NEFSC), Southeast Fisheries Science Center (SEFSC). 2016. Report of a Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in US Waters of the Western North Atlantic Ocean - AMAPPS II. https://www.nefsc.noaa.gov/psb/AMAPPS/docs/Annual%20Report%20of%202016%20AMAPPS_final.pdf

Table 9.1. Acoustic detections of beaked whales during line-transect survey mode, and the number of those detections localized (in parentheses) in NEFSC AMAPPS 2016 shipboard survey data. Positive, probable and possible indicate the degree of certainty that a given acoustic event is correctly classified as a beaked whale.

Species	Positive	Probable	Possible
Cuvier's	70 (63)	22 (18)	27 (14)
Sowerby's	5 (5)	1 (1)	0 (0)
Gervais'/True's	44 (43)	5 (3)	5 (2)
TOTAL	119 (111)	28 (22)	32 (16)

Table 9.2. Acoustic detections of beaked whales when the ship was "on chase" to identify a group of cetaceans during the NEFSC AMAPPS 2016 shipboard survey. These are in addition to the number of detections reported in Table 1. The number of unique detections could not be tallied as there is uncertainty about the independence of detections when the ship is not traveling in a straight line.

ID	Date	Reason for chase	Beaked whale clicks detected during chase
1	6/30/2016	Visual false killer whale sighting	Gervais'/True's
2	7/8/2016	Acoustic True's detection	True's
3	7/24/2016	Visual True's sighting	True's, Cuvier's
4	7/26/2016	Acoustic multiple beaked whale species	Cuvier's
5	7/30/2016	Visual striped dolphin confirmation	Gervais'/True's
6	8/15/2016	Visual striped dolphin confirmation	Gervais'/True's
7	8/22/2016	Acoustic True's detection	True's

Table 9.3. Acoustic detection state of beaked whales during the NEFSC 2016 shipboard survey, by echosounder state. All species were detected during days in which echosounders were operated in passive mode. In contrast, when echosounders were operated in active mode, detections were primarily only of Cuvier's beaked whales (with one exception).

Detection State	Echosounder State	
	Off	On
Positive	112	7
Probable	22	6
Possible	25	7
TOTAL	159	20

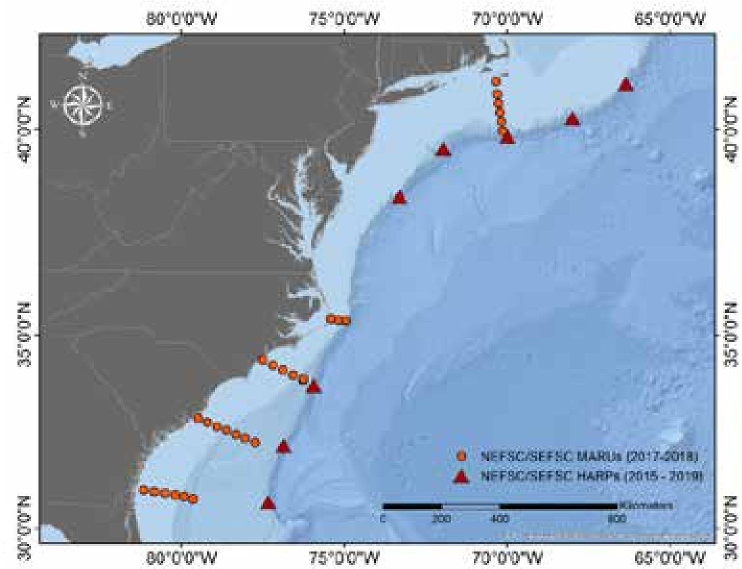


Figure 9.1. Map of bottom-mounted recorders deployed along the US eastern seaboard in conjunction with AMAPPS efforts in FY17. These data contribute to analyses of baleen whale migratory movements and shelf break acoustic ecology. Marine Autonomous Recording Units (MARUs, Cornell U.) are deployed for about six months at a time; High-frequency Acoustic Recording Packages (HARPs, SIO) are deployed for a year at a time.

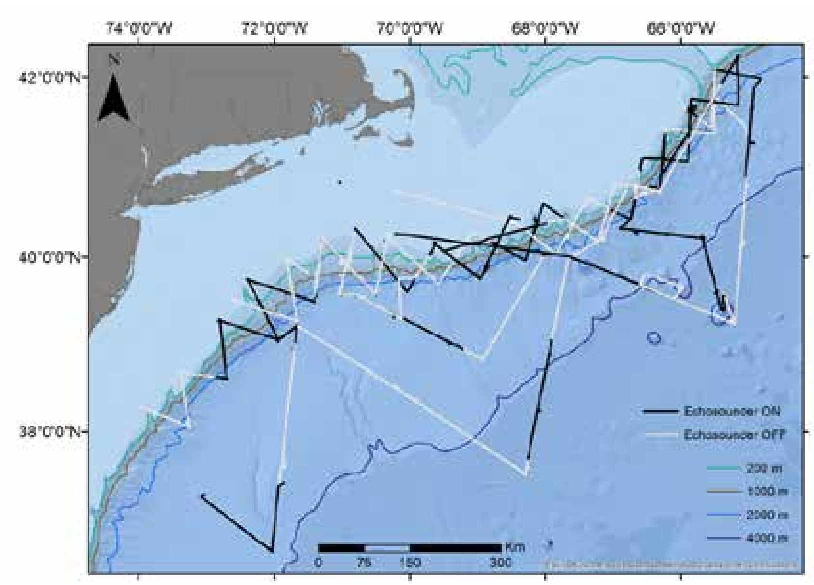


Figure 9.2. Tracklines in which towed hydrophone array data were collected during the NEFSC shipboard cetacean abundance survey conducted in 2016. Gray lines indicate days when the vessel's echosounders were operated in passive mode; black lines indicate days in which echosounders were operated in active mode. For further information on field data collection associated with this survey, see the 2016 Report of a Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in US Waters of the Western North Atlantic Ocean - AMAPPS II.

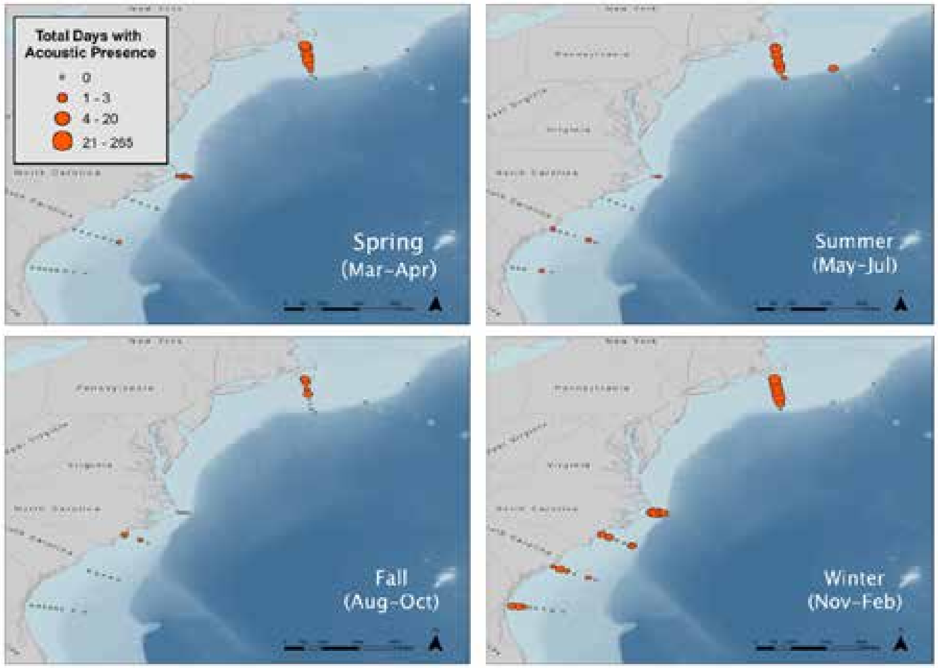


Figure 9.3. Acoustic presence of North Atlantic right whales, from October 2015 – June 2017, by site and season. Recording units include 5 lines of MARUs deployed along the continental shelf, and 3 HARPs, deployed on the shelf break offshore of Massachusetts. See text for details.

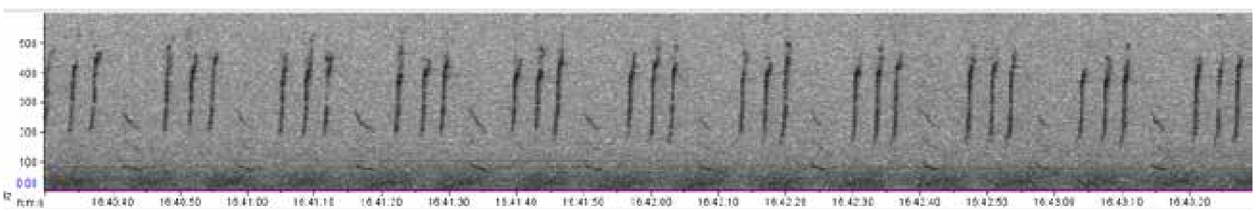


Figure 9.4. Spectrogram showing one theme from the western North Atlantic humpback whale song in 2015-2016. Note that this is an excerpt and represents only a portion of the overall song sequence; additional themes were identified but are not shown here.

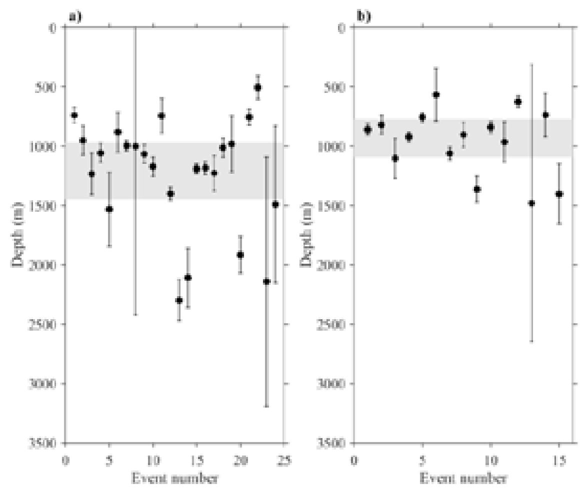


Figure 9.5. Estimated depths of (a) Cuvier's beaked whales and (b) Gervais'/True's beaked whale, based on 3-D localization of acoustic detections using towed hydrophone array data. The grey bar indicates the interquartile range between 25% and 75%.

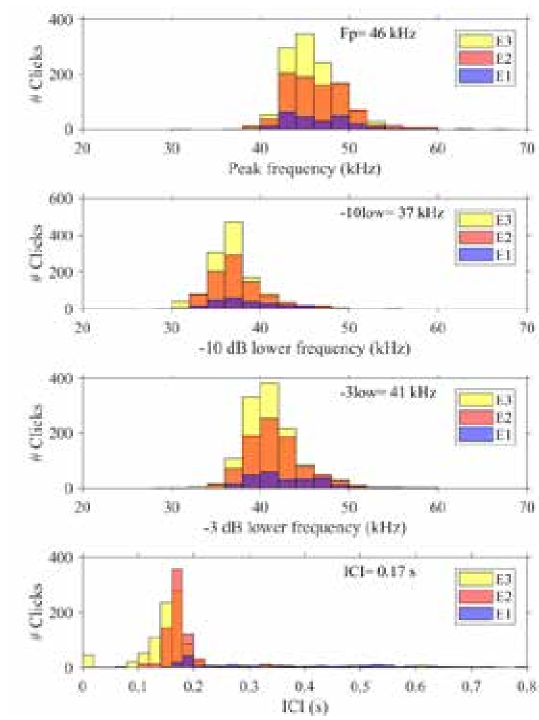


Figure 9.6. Histograms of spectral and temporal characteristics of True's beaked whale echolocation clicks, based on towed hydrophone array data collected in 2016. Data from three encounters are described, shown in purple (Encounter 1, E1), orange (Encounter 2, E2), and yellow (Encounter 3, E3). The median characteristic is reported in each subplot.

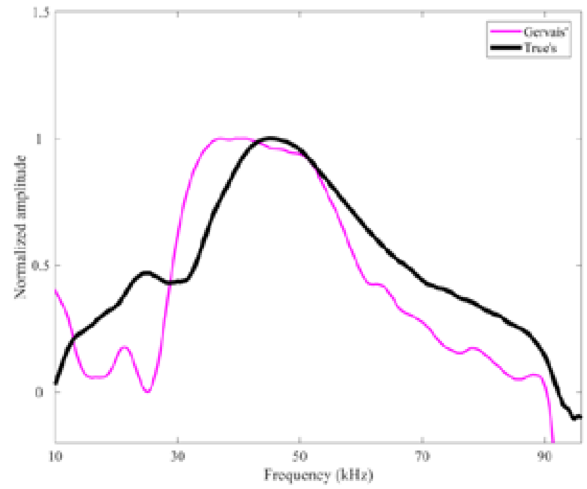


Figure 9.7. Average power spectra of Gervais' beaked whale clicks (pink), based on data from Baumann-Pickering et al. (2013) and True's beaked whale clicks (black), based on NEFSC towed hydrophone array data collected in 2016.

10 Progress on Sea Turtle Research: Northeast and Southeast Fisheries Science Centers

Debi Palka[1], Heather Haas[1], Chris Sasso[2]

[1] Northeast Fisheries Science Center, 166 Water St., Woods Hole MA 02536
[2] Southeast Fisheries Science Center, 75 Virginia Beach Dr, Key Biscayne, FL 33149

10.1 Summary

In 2017 to advance research on turtle distribution, abundance, dive patterns and habitat use, loggerhead turtles from less studied areas were tagged during several collaborative field projects. In addition tagging projects have started focusing on leatherback turtles. In 2017 leatherback turtles on nesting beaches of Florida were tagged and beaches on North Carolina were explored to determine where to conduct more tagging in 2018. In addition, a peer-reviewed paper was published that explored various statistical models when applied to loggerhead turtle satellite telemetry data to estimate utilization distribution maps. These data showed the overall predicted densities were greatest in the shelf waters along the US Atlantic coast from Florida to North Carolina. In particular the Mid-Atlantic Bight was an important summer foraging habitat. Methodologies to estimate distribution maps are continuing by adding sightings and bycatch data to the tag data.

10.2 Objectives

The AMAPPS program coordinates the data collection and analysis efforts of the NMFS Northeast and Southeast Fisheries Science Centers (NEFSC and SEFSC) to accomplish six primary objectives, three of which are relevant to the AMAPPS Turtle Ecology task:

- Collect data on distribution and abundance using visual and acoustic survey techniques;
- Conduct tag telemetry studies within surveyed regions of marine turtles, pinnipeds and seabirds to develop corrections for availability bias in the abundance survey data and collect additional data on habitat use and life-history, residence time, and frequency of use;
- Explore alternative platforms and technologies to improve population assessment studies;

To advance these objectives during 2017 field work was conducted to equip leatherback and loggerhead turtles with tags. In addition, data from previous tags were analyzed and distribution and relative density maps were produced. More details on these projects are below.

10.3 Field work

10.3.1 Leatherback turtles

To learn more about the distribution and abundance of leatherback turtles the SEFSC equipped two female leatherbacks with satellite tags that were on nesting beaches in Florida. One turtle moved north along the coast to the Carolinas before ceasing transmission. Unfortunately, the other tag broke as the turtle was returning to the water after nesting. Discussions with the tag manufacturer confirmed that early tags of this type were weak in a spot of the housing and the design has been changed to prevent such issues.

In addition the SEFSC conducted a scoping excursion to beaches in North Carolina in May 2017. Over a dozen leatherbacks were sighted. This indicates these sites are excellent candidates for future tagging work which will commence in May 2018.

10.3.2 Loggerhead turtles

The main AMAPPS loggerhead turtle effort in 2017 was focused on a July 2017 tagging cruise on the NOAA ship *Henry B. Bigelow* (in collaboration with Coonamessett Farm Foundation (CFF), Canada's Department of Fisheries and Oceans, Stony Brook University and Woods Hole Oceanographic Institute). See Chapter 6 for more details on this cruise. Consistent with AMAPPS priorities for loggerhead turtle tagging, this cruise focused effort north of areas typically sampled in previous years. Although we are unable to find any loggerhead turtles northeast of Long Island, NY we were able to find and tag five loggerhead turtles in the northern portion of the Mid-Atlantic. To date, we are only aware of three other loggerhead turtles that have been tagged in this northern section of the Mid-Atlantic.

With respect to loggerhead tagging, we also collaborated on CFF lead tagging efforts during various times in 20017. In February 2017, three CFF tags were deployed in the waters off of Cape Hatteras, NC. In May 2017, sixteen tags (mostly CFF) were deployed in the Mid-Atlantic. All tags that were deployed in February and May were parameterized consistent with AMAPPS protocols, and all satellite telemetered data from these tags are entered into the NEFSC Oracle database.

10.4 Analyses

The distribution analyses of the loggerhead turtle tag data is being conducted in two phases. The first phase was completed in 2017. This phase involved applying various models to satellite telemetry data to estimate utilization distributions of loggerhead turtles. Some tags and tagging efforts were funded through the AMAPPS program (Figure 10.1). After using simulations it was determined that geostatistical mixed effects models produced the least biased results (Winton et al. 2018). These models explicitly account for spatial and/or temporal correlation using Gaussian random fields. A total of 271 large juvenile and adult loggerhead sea turtles tagged in the western North Atlantic from 2004 to 2016 were used to predict the overall spatial distribution of tagged individuals, as well as seasonal shifts in densities at smaller time scales. These data showed the overall predicted densities were greatest in the shelf waters along the US Atlantic coast from Florida to North Carolina. In particular the Mid-Atlantic Bight was an important summer foraging habitat (Figure 10.2).

The second phase of the analysis started in 2017 through a contract with the University of Massachusetts, Dartmouth. The goal is to model distribution of loggerhead turtles using data from not only the satellite tag data, but also data from sighting surveys and locations of bycaught animals on commercial fishing vessels. Currently all of these data have been transferred and the analyses have started.

In addition to the above analyses, to investigate the distribution and abundance of loggerhead turtles, next year it is planned to utilize similar techniques being used on the cetacean data collected in other projects within AMAPPS (see Chapter 8 for more details). That is, the turtle sightings detected during visual abundance surveys will be used to estimate the distribution and abundance of loggerhead turtles at the ocean surface. Then the loggerhead turtle satellite tag data that includes dive profile information will be used to estimate an adjustment factor for availability bias that can be applied to the surface abundance estimate to obtain an abundance estimate for the loggerhead turtles in the entire water column.

10.5 References Cited

Winton MV, Fay G, Haas HL, Arendt M, Barco S, James M, Sasso C, Smolowitz R. 2018. Estimating the distribution and relative density of tagged loggerhead sea turtles in the western North Atlantic from satellite telemetry data using geostatistical mixed effects models. Mar Ecol Prog Ser 586: 217–232. https://doi.org/10.3354/meps12396.

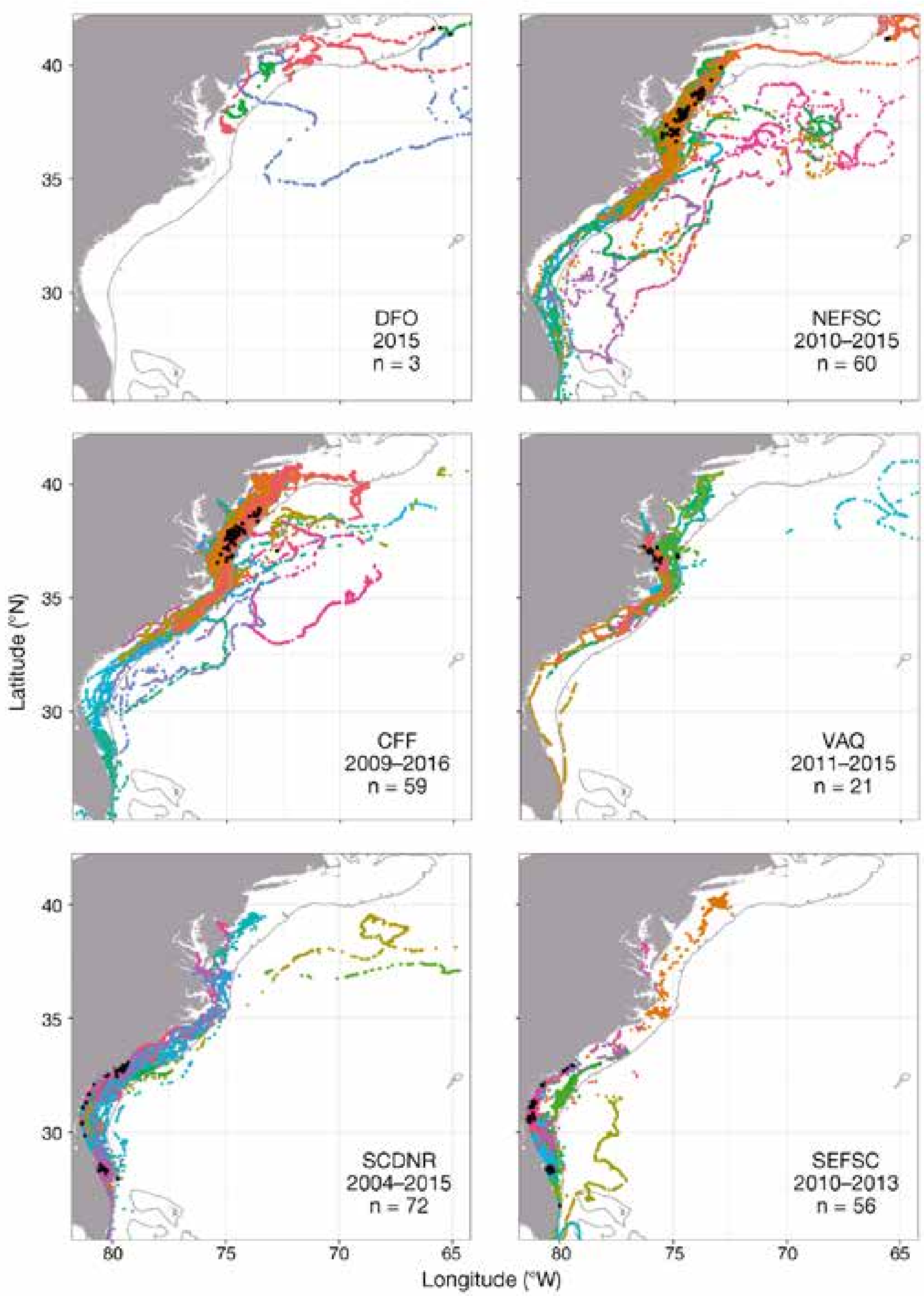


Figure 10.1. From Winton et al. (2018) Figure 1: Study area and reconstructed tracks from 271 large juvenile and adult loggerhead turtles tagged by 6 different tagging programs in the western North Atlantic from 2004 to 2016. Tracks of individual turtles are indicated by different colors. Tagging locations are indicated by black circles. The grey line denotes the 200 m bathymetric contour. DFO: Fisheries and Oceans Canada; NEFSC: NOAA Fisheries Northeast Fisheries Science Center; CFF: Coonamessett Farm Foundation; VAQ: Virginia Aquarium & Marine Science Center; SCDNR: South Carolina Department of Natural Resources; SEFSC: NOAA Fisheries Southeast Fisheries Science Center.

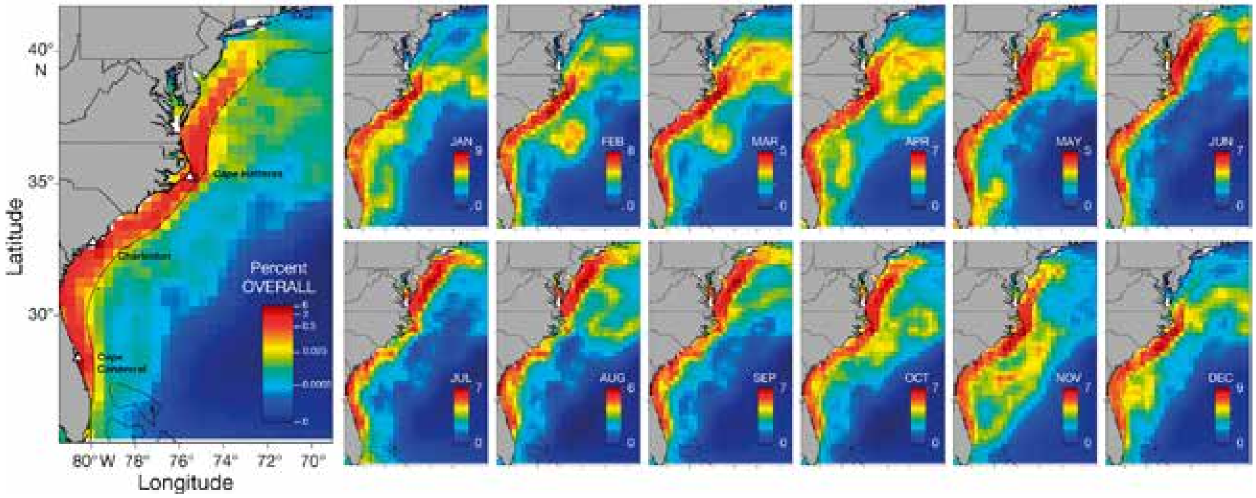


Figure 10.2. From Winton et al. (2018) Figure 5: Overall (left panel) and monthly (right panels) log density of tagged loggerhead sea turtles per 40 km resolution grid cell as predicted using a space-time geostatistical mixed effects model. Model predictions were based on daily locations of 271 large juvenile and adult loggerhead turtles tagged from 2004 to 2016. Predicted densities were scaled from 0 to 1 in each month for comparison purposes. The key indicates the proportion of the predicted density included in each grid cell. In each month, scale bars are consistent with the overall plot with the exception of the maximum value, which is indicated. The black line denotes the 200 m bathymetric contour. White triangles in the overall panel indicate the location of Cape Hatteras, North Carolina; Charleston, South Carolina; and Cape Canaveral, Florida.

11 Progress on Analyses of Oceanographic, Acoustic, and Plankton Data: Northeast Fisheries Science Center

Elisabeth Broughton[1], Michael Jech[1], and Chris Orphanides[2]

[1]Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543
[2] Northeast Fisheries Science Center, 28 Tarzwell Dr., Narragansett, RI 02882

11.1 Summary

To gain a better understanding of the underlying processes that may drive the distribution and abundance of predators, such as marine mammals, sea turtles, and sea birds, the relationships between hydrographic characteristics of the water column and distributions of lower trophic level organisms, such as fish and plankton, are being compared to the distribution patterns of the above protected species predators. Data were collected during shipboard surveys conducted during the 2009, 2011, and 2013-2017 AMAPPS Northeast Fisheries Science Center's surveys. Throughout the years, physical water characteristics and distribution and densities of various fish and planktonic trophic levels were documented using the following: Seabird 19+ and 911 conductivity-temperature-depth (CTD); Video Plankton Recorder (VPR); 61cm bongo net; 1-m^2 Multiple Opening/Closing Net Environmental Sensing System (MOCNESS); 6 ft and 10 ft Issac Kidd Midwater Trawls (IKMT); a modified 1x2m neuston net, midwater trawls; paired go-pro video cameras; Didson high definition imaging sonar; an Imaging Flow Cytobot, and multifrequency Simrad EK60 echosounders. This chapter focuses on the hydrographic and lower trophic data collected on the first leg of the 2017 NOAA ship *Henry B. Bigelow* summer turtle cruise. It also provides an update on the progress made to analyze previously collected data: post-processing the acoustic data, physical oceanographic data, enumerating the biological samples, and comparing the distributions of cetaceans and zooplankton relative to the distribution of potential prey detected by the EK60.

11.2 Background and Objectives

One of the objectives of the AMAPPS initiative is to develop spatially explicit density maps of cetaceans, sea turtles, and sea birds that incorporate environmental habitat characteristics. To describe the environmental habitat characteristics of the marine mammals, sea turtles, and sea birds detected on the shipboard surveys, environmental sampling procedures were designed to determine distributions of lower trophic levels and physical oceanography. Hydrographic, active acoustic, mesopelagic neckton, and plankton data were collected during the 2017 AMAPPS Northeast Fisheries Science Center (NEFSC) survey which were used to map the lower trophic levels and oceanographic conditions of the study area.

11.3 Field Methods

During 2017, physical water characteristics and distribution and densities of larval bluefin tuna, gelatinous zooplankton, and nekton were documented using: Seabird 19+ and 911 CTD, 61cm bongo net, a modified 1x2m neuston net, a go-pro based jelly cam and multifrequency Simrad EK60 echosounders. For more details see Chapter 6.

11.4 Results

The processing status of data collected in 2016-17 is presented in Table 11.1.

11.4.1 Bluefin Tuna

The presence of a large warm core ring (Figure 11.1) presented an opportunity to see if bluefin tuna larvae could be captured and transported northeastward within warm core rings. A total of 13 1x2 m neuston and 15 61 cm bongo tows were conducted including 5 stations within the warm core ring. Shipboard processing showed the presence of bluefin tuna larva at two of the warm core ring stations. Samples were returned to the NEFSC Narragansett lab where all ichtyoplankton will be removed and identified. Any bluefin tuna larvae found will have otoliths removed to determine age, stomach contents analyzed, and identifications confirmed by DNA analysis.

Three drifters were launched into the warm core ring on 12:30 am, 11 July EDT and have been successfully transmitting (Figure 11.2). Current drifter data can be found online.

The drifters are expected to transmit for about 3 months before the batteries were depleted but one transmitted through December 2017 and a third is still transmitting (Figure 11.2).

11.4.2 Oceanography

A total of 56 seacat 19+ CTD casts were conducted and 5 water samples for conductivity calibrations were collected. Oceanographic traces looked rather noisy so a different 19+ was used for the second half of the cruise. It was determined nothing was wrong with either instrument. The reason for the noisy data was the CTDs were being towed in water with strong oceanographic features. Data will be smoothed and outliers created by turbulence will be removed during processing. Interesting profiles included Gulf Steam eddies, shelf slope fronts, canyon fronts, and tidal intrusions. A seven station transect was conducted from the edge to the center of the warm core ring.

The Oceans and Climate Branch of the NEFSC has upgraded the CTD processing software so all casts for tow-yo type sampling, as opposed to only the first up-cast, will be served on the NEFSC Oracle database for all casts from 2017 forward.

11.4.3 Gelatinous Zooplankton

A total of 21 1x2 m neuston tows were conducted for gelatinous zooplankton sampling.

Individuals of the salp species *Salpa aspera* were preserved in ethanol from three stations. These were collected for Ann Bucklin of the University of Connecticut and will be used in an ongoing NSF study of salp genomics / transcriptomics and to help construct a DNA barcode protocol for salps.

11.4.4 VPR

Hand processing of archived data continues to improve accuracy and split categories, especially gelatinous zooplankton, into lower level taxonomic groupings. HB1303 has been completed and

HB1103 is in progress. Sorting of the gelatinous zooplankton images to lower taxonomic levels has revealed the presence of additional salp species from 2011-13, especially *Cyclosalpa sp.*, that are destroyed by net sampling.

Work is being started on several new image identification programs leveraging new commercial software and other image analysis being done at the NEFSC. Large databases of images identified to the lowest taxonomic level possible are being created to feed into the new programming to permit neural net type automatic identification programming to utilize increased sorting categories and lower level taxonomy. The larger the database the programming learns from the more accurate the resulting identifications.

11.4.5 Simrad EK60

Active acoustic data were collected during the survey to characterize spatial distributions of potential prey and investigate relationships among predator (marine mammals), prey, and oceanography. Active acoustic data were collected with the multifrequency (18, 38, 70, 120, and 200 kHz) scientific EK60 echo sounders and split-beam transducers mounted downward-looking on the retractable keel. Data were collected to 3000 m, regardless of bottom depth. The ping interval was set to 2 pings per second, but actual ping rate will be slower due to two-way travel time and signal processing requirements of the EK60. The EK60 was synchronized to the ES60 on the bridge, the Acoustic Doppler Current Profiler (ADCP), and Simrad ME70 multibeam to alleviate acoustic interference among acoustic instruments. At daily intervals throughout the survey, EK60 data were recorded in passive mode to assist with noise removal post-processing procedures. Survey speeds for underway acoustic data collection were 10 kts or less.

Active acoustic data were collected continuously but with the EK60 in passive mode on every other day during daytime operations. Acoustic data in active mode were collected continuously during nighttime operations.

Future analysis will involve post-processing of the data to remove unwanted signal (e.g., from the seafloor) and noise. Differences in scattering levels at the different frequencies will be used to identify features attributable to different kinds of scatters and the net and VPR data will be used to ground-truth the taxonomic composition of these features. The distribution of different kinds of scatters will then be examined in light of bathymetry, hydrography, and the distribution of marine mammal predators.

11.5 Acknowledgements

The data collection was funded by the Bureau of Ocean Energy Management (BOEM) and the US Navy through two Interagency Agreements for the AMAPPS project and by the NOAA Fisheries Service. Data processing and analysis of the oceanography and plankton data was funded by the Oceans and Climate Branch of the NEFSC. Analytical work on the relationships between prey and marine mammal distribution is funded by the Protected Species Branch and Oceans and Climate Branch of the NEFSC.

Table 11.1. Processing status of oceanographic and plankton samples. Identified = sample is processed but data have not yet been posted to a public database, shipped = sample is in Poland being identified, in progress = samples are being processed.

Sampling Type	HB1603	Status	HB1704	Status
911+CTD				
Profile	1	processed	0	-
Water	14	processed	0	-
CTD 19/19+				
Profile	8	processed	0	-
With gear	185	processed	56	in progress
Water	47	processed	5	in progress
Bongo				
6B3I	119	in progress	14	in progress
6B3Z	119	processed	14	shipped
Neuston				
Oblique	42	in progress	34	in progress
VPR				
Tow-yo	20	processed	0	-
Single depth	6	processed	0	-
Midwater trawl	35	processed	0	-

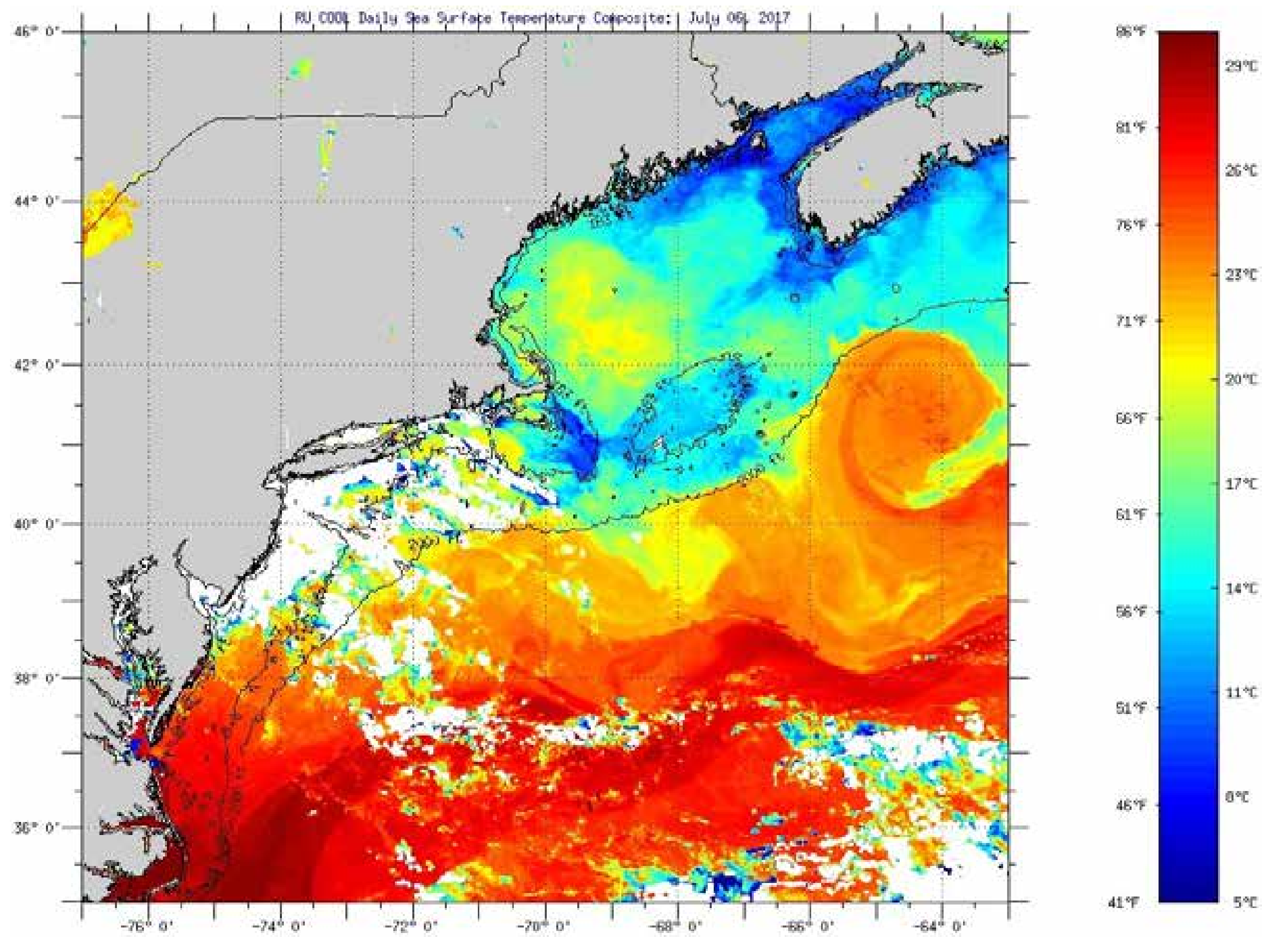


Figure 11.1. One day average satellite derived sea surface temperature for 6 July 2017 showing the large warm core ring off the Northeast Peak of Georges Bank.

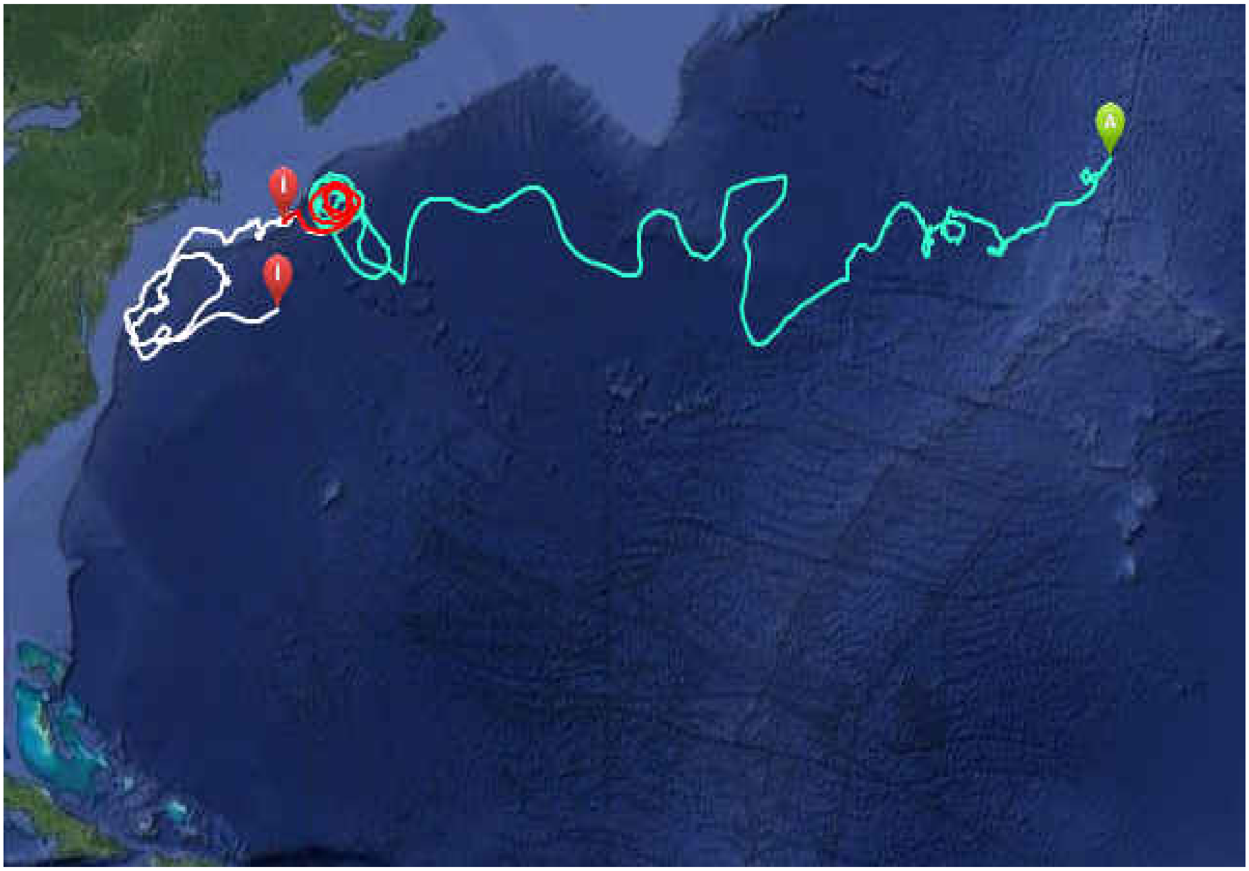


Figure 11.2. Drifter tracks as of 3 January 2018. Drifters with red endpoints are no longer active.