Marine Species Monitoring Report for the U.S. Navy's Atlantic Fleet Training and Testing (AFTT) – 2017 Annual Report



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From left to right:

Humpback whales (*Megaptera novaeangliae*) feeding off the coast of Virginia Beach, Virginia. Photographed by Jessica Aschettino, taken under National Marine Fisheries Service Scientific Research Permit No. 16239, issued to Dan Engelhaupt.

Release of Kemp's ridley sea turtle (*Lepidochelys kempii*) named 'Purple Heart', in June 2017. The turtle was hooked by a recreational angler, and released by a two-time Purple Heart recipient at the oceanfront in Virginia Beach, Virginia. Photographed by Virginia Aquarium & Marine Science Center Foundation, Inc.

Cuvier's beaked whale (*Ziphius cavirostris*). Photograph collected by the University of North Carolina Wilmington under National Marine Fisheries Service Scientific Research Permit No. 16185, issued to Duke University.

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ACRONYMS AND ABBREVIATIONS

AFAST	Atlantic Fleet Active Sonar Training
AFTT	Atlantic Fleet Training and Testing
AMAR	Autonomous Multi-channel Acoustic Recorder
AMR	Adaptive Management Review
BRS	behavioral response study
BSE	bay, sound, and estuary
BSS	Beaufort sea state
C-POD	automated click detector
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
dB	decibel(s)
DMP	Data Management Plan
DPD	detection-positive days
DPM	detection-positive minutes
DTAG	digital acoustic tag
EAR	ecological acoustic recorder
EIMS	Environmental Information Management System
ESA	Endangered Species Act
EWS	Early Warning System
F/V	fishing vessel
FACSFAC	Fleet Area Control and Surveillance Facility
GPS	Global Positioning System
HARP	high-frequency acoustic recording package
hr	hour(s)
Hz	hertz
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
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
NAS	Naval Air Station

NAVFAC	Naval Facilities Engineering Command
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
PAX	Patuxent River
photo-ID	photo-identification
POP	persistent organic pollutant(s)
QC	quality control
RFA	relative foraging area(s)
RLs	received levels
ROCCA	Real-time Odontocete Call Classification Algorithm
R/V	research vessel
sec	second(s)
SPL	sound pressure level
SPOT	Smart Position and Temperature
SSSM	switching state-space model
UDs	utilization distributions
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
yo	year old

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 2017. The U.S. Navy conducts marine mammal and sea turtle monitoring for compliance with the Letters of Authorization (NMFS 2013a, 2013b) and Biological Opinion (NMFS 2013c) 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 on-going 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 currently 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 east 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 2016 (DoN 2009, 2010a, 2010b, 2010c, 2010d, 2010e, 2011a, 2011b, 2011c, 2011d, 2012a, 2012b, 2012c, 2012d, 2013a, 2013c, 2013b, 2014a, 2014b, 2014c, 2015a, 2015b, 2016a, 2016b, 2017a, 2017b).

The U.S. Navy has invested nearly $30 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.

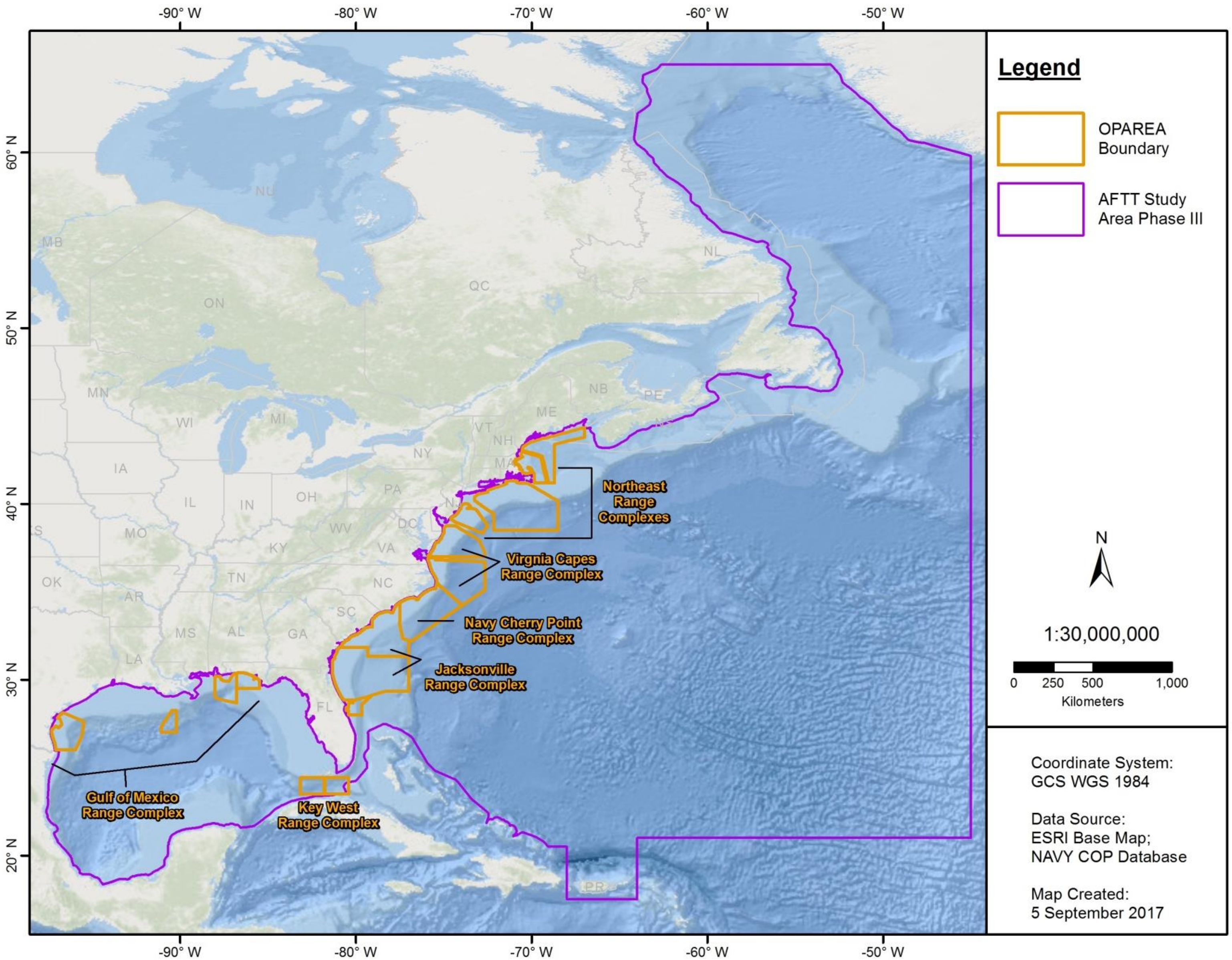

Figure 1. Atlantic Fleet Training and Testing Study Area.

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–FY17.

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
Total	**$29,569,000**

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 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 marine species monitoring 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 routinely updated as the program evolves and progresses. The most significant addition in 2013/2014 was the development of the Strategic Planning Process (DoN 2013d), which serves to guide 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 in the vicinity of 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 the specific stressors associated with the action (in specific contexts, where possible, e.g., at what distance or received level).

(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, reflecting 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 marine species monitoring activities in the AFTT Study Area in 2017 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 2017, 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 Adaptive Management Review 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 2018 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, a protected marine species monitoring program 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 Operating Area (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 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 2017, the longitudinal baseline study consisted of year-round multi-disciplinary monitoring through aerial and vessel-based visual surveys, photo-ID, tagging, biopsy sampling, and passive acoustic monitoring (PAM). Visual surveys were conducted regularly -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 Visual Baseline Aerial Surveys

Visual aerial surveys were conducted at five study sites in the AFTT Study Area in 2017. All aerial surveys were flown along established tracklines using line-transect aerial survey designs and standard Distance-sampling protocols. During the current reporting period (January–December 2017), surveys were conducted in both the offshore and nearshore waters of the Virginia Capes (VACAPES) OPAREA (**Sections 2.1.1.1 and 2.1.1.2,** respectively) and offshore waters of the Cherry Point and JAX OPAREAs (**Sections 2.1.1.3 and 2.1.1.4**, respectively). Additionally, aerial surveys were conducted in Chesapeake Bay waters near Naval Air Station (NAS) Patuxent River (PAX) (**Section 2.1.1.5**). Offshore aerial survey tracklines for the long-term Cherry Point/VACAPES OPAREAs (i.e., Norfolk Canyon, VACAPES nearshore, and Cape Hatteras sites) and JAX and PAX OPAREAs are depicted in **Figures 2**, **6**, **14**, and **18**, respectively.

2.1.1.1 *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 (FACSFAC) in VACAPES. The Norfolk Canyon survey area overlaps the VACAPES OPAREA.

A total of 54 tracklines (3812.05 kilometers [km]) over 10 days was covered in the Norfolk Canyon survey area in 2017 (**Table 2**). Survey effort occurred in 7 months. Two survey days were completed in each of May, June, and July, and one full day of effort occurred in February. Partial day effort was conducted in January, August, and September. Survey conditions during the 10 days ranged from Beaufort sea state (BSS) 1 to 5, with greater than 80 percent of effort in BSS 3 or lower. All but one cetacean sighting (98.8 percent) occurred in BSS 3 or lower. Cetacean sighting rates (sightings/1,000 km surveyed) decreased as BSS increased, with rates of 30.89 in BSS 1, 28.42 in BSS 2, 23.42 in BSS 3, and 2.08 in BSS 4. Sighting rates per month ranged from zero to 39.52/1,000 km. Sighting rate was highest in June, with 34 sightings recorded over 12 tracklines.

Table 2. Effort summary for aerial surveys conducted in the Norfolk Canyon survey area in 2017.

Month	Number of Survey Days	Tracklines Covered	Total km Flown	Total hr Underway*
January	1	4	191.80	2.6
February	1	8	564.30	6.9
May	2	14	1,028.05	13.0
June	2	12	860.40	10.4
July	2	8	579.10	7.6
August	1	4	294.75	2.4
September	1	4	293.65	2.8
Total	**10**	**54**	**3,812.05**	**45.7**

* Total hours (hr) underway reported as Hobbs hr = total engine time

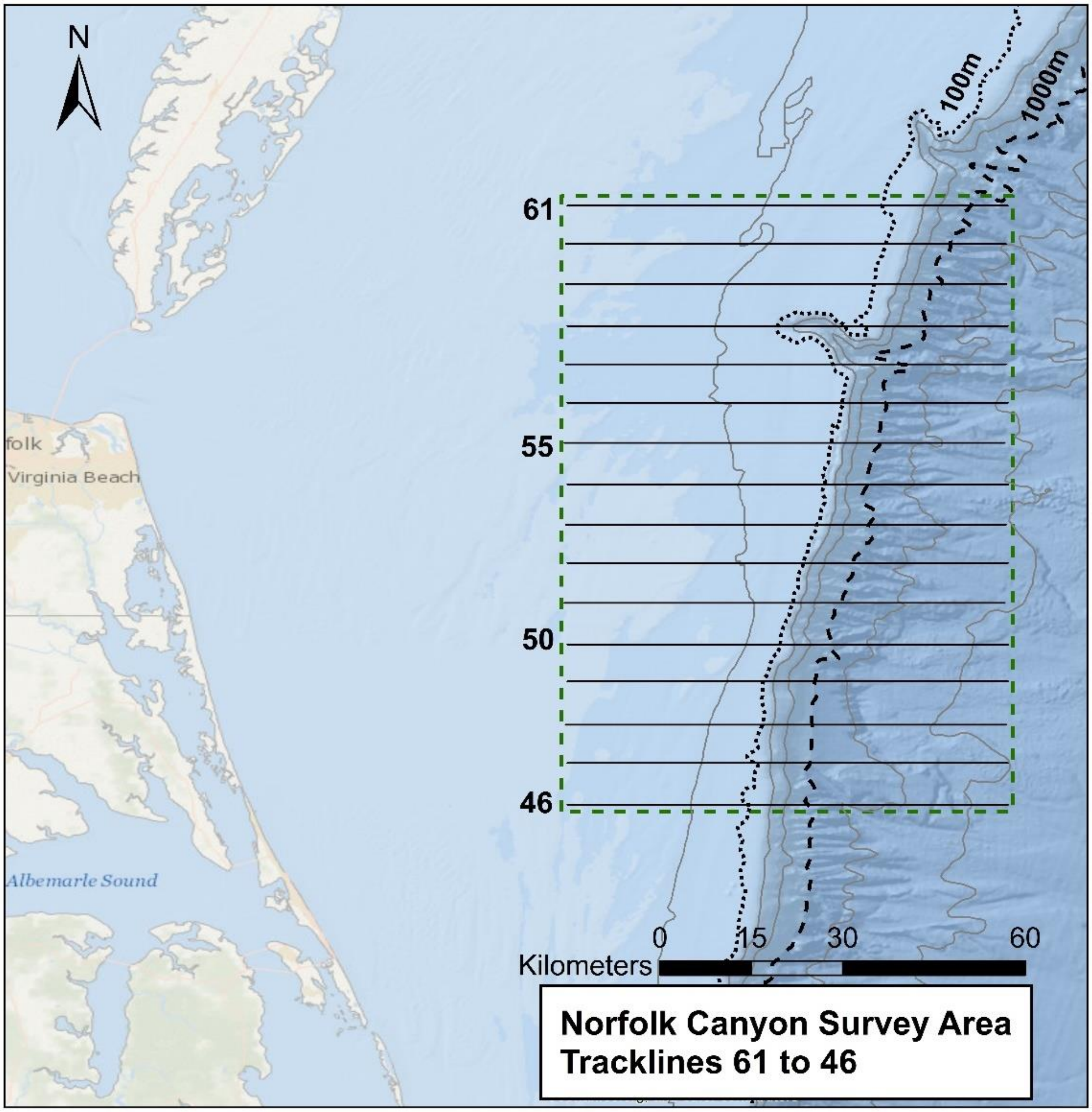

Figure 2. Norfolk Canyon survey area and aerial tracklines for 2017.

There were 86 on-effort sightings of 7,861 individual cetaceans representing 9 species (**Table 3, Figure 3**), including fin whale (*Balaenoptera physalus*; 1 sighting of 2 individuals), common dolphin (*Delphinus delphis*; 23 sightings of 6,080 individuals), Risso's dolphin (*Grampus griseus*; 9 sightings of 102 individuals), short-finned pilot whale (*Globicephala macrorhynchus*; 14 sightings of 255 individuals), sperm whale (*Physeter macrocephalus*; 5 sightings of 7 individuals), striped dolphin (*Stenella coeruleoalba;* 5 sightings of 516 individuals), Atlantic spotted dolphin (*Stenella frontalis*; 10 sightings of 469 individuals), common bottlenose dolphin (*Tursiops truncatus*; 17 sightings of 425 individuals), and Cuvier's beaked whale (*Ziphius cavirostris*; 2 sightings of 5 individuals).

Table 3. Sightings from aerial surveys conducted in the Norfolk Canyon survey area in 2017.

Common Name	Scientific Name	Numbers of Sightings [1]	Numbers of Individuals [1]
Fin whale	*Balaenoptera physalus*	1/1	2/1
Humpback whale	*Megaptera novaeangliae*	0/2	0/2
Common dolphin	*Delphinus delphis*	23/1	6,080/225
Risso's dolphin	*Grampus griseus*	9/1	102/3
Short-finned pilot whale	*Globicephala macrorhynchus*	14/0	255/0
Sperm whale	*Physeter macrocephalus*	5/1	7/1
Striped dolphin	*Stenella coeruleoalba*	5/2	516/69
Atlantic spotted dolphin	*Stenella frontalis*	10/0	469/0
Common bottlenose dolphin	*Tursiops truncatus*	17/0	425/0
Cuvier's beaked whale	*Ziphius cavirostris*	2/0	5/0
Loggerhead turtle	*Caretta caretta*	142/0	258/0
Leatherback turtle	*Dermochelys coriacea*	3/0	3/0
Unidentified shark		1/0	6/0
Manta ray	*Manta birostris*	4/0	6/0
Cownose ray	*Rhinoptera bonasus*	3/0	155/0
Basking shark	*Cetorhinus maximus*	10/0	16/0
Ocean sunfish	*Mola mola*	11/0	12/0

[1] On- and off-effort sightings and individuals are represented by #/# (on-/off-effort).

An additional 8 off-effort sightings were recorded: fin whale (1 sighting of 1 individual), humpback whale (*Megaptera novaeangliae*, 2 sightings of 2 individuals), common dolphin (1 sighting of 225 individuals), Risso's dolphin (1 sighting of 3 individuals), sperm whale (1 sighting of 1 individual), and striped dolphin (2 sightings of 69 individuals). 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. The off-effort sightings are included in the table for each species but are excluded from any calculations.

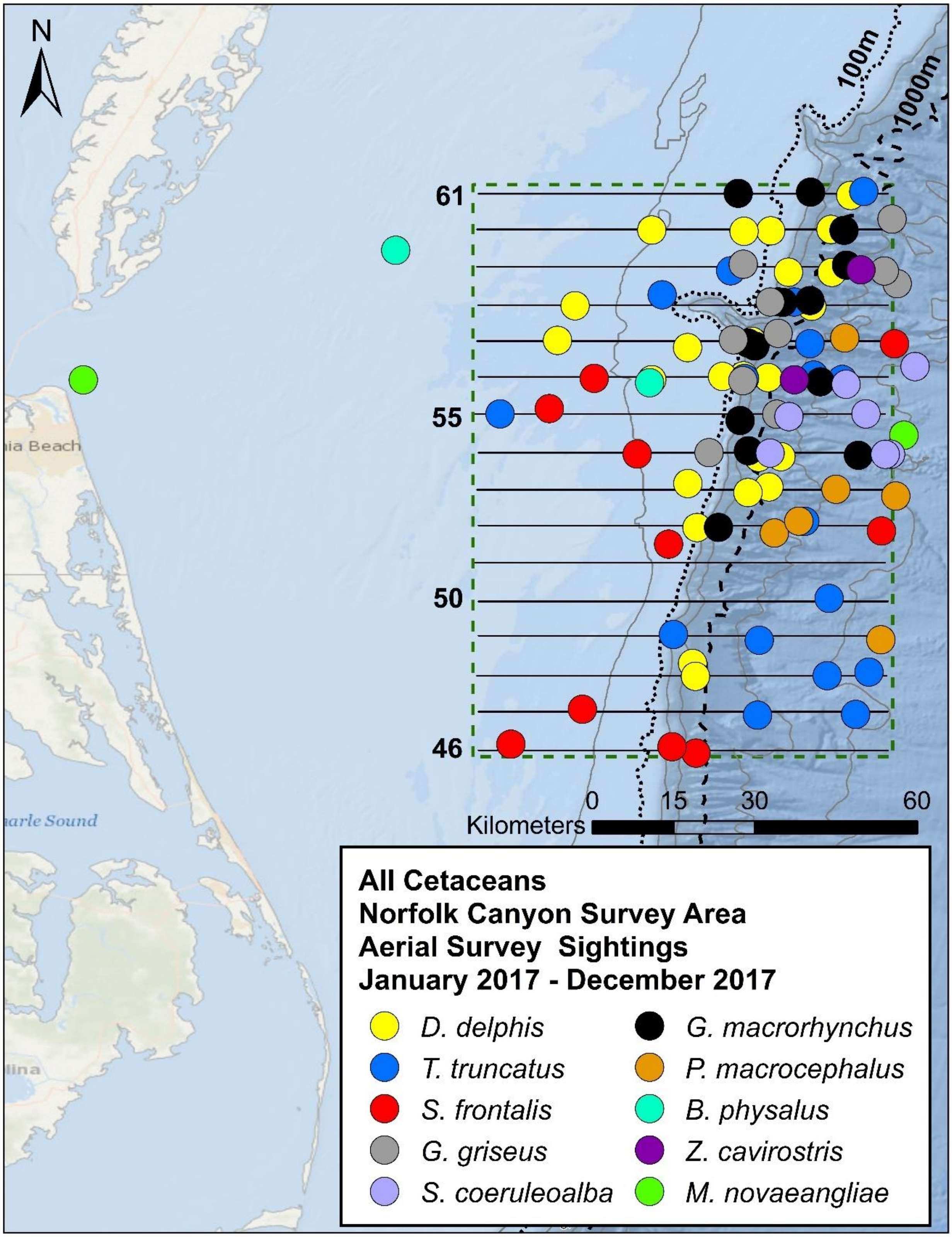

Figure 3. Cetacean sightings during aerial surveys in the Norfolk Canyon survey area in 2017.

There were 145 on-effort sightings of 261 individual sea turtles during the reporting period (**Table 3, Figure 4**). Loggerhead turtles (*Caretta caretta*) represented the majority (>99 percent) of total sea turtles sighted. Most loggerhead turtle sightings were over the continental shelf inshore of the 50-meter (m) isobath. The only other sea turtle species identified in the Cape Hatteras and Norfolk Canyon survey areas was the leatherback turtle (*Dermochelys coriacea*; 0.2 percent of total sea turtles sighted). Leatherback turtles were observed in the northern portion of the Norfolk Canyon survey area, from the inshore waters to seaward of the 1,500-m isobath. Sighting rates were negatively correlated with BSS, with rates sharply declining at >BSS 2. Ninety-two percent of all sea turtle sightings occurred in the months of May and June.

In addition to cetaceans and sea turtles, other pelagic marine vertebrates were observed (**Table 3, Figure 5**). Twenty-two sharks were recorded during the reporting period, largely inshore of the 1,000-m isobath. Six of the 22 sharks could be identified as hammerhead sharks (*Sphyrna* sp.) based on head shape, but the sightings could not be identified to species, therefore, they are presented as unidentified sharks. The remaining 16 sharks were identified as basking sharks (*Cetorhinus maximus*), and were found in high numbers during the month of May, in both shallow and deep waters. Two species of rays were identified to species: manta rays (*Manta birostris; n*=6) and cownose rays (*Rhinoptera bonasus*; *n*=155). In addition, 12 ocean sunfish (*Mola mola*) were recorded, with the majority found inshore of the 1,000-m isobath.

For more information on this study, refer to the annual progress report for this project (McAlarney et al. 2018a).

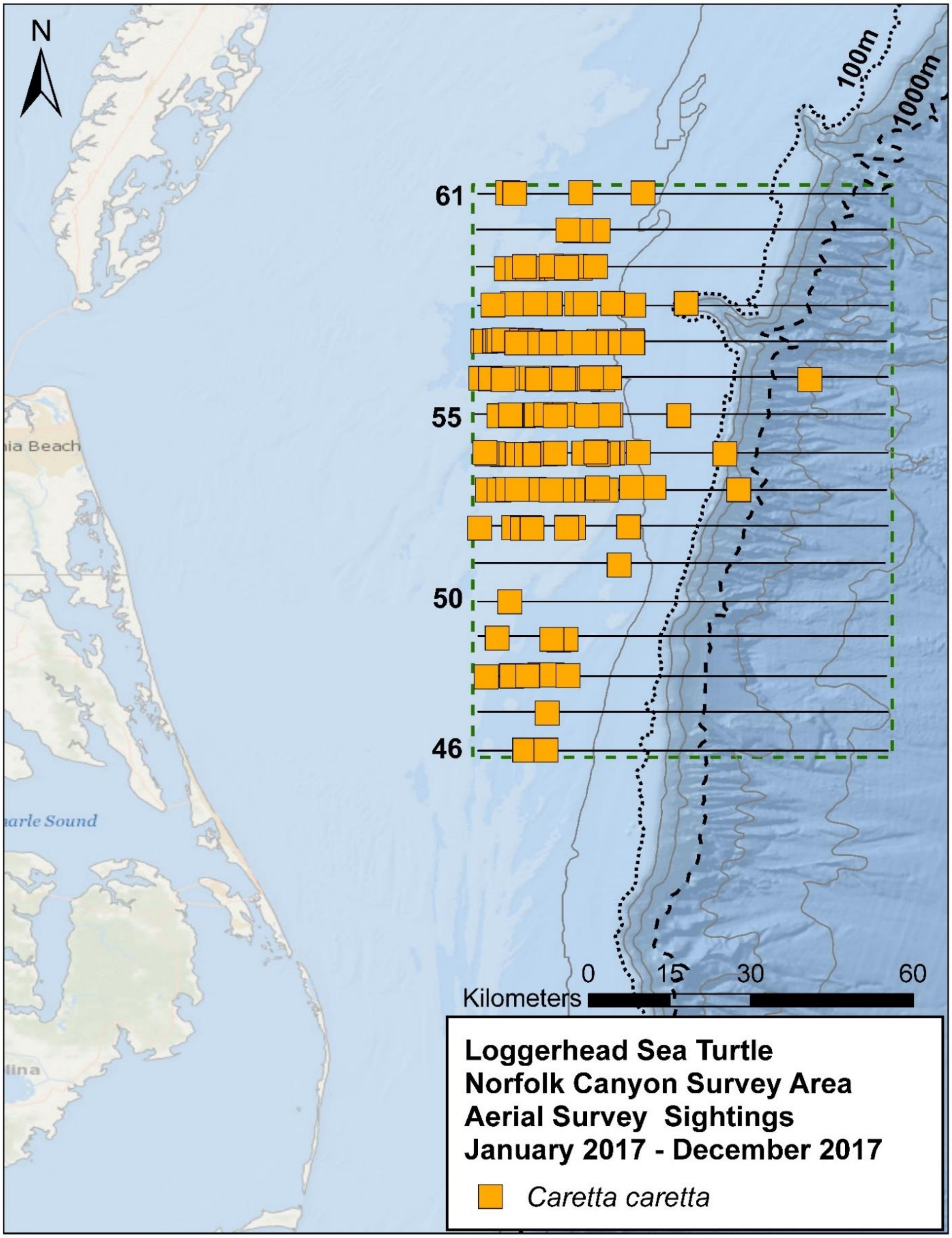

Figure 4. Loggerhead sea turtle sightings during aerial surveys in the Norfolk Canyon survey area in 2017.

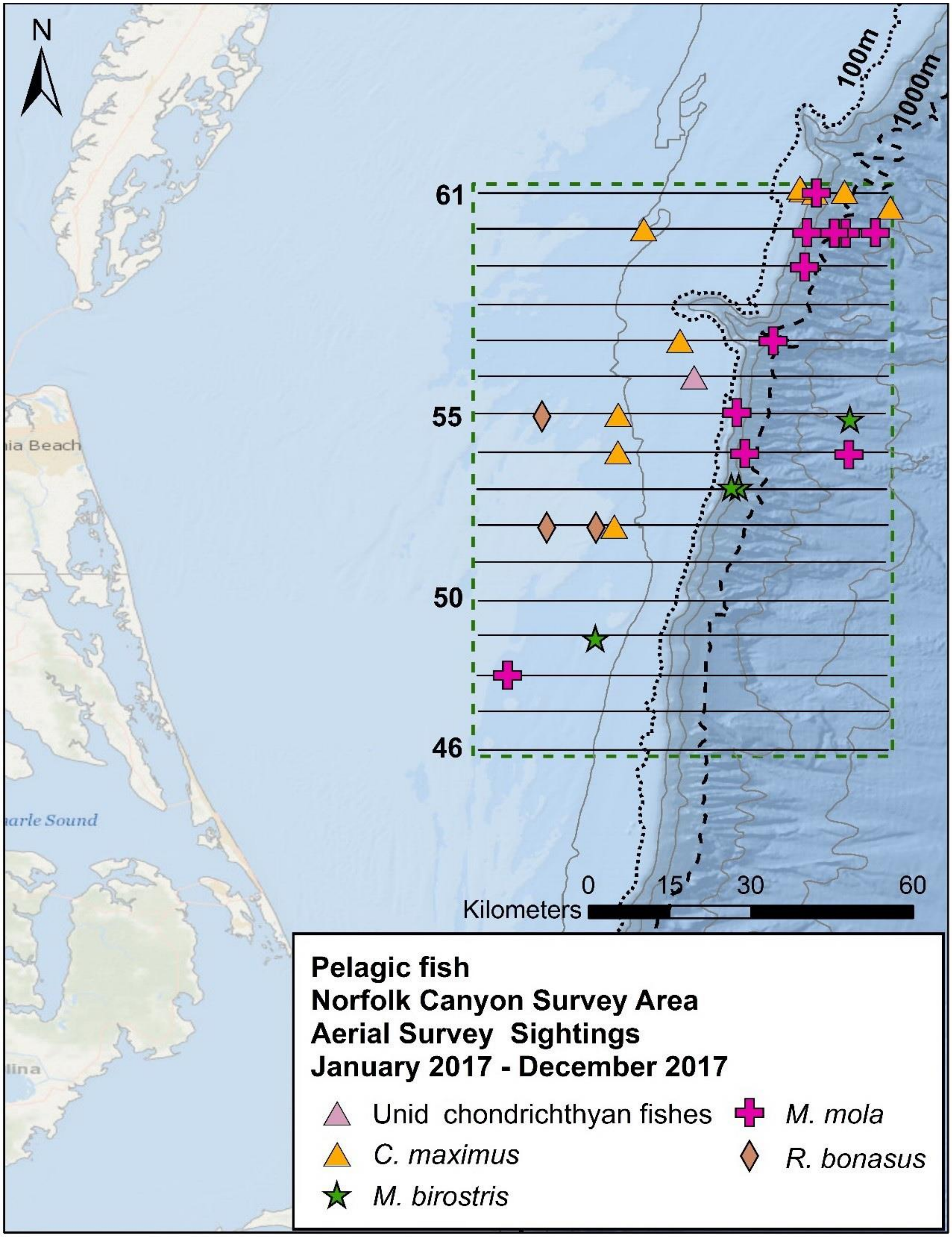

Figure 5. Pelagic fish sightings during aerial surveys in the Norfolk Canyon survey area in 2017.

2.1.1.2 *VACAPES Nearshore Aerial Surveys*

The Virginia Aquarium & Marine Science Center Foundation, Inc. (VAQF) is tasked to conduct 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 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, 2017b).

Data and results from the 2017 field effort are summarized in this report; however, a comprehensive cumulative technical report is currently being prepared that will include analysis of the full data set. This final report will encapsulate all data 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. Eighteen survey days were planned, with two per month in November–April when large whale presence was thought to be highest in the area, and one per month in 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 white 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).

A total of 11 survey days was conducted covering 114 tracklines (7,597 km) in the VACAPES nearshore survey area in 2017 (**Table 4**). Survey effort occurred in each of the first 6 months of 2017. Two survey days were achieved in 5 of the 6 months, with a single day of effort occurring in May. The central portion of the survey area was given preference. Broader survey coverage was reduced in some cases to focus on supporting vessel surveys being conducted by HDR off the mouth of Chesapeake Bay, while at other times reduced survey coverage was due to operational airspace restrictions.

Table 4. Effort summary for aerial surveys conducted in the VACAPES nearshore survey area in 2017.

Month	Number of Survey Days	Tracklines Covered	Total km Flown	Total hr Underway*
January	2	15	1,174.66	10.2
February	2	18	1,256.35	10.3
March	2	23	1,361.85	10.2
April	2	16	1,159.52	8.0
May	1	14	756.18	12.3
June	2	28	1,888.46	10.2
Total	**11**	**114**	**7,597.02**	**61.2**

* Total hours (hr) underway reported as Hobbs hr = total engine time.

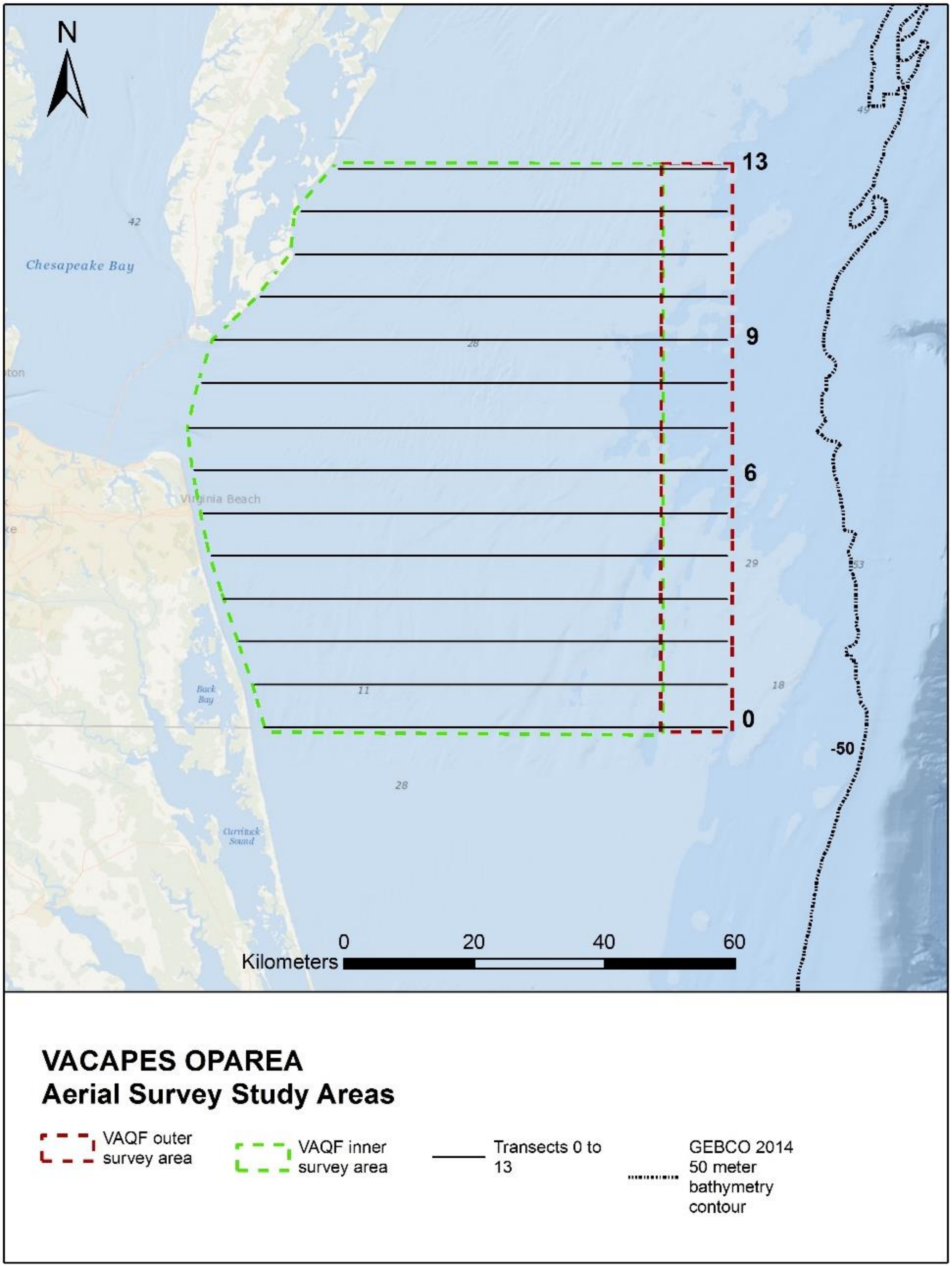

Figure 6. VACAPES nearshore survey area and aerial tracklines for 2017.

Conditions during the 11 survey days ranged from BSS 0 to BSS 4, with approximately 94 percent of effort in BSS 3 or lower. All cetacean sightings occurred in BSS 3 or lower. Cetacean sighting rates (sightings/1,000 km) decreased in sea states higher than BSS 2, with rates of 10.3 in BSS 1, 11.0 in BSS 2, 3.7 in BSS 3, and no sightings in BSS 4. Sighting rates per month ranged from 1.72/1,000 km to 12.18/1,000 km. Sighting rate was highest in June; with 23 sightings (46 percent of all sightings) recorded over 28 transect lines.

In 2017, 48 on-effort sightings of 678 individual cetaceans, representing 3 species, were recorded (**Table 5, Figure 7**), including humpback whale (2 sightings of 5 individuals), common dolphin (6 sightings of 324 individuals), common bottlenose dolphin (38 sightings of 349 individuals), and unidentified delphinid (2 sightings of 3 individuals). Eleven off-effort sightings were recorded: humpback whale (8 sightings of 8 individuals), common dolphin (1 sighting of 18 individuals), and common bottlenose dolphin (2 sightings of 4 individuals). The off-effort sightings are included in the tables and maps for each species, but excluded from any calculations.

Table 5. Sightings from aerial surveys conducted in the VACAPES nearshore survey area in 2017.

Common Name	Scientific Name	Numbers of Sightings [1]	Numbers of Individuals [1]
Humpback whale	*Megaptera novaeangliae*	4/8	5/8
Common dolphin	*Delphinus delphis*	6/1	324/18
Common bottlenose dolphin	*Tursiops truncatus*	38/2	349/4
Unidentified delphinid		2/0	3/0
Loggerhead turtle	*Caretta caretta*	219/4	225/4
Leatherback turtle	*Dermochelys coriacea*	1/0	1/0
Unidentified sea turtle		95/1	101/1
Unidentified shark		13/0	27/0
Manta ray	*Manta birostris*	1/0	1/0
Cownose ray	*Rhinoptera bonasus*	5/0	227/0
Ocean sunfish	*Mola mola*	3/0	3/0

[1] On- and off-effort sightings and individuals are represented by #/# (on-/off-effort).

There were 315 on-effort sightings of 327 individual sea turtles during the 2017 reporting period (**Table 5, Figure 8**). Loggerhead turtles represented the majority (70 percent) of total sea turtles sighted. The only other sea turtle species identified in VACAPES nearshore waters was the leatherback turtle (0.3 percent of total sea turtles sighted). Species identification for the remaining turtle sightings could not be established, and these are presented as "unidentified sea turtle." There were 4 off-effort sightings of loggerhead turtles (of 4 individuals). In 2017, sea turtles were detected during May and June, and sighting rates were negatively correlated with increasing BSS, with rates sharply declining at BSS > 2.

In addition to cetaceans and sea turtles, other pelagic marine vertebrates were observed (**Table 5**, **Figure 9**). Thirteen sightings of unidentified sharks, totaling 27 individuals, were recorded during the reporting period. Two species of rays were identified, including two sightings of single manta rays and five sightings of cownose rays, totaling 227 individuals. In addition, three ocean sunfish were recorded.

For more information on this study, refer to the annual progress report for this project (Mallette et al. 2017b).

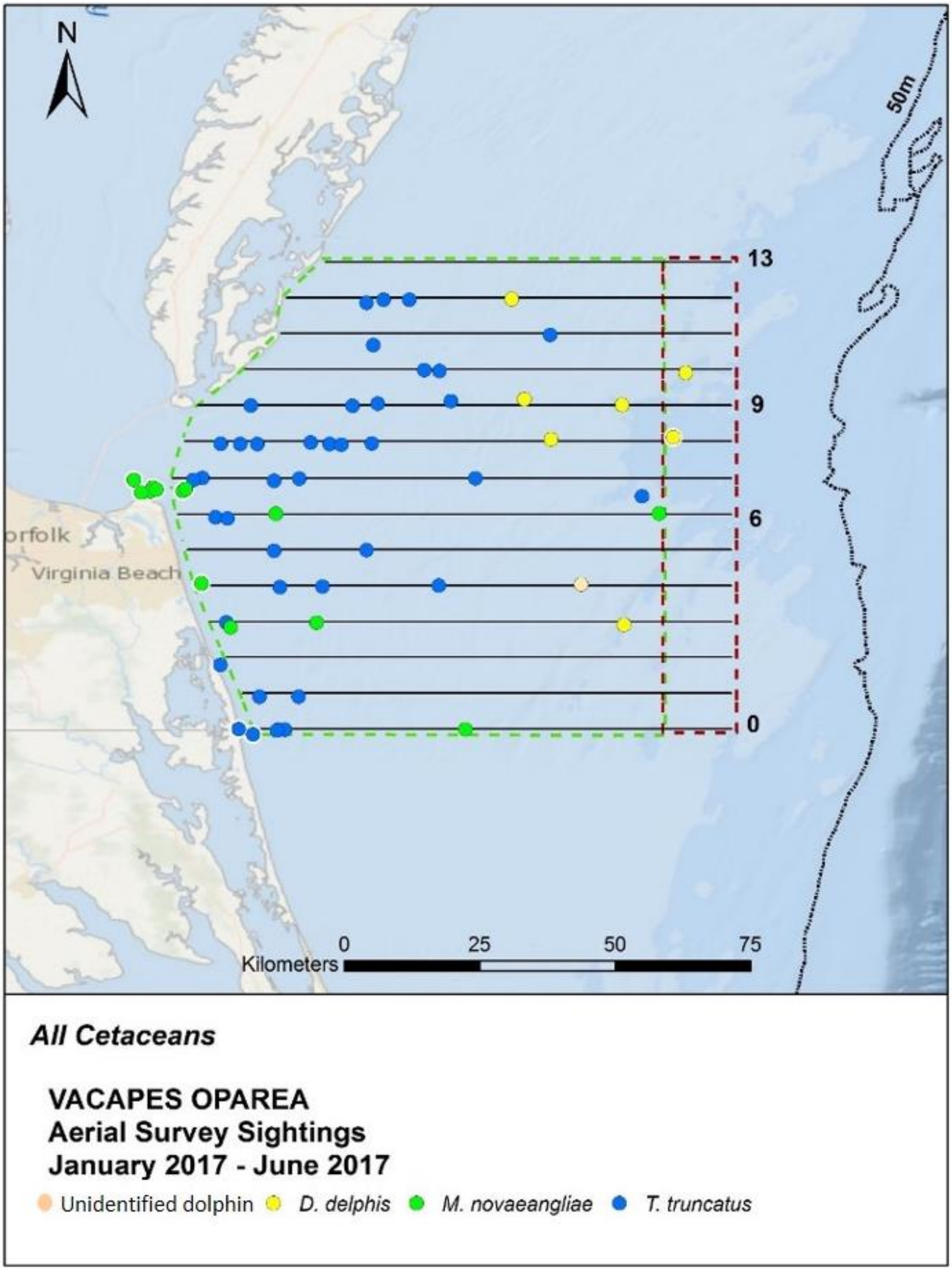

Figure 7. Cetacean sightings during aerial surveys conducted in the VACAPES nearshore survey area in 2017. Off-effort sightings are identified by the white circles.

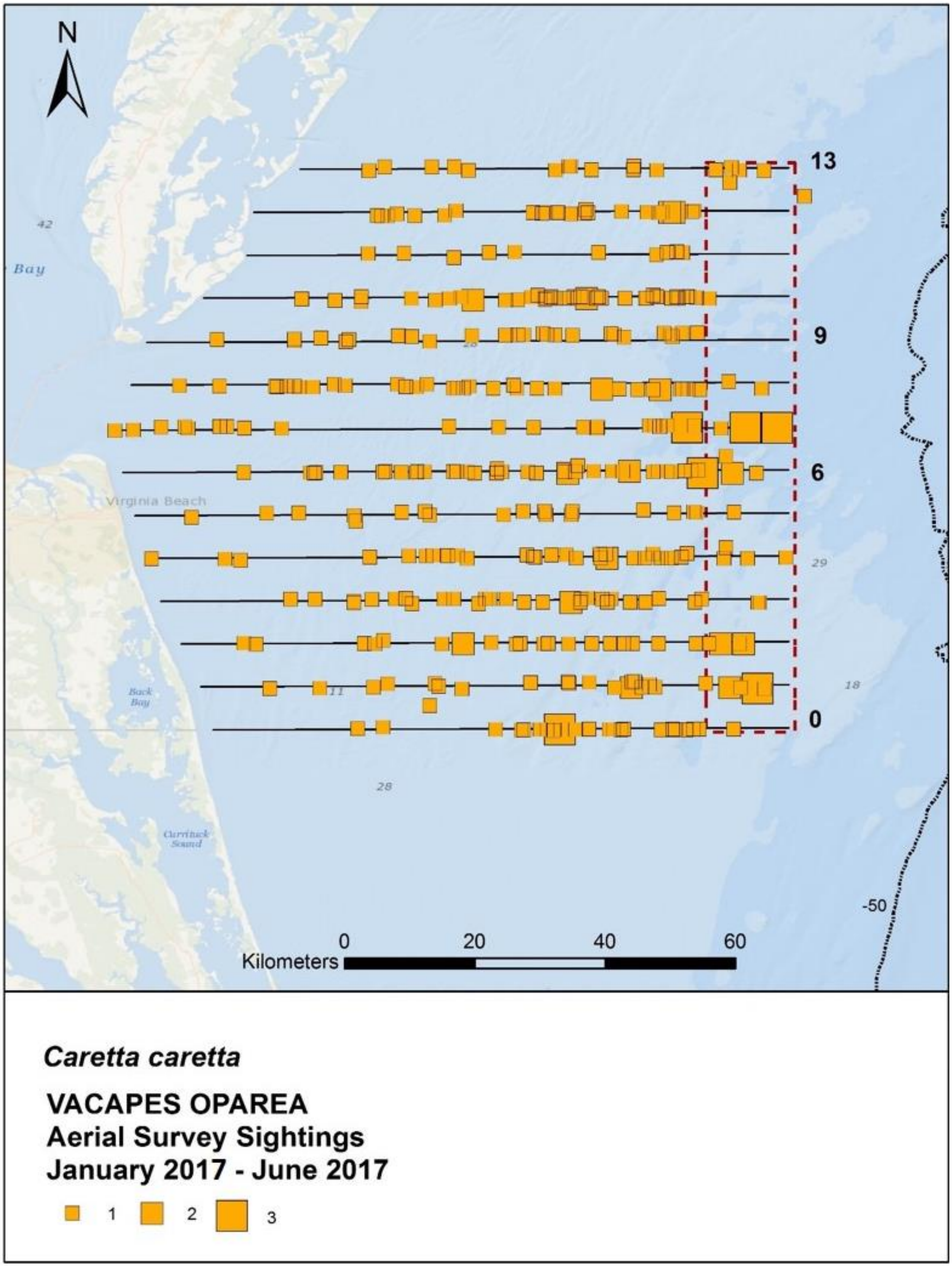

Figure 8. Sea turtle sightings during aerial surveys in the VACAPES nearshore survey area in 2017.

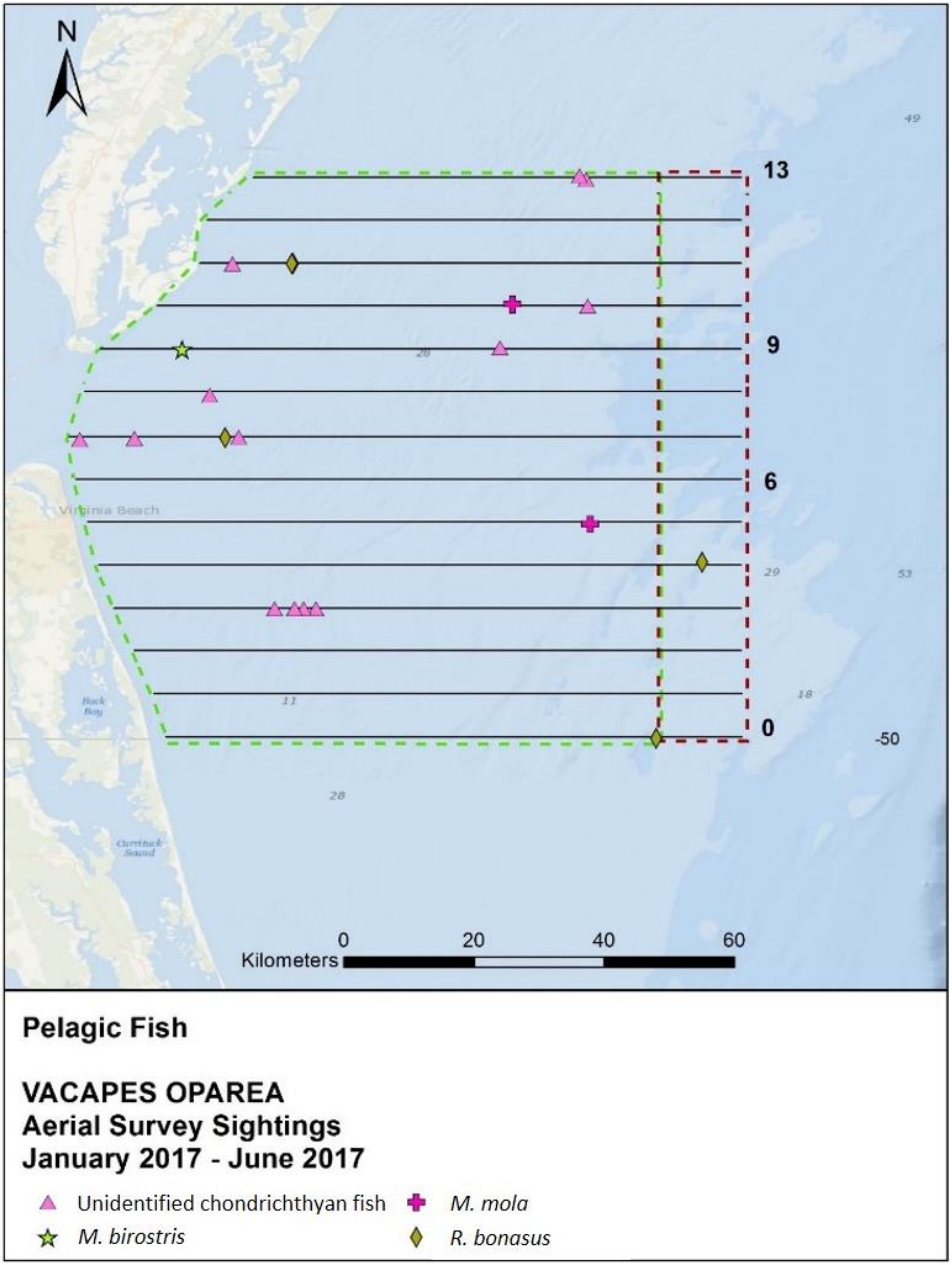

Figure 9. Pelagic fish sightings during aerial surveys in the VACAPES nearshore survey area in 2017.

2.1.1.3 *Cape Hatteras Study Area Offshore Aerial Surveys*

Aerial survey efforts began in May 2011 in the waters off the coast of Cape Hatteras, North Carolina, to assess the distribution and abundance of offshore cetacean species and sea turtles in this highly productive area. Because of the close proximity and easy transitioning from the Norfolk Canyon survey area, aerial effort in Cape Hatteras was coordinated in conjunction with Norfolk Canyon aerial surveys on an opportunistic basis in 2017. Five days of survey effort covering 36 tracklines (2,595.7 km) were conducted in the Cape Hatteras survey area in 2017 (**Table 6**, **Figure 10**). Survey effort occurred in 4 of 12 months, with 2 days of effort during the month of June, and a single day of effort occurring in February, July, and August.

Table 6. Effort summary for aerial surveys conducted in the Hatteras survey area in 2016.

Month	Number of Survey Days	Tracklines Covered	Total km Flown	Total hr Underway *
February	1	8	564.95	5.7
June	2	12	875.80	9.3
July	1	8	569.75	6.6
August	1	8	585.20	6.2
Total	**5**	**36**	**2,595.70**	**27.8**

* Total hours (hr) underway reported as Hobbs hr = total engine time

Conditions during the 5 survey days ranged from BSS 1 to BSS 5, with 93 percent of effort in BSS 3 or lower. Most cetacean sightings (97 percent) also occurred in BSS 3 or less. Cetacean sighting rates (sightings/1,000 km surveyed) decreased as BSS increased, with rates of 58.43 in BSS 1, 41.91 in BSS 2, 25.92 in BSS 3, 19.61 in BSS 4, and no sightings occurring in BSS 5. Sighting rates per day ranged from 13.79 to 56.16 sightings/ 1,000 km, with the highest sighting rate during the July survey, which also had the lowest average BSS. Sighting rates were lowest on 26 June, when sea states were considerable higher than on other survey days.

There were 99 on-effort sightings of 3,545 individual cetaceans representing 9 species (**Table 7, Figure 11**), including common bottlenose dolphin (42 sightings of 800 individuals), common dolphin (8 sightings of 1,719 individuals), Atlantic spotted dolphin (6 sightings of 376 individuals), striped dolphin (3 sightings of 226 individuals), Risso's dolphin (2 sightings of 21 individuals), short-finned pilot whale (23 sightings of 375 individuals), humpback whale (1 sighting of 1 individual), sperm whale (3 sightings of 3 individuals), Cuvier's beaked whale *(*10 sightings of 21 individuals), and unidentified delphinid (1 sightings of 3 individuals). Four off-effort sightings were recorded—2 sightings of 74 common bottlenose dolphin, 1 sighting of a single mesoplodont beaked whale (*Mesopolodon* sp.), and 1 sighting of 7 short-finned pilot whales. These are included in the table for each species, but are excluded from any calculations.

There were 40 on-effort sightings of 49 individual sea turtles (comprising 2 species) during the reporting period (**Table 7, Figure 12**). The highest number of sea turtles was in July. Loggerhead turtles represented the majority (96 percent) of total sea turtles sighted. Most loggerhead turtle sightings were over the continental shelf inshore of the 100-m isobath. The only other sea turtle species identified in the Cape Hatteras survey area was the leatherback turtle (4 percent of total sea turtles sighted), which was also observed inshore of the 100-m isobath. Sighting rates were negatively correlated with increasing BSS, with rates sharply declining at BSS > 2.

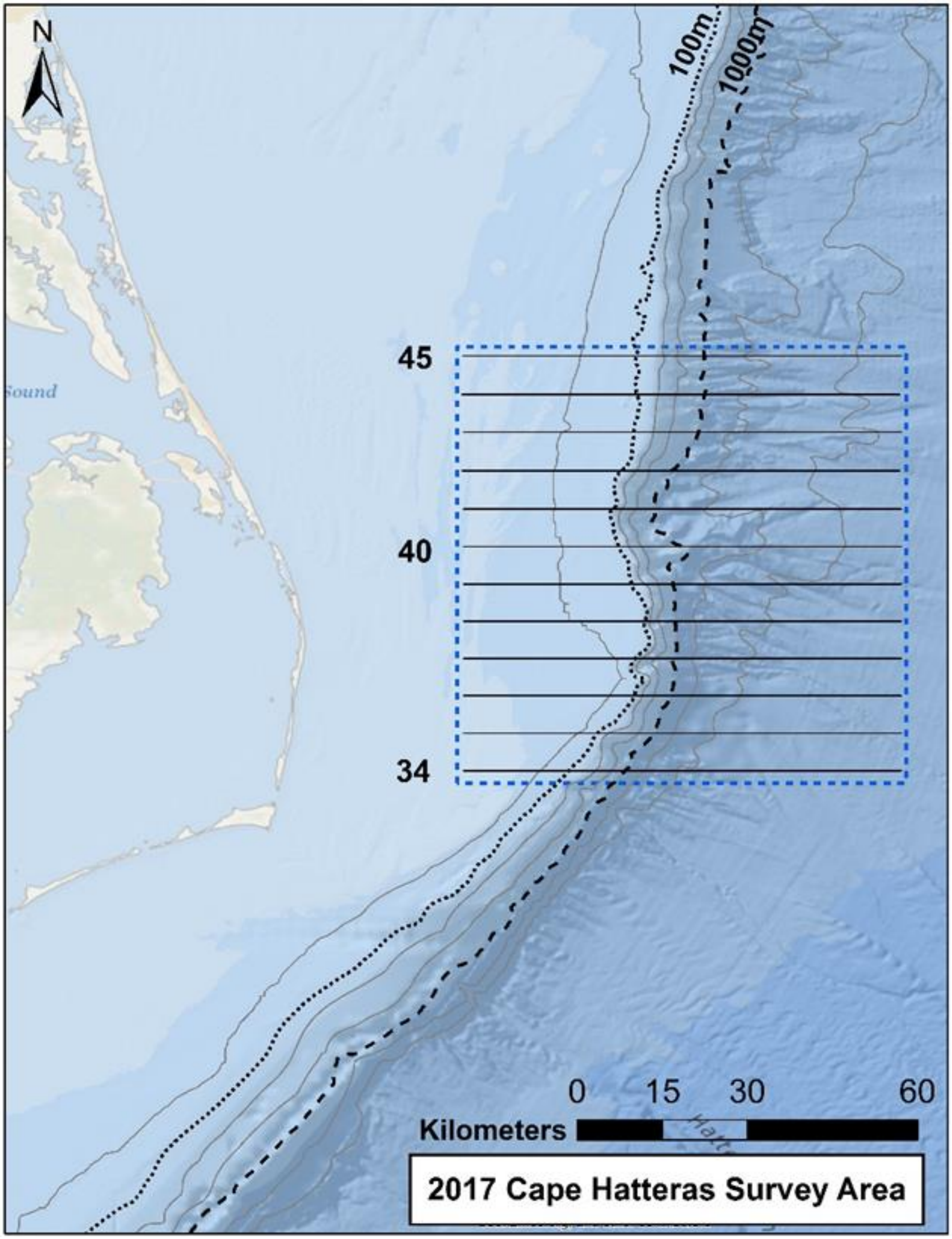

Figure 10. Cape Hatteras survey area and aerial tracklines for 2017.

Table 7. Sightings from aerial surveys conducted in the Cape Hatteras survey area in 2017.

Common Name	Scientific Name	Numbers of Sightings [1]	Numbers of Individuals [1]
Common bottlenose dolphin	*Tursiops truncatus*	42/2	800/74
Common dolphin	*Delphinus delphis*	8/0	1,719/0
Atlantic spotted dolphin	*Stenella frontalis*	6/0	376/0
Striped dolphin	*Stenella coeruleoalba*	3/0	226/0
Risso's dolphin	*Grampus griseus*	2/0	21/0
Short-finned pilot whale	*Globicephala macrorhynchus*	23/1	375/7
Humpback whale	*Megaptera novaeangliae*	1/0	1/0
Sperm whale	*Physeter macrocephalus*	3/0	3/0
Cuvier's beaked whale	*Ziphius cavirostris*	10/0	21/0
Mesoplodont beaked whale	*Mesoplodon* sp.	0/1	0/2
Unidentified delphinid		1/0	3/0
Loggerhead turtle	*Caretta caretta*	38/0	47/0
Leatherback turtle	*Dermochelys coriacea*	2/0	2/0
Unidentified shark		6/0	236/0
Basking shark	*Cetorhinus maximus*	2/0	2/0
Manta ray	*Manta birostris*	5/0	5/0
Spotted eagle ray	*Aetobatus narinari*	1/0	1/0
Ocean sunfish	*Mola mola*	8/0	8/0

[1] On- and off-effort sightings and individuals are represented by #/# (on-/off-effort).

In addition to cetaceans and sea turtles, other pelagic marine vertebrates were observed (**Table 7**, **Figure 13**). There were 8 sightings of sharks, for a total of 238 individuals, recorded during the reporting period, largely inshore of the 100-m isobath. Of the 238 sharks, 4 could be identified as hammerhead sharks based on head shape, but because none of these sightings could be identified to species, they are combined here with unidentified sharks. Two of the sharks were identified as basking sharks. In addition, 2 species of rays were identified: manta rays (n=5) and a spotted eagle ray (*Aetobatus narinari*, n=1). Finally, 8 ocean sunfish were recorded.

For more information on this study, refer to the annual progress report for this project (McAlarney et al. 2018b).

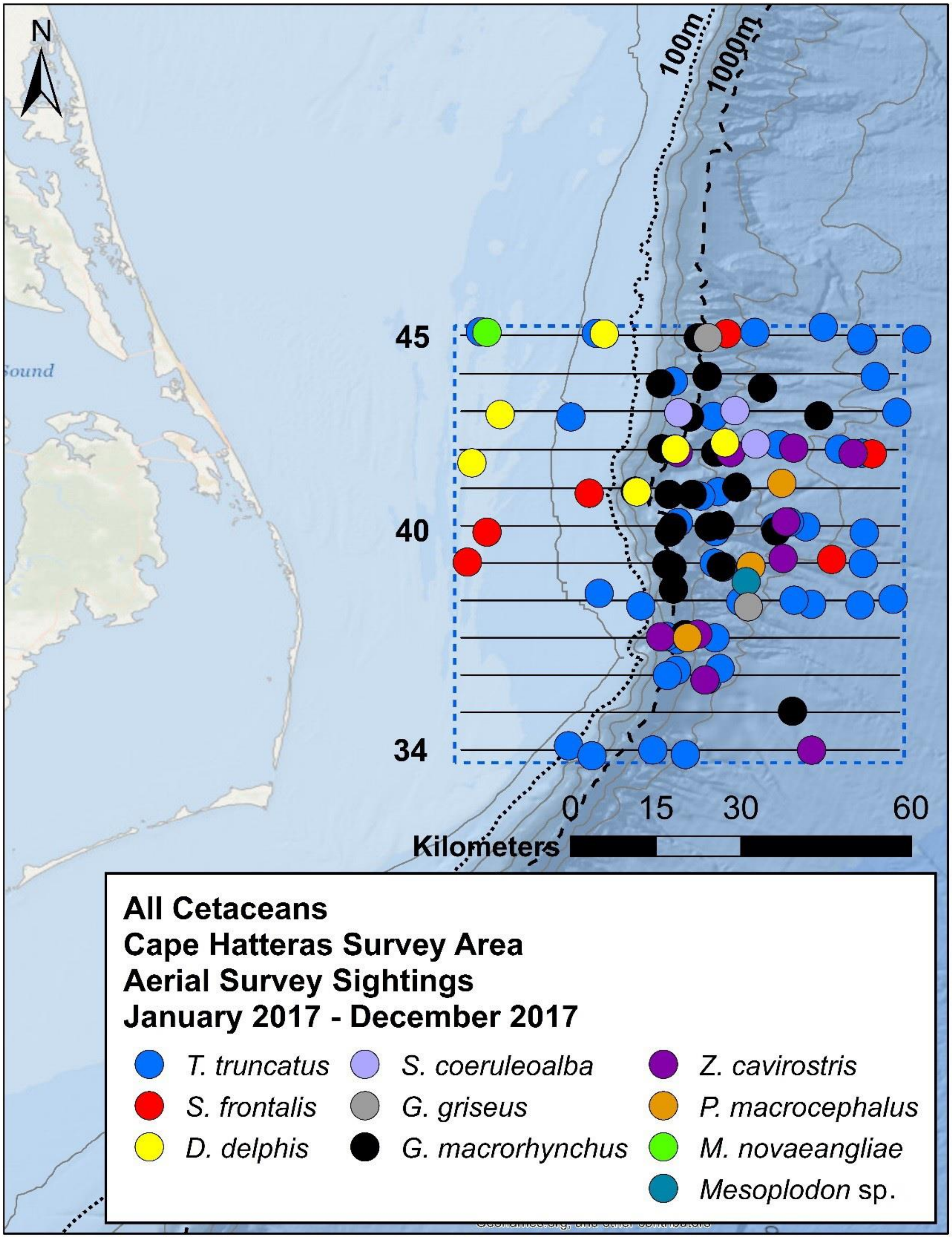

Figure 11. Cetacean sightings during aerial surveys in the Cape Hatteras survey area in 2017.

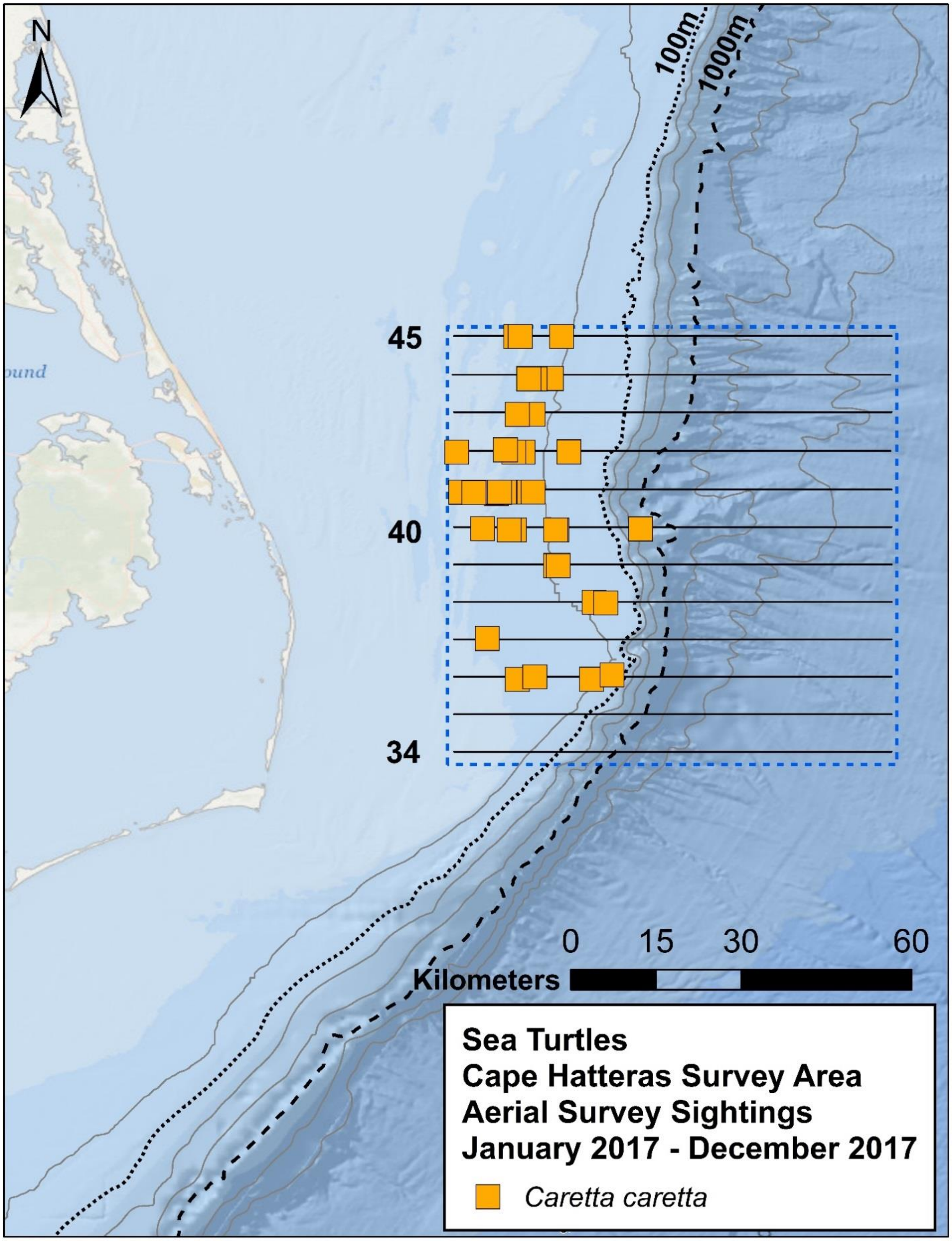

Figure 12. Sea turtle sightings during aerial surveys in the Cape Hatteras survey area in 2017.

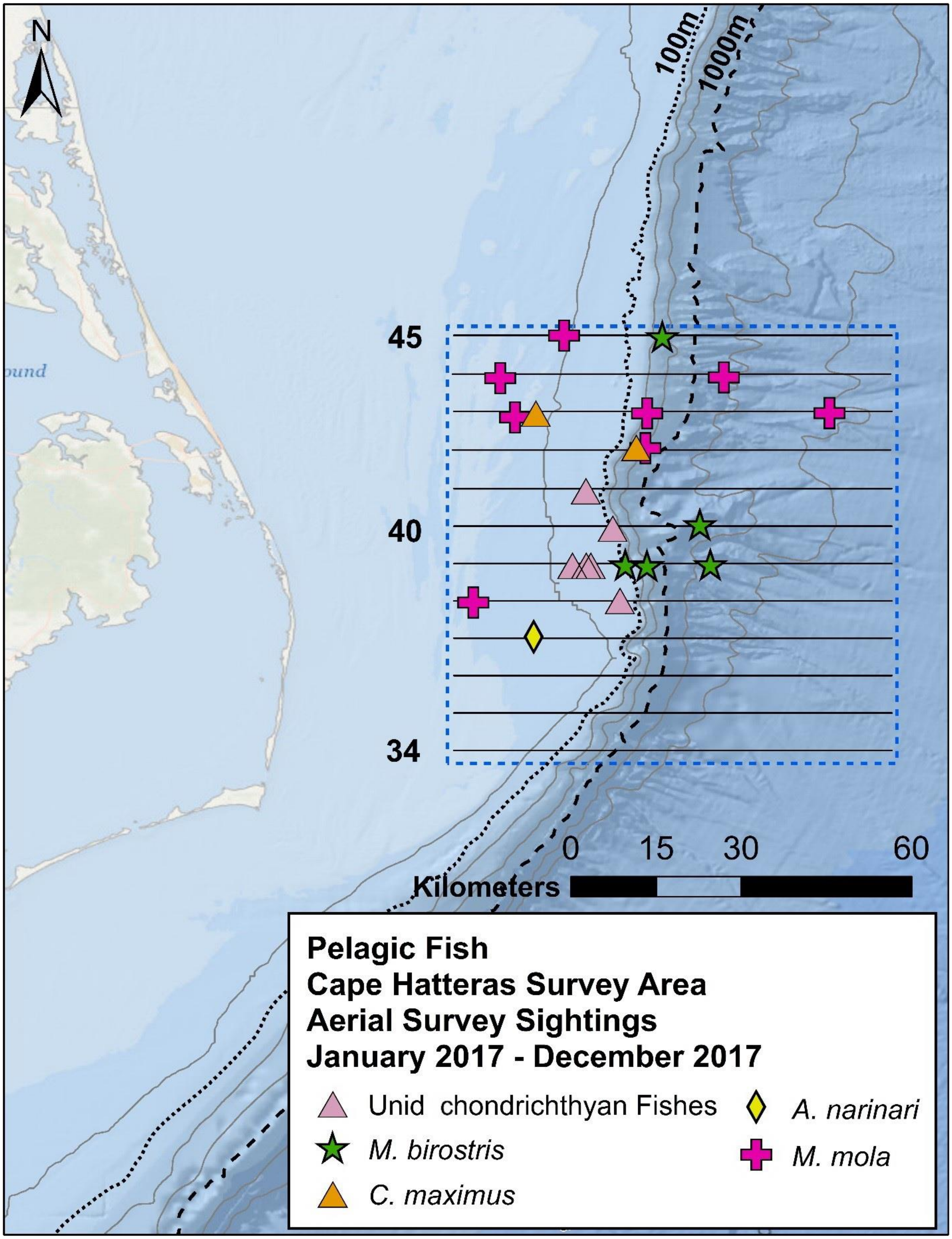

Figure 13. Pelagic fish sightings during aerial surveys in the Cape Hatteras survey area in 2017.

2.1.1.4 *Jacksonville Study Area Offshore Aerial Surveys*

Aerial survey efforts were initiated in the JAX OPAREA in 2009 to assess the distribution and abundance of offshore cetaceans in the region of the planned USWTR. The goal for 2017 was to maintain baseline monitoring of species patterns by conducting 2 consecutive days of survey effort on a quarterly basis. Typical effort covered the primary USWTR area as well as offshore trackline extensions. Researchers from UNCW conducted 7 days of aerial survey effort covering 72 tracklines and 4,656.35 km (**Table 8**) in 2017. Thirty-six tracklines were within the original survey box, while the remaining 36 extended into the offshore area (see **Figure 14**). Survey conditions ranged from BSS 1 to BSS 4, with most of the surveys flown in BSS 2 (52 percent). A total of 46 on-effort sightings of 679 cetaceans, representing 9 species, was recorded while on-effort in the JAX survey area (**Table 9, Figure 15**). Cetacean sighting rates dropped off dramatically at BSS > 2. Sighting rates dropped from 26.02/1,000 km to 0 sightings/1,000 km as sea state increased from BSS 1 to BSS 4.

Table 8. Quarterly effort summary for aerial surveys conducted in the JAX survey area in 2017.

Month	Number of Survey Days	Tracklines Covered	Total km Flown	Total hr Underway *
February	2	20	1,292.30	12.0
May	2	20	1,304.90	11.5
July	2	20	1,286.6	11.9
November	1	12	772.55	6.8
Total	**7**	**72**	**4,656.35**	**42.2**

* Total hours (hr) underway reported as Hobbs hr = total engine time

A total of 46 sightings of 679 individual cetaceans, representing 9 species, was recorded while on-effort (**Table 9, Figure 15**). These included common bottlenose dolphin (17 sightings of 212 individuals), rough-toothed dolphin (*Steno bredanensis*) (1 sighting of 36 individuals), Atlantic spotted dolphin (14 sightings of 336 individuals), minke whale (*Balaenoptera acutorostrata*) (2 sightings of 3 individuals), sperm whale (1 sighting of 1 individual), pantropical spotted dolphin (*Stenella attenuata*) (1 sighting of 2 individuals), Risso's dolphin (1 sighting of 19 individuals), short-finned pilot whale (6 sightings of 43 individuals), Kogiid whale (*Kogia* sp.) (1 sighting of 2 individuals), and unidentified delphinid (2 sightings of 24 individuals). There were also three off-effort sightings—one each for bottlenose dolphins, Atlantic spotted dolphins, and short-finned pilot whales.

A total of 97 individual sea turtles was recorded during aerial surveys in the JAX survey area in 2017 (**Table 9**). Sighting rates were negatively correlated with increasing BSS, with rates declining at higher sea states. Effort-corrected sea turtle sighting rates were higher in BSS 1 or BSS 2 than in BSS 3 or higher during this survey period. Sea turtles were observed every day of survey effort, with the highest sighting rates occurring in July. Observation rates ranged from a low of 9.96/1,000 km flown in spring to a high of 37.31/1,000 km in summer. Loggerhead turtles constituted most of sea turtles sighted (95 percent), with leatherback turtles comprising the remaining sightings (5 percent). Loggerhead turtles were recorded predominantly in the shallower waters over the continental shelf, although a small number of individuals occurred beyond the continental shelf break (**Figure 16**). Leatherback turtles were recorded predominantly in the shallower waters over the continental shelf, inshore of the 100-m isobath, although one individual occurred beyond the 200-m isobath (**Figure 16**).

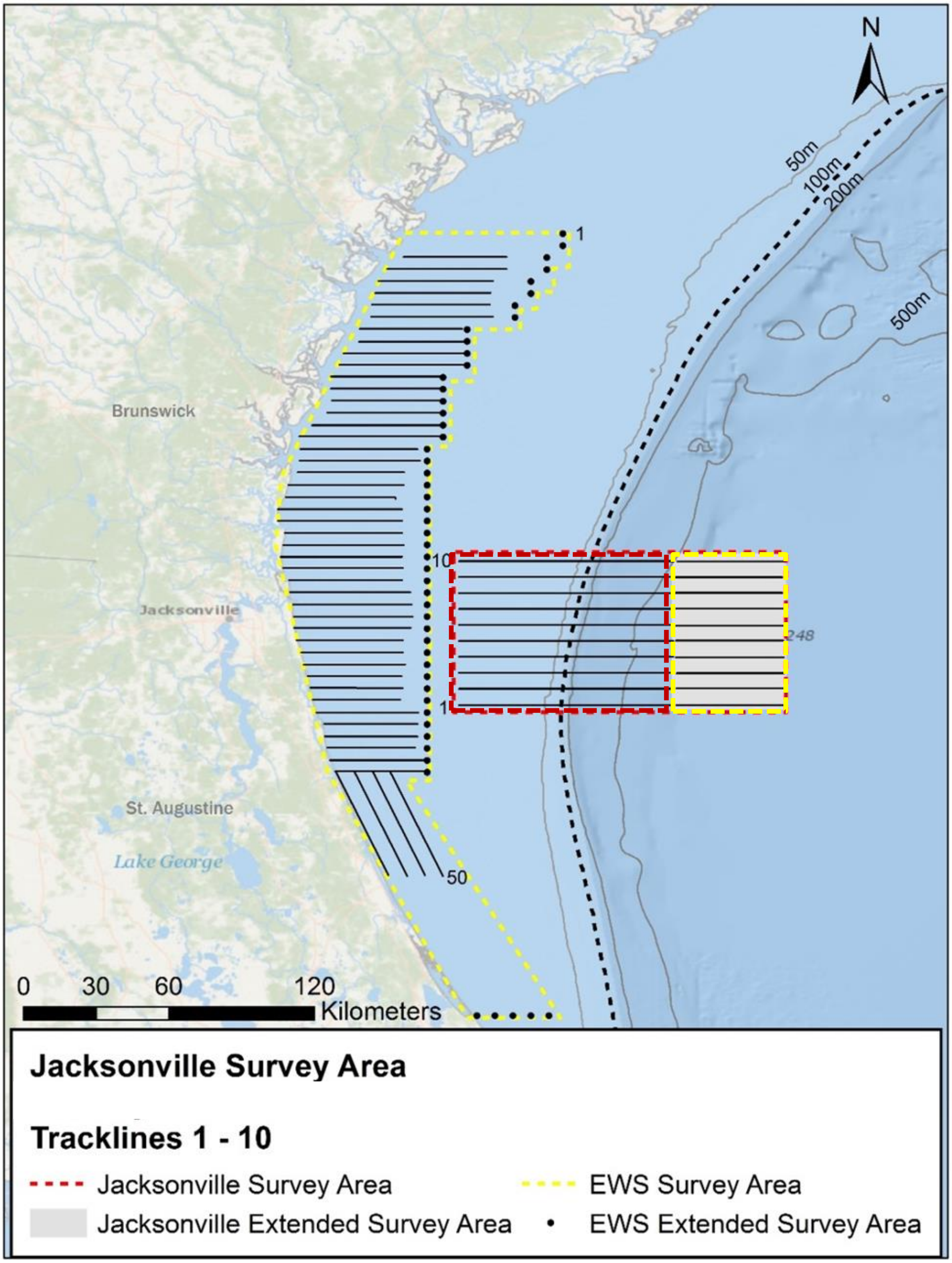

Figure 14. Jacksonville survey area and aerial tracklines for 2017.

Table 9. Sightings from aerial surveys conducted in the JAX survey area in 2017.

Common Name	Scientific Name	Number of Sightings [1]	Number of Individuals [1]
Risso's dolphin	*Grampus griseus*	1/0	19/0
Short-finned pilot whale	*Globicephala macrorhynchus*	6/1	44/3
Rough-toothed dolphin	*Steno bredanensis*	1/0	36/0
Atlantic spotted dolphin	*Stenella frontalis*	14/1	336/15
Common bottlenose dolphin	*Tursiops truncatus*	17/1	212/18
Pantropical spotted dolphin	*Stenella attenuata*	1/0	2/0
Minke whale	*Balaenoptera acutorostrata*	2/0	3/0
Sperm whale	*Physeter macrocephalus*	1/0	1/0
Kogiid whale	*Kogia* sp.	1/0	2/0
Unidentified delphinid		2/0	24/0
Loggerhead turtle	*Caretta caretta*	74/0	93/0
Leatherback turtle	*Dermochelys coriacea*	4/0	4/0
Unidentified shark		6/0	6/0
Great white shark	*Carcharodon carcharias*	1/0	1/0
Manta ray	*Manta birostris*	2/0	2/0
Ocean sunfish	*Mola mola*	3/0	4/0

[1] On- and off-effort sightings and individuals are represented by #/# (on-/off-effort).

In addition to cetaceans and sea turtles, other pelagic marine vertebrates were observed, including sharks and rays (i.e., elasmobranch fishes) (**Table 9, Figure 17**). Four ocean sunfish were sighted, with 1 seen in shallow water near the western edge of the survey area; the other 3 were much farther offshore closer to the 500-m isobath. Two manta rays were sighted inshore of the 200-m isobath with both sightings occurring in May. There were 7 sightings of sharks, totaling 7 animals. Four of the sharks could be identified as hammerhead sharks based on head shape, but because none of these sightings could be identified to species, they were combined with the unidentified sharks. One of the sharks was identified to species as great white (*Carcharodon carcharias*). Sharks showed no discernable spatial or temporal trends in occurrence.

For more information on this study, refer to the annual progress report for this project (Cummings et al. 2018).

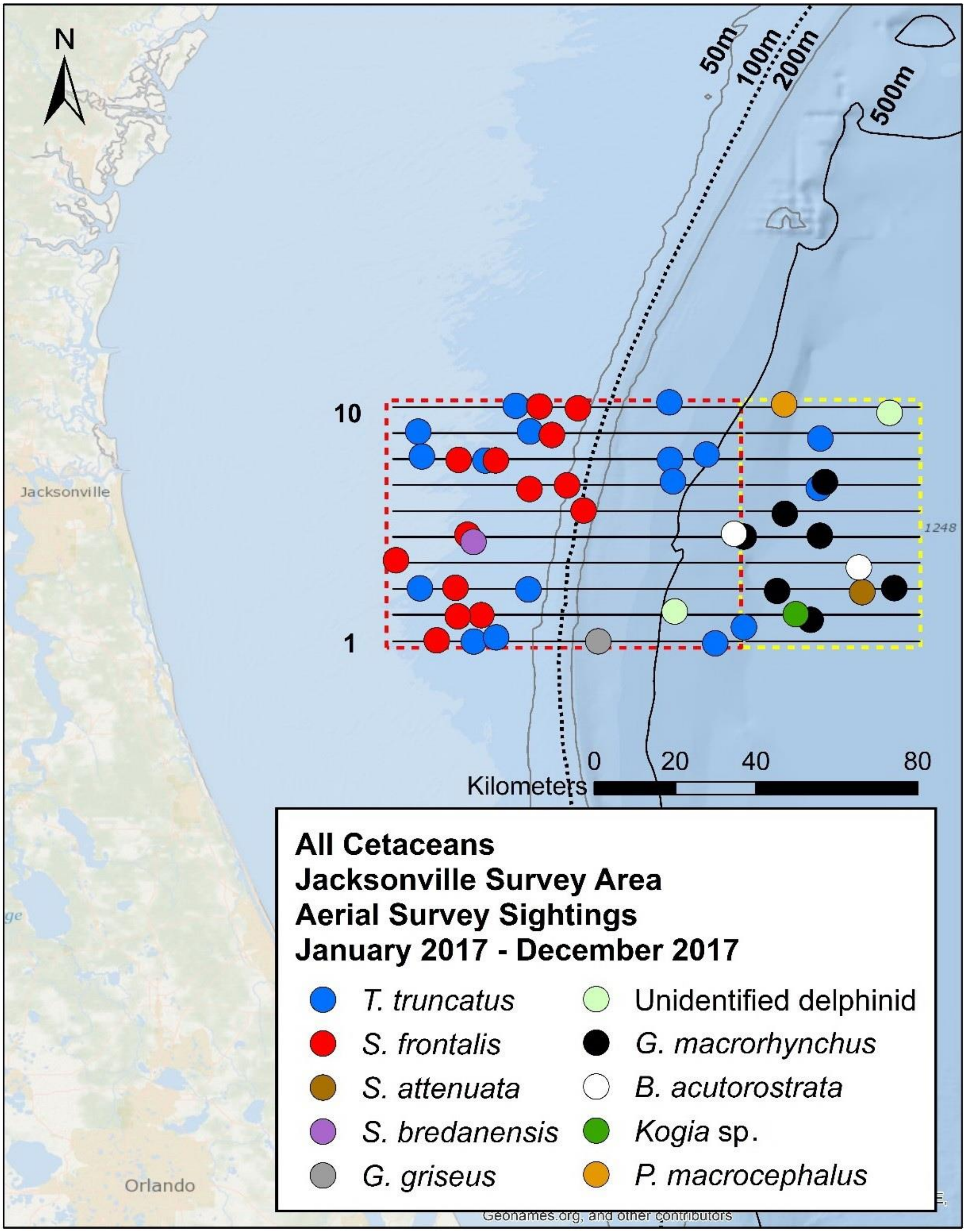

Figure 15. Cetacean sightings during aerial surveys in the JAX survey area in 2017.

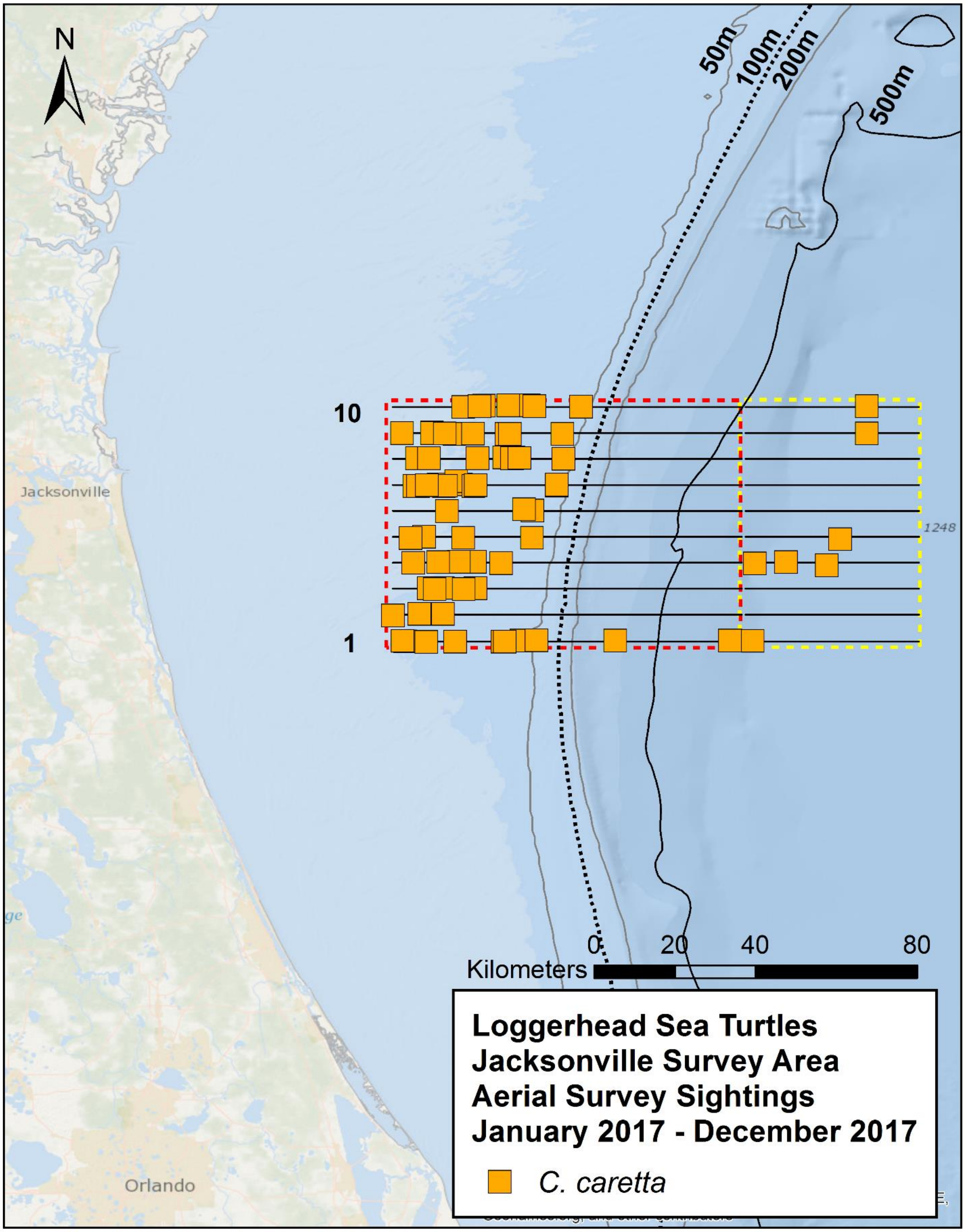

Figure 16. All sea turtle sightings during aerial surveys in the JAX survey area in 2017.

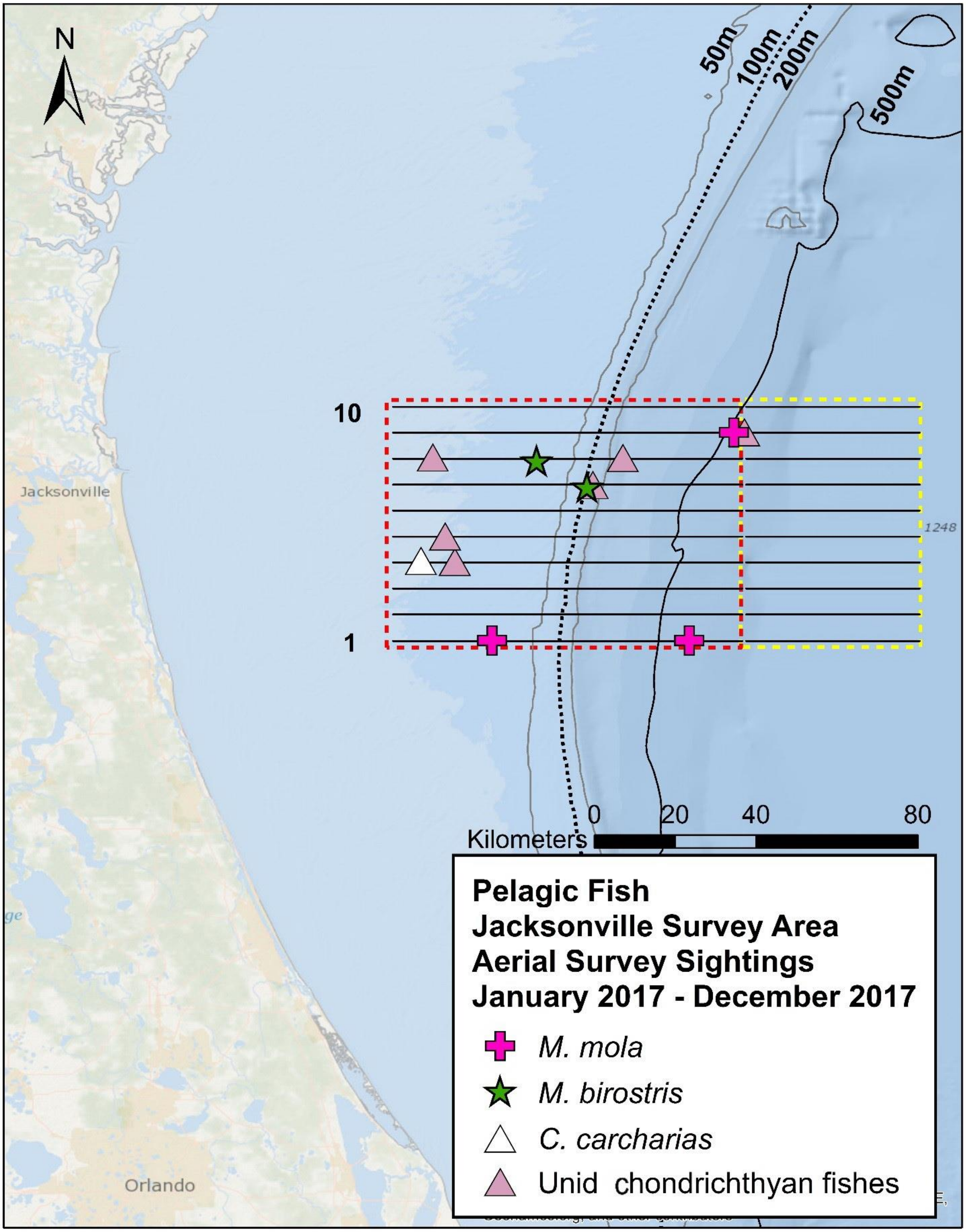

Figure 17. Pelagic fish sightings during aerial surveys in the JAX survey area in 2017.

2.1.1.5 *Chesapeake Bay (NAS Patuxent River) Aerial Surveys*

Aerial surveys were initiated in April 2015 in the waters surrounding Naval Air Station Patuxent River (NAS PAX) in Chesapeake Bay to collect information and quantitative data on the seasonal occurrence, distribution, habitat use of marine protected species to support planning and impact assessment analyses under the National Environmental Policy Act, MMPA, and ESA. These surveys occurred from April 2015 through October 2017 and a summary of all effort is presented here. A total of 28 days of aerial survey effort was conducted from 2015 through 2017 covering 15,858 km over the waters of the Chesapeake Bay and the mouth of the Potomac River, surrounding the NAS PAX site (**Table 10, Figure 18**). The study region was divided into two survey blocks: a block in Chesapeake Bay covering an area of 1,784km^2 and a block in the Potomac River covering an area of 215km^2. Seventeen parallel transects were oriented east-west, approximately 850m apart, in Chesapeake Bay and six transects in a zig-zag pattern were located in the Potomac River (**Figure 18**). The total length of designed transects was 542.4km, a distance that could be flown in a single day. Survey conditions ranged from BSS 0 to BSS 5.

Table 10. Effort summary for aerial surveys conducted in the PAX survey area from April 2015 through October 2017.

Month	Number of Survey Days	Tracklines Covered	Total km Flown	Total hr Underway*
January	1	18	586.50	5.5
February	1	18	582.10	5.6
March	1	18	584.05	5.2
April	3	45	1,494.40	14.3
May	2	36	1,158.30	12.0
June	5	90	2,890.25	26.4
July	4	67	2,198.94	21.5
August	2	36	1,162.65	11.0
September	3	54	1,713.76	15.7
October	3	54	1,733.03	16.1
November	2	36	1,164.41	10.0
December	1	18	590.00	5.4
Total	**28**	**490**	**15,858.39**	**148.70**

*Total hours (hr) underway reported as Hobbs hr = total engine time

Between April 2015 and October 2017, 20 on-effort (*n*=548 individuals) and 4 off-effort (*n*=30 individuals) sightings of common bottlenose dolphins were recorded (**Table 11, Figure 19**), although all on-effort sightings occurred between April and August (**Figure 20**) and were primarily concentrated in the southern portion of the survey area near the confluence of the Potomac River with Chesapeake Bay. All off-effort sightings of common bottlenose dolphins occurred between September 2015 and April 2016. These sightings occurred outside of the study area, in the center of the Chesapeake Bay, during return transits to Norfolk.

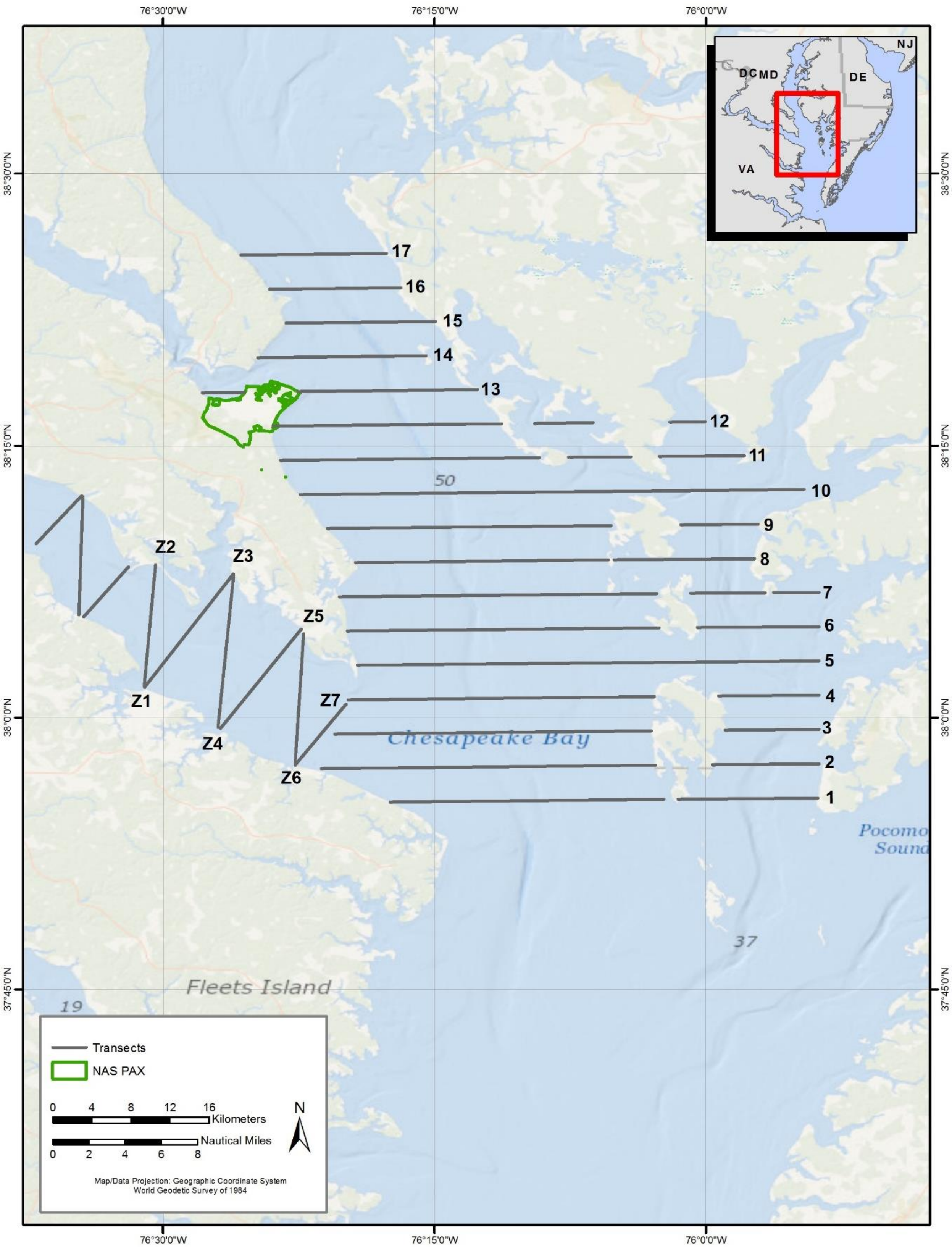

Figure 18. Aerial survey tracklines for the NAS PAX study area.

Table 11. Sightings from aerial surveys conducted in the PAX survey area from April 2015 to October 2017.

Common Name	Scientific Name	Number of Sightings [1]	Number of Individuals [1]
Common bottlenose dolphin	*Tursiops truncatus*	20/4	548/30
Loggerhead turtle	*Caretta caretta*	38/1	47/1
Unidentified turtle		3/0	3/0
Cownose ray	*Rhinoptera bonasus*	53/0	1,607/0
Ocean sunfish	*Mola mola*	1/0	1/0

[1] On- and off-effort sightings and individuals are represented by #/# (on-/off-effort).

There were 42 sightings of sea turtles recorded, with the majority (*n*=39) identified as loggerhead turtles, and 3 sightings classified as unidentified hard-shell sea turtles. All sea turtle sightings occurred during the months of May through October in the Chesapeake Bay (**Figure 21**, **Table 11**).

Cownose rays also were observed across the range of the survey area during May, July-August, and October 2016 (**Figure 22, Table 11**).

Average summer abundances in the Chesapeake Bay block were 104 bottlenose dolphins (95% confidence interval [CI]=26–420), 14 loggerhead turtles (CI=7–26), and 536 cownose rays (CI=334–860). Average summer abundances in the Potomac River block were 19 bottlenose dolphins (CI=4–89) and 12 cownose rays (CI=1–99). Loggerhead turtles were not detected in the Potomac River block, and none of these species was detected in winter. Cownose rays were the most abundant species, and for all these species, the highest estimated average abundances occurred during summer. Cumulative results from effort conducted between April 2015 and October 2017 indicate that the occurrence of bottlenose dolphins and sea turtles at the NAS PAX study site is seasonally dependent, occurring primarily in the summer months. These data provide a useful record of occurrence in the region of interest throughout different seasons but, due to the small number of detections for each species, the estimates given here can provide, at best, an approximate estimate of abundance and density of animals.

For more details on this study, including full statistical analysis, refer to the annual progress report for this project (Richlen et al. 2018a).

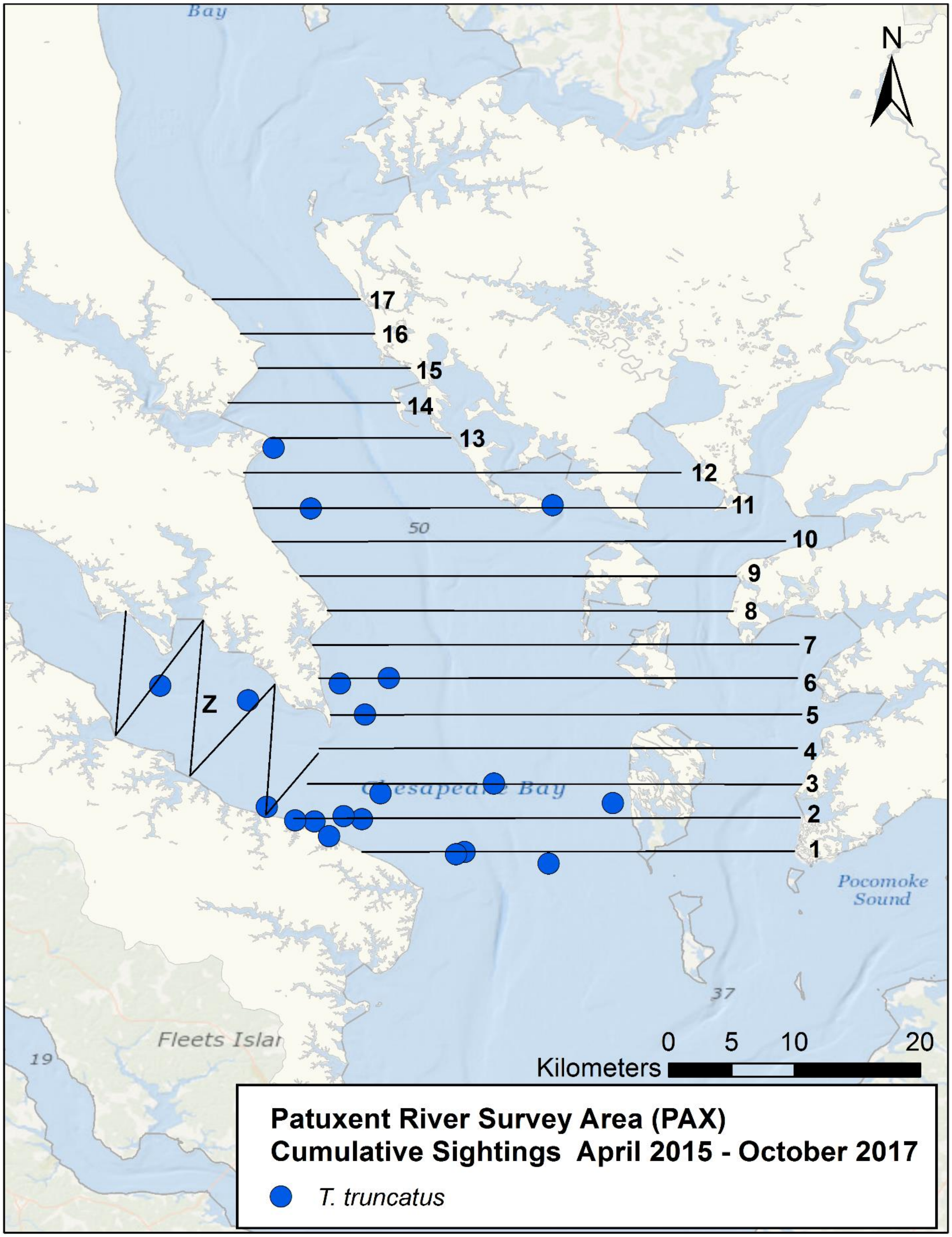

Figure 19. All on-effort bottlenose dolphin sightings from aerial surveys at the PAX study site during the study period from April 2015 through October 2017.

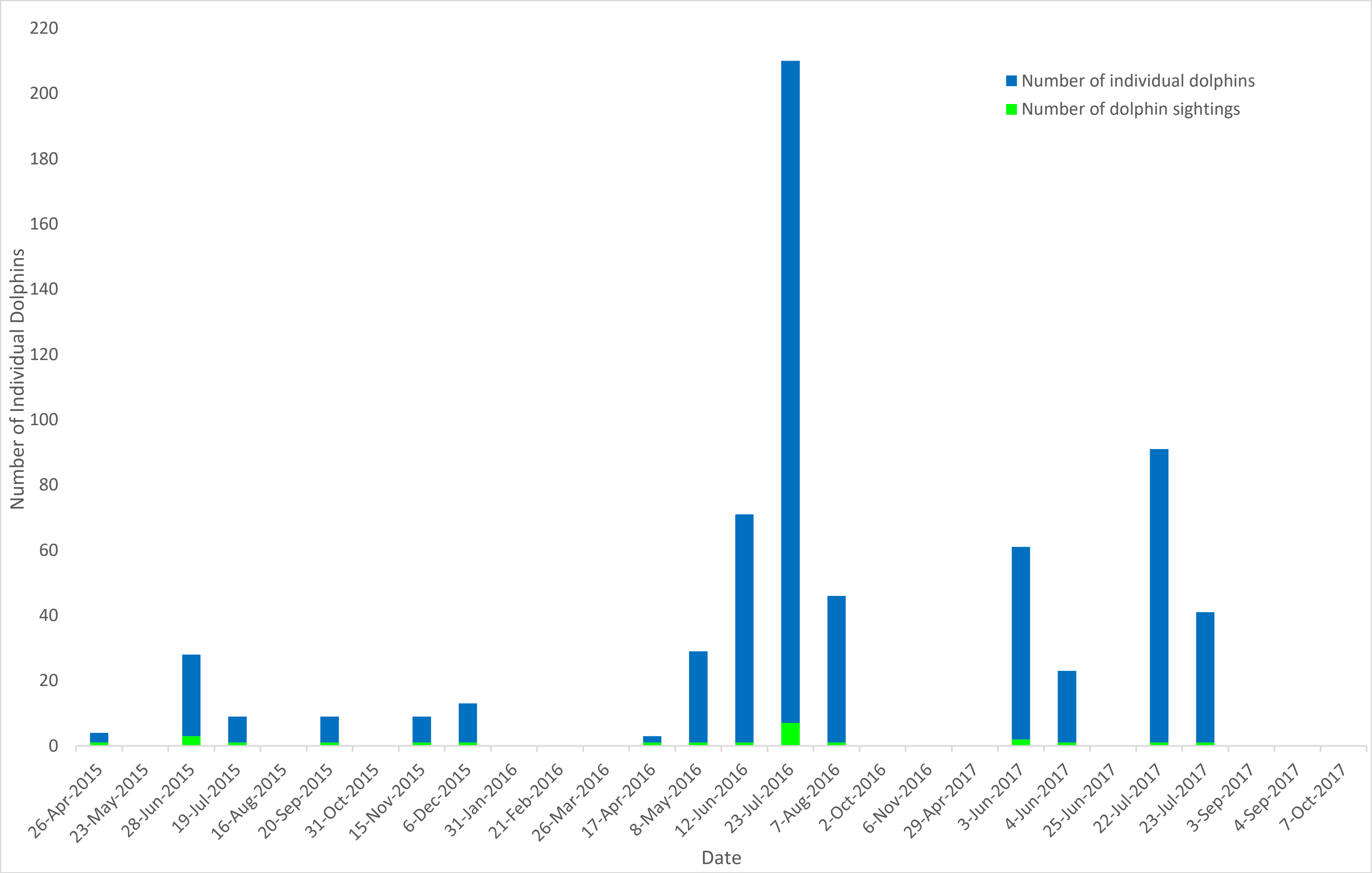

Figure 20. Number of individual bottlenose dolphins observed per survey from aerial surveys at the PAX study site during the study period from April 2015 through October 2017.

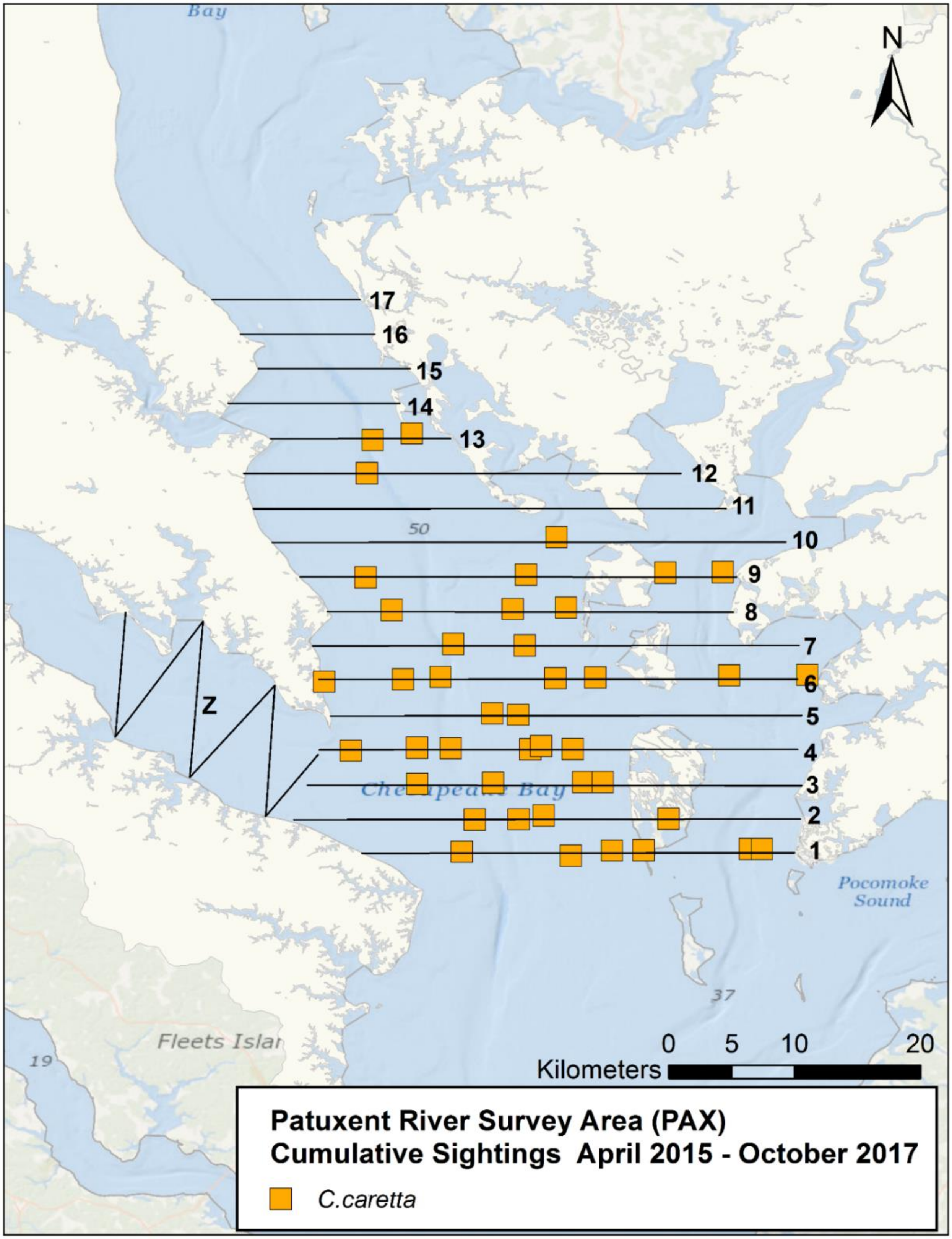

Figure 21. All on-effort sea turtle sightings from aerial surveys at the PAX study site during the study period from April 2015 through October 2017.

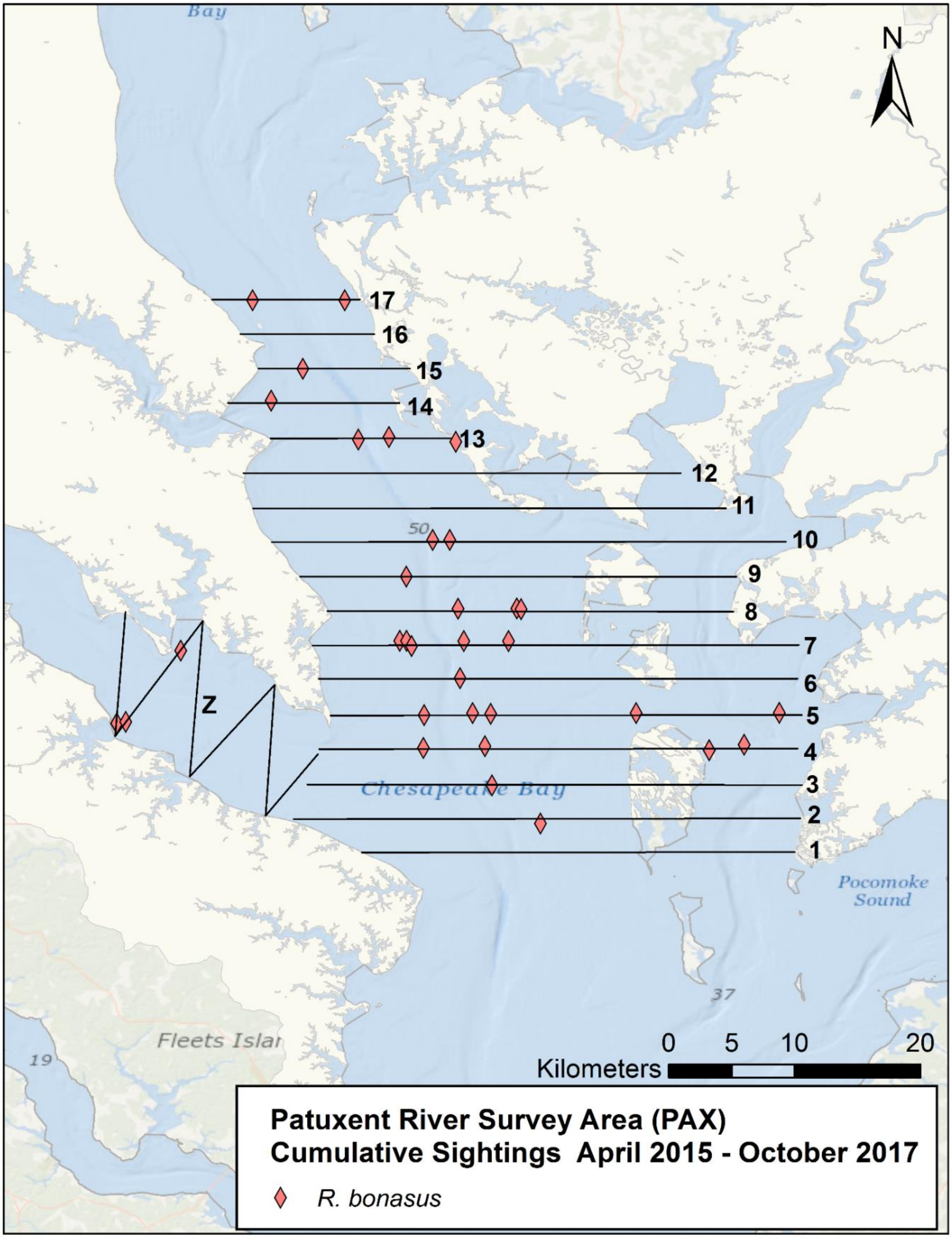

Figure 22. Cownose ray sightings from aerial surveys at the PAX study site during the study period of April 2015 through October 2017.

2.1.2 Visual Baseline Vessel Surveys

2.1.2.1 *Jacksonville Study Area Vessel Surveys*

Vessel survey effort in the JAX study area during 2017 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* and fishing vessel (F/V) *Jodie Lynn II*, with 2 observers continually scanning the trackline. A total of ten days of vessel surveys were conducted in the JAX study area during February, June, July, and November, totaling 1,424.2 km and 66.2 hr (**Table 12, Figure 23**). 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 12. Effort summary for small-vessel surveys conducted in the JAX study area in 2017.

Month	Number of Survey Days	Total Survey Time (hr: min)	Time On Effort (hr:min)	Total km Surveyed
February	2	19:52	08:51	207.7
June	3	32:44	24:33	553.0
July	3	27:04	18:43	414.0
November	2	20:24	13:59	249.5
Total	**10**	**100:04**	**66:10**	**1,424.2**

Key: hr = hour(s); km = kilometer(s); min = minute(s).

Thirty-seven cetacean sightings of 4 species were recorded during these vessel surveys. As in previous years, common bottlenose (*n*=16) and Atlantic spotted dolphins (*n*=18) were frequently observed, in addition to 2 sightings of Risso's dolphins, and a single sighting of rough-toothed dolphins (**Table 13**; **Figure 24**). Similar to observations during previous years, bottlenose dolphins were encountered throughout the JAX study area, including deeper oceanic waters, whereas Atlantic spotted dolphins were restricted to the relatively shallow continental shelf waters. Risso's dolphins were found exclusively in deeper oceanic waters, while the rough-toothed dolphins were observed inshore of the continental shelf break.

Table 13. Sightings from small-vessel surveys conducted in the JAX study area in 2017.

Common Name	Scientific Name	Number of Sightings	Number of Individuals
Common bottlenose dolphin	*Tursiops truncatus*	16	70
Atlantic spotted dolphin	*Stenella frontalis*	18	263
Rough-toothed dolphin	*Steno bredanensis*	1	50
Risso's dolphin	*Grampus griseus*	2	68
Loggerhead turtle	*Caretta caretta*	24	25
Leatherback turtle	*Dermochelys coriacea*	2	2
Unidentified sea turtle		3	3

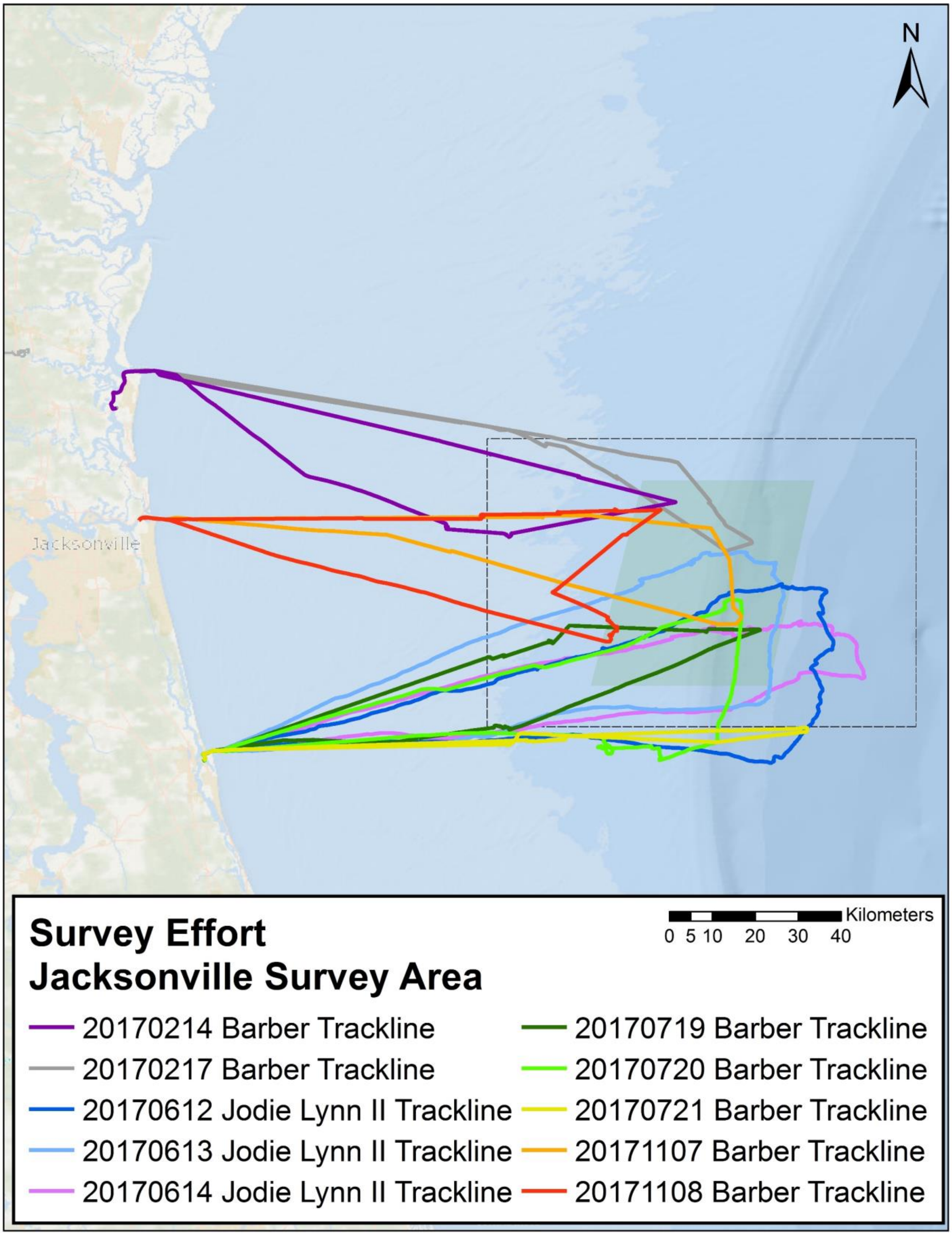

Figure 23. Survey effort during small-vessel surveys in the JAX study area in 2017.

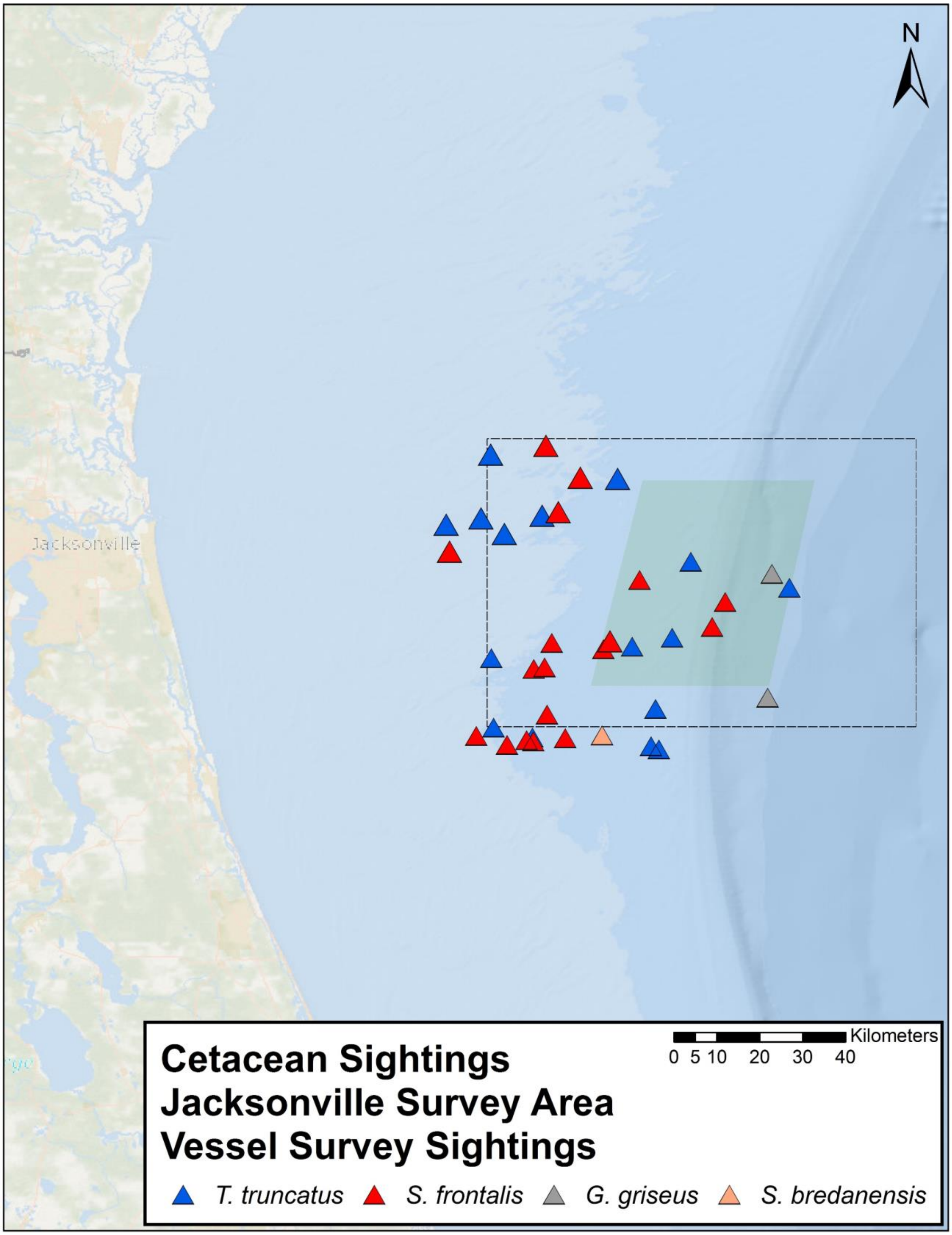

Figure 24. Cetacean sightings from small-vessel surveys conducted in the JAX study area in 2017.

Twelve biopsy samples were collected in the JAX study area during 2017 from Atlantic spotted dolphins (*n*=8), bottlenose dolphins (*n*=2), and rough-toothed dolphins (*n*=2) (**Table 14, Figure 25**). Skin samples will be analyzed for sex determination. Voucher specimens of these samples have been archived with NMFS' Southeast Fisheries Science Center in Lafayette, Louisiana.

Table 14. Biopsy samples collected from animals in the JAX study area in 2017.

Common Name	Scientific Name	No. Samples
Atlantic spotted dolphin	*Stenella frontalis*	8
Common bottlenose dolphin	*Tursiops truncatus*	2
Rough-toothed dolphin	*Steno bredanensis*	2

Thirty sea turtles were recorded in the JAX study area during 2017. As in past years, the loggerhead turtle (*n*=25) was the most frequently recorded species, with a pair of sightings of leatherback turtles (*n*=2) (**Table 13**). Most sea turtles were observed over the continental shelf (**Figure 26**).

Over 3,500 digital images were collected for species confirmation and individual identification during 2017, and 94 newly identified dolphins were cataloged (**Table 15**). To date, 20 individual Atlantic spotted dolphins have been resighted within the JAX study area (**Figure 27**). Sfr 7-008 and 9-011 were first observed together in 2013. In 2016, 7-008 was observed without 9-011, but they were again photographed together in July 2017, making Sfr 7-008 the first individual to be sighted 3 times within the JAX survey area since surveys commenced in 2009. Eight Atlantic spotted dolphins were observed on consecutive days this year in July (**Table 16**). Three of these 8 individuals also had been observed together in July of 2014, for a total of 4 Atlantic spotted dolphin individuals sighted 3 times. One pair of dolphins (Sfr 8-037 and Sfr DU 8-014) was seen together in consecutive months this year, in addition to the first trio (Sfr 6-024, Sfr 7-035, and Sfr 9-040) match documented, photographed together in both 2016 and 2017. The longest resighting to date within the JAX survey area occurred in 2017, with Sfr 2-002 seen in July 2010 and again in November 2017, for over 7 years between sightings. Finally, Sfr 7-010 and Sfr 7-015 were both resighted in 2017.

Table 15. Summary of photo-ID images taken of animals in the JAX study area in 2017 with photo-ID catalog sizes and total number of matches across all years of effort.

Species	Common Name	2017 Images	Catalog Size (New Animals)	Matches
Globicephala macrorhynchus	Short-finned pilot whale	0	29 (0)	0
Grampus griseus	Risso's dolphin	734	56 (20)	0
Stenella frontalis	Atlantic spotted dolphin	1592	199 (45)	20
Steno bredanensis	Rough-toothed dolphin	520	54 (11)	8
Tursiops truncatus	Common bottlenose dolphin	689	132 (18)	8

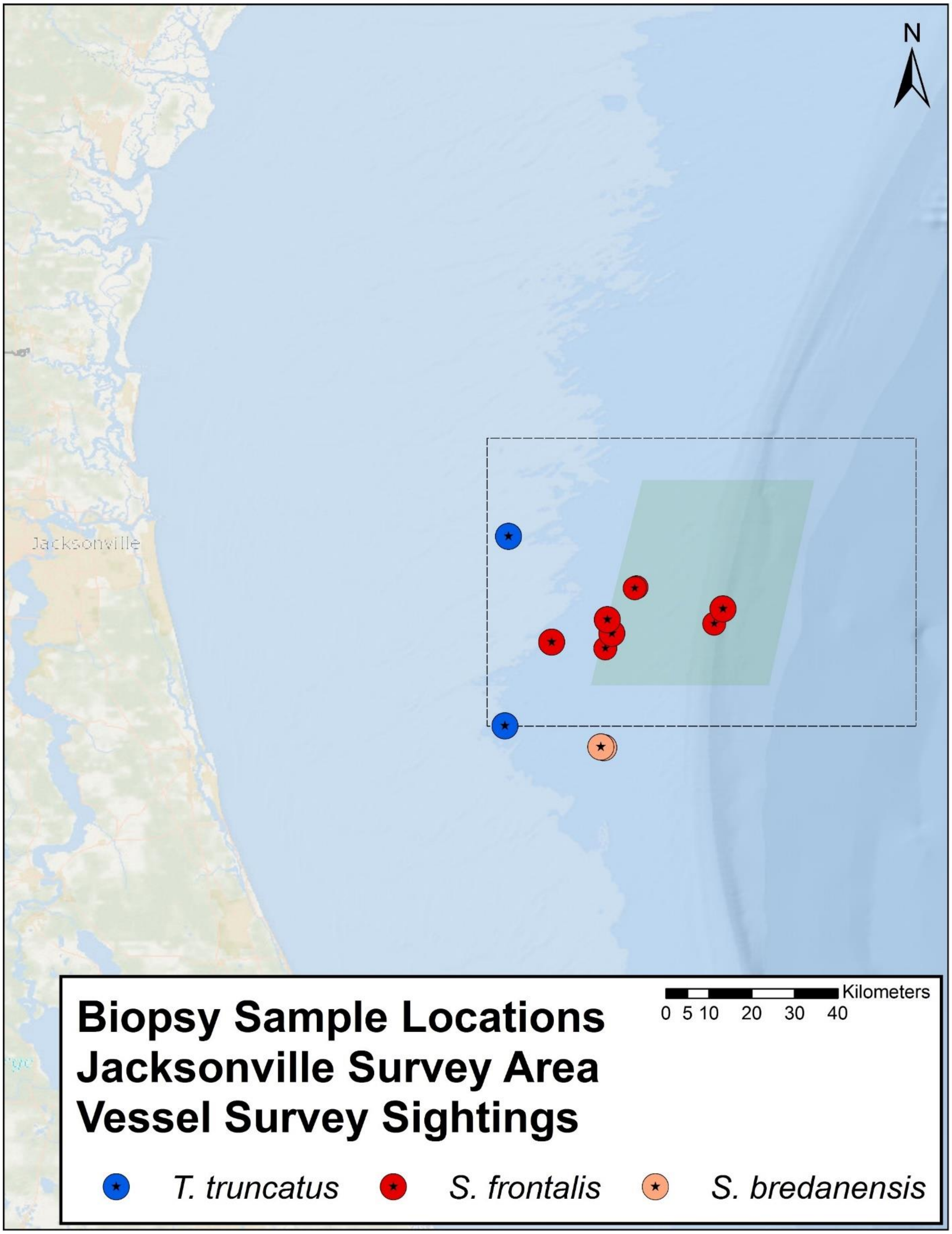

Figure 25. Locations of biopsy samples collected in the JAX study area in 2017.

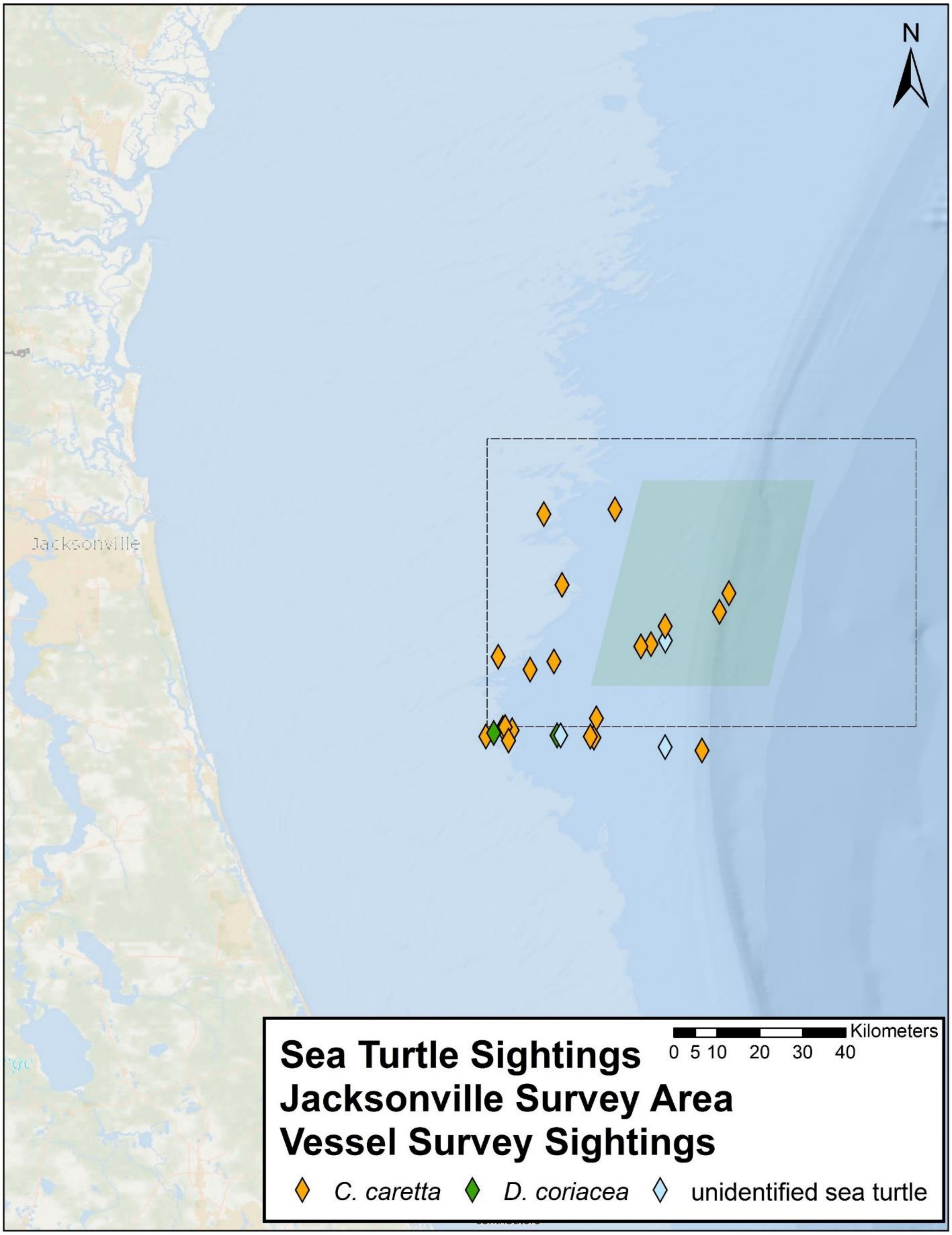

Figure 26. Sea turtle sightings from small-vessel surveys conducted in the JAX study area in 2017.

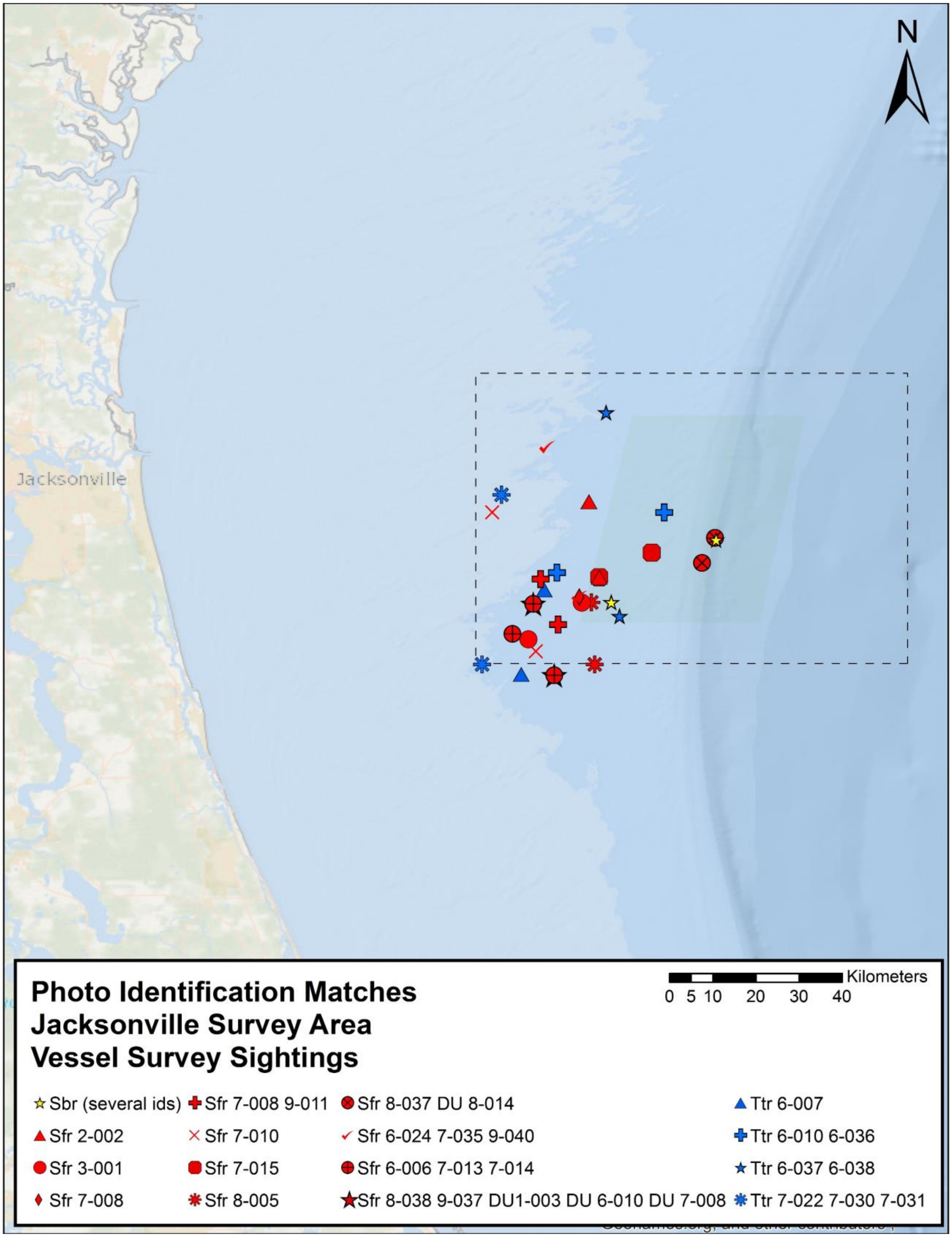

Figure 27. Locations of photo-matched dolphins within the JAX study area across all years.

Table 16. Photo-ID matches of common bottlenose (Ttr), Atlantic spotted (Sfr), and rough-toothed (Sbr) dolphins observed in the JAX study area across years.

ID	Year								
	2009	2010	2011	2012	2013	2014	2015	2016	2017
Ttr 6-007					X				X
Ttr 6-010^				X	X				
Ttr 6-036^				X	X				
Ttr 6-037^					X				X
Ttr 6-038^					X				X
Ttr 7-022^							X		X
Ttr 7-030^							X		X
Ttr 7-031^							X		X
Sfr 2-002		X							X
Sfr 3-001		X	X						
Sfr 7-008^					X			X	X
Sfr 9-011^					X				X
Sfr 7-010					X				X
Sfr 7-015						X			X
Sfr 8-005			X[m]						
Sfr 8-037^									X[y]
Sfr DU 8-014^									X[y]
Sfr 6-006^						X			X[m]
Sfr 7-013^						X			X[m]
Sfr 7-014^						X			X[m]
Sfr 8-038^									X[m]
Sfr 9-037^									X[m]
Sfr DU 1-003^									X[m]
Sfr DU 6-010^									X[m]
Sfr DU 7-008^									X[m]
Sfr 6-024^								X	X
Sfr 7-035^								X	X
Sfr 9-040^								X	X
Sbr 1-001								X[m]	
Sbr 1-002								X[m]	
Sbr 6-001								X[m]	
Sbr 6-002								X[m]	
Sbr 7-001								X[m]	
Sbr 7-002								X[m]	
Sbr 7-003								X[m]	
Sbr 7-004								X[m]	

^ Observed together in multiple sightings
[m] Resighted within same month
[y] Resighted within same year

In addition, 8 common bottlenose dolphins have been resighted in JAX. Two pairs of common bottlenose dolphins have been resighted together: one in January 2012 and July 2013, and another (Ttr 6-037 and 6-038) in September 2013 and February 2017. Ttr 6-007, first cataloged in 2013, was resighted in 2017. There has also been a common bottlenose dolphin trio resighted in the JAX survey area, first seen together in 2015 and again in 2017 (**Table 16, Figure 27**). Eight individual rough-toothed dolphins have been resighted, as they were seen on consecutive days in September 2016 (**Table 16**). The Risso's dolphin photo-ID catalog consists of 56 individuals, but we have not identified any resightings.

Cumulative

There have been eight and a half years of vessel survey effort in the JAX study area since the monitoring program began in 2009, with 574 hr and 10,024 km of effort completed (**Table 17**). Six species of cetaceans have been identified, and annual sighting totals (including unidentified and mixed-species sightings) ranged from a low of 12 in 2011 to a high of 72 in 2009–2010 (**Table 18**). Three sea turtle species have been identified, with annual sighting totals (including unidentified turtles) ranging from 24 in 2015 to 69 in 2009–2010 (**Table 19**). Over the entire study, 116 biopsy samples have been collected from six odontocete species, mostly (87 percent) from Atlantic spotted and common bottlenose dolphins (**Table 20**). Cumulative photo-ID results to date were summarized above in **Table 15.**

Table 17. Duration and distance surveyed annually in the JAX study area.

	2009–10*	2011	2012	2013	2014	2015	2016	2017	Total
Survey Hours	127	21	59	59	67	44	131	66	**574**
km Surveyed	2,074	346	937	1,022	1,227	858	2,136	1,424	**10,024**

* July 2009-December 2012.

Table 18. Numbers of cetacean sightings annually for each species in the JAX study area.

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

* July 2009-December 2012.

Table 19. 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
Caretta caretta	52	20	41	33	31	22	22	25
Dermochelys coriacea	8	3	4	1	3	2	4	2
Lepidochelys kempii	1	0	1	0	0	0	0	0
Unidentified turtle	8	3	3	1	0	0	0	3
Total	**69**	**26**	**49**	**35**	**34**	**24**	**26**	**30**

* July 2009-December 2012.

Table 20. Biopsy samples collected annually in the JAX study area.

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

* July 2009-December 2012.

For more information on this study, refer to the annual progress report for this project (Foley et al. 2018).

2.1.2.2 *Panama City Vessel Surveys*

Common bottlenose dolphins inhabit the bay and coastal waters of the Florida Panhandle (reviewed in Hayes et al. 2017). Currently, NMFS has delineated one Gulf coastal (Northern Coastal Stock) and seven bay, sound, and estuary (BSE) bottlenose dolphin stocks within the nearshore waters of the Florida Panhandle (Hayes et al. 2017). 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. 2017). 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% 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. At present, there is no current abundance estimate encompassing the entire St. Andrew Bay Stock. Furthermore, it is unknown if the Northern Coastal Stock follows a similar pattern to what is observed in the St. Joseph Bay region, with seasonal influxes into St. Andrew Bay.

For 2017, the majority of effort was spent analyzing data from the 2016 surveys, with fieldwork only conducted during July. The goals of this study were to build upon data collected during July and October 2015 to determine abundance, habitat use, and distribution patterns of bottlenose dolphins in St. Andrew Bay and adjacent coastal waters in the NSWC PCD Testing Range over an additional two sampling periods (April and October 2016). During spring and fall in the adjacent St. Joseph Bay region, the observed 2- to 3-fold increase in abundance was attributed to Northern Coastal Stock dolphins entering St. Joseph Bay waters. St. Joseph Bay summer abundance was low and animals sighted during this season were hypothesized to represent only the BSE Stock. The focus of the 2015 St. Andrew Bay surveys was to target two seasons based upon prior observations in St. Joseph Bay: summer (July), when only the St. Andrew Bay BSE Stock would be hypothesized to be in the region, and fall (October), when both the Northern Coastal Stock and St. Andrew Bay BSE Stock were hypothesized to be in the region. For the 2016 surveys, the goals were to survey during spring (April) to determine if there was an influx of dolphins in the St. Andrew Bay region, and fall (October) to provide a comparison to the 2015 fall surveys and determine if animals sighted in spring and fall were the same individuals. Specific study objectives were as follows:

1. Identify which marine mammal species occur seasonally within St. Andrew Bay and nearby coastal waters (<3 km from shoreline);
2. Calculate seasonal resight rates for individual dolphins and develop a site-fidelity index for dolphins in this region to provide baseline data for future studies to assess long-term residence;
3. Determine distribution patterns for dolphins within and between St. Andrew Bay and coastal waters;
4. Estimate seasonal abundance across the four primary sessions (2015–2016); and
5. Correlate dolphin presence with particular environmental parameters (e.g., water depth, water temperature, water salinity) and broad habitat types (e.g., shallow bay, channel, seagrass bed, surf zone, open water).

Analysis and Results from 2016 Surveys

For estuarine waters, contour transects (i.e., transects that follow a particular geographic feature) were followed either 500 m from the shoreline or along the 1-m depth contour. Contour transects in coastal waters were followed approximately 500 m and 3 km off the coastline (**Figure 28A**). The total distance of all survey transects for the estuarine and coastal waters were 200 km and 52 km, respectively.

Capture-recapture (CR) photo-ID survey effort was conducted in the St. Andrew Bay study area during 18–21, 23–27 April and 13–20 October 2016 (additional remote biopsy-sampling effort was conducted on 21–25 October and is not included in this survey summary). All BSE and coastal transects were completed three times in each primary period, totaling six times in the course of 2016. Cumulatively, 1,943 km were surveyed during 117 on-water hours (**Table 21**). A total of 177 sightings was recorded with 964 dolphins observed, including 101 calves and 27 neonates (**Figure 28C**). Mean group size was 5.4 individuals and 94 percent of all dolphins sighted were photographed (*n*=905/964) (**Table 21**).

During CR photo-ID surveys, 95 and 31 new, distinctive individuals were identified in April and October 2016, respectively (**Figure 29**). Within secondary sessions (s), the numbers of new individuals sighted were higher in s7 - s9 (April 2016) than s10 - s12 (October 2016). Including photo-ID effort (CR photo-ID and remote biopsy-sampling surveys), the total numbers of new distinctive animals were comparable between October 2015 and April 2016 (96 and 95 individuals, respectively) (**Figure 29**). The number of distinctive individuals sighted in both July and October was 114. The St. Andrew Bay study area photo-ID catalog consists of 246 distinctive individuals.

To identify movement patterns in the St. Andrew Bay region, the total numbers of distinctive animals sighted only in bay waters, only in coastal waters, and across both survey areas were determined for each survey period and across both survey areas (**Table 21**). Of the 221 distinctive dolphins sighted only in April 2016, 114 (52 percent) and 107 (48 percent) were sighted exclusively in BSE or coastal waters, respectively, with none sighted in both areas. During October 2016, of the 237 distinctive dolphins sighted only in this primary period, 153 (65 percent) and 82 (35 percent) were sighted exclusively in the BSE or CST waters, respectively, with 2 (1 percent) sighted in both survey areas. One hundred and twenty distinctive dolphins were sighted in both primary periods; 88 (73 percent) and 22 (18 percent) were sighted exclusively in BSE or coastal waters, respectively, with 10 (8 percent) sighted in both areas. For the 392 distinctive individuals in the St. Andrew Bay photo-ID catalog, 197 (50 percent) and 168 (43 percent) were sighted exclusively in BSE or coastal waters, respectively, while 27 (7 percent) were sighted in both survey areas.

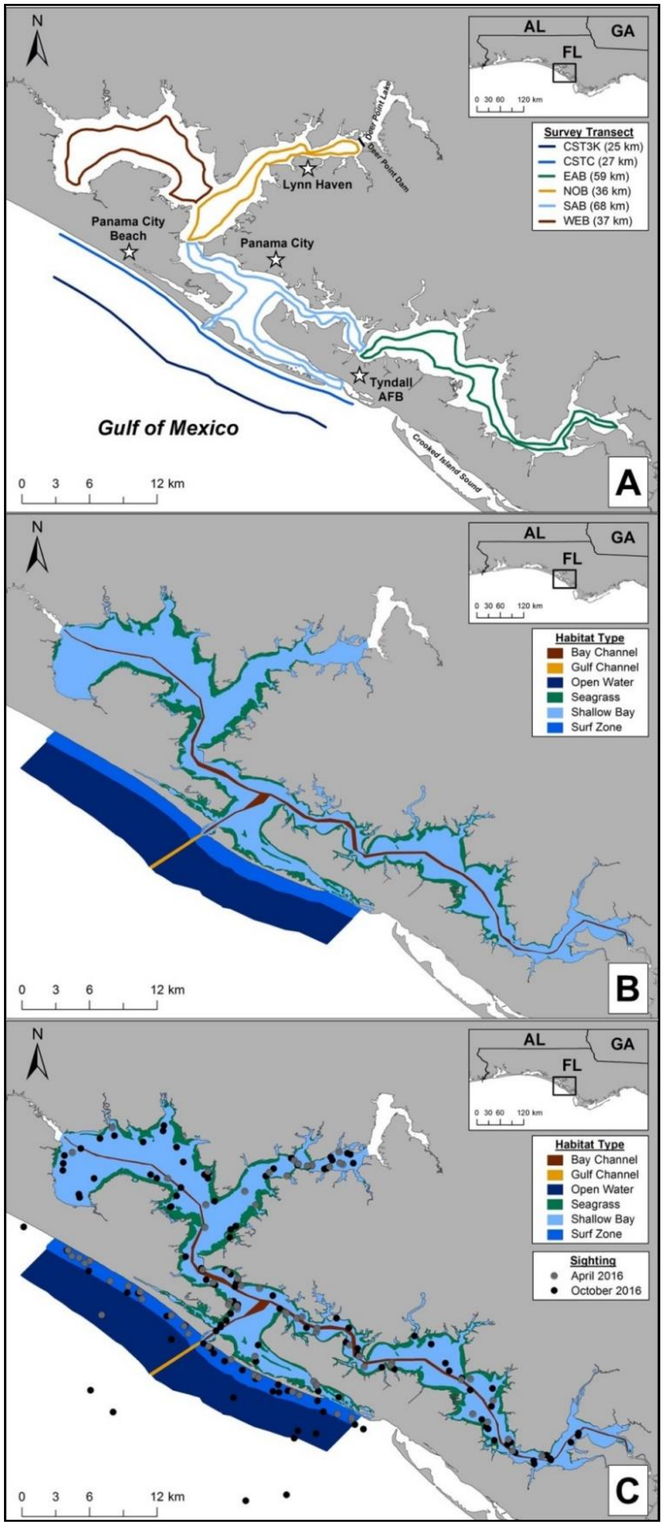

Figure 28. (A) St. Andrew Bay photo-ID study area with survey transects and survey distance (km) (coastal 3 km offshore=CST3K), coastal 500 m offshore=CSTC, East Bay=EAB, North Bay=NOB, St. Andrew Bay=SAB, and West Bay=WEB), (B) habitat types, and (C) 2016 sighting distribution.

Table 21. Common bottlenose dolphin photo-ID effort and results in the St. Andrew Bay study area, for each survey zone (bay and coastal), during April 2016, October 2016, and cumulatively (2016).

Zone	Total Hours	On-effort Hours	Total km	Survey km	Time in Contact (hr)	Total Sightings	Total Dolphins (FE)	Total Calves (PA)	Total Neonates (PA)	Mean Group Size (PA)	Dolphins Photographed	Proportion Photographed
April 2016												
Bay	42	23	714	580	14	51	289	27	13	5.7	259	0.90
Coastal	14	8	238	181	5	22	218	13	14	9.9	209	0.96
Total	**56**	**31**	**952**	**761**	**19**	**73**	**507**	**40**	**27**	**6.9**	**468**	**0.92**
October 2016												
Bay	50	25	779	544	19	90	392	54	0	4.4	378	0.96
Coastal	11	7	212	188	3	14	65	7	0	4.6	59	0.91
Total	**61**	**32**	**991**	**732**	**22**	**104**	**457**	**61**	**0**	**4.4**	**437**	**0.96**
Combined 2016												
Bay	92	48	1,493	1,124	33	141	681	81	13	4.8	637	0.94
Coastal	25	15	450	369	8	36	283	20	14	7.9	268	0.95
Total	**117**	**63**	**1,943**	**1,493**	**41**	**177**	**964**	**101**	**27**	**5.4**	**905**	**0.94**

Key: FE=field estimate; PA=photo analysis result.

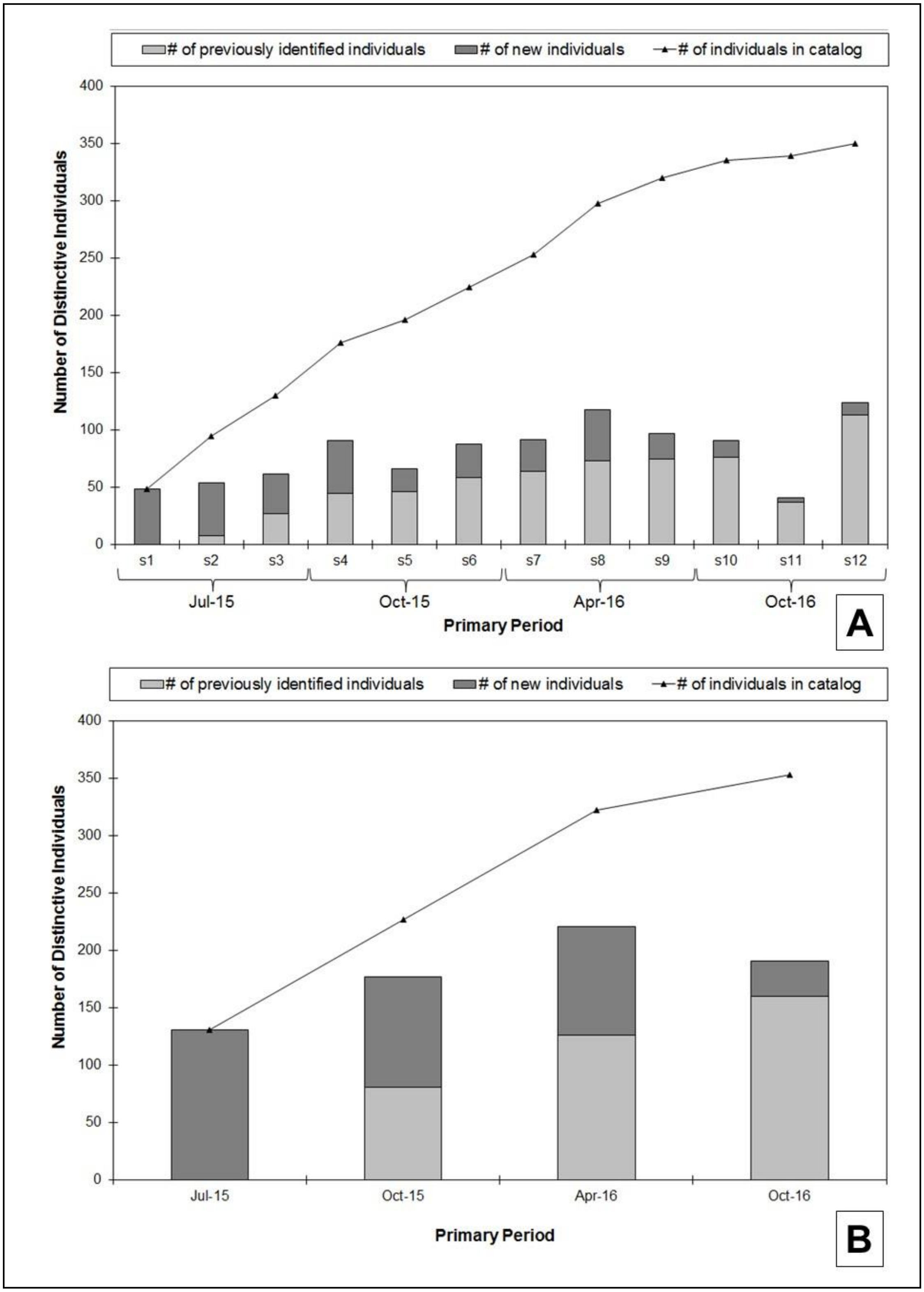

Figure 29. Number of distinctive individuals sighted and discovery curve for bottlenose dolphins in the St. Andrew Bay study area during (A) CR photo-ID survey secondary sessions and (B) all photo-ID effort (CR photo-ID and biopsy-sampling surveys) primary periods.

Total BSE abundance was lowest in April 2016 (199; 95% CI=173–246), followed by July 2015 (249; 95% CI=199–338, and highest in October 2015 (299; 95% CI=259–361) and October 2016 (315; 95% CI=274–378). Total coastal abundance was lowest in October 2016 (104; 95% CI=69–192) and October 2015 (108; 95% CI=71–204), followed by July 2015 (198; 95% CI=121–675), and highest in April 2016 (208; 95% CI=172–273). BSE Dolphin density was generally comparable across primary periods (0.77–1.16 dolphins/km^2), while coastal density was higher in July 2015 and April 2016 (1.55 and 1.63 dolphins/km^2, respectively) than October 2016 and October 2015 (0.81 and 0.84 dolphins/km^2, respectively).

To assess habitat use, all waters were classified into one of six habitat types: bay channel, gulf channel, open water, seagrass, shallow bay, and surf zone (**Figure 28B**). Each habitat type was defined as a shapefile layer using ArcGIS 10.3 (ESRI, Redlands, California). Bay and Gulf Channel boundaries were determined using the locations of channel markers/buoys. Open Water habitat was defined as all Gulf waters between 1 km and 4 km offshore. Seagrass habitat was defined by using the Florida Fish and Wildlife Research Institute Seagrass Habitat in Florida dataset (http://geodata.myfwc.com/datasets). Shallow Bay habitat was defined as all estuarine waters not Seagrass or Bay Channel habitats. Surf Zone habitat was defined as all Gulf waters from shoreline to 1 km offshore. The area of each habitat type was calculated to determine total available dolphin habitat in the St. Andrew Bay study area. To identify fine-scale habitat preference, the relative density of dolphins per habitat area was calculated by dividing the total number of dolphins sighted in each habitat by the respective habitat area (km^2). Dolphin density was also calculated for each survey area (BSE or coastal) and cumulatively by dividing robust population model abundance for a given primary period by the total area (km^2) for each respective survey area.

Most bay habitat in the St. Andrew Bay study area was classified as Shallow Bay (204.39 km^2), followed by Seagrass (41.97 km^2), and Bay Channel (29.22 km^2). In coastal waters, Open Water comprised the majority of habitat (97.41 km^2), followed by Surf Zone (29.22 km^2), and Gulf Channel (1.06 km^2). During April 2016, dolphin density was highest in the Surf Zone (6.23 dolphins/km^2) followed by Bay Channel (4.43 dolphins/km^2) and Seagrass (2.41 dolphins/km^2) habitats (**Figure 30A**). During October 2016, dolphin density was highest in Bay Channel (5.33 dolphins/km^2), followed by Seagrass (4.36 dolphins/km^2), and Surf Zone (3.90 dolphins/km^2) (**Figure 30B**). Dolphin density in April/October 2016 followed a similar pattern with Surf Zone, Bay Channel, and Seagrass having the highest densities (10.13, 9.75, and 6.77 dolphins/km^2, respectively (**Figure 30C**).

Prior to this fieldwork, little was known about the stock structure and contaminant levels of dolphins in the St. Andrew Bay region. In collaboration with the Southeast Fisheries Science Center and the Northwest Fisheries Science Center, biopsy samples were collected to provide baseline data on genetics and persistent organic pollutants (POPs) in St. Andrew Bay dolphins.

Seventeen (10 males, 7 females) remote biopsy samples were collected over 5 field days during the October 2016 St. Andrew Bay fieldwork. POP analyses were conducted by the Northwest Fisheries Science Center on 53 samples (31 males; 22 females). POP class concentrations were all higher in males than females (**Figure 31**). For both males and females, POP concentrations were highest for polychlorinated biphenyls, followed closely by dichlorodiphenyl-dichloroethanes, then chlordanes and polybrominated diphenyl ether. The lowest levels were shown for dieldrin, mirex, and hexachlorobenzene. BSE male and female dolphins had significantly higher POP concentrations than coastal dolphins in six and four of the POP classes, respectively.

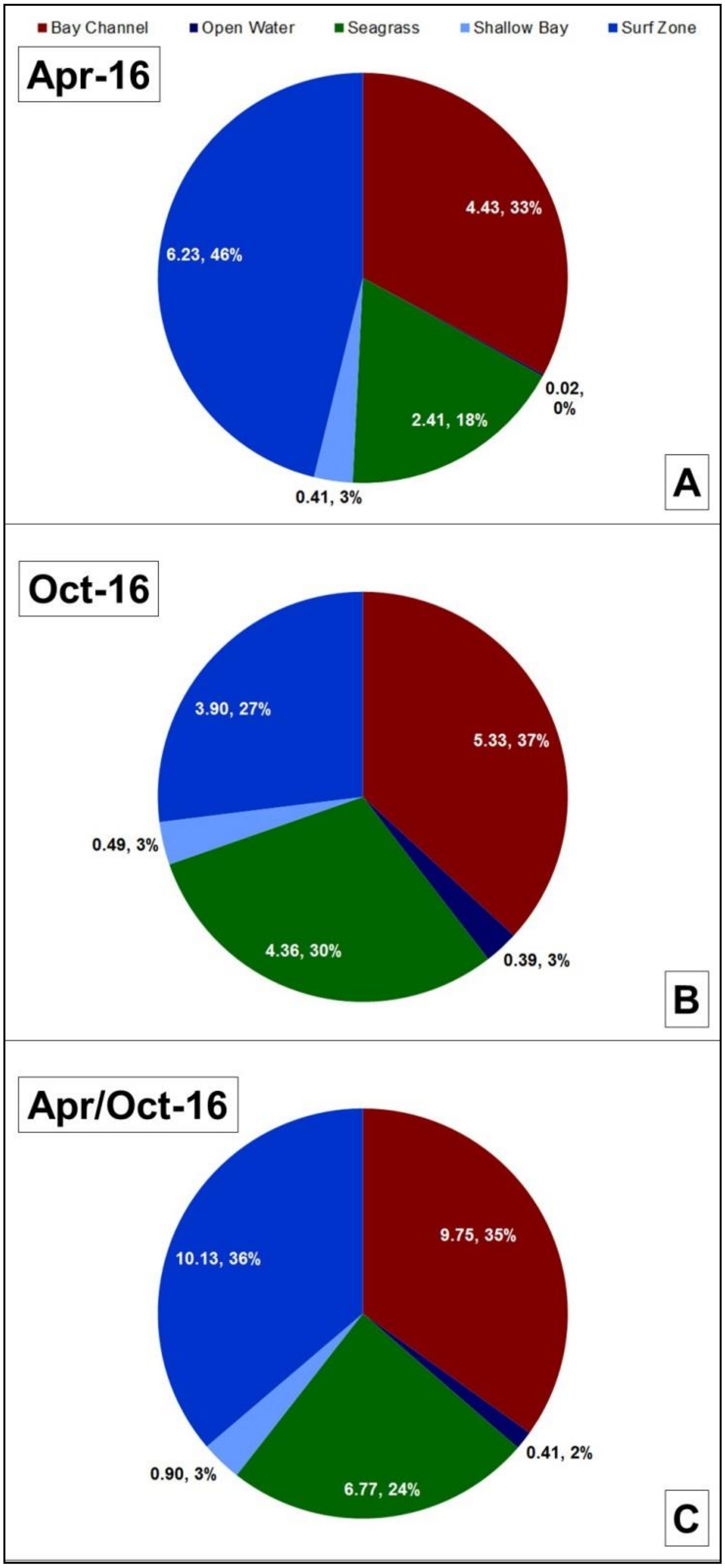

Figure 30. Density (total dolphins sighted/km^2) and percentage of dolphin habitat use in (A) July 2016, (B) October 2016, and (C) 2016 cumulatively in the St. Andrew Bay study area.

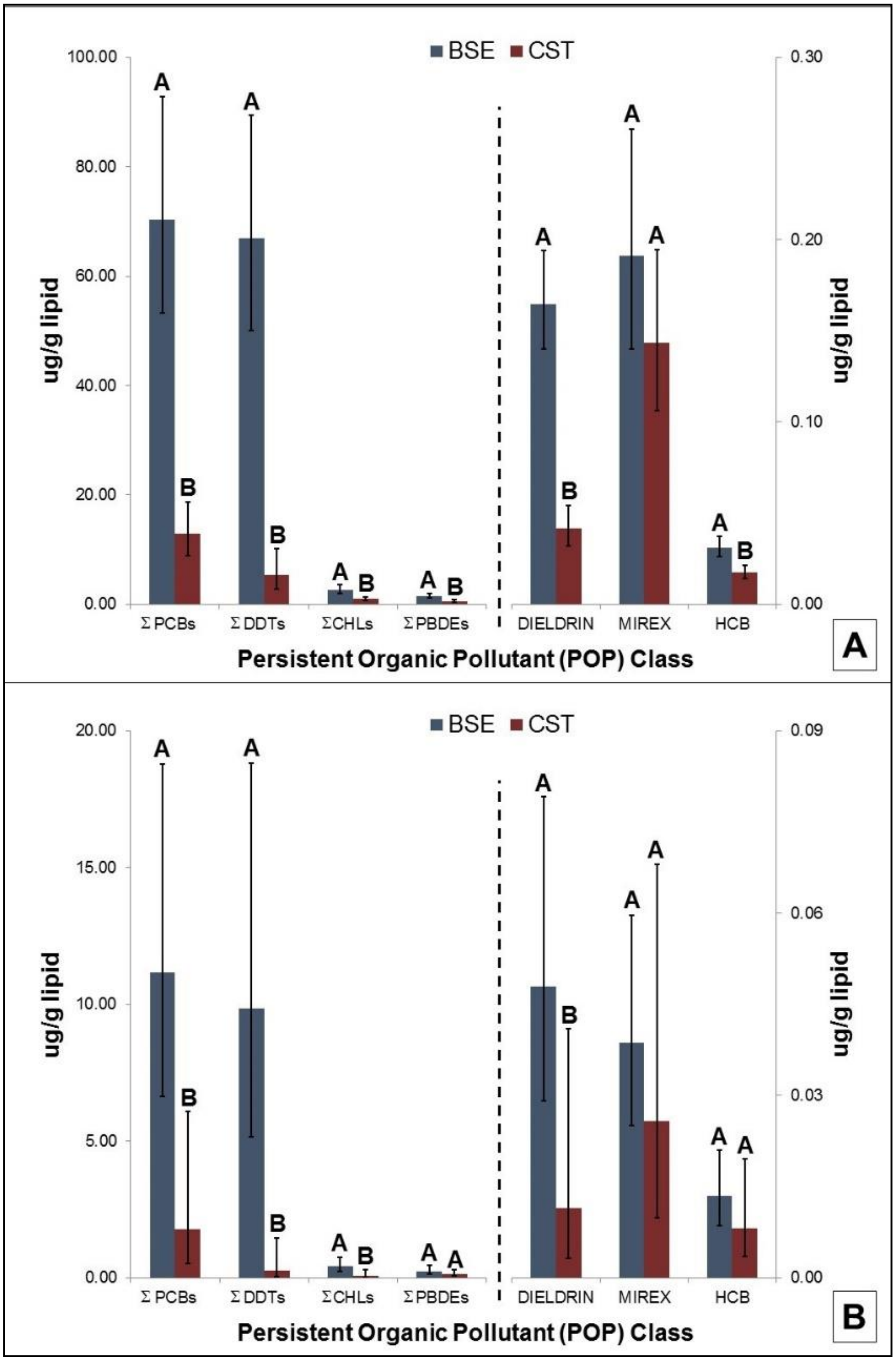

Figure 31. Concentrations (µg/g lipid; geometric mean and 95% CI) of persistent organic pollutants measured in remote biopsy blubber samples (*n*=53) of (A) male (*n*=31) and (B) female (*n*=22) bottlenose dolphins collected in St. Andrew Bay (BSE) and adjacent coastal waters (CST). Statistically significant differences between BSE and CST for any pair are indicated by different letters over the bars. PCBs=polychlorinated biphenyls; DDTs=dichlorodiphenyl-trichloroethanes; CHLs=chlordanes; PBDEs=polybrominated diphenyl ethers; and HCB=hexachlorobenzene.

The 2016 St. Andrew Bay field project built upon the 2015 work to provide a more in-depth assessment of dolphin abundance, habitat use, and distribution patterns. Based upon the small number of cataloged individuals that were sighted in both bay and coastal waters (*n*=27 of 392; 7 percent) and the connections between the estuary and the coast for potential immigration/emigration, the BSE survey area is likely representative of a semi-closed population during and, for the most part, across primary periods. The robust-design CR models with time-varying recapture had extremely narrow 95% CIs, further supporting this conclusion. However, in the case of the coastal abundance estimates, because of presumed extended movements of coastal dolphins in the northern Gulf of Mexico (Balmer et al. 2008, 2010, 2016), the CR model assumptions about immigration/emigration were likely violated. The extremely large 95% CIs for the coastal estimates likely stem from these violations. Future research investigating open population models and spatially explicit robust-design models, as well as distance-sampling methods, may provide additional insight into coastal dolphin abundance and/or density.

The estimated abundance for St. Andrew Bay (249 in July; 314 in October) is generally comparable to other northern Gulf of Mexico BSE bottlenose dolphin stocks (Hayes et al. 2017). A more comprehensive assessment of seasonal and year-round site fidelity will be possible with the inclusion of the 2016 photo-ID data. Gulf of Mexico BSE dolphins preferentially select for channel (Allen et al. 2001), spoil island (Smith et al. 2013), and seagrass (Barros and Wells 1998; Rossman et al. 2015) habitats. Dolphins in the St. Andrew Bay study area had similar habitat preferences, with dolphin density highest in Channel and Seagrass habitat types. Along the U.S. East Coast, Torres et al. (2005) observed that most dolphins sighted along the coast were within 3 km of the shoreline, with a rapid decrease in numbers from 3 to 34 km offshore. The low density of dolphins in Open Water habitat may indicate a similar distribution of dolphins in the coastal waters of the St. Andrew Bay study area.

In addition to the analysis of the 2016 survey effort, further fieldwork was conducted in the study area in July 2017. The goal of this work was the continuation of photo-ID and line-transect survey effort in Gulf of Mexico coastal waters adjacent to NSWC PCD. This work also included collecting opportunistic remote biopsy samples from BSE and coastal dolphins. The study area transect lines varied from those used previously; transects extending out to 10 km from shore were included. Additionally, transects were surveyed perpendicular to the shore compared to parallel to shore in previous years. Line-transect methodology was also included for comparison to CR surveys for abundance estimation.

The July 2017 fieldwork comprised 12 field days and 1,532 km surveyed. A total of 38 sightings was recorded, in which 280 dolphins (232 common bottlenose dolphins and 48 Atlantic spotted dolphins), 48 calves, and 0 neonates were observed. A total of 24 remote biopsy samples was collected from common bottlenose dolphins (*n*=21) and Atlantic spotted dolphins (*n*=3). Data from the 2017 surveys are currently being analyzed. Based on the current project timeline, photo analysis will be completed by mid-2018 followed by drafts of manuscripts to coauthors by the end of 2018.

For additional detailed information on this study, refer to the full technical report for this project (Balmer et al. 2017).

2.1.3 Pinniped Haul-out Surveys in Narragansett and Chesapeake Bays

Harbor seal (*Phoca vitulina concolor*) and gray seal (*Halichoerus grypus*) distribution along the U.S. Atlantic Coast appears to be expanding. Data from National Oceanic and Atmospheric Administration (NOAA) surveys have previously shown New Jersey as the southern extent for harbor and gray seals, with occasional sightings and strandings reported as far south as Florida and North Carolina for harbor and gray seals, respectively. NOAA now reports that a small group of harbor seals (<50) haul out seasonally in the Chesapeake Bay and near Oregon Inlet, North Carolina (Waring et al. 2016). Observations from Virginia, by Chesapeake Bay Bridge Tunnel (CBBT) staff and local anglers, indicate 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, which aims to investigate seal presence at select haul-out locations in Narragansett Bay (Rhode Island) and lower Chesapeake Bay and coastal waters of Virginia. The goal of this study is to acquire a better understanding of the seals' seasonal occurrence, habitat use, and haul-out patterns in these areas, which are important U.S. Navy training and testing areas and vessel transit routes. Photo-ID methods are used to identify and compare individual seals, which will provide valuable baseline information for the future assessment of relative abundance indices, seal movements, and site fidelity along the U.S. northeast and mid-Atlantic coasts.

2.1.3.1 Lower Chesapeake Bay Study

A series of systematic shore-based counts of all seal species were conducted at four haul-out locations in lower Chesapeake Bay, on the CBBT islands, which span approximately 14 km from the first haul-out site (CBBT 1) to the fourth (CBBT 4). In 2016, vessel-based counts were conducted in one area on the Eastern Shore of Virginia in collaboration with The Nature Conservancy (**Figure 32**). Efforts were made with The Nature Conservancy to coordinate counts at the CBBT and Eastern Shore sites during the same survey day in an attempt to get more of a regional count for southeastern Virginia. The number of seals hauled out and in the water was recorded during each count. Environmental data (e.g. air and water temperature) were recorded during each haul-out survey for the CBBT sites to investigate relationships between seal presence and environmental variables. Photographs of seals were collected between counts for photo-ID and a capture-recapture study (if data permits). Photographs are being used to develop local catalogs, and they will also be compared to regional catalogs (**Figure 33**).

For the third field season of the study, 27 survey days were completed from October 2016 to April 2017 for the CBBT haul-out sites. A total of 307 harbor seals were sighted. Seals were observed on 19 of the 27 (70.4%) survey days. Highest counts were recorded in January and February.

A total of 61 surveys have been conducted across three field seasons at the CBBT. Seals were recorded from mid-November to mid-May, with most (94%) being sighted at the CBBT 3 haul-out site. The majority of seals observed in the three field seasons were harbor seals. One gray seal was observed in 2014-2015 and two gray seals were observed in 2015–2016. Once seals arrived, animals were recorded on a fairly consistent basis (44 out of 47 surveys) 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 three field seasons, the average count and maximum count for a single survey have slightly increased (**Table 22**).

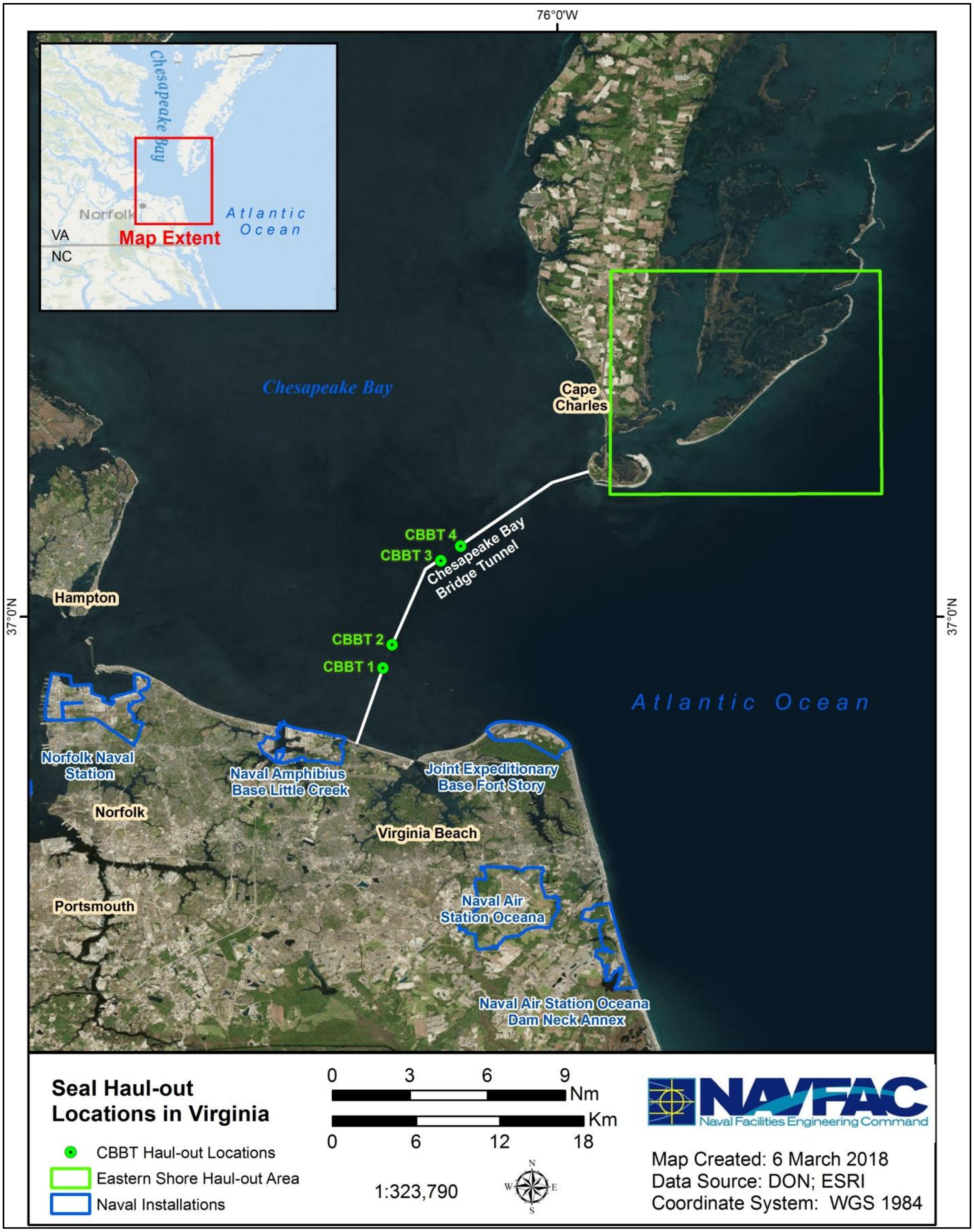

Figure 32. CBBT haul-out sites and the Eastern Shore haul-out area, and their proximity to U.S. Navy training and testing areas in Virginia.

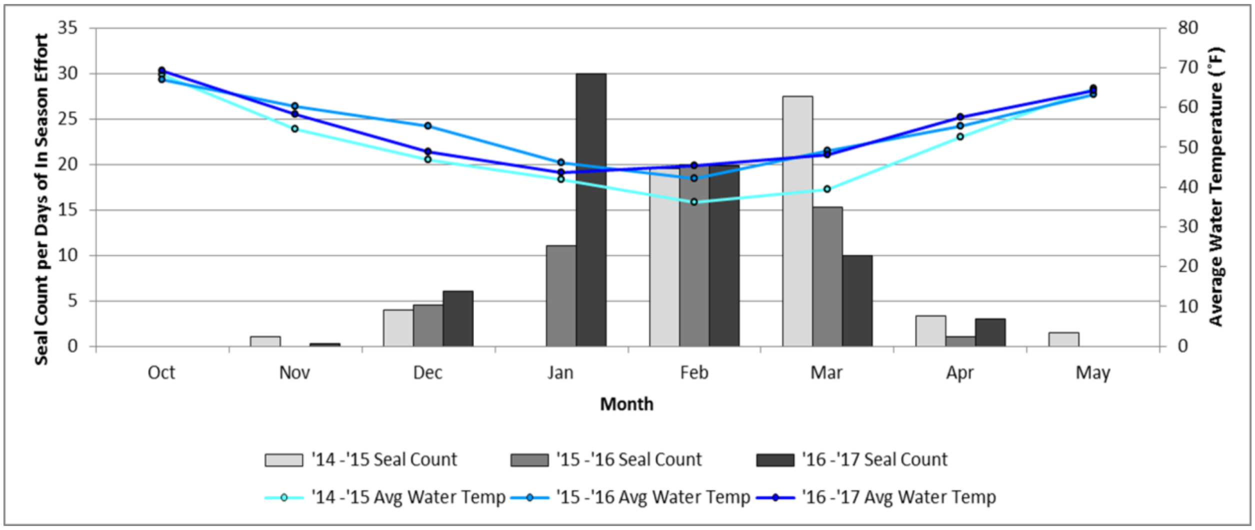

Figure 33. Seal counts per day of effort and average water temperature along the Eastern Shore haul-out area.

Table 22. Seasonal survey effort, total seal count (best estimate), max 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	Total Seal Count	Average Seal Count	Max Seal Count
2014-2015	11	113	10	33
2015-2016	14	186	13	39
2016-2017	22	307	14	40

Based on initial data exploration of "in-season" seal count for the three CBBT field seasons, several environmental variables (e.g., tidal height and wind speed) showed a noticeable relationship with seal count (from CBBT 3), but the strongest relationship was with water temperature (r= -0.59), which appears to account for a 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 33**), and seemed to coincide with some of the lowest recorded water temperatures. As water temperatures rose above 55°F, counts decreased.

Photo-ID conducted via visual matching for the first two field seasons has shown that individual harbor seals (6 out of 52 uniquely identified seals) sighted at the CBBT have been resighted both within a season 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 sites were also observed at the Eastern Shore site during multiple surveys. Images collected during the 2016–2017 field season for both the CBBT and Eastern Shore sites are currently being analyzed.

For the Eastern Shore site, 8 survey days were completed from November 2016 to April 2017. A total of 102 harbor seals were sighted. Seals were observed on 6 of the 8 (75%) survey days. Highest counts were recorded in February and March, however, seal counts were not conducted in January, and so this result may be biased. The average seal count (number of seals observed per "in season" survey day) for the Eastern Shore site was 17 seals and the maximum count for a single survey was 48 seals. We were able to coordinate counts for 6 of the 8 survey days; counts were first conducted at the CBBT haul-out sites and then the Eastern Shore site. The maximum count for a coordinated survey day was 50 seals.

Haul-out counts and photo-ID data collection have continued for the 2017–2018 field season at both the CBBT and Eastern Shore survey sites. More detail on the 2017–2018 field season will be provided in the 2017–2018 progress report.

Planning for a proof-of-concept tagging effort began during the 2016–2017 field season. The goal is to capture, tag, and release healthy harbor seals at the Eastern Shore survey site during the 2017-2018 field season. The tagging team will attempt to deploy up to 10 satellite telemetry tags and 5 acoustic transmitter tags. Researchers will attach the tags using methods consistent with similar projects conducted on this species, and in accordance with all stipulations of NMFS permit # 17670. Data collected from tags will contribute to understanding regional seal movement patterns, identifying when seals migrate in and out of the region, and documenting where they migrate to in the spring and summer. Increased knowledge of the movements, habitat utilization, and seasonality of seals found in the lower Chesapeake Bay and Virginia coastal waters will allow the Navy to limit interactions with these protected species, design better mitigation measures where interactions are unavoidable and obtain the appropriate authorizations to maintain environmental compliance.

For more information on the Lower Chesapeake Bay seal haul-out study, visit the project profile page here: https://www.navymarinespeciesmonitoring.us/reading-room/project-profiles/haul-out-counts-and-photo-identification-pinnipeds-lower-chesapeake-bay/

For more information on the seal tagging and tracking pilot project, visit the project profile page here: https://www.navymarinespeciesmonitoring.us/reading-room/project-profiles/seal-tagging-and-tracking-southeavirginia/

2.1.3.2 Narragansett Bay Study

Narragansett Bay is a well-known winter feeding ground for harbor seals, occupied roughly from late September until early May (Raposa and Dapp 2009; Schroeder 2000). The haulout studied in this project is on a rock outcrop known as “The Sisters” located near Coddington Point on Naval Station Newport (**Figure 34**). A series of systematic shore-based observations of all seal species, as well as weather and environmental conditions were conducted at the haulout. The numbers of seals hauled-out and in the water were recorded during each count throughout the season. Photographs of seals also were collected between counts for mark recapture analysis. This haulout has been studied by the Naval Undersea Warfare Center Division Newport since 2011 (**Table 23**). While completely submerged at high tide, the rocks can provide space for more than 40 seals to haul out at low tide.

The overall goal of this project was to gain an understanding of seal movement and behavior, develop a photo-ID protocol, and assess how environmental conditions may affect haulout usage. Relationships developed between environmental parameters and seal haulout may enable correction of static haulout counts to account for environmental conditions. Monitoring the Naval Station Newport site has provided insight on trends in seasonal movements, site fidelity, and relative abundance. By establishing a record of seal presence and abundance, we have furthered our understanding of the general ecology of the population in Narragansett Bay.

Figure 34. Location of the haul-out site in Narragansett Bay near Naval Station Newport.

Table 23. Summary of seal observations near Naval Station Newport.

Season	Months of observed presence	Number of observation days	Total number observed	% of days seals were observed	Maximum number hauled out	Average number hauled out
2010 – 2011	Dec-Mar	37	256	51%	26 (18 Feb 2011)	13
2013 – 2014	Jan-Mar	10	123	60%	29 (4 March 2014)	20
2014 – 2015	Dec- May	44	693	82%	44 (16 April 2015)	15
2015 – 2016	Nov – Apr	29	573	90%	49 (17 March 2016)	22
2016 – 2017	Nov –Apr	30	624	93%	45 (9 April 2017)	22

In 2015, preliminary photo-ID was conducted with WILD-ID analysis software (Bolger et al. 2012). The results confirm the presence of matches within the photo database, indicating some degree of site fidelity. This was confirmed with visual matching of photographs. In 2016, the ExtractCompare software (Hiby 2015) package was found to be a better program to better estimate populations, while also answering questions regarding site fidelity and preference. Due to issues with photographic vantage point and pelage symmetry, we extracted pelage patterns only from animals with a visible abdominal region for software comparison. Of the 624 photographed animals during this season, 159 (25%) suitable abdomens were extracted, and 87 (54%) matches were detected. 27 unique animals were identified, with 14 animals sighted more than 3 times, up to a maximum number of re-sightings for an individual at 8. Given the ratio of animals for which a successful abdomen capture is possible, this is an indication of substantial site fidelity among some animals using this haulout. A simple Lincoln-Peterson population model was fitted based on the mark-recapture results, and yields an estimate of between 200-300 animals using this haulout over the course of the season.

Photographic capture-recapture analysis has been used successfully with other similar marine mammal species (Bolger 2012; Hiby et al. 2007; Paterson et al. 2013), but with only limited success on harbor seals (e.g., McCormack 2015). Photo-ID methods could eventually lead to a better understanding of the movement of these animals within and between haulout sites. Maintaining this type of long-term dataset enhances the Navy's ability to understand how this population may respond to changes in climate and other anthropogenic disturbances.

In 2017, we studied the relationship between seal presence and environmental parameters which provides understanding of how the changing seal population may affect haulout usage under varied environmental conditions, and how changing weather and climate patterns may affect the population in the future. We also used environmental data to build a "hurdle" type zero-inflated modeling framework, with the goal of understanding how environmental parameters impact seal haulout usage. The model exhibited a very strong fit with the observed data (R^2=0.76), and suggests that the most important parameters influencing haulout usage are air temperature, wind speed and direction, water temperature, tidal stage, and time of day. The model also suggests a substantial increase in the local seal population over the duration of the study, independent of weather factors (**Figure 35**).

For more information on this study, refer to the 2016–2017 annual report for this project (Moll et al. 2017).

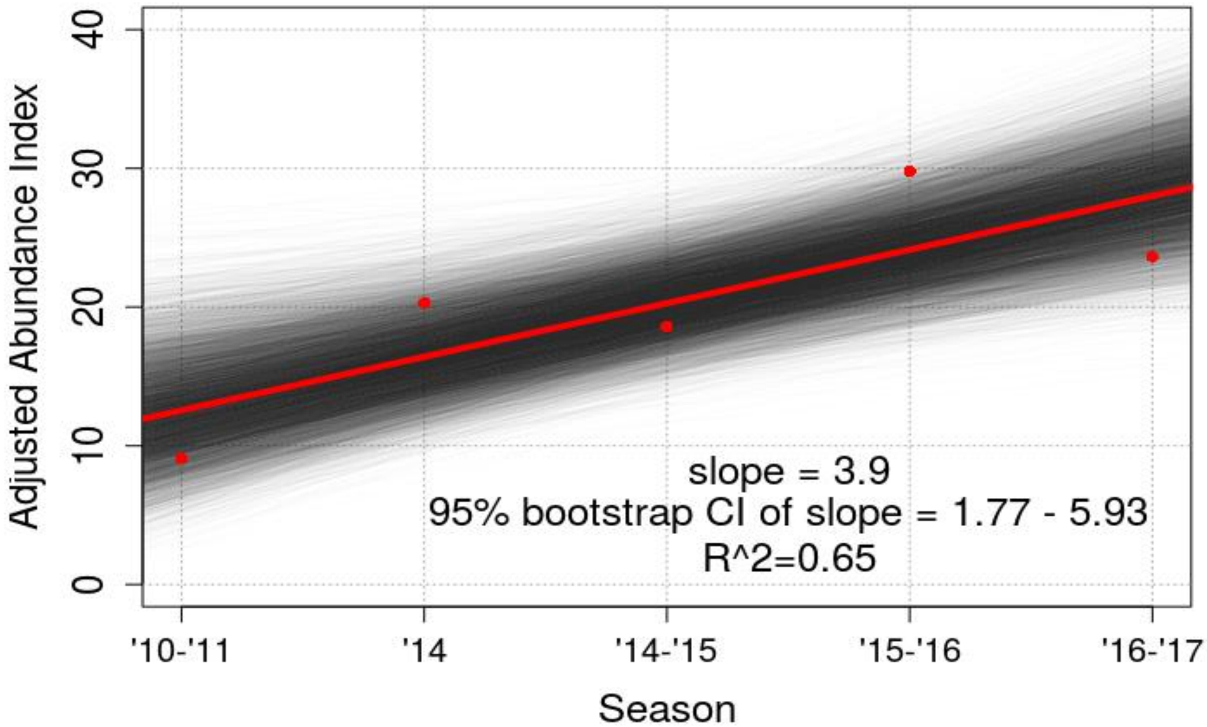

Figure 35. Model results for environmentally adjusted abundance index created by standardizing environmental parameters to remove the impact of yearly environmental variation on seal population. Red points are actual observed data, red line is best fit model, black lines are 95% confindence interval obtained through bootstrap analysis.

2.1.4 Mid-Atlantic Humpback Whale Catalog

Humpback whales are the most common mysticete in the nearshore waters off the coast of Virginia (Mallette et al. 2017b). 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, Barco et al. 2002, Mallette et al. 2016). 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 two 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), an expanding collection of photographs of 329 unique whales.

The development of the MAHWC is currently in year two of the anticipated three-year project (see Mallette and Barco 2017 for details from the first year of effort). VAQF is currently developing a collaborative, integrative platform for the MAHWC that provides a broad-scale and high-quality scientific product that can elucidate 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 marine species monitoring 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 U.S. 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. In June 2017, in Virginia Beach, Virginia, a stakeholder workshop took place, at which data-access protocols were developed, standardized protocols for data/image submission and quality assurance for the MAHWC were established, and the workflow for submission of images/sighting data between the MAHWC, larger regional catalogs, and contributors was agreed upon. Additionally, a draft web interface/database design modeled after that of the Mid-Atlantic Bottlenose Dolphin Catalog (MABDC) was developed for stakeholders to review and offer their feedback. A Stakeholder Workshop Report (Mallette et al. 2017a) summarizing the outcomes from this meeting can be accessed for further details.

The MAHWC will be hosted on the Ocean Biogeographic Information System-Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP; Halpin et al. 2009) a web-based biogeographic database of multi-platform survey data 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., MABDC, Pacific Islands Photo-Identification Network and provides a user-friendly interface that provides efficient tools for comparison of collections. 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 are being developed based upon existing examples and input from the core stakeholder group. Additionally, standardized data fields and database structure of the MAHWC are being 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 following 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 2017 seasons submitted by VAQF Research, HDR, Inc., VAQ 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 2017, the catalog included 329 unique whales. All humpback whales in the current MAHWC from 1989 through 2016 have been compared to the North Atlantic Humpback Whale Catalog (NAHWC), managed by Allied Whale (Bar Harbor, Maine). Virginia images from 2017 are at various stages of comparison with both the NAHWC and Gulf of Maine catalog, managed by the Center for Coastal Studies (Provincetown, Massachusetts). At the end of each season, the best images (including mid-Atlantic contributors) of all new whales added to the MAHWC are sent in batch to the Center for Coastal Studies and Allied Whale for inclusion and comparison with their catalogs.

Standardized protocols are being 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 are being tailored to those whales in the MAHWC. Fluke code categories have been modified 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 36**.

Dorsal fin, peduncle knuckle, and body scarring categories are also useful features to code, especially in the mid-Atlantic and southeastern regions where whales are often in shallow water and may not raise flukes above water on a dive as often as farther north. A protocol for systematically scoring humpback whale images (based on NAHWC methods) has been drafted and is being tested. The final methods will be integrated into the curator package that will be completed in year three of the project. A collection of reference images for each category of fluke and dorsal fin have been compiled to be validated by Center for Coastal Studies and Allied Whale curators. This includes “Type” feature codes with text descriptions and will also include an example image for contributors to reference when selecting a category to search for matching.

Future work planned for 2018 includes continued coordination with Duke University to implement modifications and improvements to the web-based catalog and photo-ID application as a result of feedback from the core collaborators and other contributors. The integration of test images and data into the photo-ID application will occur alongside the systematic inclusion of image submissions from Virginia sightings into the main MAHWC. VAQF will also continue to obtain feedback from stakeholders, as well as solicit contributions to the catalog from other mid-Atlantic and southeastern groups.

For more information on this study, refer to the annual progress report for this project (Mallette et al. 2018).

Fluke

	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 36. The five 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 (**Section 2.2.1**), baleen whales (**Sections 2.2.2 through 2.2.3**), and sea turtles (**Section 2.2.5**) in support of AFTT monitoring requirements.

2.2.1 Tagging of Deep-Diving Odontocete Cetaceans

Tagging activities were conducted off the coast of Cape Hatteras in 2017, building 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 fourth 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 odontocete cetaceans with satellite tags and digital acoustic tags (DTAGs), respectively. Tagging of odontocete cetaceans 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. 2017). 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 three years of field effort (Baird et al. 2015, 2016, 2017; Foley et al. 2015; Thorne et al. 2017).

During May, August, and September 2017, the fourth year of field effort was completed in support of the Atlantic Behavioral Response Study (BRS) (**Section 2.3,** Southall et al. 2018), a collaborative effort between Duke University, Southall Environmental Associates, the University of St. Andrews, and CRC—a Controlled Exposure Experiment study of cetacean reactions to military sonar. In particular, this study focuses on two primary species, Cuvier's beaked whale and short-finned pilot whales. Satellite tags were deployed on both species in May, August, and September, prior to scheduled controlled exposure experiments. Given the CEEs and their potential influence on small-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 small-scale movements and diving behavior in relation to the CEEs is summarized in Section 2.3.

CRC researchers deployed 26 SPLASH10 tags (produced by 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 24**) – 14 on Cuvier's beaked whales and 12 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.

Table 24. Summary of satellite tag deployments in the Cape Hatteras study area in 2017.

Species[1]/Tag ID	Sex/age class	Deployment Date	Depth at tagging location (m)	Tag Duration (days)	Deployment Latitude (°N)	Deployment Longitude (°W)
GmTag172	Adult Female	5/10/2017	1,488	32.61	35.54	74.73
GmTag173	Adult Male	5/11/2017	223	23.93	35.72	74.83
GmTag174	Adult Male	5/11/2017	234	31.50	35.72	74.83
GmTag175	Adult Male	5/16/2017	1,657	25.69	35.65	74.69
GmTag176	Adult Male	5/16/2017	1,724	14.33	35.64	74.69
GmTag177	Adult Female	5/17/2017	1,103	28.29	35.80	74.78
GmTag178	Sub-adult Male	5/17/2017	624	18.75	35.70	74.79
GmTag179	Adult Male	5/17/2017	578	0.37	35.70	74.80
GmTag180	Adult Male	5/17/2017	539	32.68	35.70	74.80
GmTag181*	Adult Male	8/20/2017	775	30.94	35.58	74.77
GmTag182*	Adult Male	8/20/2017	822	29.49	35.56	74.77
GmTag183	Adult Male	8/20/2017	1,522	32.29	35.60	74.72
ZcTag054	Adult Male	5/10/2017	1,500	18.12	35.58	74.71
ZcTag055	Adult Male	5/10/2017	1,546	52.89	35.57	74.71
ZcTag056	Adult Male	5/10/2017	1,705	47.87	35.53	74.70
ZcTag057	Adult Unknown	5/16/2017	1,737	49.35	35.64	74.70
ZcTag058	Sub-adult Unknown	5/16/2017	1,514	39.11	35.58	74.71
ZcTag060*	Adult Male	8/17/2017	1,058	34.67	35.59	74.76
ZcTag061*	Adult Unknown	8/17/2017	1,425	44.44	35.61	74.73
ZcTag062*	Adult Unknown	8/17/2017	1,631	12.16	35.64	74.71
ZcTag063*	Adult Male	8/20/2017	1,566	30.68	35.54	74.72
ZcTag064*	Sub-adult Unknown	8/20/2017	1,599	49.63	35.53	74.71
ZcTag065*	Adult Male	8/22/2017	546	12.78	35.53	74.79
ZcTag066*	Sub-adult Male	9/4/2017	1,210	38.38	35.59	74.75
ZcTag067*	Adult Male	9/4/2017	1,449	42.31	35.60	74.73
ZcTag068*	Adult Male	9/4/2017	1,085	39.98	35.58	74.75

[1] Gm = *Globicephala macrorhynchus* (short-finned pilot whale), Zc = *Ziphius cavirostris* (Cuvier's beaked whale), *Individuals that were subjects of the controlled exposure experiments; m=meter(s)

Tags deployed on both species were set to transmit every day, 21 hours per day for Cuvier's beaked whales and 17 hours 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 2017 field effort, the thresholds were defined as: Cuvier's beaked whale – 150 m and 33 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.

Of the 26 tags deployed, 1 tag was lost during a deployment attempt. Of the 14 tags deployed on Cuvier's beaked whales, 12 were deployed in the dorsal fin or at the base of the dorsal fin, and 2 were deployed below the base of the fin. Tag attachment duration (based on the time of the last locations received) ranged from 12.1 to 52.9 days, with the median attachment duration (39.5 days) exceeding the expected battery life (37 days). Of the 12 tags deployed on short-finned pilot whales, all were deployed on the fin or at the base of the fin. One tag (GmTag179) transmitted for less than 1 day, but the others transmitted from 14.3 to 32.6 days, with the median (28.9 days) exceeding the expected battery life (25 days).

Movement patterns of the Cuvier's beaked whales varied, with 11 of the 14 individuals remaining within 100 km of the tagging location. Most of the tagged individuals remained in small areas on the continental slope near the tagging locations, with only occasional movements off the slope (**Figure 37**). Three individuals (ZcTag057, ZcTag066, and ZcTag067) showed a greater range of movements than those previously documented. One individual moved as far as 260 km offshore (ZcTag057), one moved 288 km to the south of the tagging location (to off the coast of the North Carolina/South Carolina border) along the shelf break (ZcTag066), and one moved 236 km north of the tagging location (to off the coast of Maryland) along the shelf break (ZcTag067). Both ZcTag066 and ZcTag067 were subjects of a CEE, but the timing of these large-scale movements appeared unrelated to the CEE (i.e., the individuals left the Hatteras area more than two weeks after the CEE). These three individuals extended the known range of individuals tagged off Hatteras to the north, south, and offshore when compared to individuals tagged in previous years. A probability-density distribution from tag data obtained during all four years suggests that the core range for individuals tagged off the coast of Cape Hatteras is relatively small (50 percent core area = 1,682 km^2; **Figure 38**).

Twelve satellite tags were deployed on short-finned pilot whales (**Table 24**). The tags were deployed during 7 different encounters. The pairs of individuals in 2 of these encounters (GmTag173/GmTag174, and GmTag181/GmTag182) acted independently; while those tagged together in other encounters 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 shelf edge and shelf break over the entire duration of tag attachment (GmTag172 through GmTag177), while others had excursions off the shelf (GmTag178 and GmTag180, GmTag182, **Figure 39**). Two individuals tagged on the same day in August 2017 but in different groups (GmTag181, GmTag183) initially spent most of their time seaward of the slope, before moving almost 900 km (GmTag181) and over 750 km (GmTag183) to the south. While the two tracks to the south were generally similar, the two whales moved south independent of each other, with GmTag181 leaving the Hatteras area on 9 September 2017 and GmTag182 leaving the area on 15 September 2017. These individuals moved into an area with a broad slope off northern Florida, overlapping an area where pilot whales that were tagged off JAX, Florida, in 2016 spent considerable time. The timing of movement of these individuals far to the south appeared to be unrelated to the CEEs.

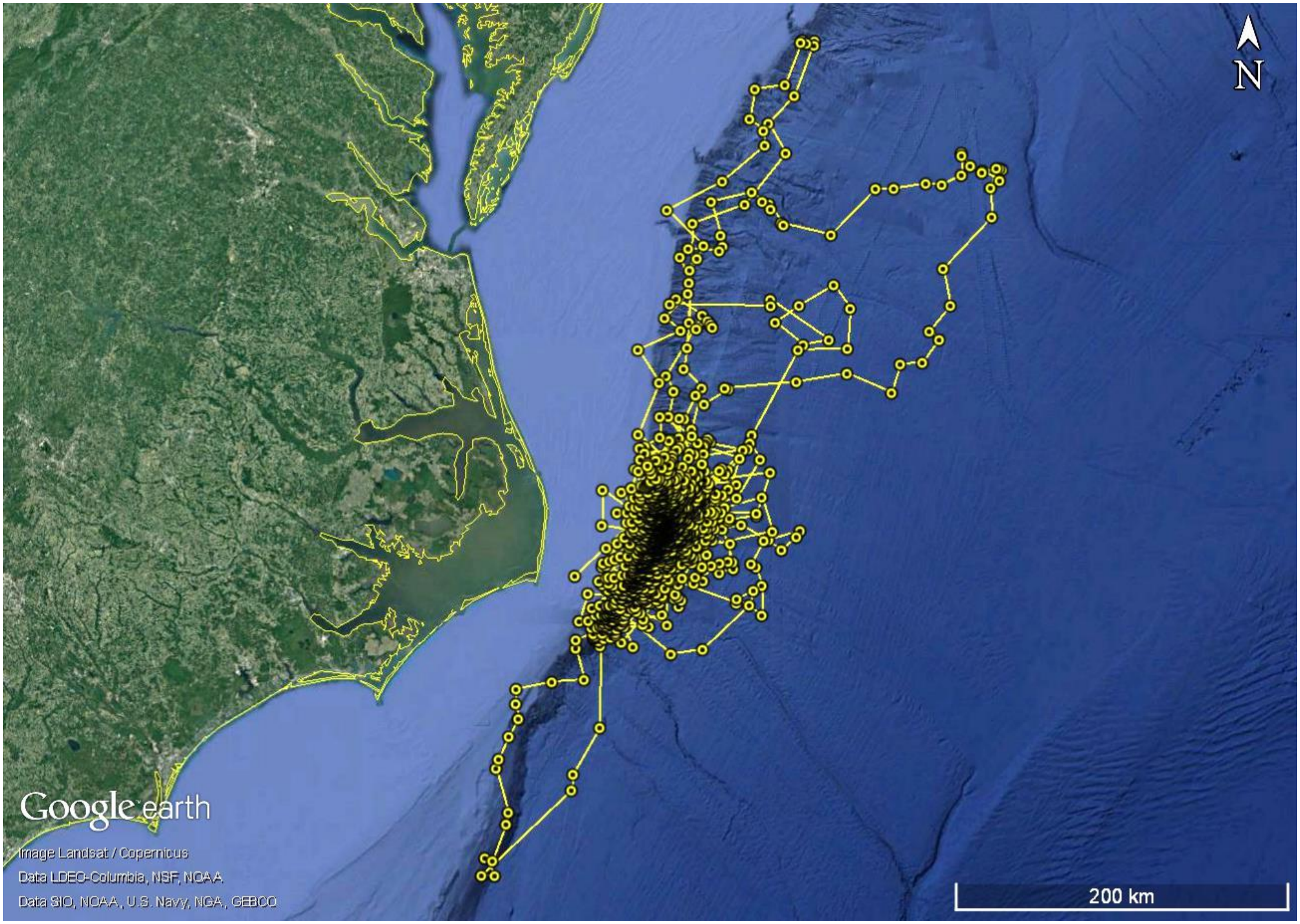

Figure 37. All filtered locations of Cuvier's beaked whales tagged in 2017 (*n*=14), with consecutive locations joined by a line.

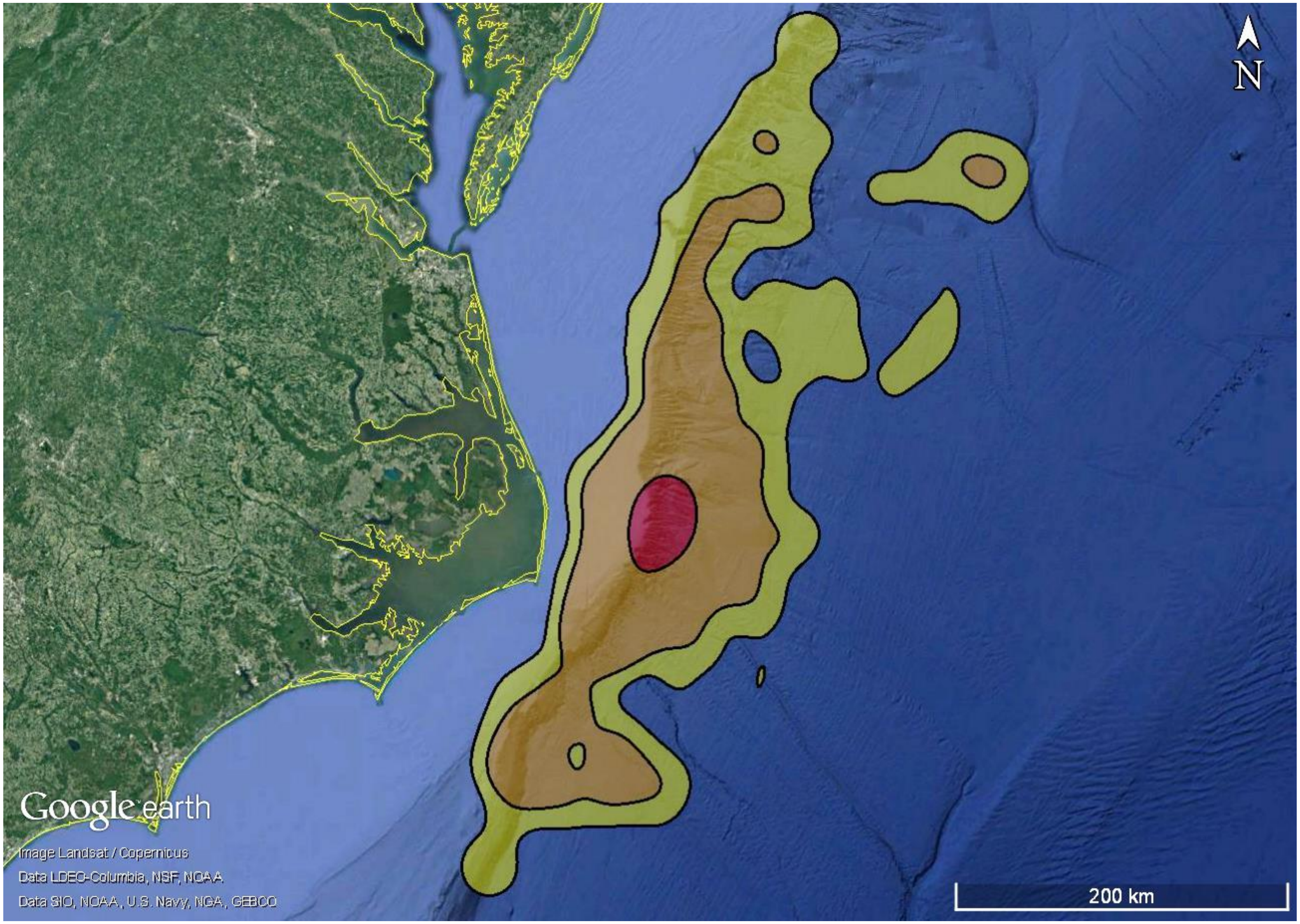

Figure 38. A probability-density representation of Cuvier's beaked whale location data from 29 individuals tagged off North Carolina in 2014 (*n*=3), 2015 (*n*=6), 2016 (*n*=6), and 2017 (*n*=14). The red area indicates the 50 percent density polygon (the "core range"), the orange represents the 95 percent polygon, and the yellow represents the 99 percent polygon.

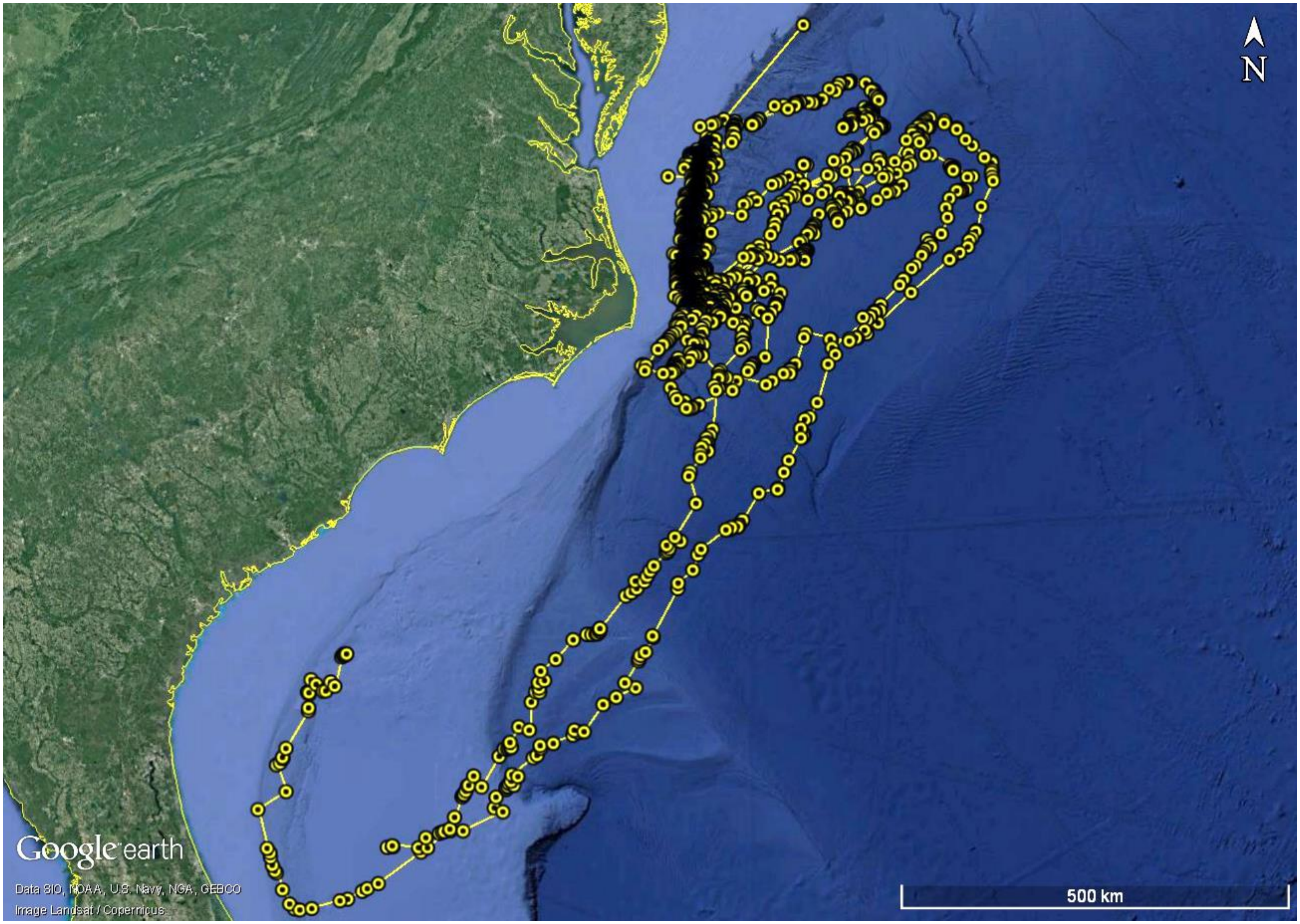

Figure 39. All filtered locations of short-finned pilot whales tagged off North Carolina in 2017, with consecutive locations joined by a line.

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*=5) and 2017 (n=11), as well as individuals tagged off JAX, Florida, in 2016 (*n*=4) is shown in **Figure 39**. While the 99 percent probability-density based on all four years covers a broad area (794,680 km^2), ranging from Florida to New York and in Canadian and international waters, the 50 percent core range of these individuals is small (25,360 km^2; **Figure 40**). This core range is centered off Cape Hatteras, North Carolina and extends up to the Norfolk Canyon, off of 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 east coast of the United States and the preference of this species for slope waters.

With 14 Cuvier's beaked whales satellite tagged in 2017, the sample size of movement data for this species off the U.S. east coast has been effectively doubled. The combined sample of location data now represents 1,150 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 2017 reflects in part the high density of Cuvier's beaked whales off Cape Hatteras (McLellan et al. 2018, in press). The primary factor limiting an even greater number of tag deployments on Cuvier's beaked whales off Cape Hatteras is suitable sea conditions for finding, approaching, and tagging this species.

While most of the tagged Cuvier's beaked whales remained in or near the core area of the animals tagged in previous years, staying near the continental slope off Cape Hatteras, individuals tagged in 2017 extended the known range of this population to the north, to the south, and offshore (**Figure 37**). While these longer-distance movements were all from tags that transmitted for long periods (38 to 49 days), they were similar in attachment durations (40 to 53 days) to individuals that remained closely associated with the core area off Cape Hatteras (e.g., ZcTag055, ZcTag064, ZcTag068), so they reflect variability in movement patterns more so than the influence of attachment duration.

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 39**). Importantly, in 2017 individual movements far to the south of Cape Hatteras, to an area off northern Florida where pilot whales tagged off Jacksonville in 2016 spent considerable time (Foley et al. 2017b), were also documented (**Figure 39**). 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 37 and 40**). 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. 2018).

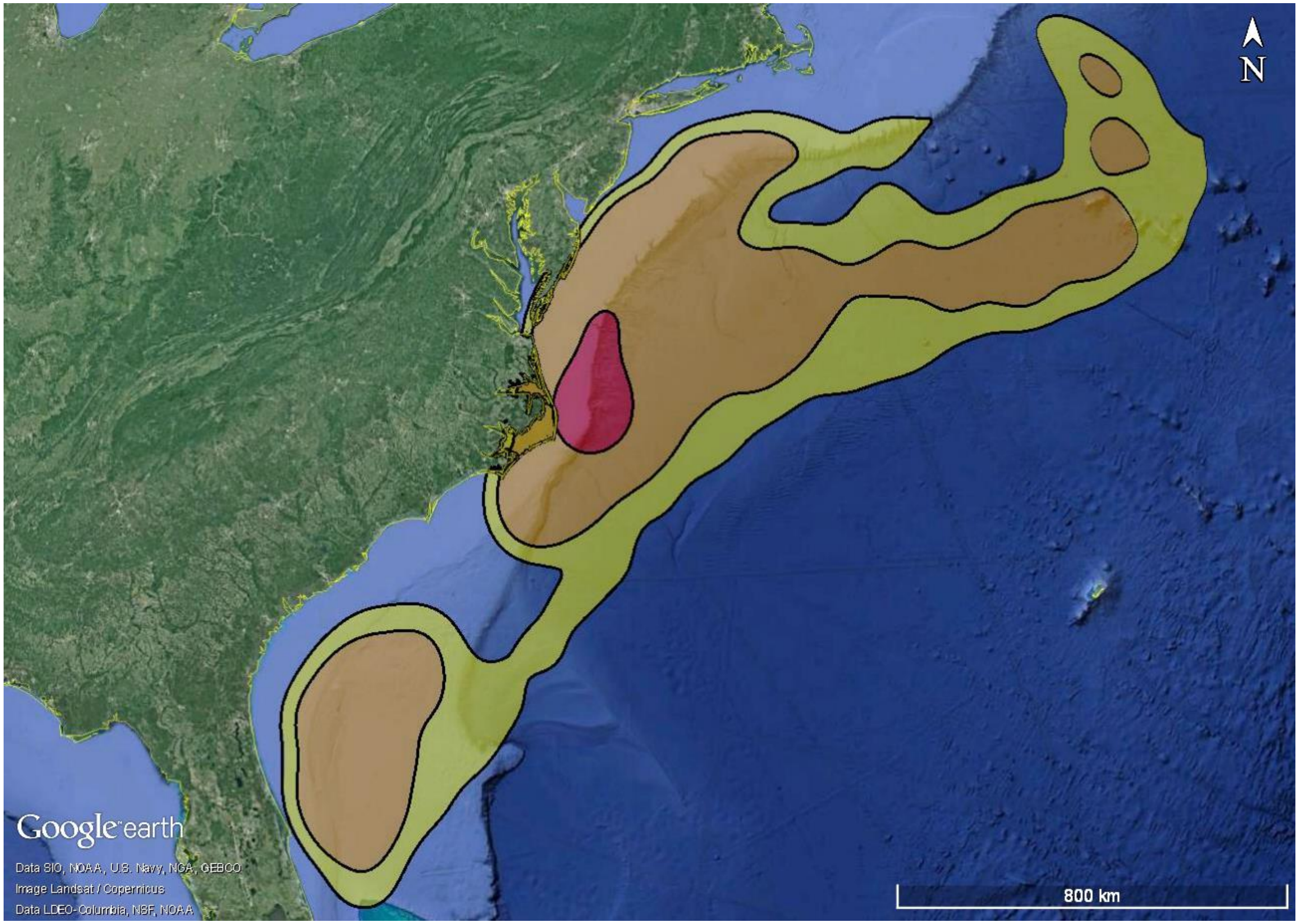

Figure 40. A probability density representation of short-finned pilot whale location data from 56 individuals tagged off North Carolina in 2014 (*n*=17), 2015 (*n*=19), 2016 (*n*=9), and 2017 (*n*=11), as well as Jacksonville, Florida, in 2016 (*n*=4). The red area indicates the 50 percent density polygon (the "core range"), the orange represents the 95 percent polygon, and the yellow represents the 99 percent polygon. Only tag attachment durations of >1 day are included.

2.2.2 North Atlantic Right Whale Tagging

North Atlantic right whales 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 right whales in the coastal waters of Florida and Georgia, as well as in offshore areas near the planned USWTR.

Currently there are few 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 right whales 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 right whales 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, with a fifth field season completed in February 2018. In February 2014, weather conditions were suitable for tagging operations on 11 days, and right whales were located on nine of those days (Nowacek et al. 2015). DTAGs were successfully deployed on right whales on seven occasions. Individual whales showed variation in movement patterns along the coastline. Only one tag was successfully deployed on a single right whale during eight days of field effort in 2015 because of a low number of animals being present on the winter grounds (Nowacek et al. 2016). 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. In 2016, 11 days of field effort were conducted, right whales were encountered on 10 days, and 7 DTAGs were deployed. This project update focuses on the efforts from the 2017 field season (Nowacek et al. 2017).

2.2.2.1 *Right Whale Sightings and Tagging*

The 2017 field efforts for this project took place during February 2017. Weather conditions were suitable for tagging operations (i.e., BSS forecast of BSS ≤3) on 6 days during this time. During these 6 days, approximately 594 km were surveyed during 30.4 hours of effort on the (R/V) *Richard T. Barber* (**Table 25, Figure 41**).

In addition to the six days focused solely on inshore North Atlantic right whale tagging, the small vessel also surveyed farther offshore on 14 and 17 February in an attempt to locate right whales that may be utilizing offshore habitats, as well as conducting broader surveys supporting Atlantic Fleet Testing and Training monitoring (**Figure 41**). The field team was 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.

Table 25. Summary of 2017 field effort conducted on the vessel (R/V) *R.T. Barber*.

Date	BSS	Survey Time (hh:mm)	At Sea Time (hh:mm)	Distance Surveyed (km)
02-Feb-17	0–2	5:52	6:22	160.90
03-Feb-17	1–4	5:11	6:05	107.34
06-Feb-17	2	6:17	6:58	124.90
07-Feb-17	3–4	3:12	4:00	22.10
08-Feb-17	2–3	3:10	6:00	68.50
12-Feb-17	2–4	6:39	7:30	110.00
14-Feb-17	2–4	4:00	10:18	81.60
17-Feb-17	2–4	4:51	9:34	126.10

* cruise with successful tag deployment and/or tracking. Key: BSS = Beaufort sea state; R/V = Research Vessel

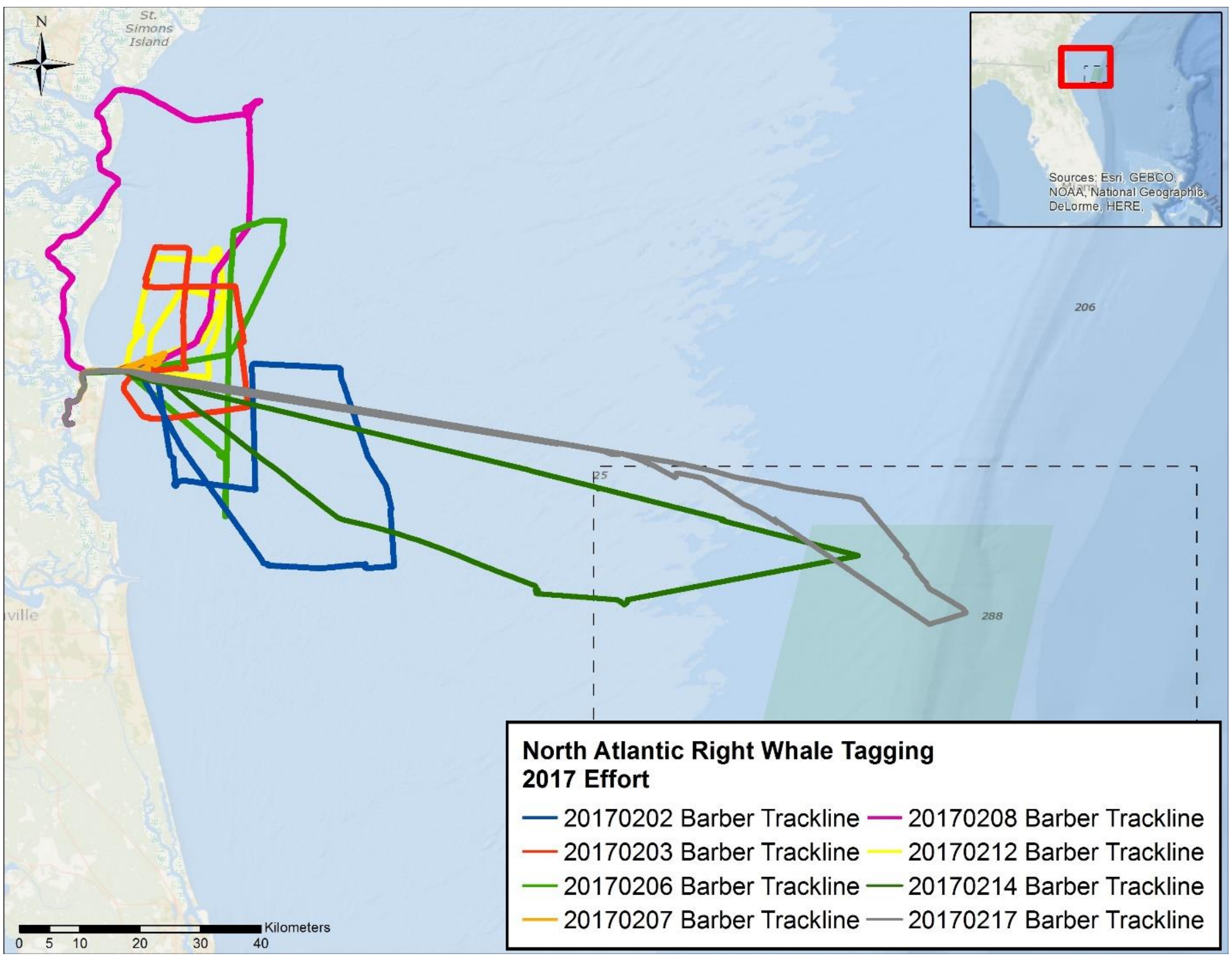

Figure 41. Map of search effort by the tagging vessel (colored lines) for each survey day in February 2017.

There were 2 separate sightings of a single right whale mother-calf pair (EGNO 2614, a 21-year-old female and calf) (NEAq 2017) in February 2017 (**Table 26**). This female and her calf were the only right whale mother-calf pair sighted on the calving grounds (3 sightings reported over 2 days 07-Feb and 08-Feb), with a total of only 5 calves born in the season (Pettis et al. 2017). Overall, only 7 whales, including 3 mother-calf pairs, were observed in the southeastern U.S. from 1 December 2016 to 1 March 2017. Right whale sightings on their wintering grounds were significantly lower in 2017 than historic levels (S.D. Kraus, New England Aquarium, pers. comm.).

Table 26. North Atlantic right whale sightings during February 2017.

Date	Latitude (°N)	Longitude (°W)	Group Size	Whale ID	Tag ID
07-Feb-17	30.70589	81.36832	2	2614+calf	Eg17_038a (deployment)
08-Feb-17	30.20559	81.20559	2	2614+calf	Eg17_038a (recovery)

During 2017, a primary objective was to obtain longer duration tag attachments. Non-invasive suction cup DTAGs (anticipated tag duration 1 to 36 hr) include Fastloc® Global Positioning System (GPS) technology, time-depth recorders, three-dimensional movement measurement, and acoustic recording capability. On 7 February, a Version 2 DTAG was deployed on right whale individual #2614 (**Table 26, Figure 42**). The tag was programmed for a 24-hour attachment, but was shed from the animal early, and recovered at 12:02 local time on 8 February. The tag is currently at the Woods Hole Oceanographic Institute in an attempt to retrieve data therefrom, of which previous attempts have not been successful. A Fastloc® GPS unit was mounted to the DTAG housing and tracked the whale's location through the first hours of the deployment (**Figure 43**). However, as Fastloc receptions ceased approximately 2.5 hr after deployment, it is assumed that the tag slid on the animal to a position below the water line, and as such, additional positions were not successfully received.

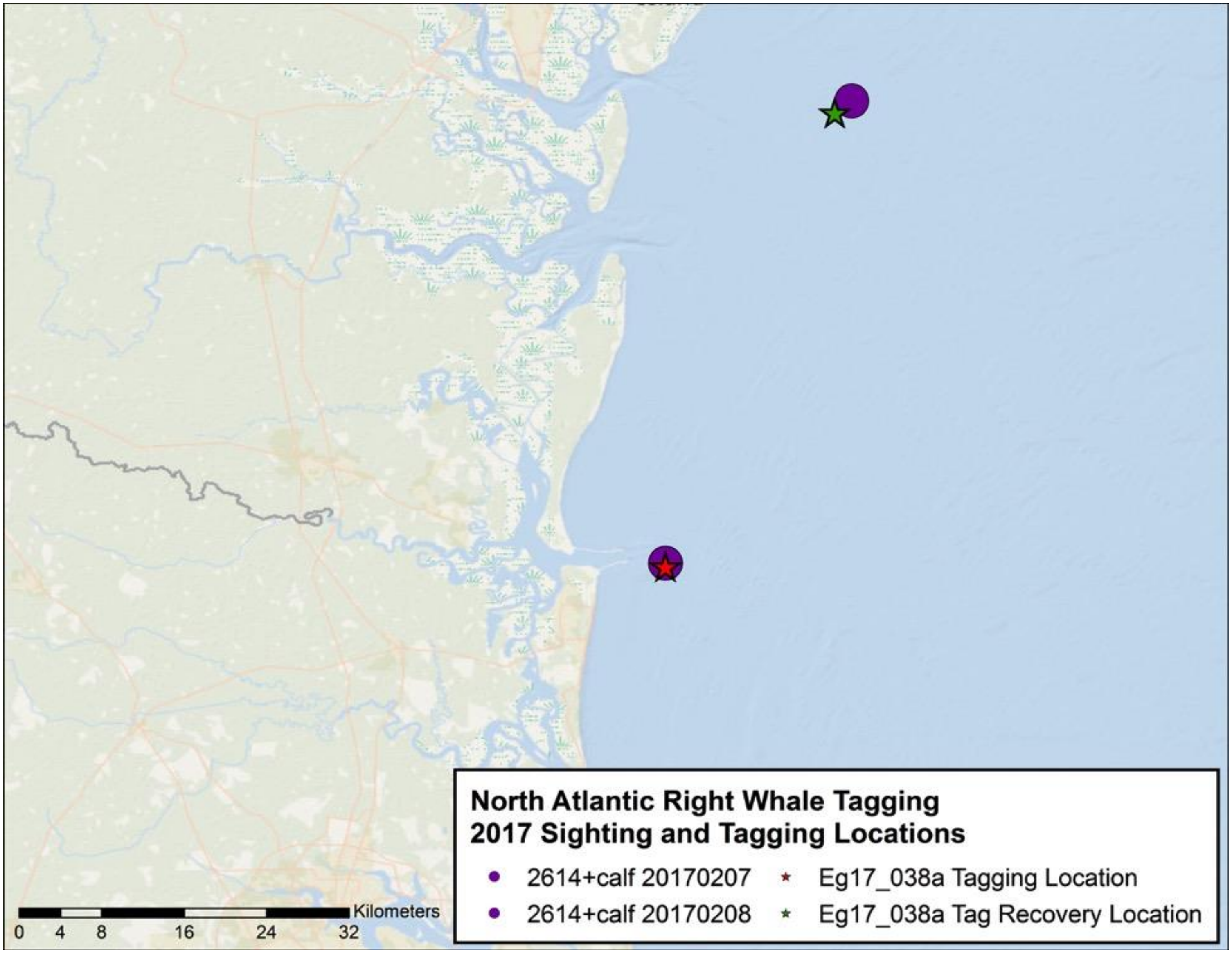

Figure 42. North Atlantic right whale sighting locations (circles), and DTAG deployment and recovery locations (red and green stars) during tagging operations in February 2017.

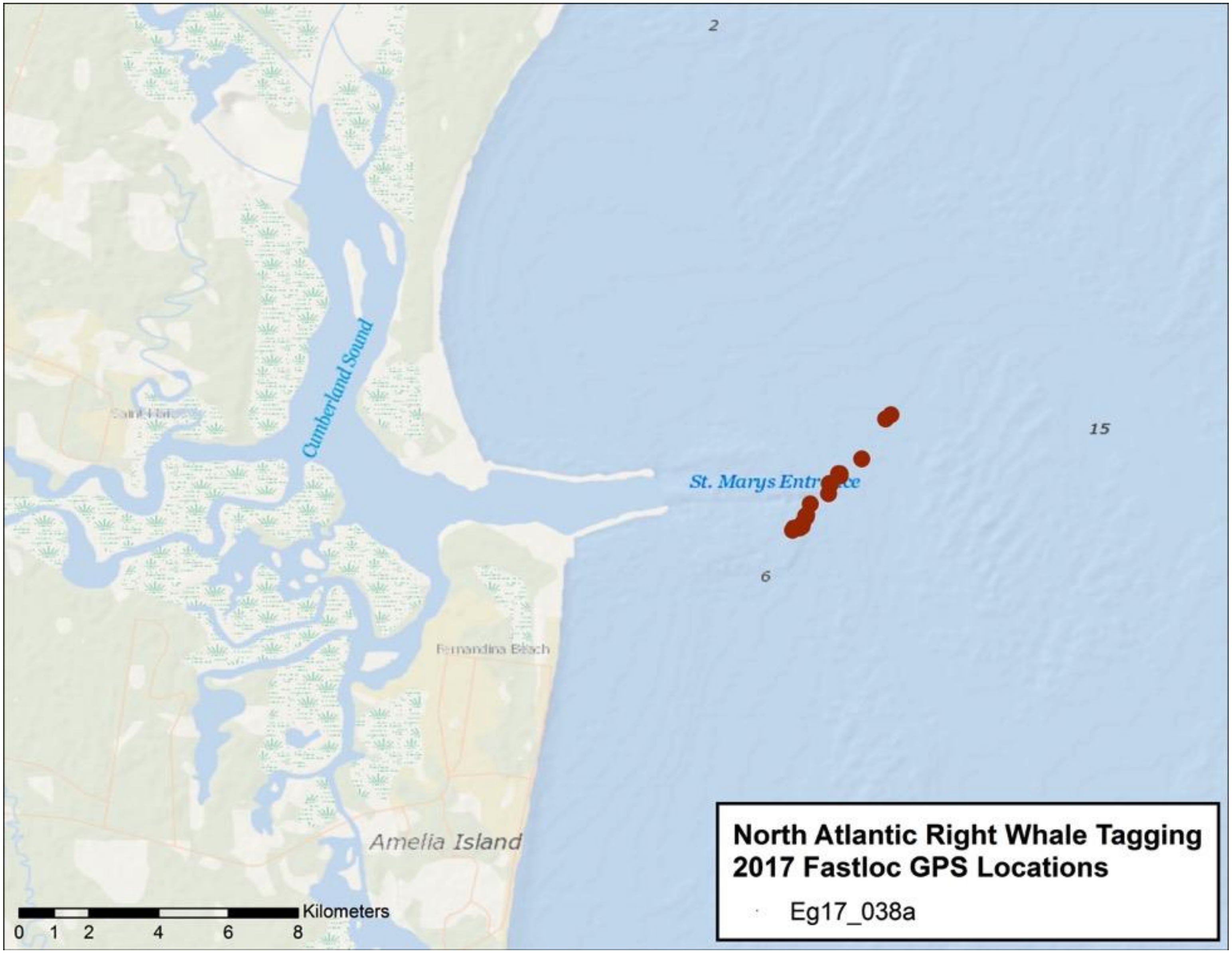

Figure 43. Fastloc GPS positions for tagged North Atlantic right whale Eg17_038a.

2.2.2.2 *DTAG Data Analyses*

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." In 2017, analyses focused on synthesis of acoustic data from all DTAG deployments from 2014 to 2016 (**Table 27**). Overall, approximately 85 hr of acoustic data have been recorded from right whales on the calving grounds. The upcall is the primary call used for right whale passive acoustic monitoring (Van Parijs et al. 2009). The upcall production rate for nursing females was extremely low, with only 0.7 upcalls/hr recorded on the tags (range 0–4.5/hr). The call rate for the pregnant female (EGNO 3101 in 2016) was much higher. This same whale was tagged while nursing about three weeks later, for a comparable tagging duration, and the upcall production rate dropped to 0. These detailed analyses have identified novel, previously undescribed call types, produced by right whale 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 2018 to publish these findings.

Table 27. Summary of acoustic tag data from 12 DTAGs deployed on 11 lactating and one pregnant female right whales as part of this study from 2014 to 2016 with detected upcalls from each tag and a calculated call rate per hour.

Date	Whale ID (EGNO)	Acoustic Record Duration (hh:mm)	Status	Up-calls Detected (Including Calls from Other Whales)	Calls Per Hour of Tag Recording
09-Feb-14	2123	1:33	Nursing	7	4.5
10-Feb-14	2040	5:49	Nursing	3	0.5
18-Feb-14	3157	11:36	Nursing	0	0
25-Feb-14	2645	5:34	Nursing	0	0
21-Feb-15	3292	23:05	Nursing	0	0
25-Jan-16	3101	4:59	Pregnant	45	9.0
30-Jan-16	3405	4:44	Nursing	0	0
31-Jan-16	1281	6:26	Nursing	0	0
01-Feb-16	1810	1:44	Nursing	0	0
17-Feb-16	3101	4:56	Nursing	0	0
17-Feb-16	1281	2:49	Nursing	3	1.06
22-Feb-16	3317	11:47	Nursing	0	0

Dive analyses of the existing DTAG data focused on summarizing the depth distribution (**Figure 44**) to quantify the percentage of time in which whales are detectable for visual vessel-based and aerial surveys in their calving habitat in the southeastern U.S. Tagging operations conducted during January–March of 2006 and 2014–2016 contributed to these analyses, and 15 tag deployments have been included. Thresholds for availability for visual surveys were determined based on water transparency estimated from surface chlorophyll data (NASA 2015). At the surface (depth ≤ 0.5 m), whales would be available to be detected by vessel and aerial surveys; between 0.6 and 2.5 m, whales would be available only for aerial surveys whereas at depths greater than 2.6 m, whales would be unavailable to be detected by either type of visual survey. To account for possible differences in the diving behavior, time spent at each depth bin was compared among 3 categories - juvenile - whales ≥ 1 and <9 years old; pregnant - adults previously unaccompanied that were subsequently sighted accompanied by a young calf <1 year old; nursing - adults accompanied by a calf <1 year old.).

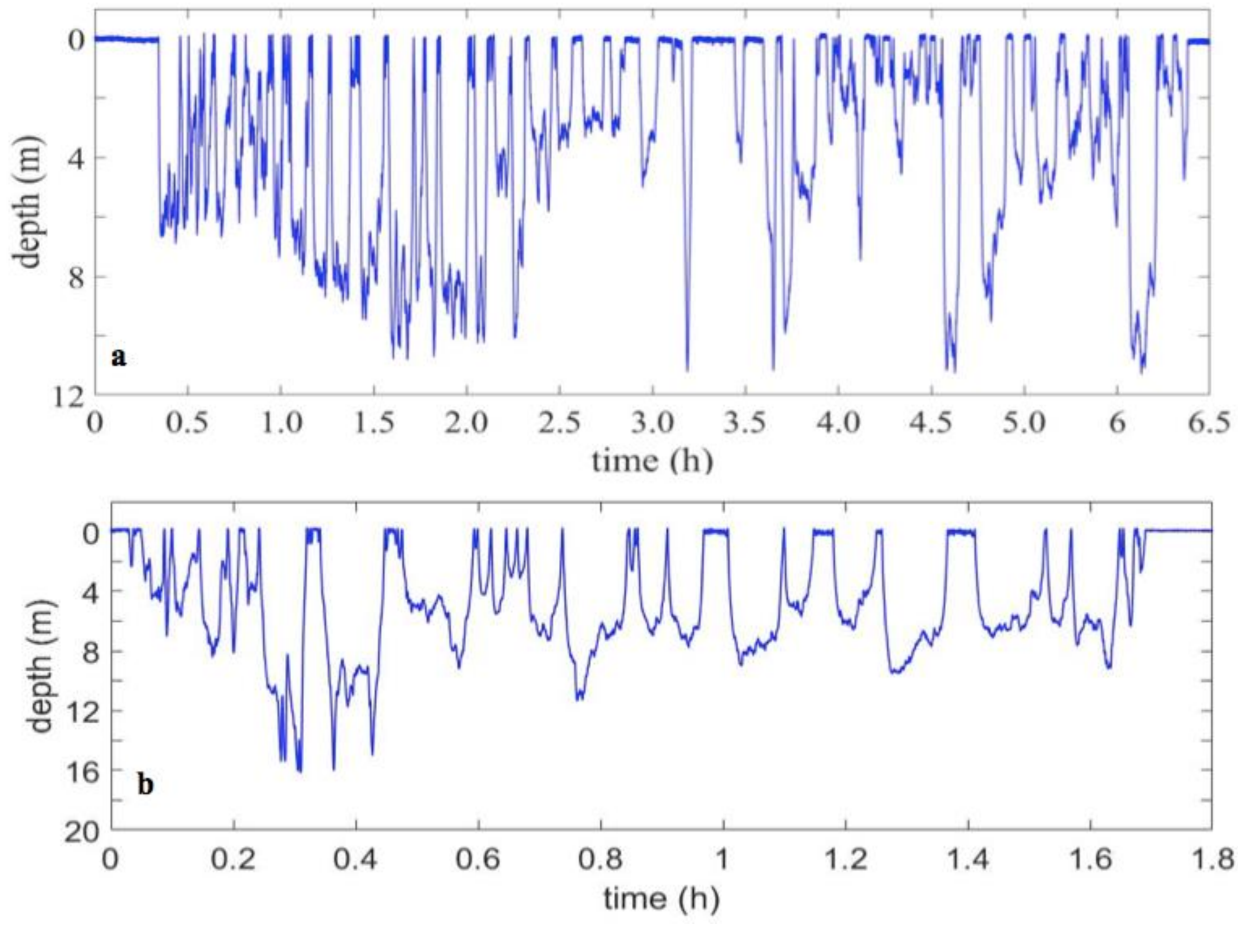

Figure 44. Dive profile of (a) a nursing female, Eg14_056a; (b) juvenile Eg06_024a.

Overall, tagged whales spent an average of 59.1 percent (+/-16 percent) of the time in depths greater than 2.6 m where they cannot be detected by either visual survey method. Juveniles spent more time unavailable for all visual surveys than other age classes. Spending more time at depths greater than 2.5 m would benefit travelling animals because of reduced drag. Pregnant females spent less time available for aerial surveys only than other age/sex classes. Variable buoyancy may affect how much time whales spend at different depth ranges. Nursing females spent more time available only for aerial surveys than other age classes suggesting that the calf's presence limits their time in depths deeper than 2.5 m. 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 2018.

A fifth year of fieldwork was completed in February 2018 with a focus to increase the sample size of tagged individuals, with an emphasis on single animals (not mother-calf pairs) when feasible. The addition of an autonomous glider deployment for acoustic monitoring of right whales is also planned for the mid-Atlantic to assess the distribution of right whales offshore of the Virginia/North Carolina region during the migration period.

For more information on this study, refer to the annual progress report for this project (Nowacek et al. 2018).

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.

Four field seasons of dedicated surveys have been conducted to date. 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 of only 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). Satellite-tagging methods were added during that field season to determine 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 Wildlife Computers (Redmond, WA) Smart Position and Temperature (SPOT)6 Argos-linked satellite tags (Aschettino et al. 2017). SPLASH10F Fastloc® GPS tags were also introduced to the project during the end of the season to test their functionality. Continued field effort for 2017/2018 began on 31 October 2017 with an additional emphasis on increased survey effort in the W-50 MINEX zone and farther offshore. Preliminary results from this season are summarized below.

Survey Effort

HDR conducted 15 nearshore vessel surveys for humpback whales between 31 October 2017 and 10 March 2018, covering 1,989 km of trackline (**Figure 45**).

Sightings

A total of 27 sightings of humpback whales was recorded during the 2017–2018 survey season. Additional baleen whale sightings included seven sightings of fin whales and one sighting of a minke whale (**Figure 45**). Twelve (40.0 percent) of the 30 total whale sightings were in the shipping lanes, and four (13.3 percent) occurred in the W-50 MINEX zone (all humpback whales). Sightings of non-target species (i.e., common bottlenose dolphins, harbor seals, and harbor porpoises [*Phocoena phocoena*]) were also recorded but are not presented in this report.

Photo-identification

The 27 sightings of 32 total individual humpback whales included 20 unique humpback whales identified using dorsal fin and fluke images. Eighteen (90.0 percent) of those whales were categorized as juveniles based on their estimated size, while the remaining two (10.0 percent) were categorized as sub-adults. Seven (35.0 percent) of the 20 individuals were re-sights from the previous three field seasons; five individuals were first seen during the 2014–2015 field season, and two were first seen during the 2015–2016 field season. The remaining 13 whales were new individuals added to HDR's growing catalog, which, currently has 119 unique humpback whales (not inclusive of one unique humpback whale identified from the Outer Continental Shelf Break Cetacean Study – see Engelhaupt et al. 2017). Seven of the 31 (22.5 percent) humpback whales were seen on more than one occasion during the 2017–2018 field season, which is considerably fewer than in the previous season (69.5 percent during 2016–2017).

Biopsy Samples

To date, two biopsy samples have been collected from humpback whales during the 2017–2018 field season. Thirty-one samples (29 humpback and two 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 was a significant difference 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 $\delta^{13}C$ 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 (± 0.9) compared to the fin whales value of 10.5 (± 0.0). Given a difference in $\delta^{15}N$ values between the two 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 δ^{13} 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 two 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.

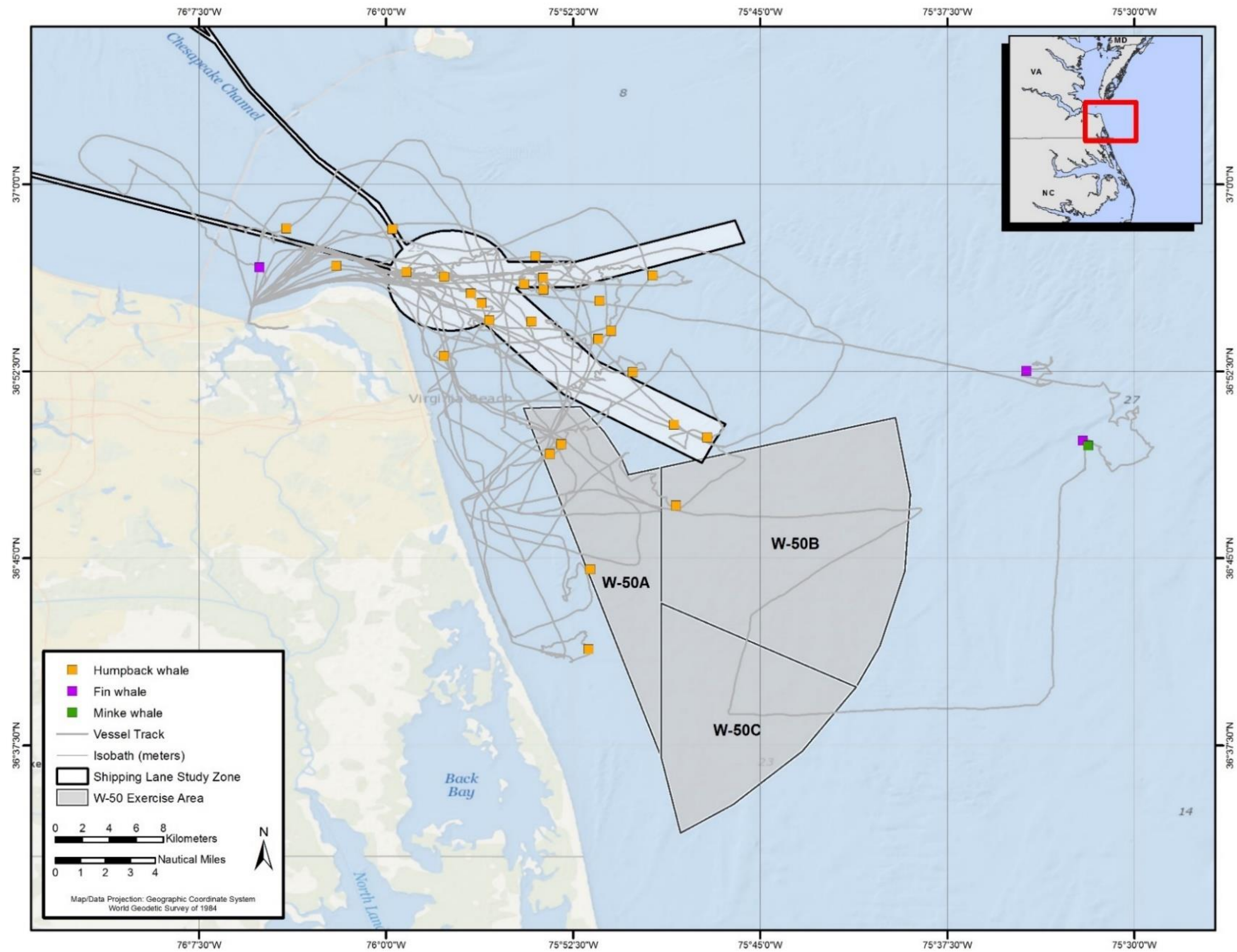

Figure 45. Nearshore survey tracks and locations of all humpback (*n*=26), minke (*n*=1), and fin (*n*=3) whale sightings from 31 October 2017 through 21 January 2018.

Tagging

Seven SPOT-6 Argos-linked satellite tags and three SPLASH10-F tags were deployed on humpback whales (6 SPOT6) and fin whales (1 SPOT6, 2 SPASH10-F) during the 2017–2018 field season (**Table 28**). The tags transmitted between 6.3 and 52.8 days (mean = 13.4 days). Four of the six tagged humpback whales were tagged during previous field seasons and exhibited considerable differences in movement patterns across seasons. For instance, although all of the previously tagged whales were previously tracked within the Chesapeake Bay mouth shipping channels, all of the whales tagged during 2017–2018 spent more time away from this area (**Figure 46**). In addition, during 10.5 days of tracking in December 2015, the movement patterns of HDRVAMn010 were concentrated in the mouth of the Chesapeake Bay with some movement just offshore of this area. However, during 10.3 days of tracking in the 2017–2018 season, this whale did not move into the mouth of the Bay but moved far offshore of Maryland and Delaware (**Figure 47**). In addition, 57.7 percent of the 2016–2017 tagged whales spent time west of the CBBT, but none of the 2017/2018 tagged whales moved west of the CBBT. Seven of the tagged whales moved into the W-50 MINEX zone (**Figure 46**).

Table 28. Satellite tag deployments on humpback whales during the 2017–2018 field season.

Species[1]	Animal ID	Estimated Age Class	Tag Type	Argos ID	Deployment Date	Last Transmission Date	Tag Duration (Days)
Mn	HDRVAMn010	Sub-adult	SPOT6	171873	31-Oct-17	11-Nov-17	10.3
Mn	HDRVAMn120	Juvenile	SPOT6	171874	22-Dec-17	06-Jan-18	15.1
Mn	HDRVAMn012	Juvenile	SPOT6	171875	29-Dec-17	05-Jan-18	6.3
Mn	HDRVAMn064	Juvenile	SPOT6	171876	29-Dec-17	20-Jan-18	21.8
Bp	HDRVABp020	Sub-adult	SPLASH10-F	172528	21-Jan-18	10-Feb-18	19.4
Bp	HDRVABp016	Sub-adult	SPLASH10-F	172529	26-Jan-18	16-Feb-18	21.0
Bp	HDRVABp041	Sub-adult	SPOT6	173171	26-Jan-18	20-Mar-18	52.8
Mn	HDRVAMn049	Sub-adult/Adult	SPOT6	171877	09-Feb-18	22-Feb-18	13.3
Mn	HDRVAMn126	Sub-adult/Adult	SPOT6	171878	09-Feb-18	13-Feb-18	4.1

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

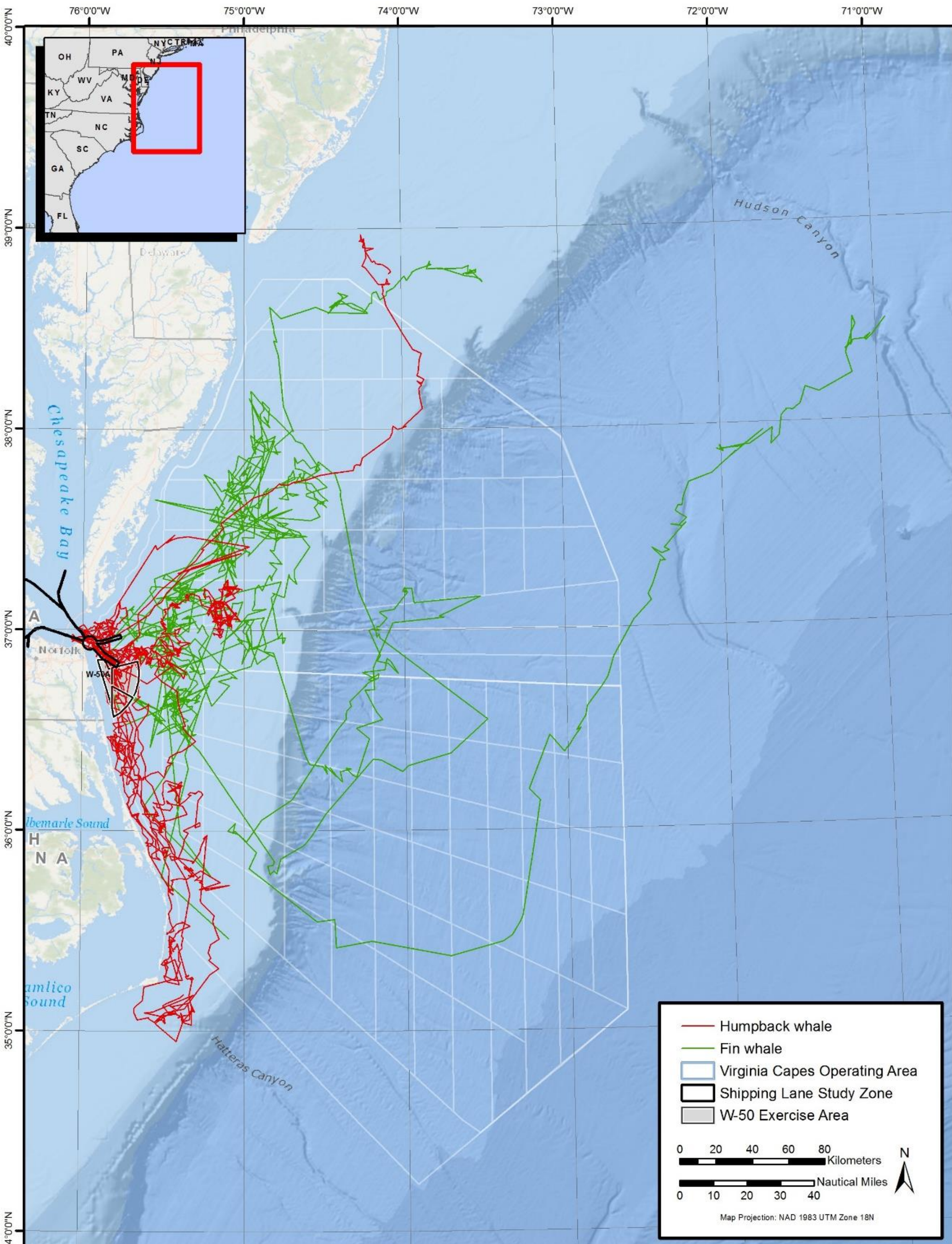

Figure 46. Tag tracklines for all humpback whales (n=6) and fin whales (n=3) tagged during the 2017/18 field season."

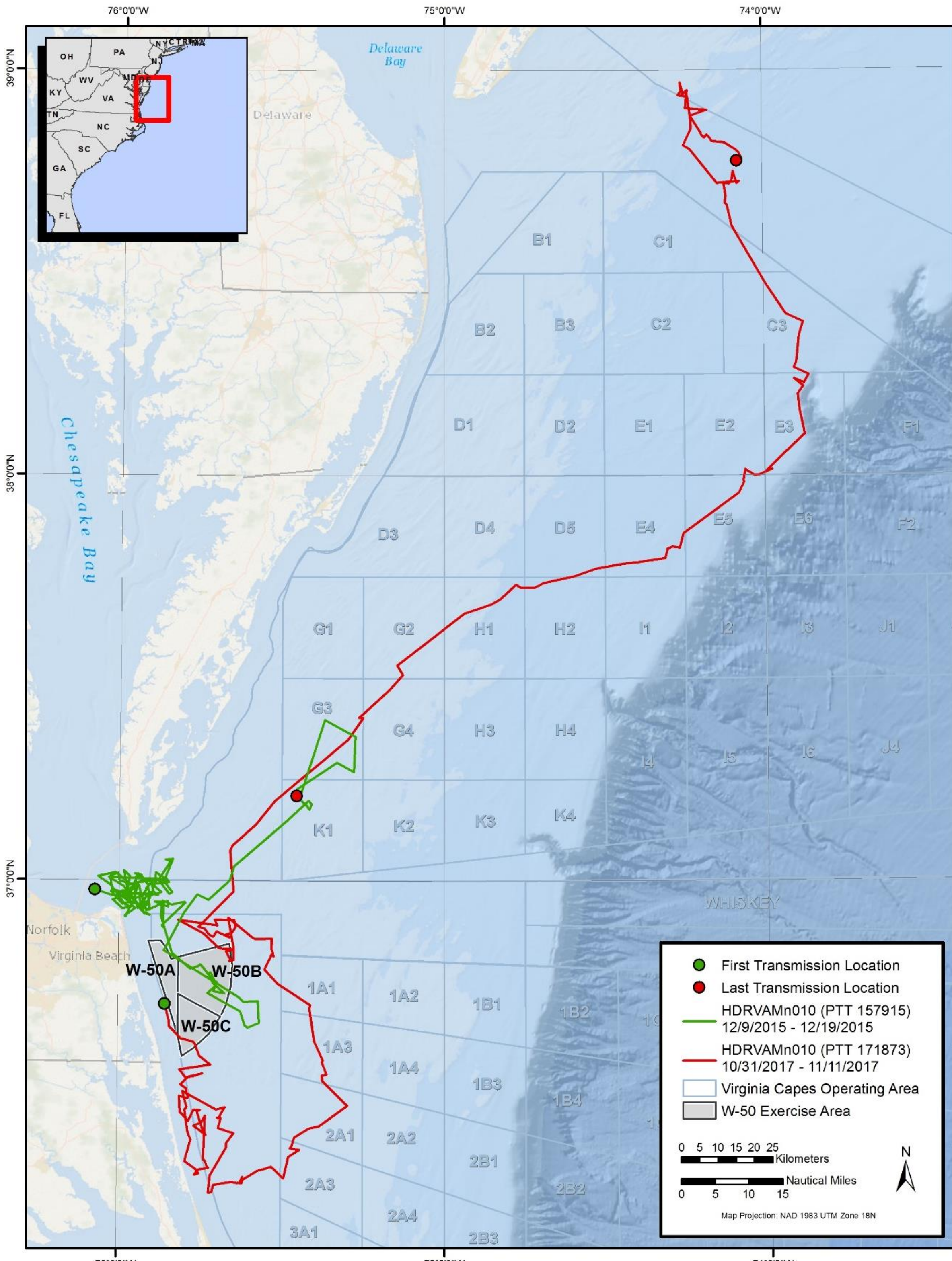

Figure 47. Comparison of the track of HDRVAMn010 between 2015 (green trackline, 10.5 days) and 2017 (red trackline, 10.3 days).

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 8 percent of the individual humpback whales in the HDR catalog have scars or injuries indicative of propeller or vessel strikes. Throughout this study, individual humpback whales have been observed with boat injuries and 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.

Over 75 percent of the humpback whales seen during the four 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). Sub-adult-sized humpback whale sightings have been highest early in the field seasons. 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. 2015, Aschettino et al. 2016, Aschettino et al. 2017).

For more information on this study, refer to the annual progress report for this project (Aschettino et al. 2018).

2.2.4 VACAPES Outer Continental Shelf 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 NAS Oceana Dam Neck Annex and within the W-50 MINEX zone (Engelhaupt et al. 2016). However, relatively limited survey effort has been conducted 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). The goal of this study is to determine the seasonal occurrence, movement patterns, site fidelity, behavior, and ecology of cetaceans in VACAPES OPAREA 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 2017 field season are summarized below.

Survey Effort

HDR conducted 14 offshore vessel surveys in 2017, covering 4,992 km of trackline. Surveys were conducted at least once per month in all months except September, October, and December, 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 253 marine mammal sightings and 49 sea turtle sightings was recorded during these vessel surveys (**Figure 48**). Twelve cetacean taxa were identified (in order of decreasing frequency): unidentified pilot whale (*Globicephala* sp.) (*n*=70), common bottlenose dolphin (*n*=62), common dolphin (*n*=46), sperm whale (*n*=21), fin whale (*n*=11), Risso's dolphin (*n*=5), short-finned pilot whale (*n*=4), minke whale (*n*=4), striped dolphin (*n*=2), humpback whale (*n*=2), Atlantic spotted dolphin (*n*=2), sei whale (*Balaenoptera borealis*) (*n*=1), and harbor porpoise (*n*=1). In addition, there were 22 sightings of unconfirmed species: unidentified delphinid (*n*=17), unidentified cetacean (*n*=2), unidentified medium whale (*n*=2), and unidentified mesoplodont (*n*=1). The loggerhead turtle (*n*=49) was the only turtle species sighted.

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. Dolphin species were sighted throughout the core study and transit areas, and loggerhead sea turtles were only sighted over the shelf in waters shallower than 150 m. 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.

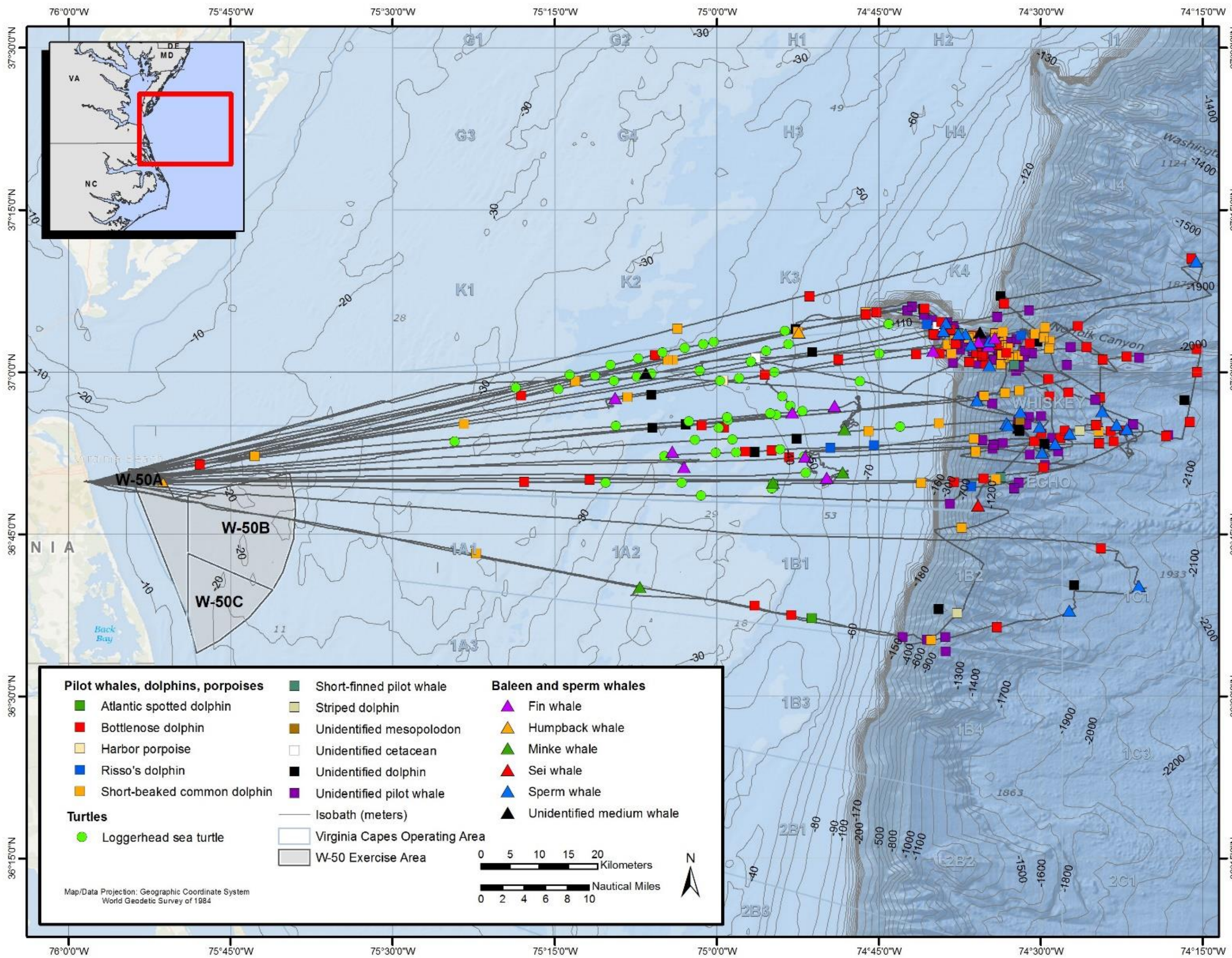

Figure 48. All tracklines and sightings of marine species for the 2017 field season.

Photo-ID

Photo-ID images were collected during 142 of the 253 marine mammal sightings. Images of pilot whales have been shared with Duke University for matching to their existing catalog of pilot whales from Cape Hatteras, North Carolina. To date, matching has been completed for images recorded through 2016; 24 matches were made between individual pilot whales sighted off Virginia and Cape Hatteras. Images of other odontocete species have been archived for future processing. The baleen and sperm whale images were added to HDR's existing catalogs, which now contain 34 fin whales, 8 minke whales, 2 sei whales, and 31 sperm whales. Fin whale images from the HDR catalog were compared to the Center for Coastal Studies fin whale catalog, but no matches were found. One of the humpback whales sighted during the offshore survey on 3 November 2017 was seen during HDR's nearshore surveys the day before.

Biopsy Samples

Three biopsies were collected from fin whales, and five from sperm whales. These samples are currently being processed, so no results are available at this time.

Tagging

Fifteen satellite tags were deployed in 2017: nine on sperm whales and six on fin whales (**Table 29**). Tag duration ranged from 3.6 to 30.8 days (mean=18.0) for sperm whales and from 6.8 to 39.0 days (mean=21.34) for fin whales. The SPLASH10 tags recorded dive depths and durations. Sperm whale maximum dive depth ranged from 1063.5 to 1735.5 m, and maximum dive duration ranged from 53 to 66 min. In comparison, fin whale maximum dive depths were much shallower and ranged from 90.5 to 92.5 m. Analysis of fin whale dive duration is currently underway.

Table 29. Satellite tag deployments on sperm and fin whales during 2017.

Species[1]	Animal ID	Tag Type	Deployment Date	Last Transmission Date	Tag Duration (Days)
Pm	HDRVAPm002	SPLASH 10	27-Feb-17	20-Mar-17	21.04
Pm	HDRVAPm003	SPLASH 10	27-Feb-17	Never transmitted	---
Pm	HDRVAPm006	SPLASH 10	26-Mar-17	26-Apr-17	30.78
Pm	HDRVAPm007	SPOT 6	26-Mar-17	25-Apr-17	29.57
Pm	HDRVAPm010	SPLASH 10	16-Jun-17	29-Jun-17	13.04
Pm	HDRVAPm018	SPLASH 10	27-Jun-17	01-Jul-17	3.57
Pm	HDRVAPm022	SPLASH 10	03-Aug-17	19-Aug-17	15.48
Pm	HDRVAPm023	SPOT 6	03-Aug-17	28-Aug-17	24.86
Pm	HDRVAPm025	SPLASH 10	03-Aug-17	09-Aug-17	5.67
Bp	HDRVABp017	SPLASH 10	06-Mar-17	02-Apr-17	26.77
Bp	HDRVABp018	SPOT 6	10-May-17	29-May-17	18.52
Bp	HDRVABp019	SPOT 6	10-May-17	19-Jun-17	39.02
Bp	HDRVABp025	SPLASH 10	17-Aug-17	24-Aug-17	6.84
Bp	HDRVABp026	SPOT 6	17-Aug-17	16-Sep-17	30.11
Bp	HDRVABp027	SPOT 6	17-Aug-17	24-Aug-17	6.77

[1] Pm = Physeter macrocephalus (sperm whale); Bp = Balaenoptera physalus (fin whale)

Locations from satellite-tagged whales show movements through numerous VACAPES 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 49**), and others moving greater distances to the north or south (or both), generally along the continental shelf edge and slope. Movements ranged from the Atlantic City OPAREA to deep waters off North Carolina (e.g., **Figure 50**). Fin whale movement patterns also varied. More time was spent on the continental shelf in the VACAPES OPAREA, and movements often extended north of the initial tagging locations. For example, one fin whale (HDRVABp019) spent time in the Atlantic City OPAREA and moved as far north as the Narragansett Bay OPAREA (**Figure 51**). Another individual (HDRVABp017) was tagged offshore of the continental shelf break in the VACAPES OPAREA and traveled approximately 900 km far offshore to the Hatteras Plain, and then moved back towards the initial tagging location and farther inshore over the continental shelf (**Figure 52**).

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 the U.S. Navy training and testing activities. The increased survey effort covering the Norfolk Canyon area and deeper waters (>1,000 m) in 2017 showed frequent sightings of marine mammals in U.S. Navy ranges near this area (K3, K4, and I4). This area is also heavily utilized by recreational and commercial fishing vessels.

Preliminary analysis of dive data shows variability within individual sperm and fin whales. Additional tag deployments continue to be a priority for future surveys. With the recent integration of Fastloc® GPS into Wildlife Computer's SPLASH10-F tags, we will be able to provide increased accuracy relative to location information combined with dive profile data for fast-moving fin whales. Future efforts will incorporate switching state-space modeling (SSSM) as a means to examine patterns of foraging and traveling within and between individuals. As additional surveys are conducted and tags are deployed on multiple species across all four 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. 2018).

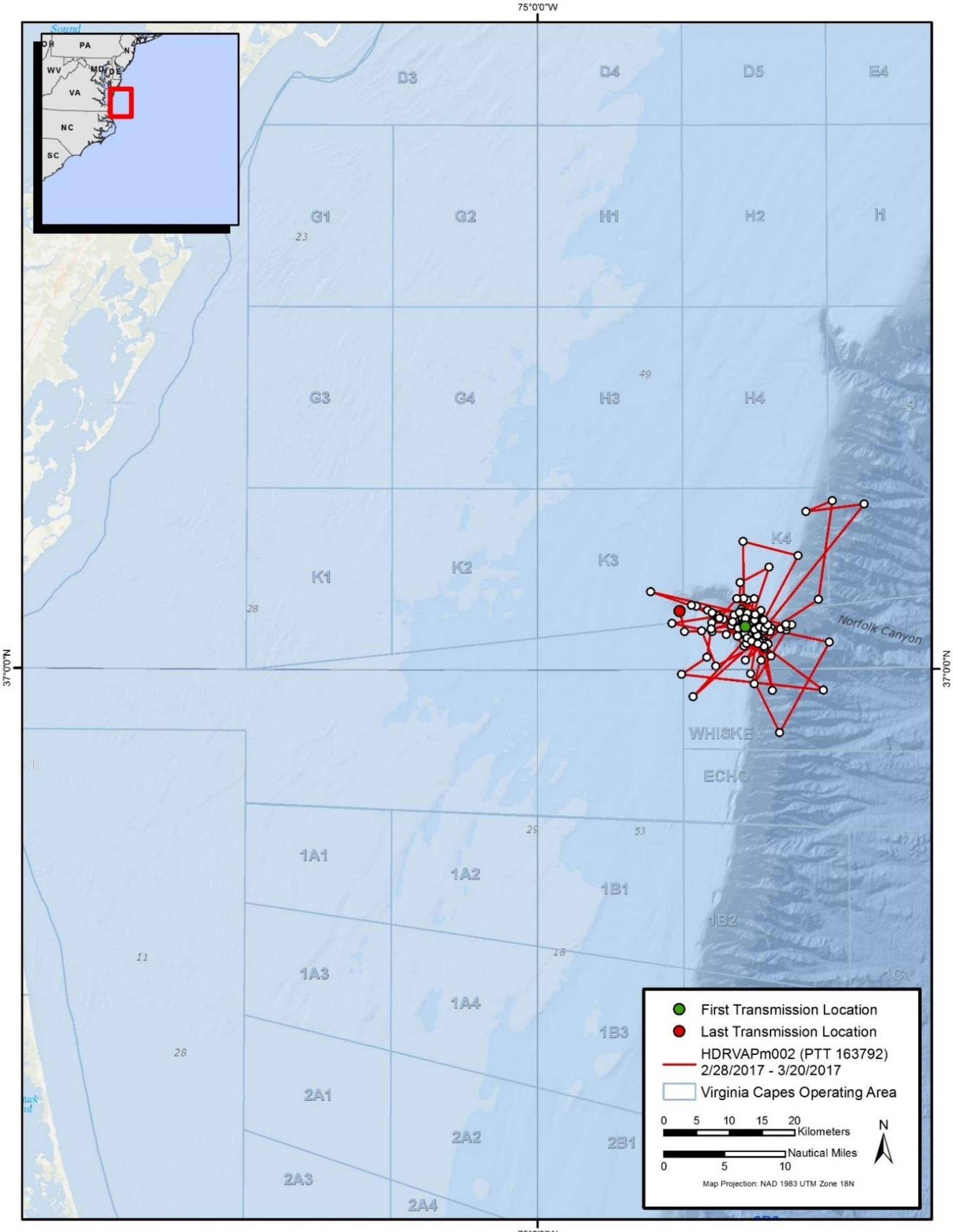

Figure 49. Filtered locations (white dots) and track of sperm whale HDRVAPm002 showing limited movement from the tagging location over 21 days of tag-attachment duration.

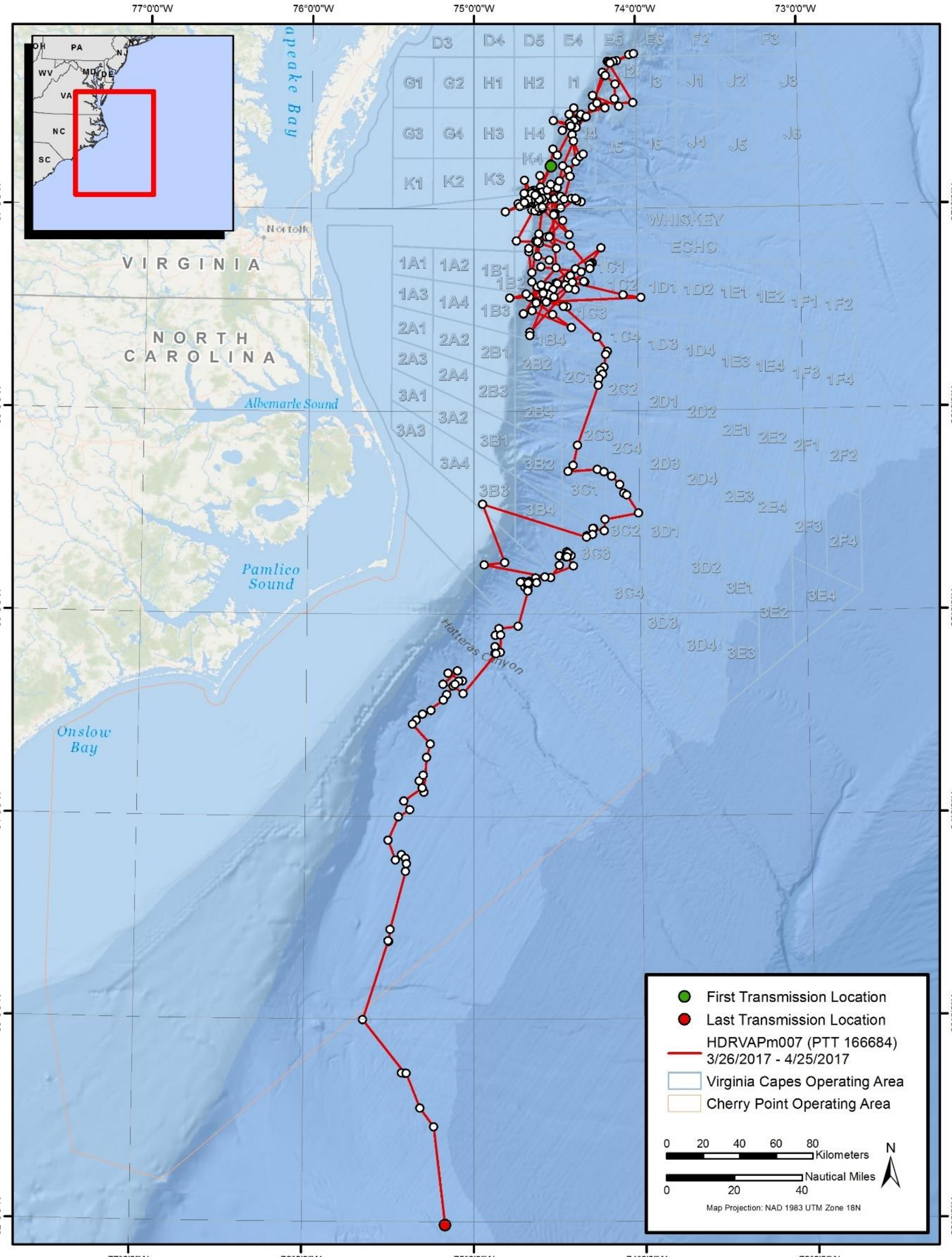

Figure 50. Filtered locations (white dots) and track of sperm whale HDRVAPm007 showing extensive movement from the tagging location over 30 days of tag-attachment duration.

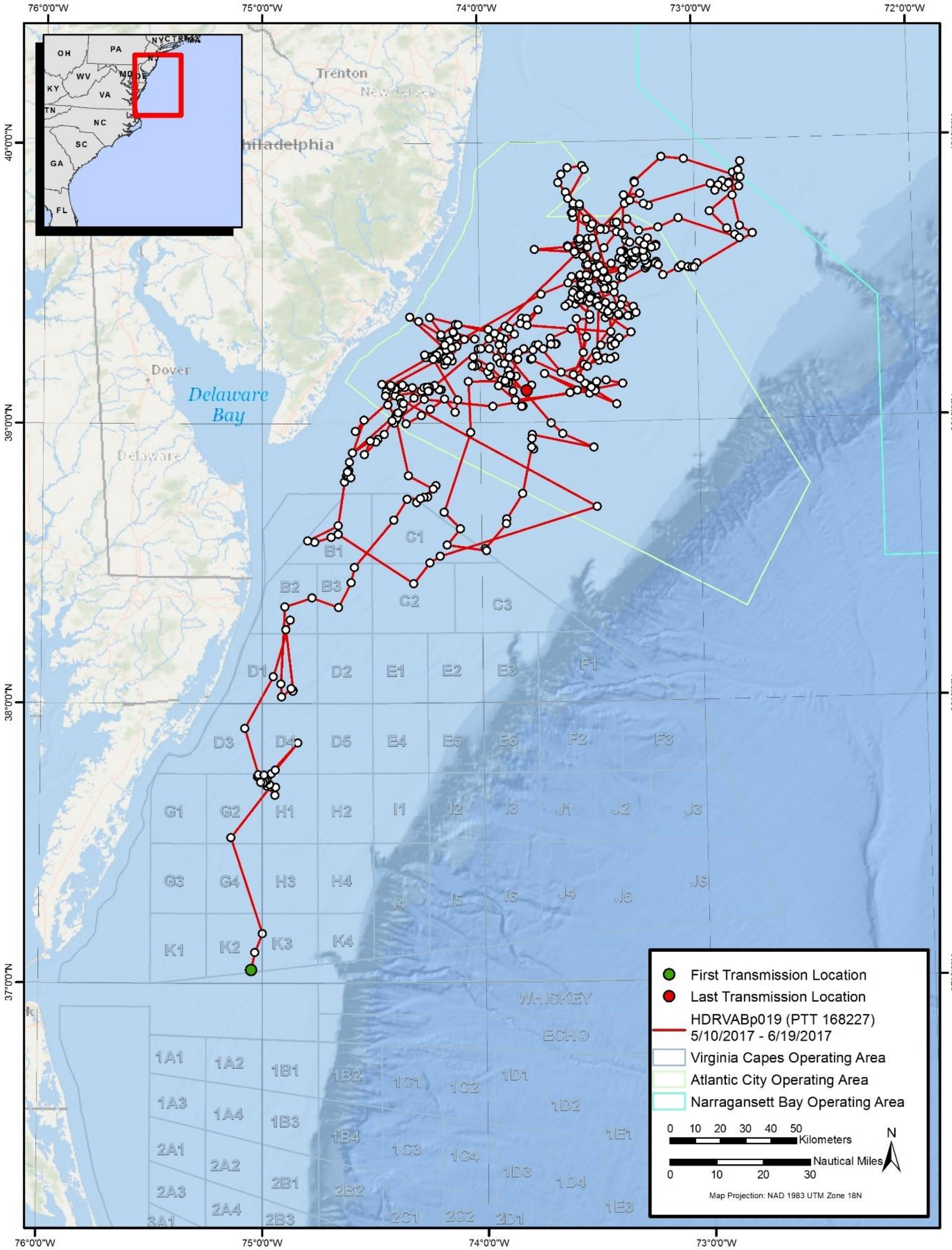

Figure 51. Filtered locations (white dots) and track of fin whale HDRVABp019 remaining in shelf waters over 39 days of tag-attachment duration.

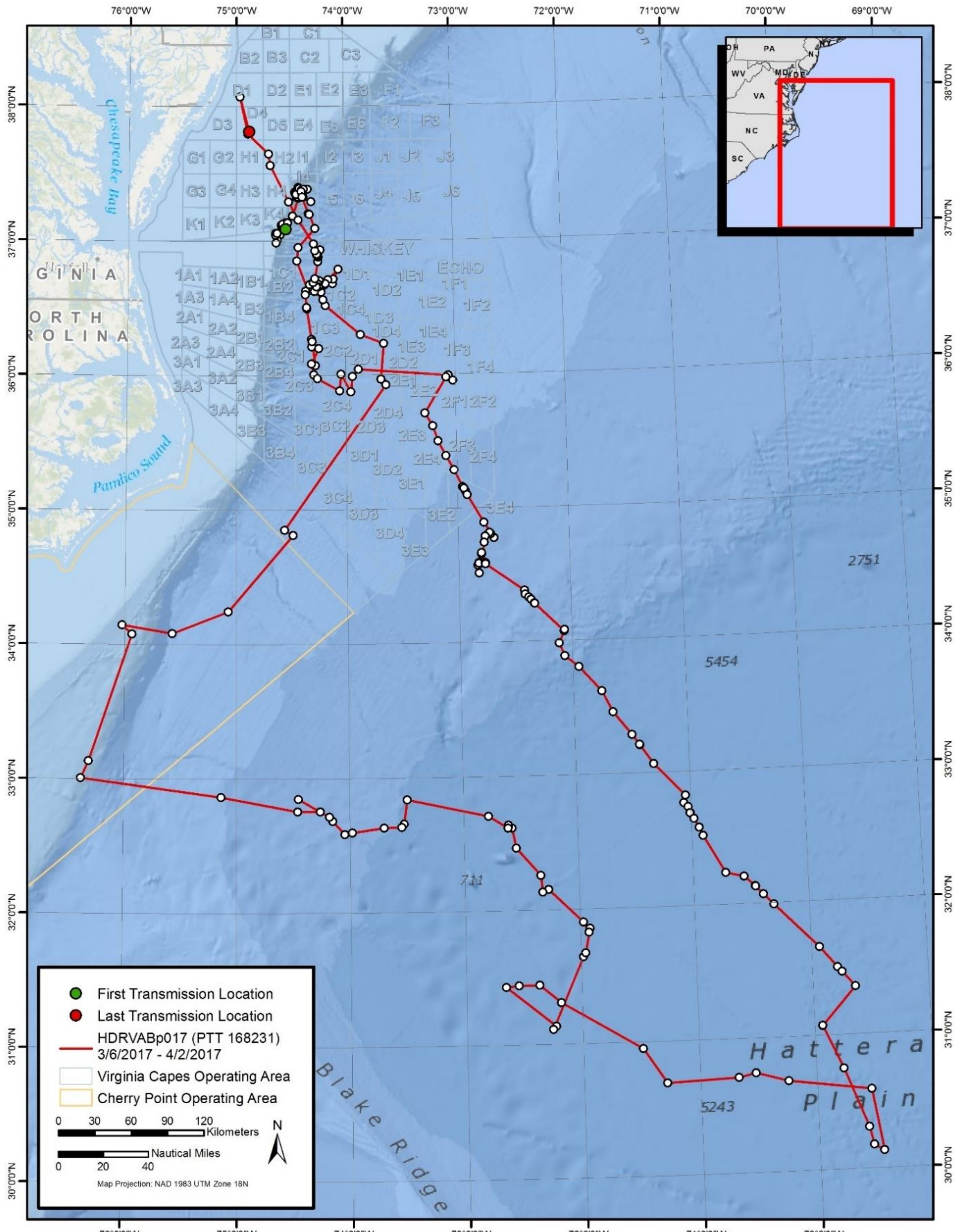

Figure 52. Filtered locations (white dots) and track of fin whale HDRVABp017 showing movement into deep offshore waters over 27 days of tag-attachment duration.

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. The goal of this project is to assess the occurrence, habitat use, and behavior of loggerhead, green (*Chelonia mydas*), and Kemp's ridley (*Lepidochelys kempii*) 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.

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 five tags deployed on green and Kemp's ridley turtles prior to 2013 is being incorporated into the analysis.

2.2.5.1 *Capture and Tagging Progress and Results*

Tagging efforts for the 2017 field season were focused on Kemp's ridley and green turtles. Of the 30 Kemp's ridley turtles hooked by recreational fishermen, 21 were candidates to be tagged, and either a satellite or acoustic tag was deployed on all 20 of these turtles (refer to **Tables 30 and 31**). All tags 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 bins. 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. Sirtrack tags (Wildlife Tracking Solutions – Hawkes Bay, NZ) were used as location only tags, and the sensors were not utilized. In addition to the 20 Kemp's ridley turtles, researchers released one cold stunned green turtle with a VEMCO acoustic tag in July of 2017.

The mean number of acoustic tag detections per turtle in 2017 was highly variable ranging from 1 to 225 per tag with a mean of 72 (±72). The median number of detections was 55. Number of different days detected ranged from 1 to 23 with a mean of 4.8 (±3.0) and a median of 4. Minimum tag duration for Kemp's ridley turtles (days from release to last detection) ranged from 1 to 118 days from release with a mean of 31 (±35) day and a median of 18 days. Minimum duration was lower in 2017 compared with 2015 (no acoustic tags were deployed in 2016). Differences among years (excluding 2013 when only one tag was deployed on a Kemp's ridley) were not significant except for a greater duration in 2015 over 2014. Researchers switched from using epoxy attachments to wire attachments in 2015. The lower duration in 2017 compared with 2015 may be, in part, due to the number of relatively small turtles (<25 cm SCL-NT) that were tagged in 2017. Smaller turtles have narrower marginal scutes, and, thus, less space between the holes drilled to attach the tag and the edge of the scute, making the possibility and timing of wire migration out of the scute more likely.

Of the ten satellite transmitters deployed in 2017, one did not transmit. For the nine others, tags transmitted for 9 to 122 days with a mean of 53.1 (±40.6) days and a median of 38.6 days. Although distance traveled was relatively high for tagged turtles, ranging from 185 to 1,744 km, total displacement from first to last transmission was low, ranging from 28 to 102 km. Most of the turtles were released in the spring or summer and spent much of their time in restricted areas apparently foraging.

Table 30. Kemp's ridley and green turtles tagged by VAQF in 2017.

Field Number	Species	Tag Type	Release Date	SCL-NT (cm)	Weight (kg)	Source
VAQS20162242	Cm	VEMCO	10-Jul-17	35.7	6.06	Stranded/cold stun
VAQS20172014	Lk	VEMCO	5-May-17	43.3	10.75	Stranded/hooked
VAQS20172015	Lk	VEMCO	5-May-17	38.3	16.6	Stranded/hooked
VAQS20172021	Lk	SPLASH	6-May-17	44.1	11.9	Stranded/hooked
VAQS20172029	Lk	Sirtrack	19-May-17	42.4	9.25	Stranded/hooked
VAQS20172030	Lk	SPOT	20-May-17	39.3	8.05	Stranded/hooked
VAQS20172036	Lk	Sirtrack	20-May-17	40.8	8.05	Stranded/hooked
VAQS20172040	Lk	SPLASH	20-May-17	45.7	12	Stranded/hooked
VAQS20172043	Lk	SPOT	1-Jun-17	30.1	3.17	Stranded/hooked
VAQS20172050	Lk	VEMCO	26-May-17	25.9	2.25	Stranded/hooked
VAQS20172061	Lk	Sirtrack	17-Jun-17	32.1	4.37	Stranded/hooked
VAQS20172065	Lk	Sirtrack	8-Jun-17	29.2	3.23	Stranded/hooked
VAQS20172080	Lk	VEMCO	22-Jun-17	27.8	2.67	Stranded/hooked
VAQS20172084	Lk	VEMCO	22-Jun-17	24.5	2.2	Stranded/hooked
VAQS20172114	Lk	VEMCO	10-Jul-17	23.5	1.8	Stranded/hooked
VAQS20172116	Lk	VEMCO	10-Jul-17	26	2.63	Stranded/hooked
VAQS20172119	Lk	SPOT	11-Jul-17	28.9	3.36	Stranded/hooked
VAQS20172145	Lk	SPOT	10-Aug-17	29.8	3.09	Stranded/hooked
VAQS20172168	Lk	VEMCO	10-Jul-17	21	1.4	Stranded/hooked
VAQS20172179	Lk	VEMCO	23-Sep-17	28.5	3.1	Stranded/hooked
VAQS20172180	Lk	VEMCO	23-Sep-17	30.9	3.56	Stranded/hooked
VAQS20172181	Lk	VEMCO	23-Sep-17	25.4	2.32	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.

Table 31. Satellite telemetry data for Kemp's ridley turtles included in analyses. This table does not include tags that did not transmit (*n*=2). 'Days' column indicates number of days from release to last transmission.

Field Number	PTT	Release Date	Last Transmission	Days	Source	Tag Manufacturer
VAQS20112010	108054	30-Jun-11	15-Jul-11	14.8	stranded	Wildlife Computers
VAQS20122175	129021	22-Jun-13	13-Jul-13	21.1	stranded	Wildlife Computers
VAQS20132229	132367	10-Jul-14	15-Aug-14	35.9	stranded	Wildlife Computers
VAQS20142152	138117	3-Sep-14	10-Oct-14	37.1	stranded	Wildlife Computers
VAQS20132227	138114	21-Oct-14	06-Jun-15	227.7	stranded	Wildlife Computers
VAQR201502	148887	16-May-15	24-Jun-15	39.3	capture	Wildlife Computers
VAQS20142244	148889	17-May-15	14-Jul-15	58.2	stranded	Wildlife Computers
VAQS20152008	148881	17-May-15	23-Jun-15	37.1	stranded	Microwave Telemetry
VAQR201503	148882	19-May-15	30-May-15	11.1	capture	Microwave Telemetry
VAQR201505	148886	30-May-15	12-Jul-15	43.1	capture	Wildlife Computers
VAQS20152049	150767	25-Jun-15	05-Jul-15	9.7	stranded	Wildlife Computers
VAQS20162089	159708	3-Jul-16	05-Aug-16	33.3	stranded	Wildlife Computers
VAQS20162029	161472	23-Jul-16	31-Aug-16	38.8	stranded	Sirtrack
VAQS20162016	159709	27-Jul-16	27-Aug-16	31.3	stranded	Wildlife Computers
VAQS20172021	169767	6-May-17	02-Jul-17	57.2	stranded	Wildlife Computers
VAQS20172030	159707	20-May-17	17-Sep-17	119.4	stranded	Wildlife Computers
VAQS20172036	169765	20-May-17	19-Sep-17	121.8	stranded	Sirtrack
VAQS20172040	169768	20-May-17	03-Jul-17	44.3	stranded	Wildlife Computers
VAQS20172043	169771	1-Jun-17	21-Jun-17	20.9	stranded	Wildlife Computers
VAQS20172065	169763	8-Jun-17	08-Jul-17	30.1	stranded	Sirtrack
VAQS20172061	169764	17-Jun-17	25-Jul-17	38.6	stranded	Sirtrack
VAQS20172119	169770	11-Jul-17	17-Aug-17	36.7	stranded	Wildlife Computers
VAQS20172145	169722	10-Aug-17	-	-	stranded	Wildlife Computers

Key: PTT=platform transmitter terminal.

Analysis Progress

One of the goals of satellite tagging Kemp's ridley turtles is to replicate analyses done with data from loggerhead turtles (Barco and Lockhart 2016). Switching State-Space Models for marine turtles (Jonsen et al. 2007) can provide inference on animal behavior and movement and reduce spatial autocorrelation by smoothing animal tracks into even time steps. These models explicitly account for location error in Argos tracking data and estimate animal behavior (area restricted search versus traveling) by parameterizing speed and turning angles in the smoothed track via a Monte Carlo Markov chain. The process of these analyses for Kemp's ridley turtles started in 2017 and include 9 deployments and 8,217 locations (**Figure 53**). All deployments had over 100 reported locations after all filters were applied. The average time between reported locations was roughly 3 hours. Satellite transmitters used in the analysis include 9.5 gram Solar PTTs manufactured by Microwave Telemetry (n=3), Sirtrack models K2G 172 (n=3) and K2G 273 (n=2), and Wildlife Computers models SPLASH-10 (n=6), SPLASH 100 (n=3), SPLASH-284A (n=1), SPOT 331B (n=1), SPOT 5 (n=2) and SPOT 6 (n=4).

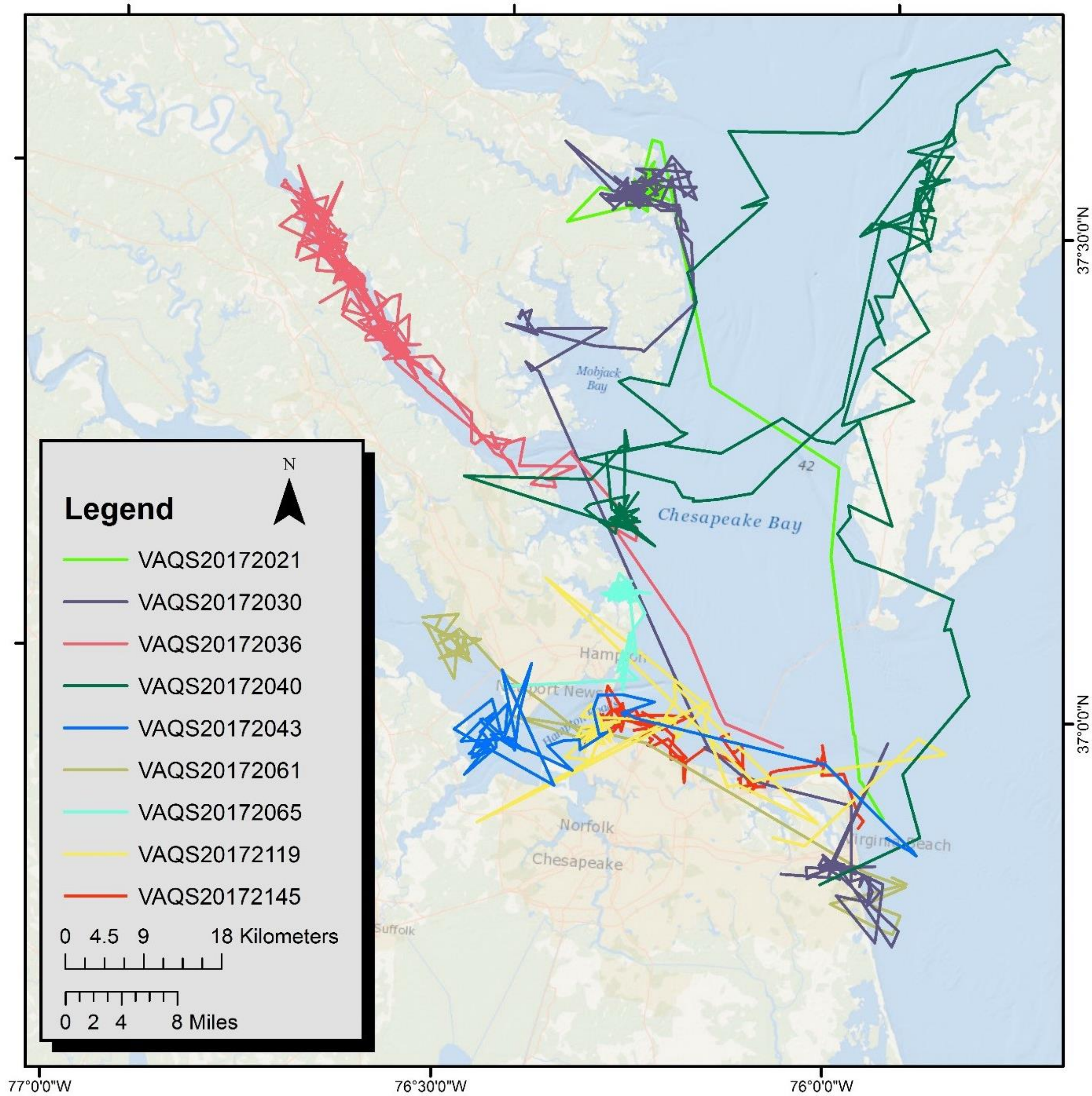

Figure 53. Tracks created from filtered ARGOS data for nine Kemp's ridley turtles tagged in 2017. This is the first time a Kemp's ridley turtle made extensive use of the York River.

Five tags were randomly chosen for SSSM testing. The test models varied time step, model span parameter, number of adaption runs, and whether tags were modeled hierarchically or individually. After reviewing test model parameters for convergence and visually inspecting outputs, a hierarchical model with a 12 hour time step and span parameter of 0.1 appeared to perform the best. This model was then rerun with all 21 deployments. The 12 hour time step limited interpolation but still provided relatively fine scale movement information. It should be noted that these results are preliminary, and other models with the full suite of tags will need to be run to see if changes should be made to model parameters. Despite only a cursory review of the initial model, the initial output appears to yield valid inference on Kemp's ridley turtle behavior in the Chesapeake Bay and mid-Atlantic coastal ocean.

This preliminary SSSM output appears to characterize Kemp's ridley turtle movements and behaviors within Chesapeake Bay and nearshore mid-Atlantic ocean waters (**Figure 54**), though few animals were tracked outside the Bay and inference there is limited. Generally, animals recruited to shallow inlets and restricted estuarine environments, presumably to forage on their preferred prey, blue crabs, while undertaking short bouts of directed travel between foraging areas. One animal, 138114, traveled south along the Outer Banks stopping for several presumed foraging bouts along the way. This animal was likely migrating south towards over-wintering areas.

While, preliminary, this analysis was a promising first step towards understanding Kemp's ridley turtle foraging habitats in the Chesapeake Bay (and limited inference beyond). The finalized outputs to follow will be valuable inputs into foraging home range, habitat use, and species ensemble models.

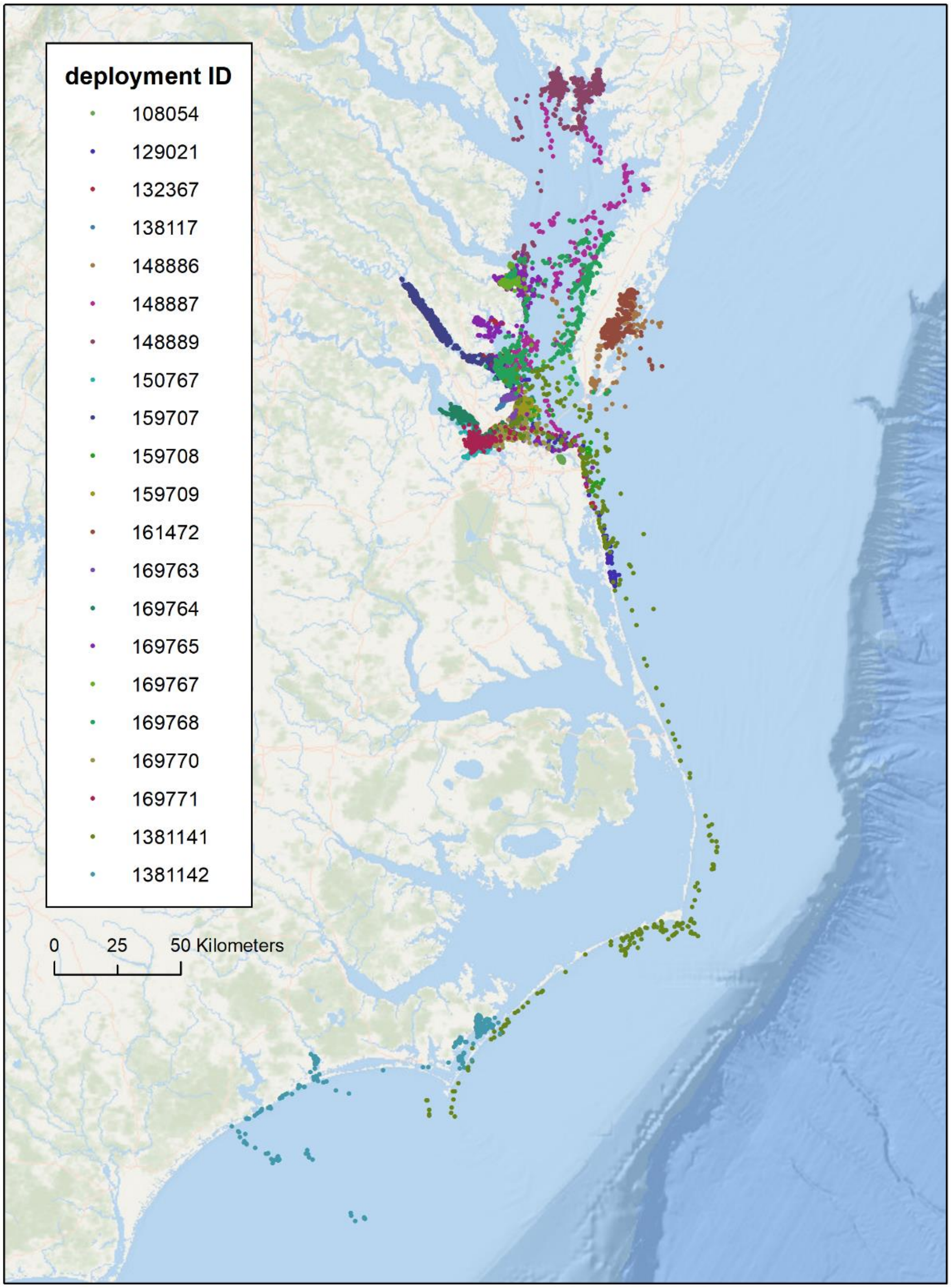

Figure 54. Filtered Kemp's ridley turtle locations used in the switching state space modeling (SSSM) analysis.

2.2.5.2 *Sensitivity analysis*

No population estimate for the Kemp's ridley turtle exists in Chesapeake Bay, and individuals tagged to date have shown selection of different foraging locations within the Bay. The intent of conducting a sensitivity analysis is to inform on the estimated sample sizes required to allow reliable inference. This will be addressed using two methods: 1) using a large existing tagging dataset for loggerheads (51 deployments) and examining how utilization distributions (UDs) change when tags are removed from the analysis and 2) using correlated random walk models to simulate additional tags and examine other areas turtles may utilize that have not been visited by turtles with extant tags.

Method 1 will be addressed using gridded UDs to facilitate comparison of UD outputs as tags are removed from the analysis. Gridded UDs are conceptually easy to interpret, can be exactly overlaid, and are regular in shape allowing for the easy generation of comparison statistics. An iteration of this analysis will also be performed truncating the loggerhead turtle tags to the transmission times of the Kemp's ridley turtle tags.

Method 2 assumes that foraging habitats are comparable between Kemp's ridley and loggerhead turtles. This may not, however, be the case. Based on existing tag data, loggerhead turtles appear to prefer to forage in the open waters of the mainstem Chesapeake Bay and in mid-Atlantic ocean waters over the continental shelf. Kemp's ridley turtles appear to prefer small inlets, embayments, and flats close to shore in the mainstem Chesapeake Bay. Another assumption is that enough loggerhead turtles have been tagged to have sampled that population effectively. Because of these concerns, caution will be taken when interpreting the results. Method 2 will be undertaken for both loggerhead and Kemp's ridley turtles, time allowing. An important metric will be how uncertainty increases in the model outputs as the number of tags is reduced.

To date, most of the work on this task has focused on developing the code base for Method 1. However, some important precursor products have been produced. After exploration of an appropriate cell size for the analysis, gridded UDs for all 51 loggerhead turtle deployments were produced, combined, and summary stats calculated. This will provide the baseline for comparison as tags are dropped iteratively from the analysis in a bootstrap-esque analysis.

A cell size of 10 km was chosen as it aggregated the available data well and was able to capture variation with the Chesapeake Bay. Small cell sizes examined did not have enough variation in the number of locations within cells to produce meaningful UDs, and larger cells did not characterize the Bay very well. 10 km grid cells also made area calculations easy to manage. The UD analysis proved to be sensitive to the initial placement of grid cells but since these UDs are not being used for management purposes this issue will be largely ignored.

The combined 90 percent UD for all 51 loggerhead turtle deployments (restricted to Chesapeake Bay and mid-Atlantic ocean shelf waters) is shown in **Figure 55**. Cells were colored by the number of individuals whose 90 percent UD falls within that cell. A large percentage of the cells were identified as foraging by only a single individual. This indicates high variation in individual behavior and suggests that this population may not have been sampled as well as previously thought.

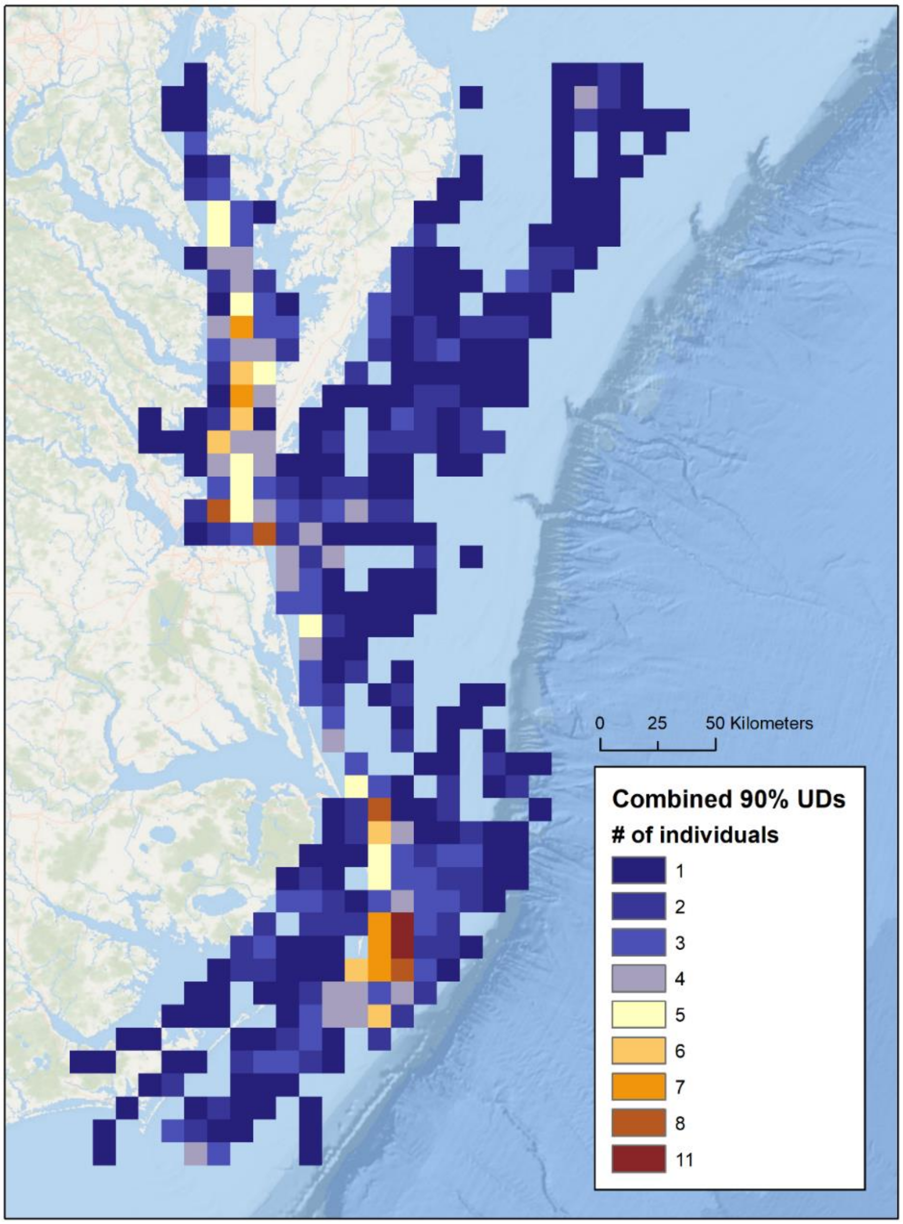

Figure 55. Combined gridded utilization distributions for 51 loggerhead turtle tag deployments, categorized by the number of turtles with 90 percent UDs within each grid cell.

The satellite- and acoustic-telemetry data collected for Kemp's ridley and green turtles for this on-going project are beginning to provide important information on the locations of Kemp's ridley turtles in relation to military facilities and training areas. In 2018, satellite and acoustic tag deployments will be continued for Kemp's ridleys, along with refining analyses and further evaluating the amount of data needed to understand sea turtle behavior and movement in Chesapeake Bay and the greater mid-Atlantic region.

For more information on the 2017 research efforts, refer to the annual progress report for this project (Barco et al. 2018). For more information on loggerhead turtle foraging behavior, a forthcoming final report for the project will be available in early 2019 (Barco et al. 2019).

2.3 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, and the University of St. Andrews worked together to complete the first field phase of this multiyear study in 2017.

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 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.

Twenty-six satellite-linked, depth-transmitting tags were deployed on focal species (14 on beaked whales, 12 on pilot whales) during field sessions in spring and fall (see Baird et al. 2018), which resulted in thousands of hours of movement and diving behavior before and following CEEs. Ten of these individuals (7 beaked whales, 3 pilot whales) were monitored during a successful CEE sequence conducted with the USS *McFaul* using full-scale 53C sonar. Additionally, a simulated sonar CEE was conducted with 7 beaked whales and 4 pilot whales when a Navy ship was unavailable; this total included mostly satellite-tagged animals but also individual focal beaked and pilot whales tagged with high-resolution DTAGs. The completion of the first year 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.

During 2017, more beaked whale CEEs were conducted than in all previous BRS (in all past locales) efforts using simulated or actual military sonar combined. This clearly illustrates the strength of this approach and validates the choice of site location and focal species for the study. Existing analytical approaches are now being applied to these data, with novel integration on different time/space scales. Although extensive analysis of the 2017 data are currently ongoing, preliminary results of the field effort and data analysis are summarized in this report.

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. 2018).

2.3.1 Controlled Exposure Experiments

During the Atlantic-BRS 2017 field effort, two CEE sequences were conducted, one of which was a simulated (scaled source) sonar event, with the other being a full-scale 53C sonar source. The first (CEE #2017-01) was conducted with the simulated mid-frequency active sonar source on 22 August. Seven beaked whales and four pilot whales were monitored with different combinations of tags and focal-follow monitoring during this sequence. The second (CEE #2017-02) was conducted in coordination with the USS *McFaul* on 12 September 2017. Seven beaked whales and three pilot whales were monitored using satellite tag sensors alone (no on-water focal-follow monitoring) during this sequence.

For CEE #2017-01, propagation modeling was conducted in situ based on real-time focal-follow positions of tagged animals (Zc17_234a and Gm17_234a). The objective was to achieve received levels (RLs) from a stationary position relative to both individuals that met the RL objectives of up to 130 decibels re 1 µPa (dB) sound pressure level (SPL) for beaked whales, and up to 160 dB re 1 µPa SPL for pilot whales. Given the dynamic nature of the focal individuals and with cognizance of the presence of the additional nine tagged individuals, RL modeling was conducted using the acoustic propagation planning tool developed by the Naval Postgraduate School for the Southern California-BRS project and adapted for the Atlantic-BRS. Several depths were modeled to evaluate potential variability in the sound field as a function of vertical movement.

The resulting propagation results at 100 m (which indicated maximum RL values of those modeled) that were used in determining the position of the (F/V) *Kahuna* with the sound source are shown below for Zc17_234a (**Figure 56**) and Gm17_234a (**Figure 57**). The propagation model results predicted that for the source location selected, RLs would vary as a function of depth, but maximum values would be approximately 131 dB re 1 µPa SPL for Zc17_234a and approximately 146 dB re 1 µPa SPL for Gm17_234a.

Once the DTAGs were recovered and analyzed, pseudotracks of the movement of both focal animals were derived using a Bayesian melding method that integrates the tag movement sensor data with fixed known surface positions from focal-follow observations from the following boat. These tracks are shown for periods before, during, and after the CEE occurred for both Zc17_234a and Gm17_234a relative to the sound source location (**Figure 58**).

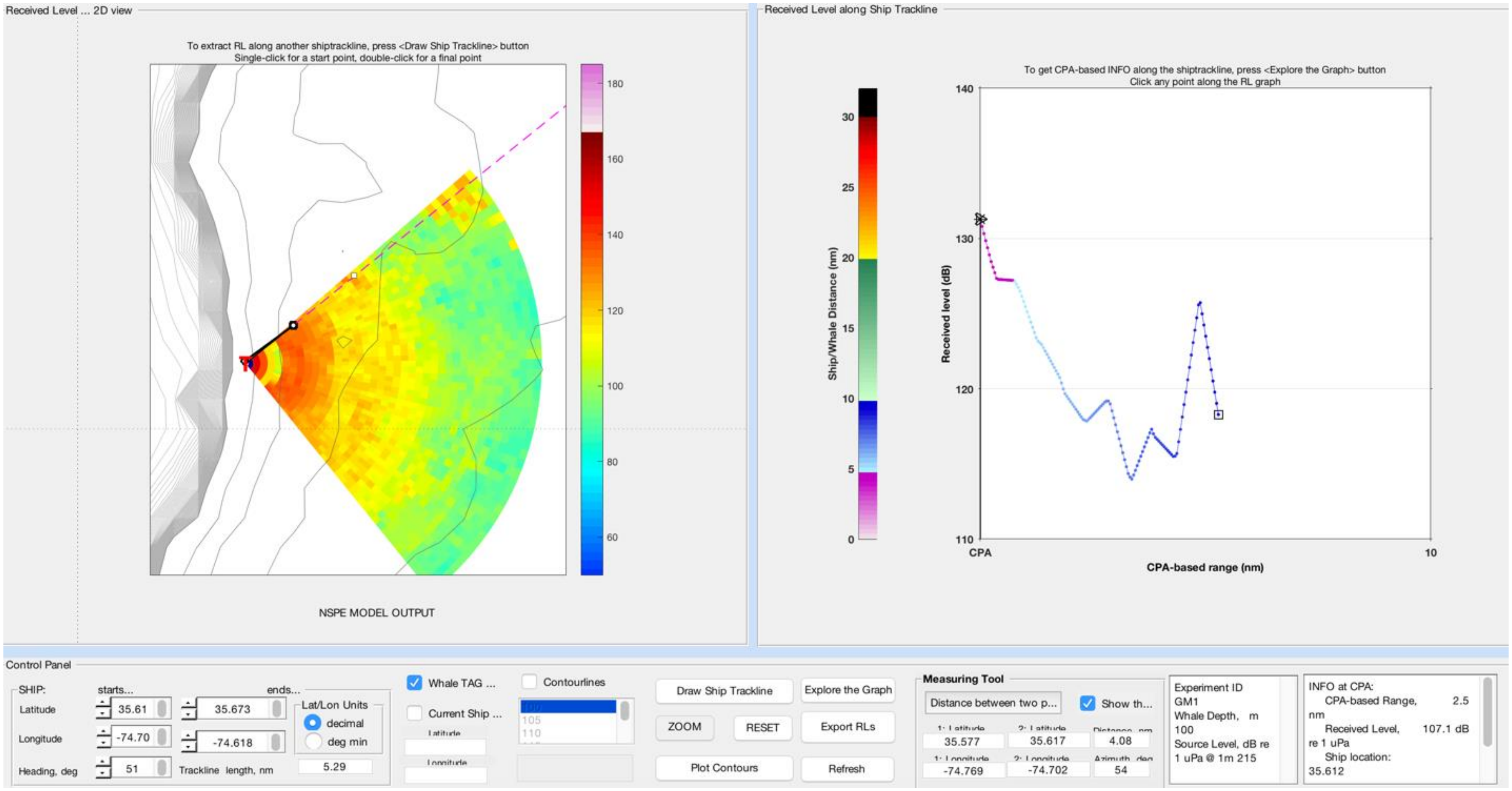

Figure 56. Modeled received levels for Zc17_234a (at location indicated by T) at 100 m depth from *in situ* acoustic propagation assuming the (F/V) *Kahuna* at starting source location selected for CEE#2017-01 (35.548; -74.770).

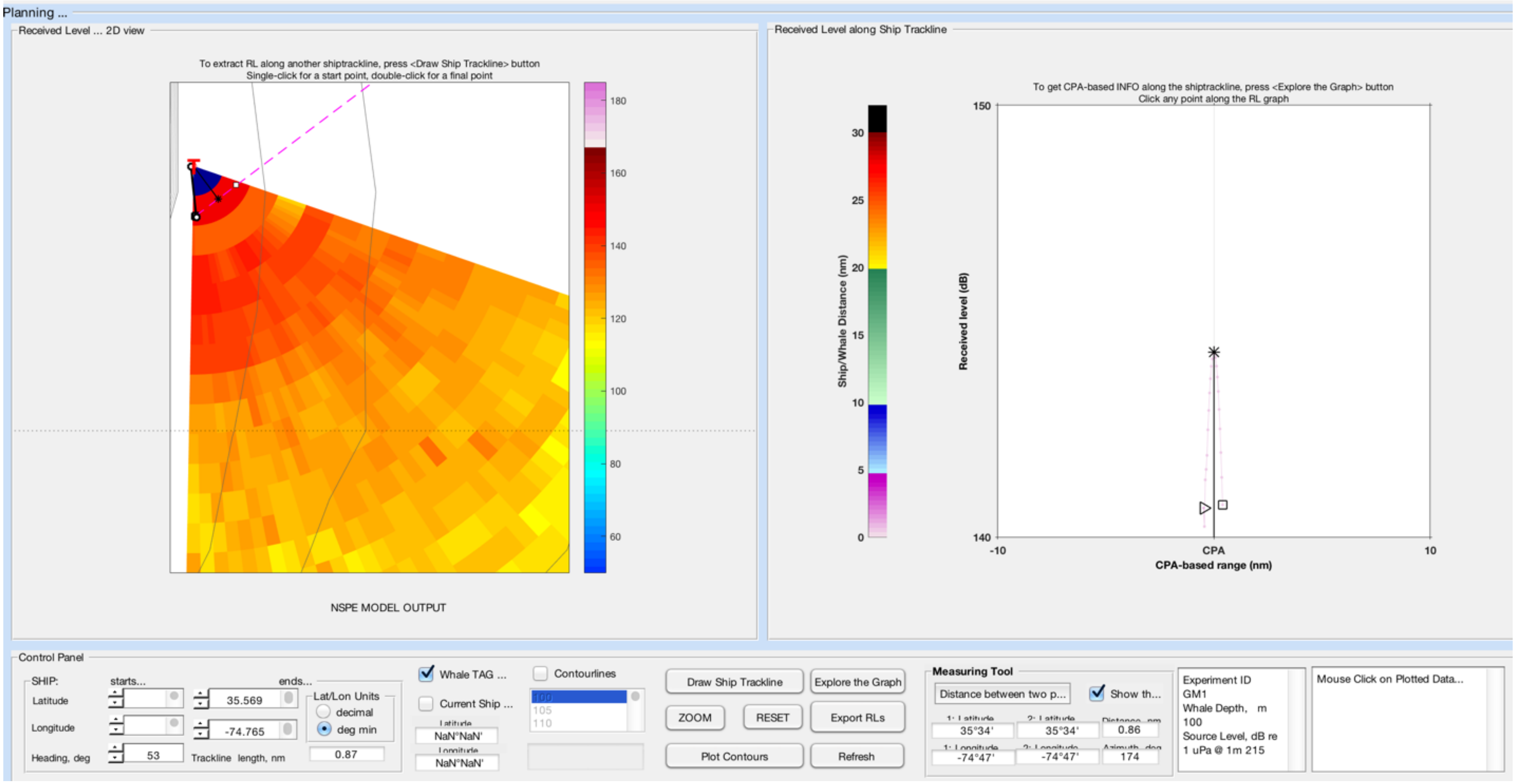

Figure 57. Modeled received levels for Gm17_234a (at location indicated by T) from in situ acoustic propagation assuming the (F/V) *Kahuna* at starting source location selected for CEE#2017-01 (35.548; -74.770).

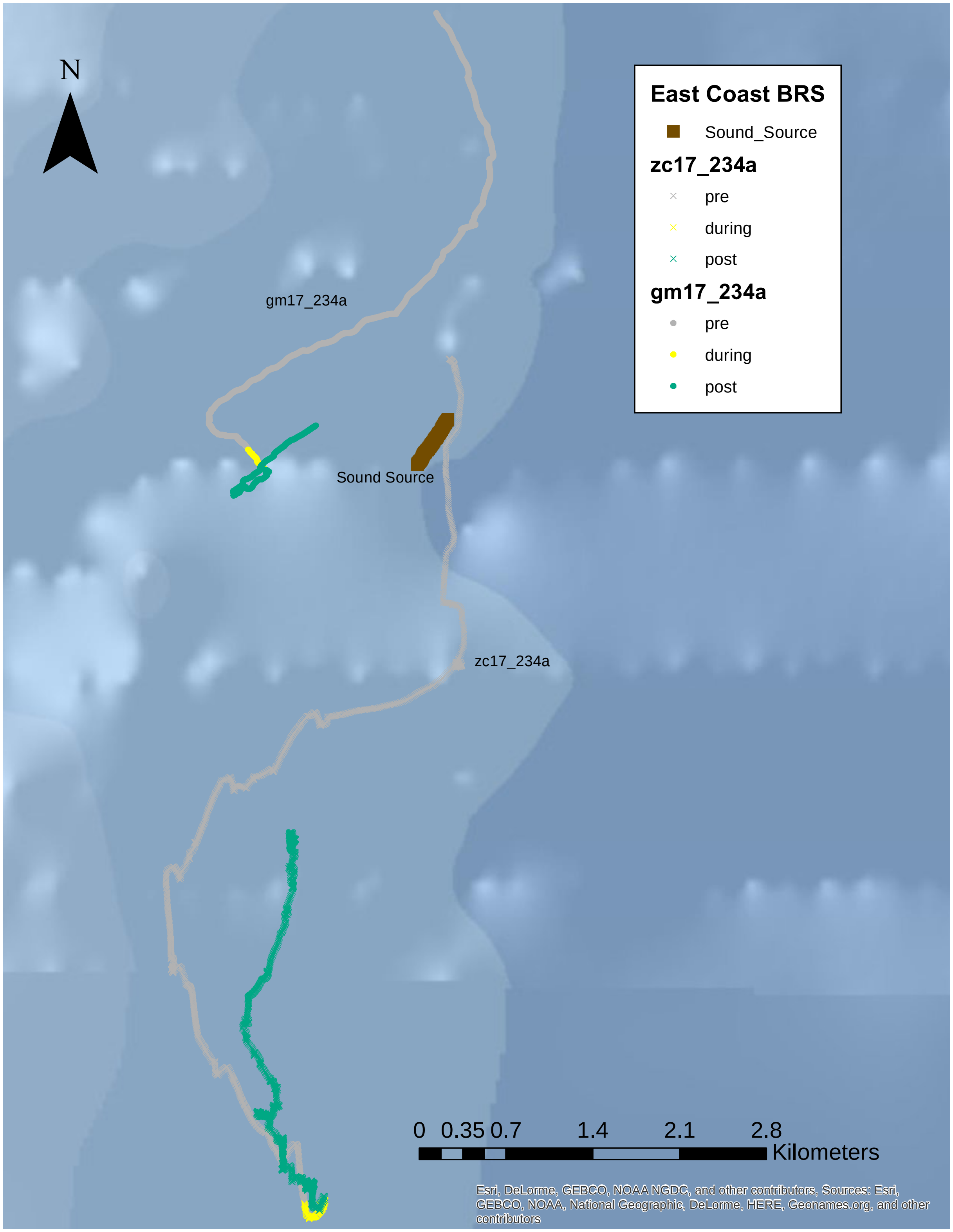

Figure 58. Pseudotracks of tagged beaked whale Zc17_234a and pilot whale Gm17_234a before (pre: gray), during (yellow), and after (post: green) during Atlantic-BRS CEE #2017-01 conducted on 22 August 2017.

2.3.2 Behavioral Response Analysis – Status and Preliminary Results

Behavioral response analyses focus on how beaked and pilot whales change their behavior from baseline conditions during periods of mid-frequency active sonar 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 also recorded from the two 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 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. 2018).

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.

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

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 a response to training and testing activities. In addition, the Marine Mammal Monitoring on Navy Ranges project 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 passive acoustic monitoring 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 (C-PODs), 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 High-Frequency Acoustic Recording Packages

Duke University and Scripps Institution of Oceanography began a long-term program using HARPs as part of a multi-disciplined 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. Deployments ended at the Onslow Bay site in 2013 but continue at the other locations (**Figure 59**). The primary objective of deployments at all locations has been to determine species distribution and document patterns of cetaceans throughout areas of interest. During 2017, HARP data were collected at the Norfolk Canyon, Cape Hatteras, and JAX sites over a bandwidth from 10 Hertz (Hz) up to 160 kilohertz (kHz). Deployment details and links to available detailed analyses from all HARP deployments can be found through the HARP data explorer on the U.S. Navy's marine species monitoring program web portal.

All HARPs deployed were in medium-sized 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).

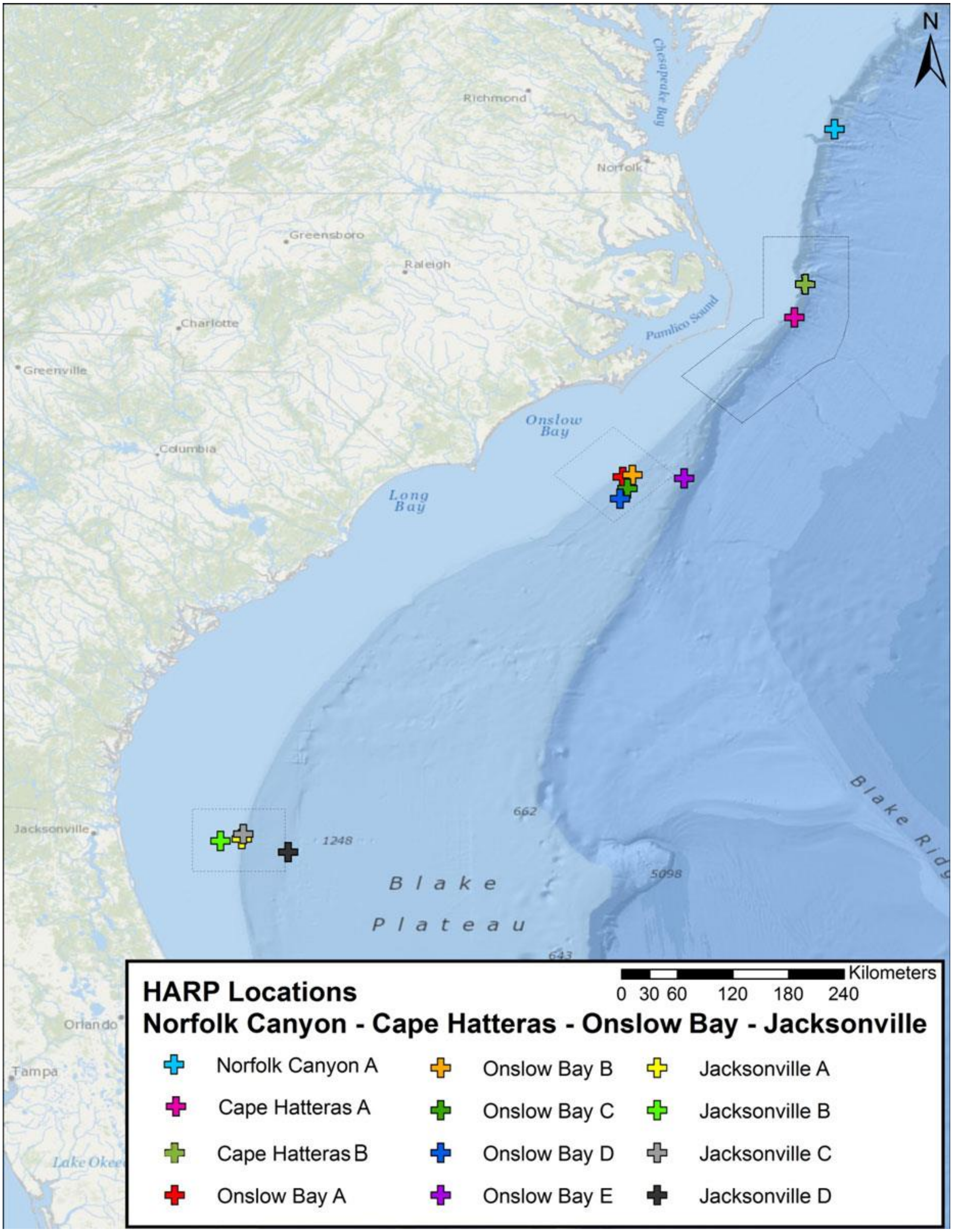

Figure 59. Location of High-frequency Acoustic Recording Package (HARPs) deployment sites in Norfolk Canyon, Cape Hatteras, Onslow Bay, and JAX, Florida.

2.4.1.1 *Norfolk Canyon*

Data Collection (Norfolk Canyon)

The HARP (NFC02A) initially deployed on 30 April 2016 near Norfolk Canyon at a depth of 968 m at 37.1652° N, 74.4666° W (Site A) was recovered on 30 June 2017 (**Table 32, Figure 59**), yielding a deployment period of over 424 days (approximately 14 months). The HARP (NFC03A) at Norfolk Canyon Site A was redeployed on 29 June 2017 at 37.1674° N, 74.4663° W at a depth of 950 m (**Table 32, Figure 59**). This instrument is still in the field and is expected to be recovered in summer 2018.

Table 32. 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

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

2.4.1.2 *Cape Hatteras*

Data Collection (Cape Hatteras)

The HARP previously deployed in April 2016 at Cape Hatteras Site A (HAT06A) recorded until February 2017, collecting 283 days of data. (**Table 33, Figure 59**). 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 a planned BRS beginning in 2017 (see section 2.3 of this report). An array of three HARPs, consisting of one single-hydrophone instrument and two four-hydrophone instruments, was deployed at Cape Hatteras site B on 9 May 2017 (**Table 33, Figure 59**). The HAT01B single-hydrophone instrument was on station until 25 October 2017 and recorded 169 days of data. The two four-hydrophone instruments were recovered on 28 June 2017 and each recorded 50 days of data.

The combination of these three instruments provides sufficient array coverage for tracking individual cetaceans; the analysis of this data will be directed at the tracking of beaked whales in coordination with BRS controlled exposure experiments. 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. A second array deployment was attempted on 29 June 2017, when the two four-channel instruments were recovered and redeployed with fresh batteries. Although both instruments were deployed successfully, after approximately a month the HAT_B#2-4C-02 instrument began transmitting with its ARGOS satellite transmitter at the surface, from a location in the central North Atlantic (33°N, 43°W). Apparently, it prematurely released its anchor weight and after returning to the surface drifted eastward in the Gulf Stream. It is unclear why the ARGOS transmitter did not send positions until the instrument was at considerable distance from shore, making recovery difficult. The instrument continues to transmit at this date (July 2018), remaining roughly stationary in the central North Atlantic gyre.

Table 33. 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	N/A	25-Oct-17	N/A	35.5835	74.7431	1,117	200 kHz	continuous

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

2.4.1.3 *Jacksonville OPAREA*

Data Collection (JAX)

The HARP (JAX13D) deployed at Site D in the JAX OPAREA in April 2016 was recovered in June 2017, having recorded continuously for 425 days. JAX14D was deployed in June 2017 at the same location and is planned for recovery in summer 2018 (**Table 34, Figure 59**).

Table 34. 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

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

For the next reporting period, Scripps Institution of Oceanography will analyze the 2017 datasets from Norfolk Canyon Site A, Cape Hatteras Site B, and JAX Site D once they are recovered in summer 2018. 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 2017, and 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 *Tursiops* Monitoring in Chesapeake Bay Near NAS Patuxent River

An aerial survey monitoring project was initiated in April 2015 (and completed in October 2017) to provide quantitative data and information on the seasonal occurrence, distribution, and density of marine mammals and sea turtles in Chesapeake Bay waters near NAS PAX (see **Section 2.1.1.5**). HDR also conducted PAM using C-PODs (Chelonia Limited, Mousehole, United Kingdom) at six locations to complement the aerial surveys by assessing the seasonality and occurrence of echolocating cetaceans (primarily common bottlenose dolphins) in the study area on a continuous basis through the duration of the project.

Five C-PODs were initially deployed in July 2015 and subsequently recovered/redeployed at intervals of 4 to 6 months through the duration of the project in November 2017. Deployment locations remained constant with the exception of a shift from site PAX 6 to PAX 7 in July 2016 (**Figure 60**).

During each of the deployment/recovery trips, HDR researchers maintained a visual lookout for dolphins while underway. These surveys were non-systematic and opportunistically conducted to maximize data collection while on the water. Time and weather permitting, efforts were made to obtain photographs to be used for photo-ID analysis. A collaboration was established with researchers from Georgetown University (Potomac-Chesapeake Dolphin Project), who also are conducting bottlenose dolphin surveys in the Potomac River. Photo-IDs will be made available for comparisons with HDR's bottlenose dolphin photo-ID catalog from Norfolk and Virginia Beach, Virginia (Engelhaupt et al. 2016). The photographs from the HDR catalog are also included as part of the MABDC, curated by Duke University.

Six sets of deployments (five instruments each) were made over the duration of the project (**Table 35**). C-PODs at all five locations (PAX 6 and 7 are combined to represent a Potomac River site) recorded good quality data during each deployment and were still logging data when recovered for refurbishment. The only C-POD failure was the fifth deployment at PAX 2. The memory card for this deployment became corrupted without any indication and the issue was not noticed until after the unit was retrieved. The data were sent back to Chelonia to see if they could be recovered and, unfortunately, the data were unrecoverable. When analyzing the data, the KERNO classifier was found to work better than the GENENC classifier, and the results were filtered for moderate- and high-quality click trains with specific SPLs. This step was to remove weak vessel sonar that could otherwise be misclassified as dolphins. Bottlenose dolphins were the only cetacean species detected and occurred at all deployment locations.

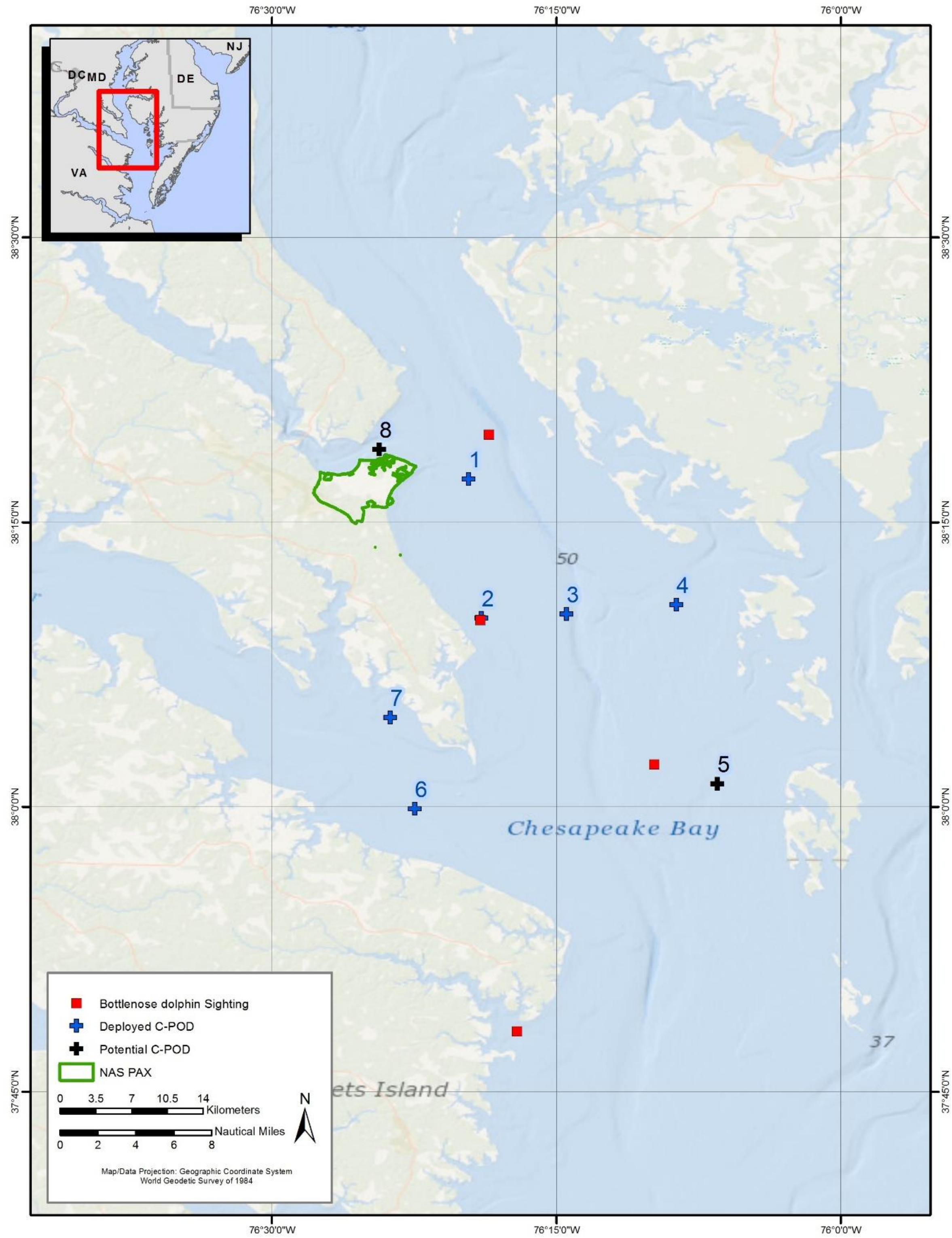

Figure 60. Locations of C-POD deployments around NAS PAX in 2016 and alternative deployment sites permitted for flexibility (black +).

Table 35. C-POD deployment summaries by site.

Site	Start	End	Logged Days	Total Dolphin DPM[1]	Total Dolphin DPD[2]	Percent DPD[3]	Percent False Positive[4]
1	07/11/2015	11/30/2017	872.08	32.61	128	14.7%	3.3%
2	07/11/2015	11/29/2017	701.03	23.93	171	24.4%	2.8%
3	07/11/2015	11/29/2017	849.3	31.50	163	19.2%	3.1%
4	07/11/2015	11/30/2017	873.65	25.69	96	11.0%	1.3%
6 & 7*	07/11/2015	11/30/2017	863.75	14.33	100	11.6%	2.0%
Total			**4159.81**	**8233**	**658**	**15.8%**	**2.6%**

[1] Detection-positive minutes (DPM) are minutes where one or more dolphin click trains have been classified in that minute.

[2] Detection-positive days (DPD) are days where one or more DPM have been recorded in that day.

[3] Percent DPD are calculated over the duration of the total recording time for each deployment.

[4] Percent False Positive is the number of false positive dolphin DPM as a percentage of total DPM

[*] Sites 6 and 7 are treated as the same location and are continuous and do not overlap.

Detection-positive minutes (DPM) are used here to quantify the number of positive detections of dolphin echolocations during each minute of analysis of CPOD data. Detection-positive days are simply the number of days where at least one DPM has been identified. Generally, over the course of the two-year study, each site had a wide range of total DPM (a proxy for dolphin occurrence and acoustic activity) as well as a range in the total DPD. Averaged across all deployments and all sites, 15.8 percent of all logged days had dolphin detections (**Table 35**). Mean DPM per day across all deployments was 1.96 (standard deviation [SD]=9.86). Very few dolphin DPM were detected in 2015; however, this was expected since the first deployment occurred in the middle of the peak season when dolphins were expected to occur in the study area, therefore limiting the amount of potential peak survey effort compared to subsequent years. Distinctive seasonal patterns can be seen at all sites, with almost all dolphin activity occurring between early April and late August; this is seen in 2016 and 2017 (**Figure 61**).

Daily activity patterns (**Figure 62**) were observed at all sites in the most active months. These patterns varied over the months and between sites, but highest activity was from approximately 20:00 until 06:00, with minimum activity around the middle of the day.

Detections from 2017 were 38% higher than 2016. In total, 38 percent more dolphin DPM were detected across all sites in 2017 than in 2016, and in both years PAX 2 had the most dolphin DPM. There were significant increases in total dolphin DPM recorded in 2017 compared to 2016 at PAX 2 (60 percent increase), PAX 4 (88 percent increase) and PAX 6/7 (145 percent increase); however, there were significant decreases in activity in 2017 at PAX 1 (50 percent decrease) and PAX 3 (20 percent decrease). Peaks in dolphin DPM per week were seen to occur 2 to 4 weeks ahead of peak mean water temperature at all sites in both 2016 and 2017 (**Figure 63**). Previous studies have demonstrated that dolphin occurrence is positively correlated with water temperature (Barco et al. 1999). The assumption is that their return to these waters in summer is related to their prey. Bottlenose dolphins along the mid-Atlantic have a diverse diet (refs), but there have been no studies of prey species in the PAX area.

For further detailed information on this project, including the aerial survey and opportunistic photo-ID components, refer to the annual progress report for this project (Richlen et al. 2018a).

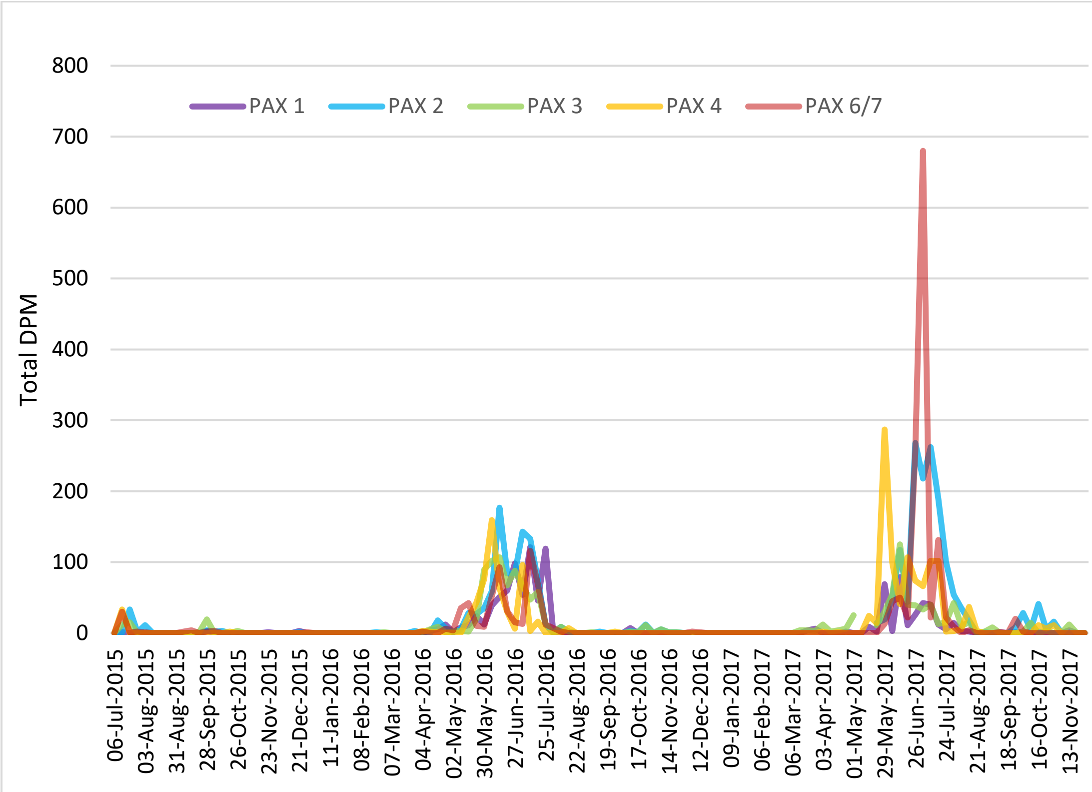

Figure 61. Weekly common bottlenose dolphin DPM for all PAX sites.

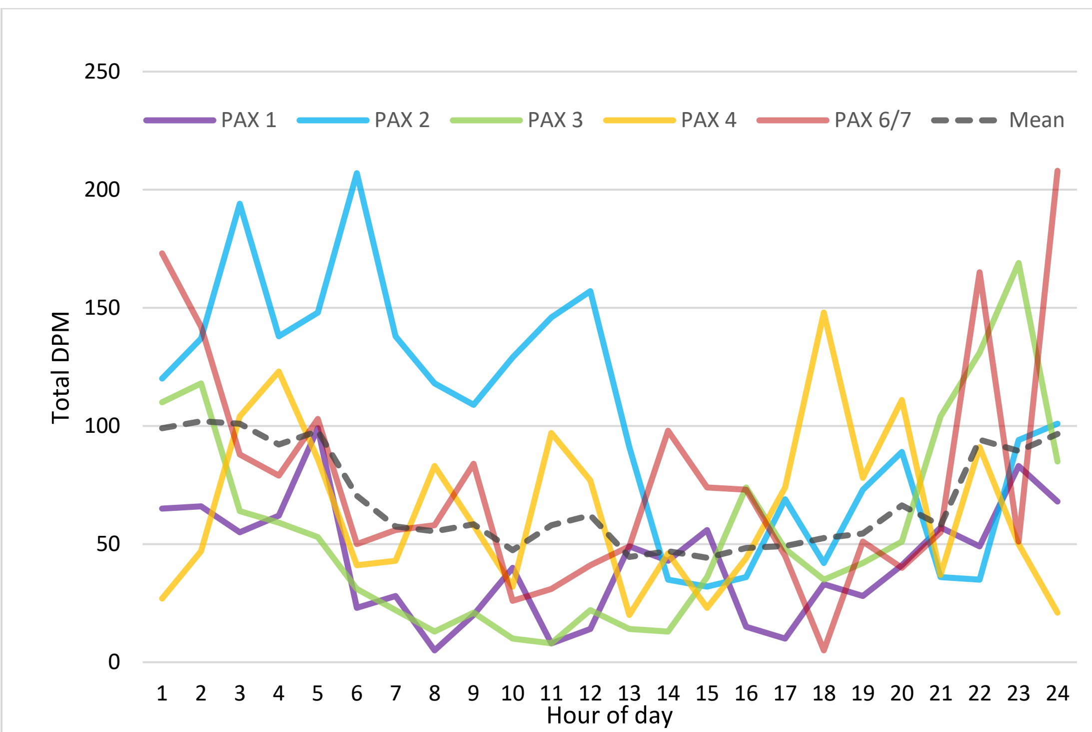

Figure 62. Hourly bottlenose dolphin DPM for all sites and all deployments. Chart starts and ends at midnight.

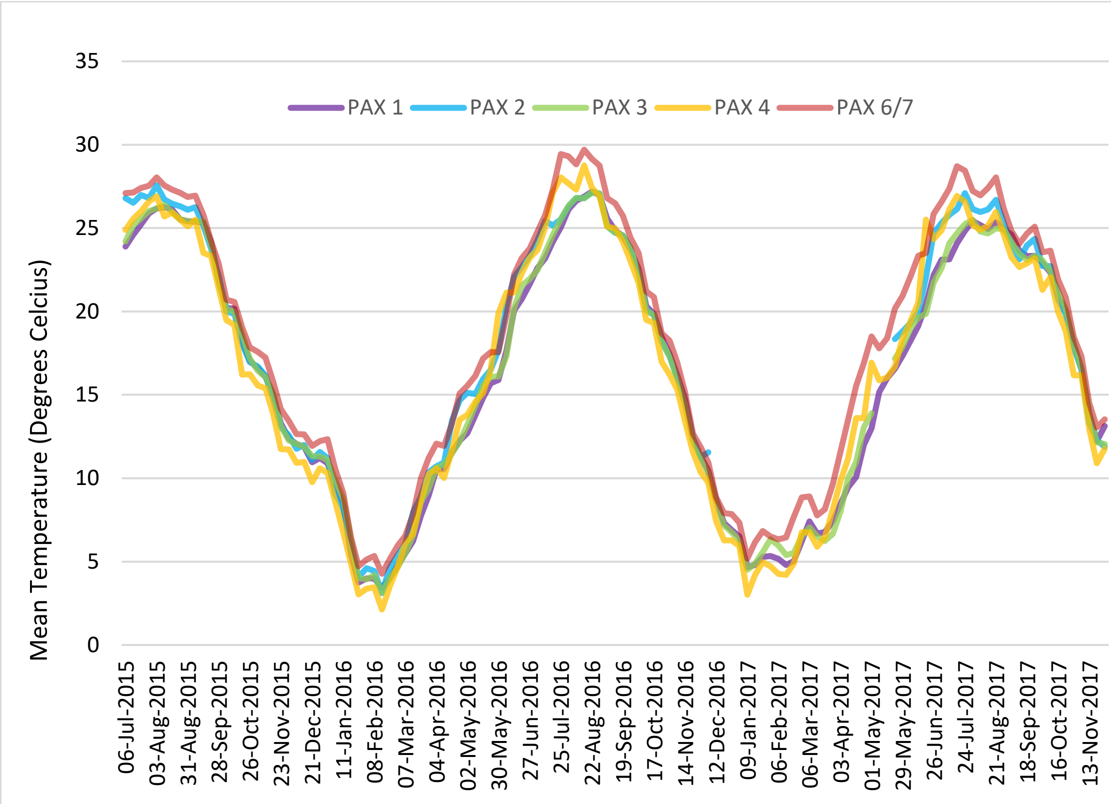

Figure 63. Weekly mean temperatures recorded by the C-PODs at each deployment location.

2.4.3 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 are currently deployed off the coast of Virginia and will be maintained for years (**Figure 64**). A combination of high-frequency AMARs, and low-frequency MARUs is deployed in two spatial configurations, with four AMARs in a linear array extending east from the mouth of the Chesapeake Bay across the continental shelf, and six MARUs deployed as a synchronized localization array within the VA WEA.

The initial deployment made in July 2015 was recovered in May 2016 and the data are currently being 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.

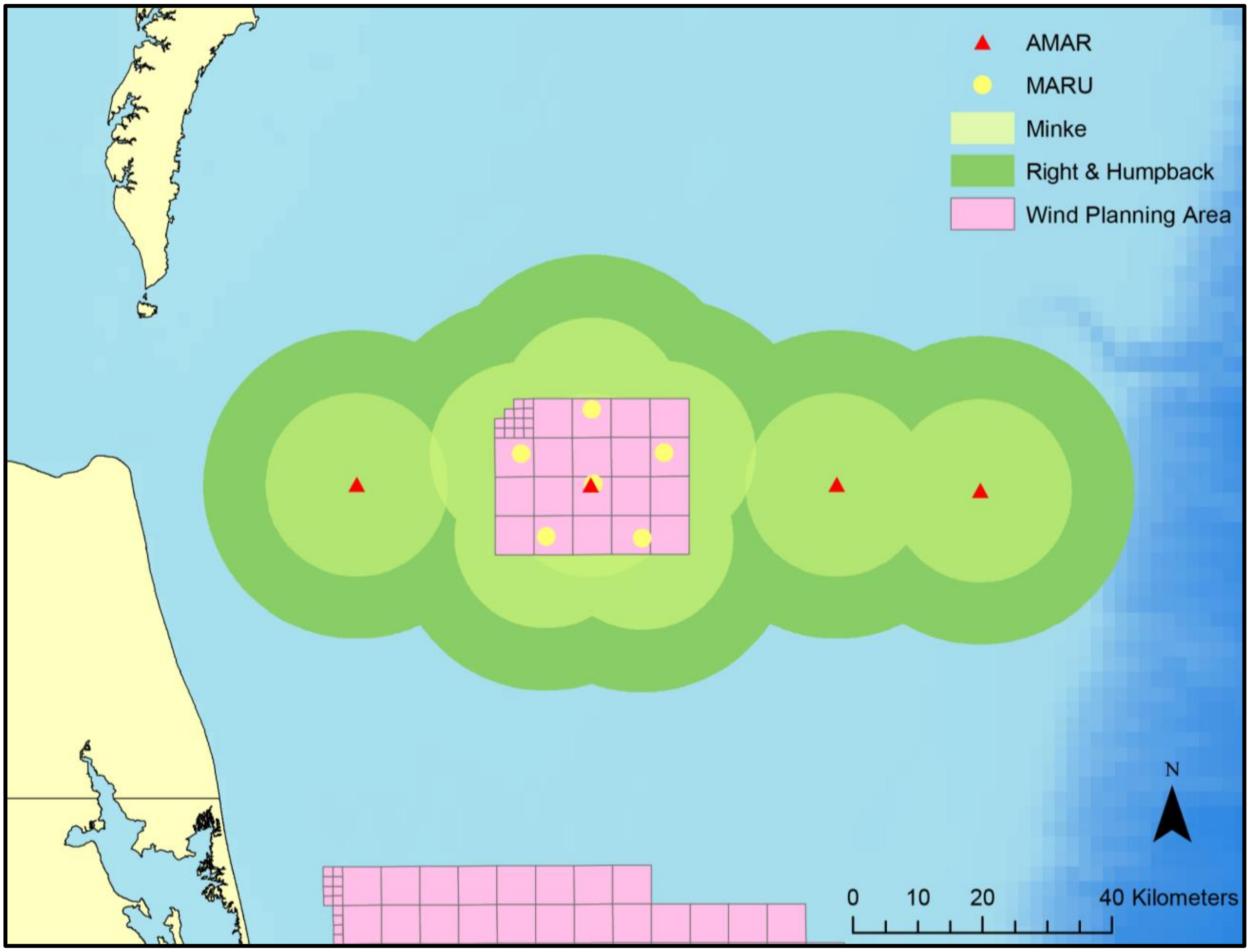

Figure 64. Map of low-frequency (MARU) and high-frequency (AMAR) passive acoustic recorders deployed across the continental shelf off the mouth of Chesapeake Bay. Green shading indicates estimated detection ranges for minke, North Atlantic right, and humpback whales.

The 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. More details on the preliminary results of the first deployment can be found in Klinck et al. (2017).

2.4.3.1 Mysticete Species and Progress to Date

Compiling preliminary results from analysis of all three AMAR transect deployments and historical MARU deployments from 2012 to 2015, shows seasonal and inter-annual variation in all four species of baleen whales (right, minke, fin, and humpback whales). Fin whales were the most commonly detected species, while minke whales were the rarest. In addition to seasonal occurrence patterns shown in right, fin, and humpback whales, inter-annual variation was present with the fall 2015–spring 2016 season showing fewer days of whale presence than the other four seasons (**Figure 65**).

The distribution of daily presence for all four whale species from the three AMAR transect deployments show differing patterns across the transect (**Figure 66**). Right whales were distributed relatively evenly, whereas minke, fin, and humpback whales showed highest proportions of daily presence on the farthest offshore AMAR. The AMAR closest to shore showed the lowest presence for all whale species.

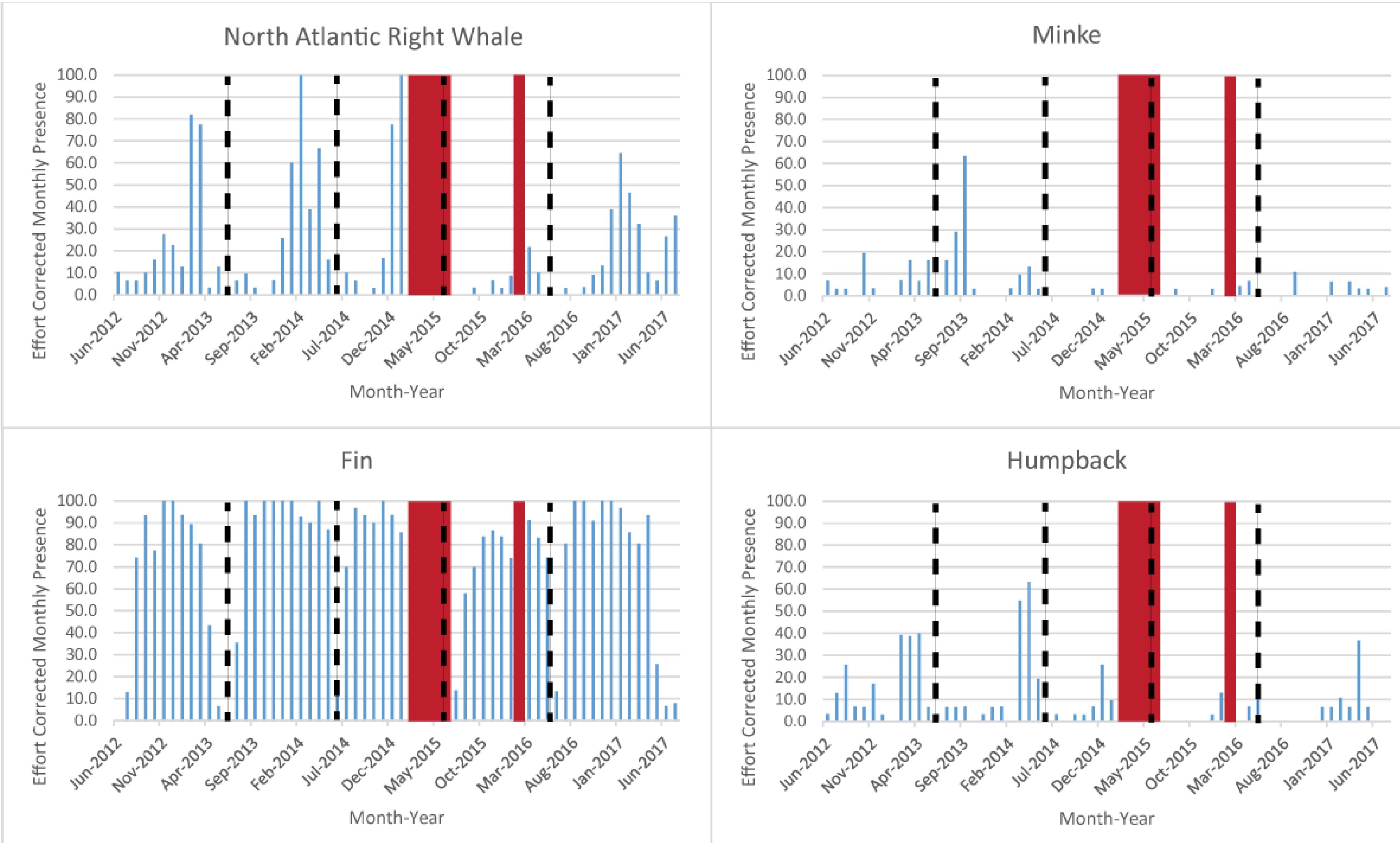

Figure 65. Average monthly presence (corrected for effort) for all four species of baleen whale from June 2012 through July 2017. The red bars show areas where no data were collected. The dotted black lines denote one year of data. Note that humpback whale analysis coverage was subsampled to 25 percent of days due to analysis time constraints. Therefore, humpback presence is considered relative and cannot be directly compared to other species.

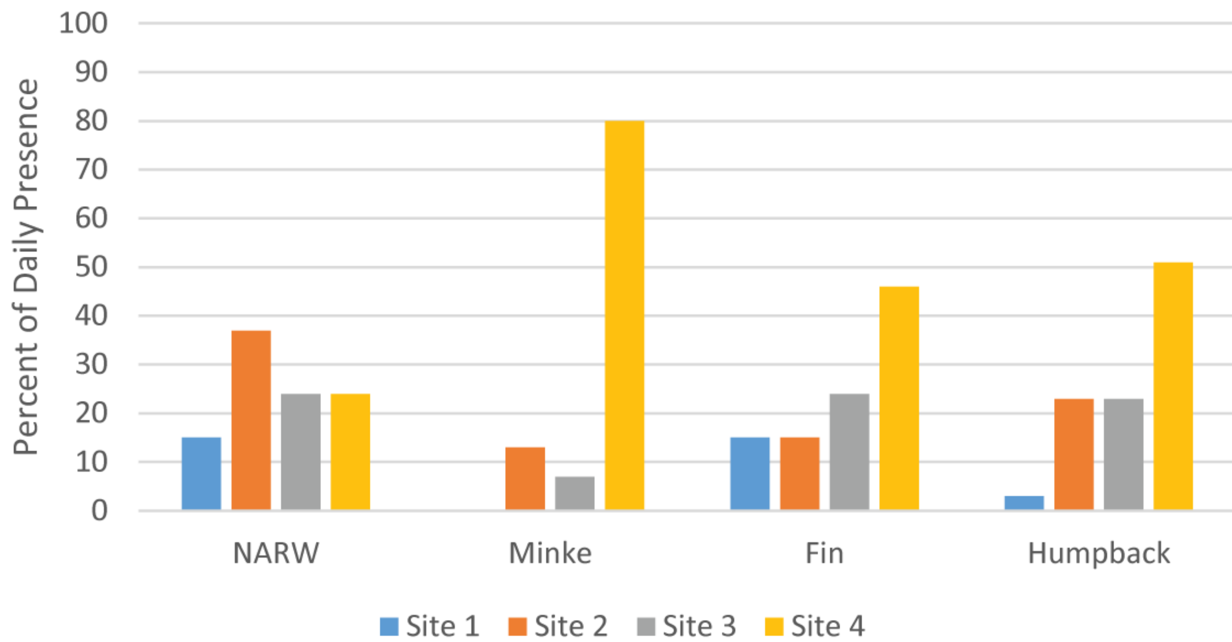

Figure 66. Percent of all daily presence of whale occurrence displayed per species per AMAR site.

2.4.3.2 *Odontocete species and Progress to Date*

The high-frequency AMAR data are being collected at a sampling rate of 375 kHz and a duty cycle of 86 sec every 685 sec. The data are being analyzed as follows:

- High-frequency odontocetes (>100 kHz). An automated click detector is being used to detect click trains of harbor porpoise and *Kogia* sp. in the data set. Every detection is visually reviewed by an analyst to confirm the detection and, if possible, to classify the signals to a species level.
- Mid-frequency odontocetes (1–100 kHz). Long-term spectral average plots with a temporal resolution of 5 sec and a frequency resolution of 200 Hz are calculated using the Triton Software Package (Scripps Whale Acoustics Lab, La Jolla, CA, USA). Data are visually and aurally inspected by experienced analysts for odontocete sounds. After initial screening, data containing odontocete whistles and clicks are analyzed using the Real-time Odontocete Call Classification Algorithm (ROCCA) software within PAMGuard to classify signals to species level (Gillespie et al. 2008). An example of an odontocete encounter is shown in **Figure 67**.

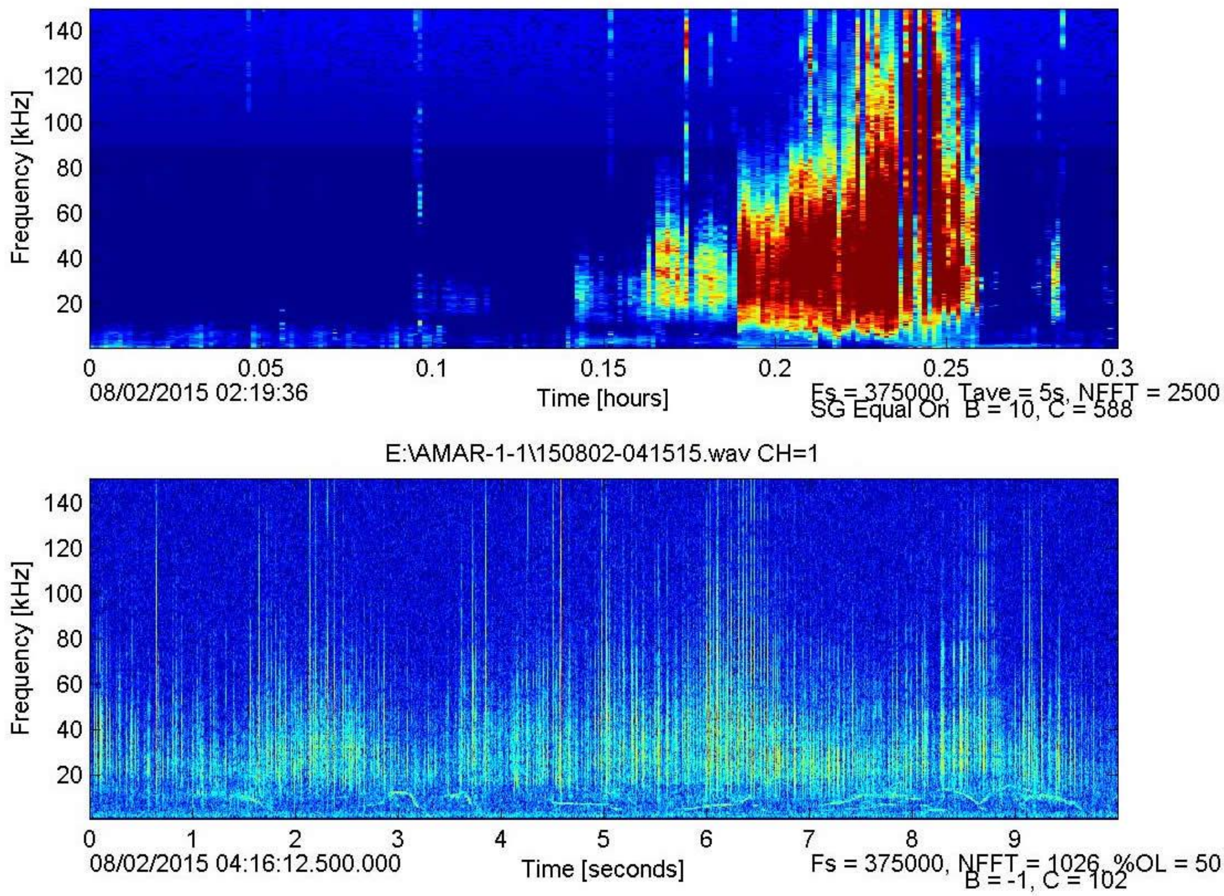

Figure 67. Long-term spectral average plot (top) indicating an odontocete encounter recorded with the inshore high-frequency recorder in August 2015. The spectrogram (bottom) shows the corresponding whistles (tonal sounds in the 10–20 kHz range) and echolocation clicks (broadband transient signals).

Preliminary results indicate a high number of odontocete encounters in the datasets with a clear inshore-offshore pattern in total number of encounters. Most encounters were registered in the inshore AMAR 1 data set (see **Figure 68**). Calling activity was higher during the summer months and lower during the winter months. The data also suggest a diel pattern in the recorded calling activity (**Figure 69**). Recorded calling rates (numbers reported in percent hours with calls) significantly increased after sunset and decreased again after sunrise.

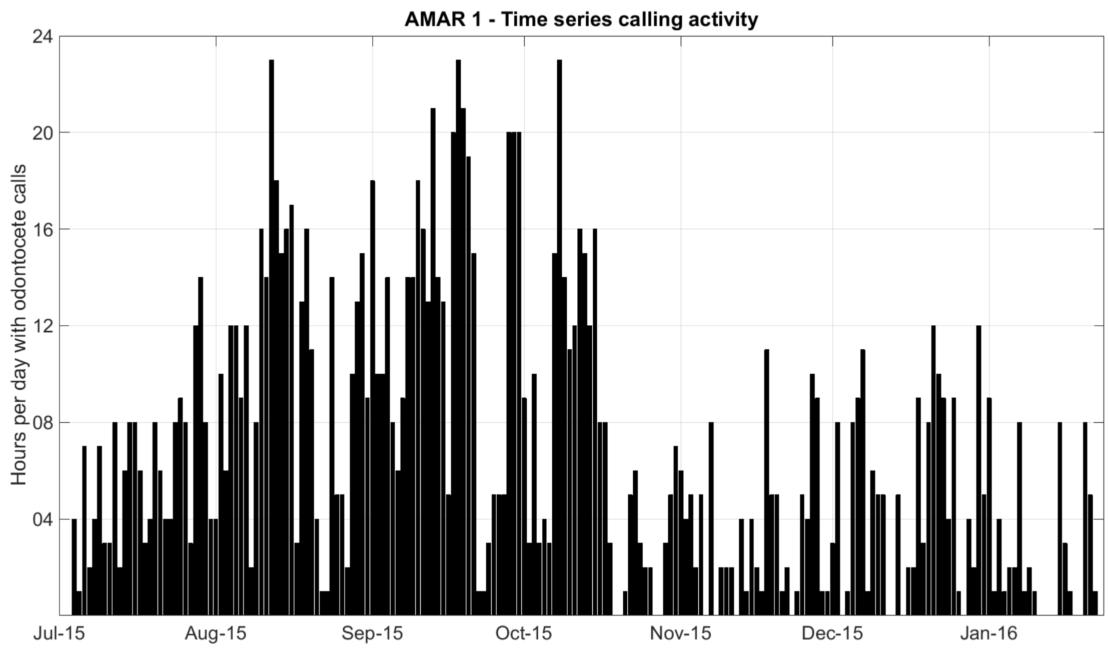

Figure 68. Time series of calling activity at location AMAR 1 between July 2015 and February 2016.

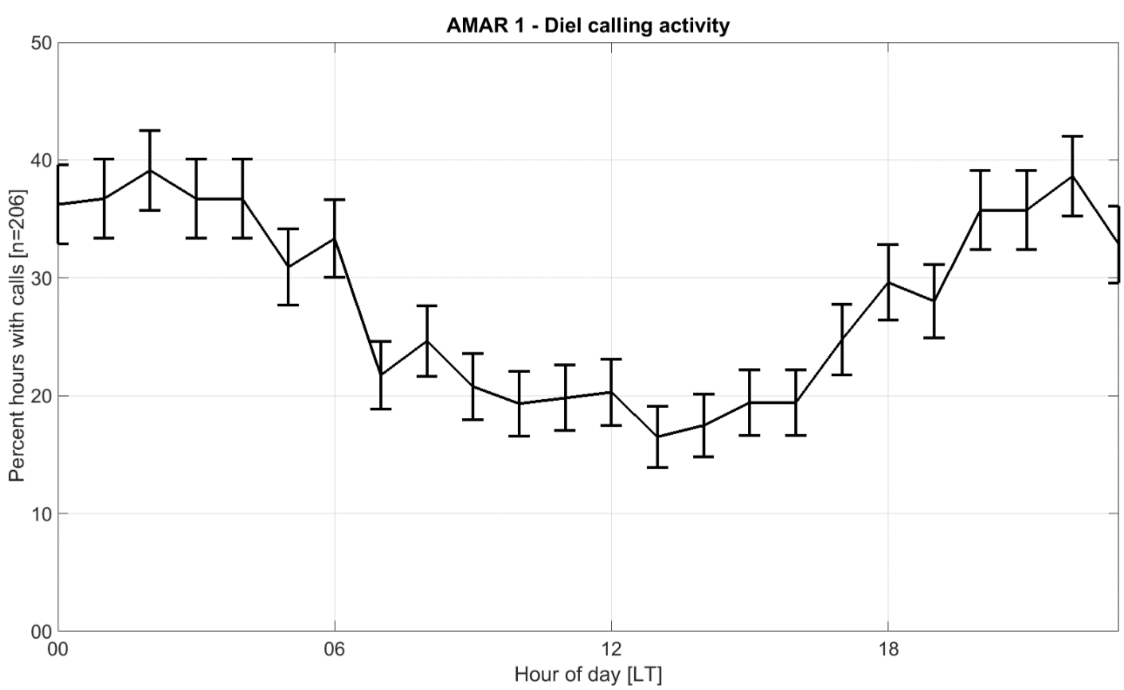

Figure 69. Diel calling activity at location AMAR 1 for the period July 2015 to February 2016.

The team is currently finishing the manual odontocete analysis, and obtained the latest version of the ROCCA classifier, which considers both signal types: clicks and whistles. ROCCA is executed through PAMGuard to detect and classify odontocete encounters in all datasets. The goal is to get some insights into odontocete species composition at each recording site. Since this analysis is somewhat slow (files are being analyzed at a speed of 5–10x real-time), this analysis is still ongoing. However, analysis should be completed in early spring 2018.

2.4.3.3 *Sonar analysis*

A wide variety of sonar signals was recorded by the AMARs during the deployment. An example is shown in **Figure 70**. A template detector was used in Raven–X (Cornell University, Ithaca, NY, USA), a MATLAB-based toolbox, to detect sonar signals in the high-frequency dataset. Data from all AMAR sites in the first 6 months of recording (deployment 1) were manually browsed and annotated for sonar events, in order to evaluate the performance (precision-recall) of the template detector. Only data from AMAR 3 were used to tune the detector and to empirically assess a suitable threshold (see **Table 36** below). Based on this analysis, it was determined that a correlation threshold between a detection and a template of >0.35 would be optimal to use for the remaining data, to significantly reduce the number of false positive detections while maintaining sufficient recall performance. The template detector was then run against AMAR sites 1, 2, and 4 to evaluate performance. The performance showed a clear inshore-offshore pattern, with more false positives occurring at site AMAR 1 (false positive rate: 3 detections per hour). The average recall and precision rates (AMARs 1, 2, and 4) were 0.77 and 0.20, respectively. The average false positive rate was 1.4 detections per hour. It should be noted that although not all individual sonar pings were detected, the detector did not miss any sonar bouts. The detector was run over all available datasets, and detections are currently being reviewed.

2.4.3.4 *Future work*

The final instrument recovery occurred in September 2017. Continued data analysis will occur during spring and summer 2018 focusing on the following major tasks:

- Explore correlations in environmental parameters, ambient noise, and oceanographic processes to the patterns of temporal occurrence and spatial distributions of baleen whales that we observed.
- Continue to determine the temporal occurrence and spatial distributions of vocalizing marine mammals (odontocetes and baleen whales) identified using a combination of automated call detection/classification software and expert human validation.
- Estimate spatial locations and movements of right whales within and near the VA WEA, using an acoustic localization array. For each right whale contact call recorded by three or more hydrophones, the location of the calling right whale will be estimated using software that computes the most likely location for the whale based on arrival time differences.
- Assess ambient sound levels throughout the VA WEA and across the continental shelf by analyzing historic and current acoustic datasets.
- Synthesize all data products to determine the potential impacts of noise generated by the construction and operation of a wind energy facility on the ecosystem.

The final cumulative technical report will be available in August 2018, and will cover details on the data collection, the baleen and odontocete acoustic data analysis, and derived results. For more information on this study, refer to the annual progress report for this project (Klinck et al. 2018).

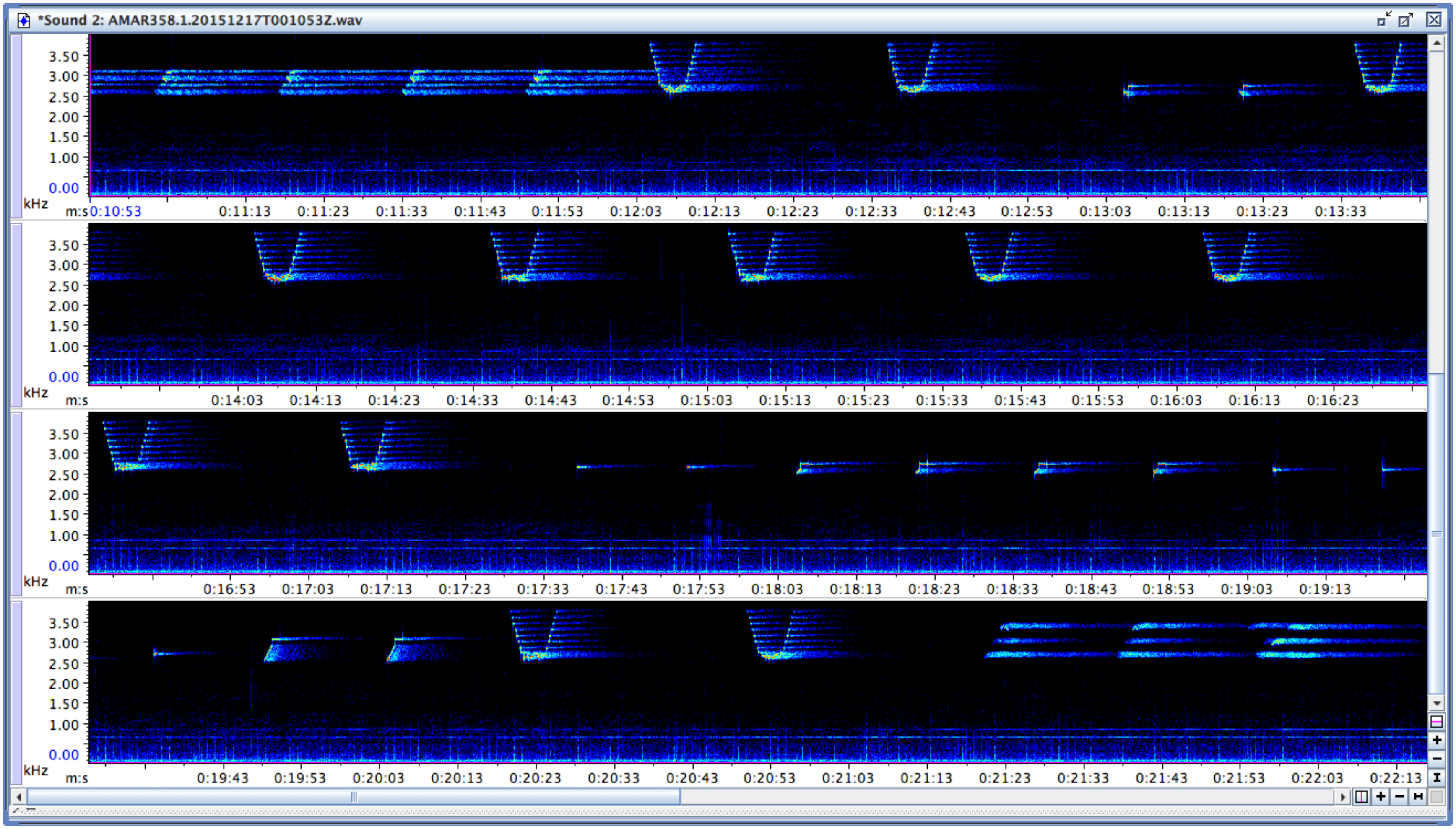

Figure 70. Example of sonar signals recorded off the Virginia coast in December 2015.

Table 36. Detector performance results for site A3 deployment 1 data. FP/hr represents the mean number of false positive detections per clock hour. TP Truth represents the number of sonar events that were detected, while FN Truth represents the number of true sonar events that were missed by the detector. Total Truth represents the number of true sonar events in the test data set. FP Test represents the number of detections that did not detect a true sonar event. The highlighted row with bold italics shows the 0.35 threshold that was used for further analysis.

Threshold	Recall	Precision	FP/hr	TP Truth	FN Truth	Total Truth	FP Test
0.2	0.941	0.007	35.83	903	57	960	175494
0.25	0.906	0.018	13.42	870	90	960	65732
0.3	0.86	0.073	2.79	826	134	960	13669
0.35	***0.805***	***0.262***	***0.53***	***773***	***187***	***960***	***2597***
0.4	0.743	0.631	0.09	713	247	960	458
0.45	0.626	0.886	0.02	601	359	960	82
0.5	0.506	0.943	0.01	486	474	960	31
0.55	0.379	0.957	0	364	596	960	17
0.6	0.278	0.958	0	267	693	960	12
0.65	0.181	0.962	0	174	786	960	7
0.7	0.118	0.95	0	113	847	960	6
0.75	0.07	0.957	0	67	893	960	3
0.8	0.04	0.974	0	38	922	960	1
0.85	0.018	0.944	0	17	943	960	1
0.9	0.007	0.875	0	7	953	960	1
0.95	0.002	0.667	0	2	958	960	1

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

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 71**). Each data-collection scenario will use some subset of fields specified in the U.S. Navy's MSM Data Standard.

3.2.1.1 *COMPASS Overview*

The mobile application ("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 72**). 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.

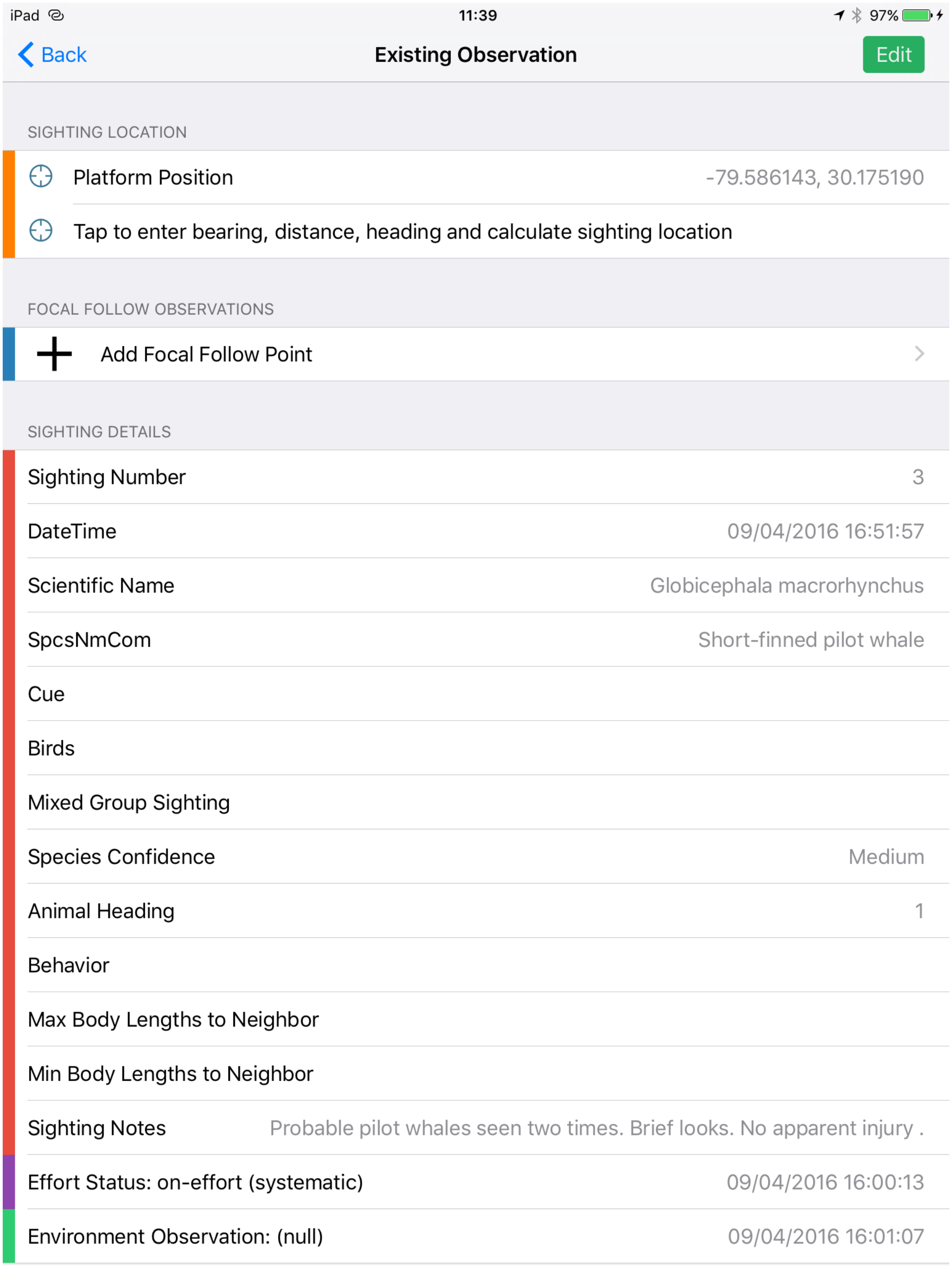

Figure 71. Screenshot of the *COMPASS* field app showing data entry fields for an observation.

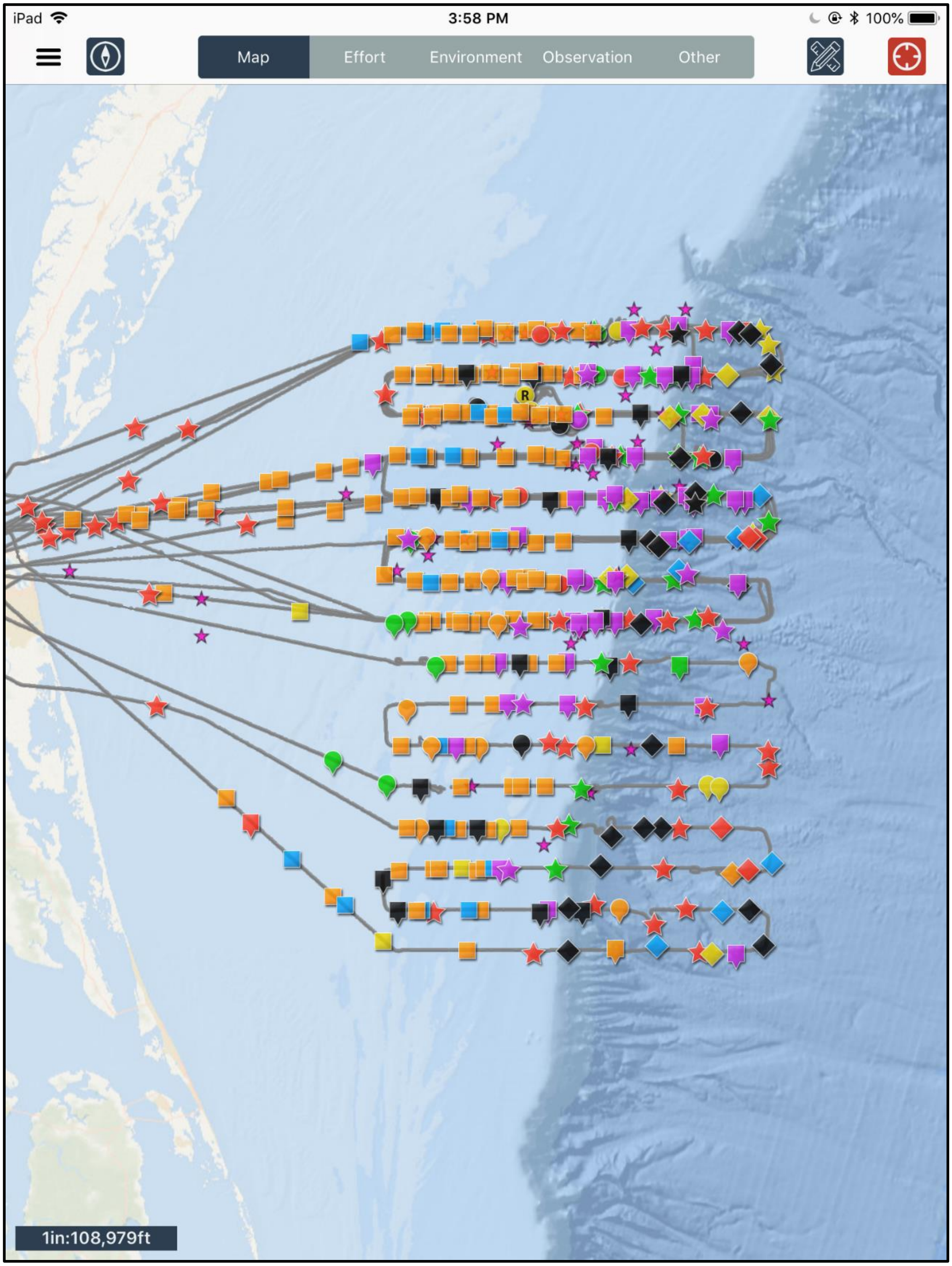

Figure 72. Screenshot from *COMPASS* field app showing the tracklines and sightings made during aerial survey efforts supporting the Norfolk Canyon project. Different custom symbols indicate sightings, symbols with 'R' indicate resightings, and gray lines are the survey tracklines flown.

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.

3.2.1.2 *Progress and Future Development*

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 symbology for map production, and many specific user requests 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 73**), 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 photographic identification, 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.

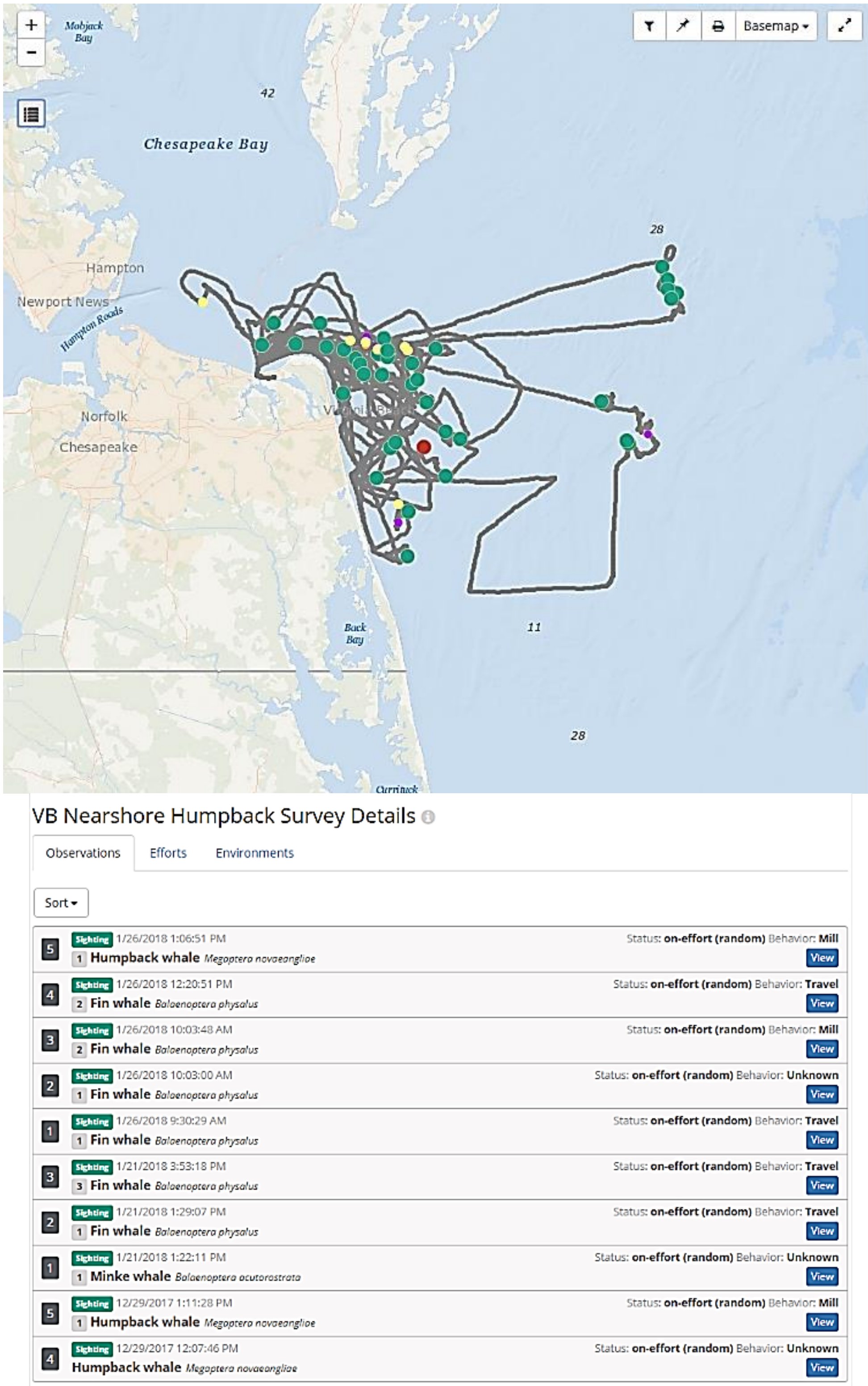

Figure 73. Screenshot from *COMPASS* web portal. The window on top shows survey track and sighting data from a coastal vessel survey, and the bottom shows sighting details for quality assurance and QC of data. Colored dots indicate protected species sightings and re-sighting information, and the gray lines are the survey tracklines.

HDR was also able to trial *COMPASS* on the 2017 NOAA Pacific Islands Fisheries Science Center Hawaiian Islands Cetacean and Ecology Assessment Survey (HICEAS). This project is a large-scale ship survey to determine the abundance and density of cetaceans and seabirds around the Hawaii Exclusive Economic Zone. This opportunity was beneficial for validating the ability of *COMPASS* to plot "big-eye" sightings and collect sighting information alongside *WinCruz*, a proven survey software. *COMPASS* performed as expected, and a number of suggested upgrades and updates were noted for future development and improved applicability for large-scale ship surveys.

While the primary development of both the data-collection app for field survey types and the web portal is complete, the user functionality needs and upgrades are being documented for future modifications and updates. Future versions of *COMPASS* will aim to support a networked version that enables multiple platforms and survey types (shore station, vessel, and aerial) to collect simultaneous data to be synchronized with the same project database. This will be particularly useful for ship shock monitoring so sighting information can be sent real-time via a mesh network to other devices without needing to push the data manually. Theodolite-survey capability is also being finalized and prepared for field trials. User guides have been generated for *COMPASS* and will be updated appropriately as functionality and user input increase.

For more information, refer to the annual progress report for this project (Richlen et al. 2018b).

3.3 Data Archiving and Access

All survey data collected under the U.S. Navy MSM program are provided to the Navy's Environmental Information Management System (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 Navy Marine Species Density Database (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, and seabird 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 2017, new datasets were submitted to OBIS-SEAMAP from seven projects in the Atlantic, Pacific, Mediterranean, and Arctic oceans. In addition, 22 datasets previously submitted to OBIS-SEAMAP were updated, refined, or expanded.

In addition to survey data, animal telemetry data collected from tagging 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: https://www.navymarinespeciesmonitoring.us/data-access1/tagging-data/.

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 as a result 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) to facilitate the U.S. Navy in developing specific projects addressing one or more intermediate scientific objectives; 2) to 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) to maximize the opportunity for input and involvement across the research community, academia, and industry. Furthermore, this process is designed to integrate various elements including:

- 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 37** summarizes U.S. Navy MSM projects currently underway in the Atlantic for 2017. 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 37. Summary of monitoring projects underway in the Atlantic for 2018.

Project Description	Intermediate Scientific Objectives	Status
Title: Tagging and Tracking of Endangered North Atlantic Right Whales in Florida Waters **Location**: JAX Range Complex **Objectives**: Assess movement patterns of right whales in coastal waters off Florida, rates of travel of individual whales, dive depths, and rates of sound production **Methods**: Observational methods combined with short-term (ca. 24 hr) non-invasive suction cup attached multi-sensor acoustic recording tags with Fastloc® GPS **Performing Organizations**: Duke University, Syracuse University **Timeline**: 2014 through 2017 **Funding**: FY13 - $335K, FY14 - $390K, FY15 - $505K, FY16 - $390K, FY17 - $278K	• 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 - winters 2014–2018** • Technical progress reports available – 2014–2017 • 2017/18 autonomous glider deployment 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 **Timeline**: 2013 through 2017 **Funding**: FY13 - $180K, FY14 - $195K, FY15 - $70K, FY16 - $183K, FY17 - $103K	• 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 summers 2013–2018** • Technical progress reports available – 2013–2017 • Loggerhead analysis complete
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 – transition to 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	**2017 transition to Atlantic BRS** **Field work spring/summer 2013–2017** • Technical progress reports available – 2013–2017

Project Description	Intermediate Scientific Objectives	Status
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 **Timeline**: 2017–2020 **Funding**: FY16 – $35K, FY17 – $1.4M	• Evaluate behavioral responses by marine mammals exposed to Navy training and testing activities	**Field work began spring/fall 2017** • Initial field sessions May and Sept 2017 • Technical progress reports available - 2018
Title: NAS Patuxent River Marine Species Surveys **Location**: Chesapeake Bay (NAS Patuxent River) **Objectives**: Assess occurrence, seasonality, and abundance of *Tursiops* in the waters near NAS Patuxent River **Methods**: Aerial surveys, photo-ID, passive acoustics **Performing Organizations**: UNC Wilmington, HDR Inc. **Timeline**: 2015–2017 **Funding**: $675K	• Estimate the density of marine mammals and sea turtles in Navy range complexes and in specific training areas • 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 and sea turtles where Navy training and testing activities occur	**Field work completed 2017** • Technical progress reports available – 2015–2017 • Final analysis in progress • Final report summer 2018
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 • Final analysis in progress

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**: Ongoing **Funding**: FY13 - $685K, FY14 - $375K, FY15 - $808K, FY16 - $368K, FY17 - $312K, FY18 - $224	• 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 sonar and underwater explosives	**Ongoing** • Current focus - Norfolk Canyon • 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**: Ongoing **Funding**: FY13 - 275K, FY14 - $350K, FY15 - $250M, FY16 - $220K, FY17 - $103K	• 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 sonar and underwater explosives	**Ongoing – transition to cetacean tagging in JAX OPAREA** • Current focus - Jacksonville USWTR • 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 mammal and sea turtle in key areas of Navy range complexes **Methods**: Passive acoustic monitoring **Performing Organizations**: Duke University, Scripps Institute of Oceanography **Timeline**: Ongoing **Funding**: FY13 - $780K, FY14 - $800K, FY15 - $680K, FY16 - $596K, FY17 - $426K	• 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 sonar and underwater explosives	**Ongoing** • Current focus – Norfolk Canyon, Hatteras, Jacksonville • Technical progress report series available
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 2019 **Funding**: FY14 - $320K, FY15 - 260K, FY16 - $370K, FY17 - $325K	• 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 2015-19** • First field season winter 2015 • Satellite tagging component added 2015/16 field season • Technical progress reports available – 2014–18
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 through 2019 **Funding**: FY15 - $75K; FY16 - $645K	• 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 2016-19** • Pilot project initiated 2015 • Technical progress reports available - 2016–2017

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**: Ongoing **Funding**: FY15 - $52K, FY16 - $57K, FY17 - $7K	• 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	**New start winter 2014-15** • 2015–17 progress report available
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 **Timeline**: 2017-2019 **Funding**: FY16 - $40K, FY17 - $164K	• 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	**New start 2017** **Field work began winter 2018**
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	• Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur	**Technical progress reports available – 2016, 2017** **Stakeholder workshop report available**

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SECTION 5 – REFERENCES

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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

Ampela, K., J. Aschettino, A. Balla-Holden, J. Bell, A. Burvall, M. Cooper, J. Crain, M. Davis, A. DiMatteo, D. Engelhaupt, P. Hille, G. Miller-Francisco, M. Richie, M. Richlen, N. Stadille, and R. Uyeyama. 2017. Mapping marine mammal activity in and near U.S. Navy training areas. Poster Presentation, Esri User Conference. 10-14 July 2017. San Diego, California.

Aschettino, J. M., D. Engelhaupt, A. Engelhaupt, M.F. Richlen, and J.T. Bell. 2017. Humpback whale affinity for shipping channels near the mouth of the Chesapeake Bay can prove fatal. Abstracts, 6th International Bio-logging Science Symposium. 25-29 September 2017. Konstanz, Germany. Presentation

Bacon, C.E., M.A. Smultea, D. Fertl, B. Würsig, E.A. Burgess, and S. Hawks-Johnson. 2017. Mixed-species associations of marine mammals in the Southern California Bight, with emphasis on Risso's dolphins (*Grampus griseus*). Aquatic Mammals 43:177-184.

Davis, G. J. Gurnee, M. Baumgartner, D. Cholewiak, and S. Van Parijs. Tracking changes in movement patterns and occurrence in four baleen whale species from 2004 to 2016 throughout the western North Atlantic Ocean using passive acoustics. Presented at the 22nd Biennial Conference on the Biology of Marine Mammals, Halifax, Nova Scotia, November 2017.

Balmer B., S. Watwood, T. Speakman, B. Quigley, K. Barry, J. Bolton, K. Mullin, P. Rosel, C. Sinclair, G. Ylitalo, E. Zolman, and L. Schwacke. Common bottlenose dolphin occurrence in St. Andrew Bay, Florida, U.S .A. and coastal waters near the Naval Surface Warfare Center, Panama City Division Testing Range. Poster presented at the 22nd Biennial Conference on the Biology of Marine Mammals, Halifax, Nova Scotia, November 2017.

Becker, E., K.A. Forney, B.J. Thayre, A.J. Debich, G.S. Campbell, K. Whitaker, A.B. Douglas, A. Gilles, R. Hoopes, and J.A.Hildebrand. 2017. Habitat-based density models for three cetacean species off Southern California illustrate pronounced seasonal differences. Frontiers in Marine Science 4:121. doi: 10.3389/fmars.2017.00121.

Cummings, E., R. McAlarney, T. Keenan-Bateman, D. Pabst, J. Stanistreet, A. Read, J. Bell, and W. McLellan. 2017. Sperm whale (*Physeter macrocephalus*) presence and behavior off the mid-Atlantic states of North Carolina and Virginia from 2011 to 2016. Abstracts, SEAMAMMS (Southeast and Mid-Atlantic Marine Mammal Symposium). 7-9 April 2017. Beaufort, North Carolina.

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

Dombroski, J.R.G., S. E. Parks, and D. P. Nowacek. Out of sight: how much time do North Atlantic right whales spend within the detection range of visual surveys? Poster presented at the 22nd Biennial Conference on the Biology of Marine Mammals, Halifax, Nova Scotia, November 2017.

Engelhaupt, A., J.M. Aschettino, D. Engelhaupt, M. Richlen, and J.T. Bell. Cetacean occurrence off Virginia's outer continental shelf. Poster presented at the 22nd Biennial Conference on the Biology of Marine Mammals, Halifax, Nova Scotia, November 2017.

Engelhaupt, D., J.M. Aschettino, A. Engelhaupt, M. Richlen, and J.T. Bell. Look both ways before crossing the channel: Humpback whale affinity for shipping channels off Virginia can be lethal. Poster presented at the 22nd Biennial Conference on the Biology of Marine Mammals, Halifax, Nova Scotia, November 2017.

Foley, H. D. Anderson, R.W. Baird, Z. Swaim, D. Waples, D. Webster; J. Bell, and A. Read. Short-finned pilot whales exhibit two modes of foraging behavior along the East Coast of the United States. Presented at the 22nd Biennial Conference on the Biology of Marine Mammals, Halifax, Nova Scotia, November 2017.

Hayslip, C. L. Irvine, M. Winsor, B. Lagerquist, D. M. Palacios, and B. Mate. The effects of placement location and degree of implantation on satellite tag attachment duration for humpback whales. Poster presented at the 22nd Biennial Conference on the Biology of Marine Mammals, Halifax, Nova Scotia, November 2017.

Henderson, E.E., J. Aschettino, M. Deakos, G. Alongi, T. Leota, and D. Engelhaupt. Tracking the Offshore and Migratory Movements of Humpback Whales in Hawaii Poster presented at the 22nd Biennial Conference on the Biology of Marine Mammals, Halifax, Nova Scotia, November 2017.

Hotchkin, C.F., J. Bort Thornton, J. Gurnee, S. Van Parijs, and M. Baumgartner. Inter- and intra-analyst agreement in real-time passive acoustic monitoring: development and evaluation of analysis protocol for monitoring from autonomous platforms. Poster presented at the 22nd Biennial Conference on the Biology of Marine Mammals, Halifax, Nova Scotia, November 2017.

Irvine, L, B. Mate, D. Palacios. Characteristics of blue whale diving and feeding activity off Southern California, USA, over multiple weeks. Presented at the 22nd Biennial Conference on the Biology of Marine Mammals, Halifax, Nova Scotia, November 2017.

Jones, D. D. Rees, B. Bartlett, and L. Busch. Harbor Seals in Virginia: Evidence for a Regular, Winter Haul-out and Seasonal Site Fidelity. Poster presented at the 22nd Biennial Conference on the Biology of Marine Mammals, Halifax, Nova Scotia, November 2017.

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