Marine Species Monitoring Report for the U.S. Navy's Atlantic Fleet Training and Testing (AFTT) – 2018 Annual Report



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From left to right:

Harbor seals (*Phoca vitulina*) hauled out in a salt marsh on the Eastern Shore, Virginia. Photographed by Danielle Jones, Naval Facilities Engineering Command Atlantic, taken under National Marine Fisheries Service General Authorization Permit No. 19826.

A social group of sperm whales (*Physeter macrocephalus*) rests at the surface. Photographed by Mark Cotter, taken under National Marine Fisheries Service Scientific Research Permit No. 16239, issued to Dan Engelhaupt.

A True's beaked whale (*Mesoplodon mirus*) about to surface off the coast of Virginia. Photographed by Todd Pusser, taken under National Marine Fisheries Service Scientific Research Permit No. 16239, issued to Dan Engelhaupt.

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ACRONYMS AND ABBREVIATIONS

AFAST	Atlantic Fleet Active Sonar Training
AFTT	Atlantic Fleet Training and Testing
AIS	Automatic Identification System
AMAR	Autonomous Multi-channel Acoustic Recorder
AMR	Adaptive Management Review
app	application
ARS	area restricted search
BRS	behavioral response study
BSE	bay, sound, and estuary
BSS	Beaufort sea state
CBBT	Chesapeake Bay Bridge-Tunnel
CEE	controlled exposure experiment
CI	confidence interval
CNO	Chief of Naval Operations
COMPASS	Cetacean Observation and Marine Protected Animal Survey Software
CR	capture-recapture
CRC	Cascadia Research Collective
CREEM	Centre for Research into Ecological and Environmental Monitoring
DMP	Data Management Plan
DTAG	digital acoustic tag
EAR	Ecological Acoustic Recorder
EIMS	Environmental Information Management System
ESA	Endangered Species Act
GPS	Global Positioning System
HARP	High-frequency Acoustic Recording Package
hr	hour(s)
ICMP	Integrated Comprehensive Monitoring Program
JAX	Jacksonville (Florida)
kHz	kilohertz
km	kilometer(s)
km^2	square kilometer(s)
LIMPET	Low-Impact Minimally Percutaneous External-electronics Transmitter
LOA	Letter of Authorization
m	meter(s)
MAHWC	Mid-Atlantic Humpback Whale Photo-ID Catalog
MARU	Marine Autonomous Recording Unit
MDist	Mahalanobis Distance
MFAS	mid-frequency active sonar
min	minute(s)
MINEX	Mine-neutralization Exercise
MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act
MSM	Marine Species Monitoring
N45	Energy and Environmental Readiness Division
NAHWC	North Atlantic Humpback Whale Catalog
NARW	North Atlantic Right Whale
NMFS	National Marine Fisheries Services
NMSDD	Navy Marine Species Density Database
NOAA	National Oceanic and Atmospheric Administration

NSWC PCD	Naval Surface Warfare Center, Panama City Division
OBIS-SEAMAP	Ocean Biogeographic Information System-Spatial Ecological Analysis of Megavertebrate Populations
ONR	Office of Naval Research
OPAREA	Operating Area
PAM	passive acoustic monitoring
photo-ID	photo-identification
POP	persistent organic pollutant(s)
QC	quality control
RL	received level
R/V	research vessel
SD	standard deviation
sec	second(s)
SMA	Seasonal Management Area
SPOT	Smart Position and Temperature
U.S.	United States
UNCW	University of North Carolina Wilmington
USWTR	Undersea Warfare Training Range
VACAPES	Virginia Capes
VAQF	Virginia Aquarium Foundation
VA WEA	Virginia Wind Energy Area
VIMS	Virginia Institute of Marine Science

SECTION 1 – INTRODUCTION

This report contains a summary of marine species monitoring activities funded by the United States (U.S.) Navy within the Atlantic Fleet Training and Testing (AFTT) Study Area during 2018. The U.S. Navy conducts marine mammal and sea turtle monitoring for compliance with the Letters of Authorization (NMFS 2013a, 2013b, 2018a, 2018b) and Biological Opinion (NMFS 2013c, 2018c) issued under the Marine Mammal Protection Act of 1972 (MMPA) and the Endangered Species Act of 1973 (ESA) for training and testing in the AFTT Study Area. This report also reflects an ongoing evolution in the approach to monitoring reports for this area. Concurrent with Phase II of the U.S. Navy's Marine Species Monitoring (MSM) Program, the U.S. Navy and the National Marine Fisheries Service (NMFS) have agreed to assess compliance based on demonstrated progress towards addressing scientific objectives, rather than on specific monitoring requirements for each range complex from effort-based metrics. This report summarizes the progress, accomplishments, and results from projects being conducted in the AFTT Study Area. Additional details on each project are available in individual technical reports linked directly from the corresponding sub-section of this report.

1.1 Background

The AFTT Study Area includes only the at-sea components of the range complexes and testing ranges in the western North Atlantic Ocean and encompasses the Atlantic coast of North America and the Gulf of Mexico (**Figure 1**). The Study Area covers approximately 2.6 million square nautical miles of ocean area, and includes designated U.S. Navy operating areas (OPAREAs) and special use airspace. The Study Area also includes several U.S. Navy testing ranges and range complexes, as well as Narragansett Bay, lower Chesapeake Bay, St. Andrew Bay, and pier-side locations where sonar maintenance and testing occurs.

In order to issue an Incidental Take Statement for an activity that has the potential to affect protected marine species, NMFS must set forth "requirements pertaining to the monitoring and reporting of such taking" (50 Code of Federal Regulations § 216.101(a)(5)(a)). A request for a Letter of Authorization (LOA) must include a plan to meet the necessary monitoring and reporting requirements, while increasing the understanding, and minimizing the disturbance, of marine mammal and sea turtle populations expected to be present. While the ESA does not have a specific monitoring requirement, the Biological Opinion issued in November 2013 by NMFS for the AFTT Study Area includes terms and conditions for continued monitoring in this region (NMFS 2013c).

The U.S. Navy previously submitted annual monitoring and mission-activities reports for AFTT, as well as for the Atlantic Fleet Active Sonar Training (AFAST) and the East Coast/Gulf of Mexico Range Complexes, to NMFS for 2009 through 2017 (DoN 2009, 2010a, 2010b, 2010c, 2010d, 2010e, 2011a, 2011b, 2011c, 2011d, 2012a, 2012b, 2012c, 2012d, 2013a, 2013b, 2013c, 2014a, 2014b, 2014c, 2015a, 2015b, 2016a, 2016b, 2017a, 2017b, 2018a, 2018b).

The U.S. Navy has invested over $33 million (**Table 1**) in monitoring activities in the AFTT Study Area since 2009. Additional information on the program is available on the U.S. Navy's MSM program website (http://www.navymarinespeciesmonitoring.us). The website serves as an online portal for information on the background, history, and progress of the program. It also provides access to reports, documentation, data, and updates on current monitoring projects and initiatives.

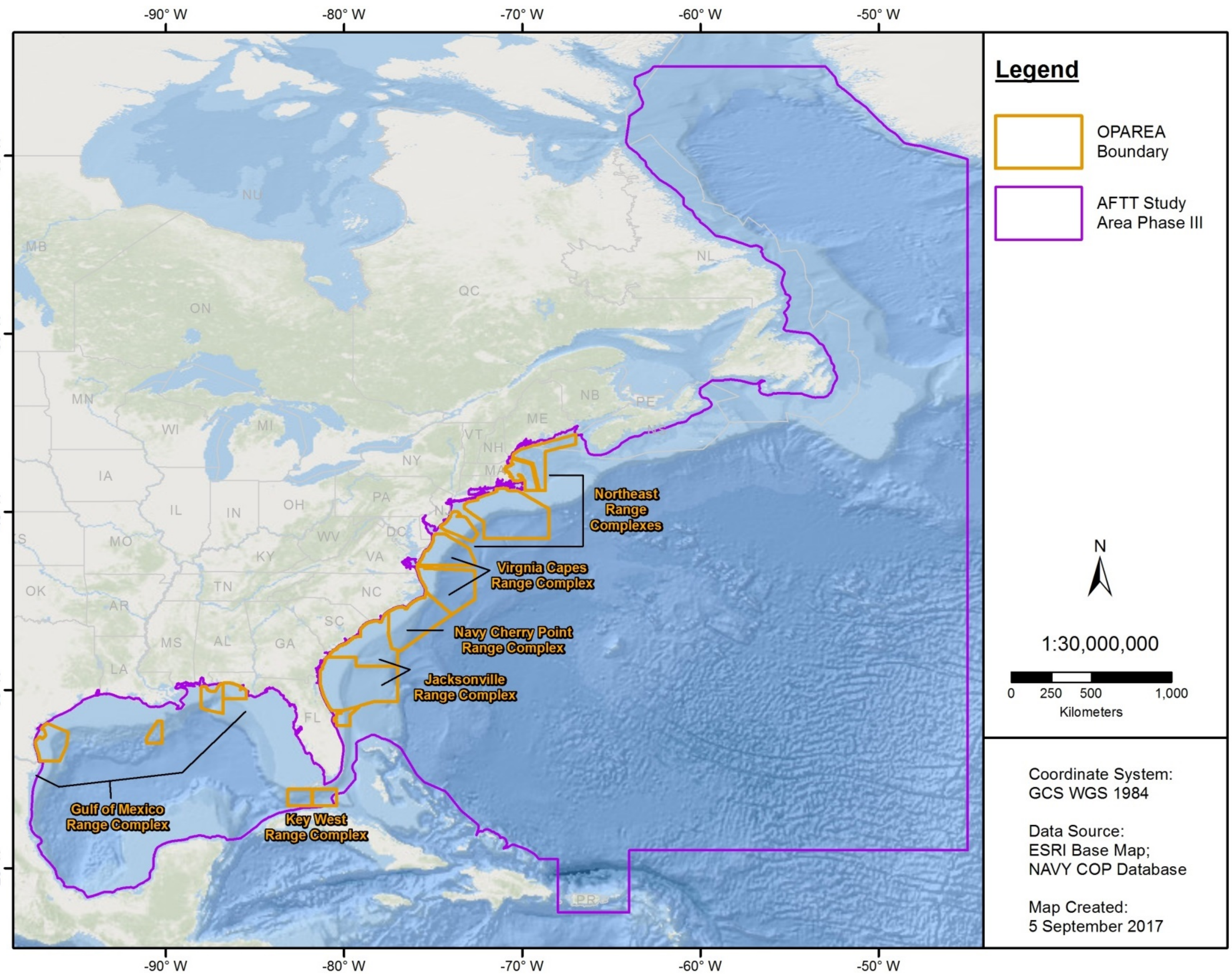

Figure 1. Atlantic Fleet Training and Testing Study Area.

Table 1. Annual funding for the U.S. Navy's Marine Species Monitoring Program in the AFTT Study Area (formerly AFAST and East Coast/Gulf of Mexico Range Complexes) during FY09–FY18.

Fiscal Year (01 Oct–30 Sept)	Funding Amount
FY09	$1,555,000
FY10	$3,768,000
FY11	$2,749,000
FY12	$3,483,000
FY13	$3,775,000
FY14	$3,311,000
FY15	$3,700,000
FY16	$3,845,000
FY17	$3,383,000
FY18	$3,476,000
Total	**$33,045,000**

Key: FY = Fiscal Year

In addition to the Fleet-funded monitoring program, the Office of Naval Research (ONR) Marine Mammals and Biology Program and the Office of the Chief of Naval Operations (CNO) Energy and Environmental Readiness Division's (N45) Living Marine Resources Program support coordinated Science & Technology and Research & Development programs focused on understanding the effects of sound on marine mammals, including physiological, behavioral, ecological, and population-level effects (DoN 2010f). These programs currently fund several significant ongoing projects relative to potential operational impacts to marine mammals within some U.S. Navy range complexes. Additional information on these programs and other ocean resource-oriented initiatives can be found at the U.S. Navy's Green Fleet – Energy, Environment, and Climate Change website.

1.2 Integrated Comprehensive Monitoring Program

The Integrated Comprehensive Monitoring Program (ICMP) provides the overarching framework for coordination of the U.S. Navy's MSM efforts (DoN 2010g) and serves as a planning tool to focus U.S. Navy monitoring priorities pursuant to ESA and MMPA requirements. The purpose of the ICMP is to coordinate monitoring efforts across all regions and to allocate the most appropriate level and type of monitoring effort for each range complex based on a set of standardized objectives, regional expertise, and resource availability. Although the ICMP does not identify specific monitoring or field projects, it provides a flexible, scalable, and adaptable framework for such projects using adaptive-management and strategic-planning processes that periodically assess progress and reevaluate objectives.

The ICMP is evaluated through the Adaptive Management Review (AMR) process to: (1) assess progress, (2) provide a matrix of goals and objectives for the following year, and (3) make recommendations for refinement and analysis of the monitoring and mitigation techniques. This process includes conducting an annual AMR meeting at which the U.S. Navy and NMFS jointly consider the prior-year goals, monitoring results, and related scientific advances to determine if monitoring plan modifications are warranted to address program goals. Modifications to the ICMP that result from AMR discussions are incorporated by an addendum or revision to the ICMP. As a planning tool, the ICMP will be updated routinely as the program evolves and progresses. The most significant addition was in 2013/2014 with the development of the Strategic Planning Process (DoN 2013d), which guides the investment of resources to most efficiently address ICMP objectives and intermediate scientific objectives developed through this process. More details on the Strategic Planning Process are provided in **Section 4**.

Under the ICMP, U.S. Navy-funded monitoring relating to the effects of U.S. Navy training and testing activities on protected marine species should be designed to accomplish one or more top-level goals as described in the current version of the ICMP (DoN 2010g):

(a) An increase in our understanding of the likely occurrence of marine mammals and/or ESA-listed marine species near the action (i.e., presence, abundance, distribution, and/or density of species).

(b) An increase in our understanding of the nature, scope, or context of the likely exposure of marine mammals and/or ESA-listed species to any of the potential stressors associated with the action (e.g., sound, explosive detonation, or expended materials), through better understanding of one or more of the following: (1) the nature of the action and its surrounding environment (e.g., sound-source characterization, propagation, and ambient noise levels); (2) the affected species (e.g., life history or dive patterns); (3) the likely co-occurrence of marine mammals and/or ESA-listed marine species with the action (in whole or part); and/or (4) the likely biological or behavioral context of exposure to the stressor for the marine mammal and/or ESA-listed marine species (e.g., age class of exposed animals or known pupping, calving, or feeding areas).

(c) An increase in our understanding of how individual marine mammals or ESA-listed marine animals respond (behaviorally or physiologically) to specific stressors associated with the action (in specific contexts, where possible, e.g., at what distance or received level [RL]).

(d) An increase in our understanding of how anticipated individual responses, to individual stressors or anticipated combinations of stressors, may affect either: (1) the long-term fitness and survival of an individual; or (2) the population, species, or stock (e.g., through effects on annual rates of recruitment or survival).

(e) An increase in our understanding of the effectiveness of mitigation and monitoring measures, including increasing the probability of detecting marine mammals to better achieve the above goals (through improved technology or methods), both generally and more specifically within the safety zone (thus allowing for more effective implementation of the mitigation). Improved detection technology will be rigorously and scientifically validated prior to being proposed for mitigation, and should meet practicality considerations (engineering, logistic, and fiscal).

(f) A better understanding and record of the manner in which the authorized entity complies with the Incidental Take Authorization and Incidental Take Statement.

CNO-N45 maintains and updates the ICMP, as necessary, to reflect the results of regulatory agency rulemaking, AMRs, best available science, improved assessment methods, and protective measures. This is done as part of the AMR process, in consultation with U.S. Navy technical experts, Fleet Commanders, and Echelon II Commands as appropriate.

1.3 Report Objectives

This report presents the progress, accomplishments, and results of MSM activities in the AFTT Study Area in 2018 and has two primary objectives:

1. Summarize findings from the U.S. Navy-funded marine mammal and sea turtle monitoring conducted in the AFTT Study Area during 2018, as well as analyses of monitoring data performed

during this time. Detailed technical reports for these efforts are referenced throughout this report and provided as supporting documents.

2. Support the AMR process by providing an overview of monitoring initiatives, progress, and evolution of the ICMP and Strategic Planning Process for U.S. Navy marine species monitoring. These initiatives continue to shape the evolution of the U.S. Navy MSM program for 2019 and beyond, to improve our understanding of the occurrence and distribution of marine mammals and sea turtles in the AFTT Study Area, and their exposure and response to sonar and explosives training and testing activities.

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SECTION 2 – MARINE SPECIES MONITORING ACTIVITIES

2.1 Occurrence, Distribution, and Population Structure

In 2005, the U.S. Navy contracted with a consortium of researchers from Duke University, the University of North Carolina Wilmington (UNCW), the University of St. Andrews, and NMFS's Northeast Fisheries Science Center to conduct a pilot study and subsequently develop a survey and monitoring plan. The plan included a recommended approach for data collection at the proposed site of the Undersea Warfare Training Range (USWTR) in Onslow Bay off the coast of North Carolina. The identified methods included surveys (aerial/shipboard, frequency, spatial extent, etc.), passive acoustic monitoring (PAM), photo-identification (photo-ID), and data analysis (e.g., standard line-transect, spatial modeling) appropriate to establish a fine-scale seasonal baseline of protected marine species distribution and abundance. As a result, an MSM Program for protected species was initiated in June 2007 in Onslow Bay. Due to a re-evaluation of the proposed location for the USWTR, the preferred location was changed to the Jacksonville (JAX) OPAREA. Therefore, a parallel monitoring program was initiated in January 2009 at the proposed USWTR site in the JAX OPAREA off the coast of Jacksonville, Florida. In addition to supporting the JAX USWTR site monitoring, the program was also refined to support the monitoring requirements set forth in the Incidental Take Statements and Terms and Conditions for AFAST and the East Coast Range Complexes issued in 2009 (collectively superseded by AFTT in 2013). The baseline occurrence-monitoring program has since expanded to include a region of U.S. Navy training activity off the coast of Cape Hatteras, North Carolina to the north (2011) as well as a study site centered on the Norfolk Canyon and shelf-break region off the mouth of the Chesapeake Bay (2015). These study areas also serve to support more recent projects involving tagging multiple species of cetaceans (Section 2.2) as well as behavioral response studies (Section 2.3). The overall approach to program design and methods has been consistent with the work that had been performed over the previous 10+ years, and work across the locations continues to evolve in response to the AMR process and changing priorities.

Although the initial intent of the Onslow Bay and JAX monitoring programs was to support development of the planned USWTR, the program evolved into established long-term study sites addressing intermediate scientific objectives within the ICMP framework for AFTT. The monitoring work at these sites provides a longitudinal baseline of data on marine species occurrence, distribution, abundance, and behavior in key U.S. Navy training areas and serves as a reference for addressing questions concerning exposure, response, and consequences.

In 2018, the longitudinal baseline study consisted of year-round multi-disciplinary monitoring through aerial and vessel-based visual surveys, photo-ID, tagging, biopsy sampling, and PAM. Visual surveys were conducted regularly year-round (weather permitting) using established tracklines and standard Distance-sampling techniques. A summary of accomplishments and basic results of these monitoring efforts for the reporting period is presented in the following subsections.

All previous annual reports on this component of the baseline monitoring program are available through the U.S. Navy's MSM program web portal (http://www.navymarinespeciesmonitoring.us).

2.1.1 Norfolk Canyon Study Area Offshore Aerial Surveys

Aerial survey efforts were initiated in the waters off the coast of Cape Hatteras, North Carolina, in May 2011 to assess the distribution and abundance of offshore cetacean species and sea turtles in this highly productive area. Beginning in 2015, the survey area was extended north following the shelf break to include the Norfolk Canyon region (**Figure 2**). In 2016, the Cape Hatteras survey area and the Norfolk Canyon survey areas were designated as unique entities. The Norfolk Canyon survey area is covered by 16 tracklines (#46–61) (**Figure 2**). This expansion resulted in a greater portion of the survey area falling within the airspace of the U.S. Navy's Fleet Area Control and Surveillance Facility, and entirely in the Virginia Capes (VACAPES) OPAREA.

A total of 97 tracklines (6,928.9 kilometers [km]) over 12 days was covered in the Norfolk Canyon survey area in 2018 (**Table 2**). Survey effort occurred in 8 months. Two survey days were completed in 4 of the 8 months (April, June, August, and December), with 1 survey day during in each the remaining 4 months (May, July, October, and November). Survey conditions during the 10 days ranged from Beaufort sea state (BSS) 0 to 4, with greater than 80 percent of effort in BSS 3 or lower.

Table 2. Effort summary for aerial surveys conducted in the Norfolk Canyon survey area in 2018.

Month	Number of Survey Days	Tracklines Covered	Total km Flown	Total Hobbs hr [1]
April	2	14	924.03	11.6
May	1	8	554.89	6.4
June	2	16	1,130.91	12.5
July	1	8	588.76	6.4
August	2	16	1,143.46	14.2
October	1	11	813.02	7.5
November	1	8	590.39	4.6
December	2	16	1,183.46	8.9
Total	**12**	**97**	**6,928.9**	**72.1**

[1] Hobbs hr (hours) = total engine time in hours.

There were 262 on-effort sightings of 9,058 individual cetaceans representing 15 species (**Table 3, Figure 3**), including common dolphin (*Delphinus delphis*; 24 sightings of 4,880 individuals), common bottlenose dolphin (*Tursiops truncatus*; 76 sightings of 1,190 individuals), Atlantic spotted dolphin (*Stenella frontalis*; 11 sightings of 1,037 individuals), Risso's dolphin (*Grampus griseus*; 22 sightings of 415 individuals), striped dolphin (*Stenella coeruleoalba;* 8 sightings of 540 individuals), short-finned pilot whale (*Globicephala macrorhynchus*; 63 sightings of 807 individuals), sperm whale (*Physeter macrocephalus*; 10 sightings of 41 individuals), True's beaked whale (*Mesoplodon mirus;* 1 sighting of 5 individuals), Sowerby's beaked whale (*Mesoplodon bidens;* 1 sighting of 4 individuals), kogiid whale (*Kogia* sp.; 5 sightings of 8 individuals), North Atlantic right whale (*Eubalaena glacialis*; 2 sightings of 8 individuals), sei whale (*Balaenoptera borealis*; 3 sightings of 4 individuals), minke whale (*Balaenoptera acutorostrata*; 1 sighting of 1 individual), fin whale (*Balaenoptera physalus*; 12 sightings of 22 individuals), and humpback whale (*Megaptera novaeangliae*; 5 sightings of 9 individuals).

An additional 40 off-effort cetacean sightings were recorded: common dolphins (4 sightings of 127 individuals), common bottlenose dolphins (27 sightings of 466 individuals), Atlantic spotted dolphins (1 sighting of 185 individuals), Risso's dolphin (3 sightings of 34 individuals), striped dolphin (1 sighting of 400 individuals) pilot whales (2 sightings of 13 individuals), sperm whale (1 sighting of 1 individual), and humpback whale (1 sighting of 1 individual). A sighting was considered off-effort if it occurred while transiting to or from the survey area or during a cross-leg between tracklines. Any cetaceans that the survey team encountered while investigating a separate sighting cue were also labeled off-effort. If two species were seen associated with the same sighting cue, both were considered to be on effort.

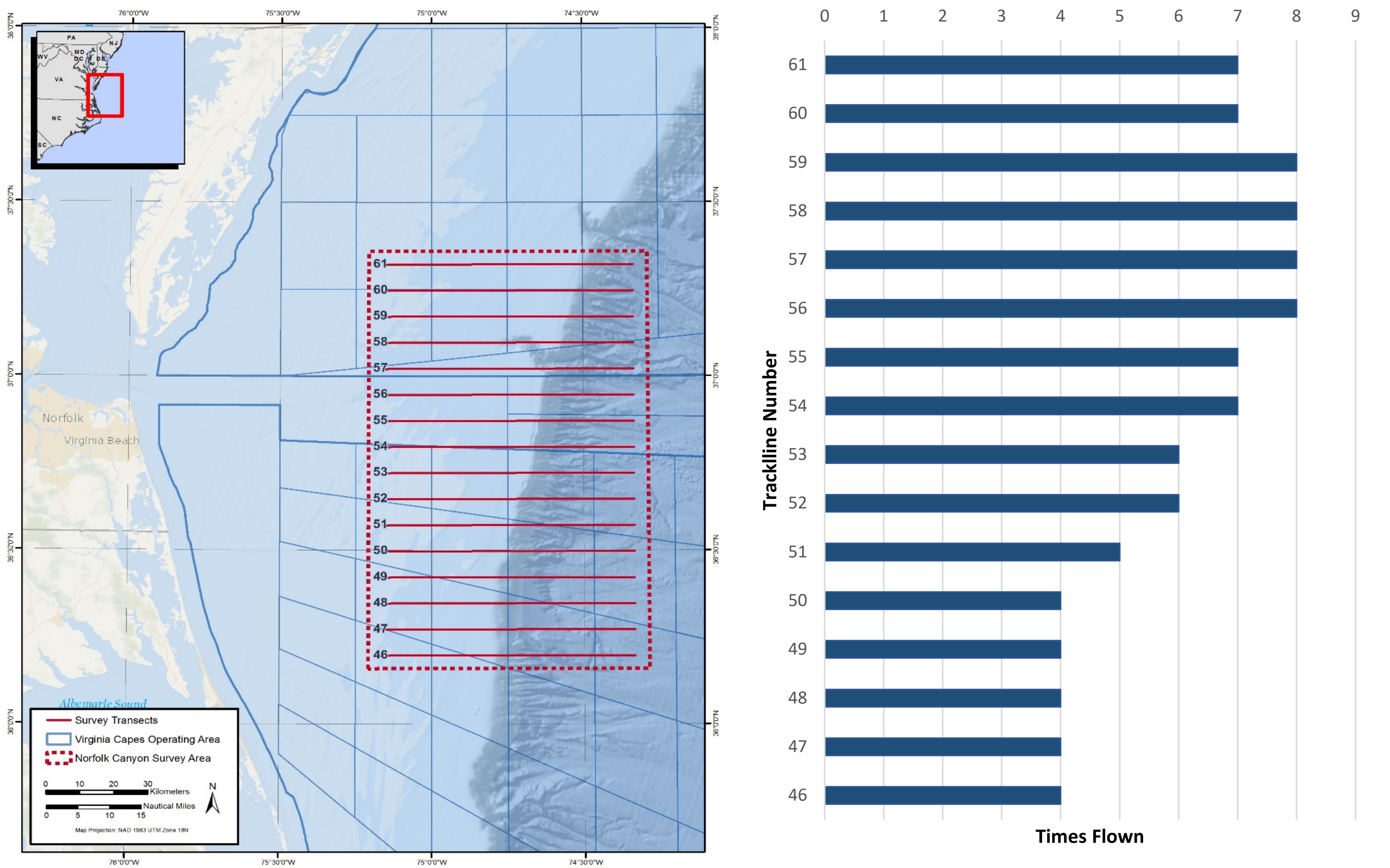

Figure 2. Established tracklines and realized effort in the Norfolk Canyon survey area for 2018.

1 **Table 3. Sightings from aerial surveys conducted in the Norfolk Canyon survey area in 2018.**

Common Name	Scientific Name	On-effort		Off-effort	
		Sightings	Individuals	Sightings	Individuals
Common dolphin	*Delphinus delphis*	24	4,880	4	127
Common bottlenose dolphin	*Tursiops truncatus*	76	1190	27	466
Atlantic spotted dolphin	*Stenella frontalis*	11	1,037	1	185
Risso's dolphin	*Grampus griseus*	22	415	3	34
Striped dolphin	*Stenella coeruleoalba*	8	540	1	400
Short-finned pilot whale	*Globicephala macrorhynchus*	63	807	2	13
Sperm whale	*Physeter macrocephalus*	10	41	1	1
True's beaked whale	*Mesoplodon mirus*	1	5	-	-
Sowerby's beaked whale	*Mesoplodon bidens*	1	4	-	-
Pygmy OR dwarf sperm whale	*Kogia* sp.	5	8	-	-
North Atlantic right whale	*Eubalaena glacialis*	2	8	-	-
Sei whale	*Balaenoptera borealis*	3	4	-	-
Minke whale	*Balaenoptera acutorostrata*	1	1	-	-
Fin whale	*Balaenoptera physalus*	12	22	-	-
Humpback whale	*Megaptera novaeangliae*	5	9	1	1
Unidentified beaked whale	n/a	2	5	1	3
Unidentified small whale	n/a	1	2	-	-
Unidentified large whale	n/a	4	4	-	-
Unidentified dolphin	n/a	8	100	5	72
Unidentified large dolphin	n/a	1	1	1	2
Unidentified cetacean	n/a	2	4	1	2
Loggerhead sea turtle	*Caretta caretta*	198	1,042	33	104
Kemp's ridley sea turtle	*Lepidochelys kempii*	20	42	3	11
Leatherback sea turtle	*Dermochelys coriacea*	20	21	4	4
Whale shark	*Rhincodon typus*	1	1	-	-
Basking shark	*Cetorhinus maximus*	5	13	-	-
Hammerhead shark	*Sphyrna* sp.	20	66	1	4
Unidentified shark	n/a	4	8	1	1
Giant devil ray	*Mobula mobular*	1	1	-	-
Chilean devil ray	*Mobula tarapacana*	14	20	-	-
Cownose ray	*Rhinoptera bonasus*	5	1,105	2	51
Large black and white mobulid	n/a	4	5	1	1
Ocean sunfish	*Mola* sp.	92	158	9	12

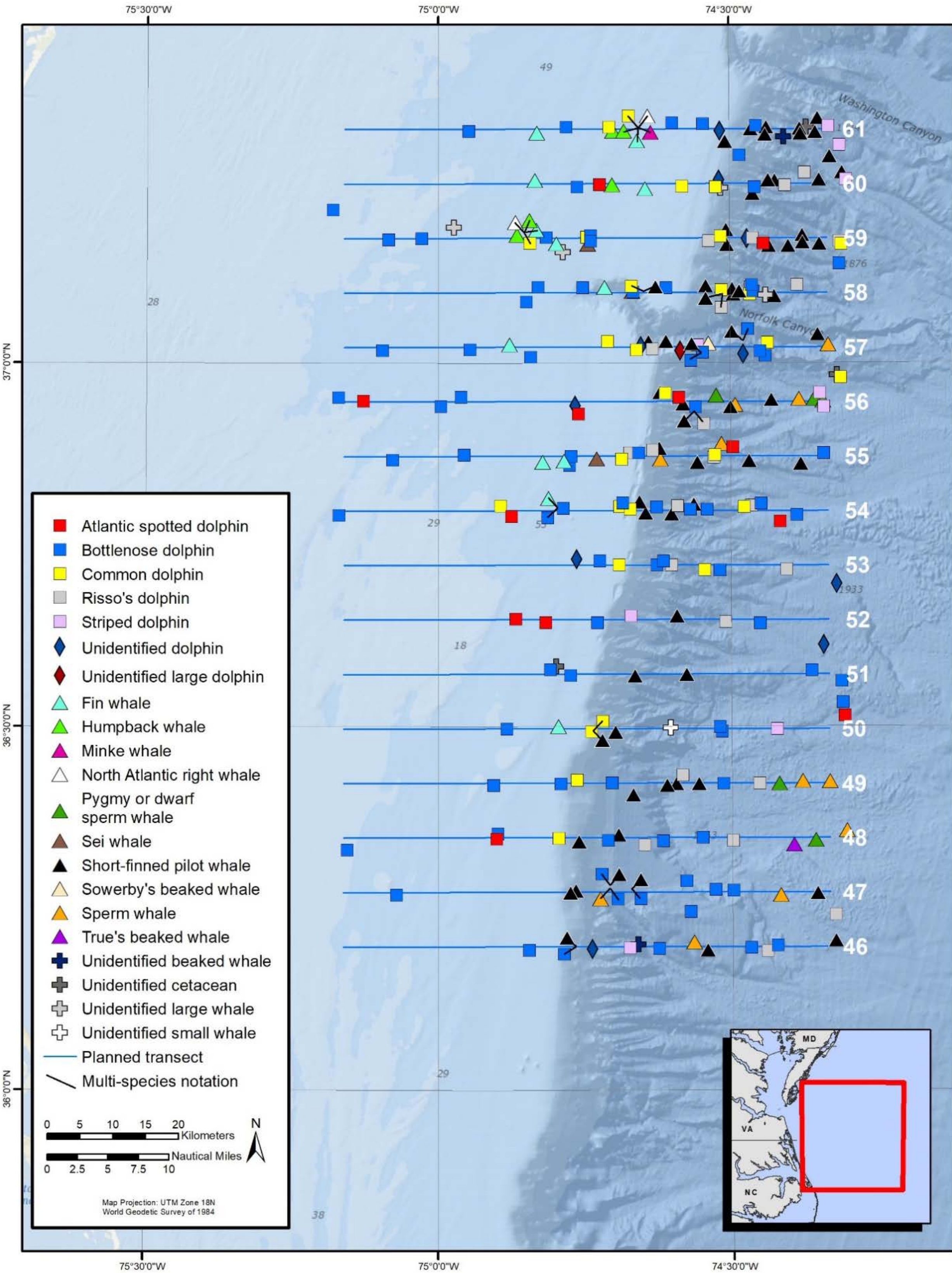

Figure 3. Cetacean sightings recorded during aerial surveys in the Norfolk Canyon survey area in 2018.

There were 238 on-effort sightings of 1,105 individual sea turtles during the reporting period (**Table 3, Figure 4**). Loggerhead turtles (*Caretta caretta*) represented the majority (94.3 percent) of total sea turtles sighted. Most loggerhead turtle sightings were over the continental shelf inshore of the 50-meter (m) isobath. The other two sea turtle species identified in the Norfolk Canyon survey area were Kemp's ridley (*Lepidochelys kempii,* 3.8 percent of total sea turtles sighted) and leatherback turtles (*Dermochelys coriacea*; 1.9 percent of total sea turtles sighted). Almost all Kemp's ridley turtles were recorded inshore of the 40-m isobath. Leatherback turtles exhibited a very similar distribution to Kemp's ridley, seen almost exclusively inshore of the 40-m isobath. Eighty-four percent of all sea turtle sightings occurred in the months of May through August.

In addition to cetaceans and sea turtles, other pelagic marine vertebrates were observed and recorded (**Table 3, Figure 5**). Eighty-eight sharks were recorded during the reporting period. Sixty-six of the 88 sharks could be identified as hammerhead sharks (*Sphyrna* sp.) based on head shape. The remaining 22 sharks were identified as basking sharks (*Cetorhinus maximus; n*=13), a whale shark (*Rhincodon typus*; *n*=1), or unidentified sharks (*n*=8)*.* The basking sharks were all recorded during the month of April, in both shallow and deep waters. These April sightings coincided with a large aggregation of copepod-and krill-feeding baleen whales, including endangered species such as sei, fin, and North Atlantic right whales (NARW).

Three species of rays were identified to species: Giant devil ray (*Mobula mobular*; *n*=1), Chilean devil rays (*Mobula tarapacana; n*=20) and cownose rays (*Rhinoptera bonasus*; *n*=1,105). There were also 4 sightings of 5 individual rays that were classified as "large black and white mobulids" since they could not be identified to species level. In addition, 158 ocean sunfish (*Mola mola*) were recorded, with the majority distributed in the northern portion of the study area near Norfolk Canyon, and along the shelf break.

Surveys for this project are anticipated to be completed by mid-2019, and a final report will be available shortly after.

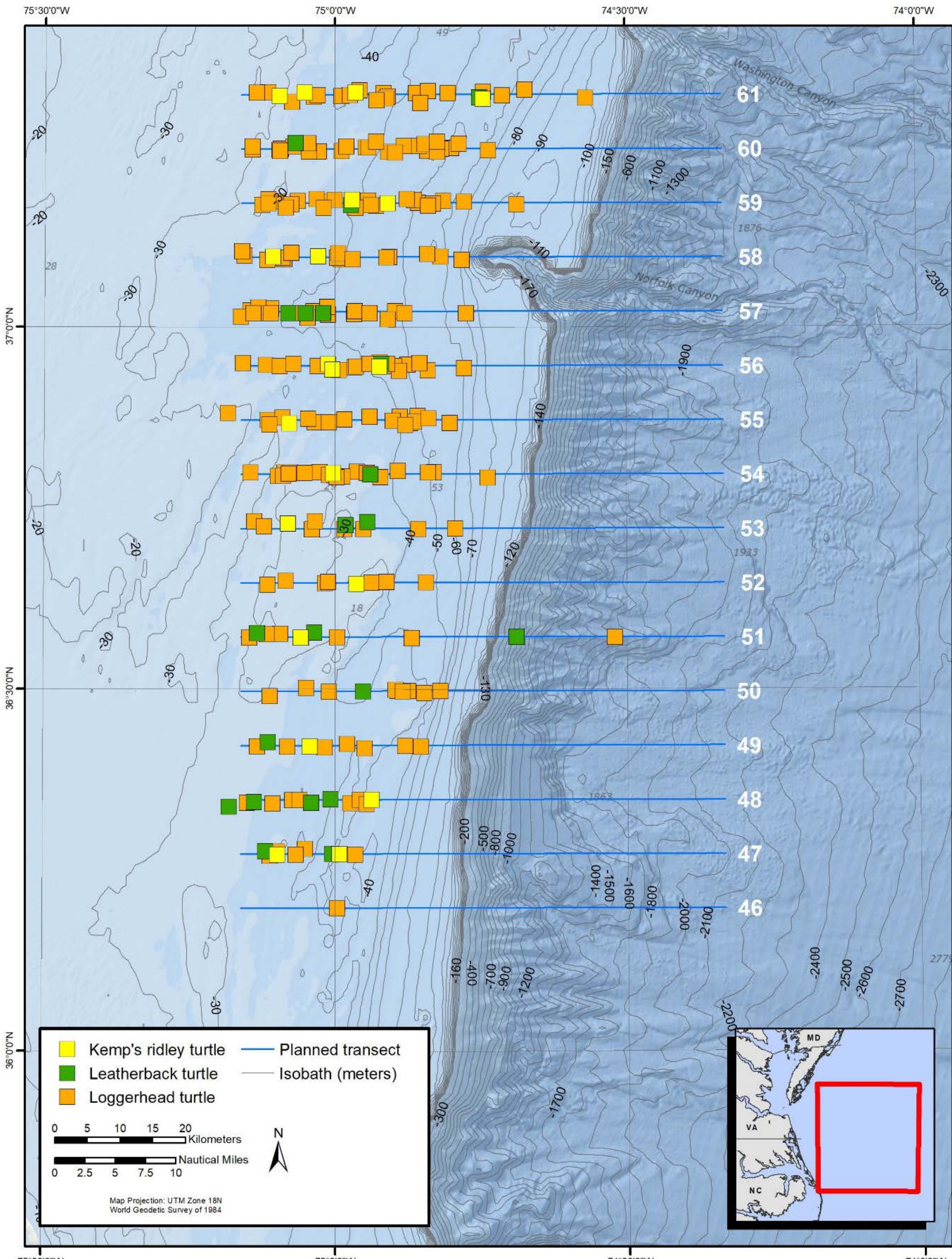

Figure 4. All sea turtle sightings recorded in the Norfolk Canyon survey area in 2018.

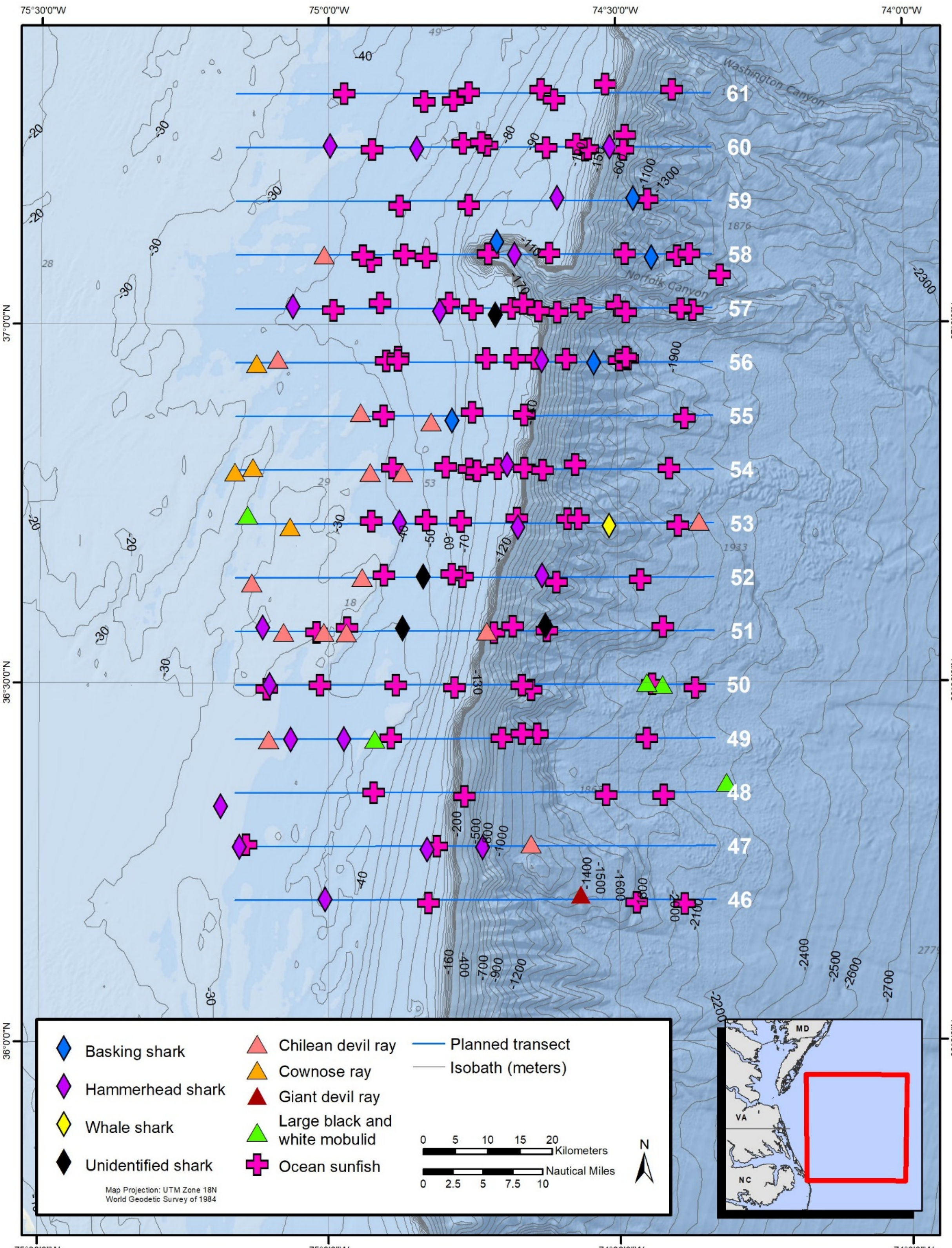

Figure 5. All pelagic marine vertebrate (other than cetaceans and sea turtles) sightings recorded in the Norfolk Canyon survey area in 2018.

2.1.2 VACAPES Nearshore Aerial Surveys

The Virginia Aquarium & Marine Science Center Foundation, Inc. (VAQF) was tasked with conducting aerial surveys for the continental shelf region off the mouth of the Chesapeake Bay within the VACAPES OPAREA. The survey site includes an approximately 6,500-square kilometer (km^2) area off the coast of Virginia Beach and the mouth of the Chesapeake Bay. These surveys build upon previous survey efforts funded by Virginia Coastal Zone Management Program (2012–2015) to document large whale occurrence near the Virginia Wind Energy Area (VA WEA) and to contribute to regional mid-Atlantic ocean-planning efforts. In total, these line-transect aerial surveys were conducted from 2012 through 2017, although surveys were not flown every month or with consistent effort between years (Mallette et al. 2014, 2016, 2017).

This report briefly summarizes information from a comprehensive cumulative technical report focusing on baleen whale occurrence along the continental shelf off Virginia. The final report (Mallette et al. 2018a) includes analysis of the full VAQF Coastal Zone Management Program and VAQF nearshore aerial datasets from 2012 through 2017.

A modified design for coordinated inshore (VAQF) and offshore (UNCW) aerial surveys was developed, based upon recommendations from the Centre for Research into Ecological and Environmental Modeling (CREEM) and discussions with UNCW and the U.S. Navy. CREEM advised periodic overlap of the survey areas between the offshore and coastal transect lines to calibrate for survey origin difference and to integrate data between sites. Two surveys per month were planned during November–April when large whale presence was thought to be highest in the area, and one per month during May–October. The plan was for one overlapping survey in each quarter or season, with the remainder non-overlapping. Two survey designs were established (**Figure 6**):

1. *Overlap*: the eastern ends of all transect lines overlapped 10 km with the western ends of the offshore lines (the red area in **Figure 6**).
2. *No Overlap (truncated)*: transect lines did not overlap with the offshore transect lines (i.e., the eastern end of the coastal lines terminated at the longitude of the western end of the offshore lines).

Overall, 4 baleen whale species—humpback, fin, NARW, and minke—were observed in the survey area, including 19 sightings of humpback whales (27 individuals), 18 sightings of fin whales (30 individuals), 7 sightings of NARWs (10 individuals) and 2 sightings of minke whales (3 individuals). Most of these observations occurred during winter and spring. No observations of baleen whales were recorded during summer surveys. The most frequent observations were single whales, but a group of four NARWs and a group of 4 humpback whales were also observed.

Spatial coverage and effort varied between the survey projects and across years/seasons. Cumulatively, 68,922.2 km of trackline were flown between February 2001 and December 2017. During 2016 and 2017, both VAQF nearshore and UNCW offshore surveys were conducted with some overlap (**Figure 7**). The greatest survey effort occurred in 2017 (total 10,828 km) during the VAQF nearshore surveys (11,912 km), and UNCW offshore surveys (8,441 km), while the smallest amount of effort occurred during the 2012 Coastal Zone Management Surveys (760 km), which started in the fall of 2012.

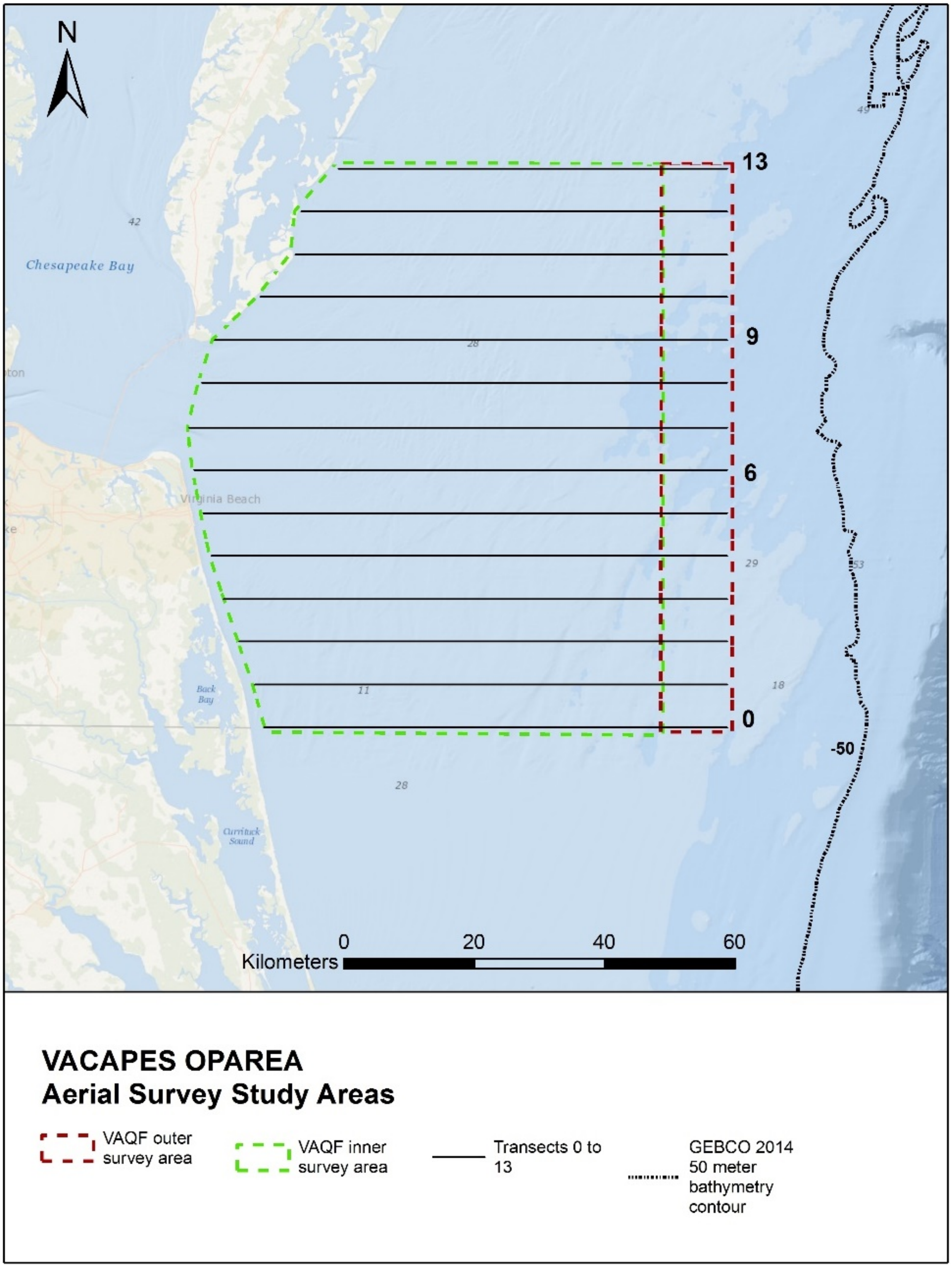

Figure 6. VACAPES nearshore survey area and aerial tracklines.

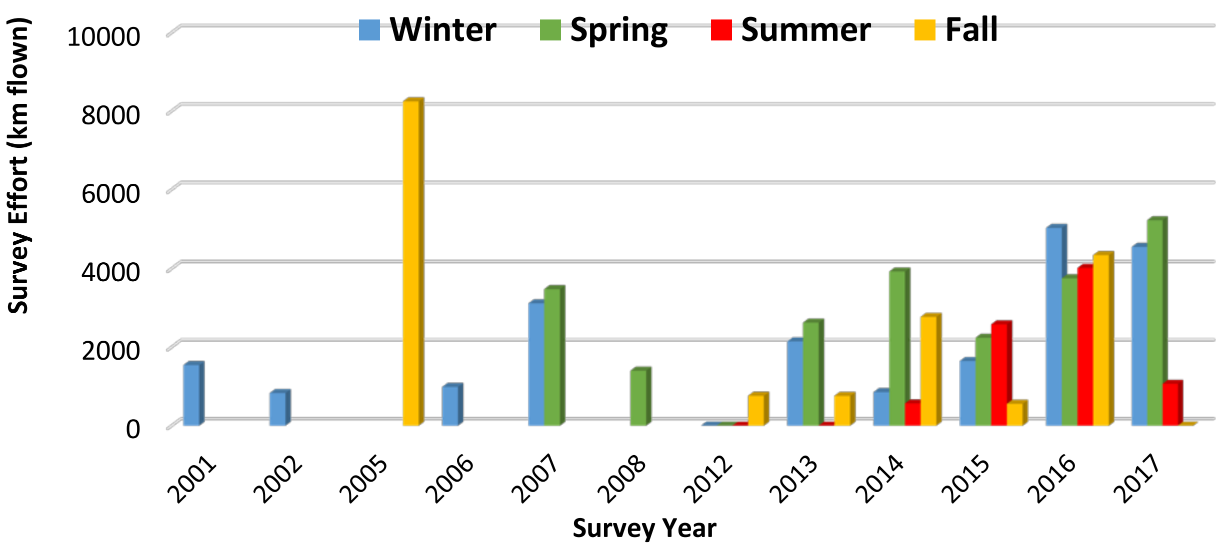

Figure 7. Seasonal survey effort (km flown) from 2001 through 2017 (winter = January–March; spring = April–June; summer = July–September; fall = October–December).

Overall sightings during winter months were distributed closer to shore, and all sightings were west of the 50-m isobath. All baleen whale species except for minke whales were documented in the VACAPES OPAREA during winter. Winter sighting rates were highest for fin whales (0.08 whales/100 km), followed by humpback (0.6 whales/100 km), NARW (0.03 whales/100 km), and minke (0.005 whales/100 km) whales. Humpback and fin whales were recorded in the Traffic Separation Schemes and Precautionary Area and within the Seasonal Management Area (SMA) (**Figure 8**). Most sightings of these 2 species tended to be distributed near the southern entrance of the Chesapeake Bay. All right whale sightings, except for one, were located east of the SMA (**Figure 9**).

Spring exhibited the second to highest sighting rates for all whales (0.12/100 km). Whale distribution during spring tended to be farther offshore than winter, with a majority of sightings along the western side of the 50-m isobath (**Figure 10**). The majority of spring sightings were of fin whales with a sighting rate of 0.08/100 km, followed by humpback (0.03/100 km), NARW (0.01/100 km), and minke (0.04/100 km) whales. Fin, minke and humpback whales were documented within the VAPCAPES OPAREA, but there were no sightings of any species within the Traffic Separation Schemes and Precautionary Area. There were two sightings of NARWs documented, east of the SMA. Although there were few nearshore sightings, humpback whales were observed closest to shore.

This project is now complete, and more details can be found in the final report (Mallette et al. 2018a).

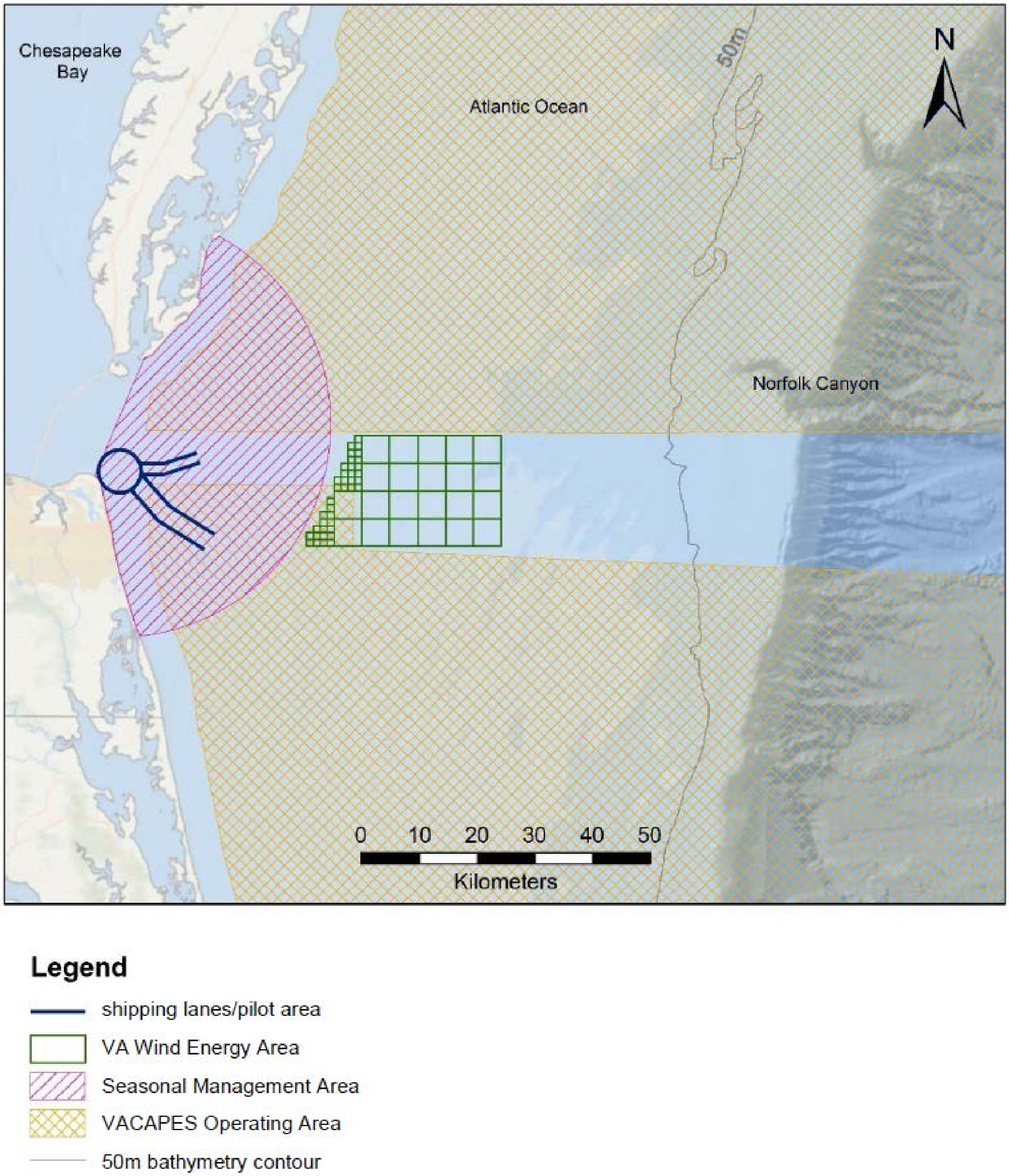

Figure 8. Study area with human use areas, including shipping lanes and pilot area, VA WEA, SMA, and VACAPES OPAREA.

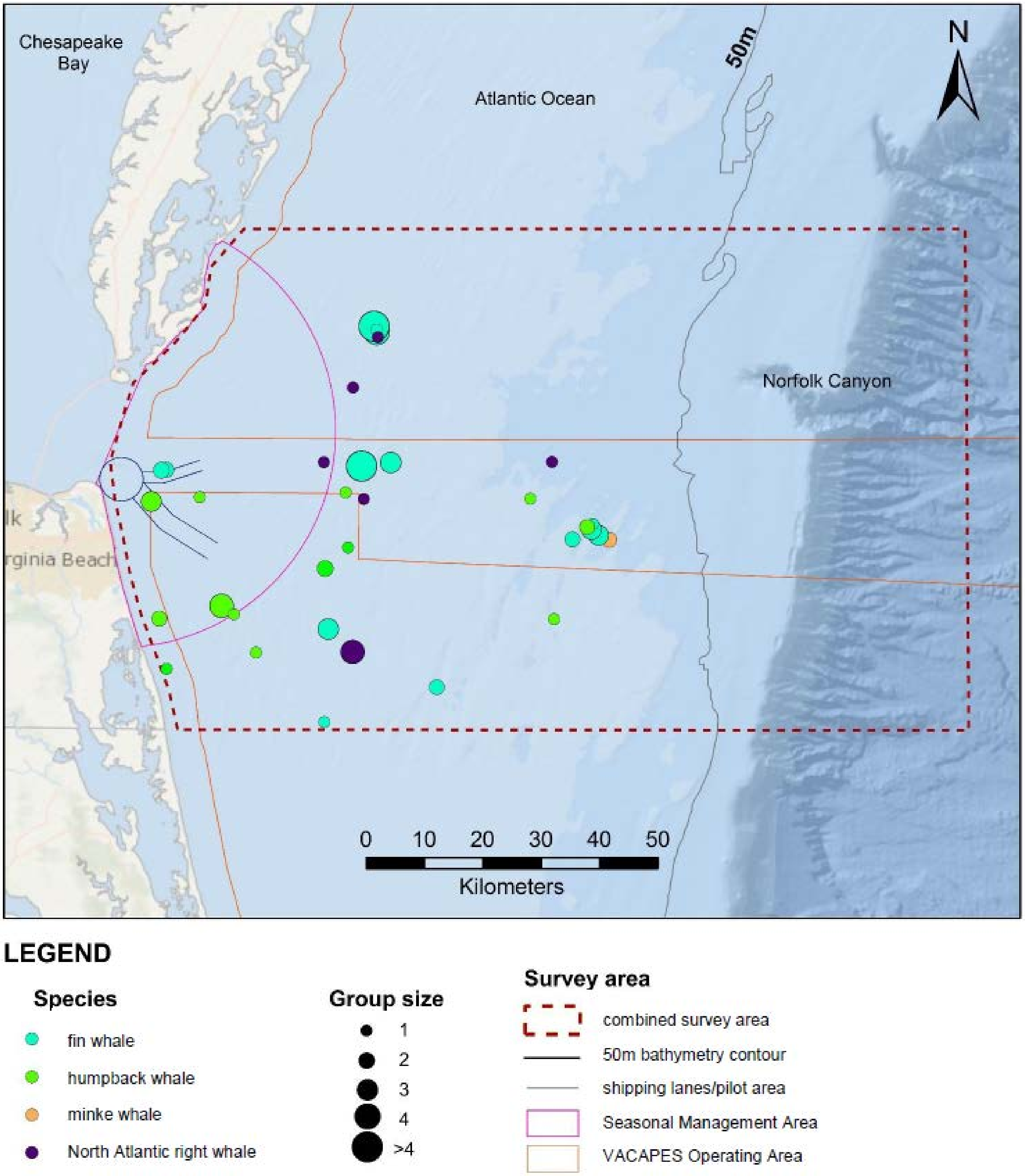

Figure 9. On-effort sightings of baleen whales during winter (January–March) aerial surveys between 2001 and 2017.

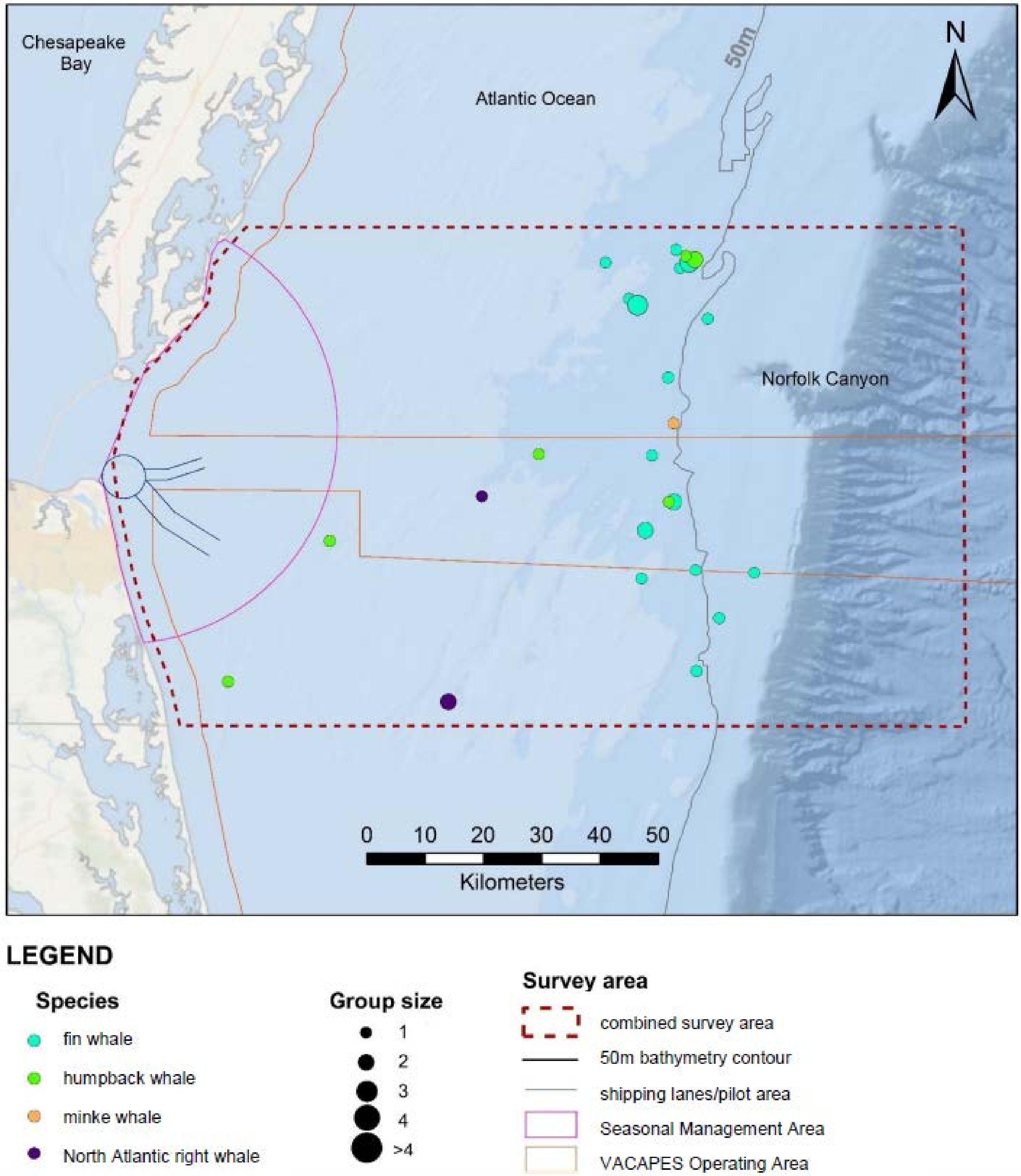

Figure 10. On-effort sightings of baleen whales during spring (April–June) aerial surveys between 2001 and 2017.

2.1.3 Jacksonville Study Area Offshore Aerial/Vessel Surveys

2.1.3.1 Aerial Surveys

Aerial surveys were conducted in the JAX OPAREA between 2009 and 2017 to assess the distribution and abundance of offshore cetaceans in the region of the planned USWTR. These aerial surveys extended over 9 years and yielded a very detailed seasonal picture of the occurrence, distribution, and abundance of marine mammals and sea turtles around the USWTR site. This work also provides an important baseline against which future changes in the marine mammal and sea turtle fauna can be assessed.

Typical effort covered the primary USWTR area as well as offshore trackline extensions (**Figure 11**). Between the survey years of 2009 and 2017, UNCW researchers conducted 144 days of aerial survey effort covering 1,147 tracklines encompassing 93,369 km. Survey conditions ranged from BSS 0 to BSS 6, with a mean BSS of 2.44. A total of 968 on-effort sightings of cetaceans was recorded in addition to 33 off-effort sightings (**Table 4, Figure 12**). Of the 968, 891 were identified to species, comprising 11 species (or genus in the case of *Kogia* sp.) and 11,493 individuals. Two species of delphinids comprised more than three-quarters of all cetacean sightings: common bottlenose dolphin and Atlantic spotted dolphin. Four species of large whales were detected, together with 5 taxa of other pelagic odontocetes.

Table 4. All cetacean sightings, including off-effort sightings (*n*=31), from aerial surveys in the JAX study area, January 2009–November 2017.

Common Name	Scientific Name	Number of Sightings	Number of Individuals
Risso's dolphin	*Grampus griseus*	54	815
Short-finned pilot whale	*Globicephala macrorhynchus*	26	326
Rough-toothed dolphin	*Steno bredanensis*	10	365
Atlantic spotted dolphin	*Stenella frontalis*	355	6,515
Common bottlenose dolphin	*Tursiops truncatus*	450	3,742
Pantropical spotted dolphin	*Stenella attenuata*	2	27
North Atlantic right whale	*Eubalaena glacialis*	6	9
Humpback whale	*Megaptera novaeangliae*	3	3
Minke whale	*Balaenoptera acutorostrata*	11	16
Sperm whale	*Physeter macrocephalus*	3	4
Kogiid whale	*Kogia* sp.	2	3
Unidentified delphinid	n/a	78	268
Unidentified cetacean	n/a	1	1

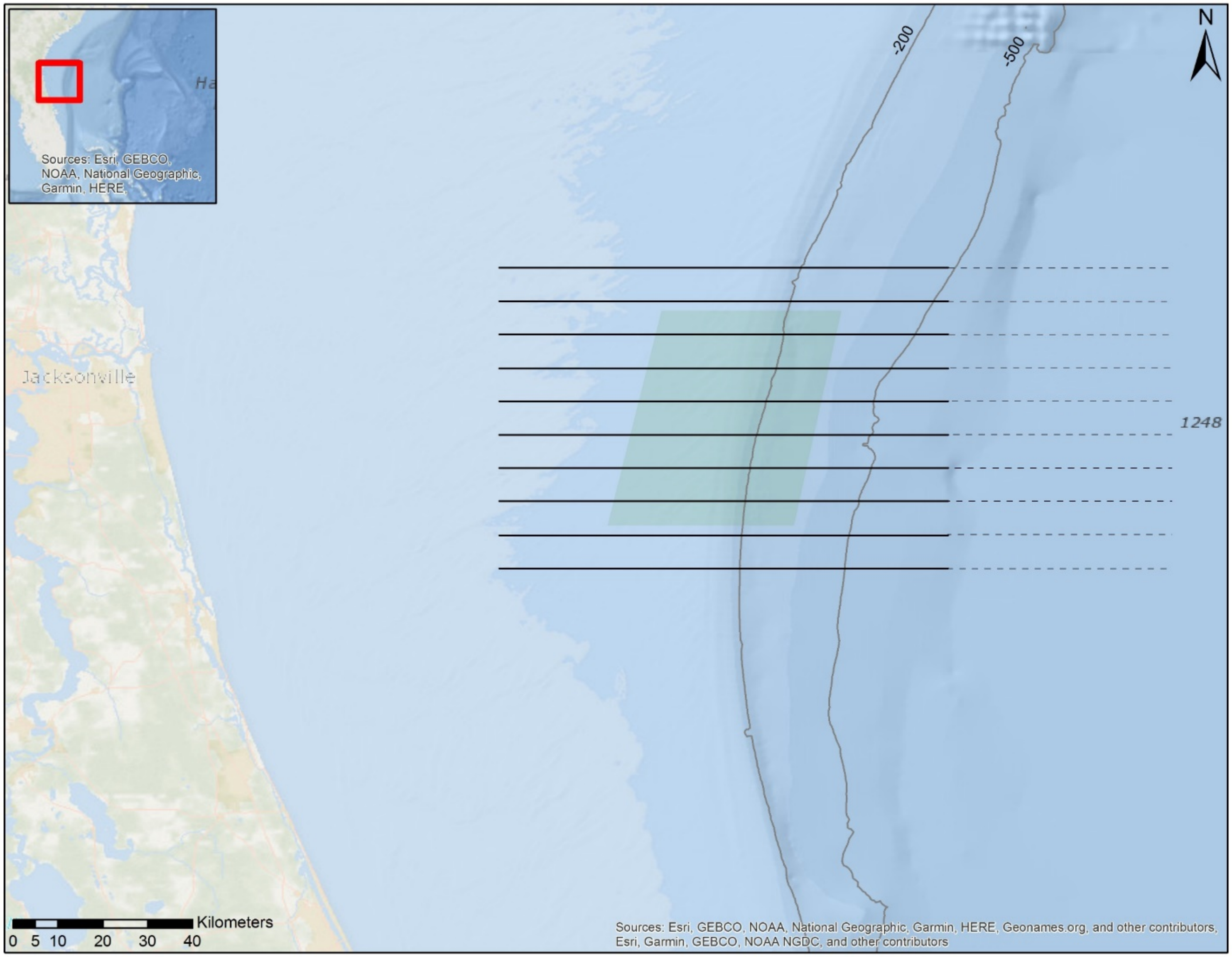

Figure 11. Aerial survey tracklines in the JAX study area, including the USWTR site (shaded area), and extended offshore tracklines (dashed lines).

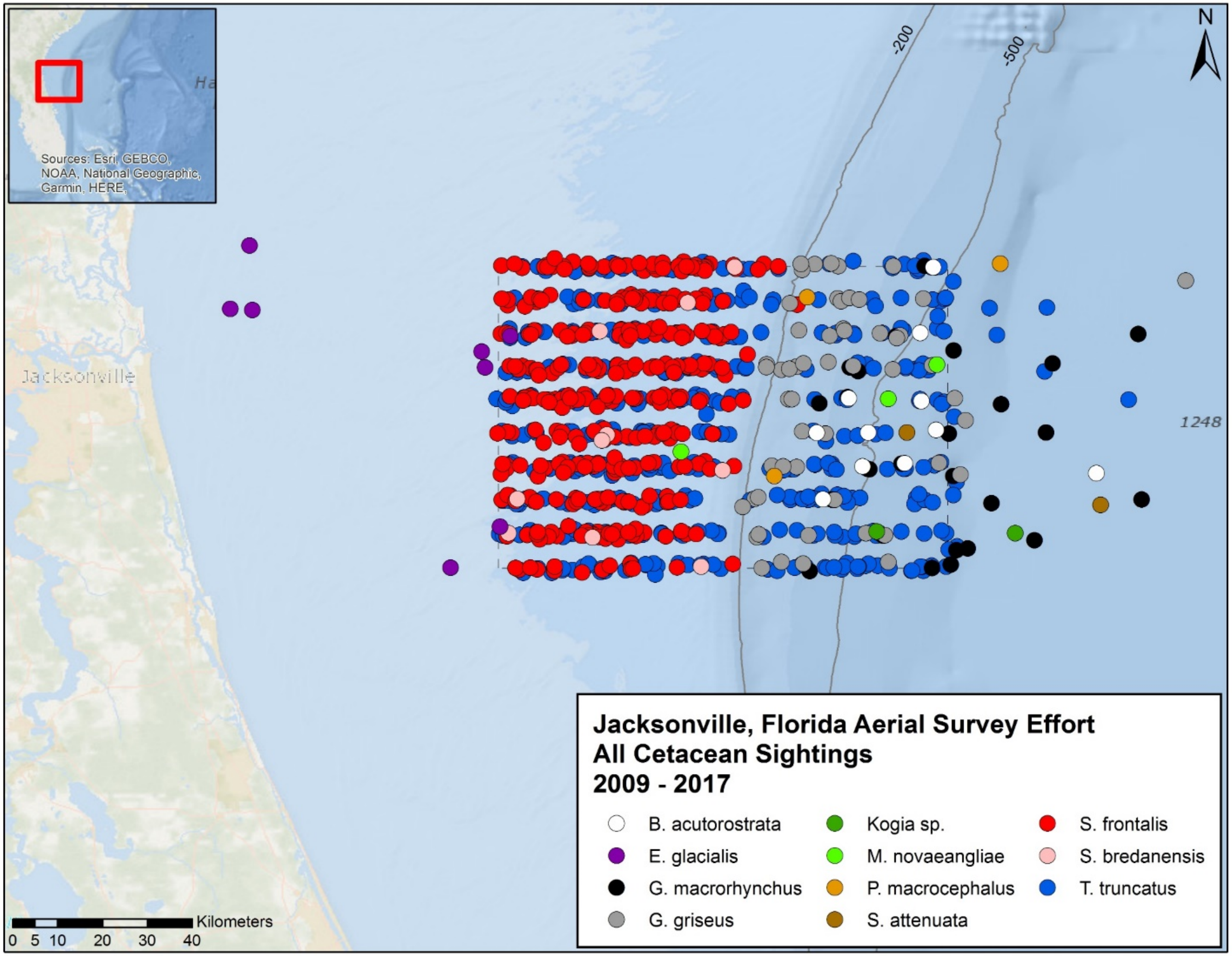

Figure 12. All cetacean sightings from aerial surveys conducted in the JAX study area, January 2009–November 2017.

A total of 4,036 sea turtle sightings was recorded, 3,437 of which were identified to species (**Table 5**). Three species of sea turtles were identified during these surveys: loggerhead, leatherback, and Kemp's ridley sea turtles (**Figure 13**).

Table 5. Sea turtle sightings from aerial surveys in the JAX study area, January 2009–November 2017.

Common Name	Scientific Name	Number of Sightings
Loggerhead sea turtle	*Caretta caretta*	3,248
Leatherback sea turtle	*Dermochelys coriacea*	186
Kemp's ridley sea turtle	*Lepidochelys kempii*	3
Unidentified sea turtle	n/a	599

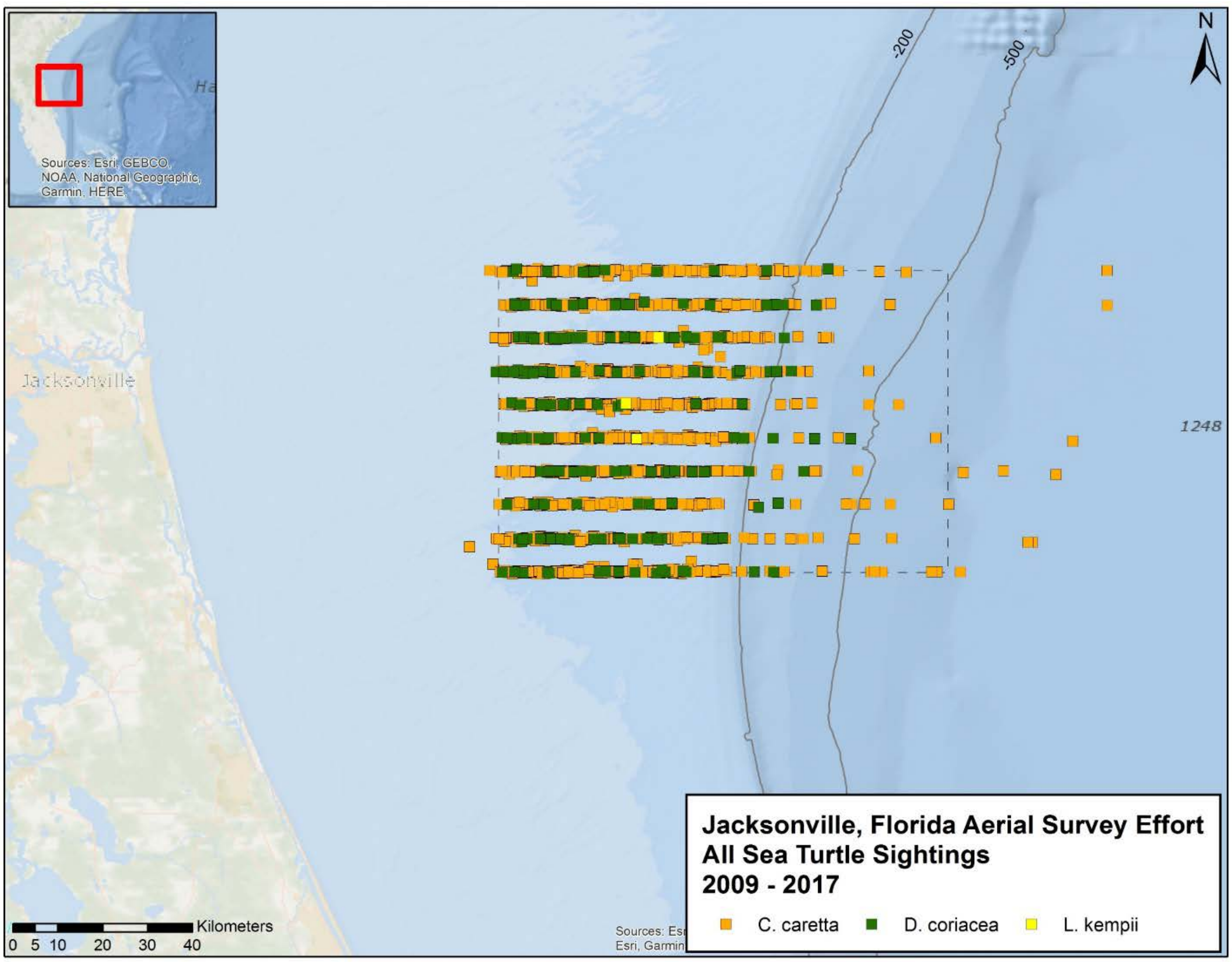

Figure 13. All sea turtle sightings from aerial surveys conducted in the JAX study area, January 2009–November 2017.

The pattern of cetacean distribution was very consistent over the entire study period. Bottlenose dolphins were encountered throughout the entire study area, but the occurrence of Atlantic spotted dolphins was restricted to shallow, shelf waters. Other pelagic odontocetes were observed only in deeper waters beyond the 200-m shelf break, with the exception of rough-toothed dolphins (*Steno bredanensis*), which were observed routinely inshore of the 200-m isobath. Large whales, with the exception of NARW, were observed only in deeper waters.

Baleen whales were observed only in winter and early spring (December to early April), but there was no other obvious pattern of seasonality in the occurrence of cetaceans. Common bottlenose and Atlantic spotted dolphins were seen in every month. Risso's dolphins were observed every month, except December. Rough-toothed dolphins were observed from January through November with no apparent seasonal pattern. Short-finned pilot whales were seen only between April and October. Too few sightings of sperm whales, pantropical spotted dolphins, and kogiids occurred to allow any conclusions to be drawn regarding their patterns of seasonality.

Data collected during these surveys were analyzed to estimate density and abundance of marine mammals and sea turtles in the JAX study area. Maps of estimated density were obtained using density-surface modeling techniques and abundances were obtained from these maps. These techniques allowed density to vary both spatially and temporally through the explanatory variables included in the models and, as data were collected throughout the year, the effects of seasonal abundance changes (if any) were investigated.

This project is now complete, and more details can be found in the final report (Foley et al. 2019a).

2.1.3.2 Vessel Surveys

Vessel survey effort in the JAX study area during 2018 focused on questions of residency and population structure of odontocete cetaceans using biopsy sampling and photo-ID methods. Surveys were conducted from the research vessel R/V *Richard T. Barber*, with 2 observers continually scanning around the vessel. Four days of vessel surveys totaling 325 km and 15.25 hours (hr) of survey effort were conducted in the JAX study area during November and December 2018 (**Table 6, Figure 14**). These surveys were conducted in BSS 0 to BSS 4 and covered the planned USWTR site and surrounding area, including shelf and deeper oceanic waters.

Table 6. Effort summary for small-vessel surveys conducted in the JAX study area in 2018.

Date	Beaufort Sea State	Total km Surveyed	Total Survey Time (hr: min)	Total At-Sea Time (hr:min)	Platform
07-Nov-18	2–3	150.4	05:41	10:12	R/V *R. T. Barber*
08-Nov-18	4	24.3	00:56	07:17	R/V *R. T. Barber*
09-Nov-18	3	47.0	05:19	11:13	R/V *R. T. Barber*
06-Dec-18	3–4	93.3	03:19	08:37	R/V *R. T. Barber*

Key: hr = hour(s); km = kilometer(s); min = minute(s); "At-Sea Time" includes off-effort transits.

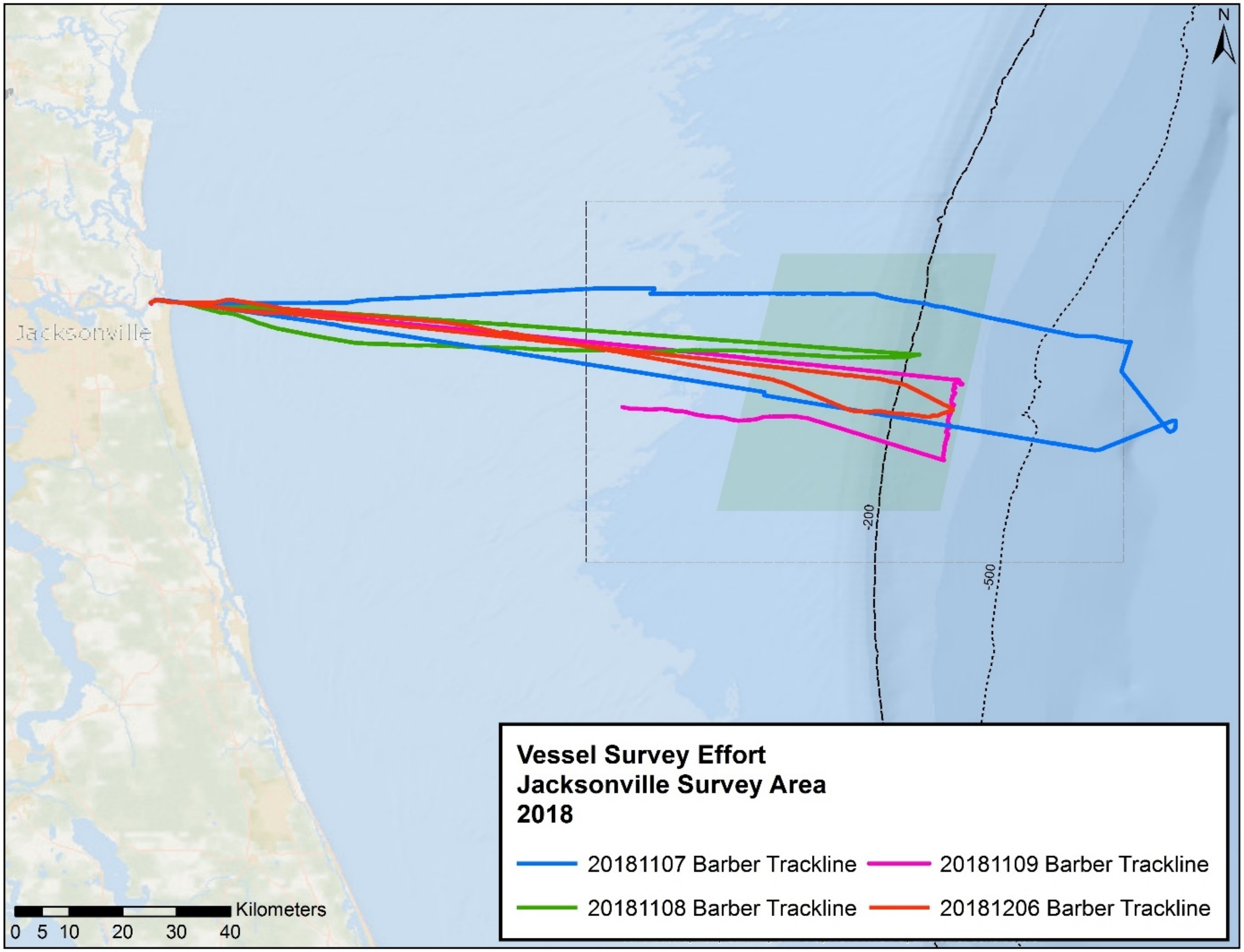

Figure 14. Survey tracks during small-vessel surveys in the JAX study area in 2018.

Five sightings of 2 cetacean species were recorded during these vessel surveys. Atlantic spotted dolphins (*n*=4) dominated the observations, in addition to one sighting of short-finned pilot whales (**Table 7**, **Figure 15**). No sea turtles were recorded during small-vessel surveys in the JAX study area during 2018.

Table 7. Cetacean sightings from small-vessel surveys conducted in the JAX study area in 2018.

Date	Time (local)	Latitude (°N)	Longitude (°W)	Species	Group Size	Biopsy Samples
09-Nov-18	10:10	30.11036	80.09855	Short-finned pilot whale	50	1
06-Dec-18	11:46	30.27389	80.41160	Atlantic spotted dolphin	2	0
06-Dec-18	12:11	30.23225	80.29360	Atlantic spotted dolphin	2	0
06-Dec-18	14:21	30.29566	80.42626	Atlantic spotted dolphin	12	0
06-Dec-18	14:46	30.30888	80.54405	Atlantic spotted dolphin	2	0

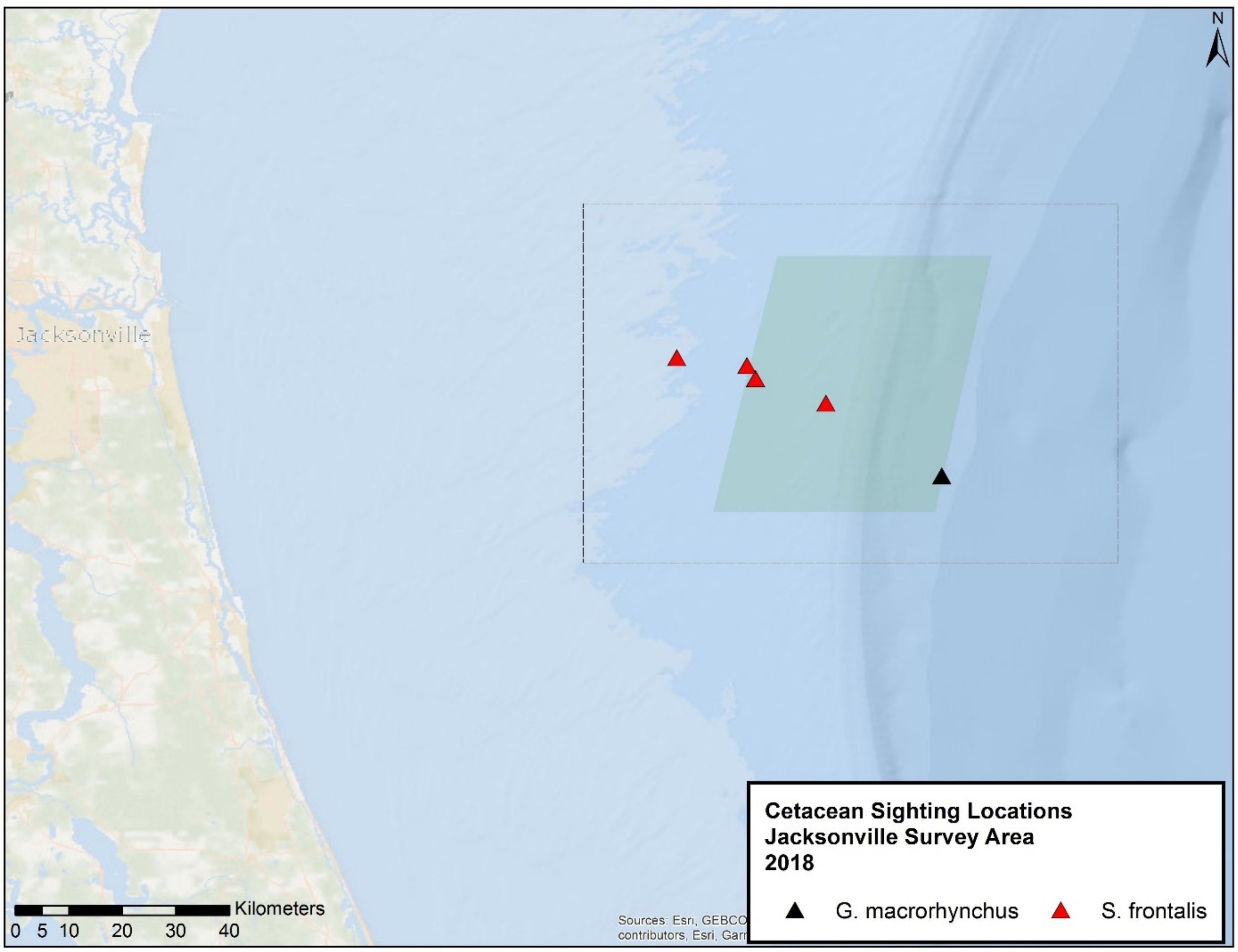

Figure 15. Cetacean sightings from small-vessel surveys conducted in the JAX study area in 2018.

One biopsy sample was collected in the JAX survey area during 2018 from a satellite-tagged short-finned pilot whale (**Table 8, Figure 16**). The skin sample will be analyzed for sex identification. A voucher specimen of this sample is archived with NMFS's Southeast Fisheries Marine Mammal Molecular Genetics Laboratory in Lafayette, Louisiana.

Table 8. Biopsy samples collected from animals in the JAX study area in 2018.

Date	Time (local)	Latitude (°N)	Longitude (°W)	Species	Sample #
9-Nov-18	13:53	30.25073	80.08764	*G. macrorhynchus*	HJF_18_005

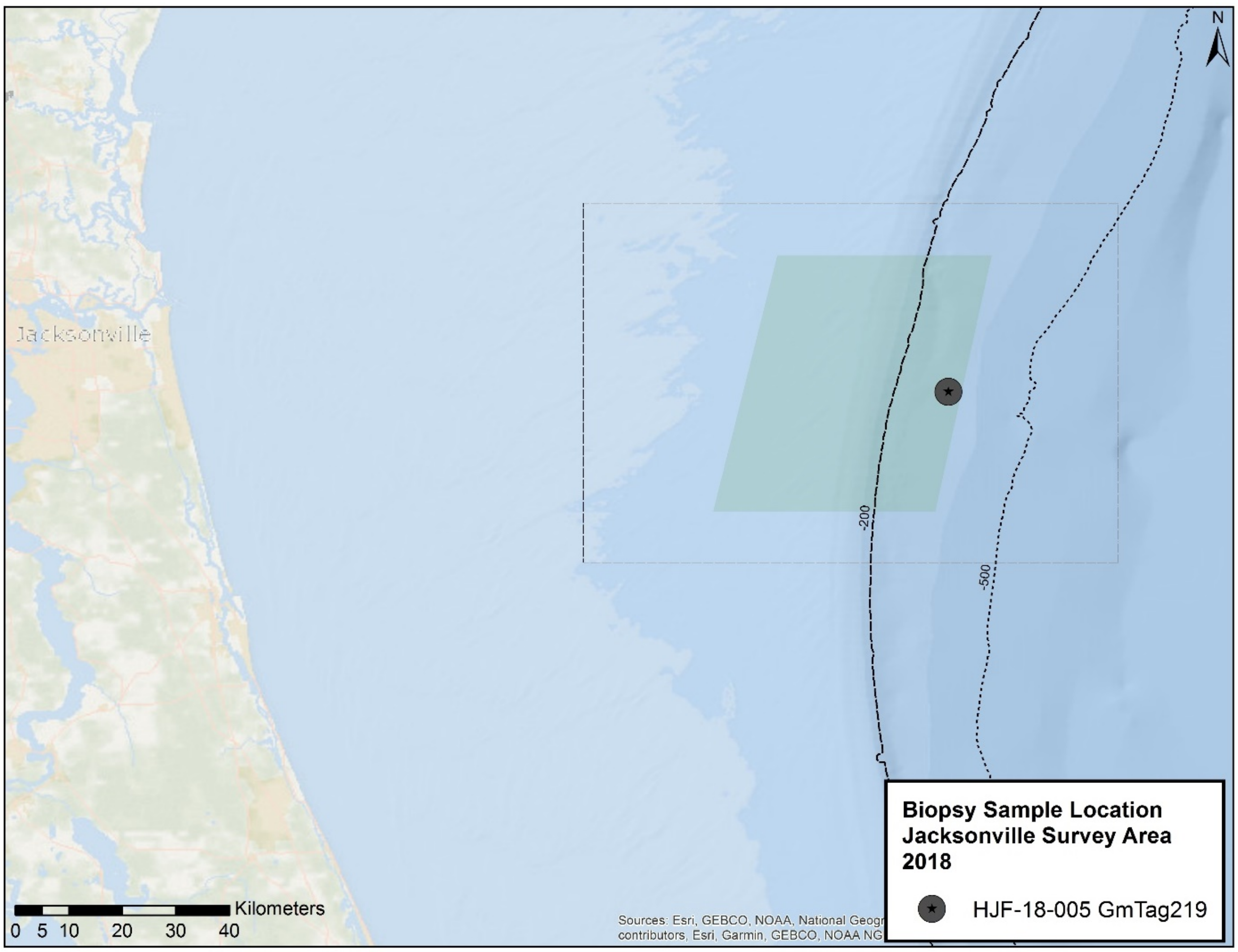

Figure 16. Location of a biopsy sample collected in the JAX study area in 2018.

Four satellite tags were deployed on short-finned pilot whales in the JAX study area on 9 November 2018 (**Table 9**, **Figure 16**). All 4 tags were deployed in the same large group of approximately 50 animals, which was structuring into distinct subgroups. Tags transmitted up to 46 days. Similar to 4 short-finned pilot whales tagged in JAX in 2016, all four tagged individuals traveled throughout the slope waters of the Blake Plateau in a clockwise direction, and repeated this loop several times before tag transmissions ceased (**Figure 17**). GmTag222, the tag of longest duration, reached Bahamian waters on 25 December 2018 before tag transmissions ended.

Table 9. Satellite tags deployed in the JAX study area in 2018.

Date	Time (local)	Latitude (°N)	Longitude (°W)	Species	Tag #	Photo-ID Code
9-Nov-18	10:18	30.12015	80.09819	*G. macrorhynchus*	GmTag219	DU_Gma_031
9-Nov-18	11:01	30.14643	80.10386	*G. macrorhynchus*	GmTag220	Gma_8-003
9-Nov-18	12:44	30.20570	80.09564	*G. macrorhynchus*	GmTag221	Gma_6-011
9-Nov-18	13:09	30.21846	80.09124	*G. macrorhynchus*	GmTag222	Gma_6-014

Nearly 1,500 digital images were collected for species confirmation and individual identification during 2018, and 28 newly identified dolphins were cataloged (**Table 10**). Photo-ID catalogs for common bottlenose and Atlantic spotted dolphins in the JAX survey area consist of 132 and 204 individuals, respectively. Twenty-three new individuals were added to the JAX short-finned pilot whale catalog in 2018 for a catalog size of 52. The Risso's dolphin catalog includes 56 unique individuals while the rough-toothed dolphin catalog consists of 54 individuals.

Table 10. Summary of photo-ID images taken of animals in the JAX study area in 2018 with photo-ID catalog sizes and total number of matches across all years of effort.

Species	2018 Images	Catalog Size (new animals)	Matches
Globicephala macrorhynchus	1272	52 (23)	0
Grampus griseus	0	56 (0)	0
Stenella frontalis	213	204 (28)	22
Steno bredanensis	0	54 (2)	0
Tursiops truncatus	0	132 (0)	0

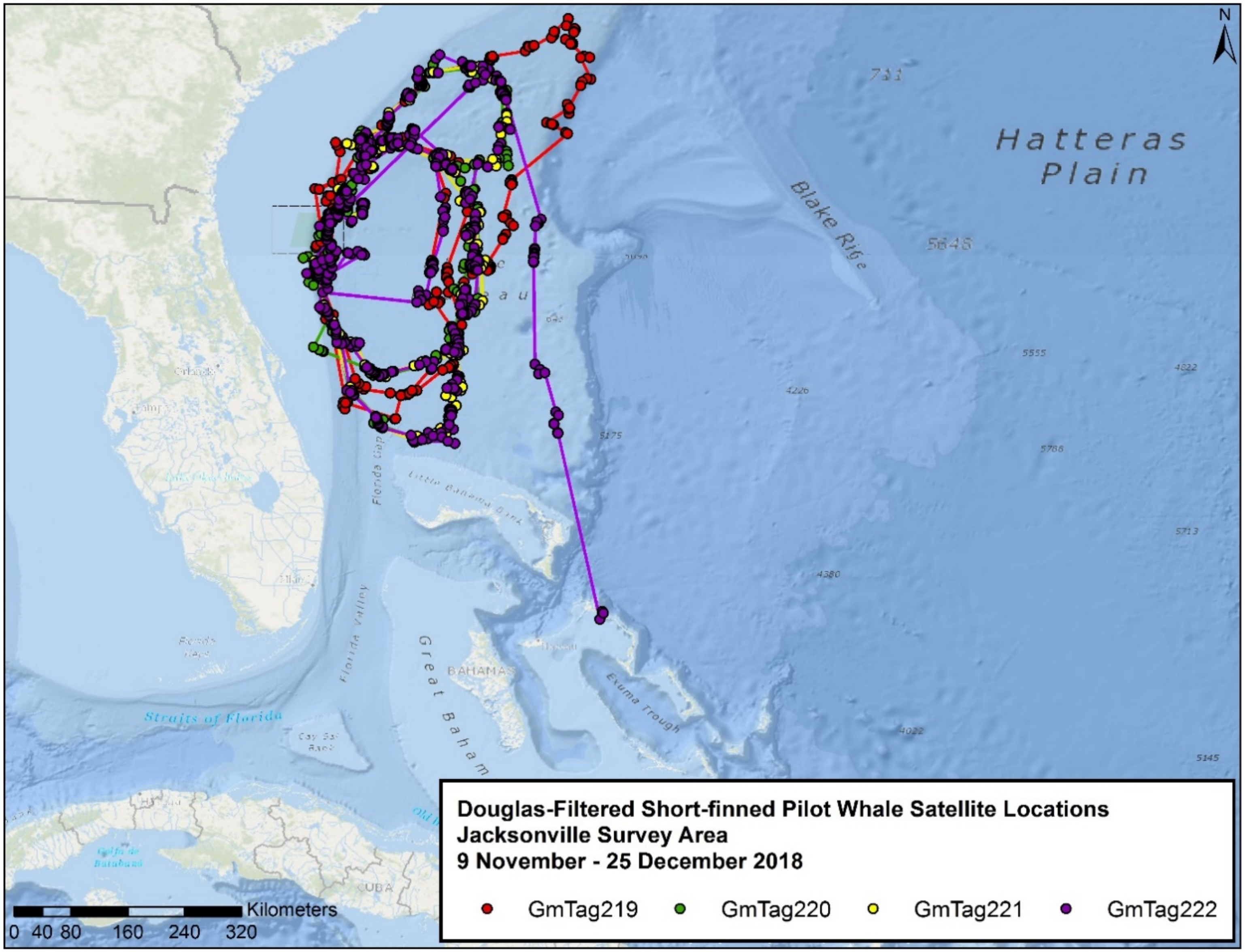

Figure 17. Reported satellite tag locations (Douglas-filtered) of short-finned pilot whales tagged in the JAX survey area in 2018.

There have been 9.5 years of vessel survey effort in the JAX study area since the monitoring program began in 2009, with 588.4 hr and 10,388.6 km of effort completed (**Table 11**). Six species of cetaceans have been identified, and annual sighting totals (including unidentified and mixed-species sightings) ranged from a low of 5 in 2018 to a high of 72 in 2009–2010 (**Table 12**). Three sea turtle species have been identified, with annual sighting totals (including unidentified turtles) ranging from 0 in 2018 to 69 in 2009–2010 (**Table 13**). Over the entire study, 117 biopsy samples have been collected from 6 odontocete species, mostly (86.3 percent) from Atlantic spotted and common bottlenose dolphins (**Table 14**).

Table 11. Duration and distance surveyed annually in the JAX study area.

Year:	2009–10*	2011	2012	2013	2014	2015	2016	2017	2018	Total
Survey Hours	127	21	59	59	67	44	131	66	15	**588.4**
km Surveyed	2,074	346	937	1,022	1,227	858	2,136	1,424	315	**10,338.6**

* July 2009-December 2010.

Table 12. Numbers of cetacean sightings annually for each species in the JAX study area.

Species	Sightings								
	2009–10*	2011	2012	2013	2014	2015	2016	2017	2018
Eubalaena glacialis	0	0	0	0	1	0	0	0	0
Globicephala macrorhynchus	3	0	0	0	0	0	5	0	1
Grampus griseus	2	0	0	1	1	1	0	2	0
Stenella frontalis	35	6	14	9	20	10	10	18	4
Steno bredanensis	0	0	0	0	0	0	2	1	0
Tursiops truncatus	19	6	23	15	18	10	18	16	0
Tursiops/Stenella mix	0	0	0	0	1	0	0	0	0
Unidentified delphinid	13	0	4	3	4	0	5	0	0
Total	**72**	**12**	**41**	**28**	**45**	**21**	**42**	**37**	**5**

* July 2009-December 2010.

Table 13. Numbers of sea turtle sightings annually for each species in the JAX study area.

Species	Sightings								
	2009–10*	2011	2012	2013	2014	2015	2016	2017	2018
Caretta caretta	52	20	41	33	31	22	22	25	0
Dermochelys coriacea	8	3	4	1	3	2	4	2	0
Lepidochelys kempii	1	0	1	0	0	0	0	0	0
Unidentified turtle	8	3	3	1	0	0	0	3	0
Total	**69**	**26**	**49**	**35**	**34**	**24**	**26**	**30**	**0**

* July 2009-December 2010.

Table 14. Biopsy samples collected annually in the JAX study area.

Species	2009–10*	2011	2012	2013	2014	2015	2016	2017	2018	Total
Globicephala macrorhynchus	0	0	0	0	0	0	5	0	1	**6**
Grampus griseus	0	0	0	1	2	0	0	0	0	**3**
Stenella attenuata	0	0	0	0	0	0	1	0	0	**1**
Stenella frontalis	0	0	19	6	19	3	7	8	0	**62**
Steno bredanensis	0	0	0	0	0	0	4	2	0	**6**
Tursiops truncatus	0	0	12	5	10	5	5	2	0	**39**

* July 2009-December 2010.

For more information on this study, refer to the annual progress report for this project (Foley et al. 2019b).

2.1.4 Panama City Vessel Surveys

Common bottlenose dolphins inhabit the bay and coastal waters of the Florida Panhandle (reviewed in Hayes et al. 2018). Currently, NMFS has delineated one Gulf coastal (Northern Coastal Stock) and 7 bay, sound, and estuary (BSE) bottlenose dolphin stocks within the nearshore waters of the Florida Panhandle (Hayes et al. 2018). Two of these BSE stocks, Choctawhatchee Bay and Apalachicola Bay, have been studied for one- to two-year periods using photo-ID surveys to estimate seasonal abundance and to provide insights into stock structure (Conn et al. 2011, Tyson et al. 2011, respectively). The St. Joseph Bay Stock, subject of the only long-term study of dolphins in the Florida Panhandle, has been studied since 2004 to understand seasonal abundance and distribution patterns (Balmer et al. 2013), assess dolphin health (Schwacke et al. 2010), and identify contaminant levels (Wilson et al. 2012, Balmer et al. 2015).

Although these studies provided valuable information for BSE stock assessment in the Florida Panhandle, little is known about the distribution and movement patterns of dolphins that are part of the Northern Coastal Stock, with hypothesized stock boundaries extending from the Big Bend region of Florida (84°W longitude) to the Mississippi River Delta (Hayes et al. 2018). During spring and fall, seasonal influxes of dolphins into the St. Joseph Bay region have been observed, in which abundance increased two- to three-fold (Balmer et al. 2008). Additionally, extended movements of several individuals have been identified (St. Joseph Bay to Destin, Florida [approximately 100 km] and to Mississippi Sound [approximately 300 km] [Balmer et al. 2016]), suggesting that the Northern Coastal Stock may seasonally co-occur with BSE stocks.

The Naval Surface Warfare Center, Panama City Division Testing Range (NSWC PCD) is located in the nearshore and offshore waters of the Florida Panhandle and Alabama, extending from the coast to over 220 km seaward, and inclusive of St. Andrew Bay, Florida. Limited data exist on the St. Andrew Bay Stock and adjacent Northern Coastal Stock. Blaylock and Hoggard (1994) conducted aerial line-transect surveys in the fall of 1992 and 1993 and estimated the abundance of the St. Andrew Bay Stock to be 124 (95% confidence interval [CI]=59–259). Bouveroux et al. (2014) conducted photo-ID surveys in a limited portion of the St. Andrew Bay Stock's boundaries and estimated abundance ranging from 89 (95% CI=71–161) in March–May 2004 to 183 (95% CI=169–208) in June–July 2007.

For 2018, the majority of effort was spent analyzing data from the 2017 surveys, and finalizing manuscript publication of the 2015 and 2016 survey data. Balmer et al. 2019 provided abundance estimates for the St. Andrew Bay BSE stock of bottlenose dolphins. Total BSE abundance was lowest in spring 2016, followed by summer 2015, and highest in fall of both 2015 and 2016, suggesting a seasonal influx of coastal stock dolphins into the area as observed in St. Joseph Bay (Balmer et al. 2008, 2018). The abundance estimates were generally similar to other northern Gulf of Mexico BSE stocks (Hayes et al. 2017). The limited area surveyed for the adjacent coastal (CST) subarea of the St. Andrew Bay study site and violation of capture-recapture model assumptions (due to likely increased immigration/emigration) resulted in extremely large confidence intervals for abundance estimates of that stock. Only 7% of individuals were sighted in both BSE and coastal Gulf of Mexico regions, suggesting limited overlap in stocks in this area.

2.1.5 Pinniped Haul-out Surveys in Lower Chesapeake Bay and Coastal Waters of Virginia

The National Oceanic and Atmospheric Administration (NOAA) 2017 Stock Assessment Report states that gray seal (*Halichoerus grypus*) and harbor seal (*Phoca vitulina*) populations currently range from New Jersey to Labrador; with scattered sightings and strandings reported as far south as North Carolina for gray seals and Florida for harbor seals (Hayes et al. 2018). However, several researchers, report that harbor and gray seal distribution along the United States (U.S.) Atlantic coast appears to be expanding or shifting (DiGiovianni et al. 2011; Johnston et al. 2015; DiGiovianni et al. 2018). Count trend data for harbor and gray seals in southern New England and Long Island index sites from 1986-2011 indicate that harbor and gray seals are showing an increased use of their more southerly range and are extending their time spent at these haul-out sites (DiGiovianni et al. 2011). Observations from Virginia, by Chesapeake Bay Bridge Tunnel (CBBT) staff and local anglers, indicate that seals have been using the CBBT islands to haul out on for many years, but that the number of animals appears to be increasing.

In 2014, the U.S. Navy initiated a study that aims to investigate seal presence at select haul-out locations in the lower Chesapeake Bay and coastal waters of Virginia. The goal of this study is to document the presence and abundance of seals in Virginia in order to gain an increased understanding of the seasonal occurrence, habitat use, and haul-out patterns of seals near important U.S. Navy installations, training and testing areas, and vessel transit routes. Photo-identification (photo-ID) methods were used to identify and compare individual seals, which will provide valuable information for the estimation of local population size, seal movements, and site fidelity along the U.S. mid-Atlantic coasts.

A series of systematic counts of all seal species were conducted at several survey locations in two different areas (**Figure 18**); 1) in the lower Chesapeake Bay along the Chesapeake Bay Bridge Tunnel (CBBT), on the four CBBT islands, and 2) on the southern tip of the Eastern Shore at five separate sites. For the 2017-2018 field season, vessel-based counts were conducted at the CBBT (in collaboration with Virginia Department of Game and Inland Fisheries and Virginia Aquarium & Marine Science Center) and Eastern Shore (in collaboration with The Nature Conservancy) survey areas. Counts were mostly conducted at the CBBT 3 and CBBT 4 haul-out sites due to CBBT construction as well as extended survey time from the vessel-based counts. Dedicated seal haul-out surveys started in the fall (October/November) and ended in the spring (April/May) to ensure the documentation of seal arrival and departure. During each survey, the number of seals hauled out and in the water was recorded with associated environmental data (e.g., air and water temperature). Photographs of seals were collected between counts for photo-ID for a mark-recapture study, and to develop a local catalog. To estimate the population abundance (N) of harbor seals utilizing the CBBT and Eastern Shore survey areas, we used the mark-recapture data from the photo-ID portion of the study and fitted a Lincoln-Petersen mark-resight model.

For the fourth field season of the study, 16 survey days were completed between 5 November 2017 and 2 April 2018 for the CBBT survey area. A best total estimate (combined in-water and hauled out) of 340 seals was recorded across the CBBT haul-out locations. Seals were observed on 15 of the 16 (93.7 percent) survey days. The total number of seals counted per survey day ranged from 0-45 seals, with the highest counts recorded in January and February.

A total of 77 survey days have been conducted across 4 field seasons at the CBBT. Seals were recorded from mid-November to mid-May, with most (94 percent) being sighted at the CBBT 3 haul-out site. The majority of seals observed in the 3 field seasons were harbor seals. One gray seal was seen during the 2014–2015 field season, and 2 gray seals were observed during the 2015–2016 season. Once seals arrived, animals were recorded on a fairly consistent basis (62 out of 77 surveys [80.5 percent]) until departure. Based on this, we termed the number of survey days between the first and last observation as "in-season effort" and used this in our analyses. Over 4 seasons, the average count and maximum count for a single survey have increased (**Table 15**).

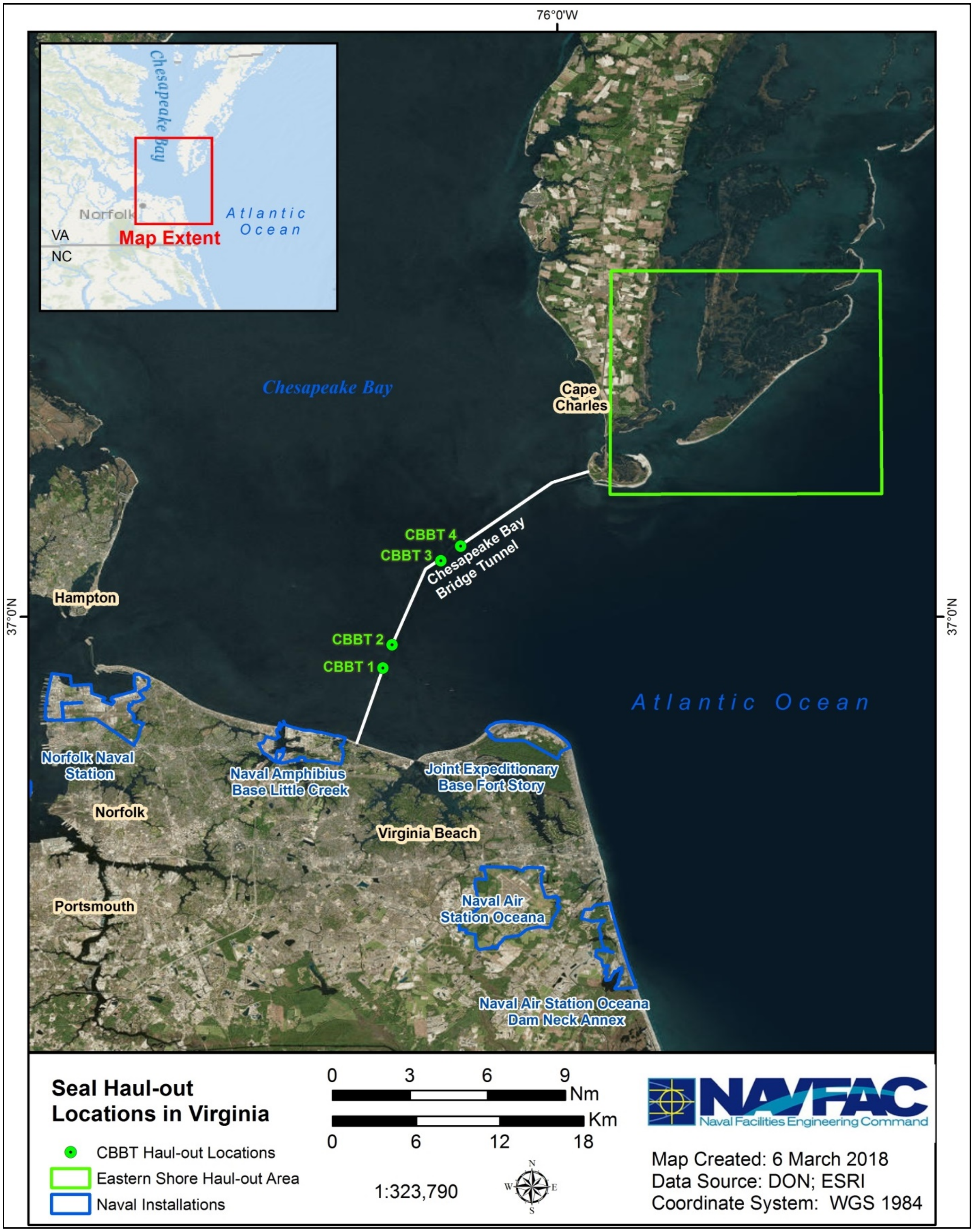

Figure 18. CBBT haul-out sites and the Eastern Shore haul-out area, and their proximity to U.S. Naval installations.

Table 15. Seasonal survey effort, total seal count (best estimate), maximum seal count for a single survey, and effort-normalized average seal count (number of seals observed per in season survey day) for CBBT.

Field Season	"In-Season" Survey Effort	Seal Counts		
		Total	Average	Maximum
2014–2015	11	113	10	33
2015–2016	14	187	13	39
2016–2017	22	308	14	40
2017–2018	15	340	23	45

Based on the initial data exploration of “in-season” seal counts for the 4 CBBT field seasons, several environmental variables (e.g., tidal height and wind speed) showed a noticeable relationship with seal count (from CBBT 3). However, the strongest relationship was with water temperature (*r*=–0.60), which appears to account for a significant proportion of variation (e.g., for regression between seal count and water temperature, R^2=0.35, p<0.001). Peak counts were recorded between January and March (**Figure 19**), and seemed to coincide with some of the lowest recorded water temperatures. As water temperatures rose above 52 degrees Fahrenheit (11 degrees Celsius), counts decreased.

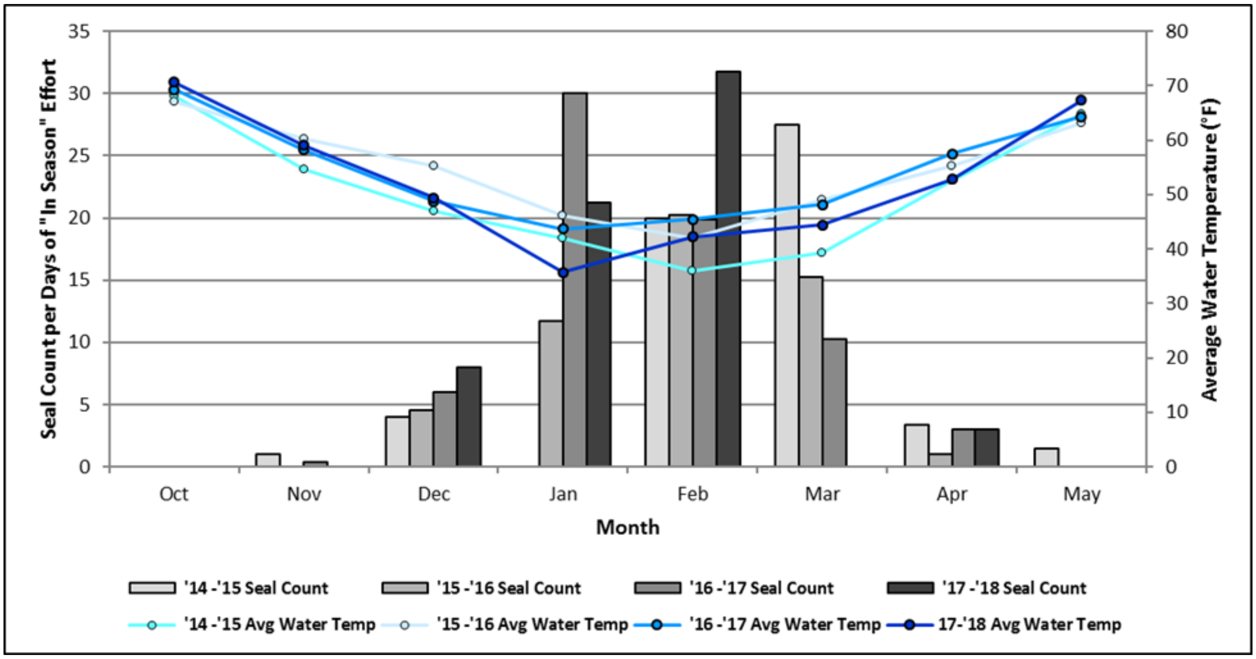

Figure 19. Average seal count by month with corresponding average monthly water temperature (degrees Fahrenheit) for the CBBT survey area. Surveys were not conducted in January 2015 or March 2018.

For the Eastern Shore survey area, haul-out counts commenced in November 2017 for the second field season. Between 3 November 2017 and 22 February 2018, 8 survey days were completed. Seals were observed on all 8 survey days, with a best estimate of 197 seals in total. The total number of seals counted ranged from 0-69 per survey day, with the highest counts were recorded in January and February. However, seal counts were not conducted in March and April due to weather conditions, and so this result may be biased.

A total of 18 survey days have been conducted across two field seasons at the Eastern Shore survey area. For both field seasons, seals were recorded from early November to late March. T The majority of seals observed in the two field seasons were harbor seals, but one gray seal was sighted on 22 February 2018. Once seals arrived, animals were recorded on a fairly consistent basis (15 out of 18 [83.3%] survey days) until departure. Over two field seasons, the number of seals observed does appear to be increasing. The maximum count for a single survey and the average seal count (number of seals observed per "in season" survey day) have increased from 24 to 69 and 15 to 25, respectively.

Photo-ID conducted via visual matching for the 2nd-4th field seasons has shown that individual harbor seals (35 out of 100 uniquely identified seals) have been resighted both within and across multiple seasons, indicating at least some degree of seasonal site fidelity in the lower Chesapeake Bay. Some individuals that have been identified at the CBBT survey area were also observed at the Eastern Shore survey area during multiple surveys. Haul-out counts and photo-ID data collection have continued for the 2018–2019 field season at both the CBBT and Eastern Shore survey areas. More detail on the current field season will be provided in the 2018–2019 progress report.

This research continues to document a regular, seasonal presence of harbor seals and occasional sightings of gray seals within the lower Chesapeake Bay and Eastern Shore, Virginia from November to April. Observations indicate that arrival and departure of seals at the CBBT study area may coincide with changes in water temperature. Reports of harbor and gray seal distribution along the U.S. Atlantic coast potentially expanding or shifting (DiGiovianni et al. 2011; Johnston et al. 2015; DiGiovianni et al. 2018) may explain the increasing trend observed in average seal count at both the CBBT and Eastern Shore survey areas. Patterns of seasonal residency and a baseline for population abundance for harbor seals within the region are beginning to emerge. However, more research is necessary to determine the level of site fidelity and whether or not harbor seal abundance is increasing within the study area. Data will continue to be collected and examined for any emerging patterns of habitat utilization and residency time, as well as population trends, which will help the Navy with ongoing environmental compliance and conservation efforts.

For more information on the Lower Chesapeake Bay seal haul-out study, please see the annual progress report (Jones et al. 2018), and visit the project profile page.

2.1.6 Mid-Atlantic Humpback Whale Catalog

Humpback whales are the most common mysticete in the nearshore waters off the coast of Virginia (Mallette et al. 2017). Evidence of seasonal use, foraging, and site fidelity from photo-ID efforts suggest the mid-Atlantic provides important seasonal habitat for humpback whales (Swingle et al. 1993, Wiley et al. 1995, Barco et al. 2002). Barco et al. (2002) suggested that some individual humpback whales overwinter in the mid-Atlantic, and that this region may serve as a supplemental winter feeding ground. Over the last 2 decades, VAQF has conducted photo-ID studies of humpback whales off the coast of Virginia and North Carolina and currently curates the Mid-Atlantic Humpback Whale Catalog (MAHWC).

VAQF is developing a collaborative, integrative platform for the MAHWC that provides a broad-scale and high-quality scientific product that can answer questions to inform the U.S. Navy and other stakeholders of the identity, residency, site fidelity, and seasonal habitat use of humpback whales in the mid-Atlantic and southeastern U.S. training areas. This project contributes to the overall community effort to help monitor the West Indies Distinct Population Segment and complements existing U.S. Navy MSM efforts (Mid-Atlantic Humpback Whale Monitoring, Mid-Atlantic Continental Shelf Break Cetacean Study, and Aerial Survey Baseline Monitoring).

The overarching goal of this project is to facilitate exchange of information among researchers who have been involved in humpback whale photo-ID efforts over the last 40 years in the North Atlantic. These efforts can also serve to support assessment of human impacts (e.g., injuries from entanglement or watercraft), body condition, and behavior (e.g., foraging). Longitudinal mark-recapture data can also serve as a non-invasive mechanism to investigate and detect changes in patterns of humpback whale occurrence, inter-annual variation, and changes in distribution and phenology over time. Survey effort and opportunistic sightings of humpback whales in the mid-Atlantic and southeastern United States have increased substantially in the past few years. To integrate data from a multitude of sources more effectively, both current and historic, a streamlined process for submissions, management, and access is necessary. In addition, simplifying and standardizing submissions from the mid-Atlantic to the broader regional and North Atlantic catalogs is essential to the efficiency of information exchange between regions. A broad data-sharing agreement was developed in order to facilitate the exchange of sighting and individual life-history information among contributors rather than requesting permission for each individual match, as is often the case with other catalogs.

The MAHWC is hosted on the Ocean Biogeographic Information System-Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP; Halpin et al. 2009), a web-based biogeographic database for marine megafauna. It provides tools for mapping and visualizing species sighting data on a global scale. Currently, OBIS-SEAMAP hosts multiple other photo-ID catalogs (e.g., Mid-Atlantic Bottlenose Dolphin Catalog, Pacific Islands Photo-Identification Network) and provides a user-friendly interface and efficient tools for comparison of collections.

Currently, the MAHWC is in the middle of the third and final year of project development (see Mallete and Barco 2017, and Mallette et al. 2018b for more detail from the first and second years of effort, respectively). Year 1 focused on engaging key stakeholders involved in humpback whale research, management, outreach, and other potential contributors to the MAHWC. This was accomplished with a stakeholder workshop (Mallette and Barco 2017) held in June 2017 that produced data-access protocols, standardized protocols for data/image submission, and outlined the workflow for submission of images and sighting data between the MAHWC and larger regional catalogs.

In year 2, data-access and data sharing protocols were finalized. Images and sighting data were collected from local contributors, standardized for integration using a template, and uploaded to OBIS-SEAMAP. Almost 2,000 sighting records were added and at least 800 “best of” images were processed, scored, and incorporated into the Photo-ID application (app). These sighting data and images from four different sites have been used to beta test the App while additional seasons and contributor’s data were processed offline. A draft Contributor Submission Package was developed to guide contributors through completing the template. These templates and the reference documents in the Submission Package continue to be tested with additional contributors as they populate templates and submit images, to ensure that protocols are clearly explained and the submission process is streamlined. For each submission from a contributor, the curator performed a complete quality control review of submissions offline and then submitted images and data in batches to the Duke programmer for upload to the Photo-ID App and to test the submission workflow.

Beta-testing and bug-fixing occurred continuously throughout the process to improve the user interface, tools for matching, and queries available to the user. Modifications to the Photo-ID App are continuing based upon feedback from the contributors and discussions among active collaborators with OBIS-hosted catalogs (e.g., Kim Urian [Mid-Atlantic Bottlenose Dolphin Catalog] and Carolyn Cush [Gulf of Mexico Dolphin Identification System]). These modifications are projected to be completed mid-February 2019, and once finalized, the beta version of the OBIS-based MAHWC will be launched for use by collaborators.

To provide quality assurance and to increase the efficiency of submissions to the MAHWC and larger catalogs, standardized protocols for coding images and categorizing and matching individuals were developed based upon existing examples and input from the core stakeholder group. Additionally, standardized data fields and database structure of the MAHWC were designed to be compatible with the U.S. Navy's MSM program. Contributors will provide pertinent data to the MAHWC catalog via standard templates and will follow image- and data-accession protocols that contribute to the maintenance and quality of the database.

Local contributor images and sighting data collected between the 2013 and 2018 seasons submitted by VAQF Research, HDR, Inc., Virginia Aquarium Whale Watch, and Rudee Flipper Whale Watch have been standardized in the contributor template and images scored based on feature codes and image quality for integration into the MAHWC. All whales submitted during this time period have been compared and new whales integrated into the catalog. As of December 2018, the catalog included 332 unique whales. All humpback whales in the current MAHWC from 1989 through 2017 have been compared to the North Atlantic Humpback Whale Catalog (NAHWC), managed by Allied Whale (Bar Harbor, Maine). Virginia images from the 2017–2018 field season are at various stages of comparison with both the NAHWC and Gulf of Maine catalog, managed by the Center for Coastal Studies (Provincetown, Massachusetts).

Of those that have been matched, at least 104 individuals have a NAHWC ID, although most sighting histories were short and many were assigned IDs based on the Virginia sightings. To determine the feasibility of incorporating aerial images into the MAHWC, images collected from aerial surveys between 2012 and 2017 were reviewed. This resulted in 38 unique whales, 19 of which were matched to MAHWC images taken from vessels. Whales with MAHWC IDs continue to be compared offline to collections from contributors in New York, New Jersey, North Carolina, Georgia, and Florida. These sighting and stranding data have not yet been formally integrated into the Photo-ID App, and matching is at different stages for each contributor.

Standardized protocols were developed for the MAHWC based upon existing photo-ID catalogs. Unique feature codes used for categorizing and filtering (e.g., dorsal fin, fluke, peduncle knuckles, body scarring) for comparison among collections were tailored to those whales in the MAHWC. Fluke code categories have been adapted from those developed by the NAHWC. Flukes are initially classified by grading from fully white (Type 1) to fully black (Type 5) coloring on the ventral surface. Within each Type, the most represented subcategories to be used in the catalog are being determined (e.g., typical, wide black trailing edge, white on trailing edge, white eyes). Examples of the subtypes "typical" and "white eyes" for each fluke type are illustrated in **Figure 20**.

Future work planned for 2019 includes wrapping up final bug-fixing for the OBIS-based catalog before formally launching the web-based Photo-ID App, developing website content for MAHWC, developing a training guide for help coding images, finalizing curator protocols for future sustainability of the catalog, and preparing and submitting project manuscripts.

For more information on this study, refer to the annual progress report for this project (Mallette and Barco 2019).

Fluke

Type	Code	Description	Example
TYPE 1 (< 20% BLACK PIGMENT)	1a 'typical'	Almost no black pigment on fluke. Can be variable amounts of black near core provided no major portion extends farther than about 1/2 way up center from peduncle to notch.	
TYPE 1 (< 20% BLACK PIGMENT)	1i 'white eyes'	White eyes to either side of notch, surrounded by darker pigment. Dark pigment usually broken speckled or gray, rather than all black. Presence of other areas of pigment not considered.	
TYPE 2 (20-40% BLACK PIGMENT)	2a 'typical'	Black core flares outwards toward trailing edge. Pattern may be largely triangular, beginning near insertion of the fluke, or more hourglass shaped with a wide base. Edges are fairly straight & continuous from the beginning of the flare to the trailing edge.	
TYPE 2 (20-40% BLACK PIGMENT)	2i 'white eyes'	White eyes to either side of notch are surrounded by darker pigment. Presence or location of other black areas not considered.	
TYPE 3 (40-60% BLACK PIGMENT)	3a 'typical'	Black core flares outwards toward trailing edge. Pattern may be largely triangular, beginning near insertion of the fluke, or more hourglass shaped with a wide base. Edges are fairly straight & continuous from the beginning of the flare to the trailing edge.	
TYPE 3 (40-60% BLACK PIGMENT)	3i 'white eyes'	White eyes to either side of notch surrounded by darker pigment. Presence or location of other black areas not considered.	
TYPE 4 (60-80% BLACK PIGMENT)	4a 'typical'	Black core flares outwards toward trailing edge. Typically pattern is hourglass shaped with a flare towards the leading edge also. Edges are fairly straight & continuous from the beginning to the trailing edge.	
TYPE 4 (60-80% BLACK PIGMENT)	4i 'white eyes'	White areas surrounded by darker pigment along both the trailing and leading edges.	
TYPE 5 (> 80% BLACK PIGMENT)	5a 'typical'	Almost no white pigment on fluke. Since poor lighting can obscure white areas on dark flukes, it is important to check for this & be certain that cases of uncertainty are categorized as "other."	
TYPE 5 (> 80% BLACK PIGMENT)	5i 'white eyes'	White areas surrounded by darker pigment along both the trailing and leading edges.	

Figure 20. The 5 main fluke types, ranging from white (Type 1) to black (Type 5), with examples of the sub-categories "typical" and "white eyes" for each.

2.2 Tagging Studies

During the reporting period, the U.S. Navy supported tagging studies of odontocetes (**Sections 2.2.1 and 2.2.4**), baleen whales (**Sections 2.2.2 through 2.2.4**), sea turtles (**Section 2.2.5**), and pinnipeds (**Section 2.2.6**) in support of AFTT monitoring requirements.

2.2.1 Tagging of Deep-Diving Odontocete Cetaceans

Tagging activities conducted off the coast of Cape Hatteras in 2018 built on work that began in 2014 to develop a more robust picture of the medium-term movement patterns of deep-diving and other odontocete cetaceans. This constituted the fifth year of the Deep Divers project, which is focused on the distribution and ecology of beaked whales (Cuvier's and *Mesoplodon* spp.) and short-finned pilot whales. Researchers from Cascadia Research Collective (CRC) and Duke University tagged deep-diving odontocetes with satellite tags and digital acoustic tags (DTAGs). Satellite tagging of odontocetes by CRC complemented ongoing research by Duke University off Cape Hatteras by providing information on the spatial use and diving behavior of these species over the medium term (weeks to months) (Baird et al. 2018). Shorter-term dive data (i.e., hours to days) can be collected using DTAGs, and longer-term movement information (i.e., months to years) using photo-ID techniques (see **Section 2.1.2.1** of this report; Foley et al. 2017). While the primary focus has been on Cuvier's beaked whales and short-finned pilot whales, a number of other species were tagged during the first 3 years of field effort (Baird et al. 2015, 2016, 2017; Foley et al. 2017; Thorne et al. 2017).

During May and August 2018, the second year of field effort (fifth year overall) was completed in support of the Atlantic Behavioral Response Study (BRS) (**Section 2.3**). The Atlantic BRS is a collaborative effort between Duke University, Southall Environmental Associates, the University of St. Andrews, and CRC—a Controlled Exposure Experiment (CEE) studying cetacean reaction ns to military sonar. This study focuses on 2 primary species in particular, Cuvier's beaked whale and short-finned pilot whales. Satellite tags were deployed on both species in May and August, prior to scheduled CEEs. Given the CEEs and their potential influence on fine-scale movements and diving behavior, this section summarizes results from satellite tagging focusing on large-scale spatial use of tagged individuals as well as diving behavior prior to the CEEs. Detailed analyses of fine-scale movements and diving behavior in relation to the CEEs is summarized in **Section 2.3**.

CRC and HDR researchers deployed 31 SPLASH10 and SPLASH10-F tags (Wildlife Computers, Redmond, Washington) with the extended-depth-range option in the Low-Impact Minimally Percutaneous External-electronics Transmitter (LIMPET) configuration (Andrews et al. 2008) (**Table 16**)—13 on Cuvier's beaked whales and 18 on short-finned pilot whales. Given the unique requirements of the BRS, the tags were programmed differently than in previous efforts, with continuous information on deep foraging dives prioritized over maximizing the longevity of the tag battery or obtaining information on all (i.e., both deep and shallow) dives. The unique tag programming for each species was based on the average number of respirations per hour from previous tagging studies, and how this affects the ability to transmit dive data to the satellite.

1 **Table 16. Summary of all satellite tag deployments in the Cape Hatteras study area in 2018.**

Species[1]/Tag ID	Sex/age class	Deployment Date	Depth at tagging location (m)	Tag Duration (days)	Deployment Latitude (°N)	Deployment Longitude (°W)
ZcTag069	Adult Male	5/24/2018	748	38.90	35.69	74.78
ZcTag070	Adult Male	5/25/2018	977	12.52	35.54	74.77
ZcTag071	Adult Male	8/5/2018	1,031	34.33	35.73	74.78
ZcTag072	Adult Male	8/5/2018	985	42.91	35.72	74.78
ZcTag073	Adult Male	8/5/2018	1,232	43.63	35.55	74.75
ZcTag074*	Adult Male	8/6/2018	n/a	0	34.47	74.77
ZcTag075	Adult Male	8/6/2018	780	41.38	35.48	74.78
ZcTag076	Adult Male	8/6/2018	872	41.78	35.47	74.78
ZcTag077	Adult Male	8/6/2018	1,181	23.72	35.51	74.75
ZcTag078	Adult Male	8/6/2018	1,240	23.23	35.57	74.74
ZcTag079	Adult Female/Sub-adult Male	8/7/2018	563	43.32	35.57	74.78
ZcTag080	Adult Male	8/7/2018	513	43.81	35.56	74.78
ZcTag081	Sub-adult Unknown	8/7/2018	1,124	57.34	35.59	74.75
GmTag197	Adult Male	5/11/2018	695	27.03	35.69	74.78
GmTag198	Adult Male	5/22/2018	814	19.53	35.73	74.79
GmTag199	Adult Female/Sub-adult Male	5/24/2018	768	7.59	35.64	74.76
GmTag200	Adult Female/Sub-adult Male	5/24/2018	754	11.30	35.76	74.80
GmTag201	Adult Female/Sub-adult Male	5/30/2018	1,056	27.50	35.79	74.79
GmTag202	Adult Female/Sub-adult Male	5/30/2018	1,235	25.63	35.62	74.79
GmTag203	Adult Female/Sub-adult Male	5/31/2018	520	17.39	35.93	74.77
GmTag204	Adult Female/Sub-adult Male	5/31/2018	455	30.17	35.93	74.78
GmTag205	Adult Male	5/31/2018	604	27.28	35.92	74.78
GmTag206	Adult Female/Sub-adult Male	5/31/2018	618	31.56	35.92	74.79
GmTag207	Adult Male	8/5/2018	289	10.23	35.74	74.82
GmTag208	Adult Female/Sub-adult Male	8/5/2018	339	10.54	35.75	74.82
GmTag209^	Adult Female/Sub-adult Male	8/6/2018	n/a	0	35.49	74.73
GmTag210	Adult Male	8/6/2018	1,173	20.50	35.48	74.75
GmTag211	Adult Female/Sub-adult Male	8/6/2018	1,196	18.00	35.48	74.75
GmTag216	Adult Male	8/26/2018	498	13.02	35.61	74.79
GmTag217	Adult Male	8/26/2018	462	27.49	35.61	74.79
GmTag218	Adult Male	8/26/2018	464	21.69	35.66	74.78

[1] Gm = *Globicephala macrorhynchus* (short-finned pilot whale), Zc = *Ziphius cavirostris* (Cuvier's beaked whale); * = tag failed on impact; ^ = tag gone shortly after deployment, likely due to a conspecific interaction; m = meter(s), n/a = not applicable

Tags deployed on both species were set to transmit every day, 21 hr per day for Cuvier's beaked whales and 17 hr per day for short-finned pilot whales, with a theoretical battery life of 37 and 25 days, respectively. These tags were programmed to provide dive statistics (e.g., start and end time, maximum depth, and duration) for any dives that exceeded predetermined species-specific depth or time thresholds. For the purposes of the 2018 field effort, the thresholds were defined as: Cuvier's beaked whale—50 m and 33 minutes (min), and short-finned pilot whales—75 m and 30 seconds (sec). These thresholds are deeper and, in the case of Cuvier's beaked whales, longer than in previous years, to reduce gaps in the behavioral record, as tags were being deployed prior to CEEs and deep foraging dives were the parameter of interest. During the May field effort, only a single time-series tag was deployed as a proof of concept, while during the August effort the majority of tags deployed on this species were programmed for time series. The result was a smaller number of tags recording dive statistics, as the theoretical maximum data collection life is longer for time-series tags. This allowed for a balance of higher-resolution, shorter-term dive data with lower-resolution, longer-term data, to increase the probability of successfully collecting dive data before, during, and after exposures.

Of the 13 tags deployed on Cuvier's beaked whales, 11 were deployed in the dorsal fin or at the base of the dorsal fin, and 1 was deployed below the base of the fin. No dive data were obtained from this latter deployment (ZcTag071), likely because the placement of the tag influenced transmissions to the satellite. The remaining tag hit the leading edge of the dorsal fin (ZcTag074) and shattered on impact, leaving a single dart in the fin; consequently no data were collected for this individual. Tag-attachment duration (based on the time of the last locations received) ranged from 12.5 to 53.7 days, with the median attachment duration (41.6 days) exceeding the expected battery life (37 days). Of the 18 tags deployed on short-finned pilot whales, 17 were deployed on the fin or at the base of the fin. The remaining tag was successfully attached to the base of the dorsal fin, but was surmised to have been removed by a conspecific shortly following the deployment. Tags on short-finned pilot whales transmitted from 7.6 to 46.7 days, with a median of 21.7 days.

Movement patterns of the Cuvier's beaked whales varied, with 9 of the 12 individuals remaining within 100 km of the tagging location. Most of the tagged individuals remained largely on the continental slope, with only occasional movements off the slope (**Figure 21**). Overall movements were within the range of movements of this species tagged in previous years. A probability-density distribution from tag data obtained during all 5 years suggests that the core range for individuals tagged off the coast of Cape Hatteras is relatively small (50 percent core area = 1,600 km^2; **Figure 22**).

With data from 12 Cuvier's beaked whales satellite tagged in 2018, the sample size of movement data for this species off the eastern U.S. coast has increased by 41 percent. The combined sample of location data now represents 1,596 days of locations, the largest sample size of satellite tag data for this species anywhere in the world. The large number of tags deployed in 2018 reflects in part the high density of Cuvier's beaked whales off Cape Hatteras (McLellan et al. 2018). The primary factor limiting an even greater number of tag deployments on Cuvier's beaked whales off Cape Hatteras is the availability of suitable sea conditions for finding, approaching, and tagging this species. All of the tagged Cuvier's beaked whales spent all or most of their time in or near the core area of the animals tagged in previous years, staying near the continental slope off Cape Hatteras, with only 2 individuals moving along the shelf edge to any degree. This further emphasizes the importance of the study area to this species.

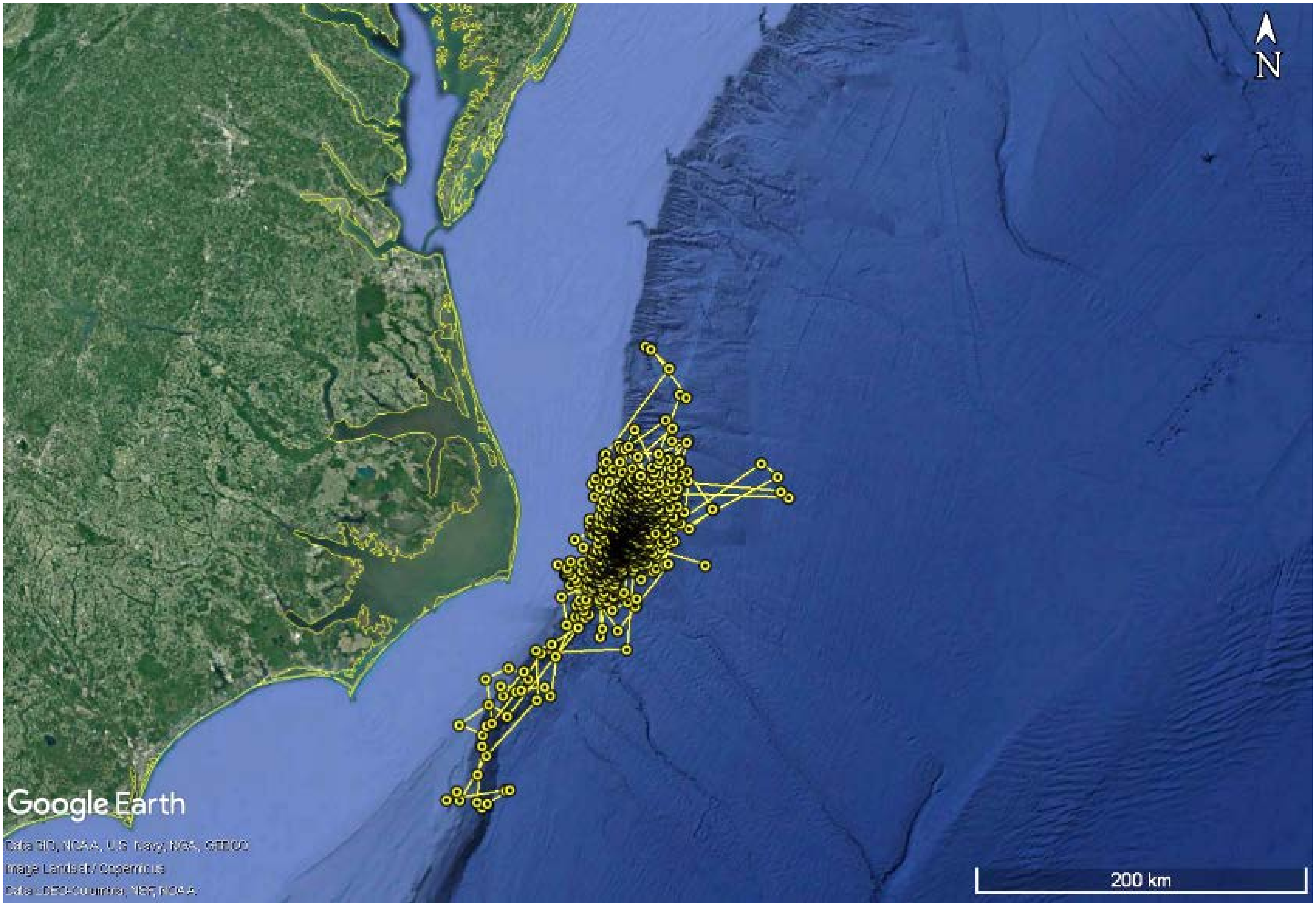

Figure 21. All filtered locations of Cuvier's beaked whales tagged in 2018 (*n*=12), with consecutive locations of each individual joined by a line.

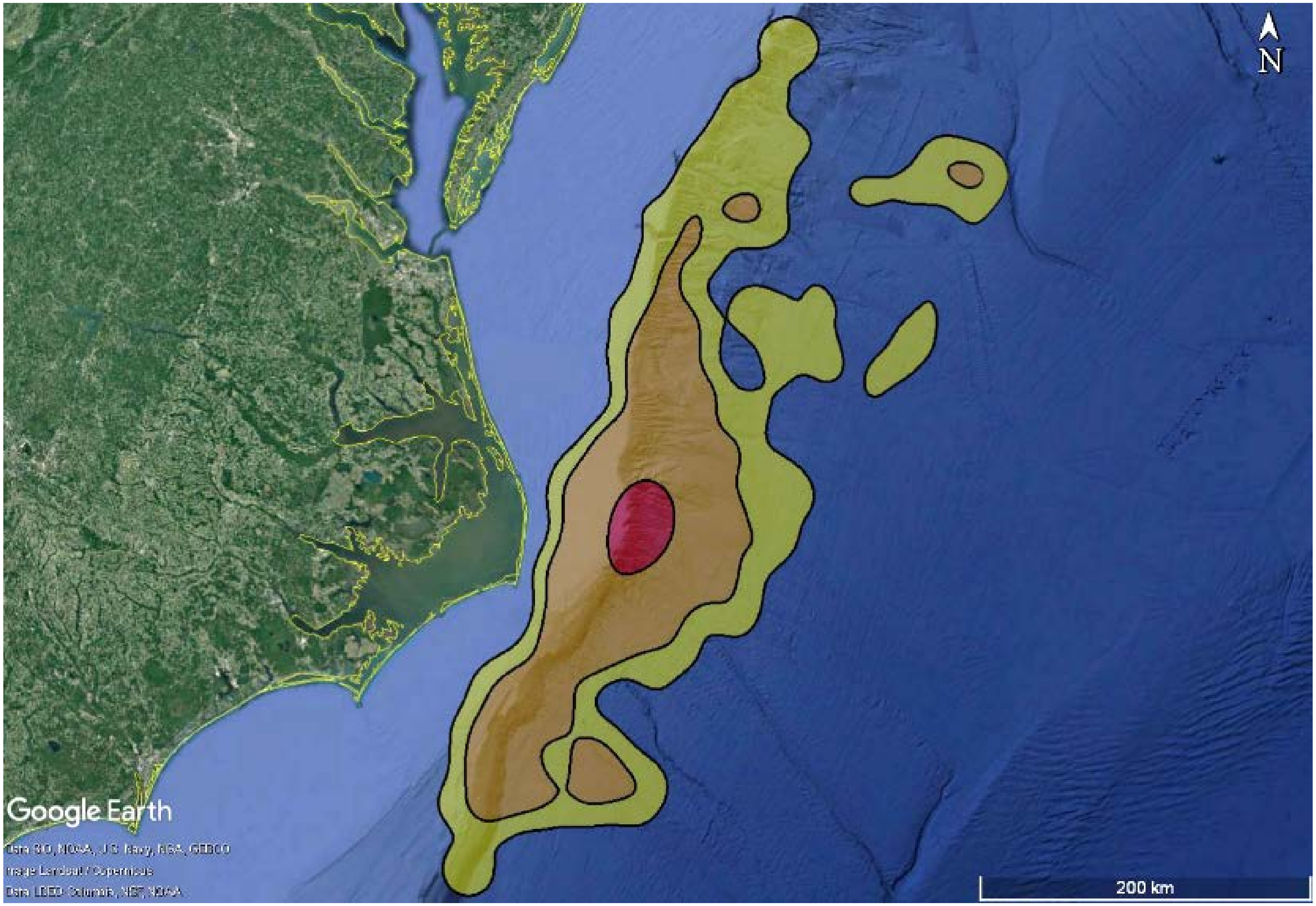

Figure 22. A probability-density representation of Cuvier's beaked whale location data, using only a single individual from each pair where individuals were acting in concert. The sample includes data from 34 individuals tagged off North Carolina: 2014 (*n*=3), 2015 (*n*=6), 2016 (*n*=5), 2017 (*n*=10), 2018 (*n*=10). The red area indicates the 50 percent density polygon (the "core range"), the orange represents the 95 percent polygon, and the yellow represents the 99 percent polygon.

Eighteen satellite tags were deployed on short-finned pilot whales (**Table 18**) during 15 different encounters. In 2 of 3 three encounters where pairs were tagged, the individuals acted independently, while in 1 of the 3, the individuals (GmTag206 and GmTag207) appeared to remain closely associated during the period of tag overlap. Mean and maximum distances moved varied considerably among individuals, as did the typical depths used, suggesting considerable variability in movement patterns and habitat use among short-finned pilot whale groups off the U.S. Atlantic coast. Several individuals remained strongly associated with the outer shelf and shelf break over the entire duration of tag attachment, while others had excursions off the shelf (GmTag199, GmTag200, GmTag210, and GmTag211, **Figure 23**). The timing of these offshore movements by these individuals appeared to be unrelated to the CEEs

A map showing combined track and location data from all short-finned pilot whales tagged off North Carolina in 2014 (*n*=17), 2015 (*n*=19), 2016 (*n*=9), 2017 (n=11), 2018 (n=17), and individuals tagged off Jacksonville, Florida, in 2016 (*n*=4) is shown in **Figure 24**. While the 99 percent probability density based on all 5 years covers a broad area (740,172 km^2), ranging from Florida to New York and into Canadian and international waters, the 50 percent core range of these individuals is small (19,688 km^2; **Figure 24**). This core range is centered off Cape Hatteras, North Carolina and extends up to the Norfolk Canyon, off the coast of Virginia. It should be noted that the 95 and 99 percent probability polygons include considerable areas not known to be habitat for short-finned pilot whales (i.e., shallow-water shelf and even some estuarine habitats), reflecting the wide shelf and steep slope along much of the eastern coast of the U.S. and the preference of this species for slope waters.

While the photo-ID work suggests that short-finned pilot whales display a high degree of site fidelity off Cape Hatteras, satellite tagging demonstrates that these animals cover a significant range north and south along the continental slope, and occasionally into offshore waters (**Figure 24**). Importantly, in 2018, 4 individuals were documented moving far offshore and primarily using pelagic waters. These individuals all eventually returned (or were returning) to slope waters. The considerable variability in movement patterns and habitat use likely reflects patterns that vary by social group and by responses to ephemeral oceanographic conditions (Thorne et al. 2017), and understanding site fidelity and association patterns determined through photo-ID will help in interpreting such variability.

Although it is approximately 15 times larger than that of Cuvier's beaked whales, the core range of short-finned pilot whales is centered in the same area as Cuvier's beaked whales (**Figures 22 and 25**). More study is necessary to determine the structure and habitat use of these stocks, but the importance of the continental slope to the east of Cape Hatteras is apparent as sample sizes increase.

For more information on this study, refer to the annual progress report for this project (Baird et al. 2019).

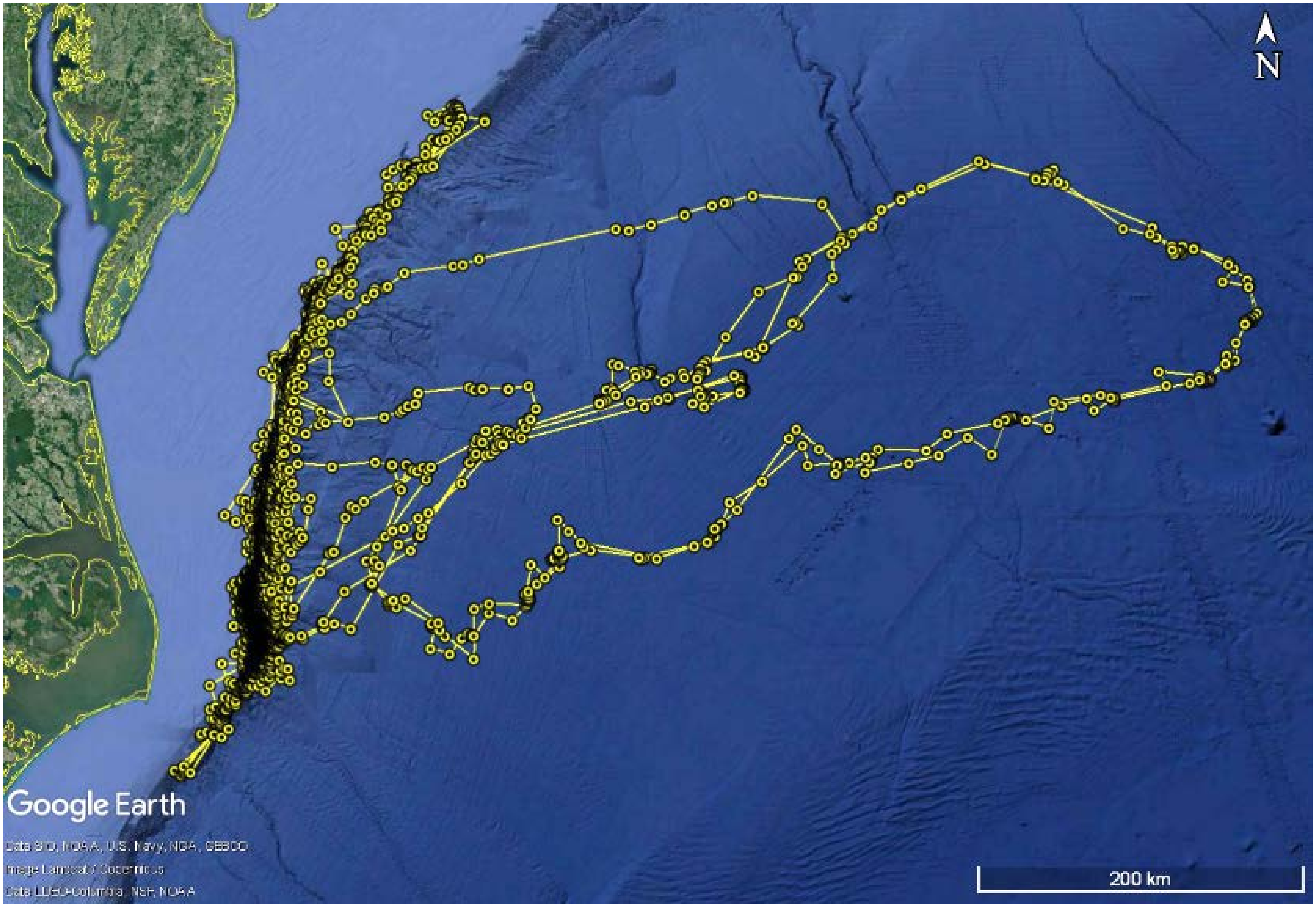

Figure 23. All filtered locations of short-finned pilot whales tagged off North Carolina in 2018, with consecutive locations of each individual joined by a line.

Figure 24. All filtered locations of short-finned pilot whales tagged off North Carolina in 2014 (*n*=17), 2015 (*n*=19), 2016 (*n*=9), 2017 (*n*=11), and 2018 (*n*=17), and off Jacksonville, Florida, in 2016 (*n*=4), with consecutive locations of each individual joined by a line. Only tag attachment durations of >1 day are shown.

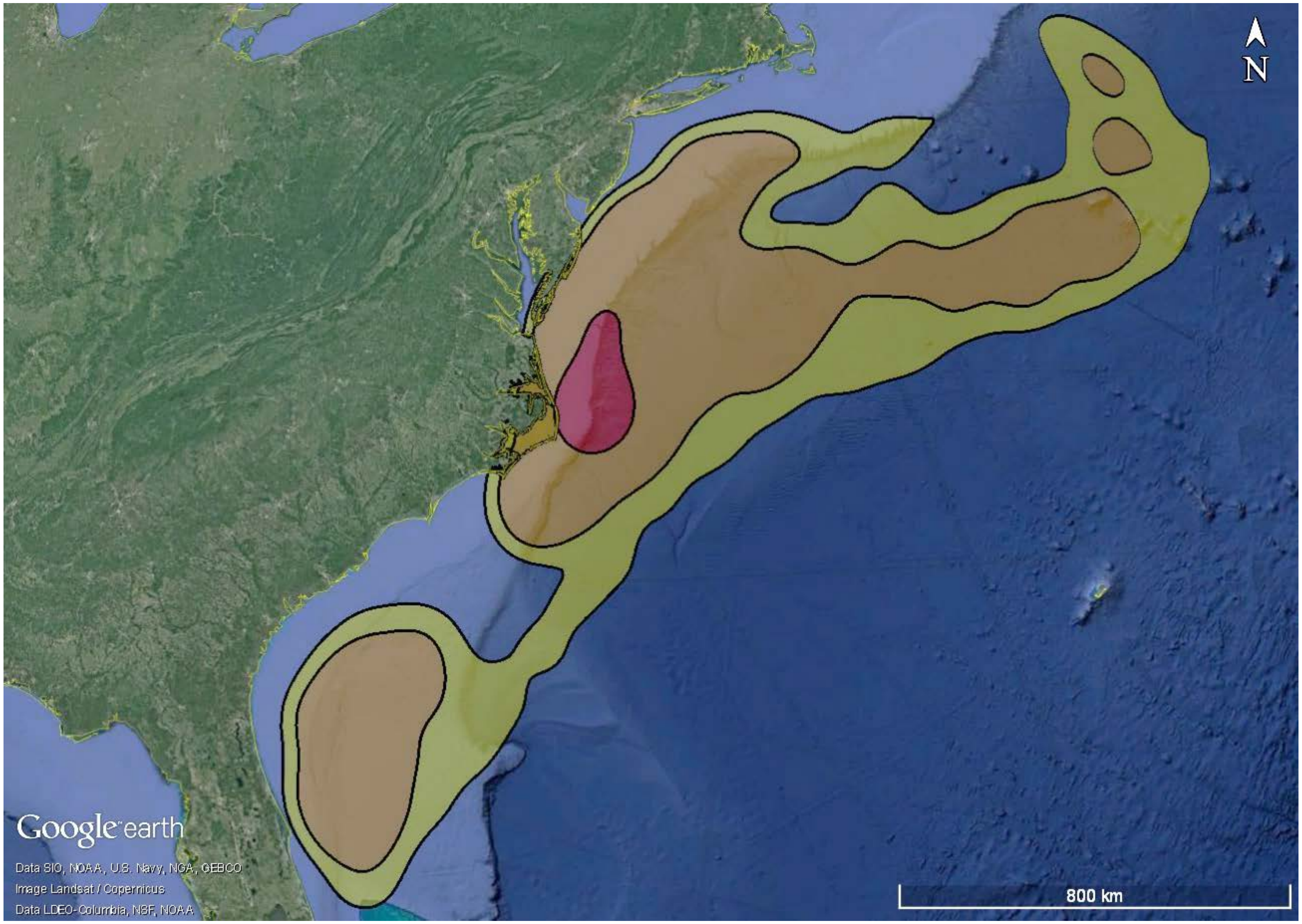

Figure 25. A probability-density representation of short-finned pilot whale location data, including individuals tagged off North Carolina in 2014 (*n*=14), 2015 (*n*=17), 2016 (*n*=5), 2017 (*n*=9) and 2018 (*n*=15), as well as Jacksonville, Florida, in 2016 (*n*=2). For pairs of individuals acting in concert, only one individual from each pair was used. Only tag attachment durations of >1 day are included. The red area indicates the 50 percent density polygon (the "core range"), the orange represents the 95 percent polygon, and the yellow represents the 99 percent polygon.

2.2.2 North Atlantic Right Whale Monitoring

NARWs migrate to coastal waters off Florida and Georgia during the winter months. The planned construction and operation of a USWTR off the Atlantic coast of Florida could result in interactions with right whales on their winter calving ground. Aerial- and vessel-based visual surveys, as well as passive acoustic monitoring, are currently being used to detect NARWs in the coastal waters of Florida and Georgia, as well as in offshore areas near the planned USWTR.

Currently there is minimal data on the movement patterns of individuals, including movement rates (either north-south or east-west), dive depths, and dive durations. The vocalization rates of individual NARWs on these wintering grounds also are poorly understood. A targeted tagging program is in progress to address these knowledge gaps by collecting horizontal-movement, dive-profile, and vocal behavior from individual whales. These data are important to inform monitoring and mitigation techniques and to increase the U.S. Navy's understanding of the potential for disturbance to NARWs as USWTR construction and training operations commence. The field team includes members from Duke University and Syracuse University. Fieldwork has been conducted out of Fernandina Beach, Florida, during February 2014, February–March 2015, January–February 2016, February 2017, and February 2018.

In 2018, the field team was on standby prepared to deploy tags if either the small-vessel or the Early Warning System aerial survey team was to spot a right whale; however, no right whales were sighted on these offshore survey days. Due to the lack of animals on the winter breeding grounds, no fieldwork was attempted, and thus no tags deployed. Despite the lack of new data, additional work and analyses were undertaken focused on sound-propagation modeling, creating and testing algorithms for detection and classification of right whale calls, and individual distinctiveness of right whale calls. Audio recordings from the DTAGs were reviewed visually and aurally in Raven Pro 1.5 (Cornell Bioacoustics Research Program, Ithaca, New York) for evidence of any right whale "upcalls." These detailed analyses have identified novel, previously undescribed call types, produced by NARW mother-calf pairs on the calving grounds. All of these new call types are low amplitude, and are not detectable except in close proximity to the whales. These calls have not been detected from vessel-based towed-array surveys from a previous study. These new calls will not be useful for passive acoustic monitoring, but do identify a mode of communication between mothers and their calves that may be impacted by noise in the environment and warrant further exploration of their function. A manuscript is planned for submission to a peer-reviewed journal in 2019 to publish these findings. These results indicate that whales of all age and sex classes spend most of their time out of visual detection range of either vessel or aerial surveys, which impacts detectability on the calving grounds. Additional analyses exploring swimming activities sub-surface, (i.e., stationary vs. active directional swimming) are being completed before submission of a manuscript to a peer-reviewed journal planned for 2019. A sixth year of fieldwork is currently ongoing in February 2019 with a focus on increasing the sample size of tagged individuals, with an emphasis on single animals (not mother-calf pairs) when feasible. For more information on this study, refer to the previous annual progress report for this project (Nowacek et al. 2018).

An autonomous Slocum G2 glider equipped with passive acoustic monitoring and near real-time reporting capabilities was also deployed in January 2018 to potentially detect right whales in the Mid-Atlantic offshore of the Virginia/North Carolina region during the migration period (**Figure 26**). The glider was programmed to travel between specified waypoints and can also be remotely piloted. The Low Frequency Detection and Classification System (LFDCS, Baumgartner and Mussoline 2011) is also capable of detecting humpback, fin, and sei whales along its journey. Details of detections can be found on the deployment project page at Robots4Whales. Tentative plans are to continue similar deployments in the coming years.

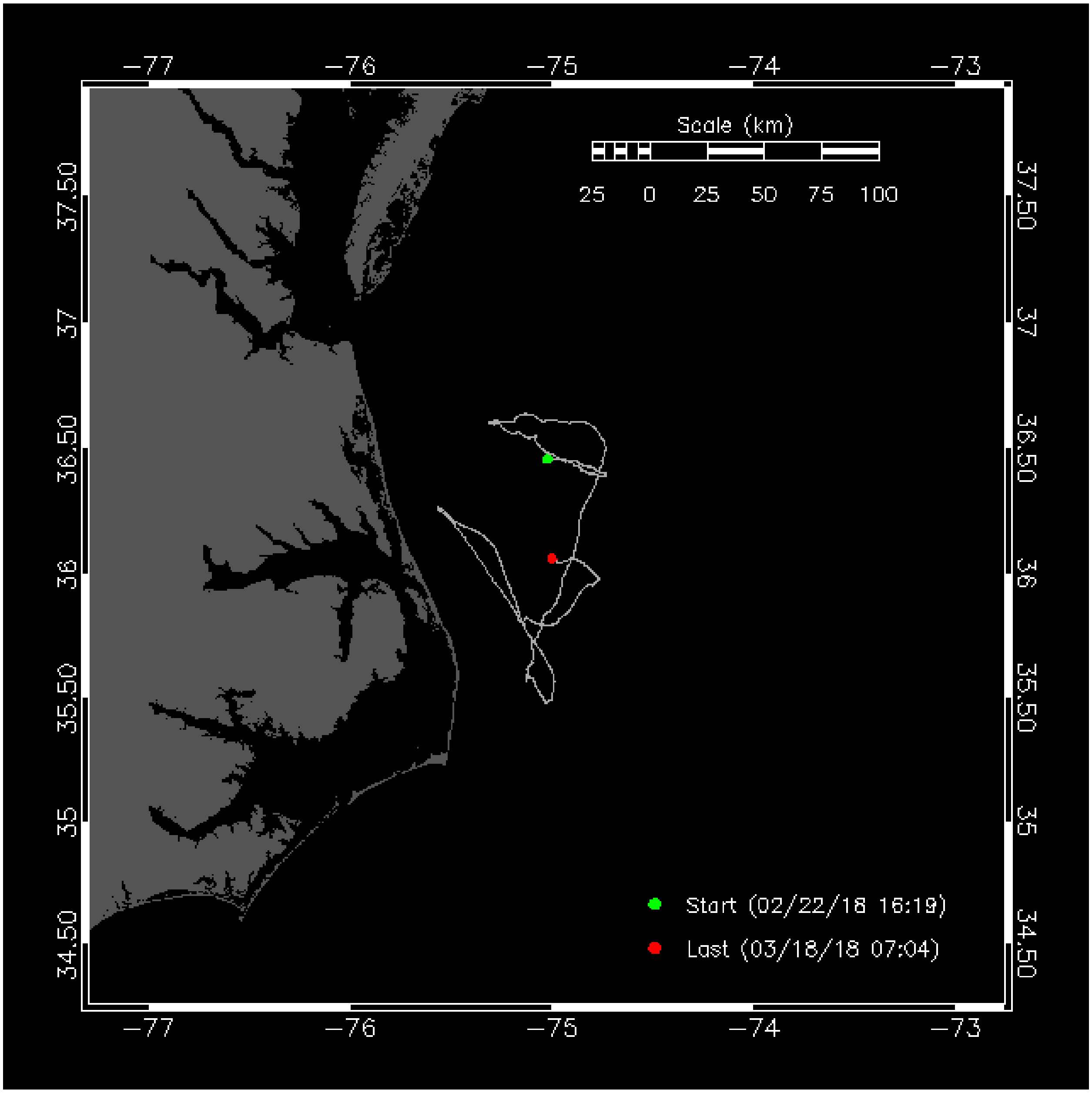

Figure 26. Map showing the trackline of the Slocum G3 glider in the northern Mid-Atlantic Bight.

2.2.3 Mid-Atlantic Humpback Whale Monitoring

During the winter, humpback whales migrate to the West Indies from feeding grounds in the Gulf of Maine, the Gulf of St. Lawrence, Newfoundland/Labrador, western Greenland, Iceland, and Norway (Katona and Beard 1990, Christensen et al. 1992, Palsbøll et al 1997). However, some whales overwinter in the mid-Atlantic region, which may serve as a supplemental feeding ground (Barco et al. 2002). Information on the movements of individuals within this region, particularly in U.S. Navy training ranges and high-traffic areas in the Chesapeake Bay and mid-Atlantic coastal waters, has historically been limited (see Swingle et al. 1993, Wiley et al. 1995, Barco et al. 2002).

Since January 2015, HDR Inc. has been monitoring humpback whales to assess their occurrence, habitat use, and behavior in and near U.S. Navy training and testing areas off Virginia. These baseline data are critical for assessing the potential for disturbance to humpback whales in this portion of the mid-Atlantic. Although humpback whales are the target of this study, data on other high-priority baleen whale species are collected when possible.

Five field seasons of dedicated surveys have been conducted to date, with the most recent season underway as of November and completed in May 2019. During the initial field season (January–May 2015), vessel and aerial surveys were conducted in conjunction with photo-ID, focal-follow, and biopsy-sampling techniques to obtain baseline data on humpback whales in the region (Aschettino et al. 2015). Data from that field season also included humpback whale sightings recorded during concurrent density surveys in December 2014 (Engelhaupt et al. 2016). The 2015/2016 field season (December 2015–May 2016) consisted only of nearshore vessel surveys to collect biopsy samples of humpback whales, as well as photo-ID and focal-follow data from humpback whales and other high-priority baleen whale species, particularly in U.S. Navy training areas (e.g., W-50 Mine-neutralization Exercise [MINEX] zone) and shipping channels (Aschettino et al. 2016). Wildlife Computers (Redmond, WA) Smart Position and Temperature- (SPOT)-6 Argos-linked satellite tags were deployed during that field season to better understand the movement patterns of humpback whales off Virginia Beach, specifically in areas of high shipping traffic and live-fire exercises. Research efforts for the 2016/2017 field season (November 2016–March 2017) included the use of nearshore vessel surveys to collect photo-ID data and biopsy samples and to deploy additional SPOT-6 satellite tags (Aschettino et al. 2017). SPLASH10-F Fastloc® GPS tags were also introduced to the project during the end of the season to test their functionality. Field effort for 2017/2018 ran from October 2017 to March 2018 with an additional emphasis on increased survey effort in the W-50 MINEX zone and farther offshore (Aschettino et al. 2018). Results from the 2018/2019 season are summarized below.

Survey Effort

HDR conducted 28 nearshore vessel surveys for humpback whales between 23 November 2018 and 20 May 2019, as well as one anomalous survey conducted on July 31, 2018. Over 170 hours of survey effort was completed and 3,147 km of trackline was covered (**Figure 27**).

Sightings

A total of 64 sightings of humpback whales was recorded during the 2018/2019 survey season. Additional baleen whale sightings included 6 sightings of minke whales (**Figure 27**). Thirty-three (47.1 percent) of the 70 total whale sightings were in the shipping lanes, and 4 (13.3 percent) occurred in the W-50 MINEX zone (all humpback whales). Sightings of non-target species (i.e., common bottlenose dolphins) were also recorded but are not presented in the findings.

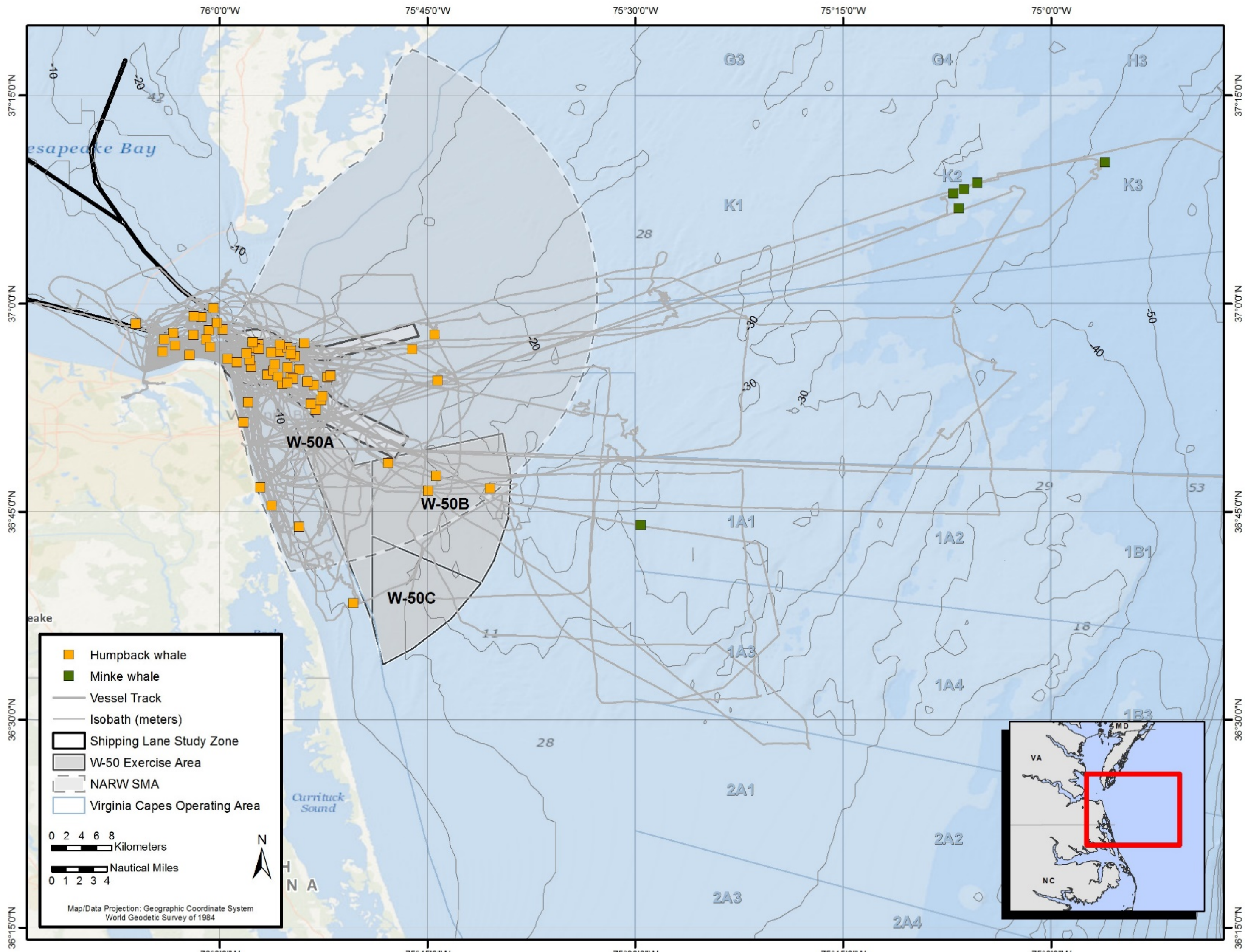

Figure 27. Nearshore survey tracks and locations of all humpback (*n*=64) and minke (*n*=6) whale sightings from 31 July 2018 through 20 May 2019.

Photo-identification

The 64 sightings of 80 total individual humpback whales included 32 unique humpback whales identified using dorsal fin and fluke images. An additional five unique whales were identified during offshore surveys conducted as part of the Outer Continental Shelf Break Cetacean Study (see Engelhaupt et al. 2017). Twenty-six (70.0 percent) of all identified humpback whales were categorized as juveniles based on their estimated sizes, while 7 (18.9 percent) were categorized as sub-adults or adults, 1 (2.7 percent) was categorized as an adult, and 3 (8.1 percent) were not assigned an age class. Five (13.5 percent) of the 37 individuals were re-sights from previous field seasons. The remaining 32 whales were new individuals added to HDR's growing catalog, which, currently has 160 unique humpback whales. Seventeen of the 37 (45.9 percent) humpback whales were seen on more than one occasion during the 2018/2019 field season.

Biopsy Samples

Nine biopsy samples were collected from humpback whales during the 2018/2019 field season and are awaiting analysis along with samples collected during the 2017/2018 and 2016/2017 seasons. Thirty-one samples (29 humpback and 2 fin whale samples) from the 2014/2015 and 2015/2016 field seasons were processed at Duke University for stable-isotope analysis. The stable-isotope signatures for all samples were comparable to those reported for other regions of the North Atlantic (Waples 2017). There were significant differences in both $\delta^{13}C$ and $\delta^{15}N$ values between the humpback and fin whales in the study area. The humpback whales were slightly more depleted in carbon and had significantly higher $\delta^{15}N$ signatures than the fin whales. The humpback whales had a mean $\delta^{15}N$ value of 14.6 (*SE*=0.9) compared to the fin whales' value of 10.5 (*SE*=0.0). Given a difference in $\delta^{15}N$ values between the 2 species of 4.1 percent, it is likely that the humpback whales are feeding at a higher trophic level than the fin whales in this area (Waples 2017).

Genetic analyses identified 14 female and 15 male humpback whales from these samples. There were no significant differences in $\delta^{13}C$ values between male and female humpback whales, but females did have significantly lower $\delta^{15}N$ values than males, indicating that the diets of the 2 sexes may differ in this area (Waples 2017). These biopsy samples will also be provided to the University of Groningen in the Netherlands for genetic analysis and integration into a larger North Atlantic humpback whale population study.

Tagging

Eight SPOT-6 and 2 SPLASH10-F Argos-linked satellite tags were deployed on humpback whales during the 2018/2019 field season (**Table 17**). The tags transmitted between 3.2 and 13.3 days (mean=10.4 days). Whales tagged during this field season showed varied movement strategies, with some exclusively spending time in the primary study area and others moving out of the study area and further offshore or to the north or south (**Figure 28**). One of the tagged humpback whales was also tagged during the 2016/2017 field season and exhibited similar movement patterns, spending considerable time within the Chesapeake Bay mouth shipping channels, during both deployments, although tag duration was short (n-3.2 and 5.2 days, respectively) (**Figure 29**).

Table 17. Satellite tag deployments on humpback whales during the 2018/2019 field season.

Species[1]	Animal ID	Estimated Age Class	Tag Type	Argos ID	Deployment Date	Last Transmission Date	Tag Duration (Days)
Mn	HDRVAMn132	Juvenile	SPOT-6	171878	31-Jul-2018	11-Aug-2018	10.7
Mn	HDRVAMn136	Juvenile	SPOT-6	173180	30-Dec-2018	06-Jan-2019	6.9
Mn	HDRVAMn146	Juvenile	SPOT-6	173181	04-Jan-2019	18-Jan-2019	13.3
Mn	HDRVAMn093	Juvenile	SPLASH10-F	172533	08-Jan-2019	12-Jan-2019	3.2
Mn	HDRVAMn151	Juvenile	SPOT-6	168230	31-Jan-2019	14-Feb-2019	13.3
Mn	HDRVAMn153	Juvenile	SPLASH10-F	173185	03-Feb-2019	17-Feb-2019	13.3
Mn	HDRVAMn154	Juvenile	SPOT-6	94814	03-Feb-2019	17-Feb-2019	13.2
Mn	HDRVAMn152	Juvenile	SPLASH10-F	178207	02-Mar-2019	13-Mar-2019	10.2
Mn	HDRVAMn162	Juvenile	SPOT-6	180409	25-Apr-2019	06-May-2019	10.5
Mn	HDRVAMn162	Juvenile	SPOT-6	180410	04-May-2019	13-May-2019	9.3

[1] Mn = *Megaptera novaeangliae* (humpback whale); Bp = *Balaenoptera physalus* (fin whale)

In January 2019, Duke University researchers initiated a concurrent archival tagging project on whales around the shipping lanes in the Chesapeake Bay study area. High-resolution archival acoustic and movement recording tags (DTAGs) will be deployed on overwintering humpback whales to better understand the factors that influence their responses to approaching vessels. More information about this project can be found in **Section 2.3.2**.

Switching-State-Space Modeling

State-space modeling was performed on data from all humpback whale satellite tags deployed prior to the 2017/2018 field season (*n*=35). These analyses were intended to be exploratory in nature and provide initial inference on animal behavior and residency. Follow-on analysis for additional tags and more complex modeling approaches will occur in the future, following the 2019/2020 field season. It was decided that a two-state model, nominally traveling and area-restricted search (ARS), would be the best first approach to inferring animal behavior from Argos data.

Estimated locations were classified into behaviors based on the mean predicted behavioral state from the model runs. Values less than 1.25 were classified as traveling. Values greater than 1.75 were classified as ARS. Values in between were classified as indeterminate behavior. After examining all candidate models, a model with a 3-hr time interval and a span parameter of 0.1 was selected as the best model. Parameter convergence was generally good, and the tracks were not overly smoothed between reported locations.

Of 3,714 modeled locations, 458 were identified as traveling, 211 were of indeterminate behavior, and the remaining 3,045 were identified as ARS, which likely represented foraging (**Figure 30**). Location predictions did not cut across land significantly. As such, no locations were dropped from the model output.

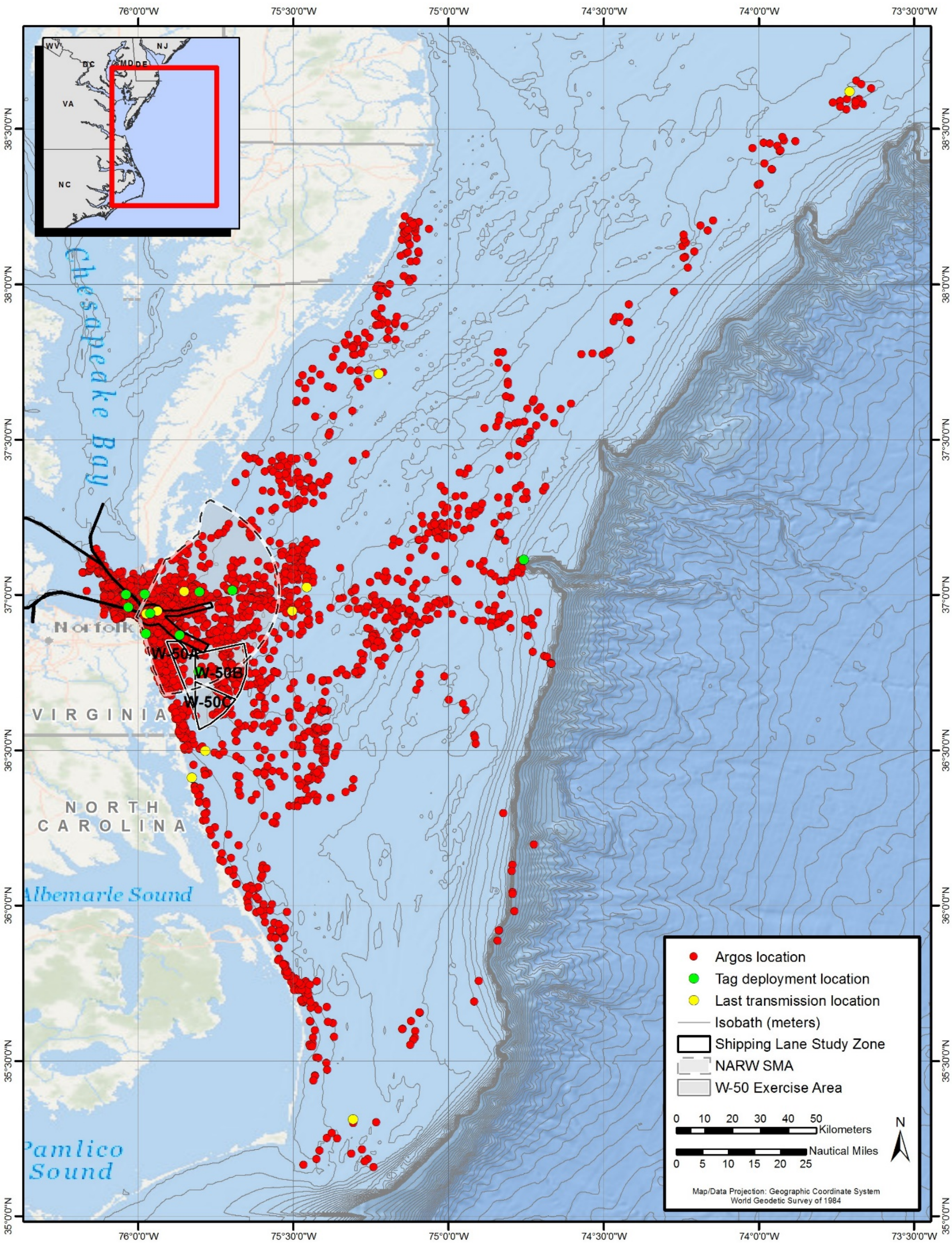

Figure 28. Argos locations for all humpback whales (*n*=10) tagged during the 2018/2019 field season.

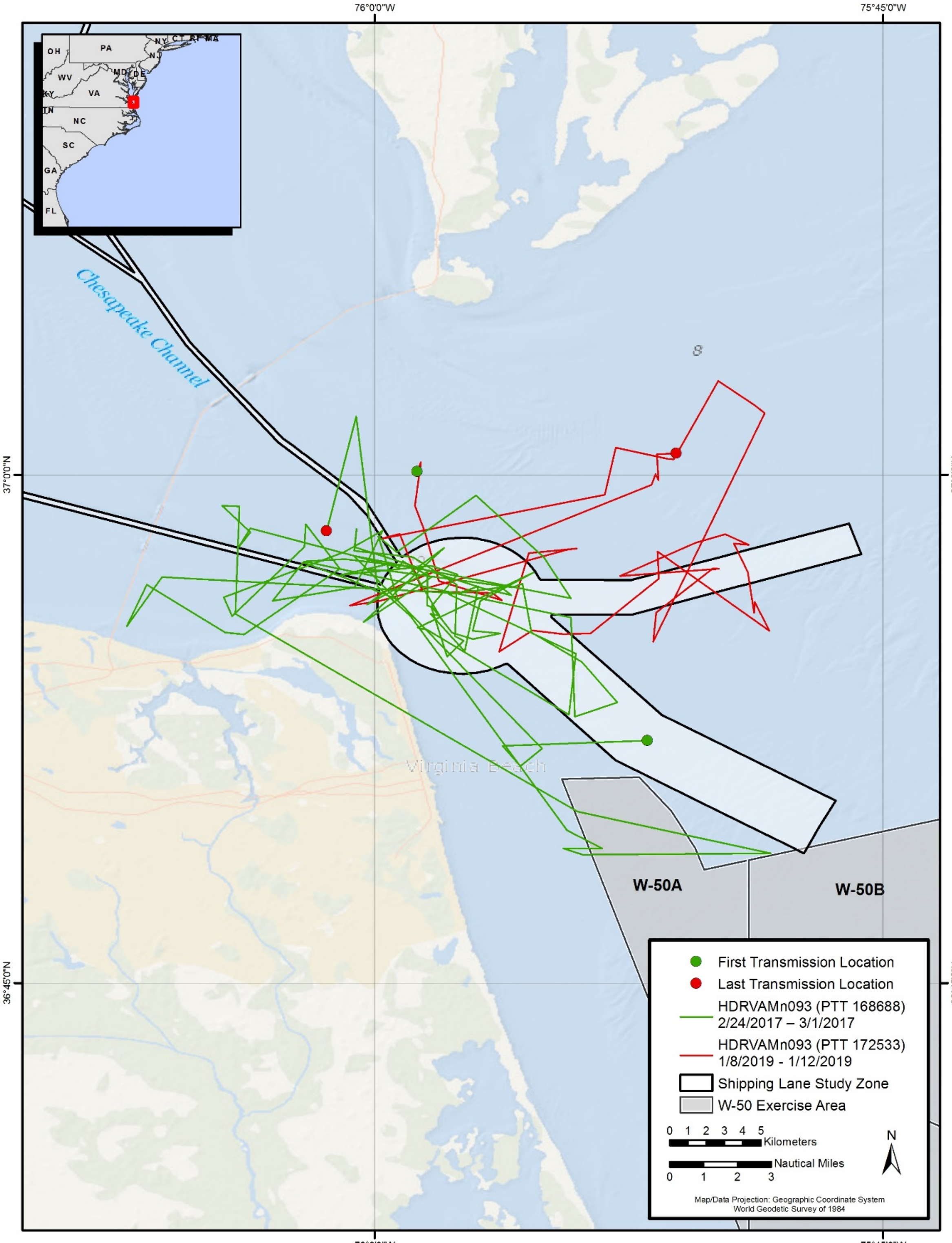

Figure 29. Comparison of the tracks of HDRVAMn093 between 2017 (green trackline, 5.2 days) and 2019 (red trackline, 3.2 days).

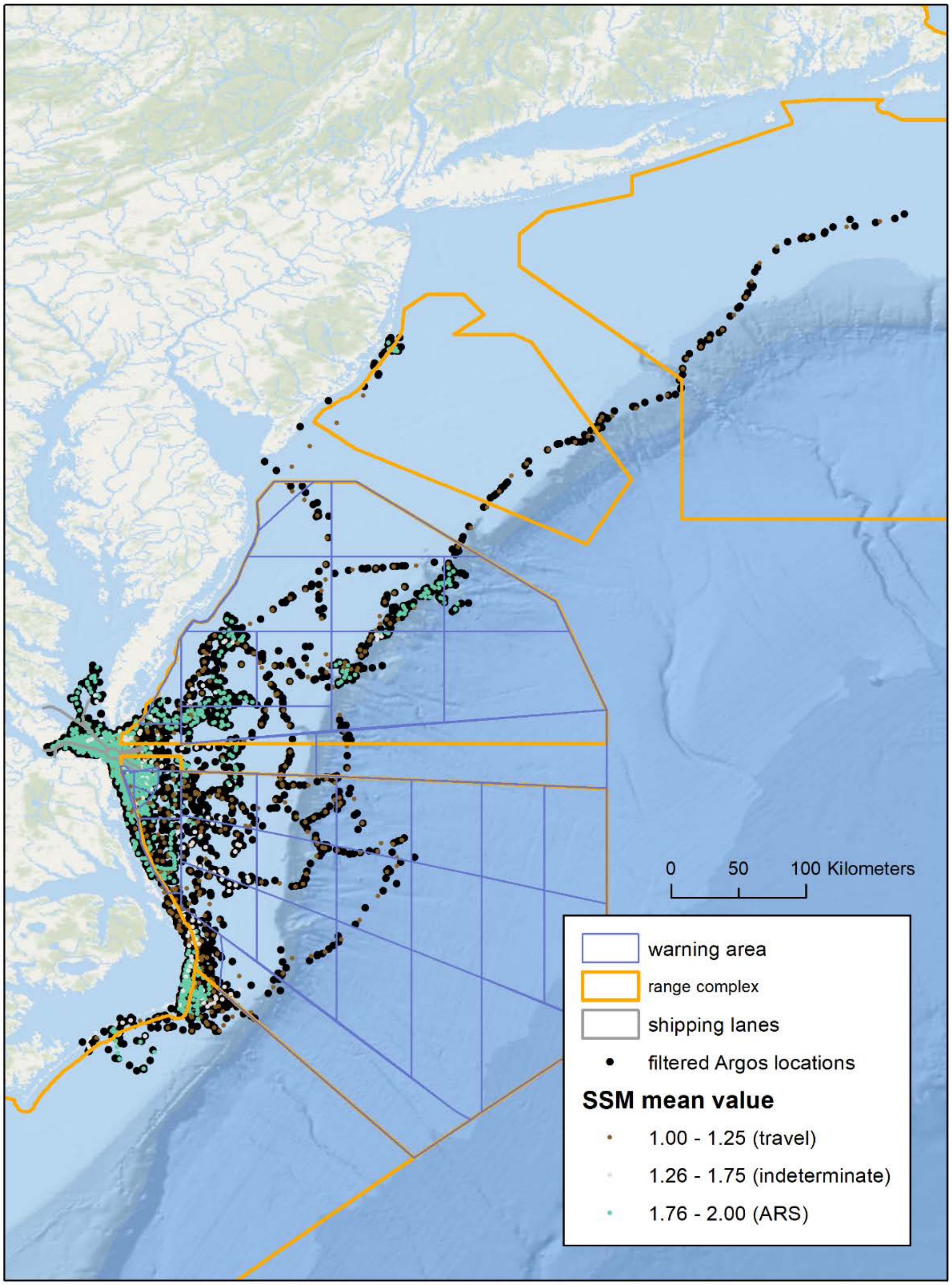

Figure 30. State-Space Modeling results for all tagged whales through the end of the 2016/2017 field season showing travel (brown dots), area-restricted search (green dots), and the indeterminate state (white dots).

Results

Data analyses for this study are ongoing. Preliminary results indicate some site fidelity to the study area for individual humpback whales and a high level of occurrence within the shipping channels, which are important high-use areas for both the U.S. Navy and commercial traffic. A smaller number of animals are also spending time in or near the W-50 MINEX zone and the offshore VACAPES OPAREA, where they are presumably within the hearing range of underwater detonation training exercises. Vessel interactions in the study area are still a concern for humpback whales. Approximately 9 percent of the individual humpback whales in the HDR catalog have scars or injuries indicative of propeller or vessel strikes or from line entanglements. Throughout this study, individual humpback whales have been observed with boat injuries or have been found dead with evidence of vessel interactions being the likely cause. In April 2017, NMFS declared an Unusual Mortality Event for humpback whales in the Atlantic from Maine to North Carolina based on elevated mortalities of this species since January 2016. Some of the whales examined thus far have exhibited evidence of pre-mortem vessel strike, but the Unusual Mortality Event investigation process is ongoing.

Approximately three quarters of the humpback whales seen during the 5 years of effort on this project appear to be juveniles, which is consistent with historic stranding and observational data collected in this area (e.g., Swingle et al. 1993, Wiley et al. 1995). Sightings of sub-adult-sized humpback whales have been highest early in the field seasons and in waters farther from shore. They are typically not re-sighted during a field season, suggesting that these whales may be passing through the area rather remaining in the primary study area for long durations. Because the juveniles are spending more time in the study area than larger animals, they may be at greater risk for injury (Aschettino et al. 2018).

For more information on this study, refer to the annual progress report for this project (Aschettino et al. 2019).

2.2.4 VACAPES Outer Continental Shelf Break Cetacean Study

Since 2012, HDR has collaborated with the U.S. Navy to conduct marine mammal surveys near Naval Station Norfolk, Joint Expeditionary Bases-Little Creek and Fort Story, and Naval Air Station Oceana Dam Neck Annex, and within the W-50 MINEX zone (Engelhaupt et al. 2016). However, relatively limited survey effort has occurred farther offshore of the Virginia coast—in the VACAPES OPAREA near the continental shelf break. Therefore, there are limited data and information on how offshore species, including beaked whales, endangered fin and sperm whales, and other large baleen whales utilize the deeper waters of this region. Vessel surveys for the VACAPES Outer Continental Shelf Cetacean Study were initially conducted from April 2015 through June 2016 in association with the Mid-Atlantic Humpback Whale Monitoring project (Aschettino et al. 2016) and became a dedicated study in July 2016 (Engelhaupt et al. 2017), followed by a second dedicated year of surveys through all of 2017 (Engelhaupt et al. 2018). The goal of this study is to determine the seasonal occurrence, movement patterns, site fidelity, behavior, and ecology of cetaceans in VACAPES OPAREA offshore waters. During the vessel surveys, researchers utilize a combination of techniques including focal follows, photo-ID, biopsy sampling, and satellite tagging. Data collected during the 2018 field season are summarized below.

Survey Effort

HDR conducted 14 offshore vessel surveys in 2018, covering 4,570 km of trackline. Surveys were conducted at least once per month in all months except January, March, July, and November, during which weather conditions prevented survey effort. The study area is located approximately 90 to 160 km off the Virginia coast, encompasses Norfolk and Washington Canyons, and ranges in depth from less than 100 m to over 2,000 m.

Sightings

A total of 187 marine mammal sightings and 36 sea turtle sightings was recorded during these vessel surveys (**Figure 31**). Fifteen cetacean taxa were identified: unidentified pilot whale (*Globicephala* sp.) (*n*=35), fin whale (*n*=34), common bottlenose dolphin (*n*=29), common dolphin (*n*=28), Risso's dolphin (*n*=11), humpback whale (*n*=8), sperm whale (*n*=8), Atlantic spotted dolphin (*n*=7), short-finned pilot whale (*n*=6), minke whale (*n*=2), North Atlantic right whale (*n*=2), pygmy sperm whale (*n*=2), Sowerby's beaked whale (*n*=2), striped dolphin (*n*=1), blue whale (*n*=1), and dwarf sperm whale (*n*=1). In addition, there were 10 sightings of unconfirmed species: unidentified dolphin (*n*=5), unidentified large whale (*n*=2), unidentified cetacean (*n*=1), unidentified medium whale (*n*=1), and unidentified beaked whale (*n*=1). Two sea turtle taxa were identified: loggerhead turtle (*n*=22) and leatherback turtle (*n*=12), and there were also 2 unconfirmed sightings: unidentified hardshell turtle (*n*=1) and unidentified turtle (*n*=1).

As expected, sightings of deep-diving species, including sperm and pilot whales, were concentrated near and farther offshore of the continental shelf break, while baleen whale sightings were recorded both on and offshore of the shelf. Coverage during 2018 included more time in waters deeper than 1,500 m than in previous seasons, resulting in more sightings of beaked whales and other deep-diving species. Dolphin species were sighted throughout the core study and transit areas, and sea turtles were only sighted over the shelf in waters shallower than 150 m, with the exception of one loggerhead sea turtle sighted in deep water. Marine mammal sightings in U.S. Navy ranges in and around the Norfolk Canyon were frequent, showing the potential for overlap between these species and U.S. Navy training activities, as well as recreational and commercial fishing activities.

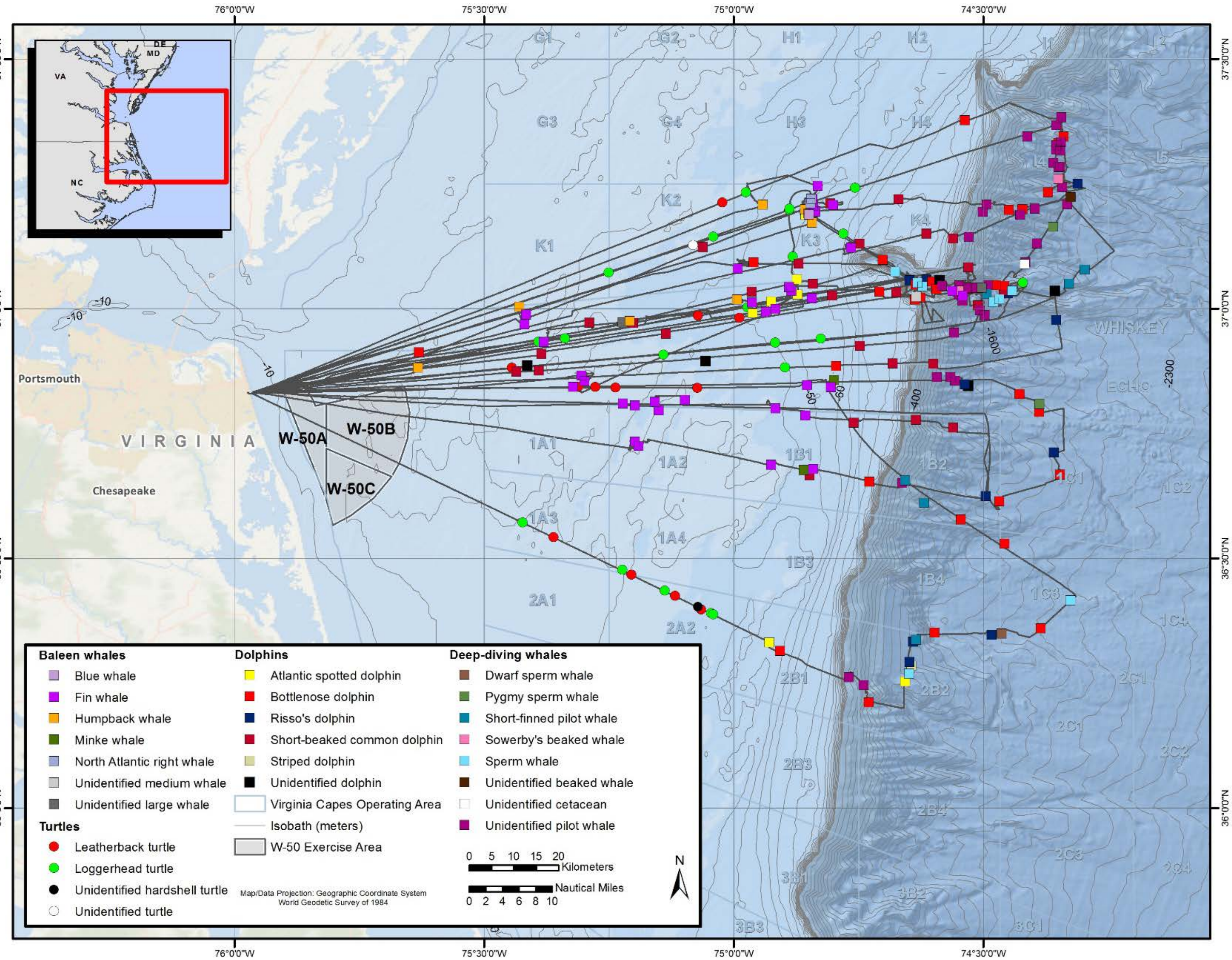

Figure 31. All tracklines and sightings of marine species for the 2018 field season.

Photo-ID

Photo-ID images were collected during 120 of the 187 marine mammal sightings. Baleen and sperm whale images were added to HDR's existing catalogs, which now contain 69 fin whales, 10 minke whales, 2 sei whales, and 59 sperm whales. Of the 69 identified fin whales, 13 (19 percent) have been re-sighted; 9 (13 percent) of them during different years ranging from 247 to 355 days between first and last sightings. Locations of all re-sighted fin whales were in water over the continental shelf inshore of the200-m depth contour. Seven of the 59 identified sperm whales (12 percent) were sighted on more than on more than one day, ranging from 9 to 428 days between sightings. Humpback whale images were incorporated into the existing nearshore catalog (Aschettino et al. 2019), adding 9 new whales and a re-sighting for a known individual, HDRVAMn049, sighted during nearshore surveys since December 2015. New HDR catalogs were created for NARWs (containing 2 individuals from vessel surveys but a total of 6 whales including aerial sightings (Cotter 2019), and Sowerby's beaked whales (containing 6 whales). Images of pilot whales through the 2016 field season were shared with Duke University for matching to their existing catalog of pilot whales from Cape Hatteras, North Carolina, yielding 24 matches between individual pilot whales sighted off Virginia and Cape Hatteras. Images of other odontocete species have been archived for future processing.

Biopsy Samples

Three biopsies were collected from fin whales, and 7 from sperm whales. A biopsy was also collected from a humpback whale, and one sloughed skin sample was collected from a sperm whale. The humpback whale sample was added to those collected during the nearshore humpback survey effort, and the fin and sperm whale samples are currently being processed. Gender results from 2017 and 2018 sperm whale samples show 3 females and 10 males, but no other results are available at the time of this summary.

Tagging

Seventeen satellite tags were deployed in 2018: 9 on sperm whales, 5 on fin whales, 2 on humpback whales, and 1 on a Sowerby's beaked whale (**Table 18**). The humpback tag data will be included in the nearshore humpback reports and therefore have been excluded from this summary. Tag duration ranged from 11.9 to 33.2 days (mean=21.4) for sperm whales and from 9.0 to 41.0 days (mean=21.1) for fin whales. The Sowerby's beaked whale tag lasted 14.5 days. The SPLASH10 and SPLASH10-F LIMPET tags recorded dive depths and duration in addition to providing locations. Sperm whale maximum dive depth ranged from 1,151 to 2,127 m, and maximum dive duration ranged from 51 to 70 min. In comparison, fin whale maximum dive depths were much shallower and ranged from 39 to 76 m, and maximum dive duration from 9 to 13 min. The Sowerby's beaked whale maximum dive depth was 871 m and maximum dive duration was 39 min.

Locations from satellite-tagged whales showed movements through numerous U.S. Navy ranges, both over the continental shelf and beyond the slope. Sperm whale movements varied, with some individuals showing little movement from their initial tagging location in the VACAPES OPAREA (e.g., **Figure 32**), and others moving greater distances to the north or south, generally along the continental shelf edge and slope. Movements ranged north through the Atlantic City and Narragansett Bay OPAREAs and south to deep waters off North Carolina in the Cherry Point OPAREA (e.g., **Figure 33**). Fin whale movement patterns from 2018 tags showed that most time was spent on the continental shelf in the VACAPES OPAREA, with 2 individuals moving north to the Atlantic City OPAREA. (**Figure 34**). The tag locations of the Sowerby's beaked whale showed movement remained in waters deeper than 1,000 m within the VACAPES OPAREA during nearly the entire tag duration (**Figure 35**).

Table 18. Satellite tag deployments on sperm and fin whales during 2018.

Species[1]	Animal ID	Tag Type	Deployment Date	Last Transmission Date	Tag Duration (Days)
Pm	HDRVAPm032	SPLASH10	22-Apr-18	15-May-18	22.21
Pm	HDRVAPm033	SPOT-6	22-Apr-18	26-May-18	33.17
Pm	HDRVAPm034	SPLASH10	22-Apr-18	15-May-18	22.17
Pm	HDRVAPm035	SPLASH10	01-May-18	24-May-18	22.20
Pm	HDRVAPm010	SPLASH10-F	25-May-18	06-Jun-18	11.91
Pm	HDRVAPm012	SPLASH10	25-May-18	16-Jun-18	19.82
Pm	HDRVAPm036	SPOT-6	25-May-18	24-Jun-18	29.94
Pm	HDRVAPm039	SPOT-6	25-May-18	10-Jun-18	15.89
Pm	HDRVAPm041	SPLASH10	06-Aug-18	21-Aug-18	14.99
Bp	HDRVABp046	SPLASH10-F	22-Apr-18	16-May-18	15.44
Bp	HDRVABp047	SPOT-6	22-Apr-18	22-May-18	29.75
Bp	HDRVABp048	SPLASH10-F	22-Apr-18	02-Jun-18	40.97
Bp	HDRVABp060	SPLASH10-F	01-May-18	11-May-18	9.02
Bp	HDRVABp050	SPOT-6	01-May-18	11-May-18	10.10
Mb	HDRVAMb001	SPLASH10	07-Sep-18	22-Sep-18	14.51

[1] Pm = *Physeter macrocephalus* (sperm whale); Bp = *Balaenoptera physalus* (fin whale); Mb = *Mesoplodon bidens* (Sowerby's beaked whale)

Tag location data from 2017 and some 2018 tags were also used for Switching State-Space Modeling analysis. Using the R package 'bsam,' estimated locations were classed into travel or ARS behavior based on the mean predicted behavioral state from model runs. Of 249 modeled locations in the 12-hr sperm whale model, 8 were identified as traveling, 34 were of indeterminate behavior, and the remaining 207 were identified as ARS. In the fin whale model, of 1317 locations, 75 were identified as traveling, 299 as intermediate, and the remaining 868 locations as ARS. Sperm whale tags showed animals utilizing the slope almost exclusively. Several tags showed ARS behavior centered around submarine canyons. Fin whale habitat use was mostly distinct from the sperm whales, with animals ranging broadly across the continental shelf, with just a few animals using the shelf break.

Fieldwork and data-analysis efforts for this project are ongoing. Preliminary results show a high diversity of marine mammal species in the study area, which is an important high-use area for U.S. Navy training and testing activities. A detailed analysis of dive data is ongoing, but results clearly show variability within individual sperm whales and individual fin whales. The dive data from the first satellite-monitored location dive behavior tag to be deployed on a Sowerby's beaked whale has provided valuable insight with respect to the behavior of this highly cryptic species that is potentially at higher risk of influence from anthropogenic noise. Tag deployments will continue to be a priority for future surveys with use of Fastloc® GPS tags on key species such as fast-moving fin whales to provide increased location accuracy combined with dive-profile data. As additional surveys are conducted and tags are deployed on multiple species across all 4 seasons, we continue to expand our knowledge of marine mammal and sea turtle occurrence and habitat use in this important U.S. Navy training range.

For more information on this study, refer to the annual progress report for this project (Engelhaupt et al. 2019).

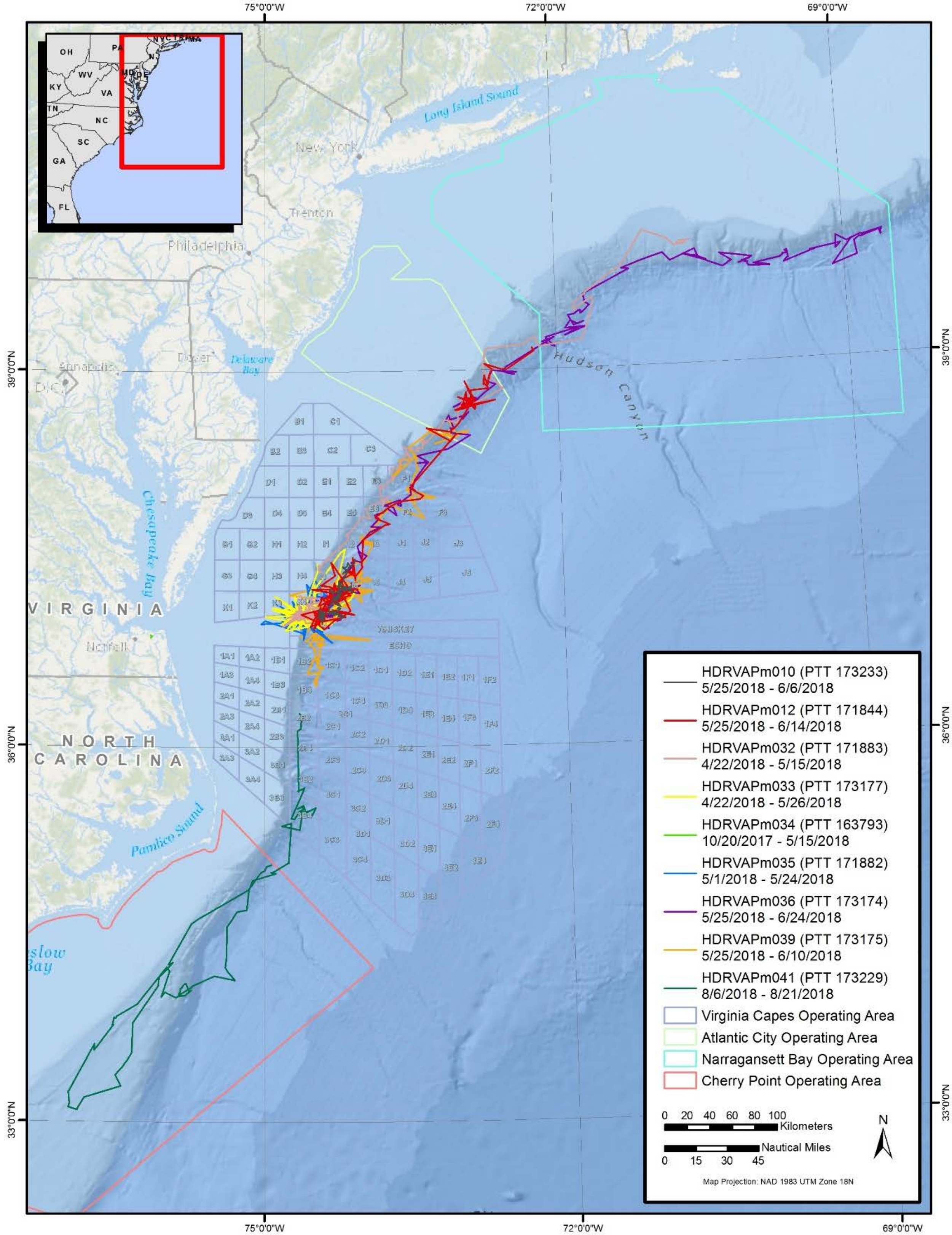

Figure 32. Tag tracks of all sperm whales tagged during 2018.

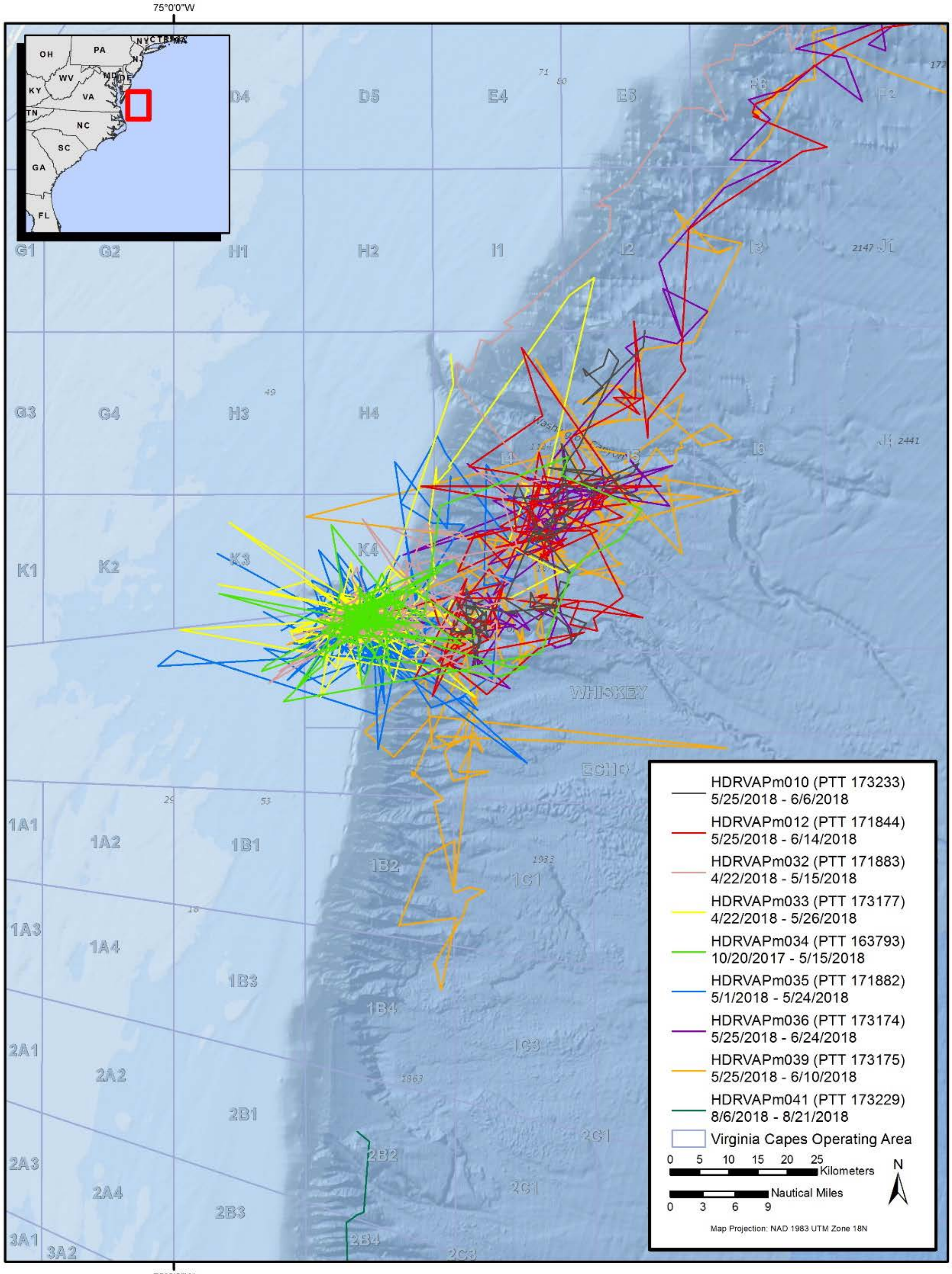

Figure 33. Tag tracks of all sperm whales tagged during 2018, zoomed to show more detail of the movement of multiple whales that stayed close to tag-deployment location in Norfolk Canyon.

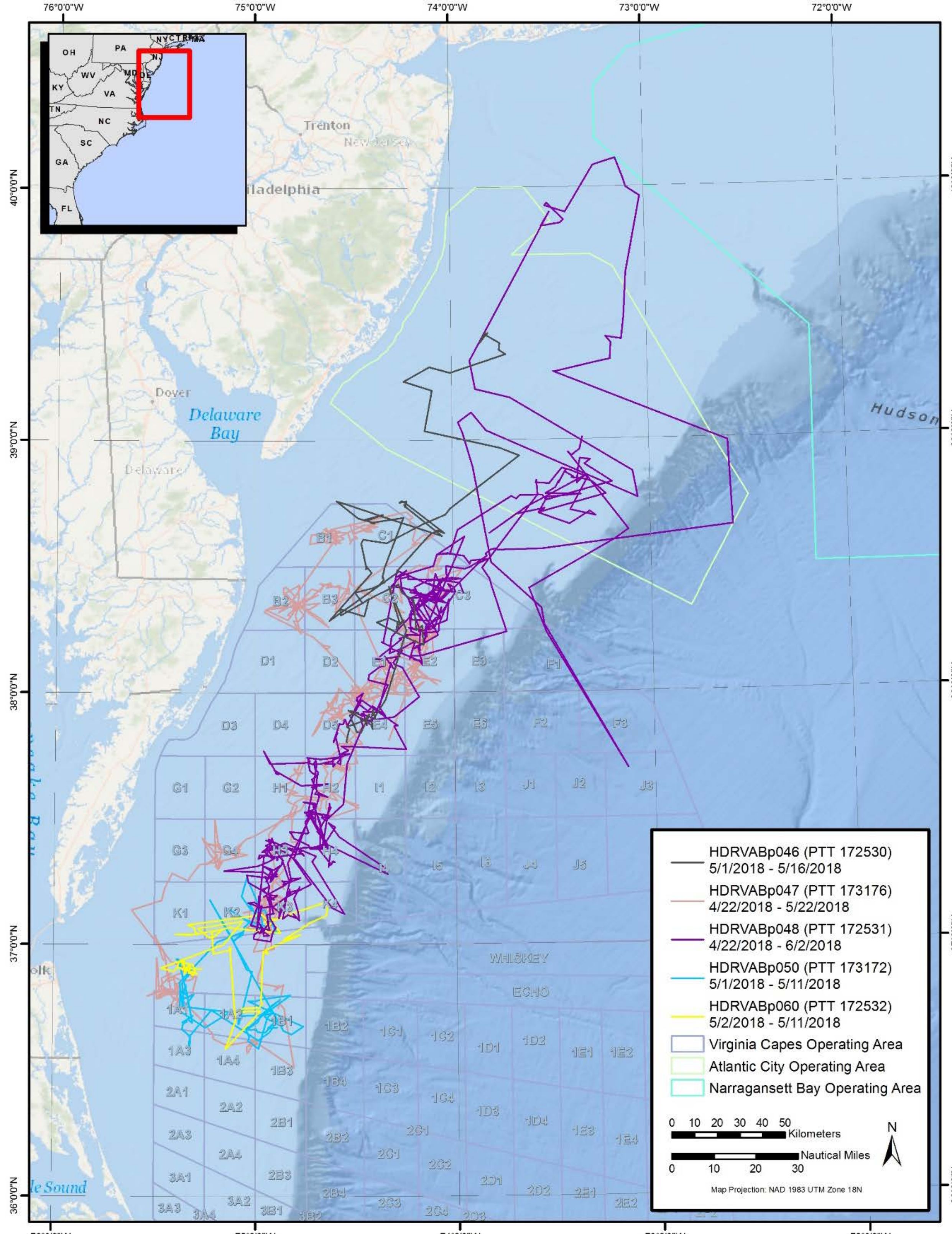

Figure 34. Tag tracks of all fin whales tagged during 2018.

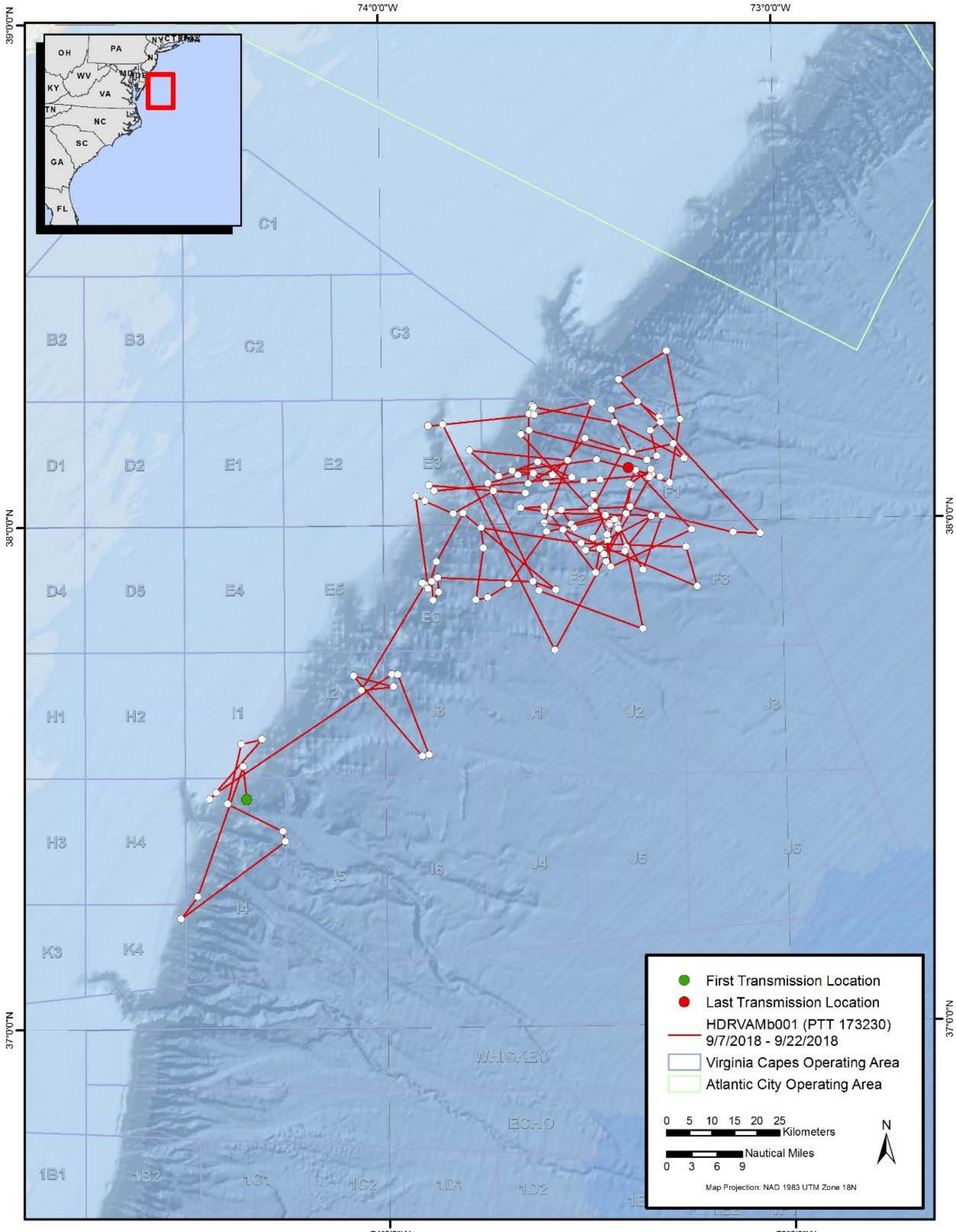

Figure 35. Filtered locations (white dots) and track of Sowerby's beaked whale HDRVAMb001 showing movements in deep offshore waters over 14 days of tag-attachment duration.

2.2.5 Sea Turtle Tagging—Chesapeake Bay and Coastal Virginia

Researchers from the Virginia Aquarium and Naval Facilities Engineering Command Atlantic have been collaborating on a project to tag and track sea turtles in lower Chesapeake Bay and coastal Virginia waters since 2013 (Barco et al. 2018). The goal of this project is to assess the occurrence, habitat use, and behavior of loggerhead, green (*Chelonia mydas*), and Kemp's ridley turtles in this region. Research methods include the use of satellite telemetry to characterize broad-scale movement patterns and the use of both satellite- and acoustic-telemetry data to characterize the occurrence of turtles in specific areas of interest to the U.S. Navy. This dataset will assist the U.S. Navy in identifying seasonal areas where cheloniid sea turtles are likely to occur in order to support environmental planning and compliance efforts.

Turtles for this multi-year project have been acquired in three ways: (1) direct capture by researchers; (2) incidental capture in commercial fisheries, recreational fisheries, or trawl operations associated with dredging; or (3) rehabilitation and release of stranded animals. In addition, data from 5 tags deployed on green and Kemp's ridley turtles prior to 2013 are being incorporated into the analysis.

Tagging efforts for the 2018 field season primarily focused on Kemp's ridley and green turtles in order to increase sample sizes for analysis and to perform a sensitivity analysis on existing loggerhead tag data. Although captures were attempted during several cruises, for a number of reasons, no wild turtles were captured and tagged in 2018. Twenty-seven turtles, 26 Kemp's ridleys and 1 green turtle, were tagged and released in 2018—17 with VEMCO (Nova Scotia, Canada) acoustic telemetry tags, 6 with SPOT satellite tags, and 4 with SPLASH satellite tags (**Table 19**). All 27 turtles stranded between 10 May and 3 September and were released from 2 to 121 days after stranding. With the exception of the last turtle released, all turtles were released less than 30 days after they entered rehabilitation. Four of the Kemp's ridleys were deemed hook-free and healthy upon assessment and were cleared for release without further examination or assessment. Of the 10 satellite tags, all were programed to collect continuous location and sensor data. SPOT tags were programed to record the percentages of time over 6-hr periods that turtles spent within defined ambient water temperature and depth intervals. Depth-recording SPLASH tags were programed to record the percentages of time over 6-hr periods that turtles spent in defined depth and temperature bins.

All but 2 turtles released with acoustic tags in 2018 were detected on the Navy's acoustic receiver array (**Figure 36, Table 20**). Seven turtles, including one of the 2 not detected on the Navy array, were detected on receivers managed by the Virginia Institute of Marine Science (VIMS) in the Chesapeake Bay near the York River. Of the 10 satellite transmitters deployed on hooked Kemp's ridley turtles in 2018, one failed to transmit. The tag that did not transmit was a SPLASH-10 283-B tag. The other 9 tags transmitted from 11 to 65 days as of 31 December 2018. The tag on the last turtle, released in early November, was still transmitting as of early February 2019 (>90 days). Mean tag duration was 38 days (standard deviation [*SD*]=16) for the 8 2018 tags that started and ended in 2018. In contrast, Kemp's ridley tags lasted a mean of 49 (*SD*=32) days in 2017.

With the exception of the last turtle released, Kemp's ridley turtles tagged in 2018 moved from release areas along the Virginia Beach oceanfront to river mouths, inland bays, and flats in the mainstem Chesapeake Bay—spending the duration of the tag life remaining within a relatively small area. This pattern was similar to what has been observed in previous years for Kemp's ridleys, but differs from most loggerheads, which stayed in deeper, more open water.

Table 19. Kemp's ridley and green turtles tagged by VAQF in 2018 listed by date of release.

Field Number	Species	Tag Type	Release Date	SCL-NT (cm)	Weight (kg)	Source
VAQS20182017	Lk	SPLASH	16-May-2018	42.6	10.60	Stranded/hooked
VAQS20182021	Lk	SPLASH	16-May-2018	49.0	16.00	Stranded/hooked
VAQS20182022	Lk	VEMCO	16-May-2018	42.0	9.35	Stranded/hooked
VAQS20182026	Lk	VEMCO	20-May-2018	43.7	11.45	Stranded/hooked
VAQS20182018	Lk	VEMCO	21-May-2018	44.3	11.55	Stranded/hooked
VAQS20182023	Lk	VEMCO	21-May-2018	36.6	6.46	Stranded/hooked
VAQS20182019	Lk	SPOT	24-May-2018	38.9	7.80	Stranded/hooked
VAQS20182024	Lk	SPOT	24-May-2018	46.4	13.00	Stranded/hooked
VAQS20182032	Lk	SPOT	24-May-2018	35.9	6.05	Stranded/hooked
VAQS20182035	Lk	VEMCO	24-May-2018	30.9	3.90	Stranded/hooked
VAQS20182020	Lk	VEMCO	27-May-2018	39.6	7.76	Stranded/hooked
VAQS20182027	Lk	VEMCO	27-May-2018	30.6	3.92	Stranded/hooked
VAQS20182037	Lk	VEMCO	27-May-2018	32.0	4.20	Stranded/hooked
VAQS20182039	Lk	VEMCO	27-May-2018	30.7	3.78	Stranded/hooked
VAQS20182048	Lk	VEMCO	1-Jun-2018	26.9	2.49	Stranded/hooked
VAQS20182057	Lk	SPOT	4-Jun-2018	37.1	7.00	Stranded/hooked
VAQS20182072	Lk	VEMCO	12-Jun-2018	23.2	2.03	Stranded/hooked
VAQS20182041	Lk	VEMCO	15-Jun-2018	35.9	6.75	Stranded/hooked
VAQS20182045	Lk	SPOT	20-Jun-2018	36.2	6.06	Stranded/hooked
VAQS20182063	Lk	SPLASH	20-Jun-2018	36.6	6.54	Stranded/hooked
VAQS20182083	Lk	VEMCO	20-Jun-2018	32.5	4.67	Stranded/hooked
VAQS20182101	Lk	VEMCO	23-Jun-2018	26.3	2.50	Stranded/hooked
VAQS20182095	Lk	VEMCO	29-Jun-2018	27.2	2.77	Stranded/hooked
VAQS20182128	Lk	VEMCO	29-Aug-2018	25.0	2.35	Stranded/hooked
VAQS20182119	Lk	SPLASH	2-Nov-2018	52.7	18.75	Stranded/floating/hooked
VAQS20182142	Lk	SPOT	11-Aug-2018	26.6	2.54	Stranded/hooked
VAQS20182160	Cm	VEMCO	11-Sep-2018	31.7	3.64	Stranded/hooked

Key: Cm=*Chelonia mydas* (green turtle); Lk=*Lepidochelys kempii* (Kemp's ridley turtle); SCL-NT=straight carapace length notch-to-tip; cm=centimeters; kg=kilograms.

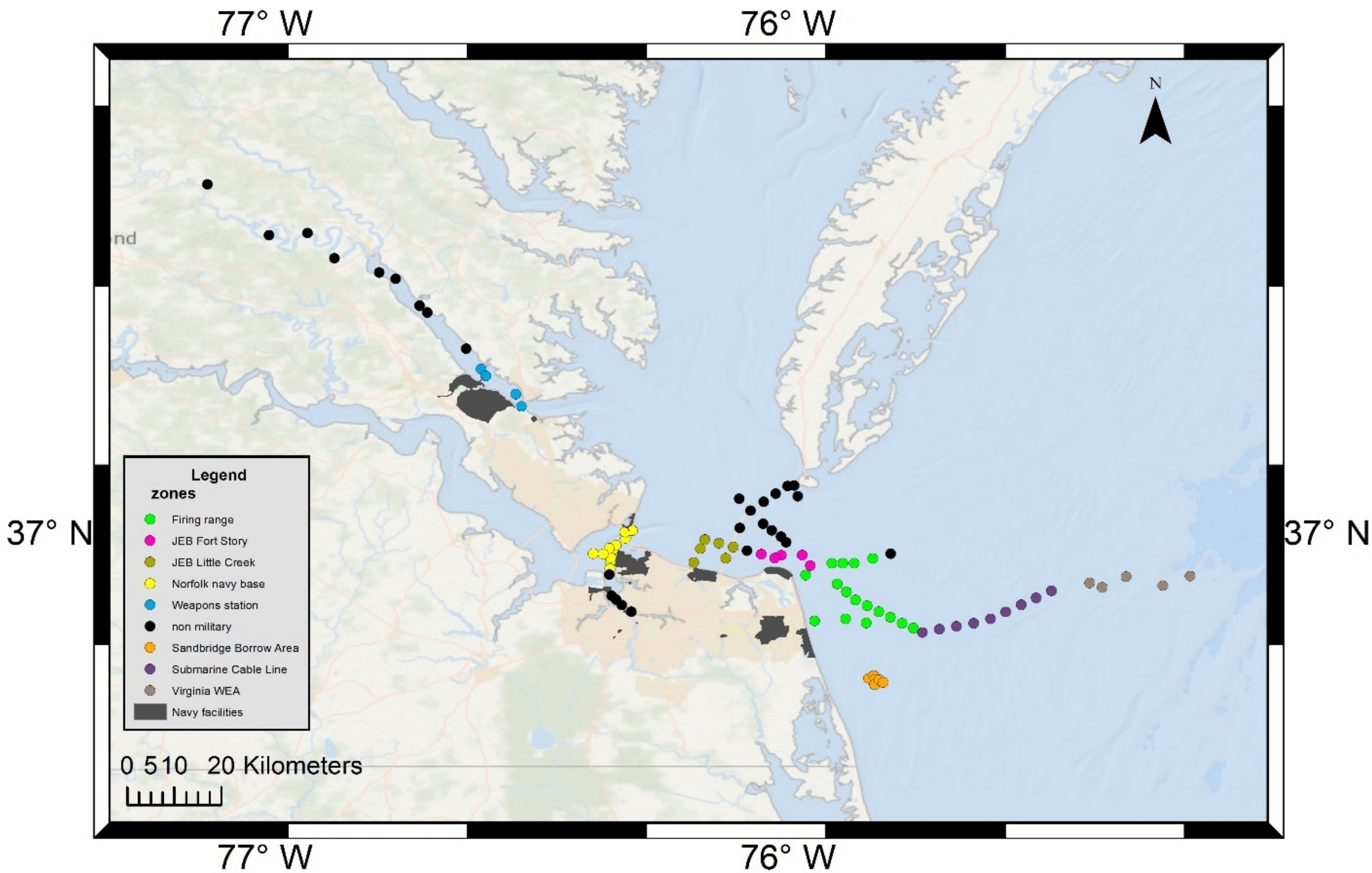

Figure 36. Locations of active Navy acoustic receivers in 2018 color coded by zone (Hager 2017).

Table 20. Preliminary detections of acoustic transmitter tags deployed in 2018 on Navy, BOEM, and VIMS arrays in Virginia.

Field Number	Species	Release Date	Tag Model	# Navy array detections	# VIMS array detections	Minimum Duration	Total Detections
VAQS20182018	Kemp's ridley	21-May-18	V16-4x	70	253	136	323
VAQS20182020	Kemp's ridley	27-May-18	V16-4x	10	0	1	10
VAQS20182022	Kemp's ridley	21-May-18	V16-4x	6	370	141	376
VAQS20182023	Kemp's ridley	21-May-18	V16-4x	38	0	2	38
VAQS20182026	Kemp's ridley	20-May-18	V16-4x	581	556	99	1,137
VAQS20182027	Kemp's ridley	18-May-18	V13-1x	13	0	2	13
VAQS20182035	Kemp's ridley	24-May-18	V13-1x	2	0	1	2
VAQS20182037	Kemp's ridley	27-May-18	V13-1x	41	13	4	54
VAQS20182039	Kemp's ridley	27-May-18	V13-1x	19	0	4	19
VAQS20182041	Kemp's ridley	15-June-18	V13-1x	44	33	70	77
VAQS20182048	Kemp's ridley	1-June-18	V13-1x	10	16	7	26
VAQS20182072	Kemp's ridley	12-June-18	V13-1x	0	0	NA	0
VAQS20182083	Kemp's ridley	20-June-18	V13-1x	1,183	0	77	1,183
VAQS20182095	Kemp's ridley	29-June-18	V13-1x	0	0	NA	0
VAQS20182101	Kemp's ridley	23-June-18	V13-1x	48	314	106	362
VAQS20182128	Kemp's ridley	11-Aug-18	V16-4x	29	0	59	29
VAQS20182160	green	11-Sep-18	V16-4x	24	0	58	24

'Total Detections'=total number of detections on all receivers; 'Minimum Duration'=number of days from release to last detection. Detection data from non-Navy receivers were provided by the Virginia Institute of Marine Science.

The tag-detection and satellite-telemetry data from sea turtles in Chesapeake Bay and nearby ocean waters, along with historic telemetry results provided by VAQF, represent an impressive collection of data from which the U.S. Navy will be able to draw from for current and future analyses of potential impacts on sea turtles. These data will assist decision makers to make informed assessments regarding management and training activities. For the final analyses related to this project, researchers are currently compiling and comparing results among project years, species, and techniques in order to provide a basic framework of sea turtle distribution and habitat use around military installations and training areas in Chesapeake Bay and in coastal ocean waters of Virginia.

Preliminary analyses suggest that there are differences in distribution between loggerhead and Kemp's ridley turtles, which may affect take estimates for the two species. Sensitivity analyses of both loggerhead and Kemp's ridley satellite telemetry, however, indicated that a greater number of tags on both species would be required before a true picture of habitat use throughout the region and across seasons could be developed. For this reason, future work includes development of resource selection models using Bayesian techniques to predict habitat preference and seasonal distribution for each species.

For more information on this project, including the completed analyses, please refer to the final report for this project, which will be available in fall 2019 (Barco et al. 2019).

2.2.6 Pinniped Tagging and Tracking in Virginia

Since the passage of the MMPA in the U.S. in 1972, and as amended (16 United States Code § 1361 14 et seq.), both harbor seal and gray seal populations have grown in the Northwest Atlantic Ocean (Hayes et al. 2018). Both species are year-round coastal inhabitants in eastern Canada and New England, and occur seasonally in the mid-Atlantic United States between September and May (Hayes et al. 2018). Harbor seals migrate to northern areas for pupping and mating in the spring and summer, and return to more southerly areas in the fall and winter. Grey seal pupping typically occurs in winter between January and February, followed immediately by mating once pups are weaned. The newly weaned pups occasionally disperse south and west of the pupping beaches beginning in the spring. Within the last decade, harbor seals have been observed returning seasonally to haul-out (resting) locations in coastal Virginia, and gray seals occasionally are observed there as well (Jones et al. 2018).

The Navy regularly engages in training, testing, and in-water construction activities in coastal Virginia and Chesapeake Bay (**Figure 37**) in order to maintain Fleet readiness and structural integrity of military installations. The lower Chesapeake Bay and coastal areas of Virginia represent one of the busiest hubs of naval activity on the East Coast and host numerous pierside facilities, installations, vessel, shipyards, and in-water training ranges. Seals seasonally inhabiting and transiting through these areas could be impacted by the use of active sonars and explosives, vessel traffic and movement, dredging, pile driving, and other activities.

Navy biologists have been researching seal occurrence in and around the Chesapeake Bay since 2013, and conducting systematic haul-out counts in the region since 2014 (see **Section 2.1.5.1**) Results from these surveys indicate that seals arrive in the area in the fall and depart in the spring (Rees et al. 2016). However, our understanding of seal movements, habitat use, haul-out patterns, and dive behavior in Virginia waters is still extremely limited. In order to assess the potential impacts on seals from Navy activities, mitigate potentially harmful interactions, and obtain appropriate authorizations to maintain environmental compliance, it is important to have a better understanding of seal distribution and behavior in these areas. Although visual haul-out studies are useful for estimating the minimum number of animals present on land at various times of the year, telemetry studies are needed to characterize seals' at-sea movements, habitat use, and dive behavior, as well as the environmental variables that may influence their distribution patterns.

Now in its second field season as of winter 2019, this proof-of-concept study was undertaken to establish whether wild seals could be successfully captured and tagged in coastal Virginia, because this has not been previously attempted in this area. Further, the study sought to establish the feasibility of using satellite tags to better understand seals' residency time in Virginia waters, their local habitat utilization patterns, and their migratory destinations in the spring. The information gathered from this effort will provide valuable baseline data needed for the future assessment of harbor seal movements and site fidelity along the U.S. Eastern Seaboard.

The capture site was located on the Eastern Shore of Virginia, where seals have been observed hauling out between fall and spring. The Eastern Shore haul-out area has several discrete haul-out sites (up to 5 different locations) where seals have been observed (Jones et al. 2018). These haul-outs are in a tidal salt marsh, consisting of muddy banks and vegetation, which is subject to tidal influx. The seals are often seen hauled out in areas with little to no vegetation, or where existing vegetation has been flattened by either the tide or the animals' weight. Seal captures followed a similar protocol as described by Jeffries et al. (1993). Seals were captured using a seine net and 3 small flat-bottomed vessels with outboard motors. Seals were brought onshore after entering the capture net adjacent to haul-out site(s).

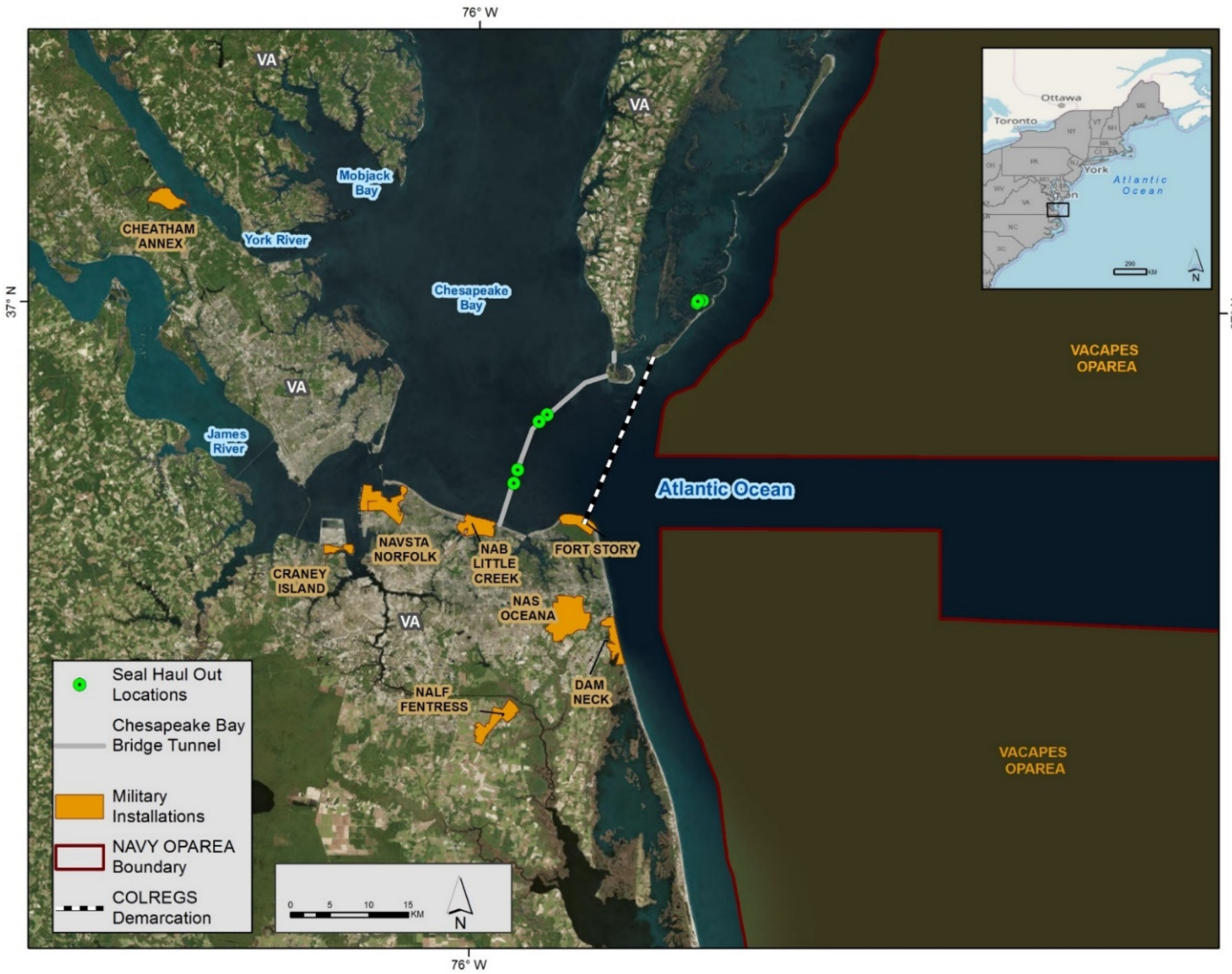

Figure 37. Seal haul-out locations in lower Chesapeake Bay and coastal Virginia, showing the Virginia Capes Range Complex (VACAPES) and sonar training areas. COLREGS = collision regulations; OPAREA = Operating Area.

Seals were outfitted with a combination of flipper tags, satellite tags, and acoustic transmitter tags. Colored (light blue), flexible, vinyl Allflex™ livestock ear tags were attached to each seals' left hind flipper webbing. These flipper tags may stay attached for multiple years, and are used for purposes of individual identification if resighted. Each seal was also instrumented with a satellite tag (either a satellite-tracked position-only [SPOT] tag, or a depth-sensing SPLASH tag), manufactured by Wildlife Computers, Inc. (Redmond, Washington). In some cases seals were also outfitted with acoustic transmitter tags manufactured by VEMCO (Bedford, Nova Scotia, Canada). The satellite tags were designed to fall off during the annual molt in July following the May-June breeding season, while the VEMCO tags had the potential to stay on longer because they are attached to the flipper tags instead of the animals' fur.

Over the course of a 10-day field window in February 2018, 7 harbor seals were captured and instrumented with satellite-tracked tags (6 SPOT tags, 1 SPLASH tag). Five of the 7 seals were also instrumented with VEMCO tags (**Table 21**). All captured seals were outfitted with vinyl flipper tags. Satellite tags varied in deployment length; the longest tag reporting period was for seal 1802, an adult male, which reported through 29 June (approximately 5 months). The shortest reporting period was for the tag attached to seal 1805, an adult female, which stopped reporting after only 2 months (the reasons for this are unknown). One juvenile gray seal was also observed in the water near the capture location and was briefly in the seine net, but escaped before the net was brought to shore.

Table 21. Summary of tagged seals in Virginia in 2018.

Date Tagged	Animal ID	Sat Tag PTT #	Date of Last Transmission	VEMCO Tag #	Length (cm)	Girth (cm)	Weight (kg)	Sex	Estimated Age
4-Feb-2018	1801	166450	23-May-18	15249	102	80	29.0	Male	Juvenile
4-Feb-2018	1802	166449	29-June-18	N/A	153	118	90.4	Male	Adult
4-Feb-2018	1803	166451	6-May-18	15251	129	99	58.8	Female	Juvenile
4-Feb-2018	1804	166452	26-May-18	15252	143	119	74.8	Female	Juvenile
6-Feb-2018	1805	166453	9-April-18	15253	121	97	49.8	Female	Adult
6-Feb-2018	1806	173502	22-June-18	N/A	149	116	82.2	Female	Adult
6-Feb-2018	1807	173503	26-April-18	15250	33	77	24.8	Female	YOY

Key: PTT = platform transmitter terminal; YOY = Young of the year, up to 1.5 years old.

Both temperature and depth data were available for seal 1802, an adult male, which was equipped with a SPLASH tag (**Figure 38**). The maximum depth recorded throughout the deployment period was 118.00 m, with a mean depth across all months of 22.38 m (*SD*=19.53). In February and March, while still in Virginia waters, this seal dove to maximum depths of 24.00 m (mean=6.94 m, *SD*=4.78) and 31.50 m (mean=6.60, *SD*=4.53), respectively, in each month. Maximum dive depths increased to 104.5 m (mean 25.34, *SD*=21.34), 118.00 m (24.75, *SD*=19.26), and 71.00 m (mean 30.54, *SD*=18.39) in April, May, and June, respectively, when the animal moved north to southern New England and then to Maine.

Filtered location data were used generate utilization distributions and calculate 50% and 95% isopleths for each tagged seal (Calenge 2006). The resulting isopleths were overlaid to create relative habitat use maps. One seal had a 95% isopleth that extended as far north as the coast of Maine, and at least two seals had a 95% isolpeth occurring off the coast of Connecticut, Rhode Island, and Massachusetts (**Figure 39**). In Virginia waters tagged seals utilized both the Chesapeake Bay and offshore waters, but the area that was utilized most heavily was near the Eastern Shore capture site in which all seven 95% isopleths intersected over the capture site and surrounding islands (**Figure 39**).

Individual seals exhibited varied haul-out behavior patterns throughout the respective satellite-tag deployment periods. Seal 1802 exhibited a strong diurnal haul-out pattern from February through May, coming out of the water to rest at approximately 16:00 local time (**Figure 40**). The warmest in-water temperature recorded by this tag was 8.75 degrees Celsius (47.75 degrees Fahrenheit) (**Figure 38**), which indicates that the animal was hauled out at temperatures above this threshold. There was a strong bimodal haul-out pattern for the 2 tags still reporting in June 2018 (1802 and 1806), indicating that these animals hauled out both in the morning and nighttime hours while in coastal Maine (**Figure 41**). Based on wet/dry data from tagged seals, no clear haul-out pattern emerged with respect to tidal fluctuations at either end of the tagged seals' range.

This proof-of-concept study was the first time researchers captured and tagged wild harbor seals in Virginia. Although findings are limited to the 7 individual seals tagged in this study under NMFS research permit #17670-04, these data provide preliminary insight into the habitat use patterns and haul-out behavior of harbor seals in and near Navy training areas and installations in Virginia, and along the U.S. Eastern Seaboard.

For more information on this study, please refer to the 2017–2018 annual progress report for this project (Ampela et al. 2019).

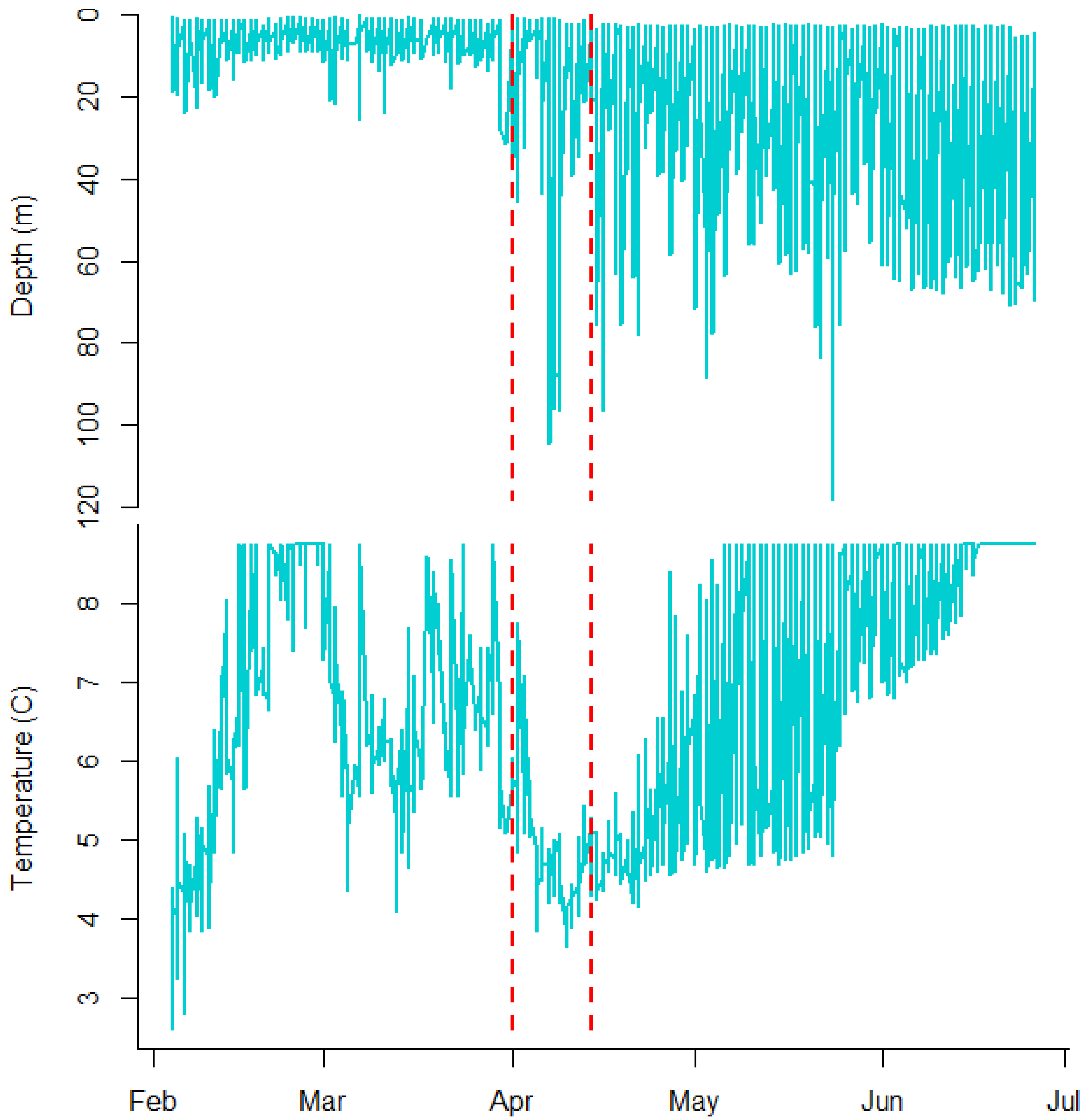

Figure 38. Time-series of depth and temperature for seal 1802, from 04 February through 29 June 2018. Vertical dashed lines demarcate the time periods the animal spent (1) in Virginia (left of the first line), (2) traveling northward (between the 2 lines), and (3) in Maine (right of the second line).

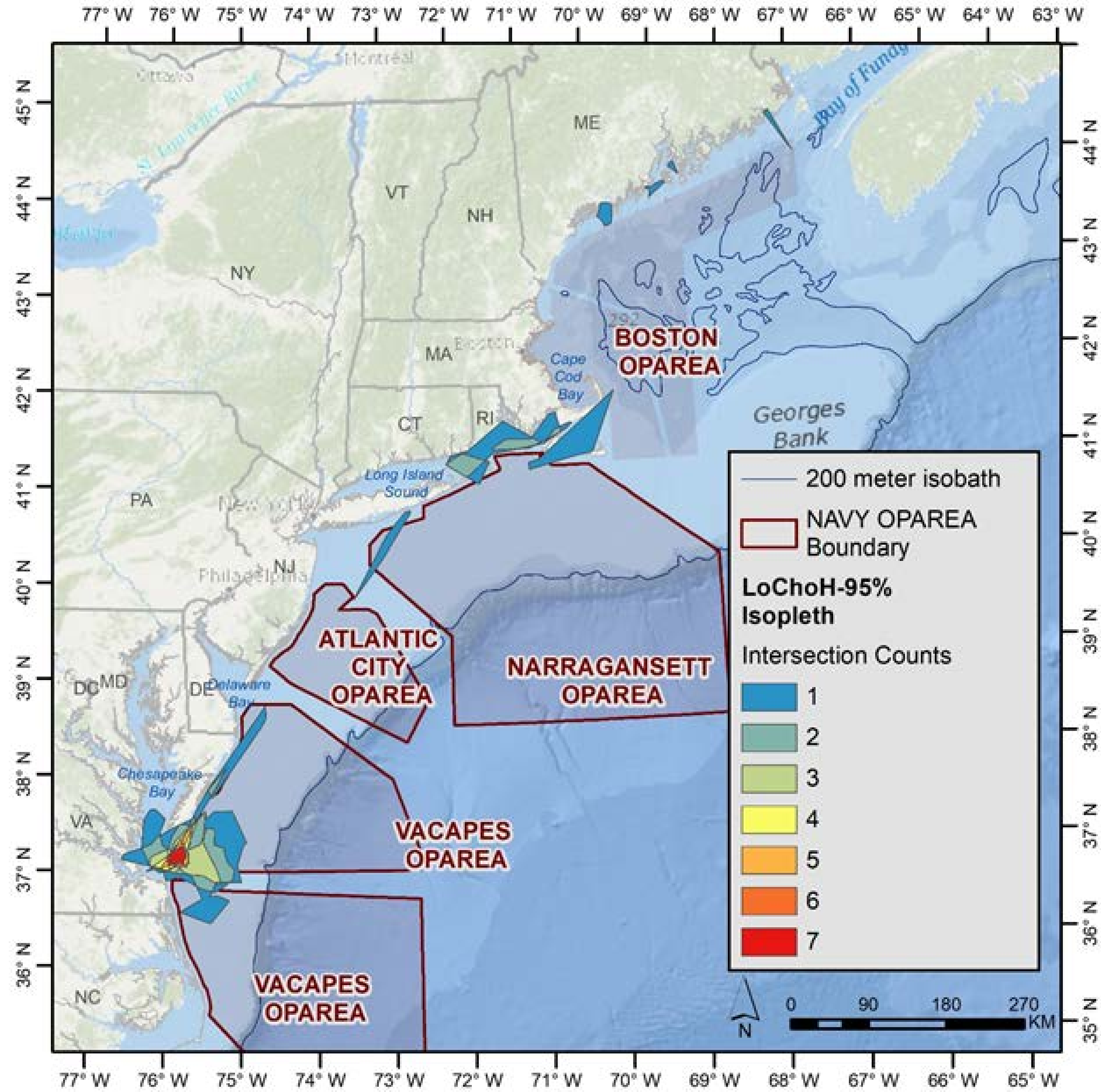

Figure 39. Depicting seal utilization distributions with 95% isopleths using the Local Convex Hull method.

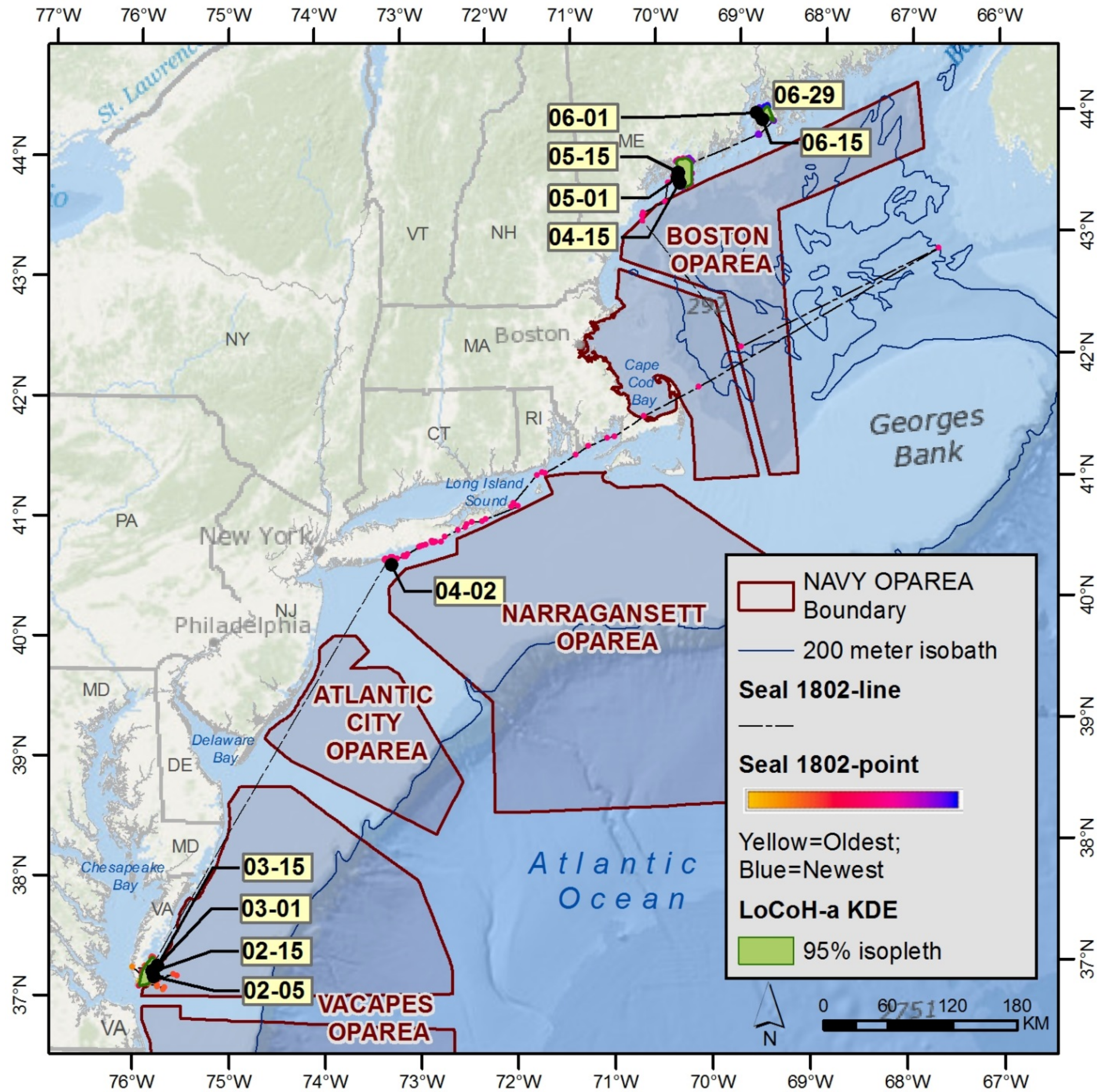

Figure 40. Habitat use map for seal 1802 (tag duration=04 February through 29 June 2018) in relation to Navy operating areas along the Eastern Seaboard. Green areas represent the 95 percent isopleth. The dotted black line connecting filtered location points (pink dots) represents the progression, not the animal's actual track.

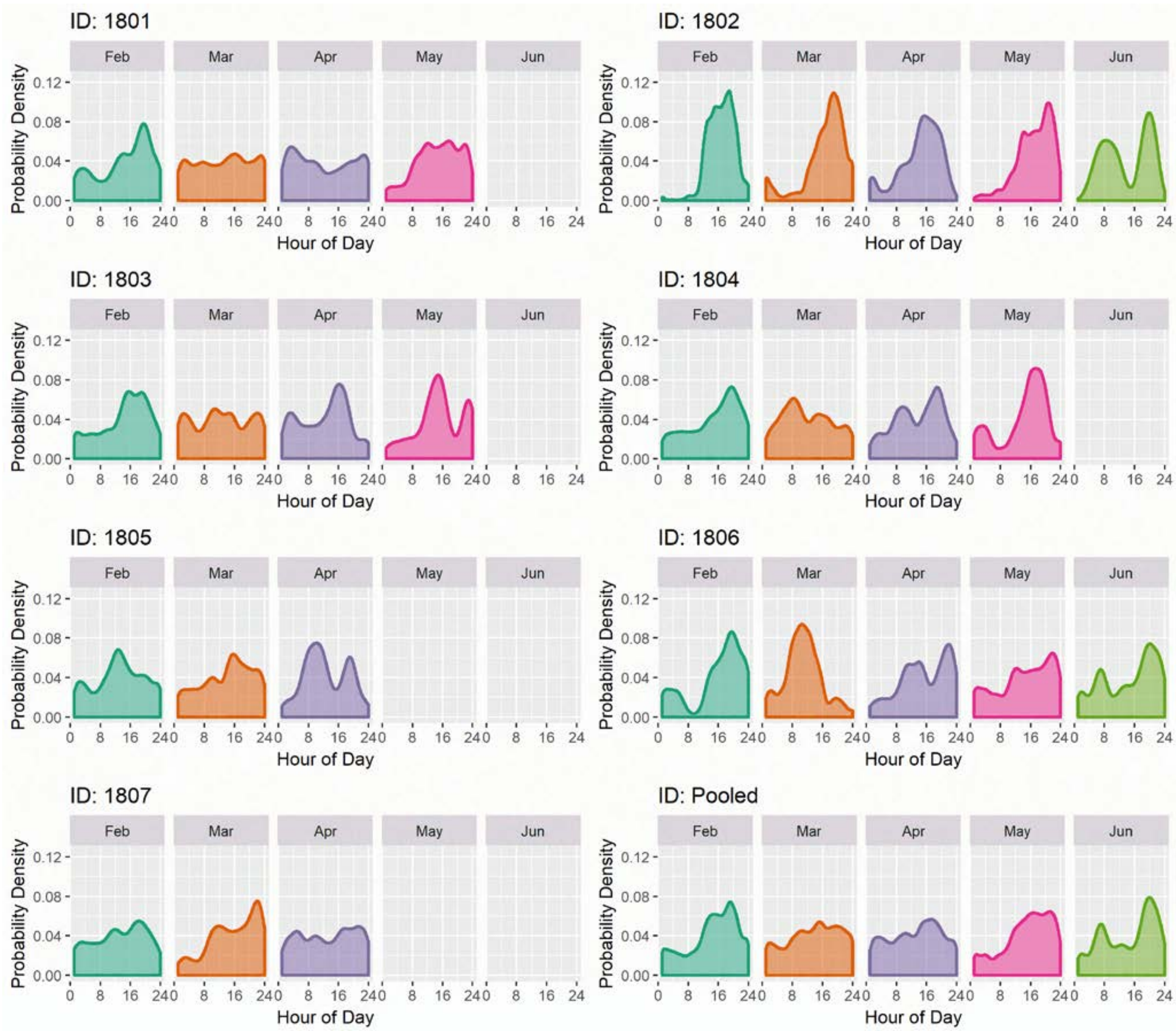

Figure 41. Monthly probability densities of time spent hauled out for all tagged seals. Hour-of-day (x-axis) is local 24-hour time.

2.3 Behavioral Response

2.3.1 Atlantic Behavioral Response Study

Different programs within the U.S. Navy have supported the development of BRS with marine mammals and military sonar over the past decade. The Atlantic-BRS project was conceived, designed, and initiated through a collaboration of researchers involved in several of these previous studies and in previous baseline monitoring of key species, including Cuvier's beaked whales and short-finned pilot whales off Cape Hatteras, North Carolina. Researchers from Southall Environmental Associates, CRC, Duke University, HDR, and the University of St. Andrews worked together to complete the second field phase of this multi-year study in 2018.

The current project was designed to transition and advance approaches from previous BRS work to examine the behavioral responses of priority marine mammal species to military sonar off the Atlantic coast of the U.S. for the first time. The Atlantic-BRS project was designed through a collaborative planning process in order to develop a prioritized experimental design. The approach employs both short-term, high-resolution acoustic tags and longer-term, coarser-resolution location and behavior tags to study responses at different temporal and spatial scales (Southall et al. 2018).

2.3.1.1 Field Effort

Thirty-one satellite-linked, depth-transmitting tags were deployed on focal species (13 on beaked whales, 18 on pilot whales) during field sessions in spring and fall (see Baird et al. 2019), which resulted in many hundreds of day of individual movement and diving behavior before and following CEEs. Fifteen of these individuals (2 beaked whales, 13 pilot whales) were monitored during 2 successful CEE sequences conducted with the both the USS *NITZE* and the USS *RAMAGE* using full-scale 53C sonar (**Table 22, Figures 42 through 45**).

During the Atlantic-BRS 2018 field effort, 8 CEE sequences were conducted, of which 4 were simulated (scaled source) sonar events and 2 used full-scale 53C sonar sources. The remaining 2 sequences were silent controls (**Table 22**). Additionally, a simulated sonar CEE was conducted with 5 pilot whales when a Navy ship was unavailable; this total included mostly satellite-tagged animals but also individual focal pilot whales tagged with high-resolution DTAGs. Nine DTAGs were deployed on pilot whales during the 2018 field effort. Although brief (<1 hr) and not involving a CEE, one DTAG deployment included the first successful simultaneously satellite tagging. The completion of year 2 of this study also represents a successful response to the complex challenges of field conditions (weather, animal distribution) and coordination with ongoing Navy training operations, which are required for success.

Individual-based analyses of the 2017 beaked whale data are now complete in terms of horizontal avoidance and changes in diving behavior. Relatively few changes were measured during either the operational or the simulated mid-frequency active sonar (MFAS) source. Analyses within individuals of the 2017 pilot whale data and all 2018 whales are ongoing. Complete, across-individuals analyses will require additional data from subsequent field efforts. However, given the type of scenario that occurred in summer 2018, with many simultaneously tagged beaked whales during a period when a Navy ship is available, major progress might be made quickly. From analyses conducted thus far on both the 2017 and 2018 data, all exposed individuals continued to utilize the study area following CEEs (i.e., there was no obvious large-scale avoidance or abandonment of habitat). We are continuing to analyze potential responses using several methods to investigate subtler potential responses to the extent possible given the resolution of available data.

Table 22. CEEs conducted during 2018 Atlantic-BRS field efforts.

CEE ID	Date	CEE Type	Focal whales	CEE duration (min)	CEE source latitude (°N) at CEE start	CEE source longitude (°W) at CEE start
18-01	15-May-18	Simulated MFAS	Gm197	30	35.90	74.79
18-02	25-May-18	Simulated MFAS	Gm18_145a; Gm197	30	35.66	74.74
18-03	30-May-18	Simulated MFAS	Gm18_150b	30	35.88	74.81
18-04	3-June-18	Real MFAS (USS *NITZE*)	Zc69; Zc70; Gm198; Gm201; Gm202	60	35.85	74.36
18-05	6-June-18	Silent Control	Gm18_157b	30	35.60	74.77
18-06	13-June-18	Real MFAS (USS *RAMAGE*)	Zc69; Gm203; Gm204; Gm205	60	35.82	74.74
18-07	8-June-18	Silent Control	Gm18_227a	30	35.75	74.79
18-08	15-Aug-18	Simulated MFAS	Gm18_239a	30	35.84	74.79

Key: CEE = controlled exposure experiment; MFAS = mid-frequency active sonar; Gm = short-finned pilot whale; Zc = Cuvier's beaked whale

For further detail on the tagging component that provided the foundation of this BRS work, refer to **Section 2.2.1** in this report, and the annual progress report for the tagging of deep-diving odontocete cetaceans (Baird et al. 2019).

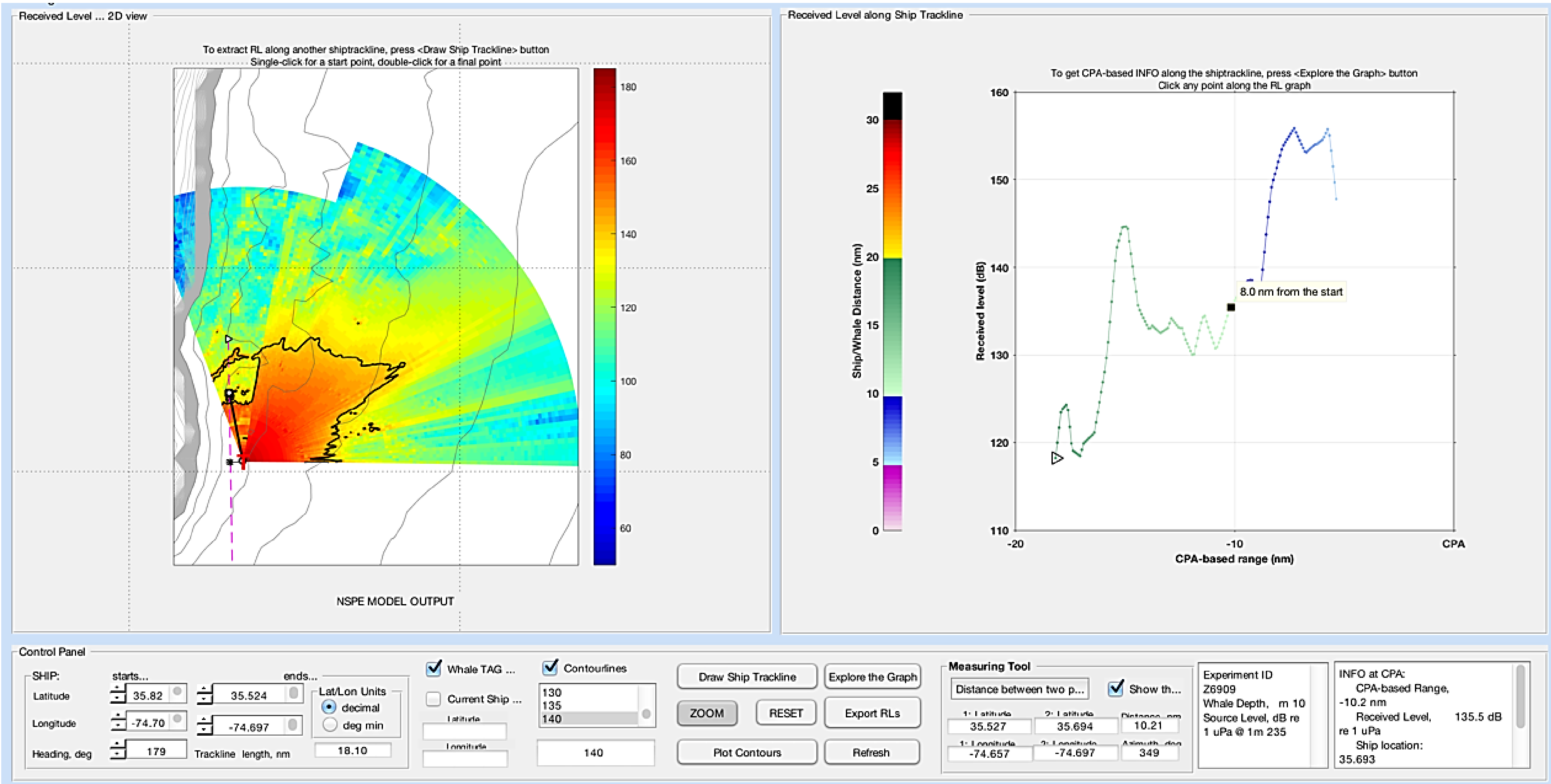

Figure 42. Received level model prediction at 2200-m depth for focal beaked whale Zc69 for Atlantic-BRS CEE# 18-06 (END position of USS *RAMAGE*).

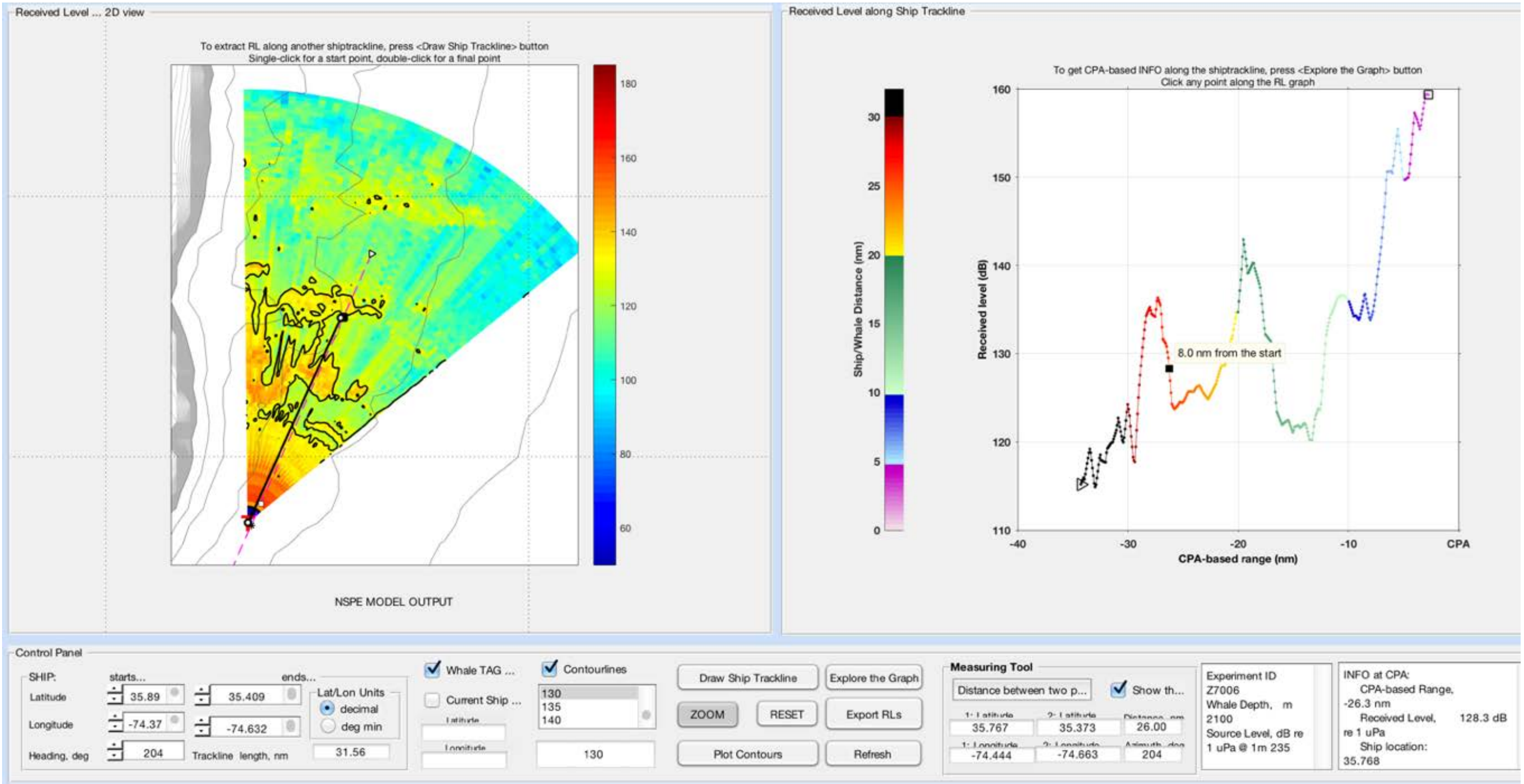

Figure 43. Received level model prediction at 100-m depth for focal pilot whale Gm198 for Atlantic-BRS CEE# 18-04 (END position of USS *NITZE*).

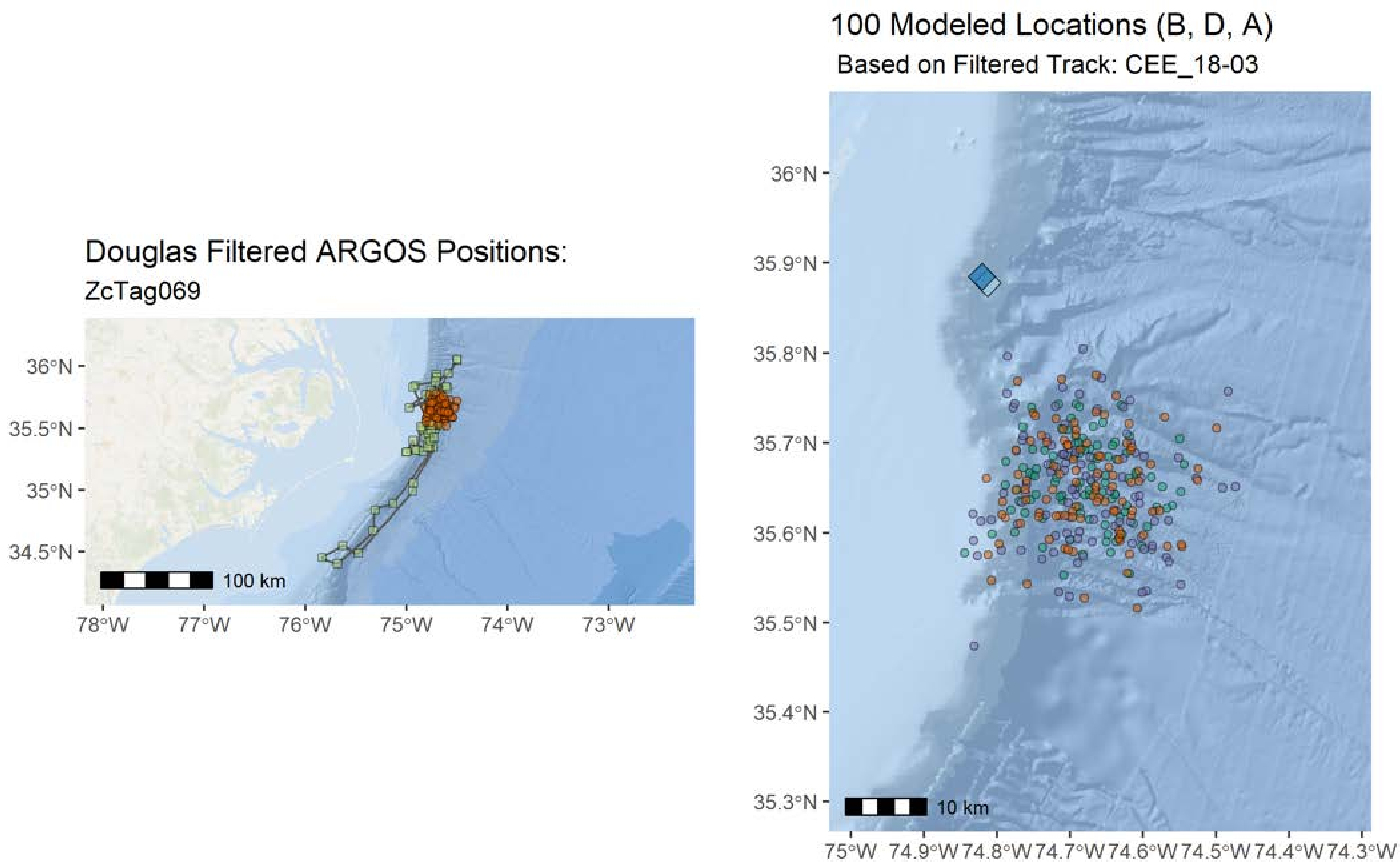

Figure 44. Available location data for tagged Cuvier's beaked whale Zc69 before (green symbols), during (orange symbols), and after (purple symbols) Atlantic-BRS CEE# 18-03. Locations of the MFAS sound source are show as diamonds, with pale blue representing location at start of CEEs, and dark blue indication ending location.

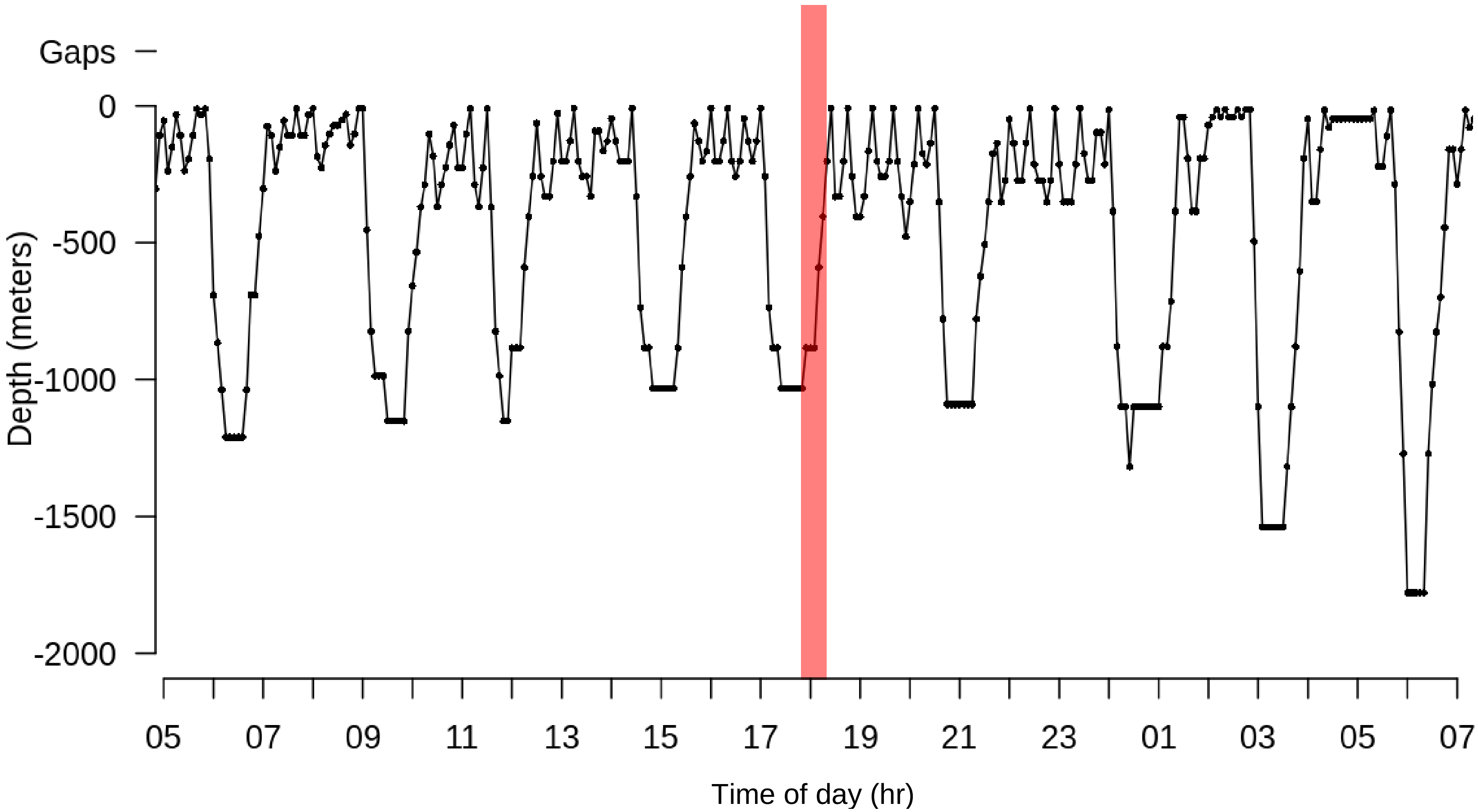

Figure 45. Estimated dive profiles for tagged beaked whale Zc70 before, during, and after Atlantic-BRS CEE# 18-03, 30 and 31 May. The red bar shows the time of simulated MFAS transmission.

2.3.1.2 CEE Exposure–Response Analyses

Changes in diving behavior are considered an important effect in behavioral response studies of deep-diving beaked whales, due to the possibility of reduced foraging success as a consequence of exposure. During the Atlantic-BRS, one aim was to collect complete time-series data consisting of entire bouts of foraging behavior. For beaked whales one deep, long-duration dive is considered a sampling unit of foraging. If these time series contain temporal gaps that span periods greater than the duration of the behavioral state in question, in this case an individual dive, accurate analysis of any response and subsequent biological interpretation of behavioral state transitions will be problematic. Similarly, accurate analysis of patterns in baseline data is needed for extended time series to account for assessment of effect. Our initial objective was to collect behavioral data from Cuvier's beaked whales to provide a continuous time-series dataset of presumed foraging behavior over a period of weeks.

We ran individual analysis for both CEEs in 2017 (#17-01: simulated MFAS; 17-02: operational MFAS from USS *MACFAUL*). We then fitted a general linear model (or generalized estimating equation if there was evidence of autocorrelation) to the distance values with exposure status (baseline, during/post), dive shape, bathymetry, distance to canyons, distance to shelf, and time since exposure as explanatory variables. As each individual only had 1 or 2 dives during the exposure event, during could not be treated as a separate category in the exposure status variable when analyzing each individual separately. This may be accomplished in further analyses where we combine all Mahalanobis Distances (MDist) values across individuals and analyze all individuals together. Combining all the data may allow us to detect more subtle responses because more data should provide more power. However, the MDist values will first need to be standardized. For the simulated MFAS exposure, baseline dives were defined as all dives before the exposure event for an individual. We then compared all baseline dives, the exposure dive, and 24 hr of post-exposure dives with the average baseline dive for that individual. Three out of 5 whales exposed to simulated MFAS during CEE #2017-01 showed a significant difference in the MDist across the during and 24 hr post exposure compared to before exposure.

For the 2017 operational MFAS CEE (#17-02; USS *MACFAUL*), exposure baseline dives were defined as all dives before the exposure event for an individual, excluding all instances of simulated MFAS exposure in CEE #17-01. If an individual had been previously exposed to the simulated MFAS source during a 24-hr period, these were removed from the data. We then compared all baseline dives, the exposure dive, and 24 hr of post-exposure dives with the average baseline dive for that individual. One of the 6 whales exposed to the USS *MACFAUL* showed a significant difference in the MDist across the 24-hr post-exposure periods compared to baseline, as well as a significant difference in time since exposure. Three of the 6 whales did not show differences with exposure status but did show significance in MDist with time since exposure. For whales ZcTag064 and ZcTag066, there were not any particularly unusual dives right after the exposure event compared with baseline. For whale ZcTag068, there is some indication that dive 81 was unusual because it was followed by a longer than normal inter-deep-dive interval, and then MDist decreased again as time since exposure increased. There appears to be no significant difference with exposure status due to the high distance values in the baseline.

While progress in this area has been limited thus far given the data collected, we recognize this as one of the three aspects of behavior we intend on analyzing. The DTAG and associated focal-follow data provide the best means of doing this at present in terms of changes in group heading/spacing and/or group call rate on fine scales. This is likely more applicable to pilot whales than beaked whales. However, at present this is limited to just 2 simulated MFAS CEEs (none of the 3 CEEs with real warships involved DTAGs). There is promise for more insight from ongoing work on social behavior and synchrony in beaked whales with the satellite tags, especially with the series data settings. Sustained resightings of individuals and photo-ID for groups may provide additional insights here, but it is recognized that this kind of analysis will likely remain distinct from the finer-scale responses possible with the DTAG and group focal follows. Additional data are needed for this as well, with a strong priority for tagging multiple individuals within groups using higher-resolution tag settings for more CEEs.

2.3.1.3 Overall Assessment and Recommendations for 2018 Effort

Behavioral response analyses focus on how beaked and pilot whales change their behavior from baseline conditions during periods of MFAS exposure in known contexts during CEEs. The analytical methods being used apply successful methods developed in other BRS studies (with these and related species), with specific questions and methods derived for differences in the nature of available data (tag type) and species in question. Broadly speaking, analyses are designed to address questions of: (a) potential avoidance behavior; (b) potential changes in behavioral state; and (c) potential changes in social behavior. Short- and longer-term consequences of disturbance are initially being evaluated separately using established analytical methods for short- and medium-term tags.

For the initial project fieldwork conducted in 2017, the extent to which any potential response as a function of exposure persisted is a matter of ongoing analysis. However, even if responses were to last several days, many tags recorded for weeks after CEEs. Additional high-resolution kinematic and acoustic data were recorded from the 2 DTAGs deployed, with the beaked whale DTAG deployment being the first successfully recovered data of this type for this high-priority species off the U.S. East Coast.

These tag deployments during the Atlantic-BRS field effort contribute to and extend a fairly robust baseline database for these species off the coast of Cape Hatteras—collected through several related and ongoing collaborations. For instance, Duke has deployed a large number of DTAGs on pilot whales to monitor behavior and behavioral responses to predator sounds and to active echo-sounders through support from both the range monitoring program and the Strategic Environmental Research and Development Program. Further, CRC has been collaborating with Duke for several years preceding the Atlantic-BRS effort to deploy dozens of satellite tags of different types on these species. More details regarding baseline analyses of movement and diving behavior for the satellite tags deployed during the Atlantic-BRS effort are provided in the parallel CRC annual report (**Section 2.2.1** and Baird et al. 2019).

Following the initial analyses of data acquired during the Atlantic-BRS spring field effort, it was clear that additional development of analytical methods (notably related to characterizing and accounting for spatial error in ARGOS data in relation to RL modeling and horizontal movement analyses) would be required. Given the limited amount of CEE data from the spring period, and following discussions with the Navy regarding analytical plans and progress, analysis plans were focused on the use of tag data acquired to test potential responses during “mock” CEE sequences in the data, where simulated exposures were assumed. These analyses enabled the Atlantic-BRS team to apply and derive analytical approaches from previous efforts. Limited definitive conclusions regarding potential responses, or lack of responses, are provided out of caution given the ongoing nature of analyses. Additional resolution and detail of 2017 CEEs were completed at a major analysis meeting in Beaufort in late February 2018, the outcomes of which were presented at the U.S. Navy’s annual marine species monitoring technical review meeting in San Diego in March 2018.

Please refer to the annual progress report for considerably more detailed information on 2018 fieldwork, preliminary results from 2017, and 2018 analyses (Southall et al. 2019).

2.3.2 Assessment of Behavioral Response of Humpback Whales to Vessel Traffic

This is an FY18 new-start project with no progress to report during 2018.

In the western North Atlantic humpback whales (Megaptera novaeangliae) feed in high-latitude summer foraging grounds off the East coast of the U.S. and Canada before migrating to Caribbean breeding grounds in winter (Katona & Beard 1990, Barco et al. 2002, Stevick et al. 2006). Since the early 1990s, juvenile humpback whales have been documented feeding in winter in coastal waters of the mid-Atlantic states (Swingle et al. 1993). The abundance of humpback whales in the North Atlantic is increasing (Stevick et al. 2003), but there are high levels of mortality in mid-Atlantic states (Barco et al. 2002). In 2017, the National Marine Fisheries Service (NMFS) declared an Unusual Mortality Event (UME) for humpback whales along the U.S. Atlantic coast. Since January 2016, 68 humpback whale strandings have occurred, with half of the whales that were examined post-mortem showing evidence of human-activity related mortality (ship strikes or entanglement).

The U.S. Navy has supported research on humpback whales near Virginia Beach since 2014 as part of the Mid-Atlantic Humpback Whale Monitoring Project. Satellite tracking data from this project shows that the distribution of these animals overlaps significantly with shipping channels (Aschettino et al. 2018). Three dead and one live whale were observed in the 2016/2017 field season with evidence of ship strikes. Given the UME, the large number of ship-related injuries, and the high spatial overlap with shipping channels, it is essential to understand the behavior of these animals around ships at the entrance of Chesapeake Bay.

In other areas, humpbacks have relatively low responses to anthropogenic sound such as sonar, especially when compared with other species (Sivle et al. 2015, Wensveen et al. 2017). Recent work in Virginia Beach (V. Janik, University of St. Andrews, P.I.) indicates that these whales do not respond to startling sounds (V. Janik, pers. comm.) Other researchers have suggested that, when whales are engaged in feeding behavior, they are less responsive to approaching ships (Laist et al. 2001), although there is also evidence that foraging behavior is disrupted by approaching ships (Blair et al. 2016) or sonar use (Sivle et al. 2016). Therefore, these whales provide a unique opportunity to study state-dependent risk of ship strike injury and disturbance in a high-mortality area. Understanding the behavioral context in which they are most likely to both encounter and respond to ships can inform ways to change human behavior to lower the likelihood of detrimental encounters. Determining when and how these whales respond to ships can help with management directives to prevent ship strikes, improving animal welfare and human safety as well as lessening the mortality occurrence of a recovering population.

Digital acoustic recording tags (DTags) will be deployed on humpback whales in conjunction with focal follows of behavior of the tagged whales. These tags will provide the opportunity to study the whales' three-dimensional movement and reactions to the sound of vessel approaches. The acoustic recorders on the DTAGs will collect information on the acoustic profile of the nearby large vessels, including the received levels of sound at the animal and the frequency characteristics of the ship noise. Kinematic parameters recorded by the tag will be used to categorize animal behavioral states (foraging, traveling, other) and measure direct avoidance responses. At each surfacing during the focal follows behavioral state, distance and bearing (to recreate the whale's track), and estimated distance to the nearest ship will be recorded.

AIS data will be utilized to collect additional information on vessels, including their size, speed, and course of the focal vessel and other ships in the area. Photo-ID images of the focal whale and its associates during the focal follow and biopsy samples will also be collected. Photo-ID images will be shared with colleagues from HDR and contributed to regional catalogs. Biopsy samples will be contributed to the sample collection curated by HDR.

Initial fieldwork for this project will be conducted over a period of two months in the winter of 2018/19, during suitable weather windows. The DTags will be programmed to record for 4 to 6 hours per day, which will allow for multiple ship approaches per animal, and facilitate collection of synoptic behavioral observations. Typically, we will deploy a single tag each day, unless a tag detaches early. Fieldwork will be conducted from the R/V Richard T. Barber with a team of 4-5 individuals, including three field scientists from Duke. The Duke field team will be based in Beaufort, North Carolina and travel to Virginia Beach when weather is conducive for tagging.

Efforts will be made to coordinate DTag deployments with individuals previously tagged with longer term satellite-linked tags (SPOT or SPLASH) to provide days to weeks of movement and behavior data providing additional context for the high resolution short-term DTag deployments. Ideally, individuals will carry both types of tag simultaneously.

2.4 Passive Acoustic Monitoring

Passive acoustic monitoring has been a significant component of the U.S. Navy's MSM program in the Atlantic since it began in 2007. Although initially used primarily to collect baseline data on the occurrence of various species, more recently statistical methods have been developed to begin examining potential changes in vocalization behaviors that could represent responses to training and testing activities. In addition, the Marine Mammal Monitoring on Navy Ranges program has been leveraging permanent, fixed acoustic training ranges to develop a suite of tools and techniques and support various projects addressing specific questions related to marine species monitoring and interactions with training and testing activities.

All current and past deployments of PAM devices including High-frequency Acoustic Recording Packages (HARPs), Marine Autonomous Recording Units (MARUs), Autonomous Multichannel Acoustic Recorders (AMARs), Ecological Acoustic Recorders (EARs), and automated click detectors, can be explored, along with accompanying metadata and links to analyses and reports, through a data viewer on the U.S. Navy's MSM program web portal.

2.4.1 Data Collection (HARPs)

Duke University and Scripps Institution of Oceanography began a long-term program using HARPs as part of a multi-disciplinary monitoring effort for Onslow Bay in 2007, which was later expanded to the JAX OPAREA in 2009, Cape Hatteras in 2012, and Norfolk Canyon in 2014. The array consisted of a single channel HARP sampling at 200 kHz and two units using four-hydrophones arranged in a small aperture (~1 m) array sampling at 100 kHz for each hydrophone (**Figure 46**). Deployments ended at the Onslow Bay site in 2013 but continue at the other locations (**Figure 47**). The primary objective of deployments at all locations has been to determine species distributions and document spatiotemporal patterns of cetaceans throughout areas of interest. During 2018, single-channel HARP data were collected at the Norfolk Canyon, Cape Hatteras, and JAX sites over a bandwidth from 10 Hertz up to 200 kilohertz (kHz). In addition, an array was deployed at the Hatteras location in coordination with the Atlantic BRS project for potential tracking of individual animals (see Gassman et al. 2015 for methods).

All single-channel HARPs deployed were in compact mooring configurations with the hydrophones suspended approximately 20 m above the seafloor. Each HARP was calibrated in the laboratory to provide quantitative analysis of the received sound field. Representative data loggers and hydrophones were also calibrated at the Navy's TRANSDEC facility to verify the laboratory calibrations (Wiggins and Hildebrand 2007).

Deployment details and links to available analyses from all HARP deployments can be found through the HARP data explorer on the U.S. Navy's MSM program web portal.

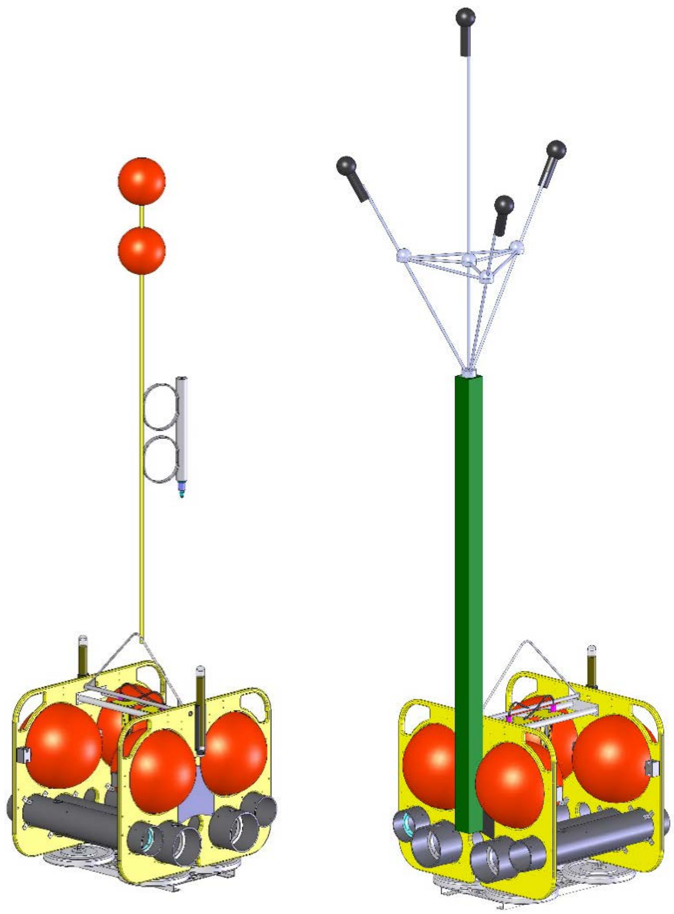

Figure 46. High-frequency Acoustic Recording Package (HARP) configurations – standard seafloor-mounted with one hydrophone (left) and tracking with four hydrophones arranged in a tetrahedron with ~1 m sensor spacing.

2.4.1.1 Norfolk Canyon

Data Collection (Norfolk Canyon)

The HARP (NFC03A) initially deployed on 29 June 2017 near Norfolk Canyon at a depth of 950 m at 37.1674° N, 74.4663° W (Site A) was recovered on 02 June 2018 (**Table 23, Figure 47**), yielding a deployment period of over 338 days (approximately 11 months). The HARP (NFC04A) at Norfolk Canyon Site A was redeployed on 02 June 2018 at 37.1645° N, 74.4659° W, with a measured depth of 1050 m (**Table 23, Figure 47**). This instrument is still in the field and is expected to be recovered in summer 2019.

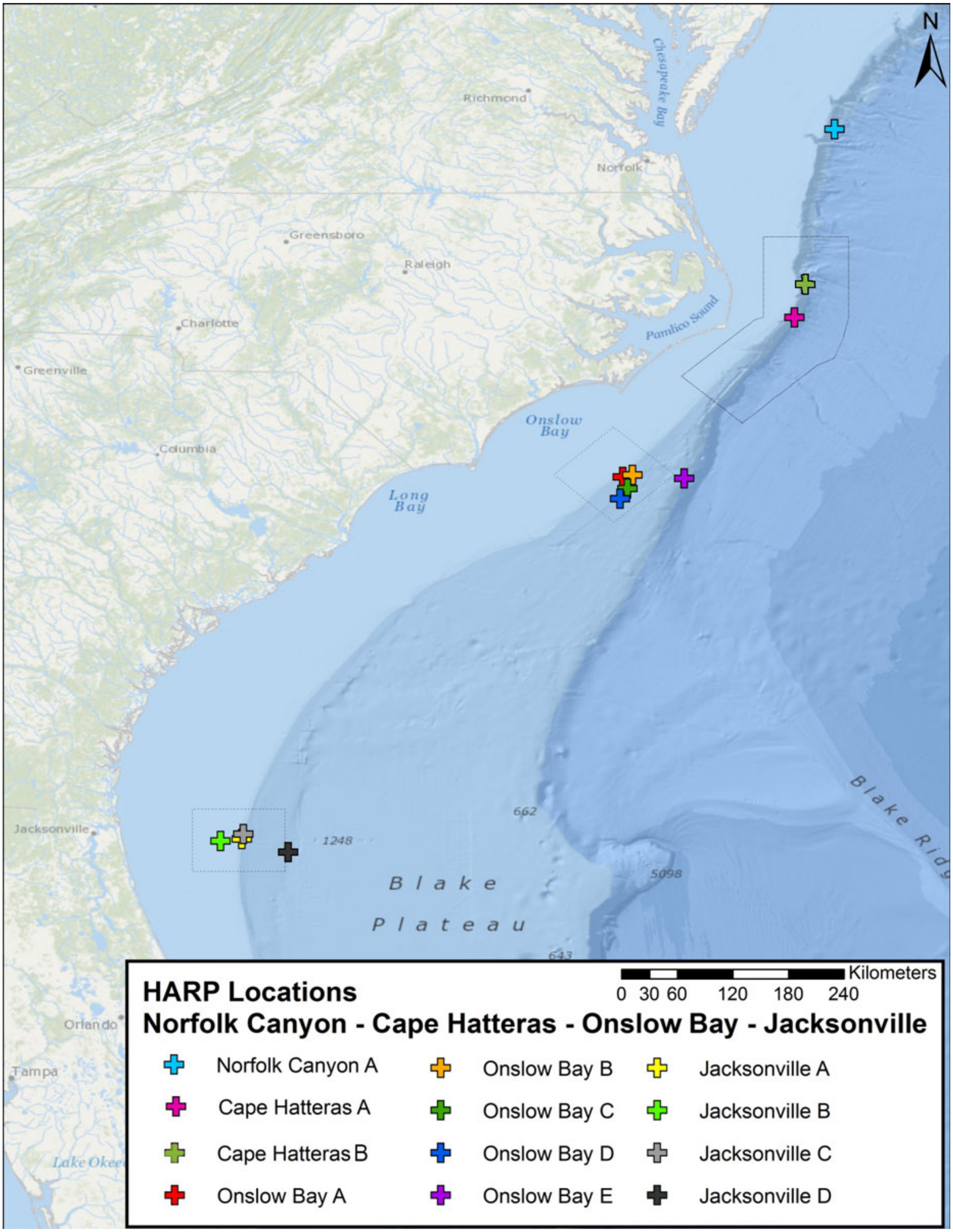

Figure 47. Location of HARPs deployment sites in Norfolk Canyon, Cape Hatteras, Onslow Bay, and JAX.

Table 23. Previous and current HARP deployments at Norfolk Canyon, with currently deployed instrument highlighted in red.

Site	Deployment Date	Retrieval Date	Recording Start Date	Recording End Date	Latitude (°N)	Longitude (°W)	Depth (m)	Sampling Rate	Duty Cycle
01A	19-Jun-14	07-Apr-15	19-Jun-14	05-Apr-15	37.1662	74.4669	982	200 kHz	continuous
02A	30-Apr-16	30-Jun-17	30-Apr-16	28-Jun-17	37.1652	74.4666	968	200 kHz	continuous
03A	29-Jun-17	N/A	29-Jun-17	N/A	37.1674	74.4663	950	200 kHz	continuous
04A	02-Jun-18	N/A	02-Jun-18	N/A	37.1645	74.4659	1050	200 kHz	continuous

Key: kHz = kilohertz, m = meter(s), N/A = not applicable.

2.4.1.2 Cape Hatteras

Data Collection (Cape Hatteras)

In May 2017, the location for HARP deployments at Cape Hatteras was moved approximately 17 nautical miles to the northeast (designated site B) to better coordinate with the location for the Atlantic BRS that initiated in 2017 (see **Section 2.3.1** of this report). An array of 3 HARPs, consisting of one single-hydrophone instrument and 2 four-hydrophone instruments, was deployed at site B from 01 June through 13 December 2018 (**Table 24, Figure 47**). The HAT01B single-hydrophone instrument was on station from 25 October through 01 June 2018, but was redeployed the same day and will be recording through its anticipated recovery timeframe of summer 2019. The four-hydrophone tracking instruments were recovered on 13 December 2018.

Table 24. Previous and current HARP deployments at Cape Hatteras, with currently deployed instrument highlighted in red.

Site	Deployment Date	Retrieval Date	Recording Start Date	Recording End Date	Latitude (°N)	Longitude (°W)	Depth (m)	Sampling Rate	Duty Cycle
02A	09-Oct-12	29-May-13	09-Oct-12	09-May-13	35.3406	74.8559	970	200 kHz	continuous
03A	29-May-13	08-May-14	29-May-13	15-Mar-14	35.3444	74.8521	970	200 kHz	continuous
04A	08-May-14	06-Apr-15	09-May-14	11-Dec-14	35.3467	74.8480	850	200 kHz	continuous
05A	06-Apr-15	29-Apr-16	07-Apr-15	29-Jan-16	35.3421	74.8572	980	200 kHz	continuous
06A	29-Apr-16	09-May-17	29-Apr-16	06-Feb-17	35.3057	74.8776	1,020	200 kHz	continuous
B#1-1C-01	09-May-17	25-Oct-17	09-May-17	25-Oct-17	35.5837	74.7492	1,118	200 kHz	continuous
B#2-4C-01	09-May-17	28-Jun-17	09-May-17	28-Jun-17	35.5797	74.7559	1,111	200 kHz	continuous
B#3-4C-01	09-May-17	28-Jun-17	09-May-17	28-Jun-17	35.5865	74.7560	1,095	200 kHz	continuous
B#2-4C-02	28-Jun-17	Lost-at-sea	28-Jun-17	N/A	35.5793	74.7569	1,040	200 kHz	continuous
B#3-4C-02	28-Jun-17	25-Oct-17	28-Jun-17	25-Oct-17	35.5861	74.7558	1,190	200 kHz	continuous
B#1-1C-02	25-Oct-17	1-Jun-18	25-Oct-17	1-Jun-18	35.5835	74.7431	1,117	200 kHz	continuous
B#1-1C-03	01-Jun-18	13-Dec-18	01-Jun-18	13-Dec-18	35.5897	74.7476	1350	200 kHz	continuous
B#2-4C-03	01-Jun-18	13-Dec-18	N/A	N/A	35.5851	74.7515	1175	200 kHz	continuous
B#3-4C-03	01-Jun-18	13-Dec-18	01-Jun-18	13-Dec-18	35.5905	74.7628	1078	200 kHz	continuous
B#1-1C-03	13-Dec-18	N/A	13-Dec-18	N/A	35.5897	74.7476	1350	200 kHz	continuous

Key: kHz=kilohertz; m=meter(s); N/A=not applicable.

The combination of these 3 instruments provides sufficient array coverage for tracking individual cetaceans; the analyses of these data will be directed toward the tracking of beaked whales in coordination with BRS CEEs. The precise position of these instruments was determined by acoustic ranging to them from a surface vessel, while the vessel's position was determined from GPS satellite navigation. The uncertainty of their final positions was 7 to 22 m. The 2 four-hydrophone HARPs were deployed for 195 days; however, one of the units had a malfunction and did not record any data. The other HARP functioned as expected and can be used with the single channel HARP for acoustic tracking of cetaceans.

2.4.1.3 Jacksonville OPAREA

Data Collection (JAX)

The HARP (JAX14D) deployed at Site D in the JAX OPAREA on 25 June 2017 was recovered on 26 June 2018, having recorded continuously for 366 days. JAX15D was deployed 26 June 2018 at the same location and is planned for recovery in summer 2019 (**Table 25, Figure 47**).

Table 25. Previous and current HARP deployments in JAX, with currently deployed instrument highlighted in red.

Site	Deployment Date	Retrieval Date	Recording Start Date	Recording End Date	Latitude (°N)	Longitude (°W)	Depth (m)	Sampling Rate	Duty Cycle
11D	23-Aug-14	02-Jul-15	23-Aug-14	22-May-15	30.1506	79.7700	806	200 kHz	continuous
12D	02-Jul-15	26-Apr-16	03-Jul-15	04-Nov-15	30.1489	79.7711	800	200 kHz	continuous
13D	26-Apr-16	N/A	26-Apr-16	N/A	30.1518	79.7702	736	200 kHz	continuous
14D	25-Jun-17	N/A	25-Jun-17	N/A	30.1527	79.7699	740	200 kHz	continuous
15D	26-June-18	N/A	26-June-18	N/A	30.1522	79.7710	740	200 kHz	continuous

Key: kHz = kilohertz; m = meter(s); N/A = not applicable.

For the next reporting period, Scripps Institution of Oceanography will analyze the 2018 datasets from Norfolk Canyon Site A, Cape Hatteras Site B, and JAX Site D, once the HARPs are recovered in summer 2019. Detailed technical reports will be available once the analyses of the datasets are complete. For more information on the HARP program, refer to the primary literature publications using data from previous HARP deployments (Davis et al. 2017, Stanistreet et al. 2016, Hodge et al. 2018).

A metadata viewer including links to individual technical reports of HARP deployments is available at: http://www.navymarinespeciesmonitoring.us/data-access1/passive-acoustic-data/harp-reports/.

2.4.2 Occurrence and Ecology of North Atlantic Shelf-Break Species

This is an FY18 new-start project with no progress to report during 2018.

Acoustically sensitive species such as beaked whales, inhabit the North Atlantic shelf break region. While all ESA listed baleen whales, such as the North Atlantic right whale (*Eubalaena glacialis*), fin (*Balaenoptera physalus*), blue (*Balaenoptera musculus*), and sei whales (*Balaenoptera borealis*), are known to use this area to different extents. NOAA's Northeast Fisheries Science Center and Scripps Institution of Oceanography (SIO) have been collaboratively deploying long-term HARP passive acoustic monitoring stations at 8 sites along the western North Atlantic shelf break since 2016. Likewise, the US Navy has been monitoring the shelf break region at 3 sites since 2007. Together these combined efforts bring the total to 11 recording sites spanning the U.S. eastern seaboard, from New England to Georgia. Earlier HARP recorders have been analyzed (e.g., Davis et al. 2017; Stanistreet et al. 2017, 2018); however, data collected since 2015 still require analysis and incorporation into the broader ecological framework.

Acoustic analyses of these recorders will allow for an improved understanding of the long term seasonal presence of marine mammals on the western North Atlantic shelf break and how their composition changes across time. This baseline information will be used to assess the effects of anthropogenic activities, such as Navy exercises, on these species and provide context to observed species responses. Analytical time is needed to run detectors on these datasets, as well as software maintenance and hardware storage for the data. In addition, support is needed to travel to collaborative meetings to report on the findings.

This project is aimed at moving the analytical component forward on a number of key scientific areas including:

- Novel broad-scale approach to assessing acoustic niche and anthropogenic contributors
- Seasonal and spatial occurrence of beaked whales and Kogiid whales
- Occurrence and acoustic behavior of baleen whales
- Anthropogenic drivers of distribution – identifying different sources and potential impacts on species
- Delphinid occurrence – focus on improving species specific identification to evaluate species diversity and habitat use across sites

2.4.3 Bryde's Whale Occurrence in the Northeastern Gulf of Mexico

This is an FY18 new-start project with no progress to report during 2018.

The Gulf of Mexico (GoM) Bryde's whale (*Balaenoptera edeni)*, the only resident baleen whale in the GoM ecosystem, has been proposed by NMFS for listing as an endangered subspecies under the US Endangered Species Act (ESA). With an estimated 33 individuals, their population size is similar to the most endangered whale populations in US waters, the North Pacific right whale (31 individuals) and the North Atlantic right whale (450 individuals). In US waters, the GoM Bryde's whales' currently known habitat is restricted to a narrow range in waters between 100-400m depth in off the northwestern Florida shelfbreak, though historic whaling records indicate these whales were once found throughout the GoM. If the whales are listed under the ESA, critical habitat must be designated, yet it is unknown whether their current distribution extends beyond the known habitat and whether they exhibit seasonal movements throughout the GoM. A Biological Status Review recommended studies to determine the full range of distribution of GoM whales and seasonality of occurrence among the highest priority data needs.

The SEFSC and Scripps Institution of Oceanography have been collaboratively deploying long-term passive acoustic monitoring stations at 5 GoM sites since 2010 to monitor the impacts of the Deepwater Horizon oil spill and subsequent restoration activities on cetaceans. High-frequency Acoustic Recording Packages deployed at the five sites, including the DeSoto Canyon (DC) in the primary GOM Bryde's whale habitat, have been continuously recording ambient noise and other acoustic events in the 10 Hz to 100 kHz frequency range, and these 8-year near-continuous recordings are available for analysis to better understand distribution and density trends of cetaceans, potentially including Bryde's whales. Data from the DC HARP site have only been evaluated for downsweep call sequences in the first few years of data

(Širović et al., 2014), and have not been evaluated for probable long-moan calls or constant tonal calls (e.g., Rice et al., 2014), which have also recently been recorded by SEFSC in the presence of GoM Bryde's whales. Analysis of this data will establish complete occurrence time-series for understanding seasonal and interannual trends and for future habitat modeling and density estimation.

2.4.4 Passive Acoustic Monitoring for Cetaceans on the Continental Shelf off Virginia

Little is known about the seasonal and spatial occurrence of marine mammals off the coast of Virginia, especially in offshore areas. This data gap presents a challenge for effective marine spatial planning. Consequently, collecting baseline data on spatial and temporal trends of cetacean occurrence in these areas is critical to minimize or mitigate risks to protected species. The Bureau of Ocean Energy Management and U.S. Navy have collaboratively funded The Bioacoustics Research Program at the Cornell Lab of Ornithology to undertake a three-year PAM study of the occurrence of cetaceans in continental shelf waters in and around the VA WEA and across the continental shelf off the mouth of Chesapeake Bay.

Ten bottom-mounted passive acoustic recorders were deployed off the coast of Virginia for 3 years (**Figure 48**). A combination of high-frequency AMARs, and low-frequency MARUs is deployed in 2 spatial configurations, with 4 AMARs in a linear array extending east from the mouth of the Chesapeake Bay across the continental shelf, and 6 MARUs deployed as a synchronized localization array within the VA WEA.

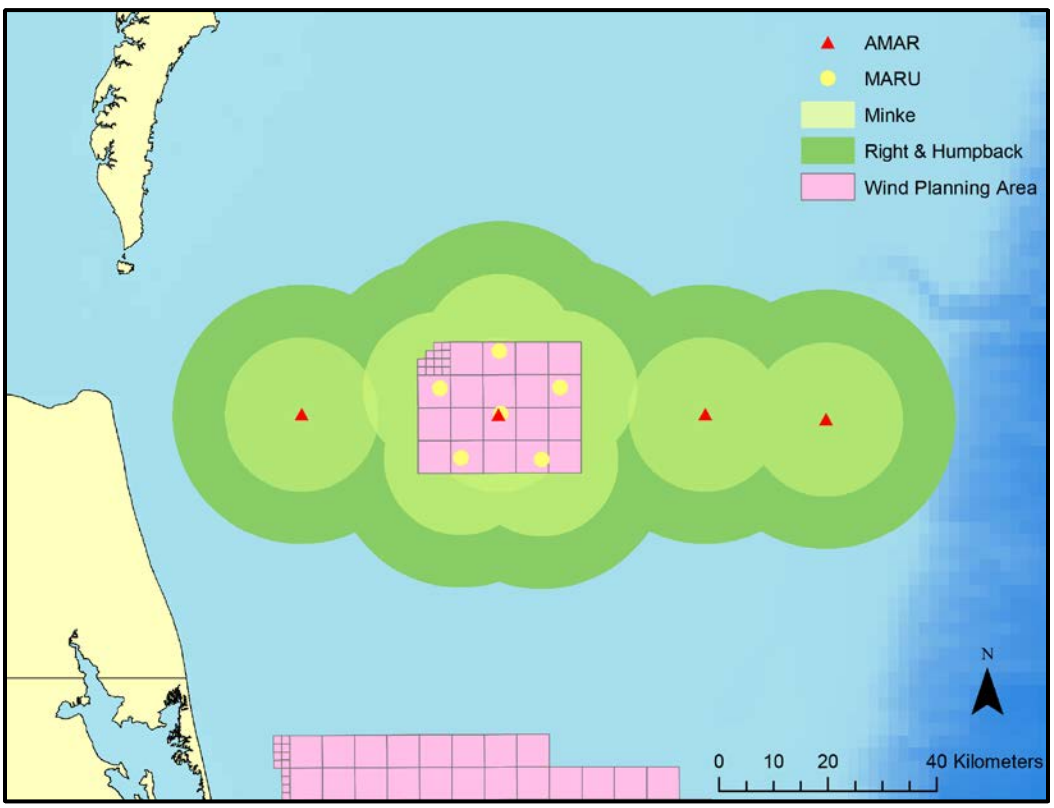

Figure 48. Map of low-frequency (MARU) and high-frequency (AMAR) passive acoustic recorders deployed across the continental shelf off the mouth of Chesapeake Bay. Green shading indicates estimated detection ranges for minke, North Atlantic right, and humpback whales.

The initial deployment made in July 2015 and recordings were made through April 2017. The data were analyzed using a combination of human analysts and automated approaches to describe the occurrence of: (1) four species of mysticetes: fin, humpback, minke, and North Atlantic right whales; odontocetes; and sonar signals.

The large geographic and temporal scale of the study enables a comparison of seasonal trends in cetacean presence across the continental shelf off the coast of Virginia, as well as inter-annual variability for this region. These results will help inform the U.S. Navy and Bureau of Ocean Energy Management of species occurrence, active seasonal periods, and high-use regions or corridors to assist with environmental regulatory compliance and spatial planning.

This project is now complete, and more details can be found in the final reports (Estabrook and Klinck 2018 and Salisbury et al. 2018).

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SECTION 3 – DATA MANAGEMENT

Large amounts of visual, telemetry, and acoustic monitoring data are acquired under the U.S. Navy's MSM program. These data inform the U.S. Navy's environmental-planning decisions, and also contribute to our general knowledge of marine species distribution, ecology, and behavior. The MSM Data Management Plan (DMP; HDR 2014), outlines procedures related to the collection, quality control (QC), formatting, security, classification, governance, processing, archiving, and reporting of data acquired under the U.S. Navy's MSM program. The DMP provides the necessary framework for effective management of all data acquired under the U.S. Navy MSM program, from the initial step of data collection through the final step of data archival. The DMP establishes the method by which data flow through the management system and the controls applied to the data during the process. Additionally, the DMP is an important tool that promotes the fullest utilization of the data through data sharing and integration amongst U.S. Navy departments, environmental planners, and researchers. This is achieved in part via the documentation and standardization of data-collection techniques among various researchers. Procedures related to MSM data collection and data management continue to evolve because of refined survey methodologies, improved technologies, and an expanded knowledge base. The DMP is a living document that reflects this evolution, and periodic revisions are driven by adaptive data management based on maturation of the program, and evolving U.S. Navy guidance on specific data-management procedures, including those outlined in the following subsections.

3.1 Data Standards

The U.S. Navy MSM program requires that all acquired data be maintained for ready dissemination to U.S. Navy environmental planners, analysts, and researchers, and formatted to ensure compatibility with existing marine databases (HDR 2014). Starting in 2013, the U.S. Navy developed a MSM Data Standard applicable to survey data acquired under the U.S. Navy MSM program. The data standard lists all potential data elements collected under the program (e.g., species, sighting location, platform location, environmental variables, etc.), their definitions, required formats for each data element, and any notes, background information, or instructions associated with data collection or data entry for each element. Marine species data are collected under the U.S. Navy MSM program by a variety of researchers, using multiple visual-survey platforms (vessel, aerial, shore-based), following a range of survey protocols. Standardization of the multiple data types associated with the U.S. Navy MSM program provides a common vocabulary for data collectors and analysis, and allows large datasets to be compiled for analysis and interpretation. Standardization across all research efforts in every naval range also enables U.S. Navy data managers to ensure that these datasets comply and are compatible with any applicable Federal data standards and data-management frameworks. Examples of standards and frameworks include the Department of Defense Spatial Data Standards for Facilities, Infrastructure, and Environment; the Department of Defense's Environmental Information Management System (EIMS); the Navy Marine Species Density Database (NMSDD); the Navy Marine Corps Intranet data network and information transfer system; and NOAA's Protected Species Observer and Data Management Program (Baker et al. 2013). This consistent data organization across surveys facilitates back-end data processing and analysis, and streamlines reporting and information sharing among various researchers and stakeholders.

Survey data typically fall into three broad categories: sightings, survey effort, and environmental information. Examples of sighting information include species, sighting location, number of animals, presence of calves, and behavioral state. Survey effort refers to the amount of time spent looking for animals, platform type, number of observers, distance traveled, and effort type (e.g., random, systematic, or transiting). Environmental conditions are also recorded, including sea state, visibility, glare, and cloud cover. The data standard specifies required attribute header names for each data variable, attribute definitions, units in which the data are expressed, and formats for each field (alpha-numeric, text, Boolean, etc.). The U.S. Navy's MSM Data Standard is designed primarily to accommodate visual survey data, including biopsy sampling, and to some extent, tag deployments. The U.S. Navy's MSM Data Standard does not currently accommodate PAM data collected under the U.S. Navy MSM program, which are subject to a different set of data-collection and data-management guidelines.

3.2 Survey Data Collection and Management Toolkit (COMPASS)

The U.S. Navy identified the need for development of a survey data-collection system that fully meets U.S. Navy's MSM Data Standard. The objectives were to streamline data-collection procedures, minimize manual data-management requirements, and increase the standardization and repeatability of data-collection efforts. In response to this need, HDR has developed a survey toolkit called *COMPASS (Cetacean Observation and Marine Protected Animal Survey Software). COMPASS* is designed to be an integrated survey data-collection and data-management system to facilitate work conducted during MSM surveys. The *COMPASS* survey toolkit integrates current mobile and web technologies to allow efficient real-time collection, processing, reporting, and delivery of marine species data. The final product will include a mobile platform for data collection in the field; a web portal to design, plan, and execute surveys and access data products; and a server-hosted database-management system for QC, team collaboration, and preliminary data processing and reporting.

Surveys conducted within the U.S. Navy MSM program include a variety of data-collection scenarios and technologies. The current beta version of the *COMPASS* system addresses the needs for the most common survey types: shore-based (theodolite), vessel-based, and aerial-based. The data-collection routines for each survey type are designed to maintain consistency with the U.S. Navy's MSM Data Standard, which specifies field names, aliases, data types, measurement units, and descriptions for data that are collected in the field (**Figure 49**). Each data-collection scenario will use some subset of fields specified in the U.S. Navy's MSM Data Standard.

The mobile app runs on the Apple iPad® platform, a widely available and familiar tablet computer. It is the primary interface for the collection of field data. The mobile app includes mapping capabilities for navigation and data collection, and functions in areas without network or cellular connectivity. It can display the data stream (e.g., sightings and effort), relevant auxiliary data (e.g., range complex boundaries, exclusion zones, passive acoustic monitoring stations, pinnacles, etc.), and customizable base-map layers (e.g., bathymetry, ortho-imagery) (**Figure 50**). Users can pan and zoom on the map, and control the visibility of data layers on the map. Users are able to search the attributes of collected data and auxiliary data, and zoom to the search results. Customizable data fields allow users to collect data relevant to each of the survey types including ancillary tasks (e.g., focal-follow studies, biopsy collection, satellite tagging, etc.). All data are stored in relational databases adhering to the U.S. Navy's MSM Data Standard. Synchronization of data collected within the mobile app to a central database server occurs via Wi-Fi, cellular data connection, or direct Universal Serial Bus connection. Transmitting collected data as soon as possible after a survey ensures that information is archived and protected, while allowing for collaborative QC review and editing through a web-based user interface. Alternatively, data can be backed up, edited, and managed locally, when web connectivity is unavailable.

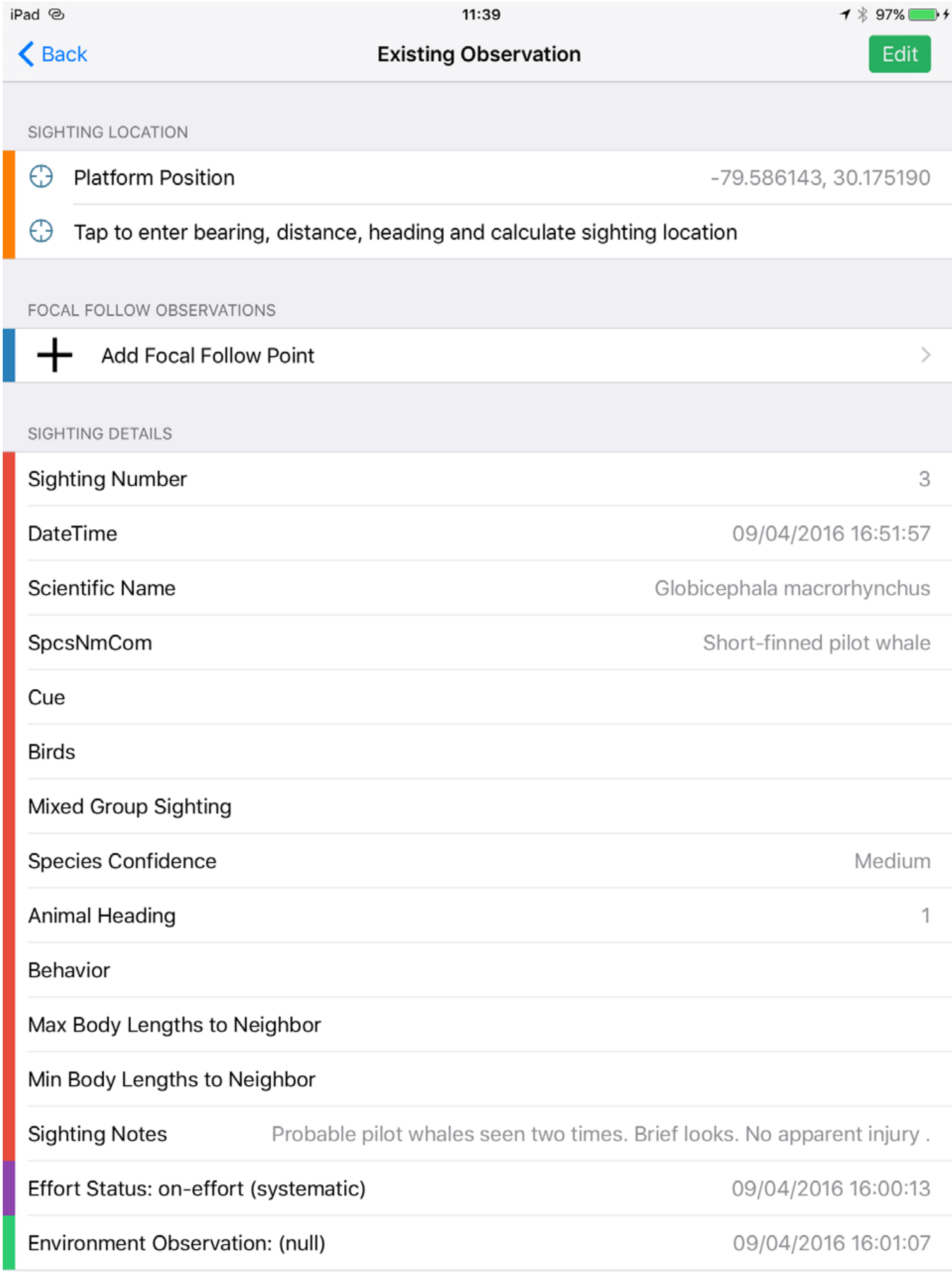

Figure 49. Screenshot of the *COMPASS* field app showing data entry fields for an observation.

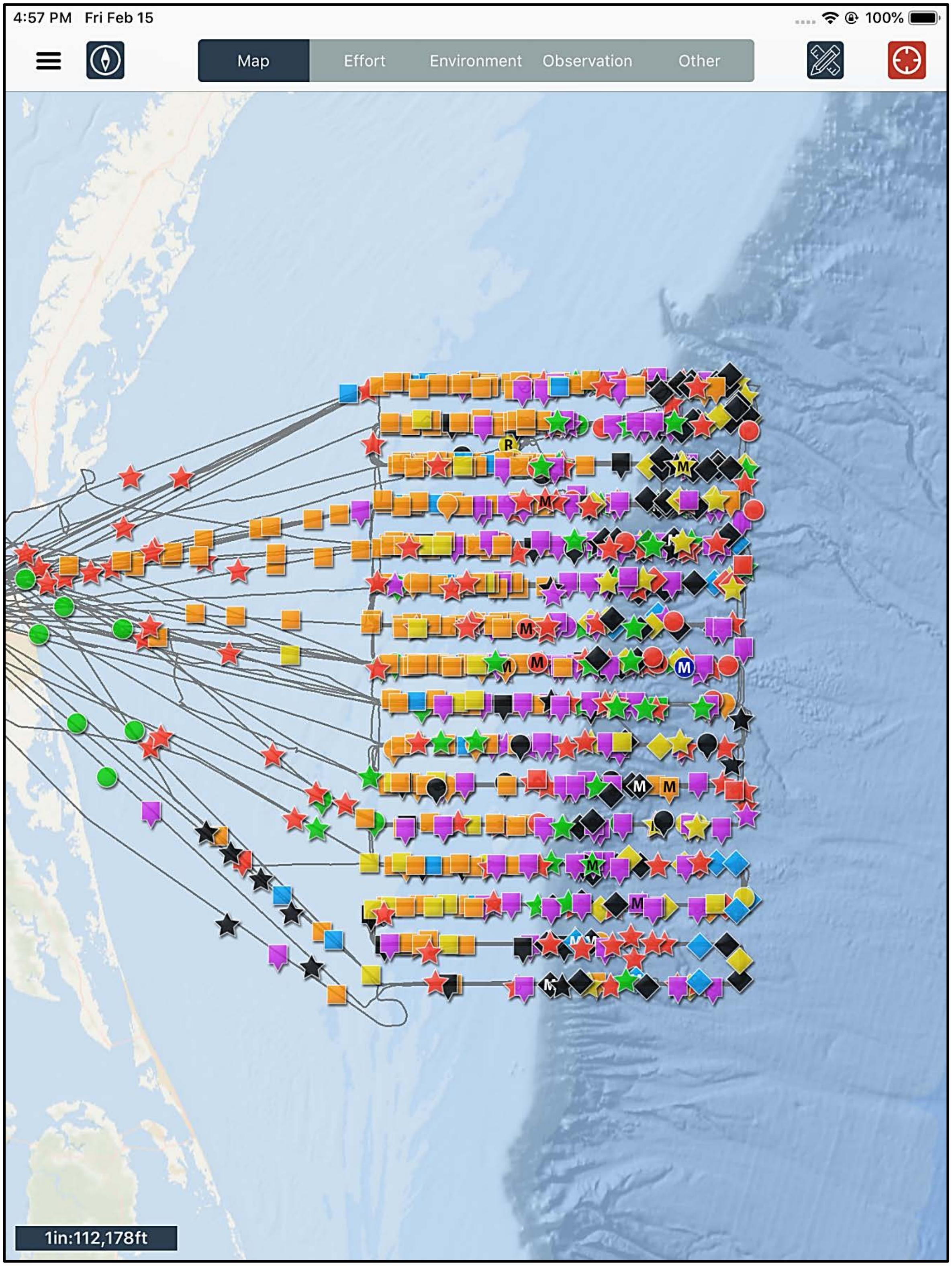

Figure 50. Screenshot from *COMPASS* field app showing tracklines and sightings made during aerial survey efforts. Different custom symbols indicate sightings, symbols with 'R' indicate resightings, symbols with 'M' indicate multi-species, and gray lines show trackline effort.

The web-based application is the central interface for the management of marine species surveys and data. It allows access from any Internet-connected computer, allowing field crews, biologists, and program managers from multiple locations to collaborate on active surveys. New users may be added easily, and authorization control will be implemented in order to designate specified users able to access different aspects of the surveys and data management. Field crews may use the web application to verify and perform QC checks on data uploaded from the mobile app. Accessing these data via the web allows field crews to verify that collected data have been transmitted successfully to the server and also provides an opportunity to review, as well as annotate, field data from laptop computers. If Internet access is unavailable, QC checks in the field can be conducted in the mobile app.

Prior to initiating a survey, the web portal is used to set up a new survey, assign authorized users of the system for that survey, and configure survey-specific information including species lists, equipment descriptions, etc. The web portal will provide instructions for the loading of pre-built base maps, which will be created for the most common survey areas. Pre-built base maps will cover the instrumented U.S. Navy training ranges and other areas of interest. The web portal will also provide instructions to load any additional feature data required for the survey including tidal data, tracklines, waypoints of interest, passive acoustic mooring positions, etc.

After the survey is completed and the data are synced to a central database server, primary access to the survey data will occur through a web-based interface. This user interface allows access to the centralized back-end database, and facilitates QC review and editing. It allows a broader set of specified users (e.g., field crews, biologists, program managers, external clients) access to the data, while controlling access through the use of user accounts and permissions. Project managers will use the web application interface to monitor data collection and QC activity, and to export data.

Initial development has been completed for each of the survey platform types, including both the data-collection app and web portal. Additional functionality has been added including customized species lists, customized symbols for map production, and many specific user options to help facilitate ease of use in the field (e.g., heads-up map orientation; user-selected units for distance, horizontal angle, and depth). Additional development has been completed for data outputs into multiple formats (daily summary reports, ArcGIS Map Package files, and flat table database file). With basic functionality complete, follow-on efforts will build off the existing structure and development efforts to further enhance the interface, outputs, and add customized functionality to facilitate ease of use for data input and output.

Following successful initial testing of the app in the aerial-survey configuration in 2016 (during Full Ship Shock Trials, a U.S. Navy training exercise near JAX, Florida), *COMPASS* has been used on a number of other field projects for testing and validation purposes during 2017. HDR is currently using *COMPASS* for multiple vessel surveys offshore of Virginia Beach, Virginia (**Figure 51**), including the Mid-Atlantic Humpback Whale Monitoring project (see **Section 2.2.3**) and the Outer Continental Shelf Break Cetacean Study (**Section 2.2.4**) These small-vessel surveys focus on photo-ID, biopsy sampling, and satellite tagging of large whales. In addition to overall software stability, these efforts have been particularly useful for testing the functionality of related data for the specific field activities beyond visual detection and counting of marine species. For each biopsy and tagging attempt, position and time-stamp logging information are captured along with other ancillary information that is essential for permit reporting.

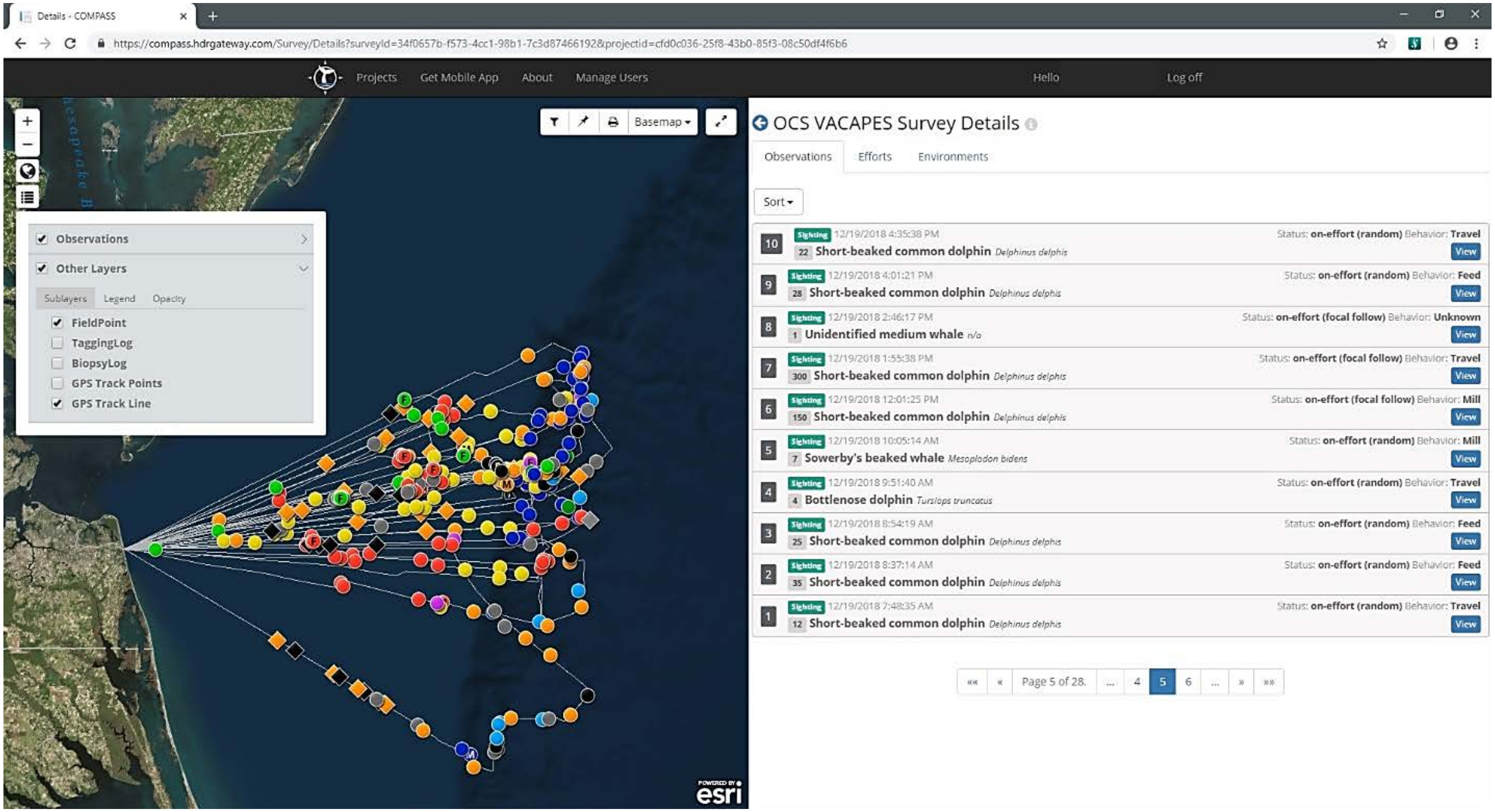

Figure 51. Screenshot from *COMPASS* web portal showing tracklines and sightings made during vessel surveys supporting the VACAPES OCS project. The left side of the screen is the map of sighting data and filtering options for the display and map output. The right side of the screen shows the sighting data that can be sorted, filtered, and edited for the survey.

In 2017, additional added functionality included customized species lists, customized symbology for map production, addition of multiple mobile mapping tools, survey customizability, additional options for units, and customization of summary reports. In 2018, more enhancements were added to both the mobile and web components. Refinement of survey statistics was completed, along with the addition of a dynamic map legend, more data filtering options, improved online mapping, addition of "quick-sighting" option for data collection, and other functionality enhancements. Testing also continued on various projects for all 3 survey types. The ability to use *COMPASS* on active survey projects has allowed for real-world testing opportunities to identify bugs and continue improving workflow issues in a number of dynamic scenarios.

Final development will be complete in early 2019, and *COMPASS* source code, including a complete field user guide, will be delivered to Naval Facilities Engineering Command as a final deliverable. For more information, refer to the annual progress report for this project (Richlen et al. 2019).

3.3 Data Archiving and Access

All survey data collected under the U.S. Navy MSM program are provided to the Navy's EIMS, a geographic information system-based toolset to support U.S. Navy environmental and range-sustainment programs, including environmental planning for at-sea training/testing and at-sea regulatory compliance. Data are uploaded to EIMS in the form of geodatabase files, containing feature classes for sightings (points) and survey tracklines (polylines). Source data from all surveys also are uploaded for archival purposes, accompanied by all relevant metadata. Marine species data maintained in this centralized location allow the U.S. Navy to track all MSM data collected in various training ranges and to use this information to build the NMSDD. Under U.S. federal laws, the U.S. Navy is required to estimate the impacts of U.S. Navy-generated underwater sound on protected marine species, and to calculate the numbers of animals that may be affected by the sound generated during U.S. Navy training and testing activities. In order to calculate accurate "take" estimates, the U.S. Navy must consider marine species density estimates (number of animals per unit area) for all U.S. Navy training and testing ranges. The NMSDD provides the U.S. Navy with data necessary to quantify impacts of sound on protected marine species. In range complexes where density information is lacking, the NMSDD can be used to extrapolate or predict densities to calculate takes where little or no information exists.

The U.S. Navy MSM data-management team effectively disseminates data to facilitate information sharing among stakeholders, and to advance the general knowledge of marine species distribution and behavior. This information dissemination is achieved in part by the delivery of U.S. Navy MSM visual survey data to the OBIS-SEAMAP database, an interactive online archive for marine mammal, sea turtle, seabird, and selected fish data. Researchers worldwide contribute datasets to Duke University's Marine Geospatial Ecology and Marine Conservation Ecology Laboratories, which maintain OBIS-SEAMAP. The U.S. Navy provides all MSM survey data to OBIS-SEAMAP to contribute to the knowledge of global patterns of marine species distribution and biodiversity. Once these datasets are provided to OBIS-SEAMAP and have been through a review process, the information is published at http://seamap.env.duke.edu/partner/NAVY. In 2018, 40 new datasets from 9 Fleet-funded Atlantic and Pacific projects were submitted to OBIS-SEAMAP.

In addition to visual survey data, animal telemetry data collected from tagging studies are provided to a variety of publically-available databases, including movebank.org, seaturtle.org, and the Animal Telemetry Network (https://ioos.noaa.gov/project/atn/). A summary of Navy-funded animal telemetry data and links to these databases can be found on the MSM web portal at: hhttps://www.navymarinespeciesmonitoring.us/data-access1/tagging-data/.

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SECTION 4 – ADAPTIVE MANAGEMENT AND STRATEGIC PLANNING PROCESS

4.1 Adaptive Management

Adaptive management is an iterative process of optimal decision-making in the face of uncertainty, with an aim to reduce uncertainty over time via system monitoring and feedback. Within the natural resource management community, adaptive management involves ongoing, real-time learning and knowledge creation, both in a substantive sense and in terms of the adaptive process itself. Adaptive management focuses on learning and adapting, through partnerships of managers, scientists, and other stakeholders. Adaptive management helps managers maintain flexibility in their decisions, knowing that uncertainties exist, and provides managers the latitude to change direction to improve understanding of ecological systems and achieve management objectives. Taking action to improve progress toward desired outcomes is another function of adaptive management.

The AMR process involves NMFS, the Marine Mammal Commission (MMC), and other experts in the scientific community through technical review meetings and ongoing discussions. Dynamic revisions to the compliance monitoring structure because of AMR include the development of the Strategic Planning Process (DoN 2013d*)*, which is a planning tool for selection and management of monitoring projects, and its incorporation into the ICMP. Phase II monitoring addresses the ICMP top-level goals through a collection of specific regional and ocean-basin studies based on scientific objectives. The AMR process and reporting requirements serve as the basis for evaluating performance and compliance.

4.2 Strategic Planning Process

The U.S. Navy MSM program has evolved and improved because of the AMR process through changes including:

- Recognize the limitations of effort-based compliance metrics.
- Develop a conceptual framework based on recommendations from the Scientific Advisory Group (DoN 2013d).
- Shift focus to projects based on scientific objectives that facilitate generation of statistically meaningful results upon which natural resources management decisions may be based.
- Focus on priority species or areas of interest as well as best opportunities to address specific monitoring objectives in order to maximize return on investment.
- Increase transparency of the program and management standards, improving collaboration among participating researchers, and improve accessibility to data and information resulting from monitoring activities.

As a result, U.S. Navy's compliance monitoring has undergone a transition with the implementation of the Strategic Planning Process under MMPA Authorizations for AFTT and Hawaii-Southern California Training and Testing. Under this process, Intermediate Scientific Objectives serve as the basis for developing and executing new monitoring projects across the U.S. Navy's training and testing ranges (both Atlantic and Pacific). Implementation of the Strategic Planning Process involves coordination among Fleets, systems commands, CNO-N45, NMFS, and the MMC and has five primary steps:

1. **Identify overarching intermediate scientific objectives:** Through the adaptive management process, the U.S. Navy coordinates with NMFS as well as the MMC to review and revise the list of intermediate scientific objectives that are used to guide development of individual monitoring projects. Examples include addressing information gaps in species occurrence and density, evaluating behavioral response of marine mammals to U.S. Navy training and testing activities, and developing tools and techniques for passive acoustic monitoring.
2. **Develop individual monitoring project concepts:** This step generally takes the form of soliciting input from the scientific community in terms of potential monitoring projects that address one or more of the intermediate scientific objectives. This can be accomplished through a variety of forums including professional societies, regional scientific advisory groups, and contractor support.
3. **Evaluate, prioritize, and select monitoring projects:** U.S. Navy technical experts and program managers review and evaluate all monitoring project concepts and develop a prioritized ranking. The goal of this step is to establish a suite of monitoring projects that address a cross-section of intermediate scientific objectives spread over a variety of range complexes.
4. **Execute and manage selected monitoring projects:** Individual projects are initiated through appropriate funding mechanisms and include clearly defined objectives and deliverables (e.g., data, reports, publications).
5. **Report and evaluate progress and results:** Progress on individual monitoring projects is updated through the U.S. Navy's marine species monitoring web portal as well as annual monitoring reports submitted to NMFS. Both internal review and discussions with NMFS through the adaptive management process are used to evaluate progress toward addressing the primary objectives of the ICMP and serve to periodically recalibrate the focus on the U.S. Navy's MSM program.

These steps serve three primary purposes: (1) facilitate the U.S. Navy in developing specific projects addressing one or more intermediate scientific objectives; (2) establish a more structured and collaborative framework for developing, evaluating, and selecting monitoring projects across all areas where the U.S. Navy conducts training and testing activities; and (3) maximize the opportunity for input and involvement across the research community, academia, and industry. Furthermore, this process is designed to integrate various elements:

- Integrated Comprehensive Monitoring Program top-level goals
- Scientific Advisory Group recommendations
- Integration of regional scientific expert input
- Ongoing AMR dialog between NMFS and U.S. Navy
- Lessons learned from past and future monitoring at U.S. Navy training and testing ranges
- Leverage research and lessons learned from other U.S. Navy-funded science programs

The Strategic Planning Process will continue to shape the future of the U.S. Navy's MSM program and serve as the primary decision-making tool for guiding investments. **Table 26** summarizes U.S. Navy MSM projects currently underway in the Atlantic for 2018. Additional details on these projects as well as results, reports, and publications can be accessed through the U.S. Navy's marine species monitoring web portal as they become available.

Table 26. Summary of monitoring projects in the Atlantic for 2019-20.

Project Description	Intermediate Scientific Objectives	Status
Title: North Atlantic Right Whale Monitoring **Location**: Mid-Atlantic and Southeast calving grounds **Objectives**: Assess behavior of right whales in coastal waters of the Southeast calving grounds, including rates of travel of individuals, dive behavior, and rates of sound production; Assess seasonal distribution in the Mid-Atlantic region. **Methods**: Observational methods combined with short term (ca. 24 hour) non-invasive suction cup attached multi-sensor acoustic recording tags with Fastloc GPS; Autonomous underwater gliders equipped with passive acoustic monitoring capabilities and near real-time reporting. **Performing Organizations**: Duke University, Syracuse University, Woods Hole Oceanographic Institution **Timeline**: 2014 through 2020 **Funding**: FY13 – $335K, FY14 – $390K, FY15 – $505K, FY16 – $390K, FY17 – $278K, FY18 – $268k, FY19 - TBD	• Establish the baseline habitat uses and movement patterns of marine mammals where Navy training and testing activities occur • Establish the baseline vocalization behavior of marine mammals and sea turtles where Navy training and testing activities occur • Establish the baseline behavior (foraging, dive patterns, etc.) of marine mammals where Navy training and testing activities occur	**Field work ongoing** • DTag deployments on SE calving grounds 2014-17 • Technical progress reports available – 2014–2017 • 2018/19 autonomous glider deployments in mid-Atlantic • 2019/20 shift focus to occurrence in Mid-Atlantic
Title: Lower Chesapeake Bay Sea Turtle Tagging and Tracking **Location**: Lower Chesapeake Bay (Hampton Roads) **Objectives**: Assess occurrence and behavior of loggerhead, green, and Kemp's ridley sea turtles in the Hampton Roads region of Chesapeake Bay and coastal Atlantic Ocean **Methods**: Satellite, GPS, and acoustic telemetry tags **Performing Organizations**: Virginia Aquarium and Marine Science Center Foundation, NAVFAC Atlantic, CheloniData LLC **Timeline**: 2013 through 2019 **Funding**: FY13 – $180K, FY14 – $195K, FY15 – $70K, FY16 – $183K, FY17 – $103K, FY18 – $0	• Estimate the density of marine mammals and sea turtles in Navy range complexes and in specific training areas • Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to Navy training and testing activities	**Field work complete** • Technical progress reports available – 2013–2018 • Loggerhead analysis complete • Final Kemp's Ridley analysis underway • Loggerhead publication in prep

Project Description	Intermediate Scientific Objectives	Status
Title: Occurrence, Ecology, and Behavior of Deep Diving Odontocetes **Location**: Cape Hatteras **Objectives**: Establish behavioral baseline and foraging ecology. Assess behavioral response to acoustic stimuli and Navy training activities **Methods**: Visual surveys, biopsy sampling, DTAGs, satellite tags **Performing Organizations**: Duke University, Woods Hole Oceanographic Institution, Cascadia Research Collective **Timeline**: 2013–2017 **Funding**: FY12 – $275K, FY13 – $250K, FY14 – $510K, FY15 – $520K, FY16 – $420K, FY17 – transitioned under Atlantic BRS	• Determine what populations of marine mammals are exposed to Navy training and testing activities • Establish the baseline behavior (foraging, dive patterns, etc.) of marine mammals where Navy training and testing activities occur • Evaluate behavioral responses by marine mammals exposed to Navy training and testing activities	**Transitioned to Atlantic BRS - 2017** • Technical progress reports available – 2013–2018
Title: Atlantic Behavioral Response Study **Location**: Cape Hatteras **Objectives**: Assess behavioral response of beaked and pilot whales to mid-frequency tactical sonar **Methods**: Controlled exposure experiments **Performing Organizations**: Duke University, Woods Hole Oceanographic Institution, Cascadia Research Collective, Southall Environmental Associates, HDR Inc. **Timeline**: 2017–2020 **Funding**: FY16 – $35K, FY17 – $1.25M, FY18 – $1.4M, FY19 – $1.4M	• Evaluate behavioral responses by marine mammals exposed to Navy training and testing activities	**Field work ongoing** • Technical progress reports available – 2017–2018 • Multiple publications in prep
Title: Bottlenose Dolphin Occurrence in Estuarine and Coastal Waters near Panama City, Florida **Location**: St. Andrew Bay and nearshore waters of Panama City, Florida **Objectives**: Determine species occurrence, and distribution, habitat use, and abundance of *Tursiops* in St. Andrew Bay and coastal waters adjacent to the Naval Surface Warfare Center, Panama City Division. **Methods**: Small-vessel visual line transect surveys, photo-ID, biopsy sampling **Performing Organizations**: NOAA Hollings Marine Laboratory **Timeline**: 2015–2017 **Funding**: FY15 – $112K, FY16 – $210K	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Establish the baseline habitat uses and movement patterns of marine mammals where Navy training and testing activities occur • Estimate the density of marine mammals and sea turtles in Navy range complexes and in specific training areas.	**Field work completed 2017** • Technical progress report available – 2015–2017 • Publications available and in prep

Project Description	Intermediate Scientific Objectives	Status
Title: Baseline Monitoring for Marine Mammals in the East Coast Range Complexes – Aerial Surveys **Location**: Virginia Capes, Cherry Point, and Jacksonville Range Complexes **Objectives**: Assess occurrence, habitat associations, and density of marine mammals and sea turtles in key areas of Navy range complexes **Methods**: Visual surveys (aerial) **Performing Organizations**: HDR Inc., UNC Wilmington **Timeline**: 2007-2019 **Funding**: FY13 – $685K, FY14 – $375K, FY15 – $808K, FY16 – $368K, FY17 – $312K, FY18 – $224k	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Estimate the density of marine mammals and sea turtles in Navy range complexes and in specific training areas • Determine what populations of marine mammals are exposed to Navy training and testing activities • Evaluate trends in distribution and abundance of populations that are regularly exposed to Navy training and testing activities	**Current focus – Norfolk Canyon** • Surveys complete spring 2019 • Technical progress report series available
Title: Baseline Monitoring for Marine Mammals in the East Coast Range Complexes – Vessel Surveys **Location**: Virginia Capes, Cherry Point, and Jacksonville Range Complexes **Objectives**: Assess occurrence, habitat associations, and stock structure of marine mammals and sea turtles in key areas of Navy range complexes **Methods**: Aerial and vessel visual surveys, biopsy sampling, photo-ID **Performing Organizations**: Duke University, Cascadia Research Collective **Timeline**: 2007-2020 **Funding**: FY13 – 275K, FY14 – $350K, FY15 – $250M, FY16 – $220K, FY17 – $103K, FY18 – $261k	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Estimate the density of marine mammals and sea turtles in Navy range complexes and in specific training areas • Determine what populations of marine mammals are exposed to Navy training and testing activities • Evaluate trends in distribution and abundance of populations that are regularly exposed to Navy training and testing activities	**Current focus – Jacksonville USWTR** • Transitioned to photo ID and tagging in 2018 • Technical progress report series available

Project Description	Intermediate Scientific Objectives	Status
Title: Baseline Monitoring for Marine Mammals in the East Coast Range Complexes – Passive Acoustics **Location**: Virginia Capes, Cherry Point, and Jacksonville Range Complexes **Objectives**: Assess occurrence, habitat associations, density, stock structure, and vocal activity of marine mammals in key areas of Navy range complexes **Methods**: Passive acoustic monitoring **Performing Organizations**: Duke University, Scripps Institute of Oceanography **Timeline**: 2007-2019 **Funding**: FY13 – $780K, FY14 – $800K, FY15 – $680K, FY16 – $596K, FY17 – $426K, FY18 – $299k	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Establish the baseline vocalization behavior of marine mammals where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to Navy training and testing activities	**HARP deployments ongoing** • Current focus – Norfolk Canyon, Hatteras, Jacksonville • Technical progress report series available • Analysis focus shifted to Shelf Break Species Acoustic Ecology in 2019
Title: Acoustic Ecology of Northwest Atlantic Shelf Break Species **Location**: Northwest Atlantic **Objectives**: Assess seasonal and spatial, acoustic niches, and anthropogenic drivers of distribution throughout the Northwest Atlantic shelf break region **Methods**: Passive acoustic monitoring **Performing Organizations**: Northeast Fisheries Science Center **Timeline**: 2019-2021 **Funding**: FY18 – $143k	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Establish the baseline vocalization behavior of marine mammals where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to Navy training and testing activities	**New start 2019**
Title: Occurrence of Bryde's Whales in Northeastern Gulf of Mexico **Location**: Northeastern Gulf of Mexico **Objectives**: Assess seasonal and occurrence of Bryde's whales in the Northeastern Gulf of Mexico **Methods**: Passive acoustic monitoring **Performing Organizations**: Southeast Fisheries Science Center **Timeline**: 2019-2021 **Funding**: FY18 – $78k	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Establish the baseline vocalization behavior of marine mammals where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to Navy training and testing activities	**New start 2019**

Project Description	Intermediate Scientific Objectives	Status
Title: Mid-Atlantic Humpback Whale Monitoring **Location**: VACAPES Range Complex **Objectives**: Assess occurrence, habitat use, and baseline behavior of humpback whales in the mid-Atlantic region **Methods**: Focal follow observational methods, photo-ID, biopsy sampling, satellite tagging **Performing Organizations**: HDR, Inc. **Timeline**: 2015 through 2020 **Funding**: FY14 – $320K, FY15 – $260K, FY16 – $370K, FY17 – $325K, FY18 – $0, FY19 – $250k	• Establish the baseline habitat uses and movement patterns of marine mammals where Navy training and testing activities occur • Establish the baseline behavior (foraging, dive patterns, etc.) of marine mammals where Navy training and testing activities occur	**Field work ongoing** • Satellite tagging component added 2015/16 field season • Technical progress reports available – 2014–18 • Vessel response component added winter of 2018–19
Title: Behavioral Response of Humpback Whales to Vessel Traffic **Location**: Chesapeake bay and Nearshore Mid-Atlantic **Objectives**: Understand the behavioral response of humpback whales to approaching vessels in the shipping channels at the mouth of the Chesapeake Bay. **Methods**: Dtagging, satellite tagging, and focal follow observational methods **Performing Organizations**: Duke University, HDR Inc. **Timeline**: 2019-20 **Funding**: FY19 – $95K	• Establish the baseline behavior (foraging, dive patterns, etc.) of marine mammals where Navy training and testing activities occur • Evaluate behavioral responses of marine mammals exposed to Navy training and testing activities	**Winter 2018–19 pilot project**
Title: VACAPES Continental Shelf Break Cetacean Study **Location**: VACAPES Range Complex **Objectives**: Assess occurrence, habitat use, and baseline behavior of cetaceans in the mid-Atlantic region **Methods**: Visual surveys, focal follow observational methods, photo-ID, biopsy sampling, satellite tagging **Performing Organizations**: HDR, Inc. **Timeline**: 2015- 2020 **Funding**: FY15 – $75K, FY16 – $645K, FY17 – $0, FY18 – $321K	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Establish the baseline habitat uses and movement patterns of marine mammals where Navy training and testing activities occur • Establish the baseline behavior (foraging, dive patterns, etc.) of marine mammals where Navy training and testing activities occur	**Field work ongoing** • Technical progress reports available – 2016–2018

Project Description	Intermediate Scientific Objectives	Status
Title: Haul Out Counts and Photo-Identification of Pinnipeds in Chesapeake Bay, Virginia **Location**: Chesapeake Bay **Objectives**: Document seasonal occurrence, habitat use, and haul-out patterns of seals **Methods**: Visual surveys, photo-ID **Performing Organizations**: NAVFAC Atlantic **Timeline**: 2015-2020 **Funding**: FY15 – $52K, FY16 – $57K, FY17 – $7K, FY18 – $29k, FY19 – $260k	• Estimate the density of marine mammals and sea turtles in Navy range complexes and in specific training areas • Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to sonar and underwater explosives	**Field work ongoing** • Technical progress reports available – 2016–2018
Title: Seal Tagging and Tracking in Virginia **Location**: Lower Chesapeake Bay (Hampton Roads) **Objectives**: Document habitat use, movement and haul-out patterns of seals in the Hampton Roads region of Chesapeake Bay and coastal Atlantic Ocean **Methods**: Photo-ID, tagging **Performing Organizations**: NAVFAC Atlantic, Naval Undersea Warfare Center, The Nature Conservancy, Atlantic Marine Conservation Society, Virginia Aquarium & Marine Science Center Foundation, HDR Inc. **Timeline**: 2017–2020 **Funding**: FY16 – $40K, FY17 – $164K, FY18 – $46k, FY19 – $32k	• Estimate the density of marine mammals and sea turtles in Navy range complexes and in specific training areas • Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to sonar and underwater explosives	**Field work began winter 2017/18** • Technical progress report available – 2017/18
Title: Mid-Atlantic humpback Whale Catalog **Location**: Northwest Atlantic **Objectives**: Establish a centralized collaborative humpback whale photo-id catalog for the mid-Atlantic and southeast regions to support management and environmental planning **Methods**: Photo-ID **Performing Organizations**: Organizations: Virginia Aquarium & Marine Science Center Foundation, Duke University **Timeline**: 2017–2019 **Funding**: FY16 – $106K, FY17 – $74K, FY18 - $75k	• Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur	• Stakeholder workshop report available • Technical progress reports available – 2016–2018

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APPENDIX A

RECENT PUBLICATIONS AND PRESENTATIONS RESULTING FROM AFTT-RELATED MONITORING INVESTMENTS

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Appendix A: Recent Publications and Presentations Resulting from AFTT-related Monitoring Investments

Barco, S.G., M.L. Burt, R.A. DiGiovanni, Jr., W.M. Swingle, and A.S. Williard. 2018. Loggerhead turtle *Caretta caretta* density and abundance in Chesapeake Bay and the temperate ocean waters of the southern portion of the Mid-Atlantic Bight. Endangered Species Research 37: 269-287.

Baumann-Pickering, S., J.S. Trickey, A. Širović, C.S. Oedekoven, J.A. Hildebrand, L. Thomas, S.M. Wiggins, and M.A. Roch. 2018. Impact of mid-frequency active sonar on beaked whale echolocation from long-term passive acoustic recordings. Abstracts, ESOMM-2018, 6th International Meeting on the Effects of Sounds in the Ocean on Marine Mammals, The Hague, The Netherlands, 9-14 September 2018.

Foley, H.J. 2018. Spatial ecology and movement patterns of deep-diving odontocetes in the western North Atlantic. Master's Thesis, North Carolina State University.

Harris, C.M., L. Thomas, E.A. Falcone, J. Hildebrand, D. Houser, P.H. Kvadsheim, F.P.A. Lam, P.J.O. Miller, D.J. Moretti, A.J. Read, H. Slabbekoorn, B.L. Southall, P.L. Tyack, D. Wartzok, and V.M. Janik. 2018. Marine mammals and sonar: Dose-response studies, the risk-disturbance hypothesis and the role of exposure context. Journal of Applied Ecology 55:396-404.

Henderson, E.E., J. Aschettino, M. Deakos, G. Alongi, T. Leota, and D. Engelhaupt. 2018. Tracking the offshore and migratory movements of humpback whales in Hawaii. Abstracts, Southern California Marine Mammal Workshop 2018. 26-27 January 2018. Newport Beach, California.

Henderson, E.E., T.A. Helble, G.R. Ierley, and S.W. Martin. 2018. Identifying behavioral states and habitat use of acoustically tracked humpback whales in Hawaii. Marine Mammal Science 34:701-717.

Hodge, L.E.W., S. Baumann-Pickering, J.A. Hildebrand, J.T. Bell, E.W. Cummings, H.J. Foley, R.J. McAlarney, W.A. McLellan, D.A. Pabst, Z.T. Swaim, D.M. Waples, and A.J. Read. 2018. Heard but not seen: Occurrence of *Kogia* spp. along the western North Atlantic shelf break. Marine Mammal Science 34: 1141-1153.

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Martin, C.R., S.W. Martin, and E.E. Henderson. 2018. Estimating received levels of acoustically tracked whales from Navy mid-frequency active sonar. Journal of the Acoustical Society of America 144: 1885-1886.

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Merkens, K., D. Mann, V.M. Janik, D. Claridge, M. Hill, and E. Oleson. 2018. Clicks of dwarf sperm whales (*Kogia sima*). Marine Mammal Science 34: 963-978.

Patel, S.H., S.G. Barco, L.M. Crowe, J.P. Manning, E. Matzen, R.J. Smolowitz, and H.L. Haas. 2018. Loggerhead turtles are good ocean-observers in stratified mid-latitude regions. Estuarine, Coastal and Shelf Science 213:128-136.

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Stanistreet, J.E., D.P. Nowacek, J.T. Bell, D.M. Cholewiak, J.A. Hildebrand, L.E.W. Hodge, S.M. Van Parijs, and A.J. Read. 2018. Spatial and seasonal patterns in acoustic detections of sperm whales *Physeter macrocephalus* along the continental slops in the western North Atlantic Ocean. Endangered Species Research 35:1-13.

Van Cise, A.M., S.D. Mahaffy, R.W. Baird, T.A. Mooney, and J. Barlow. 2018. Song of my people: Dialect differences among sympatric social groups of short-finned pilot whales in Hawai'i. Behavioral Ecology and Sociobiology 72:193.

Winton, M.V., G. Fay, H.L. Haas, M. Arendt, S. Barco, M.C. James, C. Sasso, and R. Smolowitz. 2018. Estimating the distribution and relative density of satellite-tagged loggerhead sea turtles using geostatistical mixed effects models. Marine Ecology Progress Series.

Publications and presentations from previous years also are available in the reading room of the U.S. Navy's Marine Species Monitoring Program website:

http://www.navymarinespeciesmonitoring.us/reading-room/publications