Marine Species Monitoring for the U.S. Navy's Atlantic Fleet Training and Testing (AFTT) – 2019 Annual Report

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A blue whale (*Balaenoptera musculus*) off the coast of Virginia. Photographed by Mark Cotter, taken under National Marine Fisheries Service Scientific Research Permit No. 16239, issued to Dan Engelhaupt, HDR.

Cuvier's beaked whale (*Ziphius cavirostris*) surfaces off Cape Hatteras, North Carolina. Photographed by Danielle Waples, Duke University, taken under National Marine Fisheries Service General Authorization Permit Nos. 16185 and 19903, issued to Andrew Read, Duke University.

Cow and calf dwarf sperm whales (*Kogia sima*) rest on the surface of deep offshore waters off the coast of Virginia. Photographed by Todd Pusser, taken under National Marine Fisheries Service Scientific Research Permit No. 16239, issued to Dan Engelhaupt, HDR.

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ACRONYMS AND ABBREVIATIONS

AFAST	Atlantic Fleet Active Sonar Training
AFTT	Atlantic Fleet Training and Testing
AIS	Automatic Identification System
AMR	Adaptive Management Review
App	application
BRS	behavioral response study
BSS	Beaufort sea state
CBBT	Chesapeake Bay Bridge-Tunnel
CEE	controlled exposure experiment
CNO	Chief of Naval Operations
COMPASS	Cetacean Observation and Marine Protected Animal Survey Software
DMP	Data Management Plan
DTAG	digital acoustic tag
EIMS	Environmental Information Management System
ESA	Endangered Species Act
GOM	Gulf of Mexico
GPS	Global Positioning System
HARP	High-frequency Acoustic Recording Package
ICMP	Integrated Comprehensive Monitoring Program
JAX	Jacksonville (Florida)
kHz	kilohertz
km	kilometer(s)
LOA	Letter of Authorization
m	meter(s)
MAHWC	Mid-Atlantic Humpback Whale Photo-ID Catalog
MFAS	mid-frequency active sonar
MINEX	Mine-neutralization Exercise
MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act
MSM	Marine Species Monitoring
N45	Energy and Environmental Readiness Division
NAHWC	North Atlantic Humpback Whale Catalog
NARW	North Atlantic Right Whale
NMFS	National Marine Fisheries Services
NMSDD	Navy Marine Species Density Database
NOAA	National Oceanic and Atmospheric Administration
OBIS-SEAMAP	Ocean Biogeographic Information System-Spatial Ecological Analysis of Megavertebrate Populations
ONR	Office of Naval Research
OPAREA	Operating Area
PAM	passive acoustic monitoring
photo-ID	photo-identification
QC	quality control
RL	received level
R/V	research vessel
SE	standard error
SPOT	Smart Position and Temperature
U.S.	United States
USWTR	Undersea Warfare Training Range
VACAPES	Virginia Capes
VAQF	Virginia Aquarium Foundation

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 2019. The U.S. Navy conducts marine mammal and sea turtle monitoring for compliance with the Letters of Authorization (NMFS 2018a, 2019) and Biological Opinion (NMFS 2018b) issued under the Marine Mammal Protection Act of 1972 (MMPA) and the Endangered Species Act of 1973 (ESA) for training and testing in the AFTT Study Area. This report also reflects an ongoing evolution in the approach to monitoring reports for this area. Concurrent with Phase II of the U.S. Navy's Marine Species Monitoring (MSM) Program, the U.S. Navy and the National Marine Fisheries Service (NMFS) have agreed to assess compliance based on demonstrated progress towards addressing scientific objectives, rather than on specific monitoring requirements for each range complex from effort-based metrics. This report summarizes the progress, accomplishments, and results from projects being conducted in the AFTT Study Area. Additional details on each project are available in individual technical reports linked directly from the corresponding sub-section of this report.

1.1 Background

The AFTT Study Area includes only the at-sea components of the range complexes and testing ranges in the western North Atlantic Ocean and encompasses the Atlantic coast of North America and the Gulf of Mexico (GOM) (**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 2018 by NMFS for the AFTT Study Area includes terms and conditions for continued monitoring in this region (NMFS 2018b).

The U.S. Navy has invested over $37 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, and data, as well as updates on current monitoring projects and initiatives.

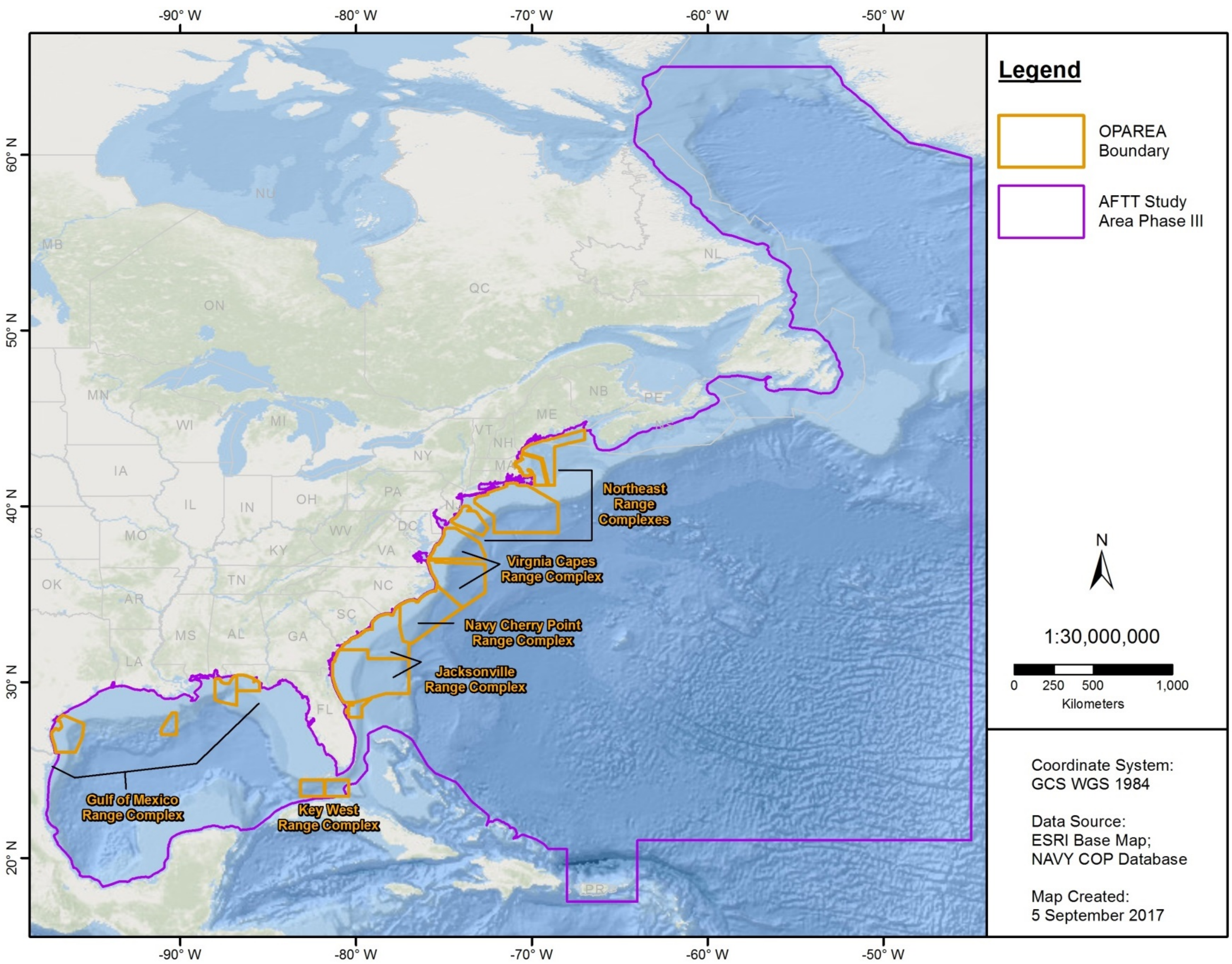

Figure 1. Atlantic Fleet Training and Testing Study Area.

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–FY19.

Fiscal Year (01 Oct–30 Sept)	Funding
2009	$1,555,000
2010	$3,768,000
2011	$2,749,000
2012	$3,483,000
2013	$3,775,000
2014	$3,311,000
2015	$3,700,000
2016	$3,845,000
2017	$3,383,000
2018	$3,476,000
2019	$4,187,000
Total	**$37,232,000**

In addition to the monitoring program supporting training and testing activities, the Office of Naval Research (ONR) Marine Mammals and Biology Program and the Office of the Chief of Naval Operations (CNO) Energy and Environmental Readiness Division's (N45) Living Marine Resources Program support coordinated Science & Technology and Research & Development programs focused on understanding the effects of sound on marine mammals, including physiological, behavioral, ecological, and population-level effects (DoN 2010a). 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 Energy, Environment, and Climate Change website.

1.2 Integrated Comprehensive Monitoring Program

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

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

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

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

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

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

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

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

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

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

1.3 Report Objectives

This report presents the progress, accomplishments, and results of MSM activities in the AFTT Study Area in 2019 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 2019, as well as analyses of monitoring data performed during this time. Detailed technical reports for these efforts are referenced throughout this report and provided as supporting documents.
2. Support the AMR process by providing an overview of monitoring initiatives, progress, and evolution of the ICMP and Strategic Planning Process for U.S. Navy marine species monitoring. These initiatives continue to shape the evolution of the U.S. Navy MSM program for 2020 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, the University of St. Andrews, and NMFS's Northeast Fisheries Science Center to conduct a pilot study and subsequently develop a survey and monitoring plan. The plan included a recommended approach for data collection at the proposed site of the Undersea Warfare Training Range (USWTR) in Onslow Bay off the coast of North Carolina. The identified methods included surveys (aerial/shipboard, frequency, spatial extent, etc.), passive acoustic monitoring (PAM), photo-identification (photo-ID), and data analysis (e.g., standard line-transect, spatial modeling) appropriate to establish a fine-scale seasonal baseline of protected marine species distribution and abundance. As a result, an MSM Program for protected species was initiated in June 2007 in Onslow Bay. Due to a re-evaluation of the proposed location for the USWTR, the preferred location was changed to the Jacksonville (JAX) OPAREA. Therefore, a parallel monitoring program was initiated in January 2009 at the proposed USWTR site in the JAX OPAREA off the coast of Jacksonville, Florida. In addition to supporting the JAX USWTR site monitoring, the program was also refined to support the monitoring requirements set forth in the Incidental Take Statements and Terms and Conditions for AFAST and the East Coast Range Complexes issued in 2009 (collectively superseded by AFTT in 2013). The baseline occurrence-monitoring program has since expanded to include a region of U.S. Navy training activity off the coast of Cape Hatteras, North Carolina, to the north (2011) as well as a study site centered on the Norfolk Canyon and shelf-break region off the mouth of the Chesapeake Bay (2015). These study areas also serve to support more recent projects involving tagging multiple species of cetaceans (Section 2.2), as well as behavioral response studies (Section 2.3). The overall approach to program design and methods has been consistent with the work that had been performed over the previous 10+ years, and work across the locations continues to evolve in response to the AMR process and changing priorities.

Although the initial intent of the Onslow Bay and JAX monitoring programs was to support development of the planned USWTR, the program evolved into established long-term study sites addressing intermediate scientific objectives within the ICMP framework for AFTT. The monitoring work at these sites provides a longitudinal baseline of data on marine species occurrence, distribution, abundance, and behavior in key U.S. Navy training areas and serves as a reference for addressing questions concerning exposure, response, and consequences. In 2019, work addressing occurrence, distribution, and population structure involved visual aerial, vessel, and shore-based surveys, as well as passive acoustic monitoring. The vessel surveys supported multi-disciplinary methods including photo identification, biopsy sampling, unmanned aerial vehicle observations, and tagging (Section 2.2). A summary of accomplishments and results of these monitoring efforts for the reporting period is presented in the following subsections.

2.1.1 Visual Methods

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. The survey area was extended north following the shelf break to include the Norfolk Canyon region in 2015 (**Figure 2**) and the Cape Hatteras study area and the Norfolk Canyon study areas were designated as unique entities in 2016. Aerial surveys in the Cape Hatteras Study area were discontinued in 2017.

The Norfolk Canyon study area consists of 16 tracklines (#46–61) (**Figure 2**) with coverage beginning in 2015. Results through September 2017 are reported in McAlarney et al., 2018. Surveys recommenced in April 2018 after a hiatus and continued through August 2019 when they were permanently discontinued; surveys covered 15 of 17 months during that period (**Table 2**). September was the only month between both years in which a survey was not flown. A total of 185 tracklines (13,364.5 kilometers [km]) was completed over 23 days. Survey conditions during the 23 days ranged from Beaufort sea state (BSS) 0 to 4, with greater than 90 percent of effort in BSS 3 or lower.

Table 2. Effort summary for aerial surveys conducted in the Norfolk Canyon study area in 2018–2019.

Month	Number of Survey Days	Tracklines Covered	Total km Flown	Total Hobbs hr [1]
January	3	24	1,766.8	15.3
February	1	8	570.4	4.8
March	2	16	1,178.8	10.0
April	3	22	1,514.5	16.9
May	1	8	554.9	6.4
June	4	32	2,300.6	22.2
July	2	16	1,173.6	11.6
August	3	24	1,718.0	19.2
October	1	11	813.0	7.5
November	1	8	590.4	4.6
December	2	16	1,183.5	9.4
Total	**23**	**185**	**13,364.5**	**127.9**

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

There were 490 on-effort sightings of 19,498 individual cetaceans representing 16 species, and additional 90 off-effort cetacean sightings were recorded (**Table 3, Figure 3**). 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 logged as off-effort. If two species were seen associated with the same sighting cue, both were considered to be on-effort.

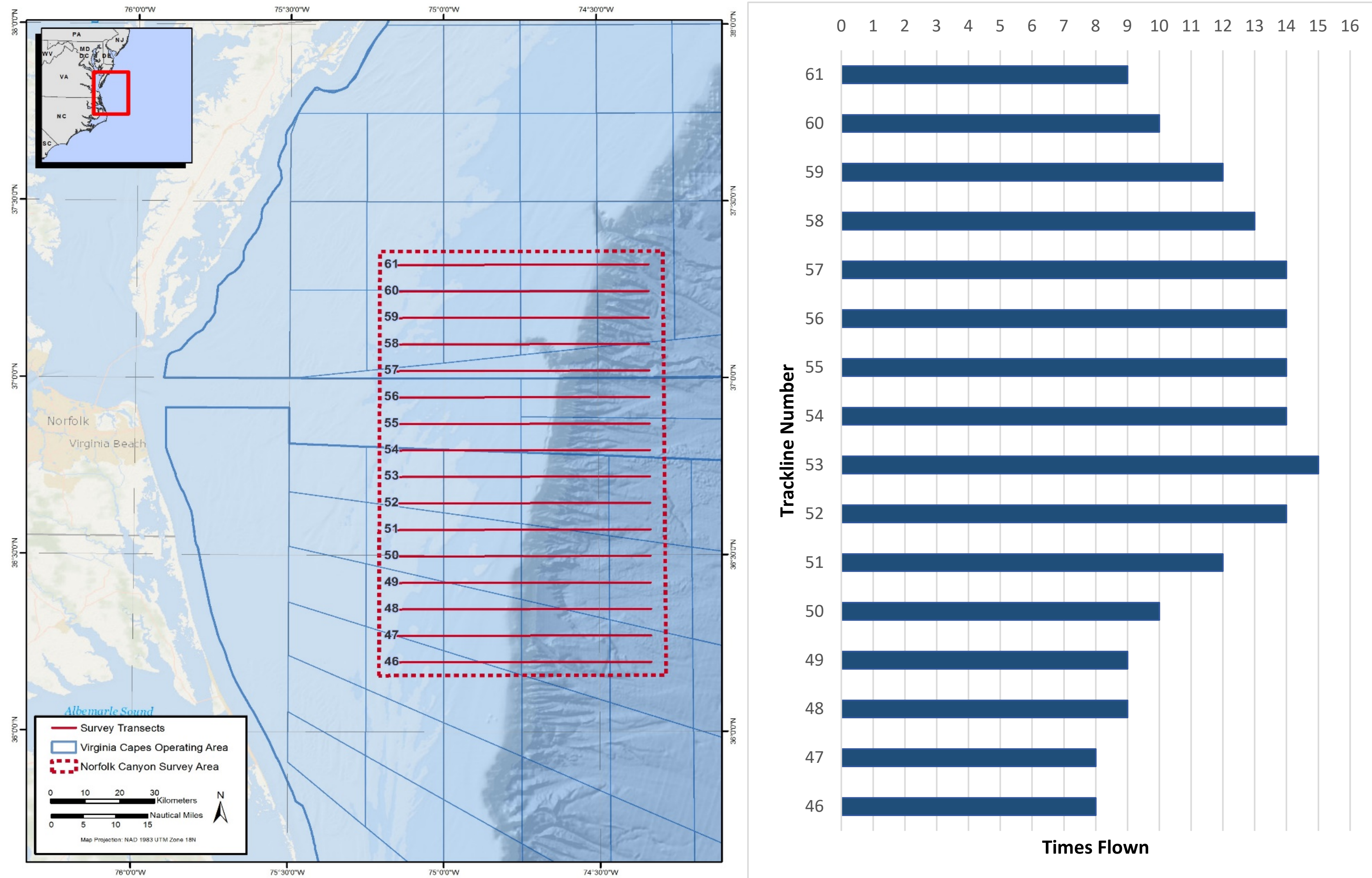

Figure 2. Established tracklines and realized survey effort in the Norfolk Canyon study area for 2018–2019.

Table 3. Sightings from aerial surveys conducted in the Norfolk Canyon survey area in 2018–2019.

Common Name	Scientific Name	On-effort		Off-effort	
		Sightings	Individuals	Sightings	Individuals
Common dolphin	*Delphinus delphis*	59	11,103	7	307
Common bottlenose dolphin	*Tursiops truncatus*	147	2,519	44	855
Atlantic spotted dolphin	*Stenella frontalis*	22	1,874	2	210
Risso's dolphin	*Grampus griseus*	44	1,062	4	43
Striped dolphin	*Stenella coeruleoalba*	17	1,235	1	400
Short-finned pilot whale	*Globicephala macrorhynchus*	94	1,297	4	45
Sperm whale	*Physeter macrocephalus*	22	61	2	2
True's beaked whale	*Mesoplodon mirus*	1	5	-	-
Sowerby's beaked whale	*Mesoplodon bidens*	1	4	-	-
Pygmy or dwarf sperm whale	*Kogia* sp.	10	17	1	1
North Atlantic right whale	*Eubalaena glacialis*	2	8	-	-
Sei whale	*Balaenoptera borealis*	3	4	-	-
Minke whale	*Balaenoptera acutorostrata*	4	4	2	2
Fin whale	*Balaenoptera physalus*	25	57	2	2
Humpback whale	*Megaptera novaeangliae*	9	22	8	9
Blue whale	*Balaenoptera musculus*	1	1	-	-
Unidentified beaked whale	n/a	5	9	2	4
Unidentified small whale	n/a	1	2	-	-
Unidentified large whale	n/a	6	6	1	1
Unidentified dolphin	n/a	12	198	8	228
Unidentified cetacean	n/a	5	10	2	5
Loggerhead sea turtle	*Caretta caretta*	327	1,387	42	115
Kemp's ridley sea turtle	*Lepidochelys kempii*	25	49	4	13
Leatherback sea turtle	*Dermochelys coriacea*	34	36	6	6
Unidentified hardshell turtle	n/a	21	24	-	-
Whale shark	*Rhincodon typus*	1	1	-	-
Basking shark	*Cetorhinus maximus*	8	16	1	1
Hammerhead shark	*Sphyrna sp.*	34	99	1	4
Blue shark	*Prionace glauca*	1	3	-	-
Great white shark	*Carcharodon carcharias*	1	1	-	-
Unidentified shark	n/a	11	15	1	1
Manta ray	*Mobula birostris*	4	4	-	-
Giant devil ray	*Mobula mobular*	2	2	-	-
Chilean devil ray	*Mobula tarapacana*	67	183	4	6
Cownose ray	*Rhinoptera bonasus*	23	15,610	2	51
Large black and white mobulid	n/a	4	5	1	1
Ocean sunfish	*Mola sp.*	221	275	13	17

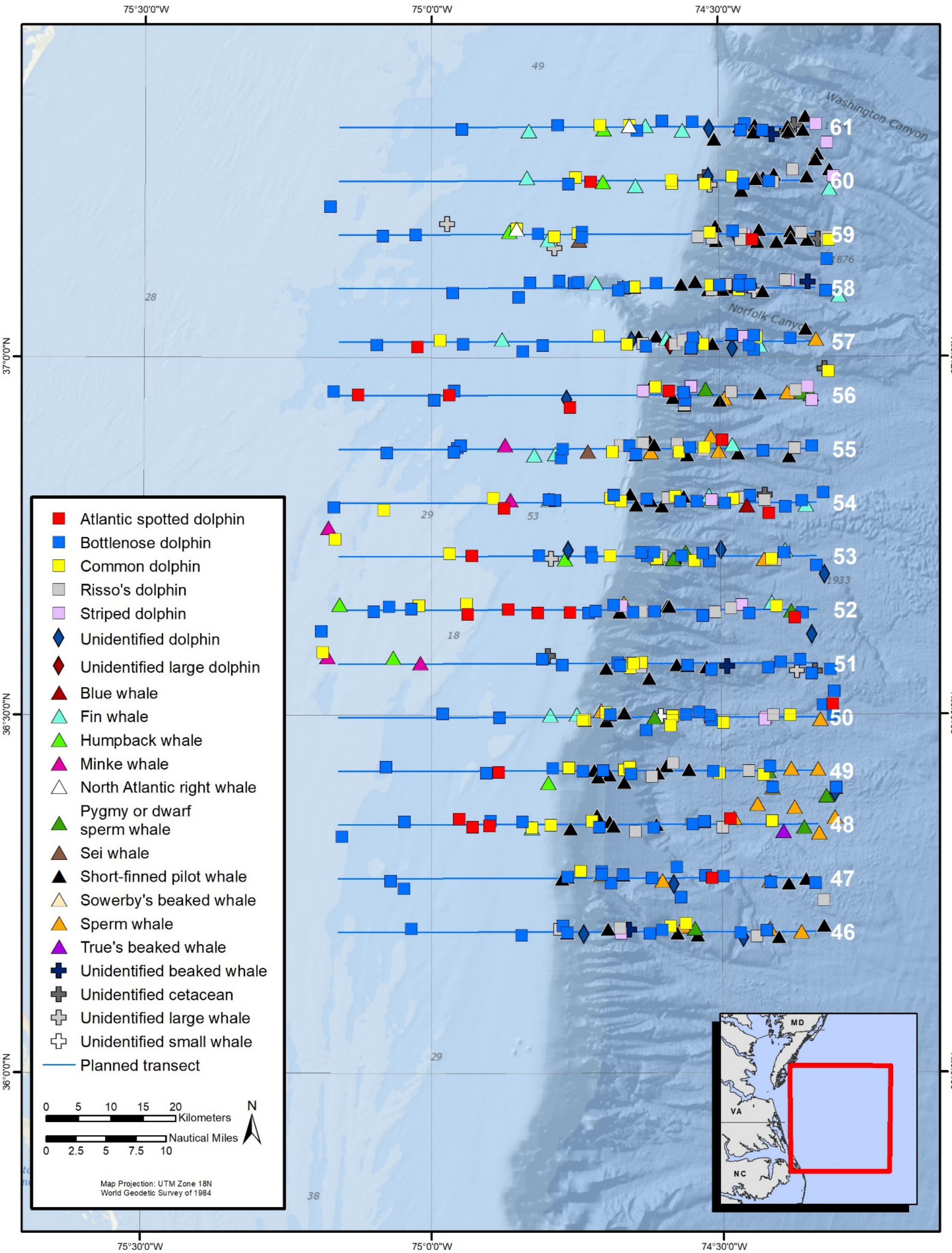

Figure 3. All cetacean sightings recorded in the Norfolk Canyon study area in 2018–2019.

There were 407 on-effort sightings, totaling 1,496 individuals, of three sea turtle species during the study (**Table 3, Figure 4**). Loggerhead turtles (*Caretta caretta*) represented the majority (92.7 percent) of total sea turtles sighted. Almost all sea turtle sightings were over the continental shelf inshore of the 80-meter (m) isobath. The other two sea turtle species identified in the Norfolk Canyon survey area were Kemp's ridley (*Lepidochelys kempii,* 3.3 percent of total sea turtles sighted) and leatherback turtles (*Dermochelys coriacea*; 2.4 percent of total sea turtles sighted). Unidentified hardshell turtles represented 1.6 percent of total sea turtles recorded. Almost all Kemp's ridley turtles were recorded inshore of the 40 m isobath. Leatherback turtles exhibited a similar distribution to Kemp's ridley, seen almost exclusively inshore of the 40 m isobath. Eighty-eight percent of all (both on- and off-effort) sea turtle sightings occurred in the months of May through August.

In addition to cetaceans and sea turtles, other pelagic marine vertebrates were observed and recorded (**Table 3**, **Figure 5**). One hundred forty sharks were recorded during the reporting period, and 103 of them could be identified as hammerhead sharks (*Sphyrna* sp.) based on head shape. The remaining 37 sharks were identified as basking sharks (*Cetorhinus maximus; n*=17), blue sharks (*Prionace glauca*; *n*=3), a whale shark (*Rhincodon typus*; *n*=1), a white shark (*Carcharodon carcharias*; *n*=1), or unidentified sharks (*n*=15). The basking sharks were all recorded during the months of January–April, in both shallow and deep waters. The April 2018 sightings coincided with a large aggregation of copepod- and krill-feeding baleen whales, including endangered species such as sei, fin, and North Atlantic right whales (NARW).

Four species of rays were identified to species: manta ray (*Mobula birostris*; *n*=4), giant devil ray (*Mobula mobular*; *n*=2), Chilean devil ray (*Mobula tarapacana; n*=188) and cownose ray (*Rhinoptera bonasus*; *n*=15,661). There were also 5 sightings of 6 individual rays that were classified as "large black and white mobulids" since they could not be identified to species level. In addition, 371 ocean sunfish (*Mola* sp.) were recorded (combined on- and off-effort sightings), with the majority distributed on either side of the shelf break throughout the study area.

For more information on this project, please refer to the final report for this project (Cotter 2019).

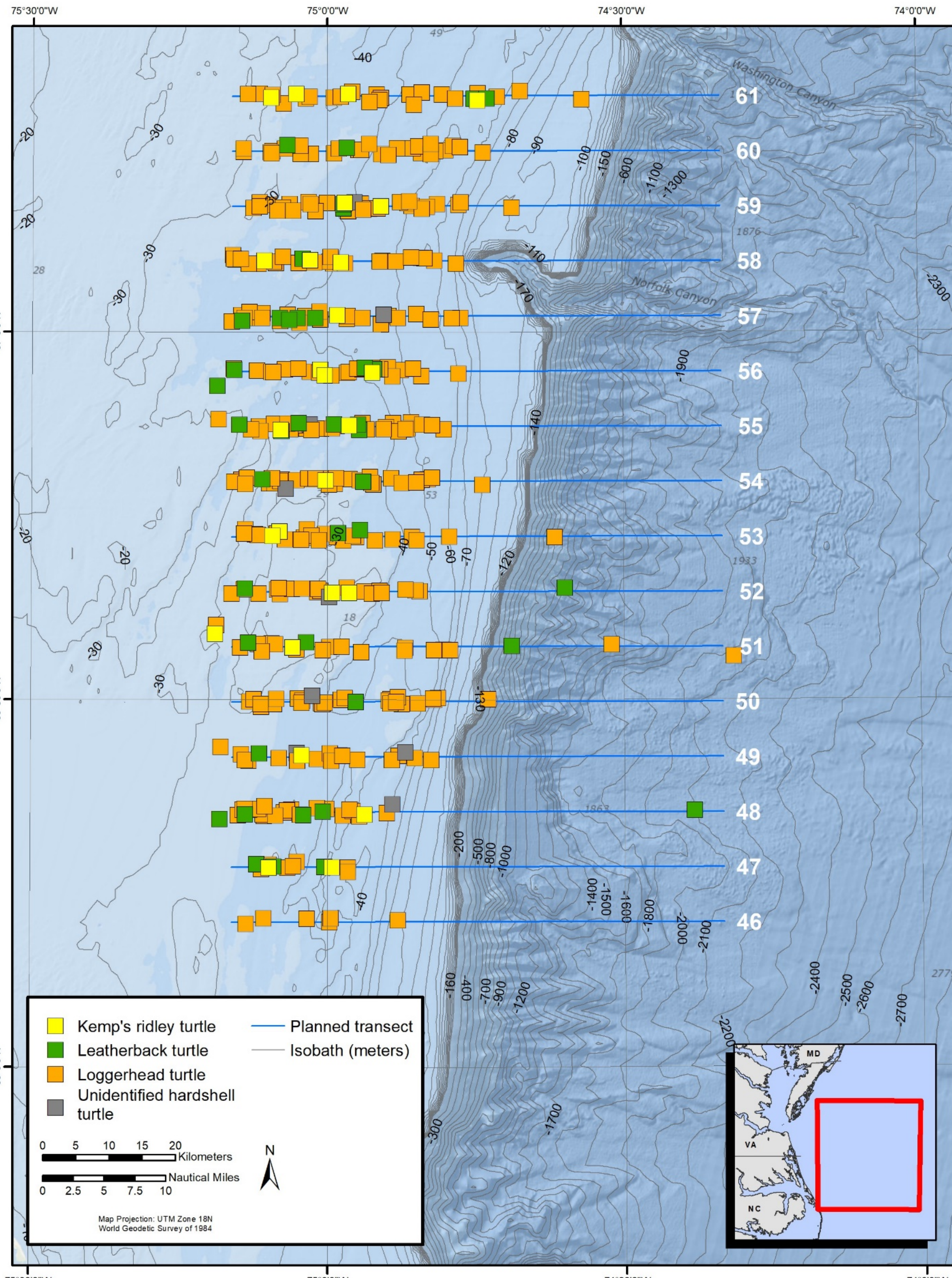

Figure 4. All sea turtle sightings recorded in the Norfolk Canyon study area in 2018–2019.

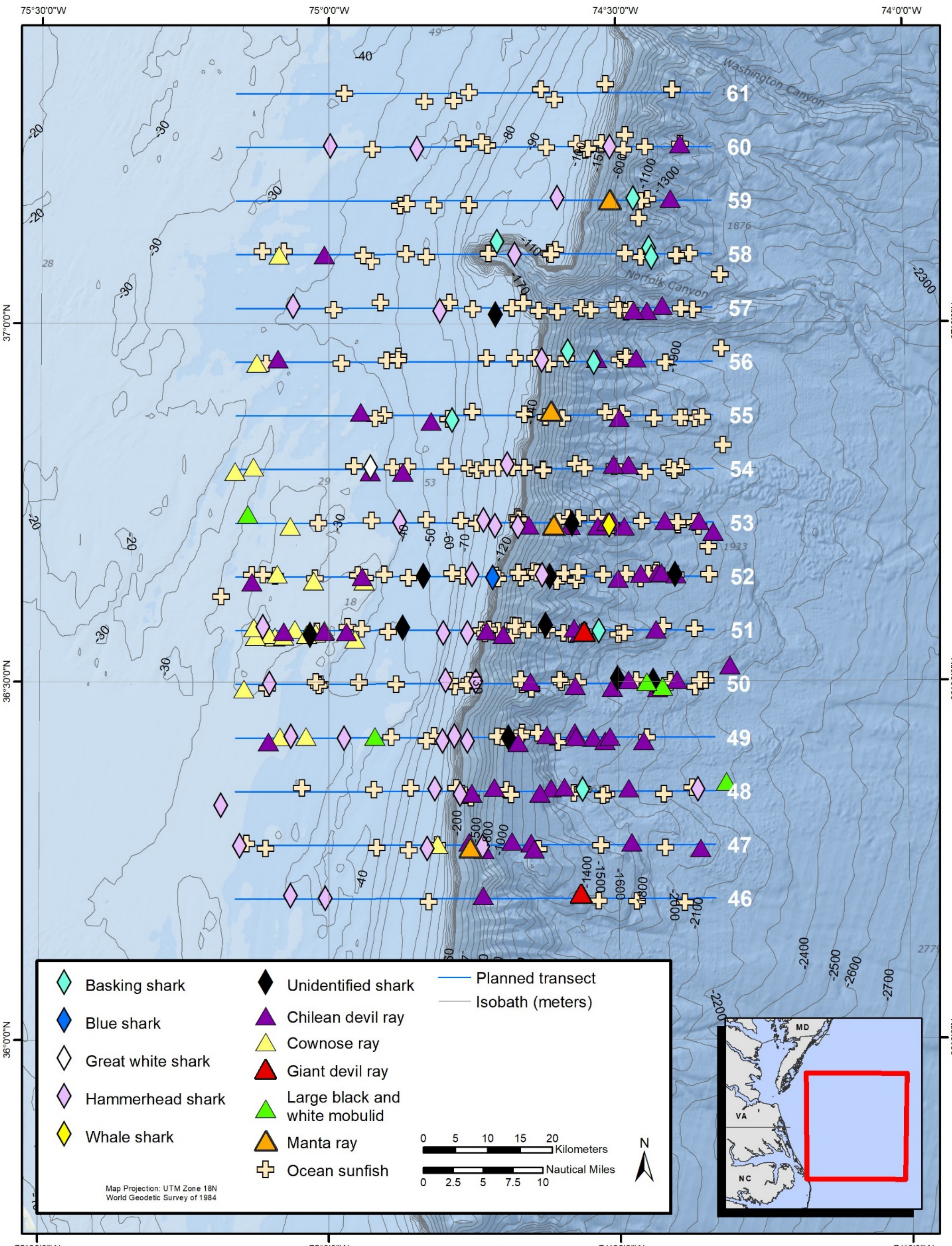

Figure 5. All pelagic marine vertebrate (other than cetaceans and sea turtles) sightings recorded in the Norfolk Canyon study area for all 2018–2019 surveys.

2.1.1.2 Photo-identification Analysis off Cape Hatteras, North Carolina

As a component to supplement the Atlantic Behavioral Response Study (section 2.3.1), Duke University continued photo-ID fieldwork in the Cape Hatteras study area during 2019 to confirm species, identify individual animals, and conduct follow-up monitoring of satellite-tagged animals. These matching analyses build upon established photo-ID catalogs and photographs previously collected in other AFTT monitoring and study areas, including Jacksonville, Florida and Onslow Bay, North Carolina. Digital photographs were obtained from five species, with most taken of Cuvier's beaked whales (*Ziphius cavirostris*), one of the two primary focal species (along with short-finned pilot whales) of the Atlantic BRS. The other cetacean species that had photographs taken were sperm whale, short-finned pilot whale, Risso's dolphin, and common bottlenose dolphin (**Table 4**). All digital images were individually graded for photographic quality and animal distinctiveness. All images of sufficient quality and distinctiveness were then sorted by individual within a sighting and assigned temporary identifications. The best image for each individual in that sighting was selected, and these images were cropped and placed into a folder for each sighting.

Table 4. Cetacean sightings with number of photo-ID images collected for species in the Cape Hatteras study area in 2019.

Species	Common Name	Number of Sightings	Number of Photo-ID Images
G. macrorhynchus	Short-finned pilot whale	14	725
G. griseus	Risso's dolphin	1	1
P. macrocephalus	Sperm whale	2	53
T. truncatus	Bottlenose dolphin	7	151
Z. cavirostris	Cuvier's beaked whale	73	11,498
Total		**97**	**12,428**

Images of 174 newly identified animals were added to three existing photo-ID catalogs of Cuvier's beaked whales, short-finned pilot whales, and common bottlenose dolphins, and 103 new photo-ID matches were made within these three catalogs. To date, photo-ID catalogs for 11 species have been assembled in the Cape Hatteras area, across multiple AFTT marine species monitoring projects, with 516 individuals re-sighted across all species (**Table 5**).

Totals of 104 new identifications and 78 new re-sights were added to the short-finned pilot whale catalog in 2019 (**Table 5**). Much of this increase represents images collected in 2018 and processed in 2019. The current re-sight rate of short-finned pilot whales is 34 percent compared to 31 percent in 2018. More than 190 short-finned pilot whales have been seen on three or more occasions and three animals have been re-sighted more than seven times. Five short-finned pilot whales were satellite-tagged during 2019 and two of those animals were matched to the photo-ID catalog. The three pilot whales that have been sighted the most frequently have all been satellite-tagged.

Table 5. Cetacean sightings with number of photo-ID images collected for species in the Cape Hatteras study area in 2019.

Species	New Images Collected	New Identifications	Catalog Size	New Matches	Matches To Date
B. physalus	0	0	1	0	0
D. delphis	0	0	46	0	1
G. macrorhynchus	725	104	1,260	78	436
G. grampus	1	0	46	0	6
Kogia sp.	0	0	1	0	0
M. novaeangliae	0	0	2	0	0
P. macrocephalus	53	0	20	0	1
S. clymene	0	0	3	0	0
S. frontalis	0	0	24	0	0
T. truncatus	151	20	349	2	19
Z. cavirostris	11,498	50	177	23	53

Short-finned pilot whale individuals have been documented returning to the Cape Hatteras area over extended periods. More than 100 pilot whales have spans of five or more years between their first and last sightings and 14 individuals have periods of 10 or more years between sightings. These long-term re-sights demonstrate that both male and female short-finned pilot whales exhibit strong site fidelity to the Cape Hatteras area.

Fifty new identifications were added to the Cuvier's beaked whale photo-ID catalog during 2019, and 23 new re-sights were made (**Table 5**). This represents a substantial increase in Cuvier's beaked whale photo-ID effort compared to 2018 when only 15 new identifications and 10 re-sights were added to the catalog. The current re-sight rate for Cuvier's beaked whales in the Cape Hatteras area is 30 percent, compared to a re-sight rate of 24 percent in 2018. To date, 30 of the 53 matched Cuvier's beaked whales have been seen across multiple years, and eight of those have been re-sighted more than three years apart. Sixteen Cuvier's beaked whales were tagged in 2019 as part of the BRS project, and two of those individuals, first seen in 2018, were matched to the photo-ID catalog.

In addition to taking photographs of the dorsal fin and body scarring, used for photo-ID, Duke researchers also attempt to obtain high-quality images of the head of each animal. These photographs are used to identify adult male Cuvier's beaked whales (with erupted teeth) to better understand the demographics of this population (**Table 6**). Animals are classified as adult males if they have erupted teeth at the tip of their lower rostrum, or extensive linear scarring, which is believed to be caused from interactions with other adult males (McSweeney et al. 2007, Falcone et al. 2009). Currently, animals are classified as adult females only if photographed with a dependent calf (an individual <50 percent of the body length of the other individual surfacing in proximity; McSweeney et al. 2007). Researchers in Hawaiʻi (McSweeney et al. 2007, Baird 2016) use the accumulation of cookie cutter shark (*Isistius brasiliensis*) scars to differentiate adult females from sub-adult animals, but these scars are rarely seen on Cuvier's beaked whales off Cape Hatteras. Researchers in the Mediterranean (Coomber et al. 2016) use pigmentation patterns to differentiate males and females, but these patterns may vary between regions. Whales are classified as sub-adult males if photographs show teeth just beginning to erupt from the lower jaw. There is currently no method based on Cape Hatteras photographs to classify whales as sub-adult females. Most animals in the catalog have not yet been identified to age or sex class. These include animals where there is a photograph of the head as well as the body, but the whales have no erupted teeth and minimal scarring, as well as whales with minimal scarring but no head photograph. These also include animals with moderate amounts of scarring but no photograph of their heads to confirm whether or not they are adult males. Many of these non-classified whales are likely adult or sub-adult females or sub-adult males.

Table 6. Age class, gender classification, and number of Cuvier's beaked whales in catalog based on photographs.

Age Class	Gender	Defining Characteristics	Number
Adult	Male	Erupted teeth, extensive linear scarring	65
Adult	Female	Presence of a dependent calf	8
Subadult	Male	Teeth beginning to erupt	4
Subadult	Female	None at present time	0
Unknown	Unknown	No photograph of head Photograph of head but no erupted teeth/minimal scarring	100

Follow-up monitoring of the health of satellite-tagged animals continues to be an important focus of photo-ID efforts. Photographic re-sightings of tagged individuals exist for four species: Cuvier's beaked whale, short-finned pilot whale, Risso's dolphin, and common bottlenose dolphin. A single Risso's dolphin was re-sighted on the day after it was tagged in 2016, and a single common bottlenose dolphin was re-sighted five days after tagging in 2014. Most re-sightings have been of satellite-tagged short-finned pilot whales and Cuvier's beaked whales.

To date 79 short-finned pilot whales have been satellite-tagged off Cape Hatteras and 29 of these (37 percent) have been re-sighted. Most of these re-sightings occurred within the same field season but 10 (34 percent) have been re-sighted across multiple years after being tagged. Fifty-eight Cuvier's beaked whales have been satellite-tagged from 2014 through 2019, and 33 (57 percent) have been resighted. Most of the re-sightings occurred within the same field season, but 10 (30 percent) were re-sighted over multiple years after being tagged. Photo-ID provides a useful means to document and assess the long-term effects of tagging on individual short-finned pilot whales and Cuvier's beaked whales. In general, there are few instances of long-term damage to the dorsal fin of tagged animals and most individuals appear to be well-healed.

For more information on this study, refer to the annual progress report for this project (Waples and Read 2020).

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

There has been some debate in recent years about the southern range extent for harbor and gray seal stocks in the western North Atlantic. Until 2018, National Oceanic and Atmospheric Administration (NOAA) Stock Assessment Reports indicated that the gray seal and harbor seal populations range from New Jersey to Labrador; with scattered sightings and strandings reported as far south as North Carolina for gray seals, and Florida for harbor seals (Hayes et al. 2019). Other researchers report that harbor and gray seal distribution along the United States (U.S.) Atlantic coast appears to be expanding or shifting (DiGiovanni et al. 2011; Johnston et al. 2015; DiGiovanni et al. 2018). This range expansion, especially in the case of the harbor seal, may be due to rapid growth of gray seal populations in Canada and now the Northeastern U.S. (Cammen et al. 2018; Wood et al. 2019). More recently, NOAA Stock Assessment

Reports indicate North Carolina as the new southern range extent for the harbor seal population. However, the geographic range for the gray seal population, mentioned above, remains the same (Hayes et al. 2019). Observations from Virginia, by Chesapeake Bay Bridge Tunnel (CBBT) staff and local anglers, indicate that seals have been using the CBBT islands to haul out on for many years, but that the number of animals appears to be increasing. Additionally, annual pinniped stranding numbers have increased in Virginia since the early 1990s (Costidis et al. 2019).

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

A series of systematic counts of all seal species were conducted at two different survey areas (**Figure 6**); 1) in the lower Chesapeake Bay along the CBBT, on the four "islands" (referred to as CBBT 1, CBBT 2, CBBT 3, and CBBT 4), and 2) on the southern tip of the Eastern Shore, which is comprised of about five main haul-out locations.

For the 2018/2019 field season, vessel-based counts were conducted at the CBBT (in collaboration with Virginia Department of Game and Inland Fisheries and HDR Inc.) and Eastern Shore (in collaboration with The Nature Conservancy) survey areas. For this season, the use of an unmanned aircraft system, i.e., drone, for the Eastern Shore survey area was added to help improve count accuracy during vessel-based point counts. This was important when there were a high number of animals hauled out (approximately 30 or more animals) because animals could be hidden due to the close proximity of individuals hauled out.

Dedicated haul-out surveys commenced each fall (October/November) and ended in the spring (April/May) to ensure the documentation of seal arrival and departure for each season. The aim was to conduct vessel surveys at the CBBT and Eastern Shore survey areas at least two times per month during the field season. During each survey, the number of seals hauled out and in the water was recorded with associated environmental data (e.g., air and water temperature). Photographs of seals were collected between counts for photo-ID for a mark-recapture study to estimate local population abundance, and to develop a local catalog.

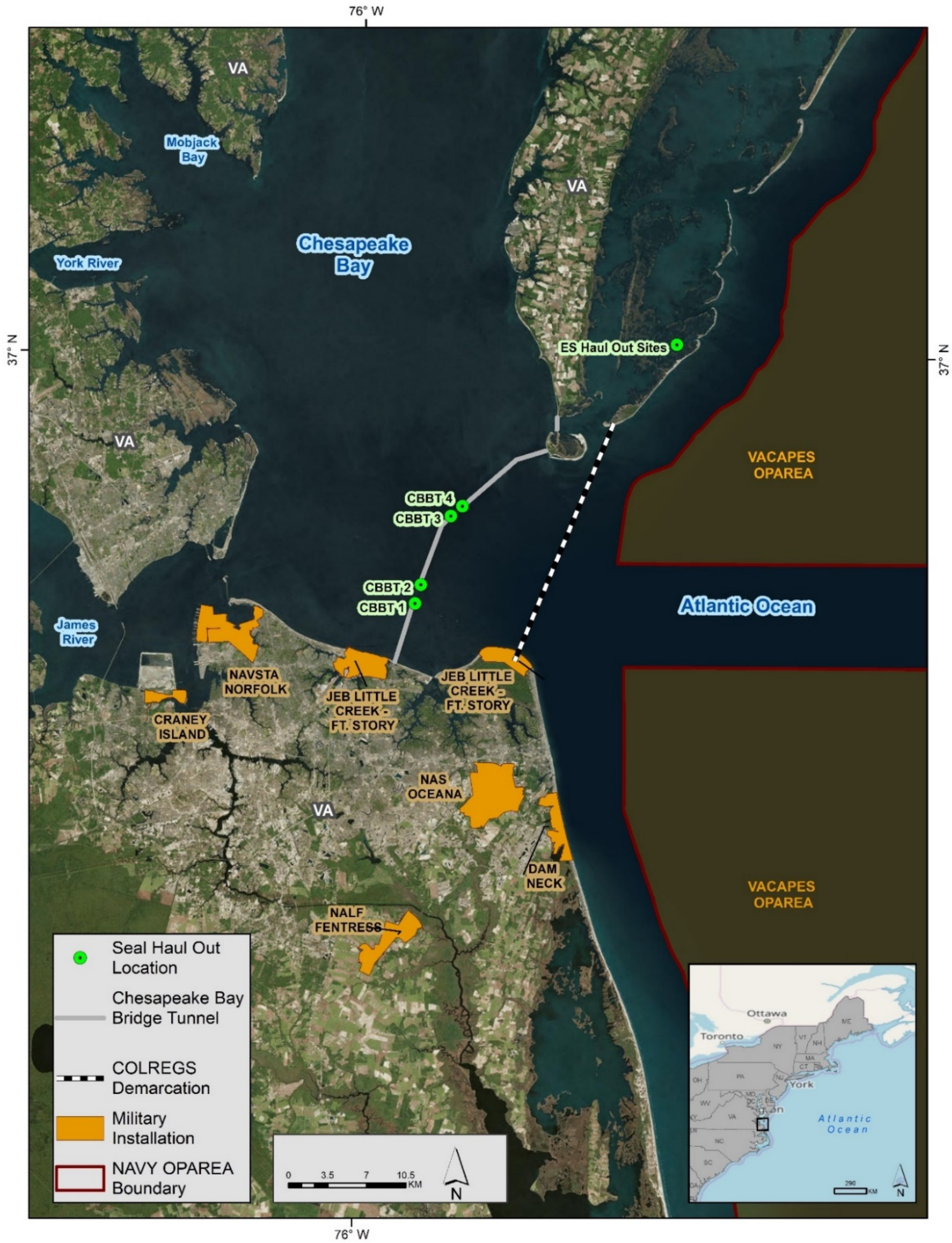

Figure 6. CBBT and Eastern Shore haul-out locations and their proximity to U.S. Naval installations. COLREGS = collision regulations; OPAREA = Operating Area; VACAPES= Virginia Capes Range Complex.

Haul-out Count Results

CBBT

For the fifth field season of the study, 11 survey days were completed at the CBBT survey area between 18 November 2018 and 24 April 2019. A best total estimate (combined in-water and hauled out) of 82 seal sightings was recorded across the CBBT haul-out locations. Seals were observed on 10 of the 11 (90.9 percent) survey days. The total number of seals counted per survey day ranged from 0-17 seals, with the highest counts recorded in December and March.

A total of 88 survey days have been conducted across five field seasons at the CBBT survey area. Seals have been consistently recorded from mid-November to early May, with most sightings (85.8 percent) recorded at the CBBT 3 haul-out site. The majority of seals observed were harbor seals. One gray seal was seen during the 2014/2015 field season, and two gray seal sightings were recorded during the 2015/2016 season. Once seals arrived, animals were recorded on a fairly consistent basis (69 out of 88 survey days [78.4 percent]) until departure. Based on this, the number of survey days between the first and last seal observation were termed as “in-season” survey effort, and subsequently used this in the analyses. The number of seals observed appeared to be increasing over the first four field seasons; given the increase in maximum count for a single survey day and average number of seals observed per “in season” survey day. However, a drop in both max and average count occurred for the 2018/2019 season (**Table 7**). The difference between the mean counts across the five field seasons was statistically significant ($F_{stat} = 3.076$, $p = 0.022$), specifically for the mean counts for the 2017/2018 and 2018/2019 seasons ($Q_{stat} = 4.37$).

Table 7. Seasonal survey effort, total seal count (best estimate), maximum seal count for a single survey, and effort-normalized average seal count (number of seals observed per “in season survey” day) for the CBBT survey area.

Field Season	"In-Season" Survey Effort	Seal Counts		
		Total	Average	Maximum
2014–2015	11	113	10	33
2015–2016	14	187	13	39
2016–2017	22	308	14	40
2017–2018	15	340	23	45
2018-2019	10	82	8	17

Eastern Shore

For the Eastern Shore survey area, haul-out counts commenced in November 2018 for the third field season. Thirteen survey days were completed between 1 November 2018 and 22 April 2019. Seals were observed on 11 of the 13 (84.6 percent) survey days, with a best total estimate of 160 seal sightings. The total number of seals counted ranged from 0-66 per survey day, with the highest counts were recorded in January and February.

A total of 31 survey days have been conducted across three field seasons at the Eastern Shore survey area. Seals have been recorded from early November to early April. The majority of seals observed were harbor seals, but one gray seal was sighted during the 2017/2018 field season and two gray seal sightings were recorded during the 2018/2019 season. Once seals arrived, animals were recorded on a fairly consistent basis (26 out of 31 [83.9 percent] survey days) until departure. Based on this, the number of survey days between the first and last seal observation were termed as “in-season” survey effort, and subsequently used this in the analyses. The number of seals observed appeared to be increasing over the first two field seasons; given the increase in maximum count for a single survey and average number of seals observed per "in season" survey day. As with the CBBT survey area, a drop in both max and average count occurred for the 2018/2019 season (**Table 8**). However, the difference between the mean counts across the three field seasons was not statistically significant (F_{stat} = 3.422, p = 0.437).

Table 8. Seasonal survey effort, total seal count (best estimate), maximum seal count for a single survey, and effort-normalized average seal count (number of seals observed per "in season survey" day) for the Eastern Shore survey area.

Field Season	"In-Season" Survey Effort	Seal Counts		
		Total	Average	Maximum
2016–2017	7	105	15	24
2017–2018	8	197	25	69
2018-2019	11	160	15	66

Photo-ID Results: CBBT and Eastern Shore Combined

After reviewing the photo-ID data, 112 harbor seals were uniquely identified. Of the 112 individuals, 72 were observed only once and 40 were resighted both within and across multiple seasons (e.g., one individual, CB053, was sighted across four different field seasons), indicating at least some degree of seasonal site fidelity in the lower Chesapeake Bay and coastal Virginia waters. The majority of identified seals (n=71) have been sighted only at the CBBT survey area, with some (n=34) being sighted only at the Eastern Shore survey area. However, seven identified seals have been sighted at both survey areas on separate survey days.

The abundance estimates calculated from the Lincoln-Peterson model for the 2015-2019 field seasons ranged from 88 (95% CI: 47.67-128.66) to 221 (95% CI: 83.61-357.40) individual harbor seals (**Figure 7**). Abundance estimates increased from the 2015/2016 to 2018/2019 field seasons, with the exception of the 2017/2018 season, in which a decrease in abundance (n=125 individuals) was observed. Regression analysis results indicated that the slope was not statistically significant (p = 0.16), therefore, the population does not appear to be increasing or decreasing, and may be stable. With the abundance showing a fluctuation across seasons and no discernable trend, a mean abundance estimate for all four seasons was calculated, n=159 individuals (95% CI: 148.61-168.96). Given the CI, this estimate may be a reliable representation of the number of harbor seals using both the CBBT and Eastern Shore survey areas.

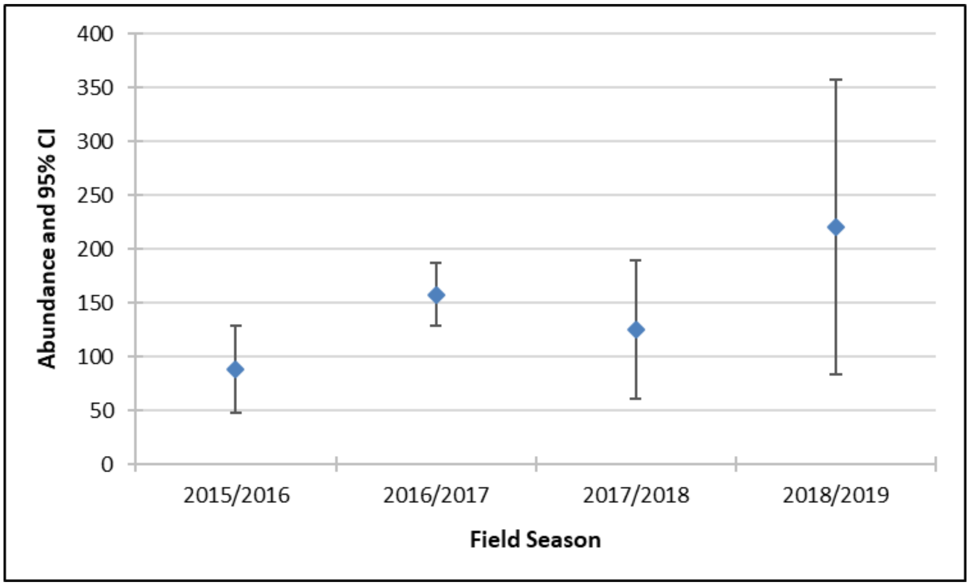

Figure 7. Total abundance estimates (blue diamonds) and 95% confidence intervals (CIs) for the CBBT and Eastern Shore survey areas combined during each of the field seasons: 2015/2016, 2016/2017, 2017/2018, and 2018/2019.

Summary

This research continues to document a regular, seasonal presence of harbor seals and occasional sightings of gray seals within the lower Chesapeake Bay and Eastern Shore, Virginia from November to May. Patterns of seasonal residency and a baseline for population abundance for harbor seals within the region have now been documented. Reports of harbor and gray seal distribution along the U.S. Atlantic coast potentially expanding or shifting (DiGiovianni et al. 2011; Johnston et al. 2015; DiGiovianni et al. 2018) as well as an increase in gray seal pupping and overall, abundance, in the Northeastern U.S. (Wood et al. 2019) may explain the increasing trend observed in average seal count from 2014-2018, and the abundance estimates calculated for this study area. A Northeast U.S. Pinniped unusual mortality event was declared in 2018, which may have been a potential factor in the observed decrease in seal counts for the study area for the 2018/2019 field season. However, more research is necessary to determine the level of site fidelity and whether or not harbor seal abundance is increasing, decreasing or stable within the study area. Haul-out counts and photo-ID data collection have continued for the 2019/2020 field season at both the CBBT and Eastern Shore survey areas. Data will continue to be examined for any emerging patterns of habitat utilization and residency time, as well as population trends, which will help the Navy with ongoing environmental compliance and conservation efforts.

For more information on the Virginia seal haul-out study, please see the annual progress report (Jones and Rees 2020), and visit the project profile page.

2.1.1.4 Mid-Atlantic Humpback Whale Catalog

Humpback whales are the most common mysticete in the nearshore waters off the coast of Virginia (Mallette et al. 2017). Evidence of seasonal use, foraging, and site fidelity from photo-ID efforts suggest the mid-Atlantic provides important seasonal habitat for humpback whales (Swingle et al. 1993, Wiley et al. 1995, Barco et al. 2002). Barco et al. (2002) suggested that some individual humpback whales overwinter in the mid-Atlantic, and that this region may serve as a supplemental winter feeding ground.

Over the last two decades, the Virginia Aquarium Foundation (VAQF) has conducted photo-ID studies of humpback whales off the coast of Virginia and North Carolina and currently curates the Mid-Atlantic Humpback Whale Catalog (MAHWC).

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

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

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

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

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

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

To provide quality assurance and to increase the efficiency of submissions to the MAHWC and larger catalogs, standardized protocols for coding images and categorizing and matching individuals were developed based upon existing examples and input from the core stakeholder group. Standardized protocols were developed for the MAHWC based upon existing photo-ID catalogs. Unique feature codes used for categorizing and filtering (e.g., dorsal fin, fluke, peduncle knuckles, body scarring) for comparison among collections were tailored to those whales in the MAHWC. Fluke code categories have been adapted from those developed by the NAHWC. Flukes are initially classified by grading from fully white (Type 1) to fully black (Type 5) coloring on the ventral surface. Within each Type, the most represented subcategories to be used in the catalog are being determined (e.g., typical, wide black trailing edge, white on trailing edge, white eyes). Examples of the subtypes "typical" and "white eyes" for each fluke type are illustrated in **Figure 8**. Additionally, standardized data fields and database structure of the MAHWC were designed to be compatible with the U.S. Navy's MSM program. Contributors will provide pertinent data to the MAHWC catalog via standard templates and will follow image- and data-accession protocols that contribute to the maintenance and quality of the database.

Local contributor images and sighting data collected between the 2013 and 2019 seasons submitted by VAQF Research, HDR Inc., Virginia Aquarium Whale Watch, and Rudee Flipper Whale Watch have been standardized in the contributor template and images scored based on feature codes and image quality for integration into the MAHWC. All whales submitted during this time period have been compared and new whales integrated into the catalog.

In an attempt to understand the stock identity and demography of humpback whales that winter off the U.S. Mid-Atlantic states, the Center for Coastal Studies (Provincetown, Massachusetts) recently completed a match of the Gulf of Maine Humpback Whale Catalog for whales cataloged in the MAHWC from 2002 to 2019. A total of 102 individuals had sighting histories in the Gulf of Maine. Long-term studies in the Gulf of Maine have yielded data on age and sex that inform the demography of mid-Atlantic whales, and recent matches to the MAHWC have helped to clarify the status of individuals impacted by human activities. The best estimate of exchange with the Gulf of Maine during this period was 39.6 percent based on individuals first seen alive with adequate quality fluke documentation, and this estimate was not significantly different from the prior published estimate of 45.5 percent through 2000 (Barco et al. 2002).

As of December 2019, all humpback whales in the current MAHWC from 1989 through 2018 have been compared to the North Atlantic Humpback Whale Catalog (NAHWC), managed by Allied Whale (Bar Harbor, Maine). The 2018 MAHWC report yielded 123 matches, with an additional 208 matches from the 2019 report for a total of 224 individual mid-Atlantic whales matched to the NAHWC.

The catalog will officially launch for public use in early 2020 along with final bug fixes, development of website content, a training guide for help coding images, final curator protocols for future sustainability of the catalog, and preparation of a project manuscript.

Fluke

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

Figure 8. 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.

2.1.2 Passive Acoustic Methods

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

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

2.1.2.1 High-frequency Acoustic Recording Packages

Duke University and Scripps Institution of Oceanography began a long-term program using High-frequency Acoustic Recording Packages as part of a multi-disciplinary monitoring effort for Onslow Bay in 2007, which was later expanded to the JAX OPAREA in 2009, Cape Hatteras in 2012, and Norfolk Canyon in 2014. Deployments ended at the Onslow Bay site in 2013 but have continue at the other locations (**Figure 10**). The primary objective of deployments at all locations has been to determine species distributions and document spatiotemporal patterns of cetaceans throughout areas of interest. During 2019, single-channel HARP data were collected at the Norfolk Canyon, Cape Hatteras, and JAX sites over a bandwidth from 10 Hertz up to 200 kHz. In addition, an array was deployed at the Hatteras location in coordination with the Atlantic BRS project for potential tracking of individual animals (see Gassman et al. 2015 for methods). The array consisted of a single channel HARP sampling at 200 kilohertz (kHz) and two units using four-hydrophones arranged in a small aperture (~1 m) array sampling at 100 kHz for each hydrophone (**Figure 9**).

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

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

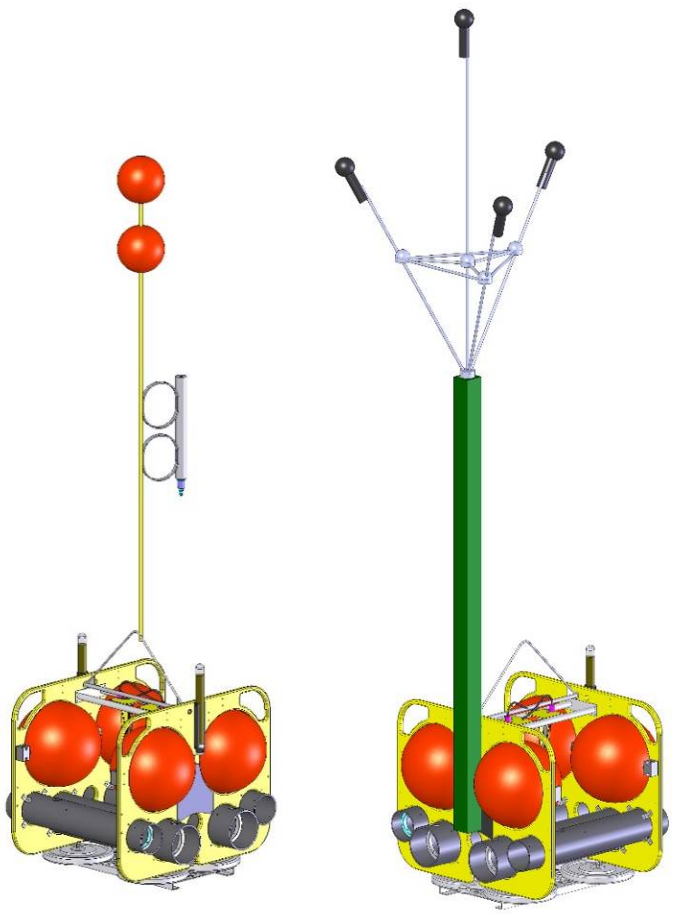

Figure 9. High-frequency Acoustic Recording Package (HARP) configurations—standard seafloor-mounted with one hydrophone (left) and tracking with four hydrophones arranged in a tetrahedron with ~1 m sensor spacing.

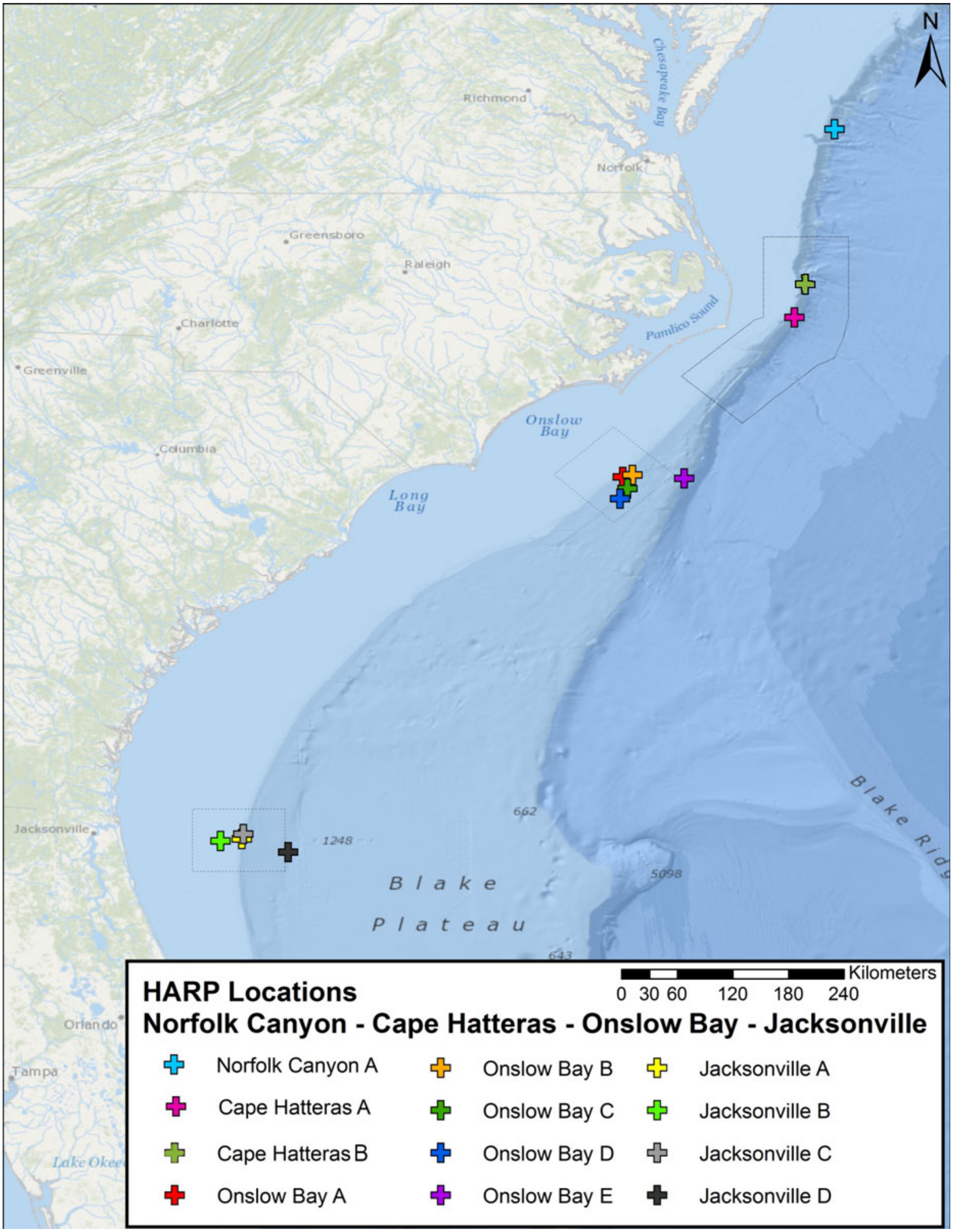

Figure 10. Location of HARPs deployment sites in Norfolk Canyon, Cape Hatteras, Onslow Bay, and JAX.

Norfolk Canyon Data Collection (Table 9, Figure 10)

NFC04A initially deployed on 2 June 2018 at Site A near Norfolk Canyon at a depth of 1050 m was recovered on 19 May 2019. The Norfolk Canyon Site A unit was redeployed was redeployed on 19 June 2019. This instrument is still in the field and is expected to be recovered in summer 2020.

Cape Hatteras Data Collection (Table 10, Figure 10)

In May 2017, the location for HARP deployments at Cape Hatteras was moved approximately 17 nautical miles to the northeast (designated site B) to better coordinate with the location for the Atlantic BRS (see **Section 2.3.1** of this report). An array of 3 HARPs, consisting of one single-hydrophone instrument and 2 four-hydrophone instruments, was deployed at site B from 17 May through 24 October 2019. The single-hydrophone instrument was refurbish in May and October 2019 and will be recovered in the fall of 2020 at which point HARP deployments at the Cape Hatteras study site will be permanently discontinued.

The array deployments provide sufficient coverage for tracking individual cetaceans; the analyses of these data will be directed toward the potential tracking of beaked whales in coordination with Atlantic BRS controlled exposure experiments.

Jacksonville Data Collection (Table 11, Figure 10)

The HARP deployed at Site D in the JAX OPAREA on 26 June 2018 (JAX15D) was refurbished on 15 June 2019 and will be recovered in the summer of 2020 at which point HARP deployments at the Jacksonville site will be permanently discontinued.

Table 9. 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	2-Jun-18	29-Jun-17	2-Jun-18	37.1674	74.4663	950	200 kHz	continuous
04A	02-Jun-18	19-May-19	02-Jun-18	N/A	37.1645	74.4659	1050	200 kHz	continuous
05A	19-May-19	N/A	19-May-19	N/A	37.1645	74.4659	1050	200 kHz	continuous

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

Table 10. 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
HAT_B_01_01	09-May-17	25-Oct-17	09-May-17	25-Oct-17	35.5837	74.7492	1,118	200 kHz	continuous
HAT_B_01_02_C4	09-May-17	28-Jun-17	09-May-17	28-Jun-17	35.5797	74.7559	1,111	200 kHz	continuous
HAT_B_01_03_C4	09-May-17	28-Jun-17	09-May-17	28-Jun-17	35.5865	74.7560	1,095	200 kHz	continuous
HAT_B_02_02_C4	28-Jun-17	Lost-at-sea	28-Jun-17	N/A	35.5793	74.7569	1,040	200 kHz	continuous
HAT_B_02_03_C4	28-Jun-17	25-Oct-17	28-Jun-17	25-Oct-17	35.5861	74.7558	1,190	200 kHz	continuous
HAT_B_03_01	25-Oct-17	1-Jun-18	25-Oct-17	1-Jun-18	35.5835	74.7431	1,117	200 kHz	continuous
HAT_B_04_01	01-Jun-18	13-Dec-18	01-Jun-18	13-Dec-18	35.5897	74.7476	1350	200 kHz	continuous
HAT_B_04_02_C4	01-Jun-18	13-Dec-18	N/A	N/A	35.5851	74.7515	1175	200 kHz	continuous
HAT_B_04_03_C4	01-Jun-18	13-Dec-18	01-Jun-18	13-Dec-18	35.5905	74.7628	1078	200 kHz	continuous
HAT_B_05_01	13-Dec-18	18-May-19	14-Dec-18	18-May-19	35.5897	74.7476	1350	200 kHz	continuous
HAT_B_06_01	18-May19	24-Oct-19	18-May-19	N/A	35.5844	74.7479	1120	200kHz	continuous
HAT_B_05_02_C4	17-May-2019	24-Oct-2019	17-May-2019	N/A	35.5805	-74.7455	1217	200kHz	continuous
HAT_B_05_03_C4	17-May-2019	24-Oct-2019	17-May-2019	N/A	35.5848	-74.7415	1227	200kHz	continuous
HAT_B_07_01	24-Oct-2019	N/A	25-Oct-2019	N/A	35.5826	-74.7501	1100	200kHz	continuous

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

Table 11. 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	25-Jun-17	26-Apr-16	25-Jun-17	30.1518	79.7702	736	200 kHz	continuous
14D	25-Jun-17	26-Jun-18	25-Jun-17	26-Jun-18	30.1527	79.7699	740	200 kHz	continuous
15D	26-June-18	15-Jun-19	26-June-18	N/A	30.1522	79.7710	740	200 kHz	continuous
16D	15-Jun-19	N/A	15-Jun-19	N/A	30.155	79.771	735	200 kHz	continuous

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

For the next reporting period, Scripps Institution of Oceanography will continue to analyze data from 2018-18 deployments from Norfolk Canyon Site A, Cape Hatteras Site B, and JAX Site D. Detailed technical reports will be available through the HARP metadata explorer once the analyses of the datasets are complete. All data from previous and current deployments is being contributed to a broad collaborative analysis of North Atlantic shelf break species (see **Section 2.1.2.2**). For more information on the HARP program, refer to the primary literature publications using data from previous HARP deployments (Davis et al. 2017, Stanistreet et al. 2016, Hodge et al. 2018).

2.1.2.2 Occurrence and Acoustic Ecology of North Atlantic Shelf-Break Species

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

Acoustic analyses of these recorders will allow for an improved understanding of the long-term seasonal presence of marine mammals on the western North Atlantic shelf break, and how their composition changes across time. This baseline information will be used to assess the effects of anthropogenic activities, such as Navy exercises, on these species and provide context to observed species responses.

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

- Novel broad-scale approach to assessing acoustic niche and anthropogenic contributors
- Seasonal and spatial occurrence of beaked whales and *Kogiid* whales
- Occurrence and acoustic behavior of baleen whales
- Anthropogenic drivers of distribution – identifying different acoustic sources and potential impacts

Preliminary analyses conducted in 2019 focused on data collected from 2015 through 2017 at eight sites along the continental shelf break (**Figure 11, Table 12**). Sound files were divided into three separate data sets to facilitate analyses based on the following frequency bands: (1) Low-frequency, 10-1000 Hz; (2) Mid-frequency, 10-5000 Hz; and (3) High-frequency, 1000-100,000 Hz.

The Low-Frequency Detection and Classification System (LFDCS), was used to identify and distinguish species-specific vocalizations and extract the presence of five mysticete species: blue (*Balaenoptera musculus*), fin (*Balaenoptera physalus*), humpback (*Megaptera novaeangliae*), North Atlantic right (NARW) (*Eubalaena glacialis*), and sei whales (*Balaenoptera borealis*). The high-frequency acoustic data sets were used to extract the presence of echolocation clicks from six beaked whale species: Blainville's beaked whales (*Mesoplodon densirostris*), Cuvier's beaked whale, Gervais'/True's beaked whale (*Mesoplodon europaeus/Mesoplodon mirus* respectively), Northern bottlenose whales (*Hyperoodon ampullatus*), and Sowerby's beaked whale (*Mesoplodon bidens*), as well as sperm whales (*Physeter macrocephalus*), Kogia spp., and a grouping of at least 12 delphinid species known to occur in the region. The HARP data was also examined for the presence of four types of anthropogenic noise: broadband ship sounds, airguns, explosions, and echosounders.

Acoustic niche results from these analyses are presented in Van Parijs et al., 2020 and will be incorporated into the broader ecological analyses to be conducted once the remaining data from 2017 through 2019 is processed. Work on this project for the coming year will include:

- Baseline analyses of additional data from 2017 to 2019 for the eight sites discussed above
- Addition of data from the Navy-funded HARP deployments to these baseline acoustic niche data
- Cross checking and improving detector accuracy for beaked whales and delphinids if possible
- Identifying and analyses of seismic and sonar activities on select recorders following further impact assessment analyses
- Development of acoustic metrics and species composition analyses

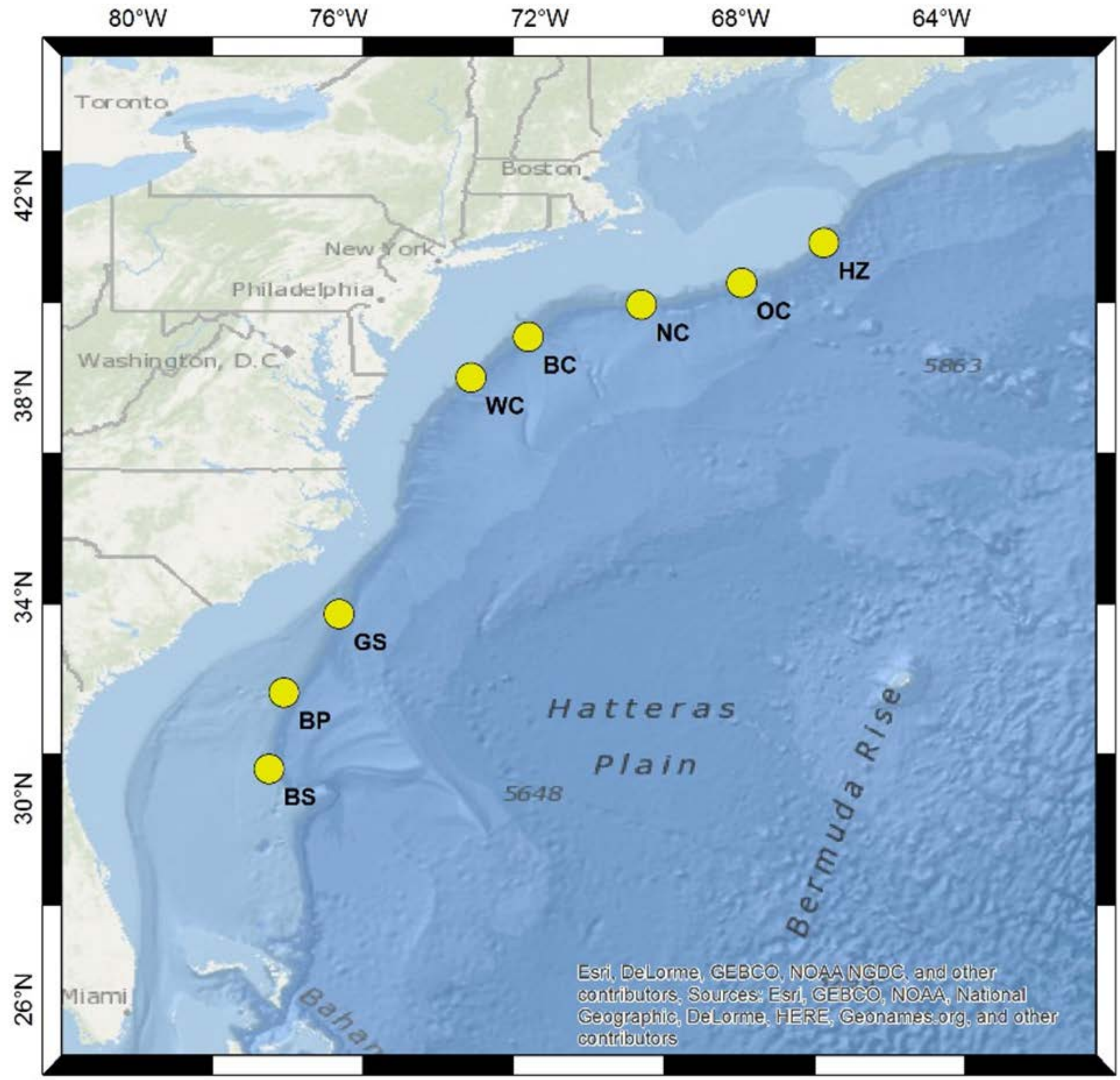

Figure 11. HARP deployment sites for data collected from 2015 through 2017.

Table 12. HARP deployment sites and recording details for data analyzed from 2015 through 2017.

Site	Recording Start Date	Recording End Date	Recording Duration (days)
Heezen Canyon (HZ)	06/27/2015	03/25/2016	273
Oceanographer Canyon (OC)	04/26/2015	02/09/2016	290
Nantucket Canyon (NC)	04/27/2015	09/18/2015	145
Heezen Canyon	04/22/2016	06/19/2017	423
Oceanographer Canyon	04/24/2016	05/18/2017	389
Nantucket Canyon	04/21/2016	05/24/2017	398
Babylon Canyon (BC)	04/20/2016	06/10/2017	416
Wilmington Canyon (WC)	04/20/2016	06/29/2017	435
Gulf Stream (GS)	04/29/2016	06/26/2017	423
Blake Plateau (BP)	04/28/2016	06/26/2017	424
Blake Spur (BS)	04/23/2016	06/10/2017	413

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

The GOM Bryde's whale (*Balaenoptera edeni*), estimated to have a population size of 33 individuals in U.S. waters, was recently listed as endangered under the ESA (Hayes et al. 2018). The majority of modern sightings occur in waters between the 100–400 m water depths in an area near the De Soto Canyon off northwestern Florida (Soldevilla et al. 2014). Occurrence patterns from one year of long-term passive acoustic monitoring and two recent summer and fall surveys indicate the whales are found year-round within this primary habitat, but also suggest there may be seasonal movements throughout, and potentially out of, this area. High densities of anthropogenic activities occur throughout the GOM, including oil and gas exploration and extraction, fisheries, shipping, and military activities and several of these activities overlap with the whales' primary habitat. Understanding seasonal distribution and density will improve understanding of potential impact of human activities in the core habitat and assist in developing effective mitigation measures as needed.

The SEFSC and Scripps Institution of Oceanography have been collaboratively deploying long-term passive acoustic monitoring stations at five GOM sites since 2010 to monitor the impacts of the Deepwater Horizon oil spill and subsequent restoration activities on cetaceans (**Figure 12)**. High-frequency Acoustic Recording Packages (HARPs), deployed at the five sites, including the De Soto Canyon (DC) HARP in the primary GOM Bryde's whale habitat, have been continuously recording ambient noise and other acoustic events in the 10 Hz to 100 kHz frequency range, and these 8-year near-continuous recordings are available for analysis to better understand distribution and density trends of GOM Bryde's whales. The focus of this project in 2019 was on developing automated detectors and running and validating the detectors on data from the DC HARP in the core habitat collected between October 2010 and July 2014, and to establish complete occurrence time-series for understanding seasonal and interannual trends and for future habitat modeling and density estimation.

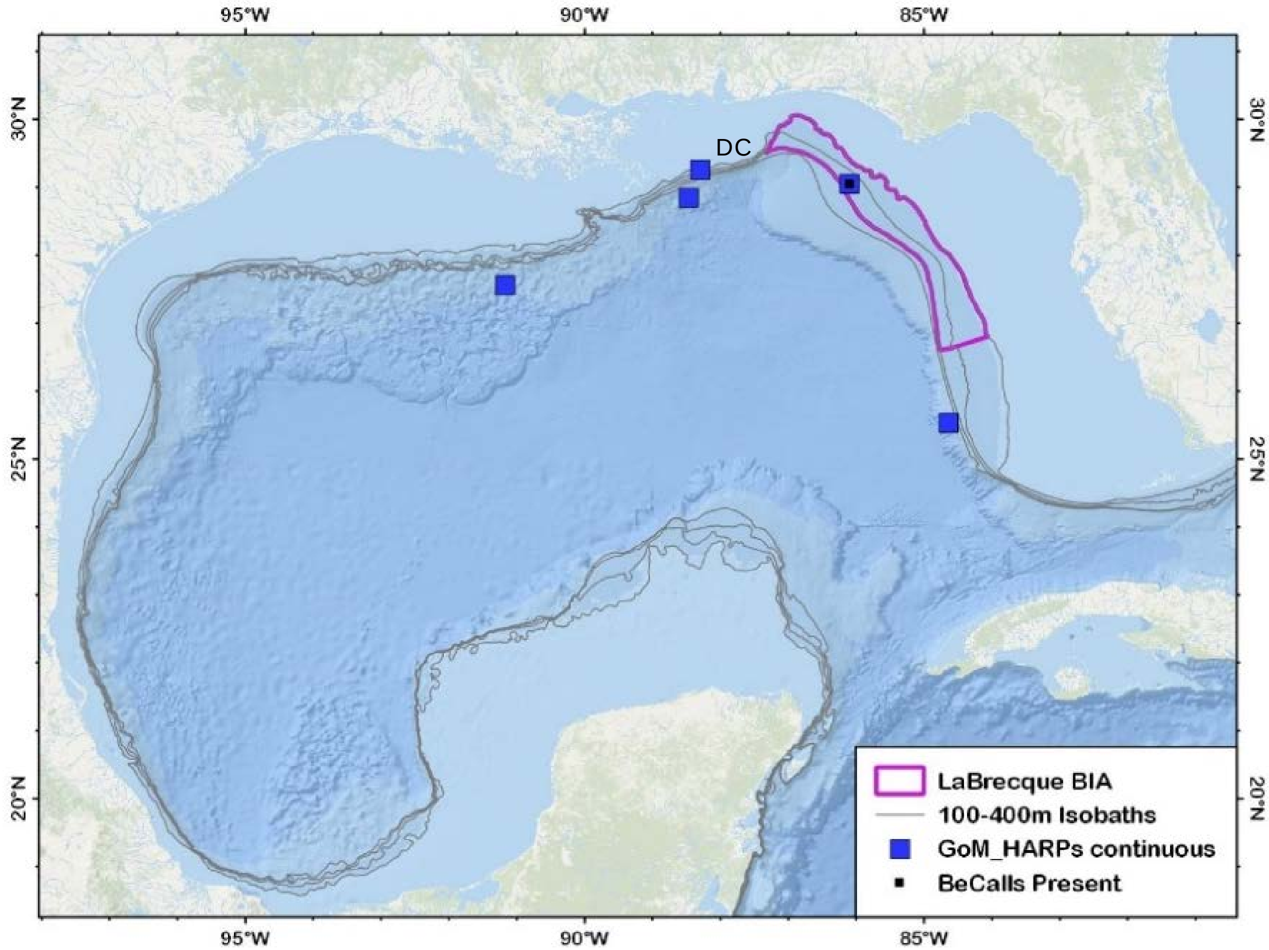

Figure 12. Historic long-term passive acoustic monitoring stations in the Gulf of Mexico since 2010. The core habitat (BIA) of Gulf of Mexico Bryde's whales is indicated, including the De Soto Canyon (DC) site, where downsweep call sequences have previously been detected.

Development and characterization of automated detectors of GOM Bryde's whale calls has been completed. Automated detectors for GOM Bryde's whale long-moan calls and downsweep pulse sequences were developed on training data from three days of the DC09 deployment and characterized on a 1% randomly selected test data subset of manually-reviewed 30-minute segments. The most effective detectors were spectrogram cross-correlation detectors developed in Ishmael. Thresholds were optimized to minimize miss rates without introducing an excessive number of false detections; false detections are removed in a subsequent validation step. The best long-moan detector had a miss rate of 6.5% and false detection rate of 26.4% on the test dataset. The best downsweep pulse sequence detector had a miss rate of 12.6% and a false detection rate of 69% on the test dataset. Downsweep pulse sequence false detections were typically associated with either pulsed long-moan calls or seismic airgun pulses.

The ambient noise analyses have been completed on the entire 8-year dataset. The underwater ambient soundscape at all sites had spectral shapes with higher levels at low frequencies compared to higher frequencies, owing to the dominance of ship noise and seismic airgun surveys at frequencies below 100 Hz and local wind and waves above 100 Hz. The years 2016 and 2017 had the lowest spectrum levels below 100 Hz while Dec 2013-June 2014 also had low levels. There appears to be a seasonal pattern in overall noise levels with lower noise levels in spring and summer compared to fall and winter, and this is typically most apparent above 100 Hz. This is likely due to the increased noise from wind and waves of winter storms. Spectral peaks around 100-300 Hz, which may be from fish chorusing, occur during spring 2011 and spring and summer 2013, and may have led to reduced detectability of GOM Bryde's whale calls at these times due to masking effects.

The automated detectors have been run on the complete 8-year dataset and the validation of the detections has been completed for the first deployment. In the 2010-2018 data at the De Soto Canyon site, GOM Bryde's whale long moan calls were preliminarily detected in all seasons and all years with no apparent evidence of seasonality. Preliminary call detections ranged between 28,002 and 101,071 calls per deployment. Preliminary results indicate they were detected on nearly every day of every year and on between 67-95% of hours with recording effort. Validation of auto-detections yielded a 2.0% false detection rate for the long-moan call detector for the DC02 deployment and show a similar gap in detections in November 2010 as was found for downsweep pulse sequences by Širović et al. (2014). Based on preliminary, pre-validated results, there appears to be an increase in hourly call detection rates at night compared to day for preliminary detections, and an increase in hourly call detection rates during fall, then summer with lower detection rates in late winter and late summer.

Preliminary results yielded between 6,803 and 23,067 Downsweep Pulse Sequence detections per deployment for deployments DC02-DC11. Preliminary detections occurred on 88-99% of days per deployment and 30-51% of hours per deployment. However, these preliminary detections represent a major overestimate as false detection rates for this detector are expected to be around 69%. Validation of auto-detections on the DC02 dataset indicated 97.6% false detections, with 218 true downsweep calls heard on only 12 days of the 110 days of data. Nearly 65% of the false detections during this deployment occurred over the course of a few days when ship noise was prevalent. For the DC02 dataset, true detections of downsweep pulse sequences (218) are 2 orders of magnitude lower than true detections of long-moan calls (22,278) during this time period. For more detail on these analyses, please see Soldevilla et al. 2020.

During 2020, detections from 2014-2018 will be validated and results written up for peer-reviewed publication to improve understanding of the long-term variability in GOM Bryde's whale presence at this site. Further, to better understand the observed interannual variability in occurrence with respect to the entire core habitat, passive acoustic monitoring will be initiated at an additional 17 sites that should completely cover the core habitat. This study will provide further information to interpret the changes seen at this site over 8 years and to understand how call density varies seasonally throughout the core habitat.

2.1.2.4 Autonomous Glider Deployments

Two autonomous Slocum G3 gliders equipped with digital acoustic monitoring (or DMON) instruments and near real-time reporting capabilities were deployed and operated in the mid-Atlantic Bight to the north and south of Cape Hatteras, North Carolina, in January 2019 to potentially detect right whales in the Virginia/North Carolina region during the migration period (**Figure 13** and **Figure 14**). The gliders were programmed to survey pre-determined cross-shelf transects by traveling between specified waypoints from roughly the 20 m isobath eastward to the shelf break as local currents allowed, but also could be remotely piloted in the event mechanical or environmental factors required intervention for course deviation.

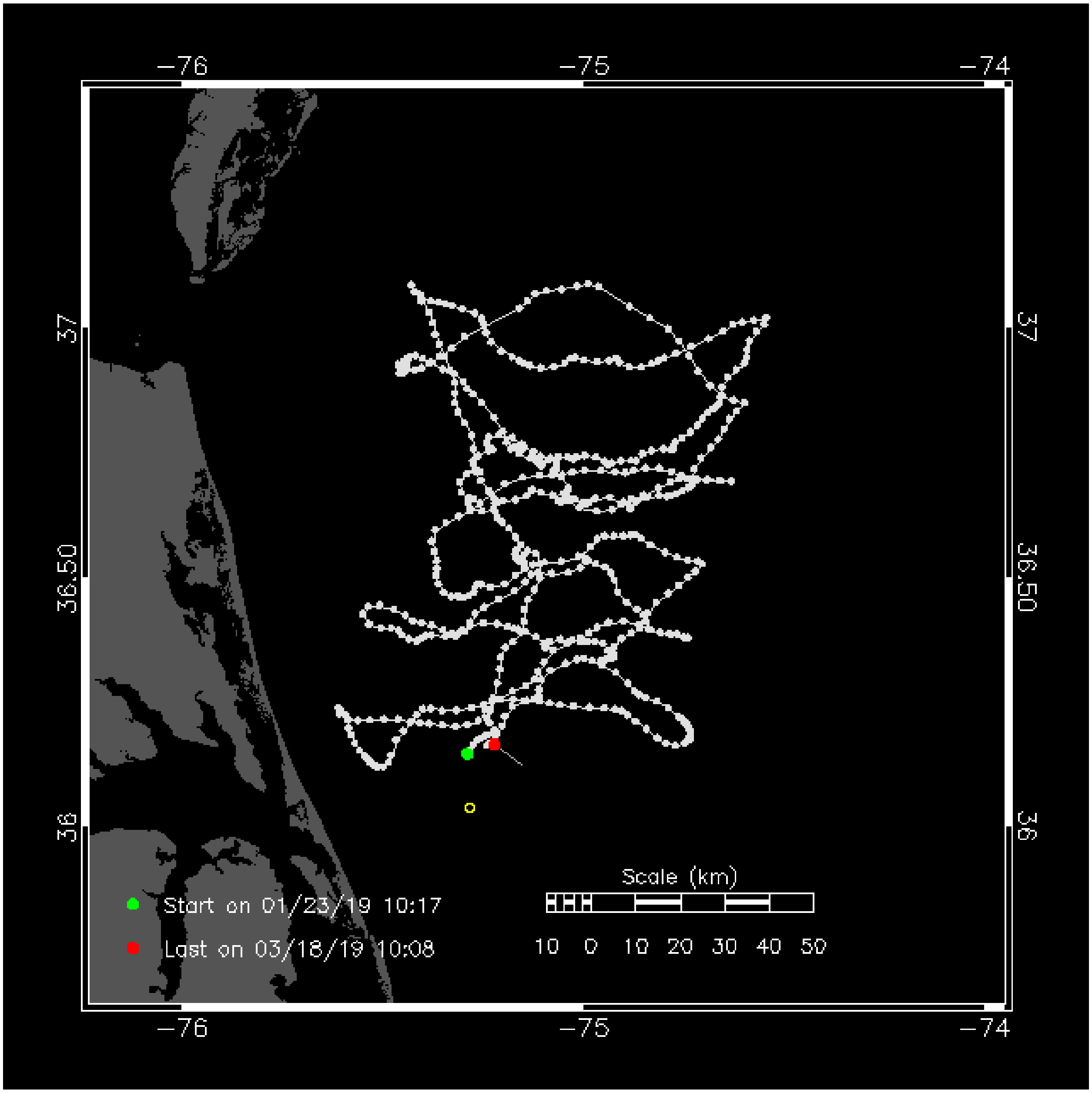

Figure 13. Map showing the trackline of the Slocum G3 glider deployed to the north of Cape Hatteras, North Carolina in January 2019.

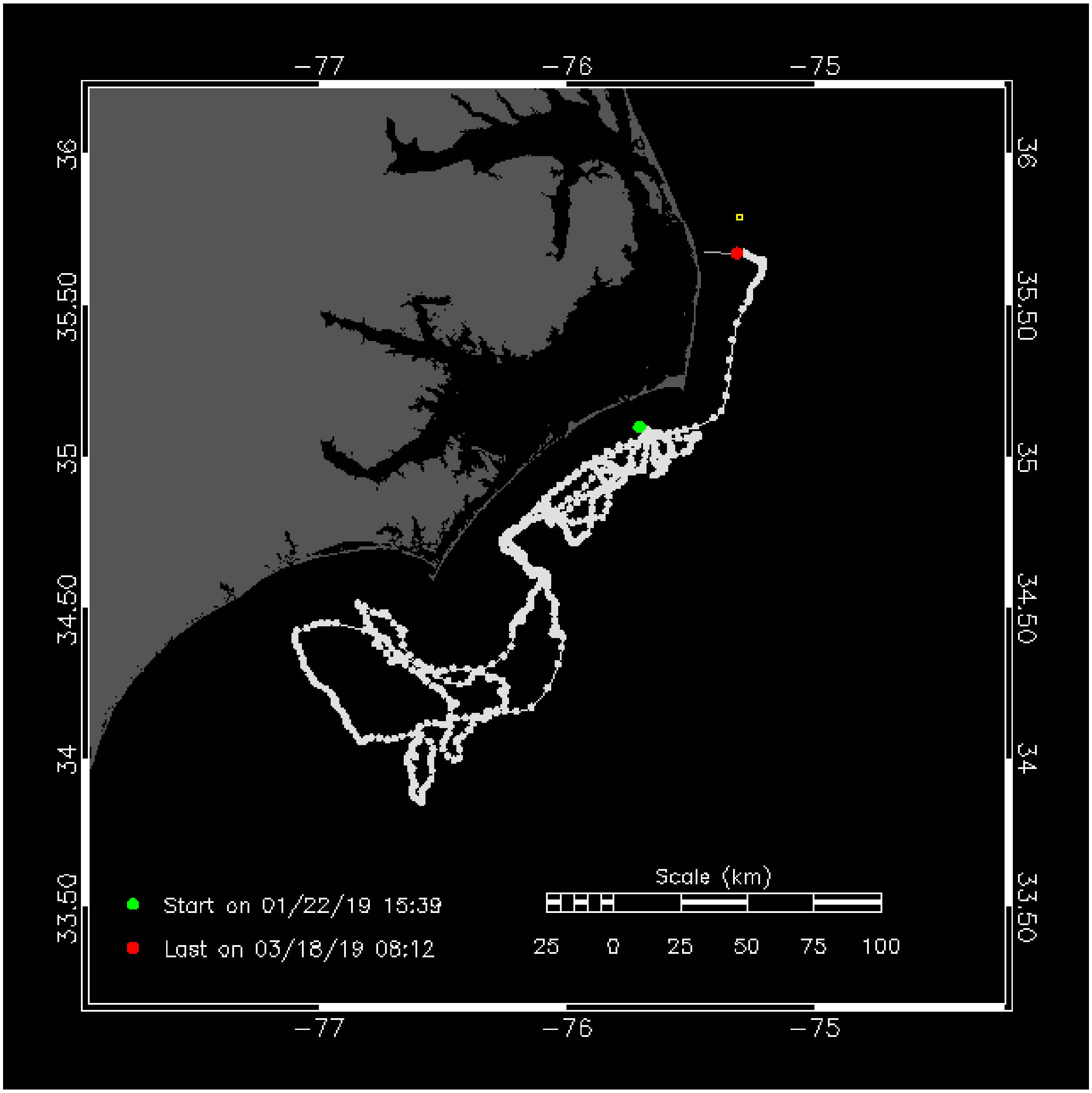

Figure 14. Map showing the trackline of the Slocum G3 glider deployed to the south of Cape Hatteras, North Carolina in January 2019.

Both gliders were deployed within one day of each other in late January 2019, and although winter storms tended to move the glider deployed to the north of Cape Hatteras off the pre-determined survey track, the instrument generally was able to stay in the study area and traverse across the shelf successfully. The glider deployed to the south of Cape Hatteras needed remote pilot intervention to avoid being caught in the powerful Gulf Stream currents. The maneuvers were successful, but the glider repeatedly made contact with the sea floor, which filled its nose cone with sediment, effectively disabling the acoustic altimeter housed in the nose. The principal investigators successfully intercepted the instrument at sea in early February to clean the nose cone, and the unit was redeployed and able to complete the modified survey plan.

Sensor data from the gliders were relayed to shore every two hours and posted on the project's publically accessible website at Robots4Whales. Pressure, temperature, conductivity (to derive salinity measurements), chlorophyll fluorescence, and turbidity metrics were transmitted in near real time. The temperature and salinity observations clearly demonstrated the two environments in which the gliders were deployed, with the area north of Cape Hatteras much cooler and fresher, reflecting currents originating to the north along with the influence of cold slope waters sourced from north of the Gulf Stream wall. The area to the south of Cape Hatteras was much warmer and saltier, reflecting the strong influence from the Gulf Stream and coastal waters originating to the south. The digital acoustic monitoring instrument was programmed with the Low-frequency Detection and Classification System (Baumgartner and Mussoline 2011, Baumgartner et al. 2013) and is capable of detecting humpback, fin, and sei whales in addition to NARWs (**Figure 14**). Detection data were transmitted in near real time to shore where they were reviewed daily by trained personnel, and the results were posted on the project website, distributed to interested parties by automated email messages, and made available for display in the Whale Alert App.

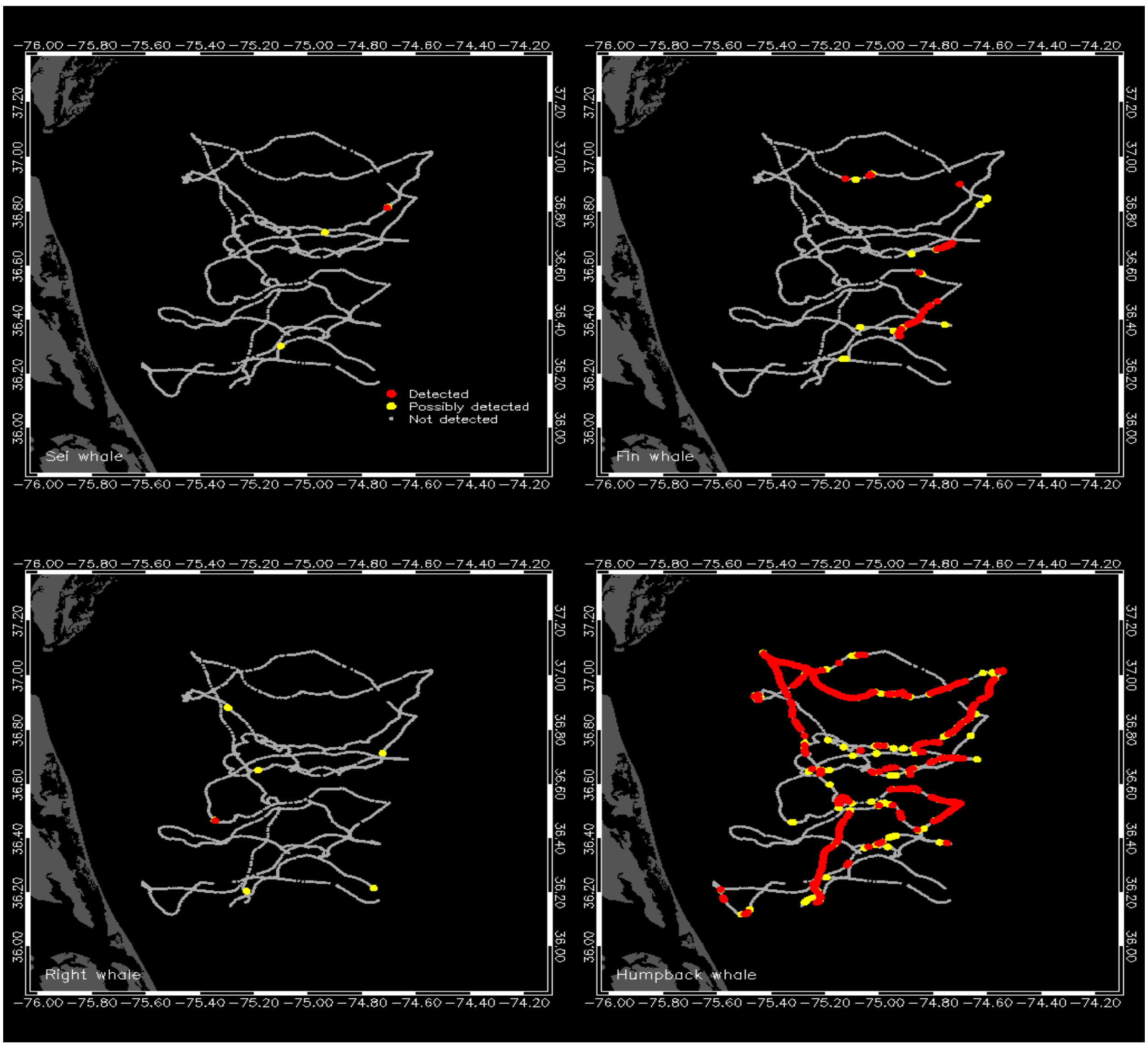

Figure 15. Near real-time acoustic detections from the northern Slocum G3 glider.

Of the four baleen whale species monitored, humpback whales were the most commonly recorded on the northern glider. Fin whale detections were also fairly common, while sei whales were detected on a single occasion (**Figure 15**). There was a single day with several NARW calls (**Figure 16**), but a subsequent aerial survey aboard a United States Coast Guard C-130 was unsuccessful at locating any NARWs. The flight did not occur until four days after the glider detection, and important lessons were learned during the exercise that can be applied to any future rapid-response flights triggered by NARW glider detections.

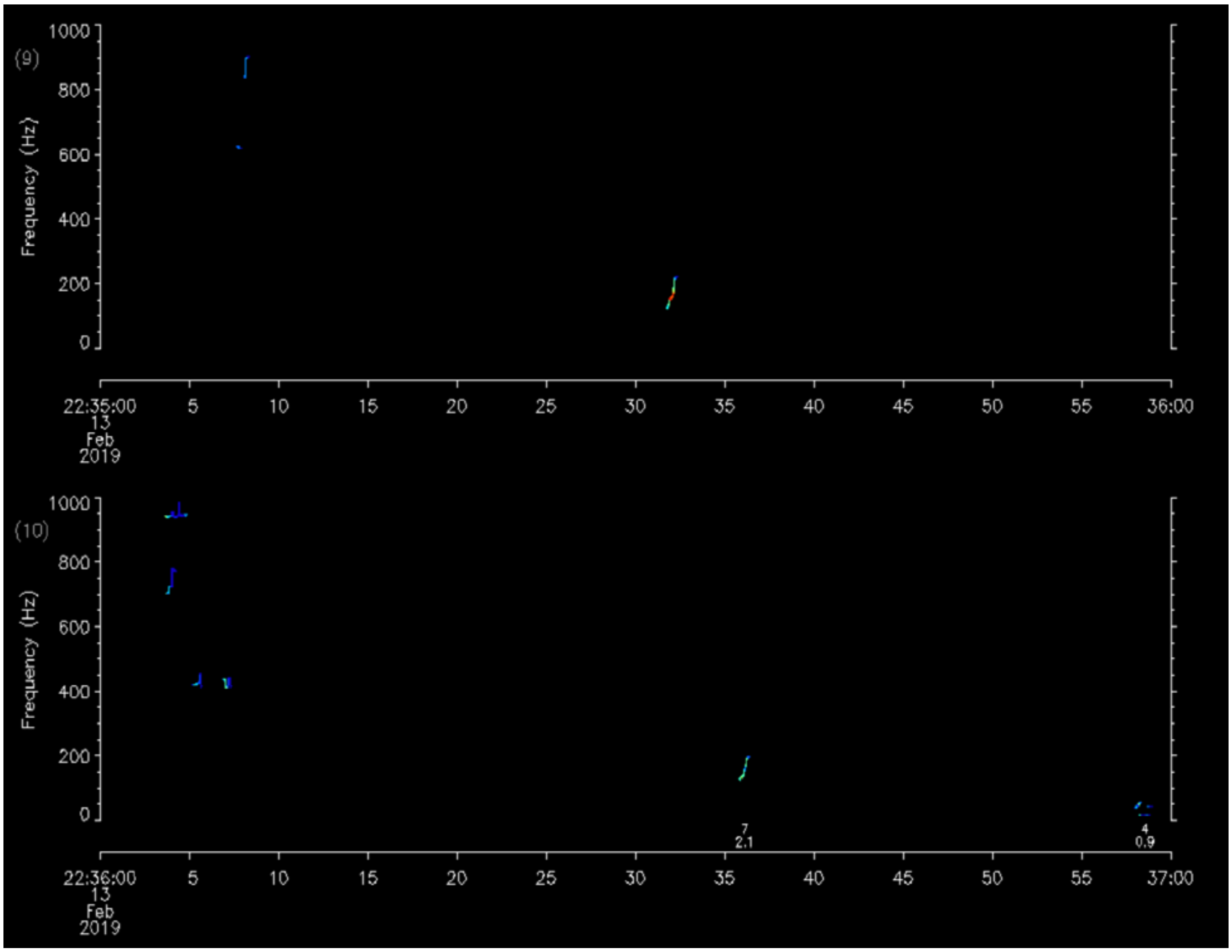

Figure 16. Pitch tracks of right whale upcalls detected on the northern Slocum G3 glider on 14 February 2019.

The southern glider had "possible detections" of all four species (including two occurrences each of fin and sei whales), but detections of humpbacks were the only detections classified as "detected" with high confidence (**Figure 17**).

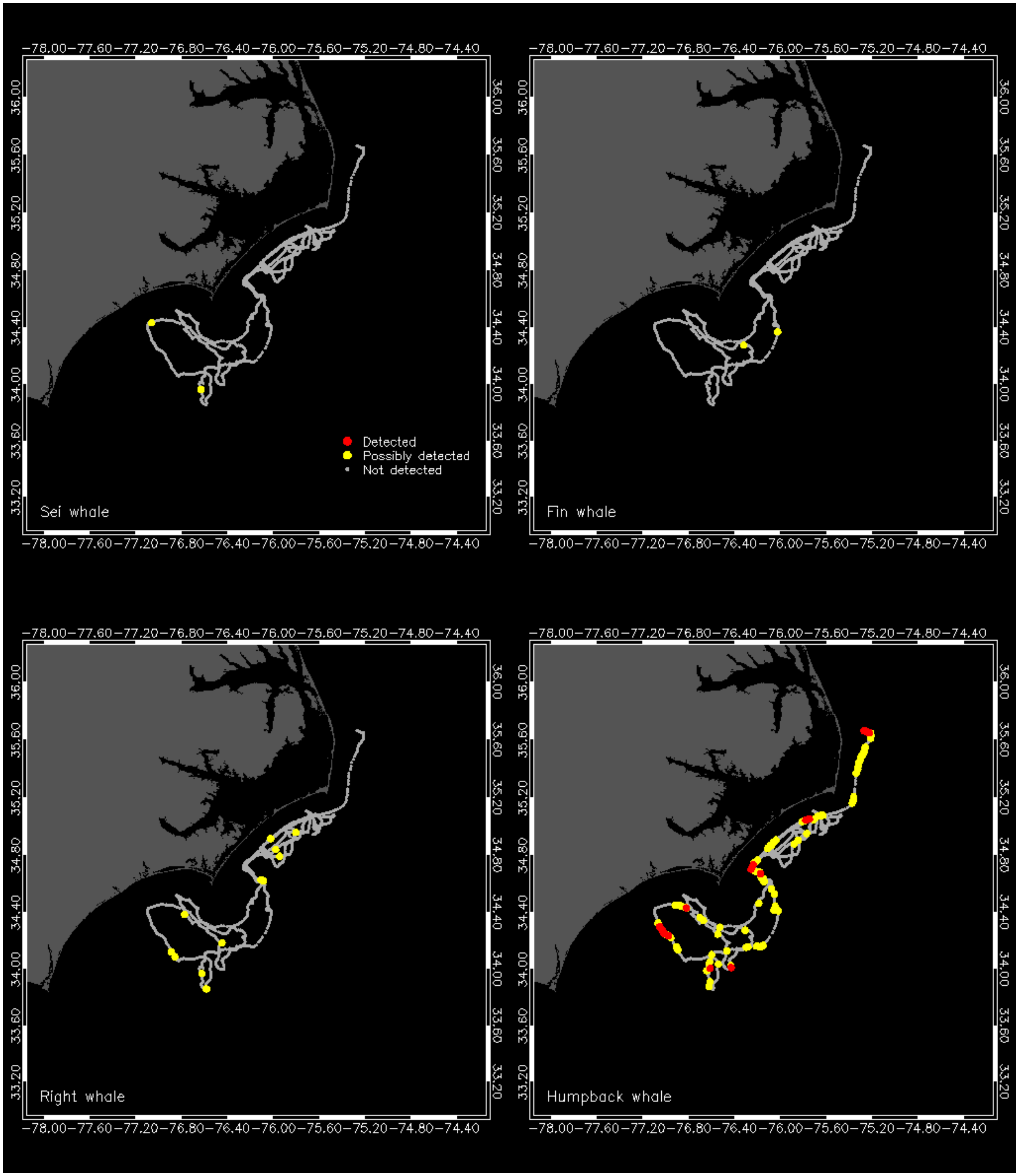

Figure 17. Near real-time acoustic detections from the Slocum G3 glider deployed to the south of Cape Hatteras, North Carolina.

Details of the glider deployments and associated analyses can be found in Baumgartner 2020.

2.2 Tagging Studies

During the reporting period, the U.S. Navy supported tagging fieldwork and associated analyses for odontocetes (**Sections 2.2.1 and 2.2.3**), baleen whales (**Sections 2.2.2 and 2.2.3**), pinnipeds (**Section 2.2.4**), and sea turtles (**Section 2.2.5**), in support of AFTT monitoring requirements.

2.2.1 Tagging of Deep-Diving Odontocete Cetaceans

In 2019, tagging activities were conducted off the coast of Cape Hatteras in association with the Atlantic BRS study (**Section 2.3**). These deployments built on the Deep Divers project that began in 2014 to develop a more robust picture of the medium-term movement patterns of deep-diving and other odontocete cetaceans off North Carolina. While the primary focus has been on Cuvier's beaked whales and short-finned pilot whales, a number of other species were tagged during the first 3 years of the Deep Divers project (Baird et al. 2015, 2016, 2017; Foley et al. 2017; Thorne et al. 2017). This constituted the sixth year of tagging with a continued focus on the distribution and ecology of Cuvier's beaked whales and short-finned pilot whales. Satellite tagging provided information on the spatial use and diving behavior of deep diving odontocetes over the medium term (weeks to months) (Baird et al. 2018). Shorter-term dive data (i.e., hours to days) can be collected using digital acoustic tags (DTAGs), and longer-term movement information (i.e., months to years) using photo-ID techniques (see **Section 2.1.1.2** of this report).

During May–August 2019, the third year of field effort was completed in support of the Atlantic BRS (**Section 2.3**). Satellite-tag deployments were conducted by researchers from Bridger Consulting Group in coordination with the Atlantic-BRS team aboard Duke University vessels. The Atlantic-BRS is a collaborative effort between Duke University, Southall Environmental Associates, and the University of St. Andrews—a Controlled Exposure Experiment (CEE) studying cetacean reaction to military sonar. The goal of this study was to deploy satellite tags prior to scheduled CEEs on two primary species in particular, Cuvier's beaked whale and short-finned pilot whale. Given the CEEs and their potential influence on fine-scale movements and diving behavior, this section summarizes the satellite, focusing on large-scale spatial use of tagged individuals as well as diving behavior prior to the CEEs. Detailed analyses of fine-scale movements and diving behavior in relation to the CEEs are summarized in **Section 2.3.1.2**.

Overall, 21 satellite tags were deployed—16 on Cuvier's beaked whales and five on short-finned pilot whales (**Table 13**). The Douglas-filtered ARGOS locations and pseudo-tracks for all satellite-tagged Cuvier's beaked whales and short-finned pilot whales during the 2019 field season are shown in **Figure 18** and **Figure 19**, respectively. **Figure 20** (for Cuvier's beaked whale "ZcTag082") and **Figure 21** (for short-finned pilot whale "GmTag226") shows an example of all filtered location positions for the entire satellite-tag deployment period for those given individuals. The figures also indicate the start and end locations of the respective CEEs conducted while the tag was transmitting on the animal. The tagged animals in the figures were exposed to two CEEs each, #19-01 and 19-02 for the Cuvier's beaked whale "ZcTag082", and #19-03 and 19-04 for the short-finned pilot whale "GmTag226".

Table 13. Summary of all satellite tag deployments during Atlantic-BRS field efforts in 2019.

Species[1]/Tag ID	Deployment Date	Tag Duration (days)	Deployment Latitude (°N)	Deployment Longitude (°W)
ZcTag082	5/11/2019	53	35.5216	74.7619
ZcTag083	5/11/2019	40	35.5734	74.7486
ZcTag084	5/23/2019	44	35.5318	74.7276
ZcTag085	5/27/2019	41	35.6930	74.7464
ZcTag086	5/28/2019	14	35.5957	74.7301
ZcTag087	6/2/2019	21	35.6000	74.7255
ZcTag088	6/2/2019	44	35.6091	74.7234
ZcTag089	6/2/2019	28	35.5780	74.7342
ZcTag090	7/29/2019	16	35.5932	74.7469
ZcTag091	7/29/2019	14	35.6193	74.7494
ZcTag092	7/30/2019	41	35.5359	74.7259
ZcTag093	7/30/2019	25	35.5398	74.7284
ZcTag094	7/30/2019	3	35.5909	74.7411
ZcTag095	8/12/2019	38	35.6509	74.7385
ZcTag096	8/12/2019	44	35.6474	74.7357
ZcTag097	8/12/2019	37	35.6301	74.7412
GmTag223	5/8/2019	1	35.6876	74.7749
GmTag224	7/28/2019	32	35.8364	74.8316
GmTag225	7/28/2019	11	35.8532	74.8162
GmTag226	7/28/2019	25	35.8479	74.8103
GmTag227	7/28/2019	10	35.8560	74.8108

[1] Zc = *Ziphius cavirostris* (Cuvier's beaked whale); Gm = *Globicephala macrorhynchus* (short-finned pilot whale)

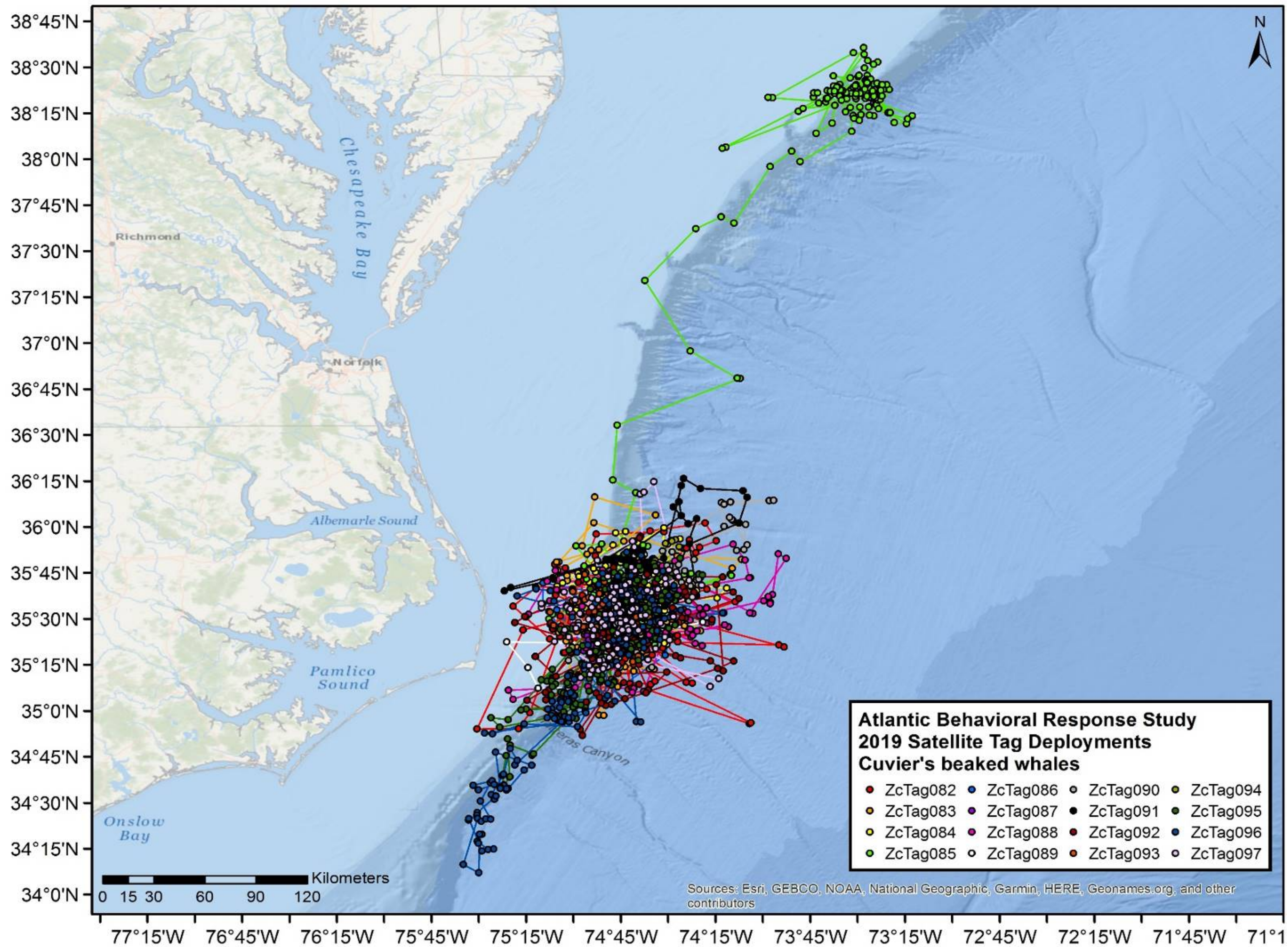

Figure 18. Douglas-filtered ARGOS positions for all 16 Cuvier's beaked whale satellite tag deployments in 2019.

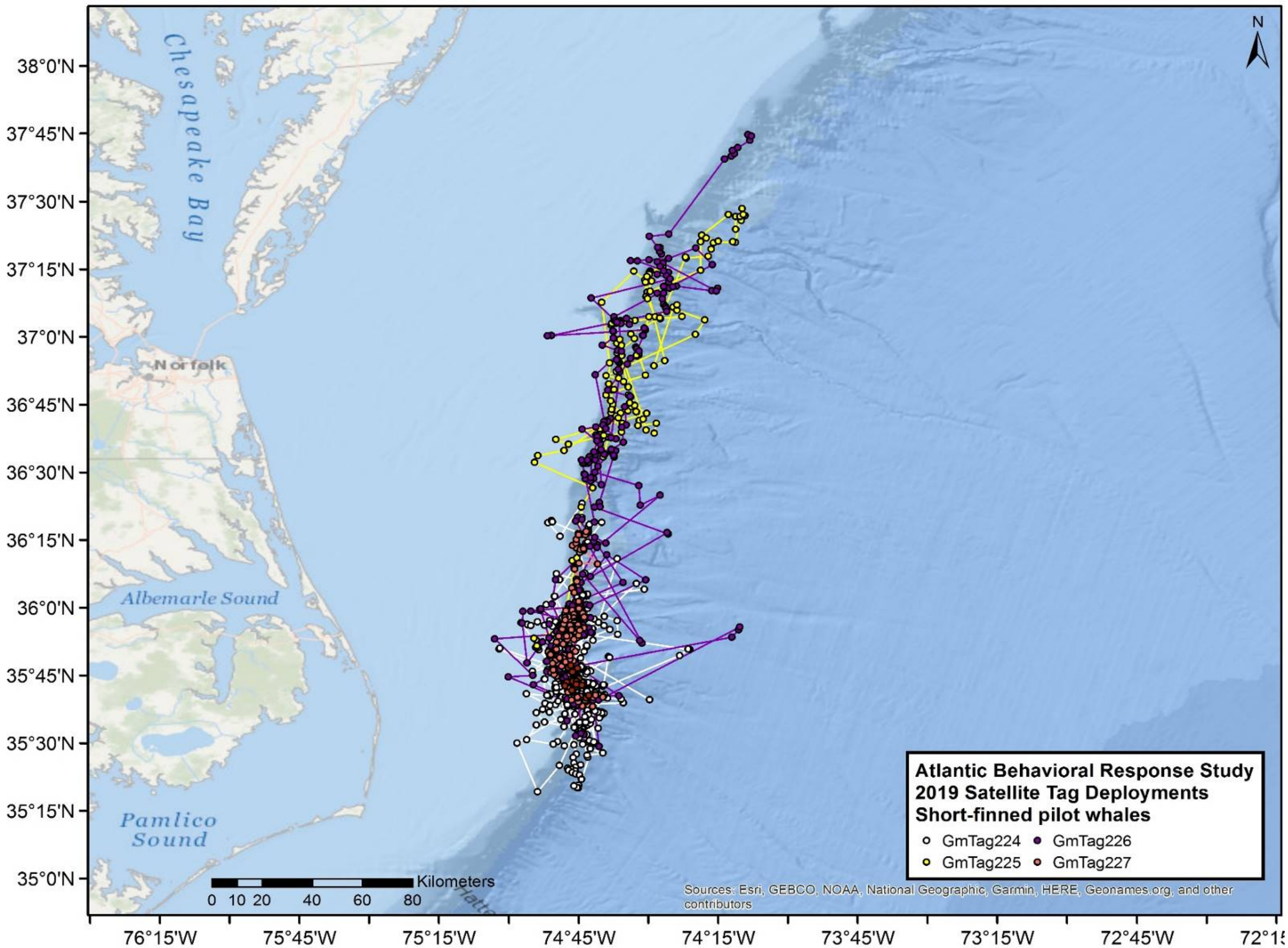

Figure 19. Douglas-filtered ARGOS positions for all four short-finned pilot whale satellite tag deployments in 2019.

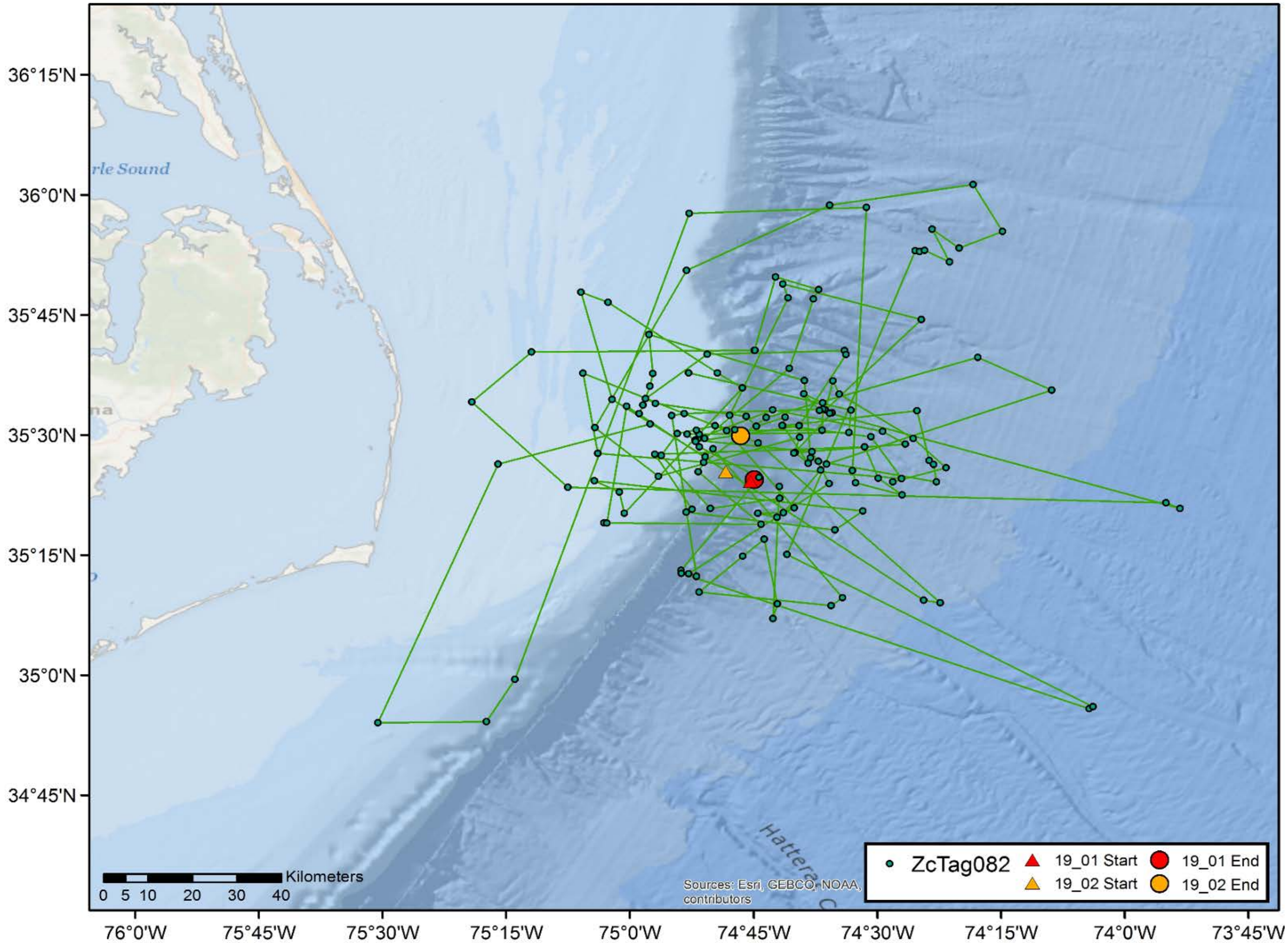

Figure 20. Douglas-filtered ARGOS positions for entire track of "ZcTag082" showing positions of CEEs conducted while tag was deployed.

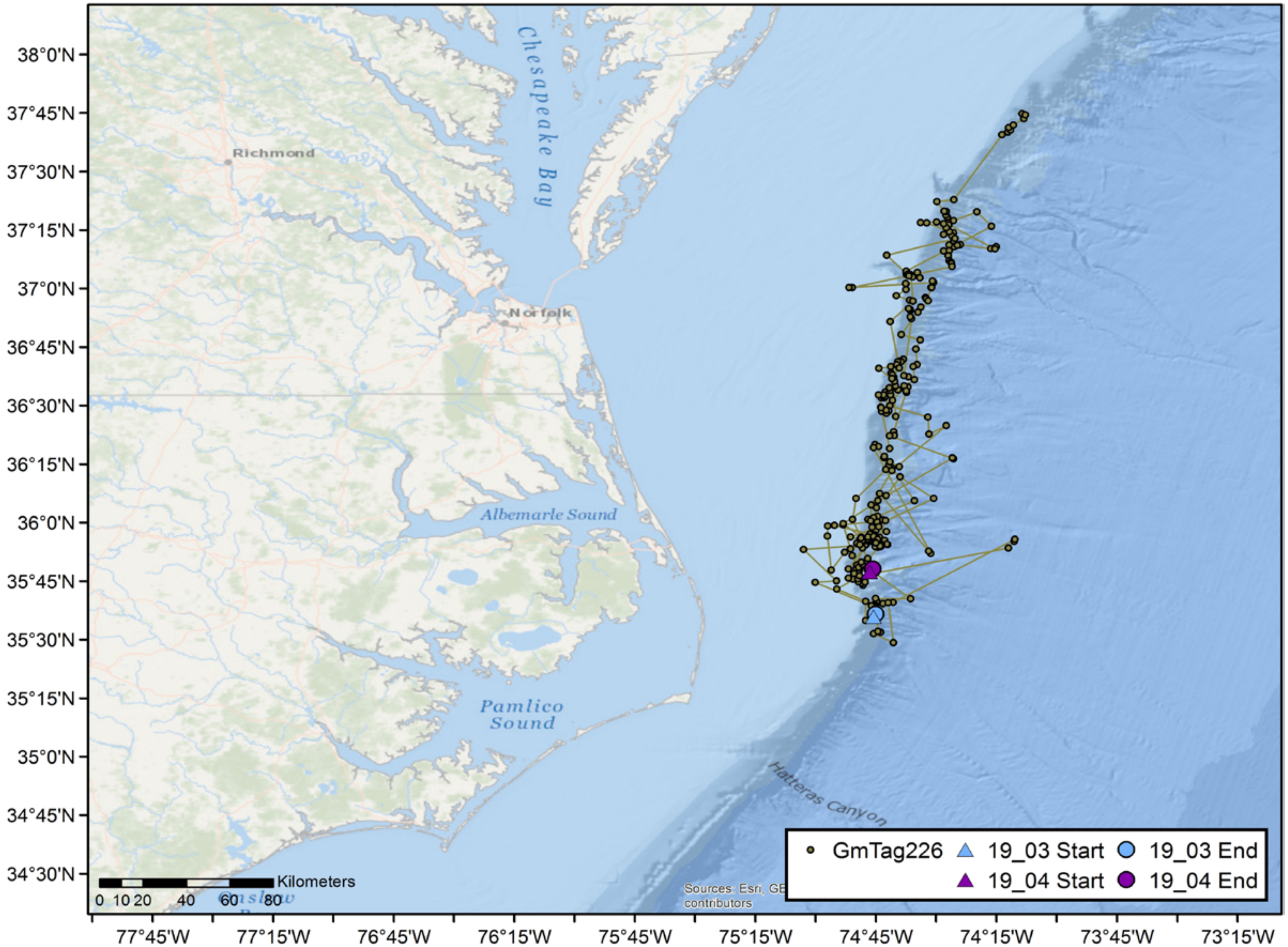

Figure 21. Douglas-filtered ARGOS positions for entire track of "GmTag226" showing positions of CEEs conducted while tag was deployed.

2.2.2 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.

Dedicated surveys began in January 2015 when vessel and aerial surveys were conducted in conjunction with photo-ID, focal-follow, and biopsy-sampling techniques to obtain baseline data on humpback whales in the region (Aschettino et al. 2015). Data from that field season also included humpback whale sightings recorded during concurrent density surveys in December 2014 (Engelhaupt et al. 2016). The 2015/2016 field season (December 2015–May 2016) consisted only of nearshore vessel surveys to collect biopsy samples of humpback whales, as well as photo-ID and focal-follow data from humpback whales and other high-priority baleen whale species, particularly in U.S. Navy training areas (e.g., W-50 Mine-neutralization Exercise [MINEX] zone) and shipping channels (Aschettino et al. 2016). Wildlife Computers (Redmond, WA) Smart Position and Temperature- (SPOT)-6 Argos-linked satellite tags were deployed during that field season to better understand the movement patterns of humpback whales off Virginia Beach, specifically in areas of high shipping traffic and live-fire exercises. Research efforts since the 2016/2017 field season have included the use of nearshore vessel surveys to collect photo-ID data and biopsy samples and to deploy SPOT-6 and SPLASH10-F Fastloc® Global Positioning System (GPS) tags (Aschettino et al. 2017, Aschettino et al. 2018). The 2018/19 season also included collaboration with a new project examining the response of humpbacks to approaching ships (see **section 3.2.2**).

Survey Effort

HDR conducted 28 nearshore vessel surveys for humpback whales between 23 November 2018 and 20 May 2019, as well as one out-of-season survey conducted on July 31, 2018. Over 170 hours of survey effort were completed and 3,147 km of trackline were covered (**Figure 22**). Fifteen survey days were completed during the 2019/2020 field season (between 21 December 2019 and 27 March 2020). Only basic details of these surveys will be presented in this report.

Sightings

A total of 64 sightings of humpback whales was recorded during the 2018/2019 survey season. Additional baleen whale sightings included 6 sightings of minke whales (**Figure 22**). Thirty-three (47.1 percent) of the 70 total whale sightings were in the shipping lanes, and 4 (13.3 percent) occurred in the W-50 MINEX zone (all humpback whales). Sightings of non-target species (i.e., common bottlenose dolphins) also were recorded but are not presented here. During the 2019/2020 season there were 44 humpback whale sightings, 2 minke whale sightings, and 1 fin whale sighting.

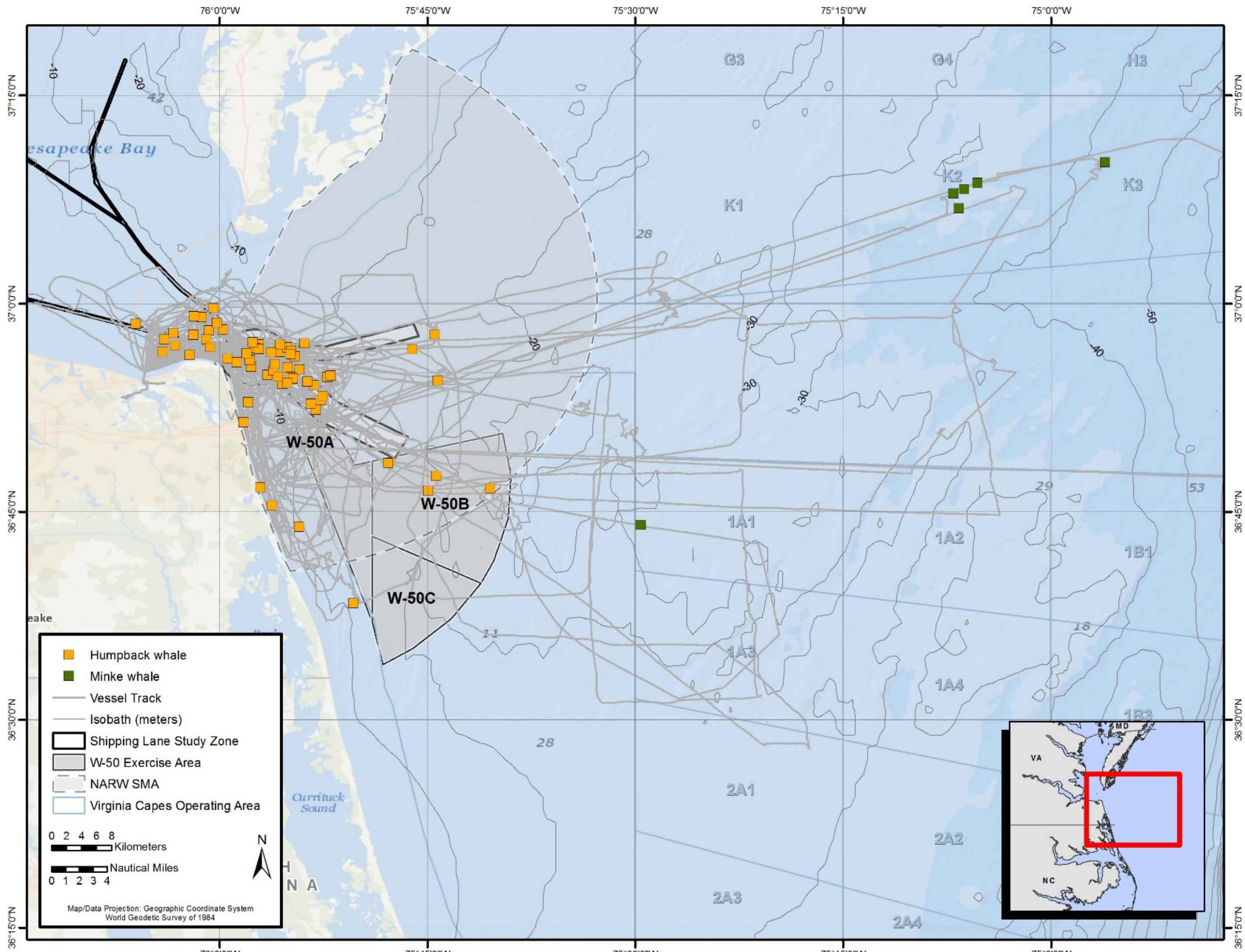

Figure 22. Nearshore survey tracks and locations of all humpback (n=64) and minke (n=6) whale sightings from 31 July 2018 through 20 May 2019.

Photo-identification

The 64 sightings of 80 total individual humpback whales included 32 unique humpback whales identified using dorsal fin and fluke images. An additional five unique whales were identified during offshore surveys conducted as part of the Outer Continental Shelf Break Cetacean Study (see **section 2.2.3**). Twenty-six (70.0 percent) of the identified humpback whales were categorized as juveniles based on their estimated sizes, while 7 (18.9 percent) were categorized as sub-adults or adults, 1 (2.7 percent) was categorized as an adult, and 3 (8.1 percent) were not assigned an age class. Five (13.2 percent) of the 38 individuals were re-sights from previous field seasons. The remaining 33 whales were new individuals added to HDR's growing catalog, which at the end of the 2018/2019 season contained 158 unique humpback whales. Seventeen of the 38 (44.7 percent) humpback whales were seen on more than one occasion during the 2018/2019 field season. During the 2019/2020 season, the 44 sightings of 60 individual humpback whales included 28 unique humpback whales, four of which had been seen previously, bringing the total catalog size to 182 individuals.

Biopsy Samples

Nine biopsy samples were collected from humpback whales during the 2018/2019 field season, and seven samples were collected during the 2019/2020 season and are awaiting analysis along with samples collected during the previous field seasons. Thirty-one samples (29 humpback and two fin whale samples) from 2014–2016 were also processed for stable-isotope analysis. The stable-isotope signatures for all samples were comparable to those reported for other regions of the North Atlantic (Waples 2017). There were significant differences in both $\delta^{13}C$ and $\delta^{15}N$ values between the humpback and fin whales in the study area. The humpback whales were slightly more depleted in carbon and had significantly higher $\delta^{15}N$ signatures than the fin whales. The humpback whales had a mean $\delta^{15}N$ value of 14.6 (standard error [*SE*]=0.9) compared to the fin whales' value of 10.5 (*SE*=0.0). Given a difference in $\delta^{15}N$ values between the 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 δ13C values between male and female humpback whales, but females did have significantly lower δ15N values than males, indicating that the diets of the two sexes may differ in this area (Waples 2017). These biopsy samples have also been provided to the University of Groningen in the Netherlands for genetic analysis and integration into a larger North Atlantic humpback whale population study.

Tagging

Seven SPOT-6 and three SPLASH10-F Argos-linked satellite tags were deployed on humpback whales during the 2018/2019 field season (**Table 14**). The tags transmitted between 3.2 and 13.3 days (mean=10.4 days). Whales tagged during this field season showed varied movement patterns, with some exclusively spending time in the primary study area and others moving out of the study area and farther offshore or to the north or south (**Figure 23**). One of the tagged humpback whales also was tagged during the 2016/2017 field season and exhibited similar movement patterns, spending considerable time within the Chesapeake Bay mouth shipping channels during both deployments, although tag duration was short (*n*=3.2 and 5.2 days, respectively) (**Figure 24**). An additional nine SPLASH10-F tags were deployed on humpback whales during the 2019/2020 season, as well as one SPLASH10 tag on a fin whale. Details of these tags are provided in the 2020 Annual Progress Report for this project (Aschettino et al. 2020b).

Table 14. Satellite-tag deployments on humpback whales during the 2018/2019 field season.

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

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

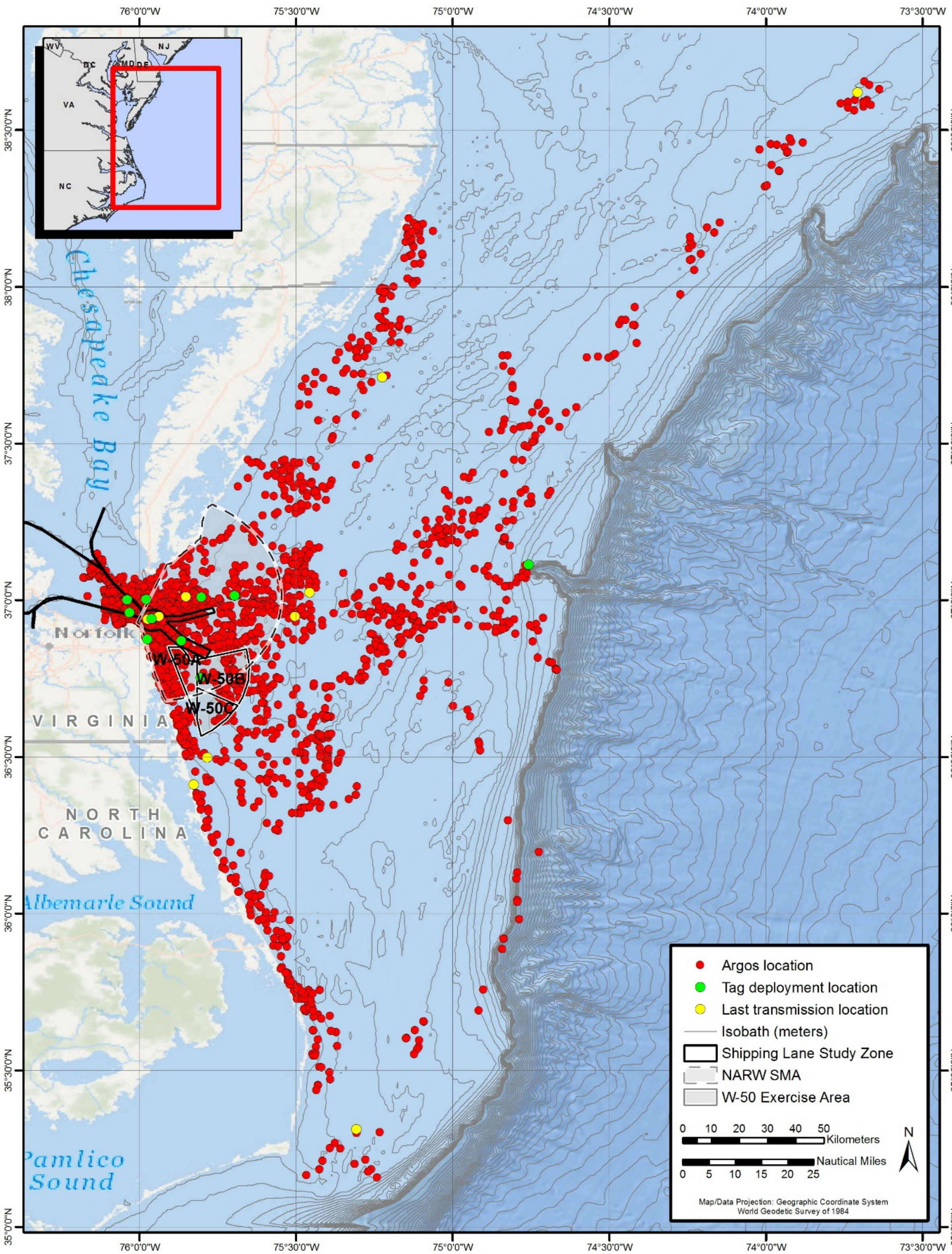

Figure 23. Argos locations for all humpback whales (*n*=10) tagged during the 2018/2019 field season.

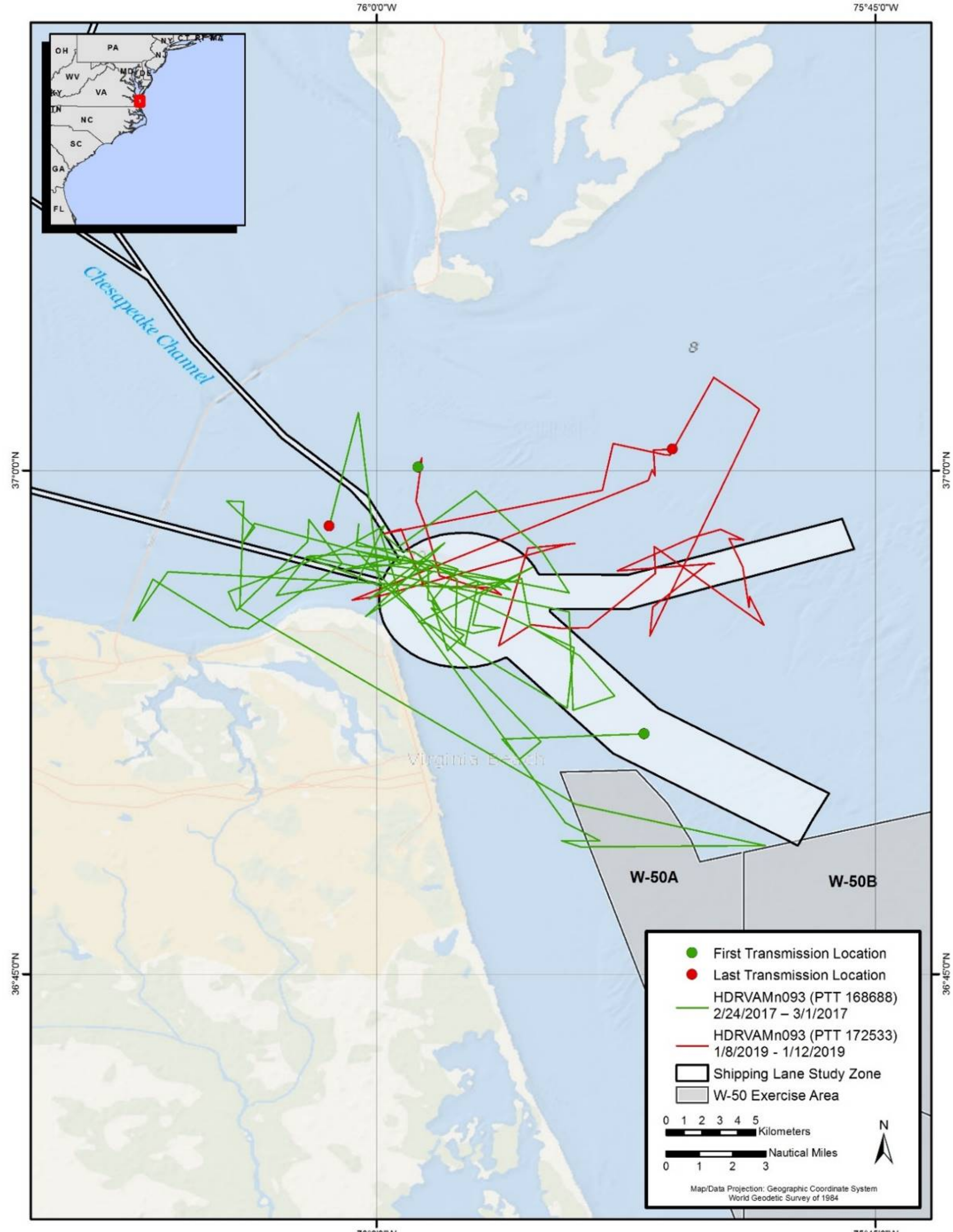

Figure 24. Comparison of the tracks of HDRVAMn093 between 2017 (green trackline, 5.2 days) and 2019 (red trackline, 3.2 days).

Results

Data analyses for this study are ongoing. Preliminary results indicate some site fidelity to the study area for individuals 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 broader offshore VACAPES OPAREA, where they are presumably within the hearing range of underwater detonation training exercises. Vessel interactions in the study area are still a concern for humpback whales. Approximately 9 percent of the individual humpback whales in the catalog have scars or injuries indicative of propeller or vessel strikes or from line entanglements. Throughout this study, individual humpback whales have been observed with boat injuries or have been found dead with evidence of vessel interactions being the likely cause. In April 2017, NMFS declared an Unusual Mortality Event for humpback whales in the Atlantic from Maine to North Carolina based on elevated mortalities of this species since January 2016. Some of the whales examined thus far have exhibited evidence of pre-mortem vessel strike, but the Unusual Mortality Event investigation process is ongoing (https://www.fisheries.noaa.gov/national/marine-life-distress/2016-2020-humpback-whale-unusual-mortality-event-along-atlantic-coast).

Approximately three-quarters of the humpback whales seen throughout this project appear to be juveniles, which is consistent with historic stranding and observational data collected in this area (e.g., Swingle et al. 1993, Wiley et al. 1995). Sightings of sub-adult-sized humpback whales have been highest early in the field seasons and in waters farther from shore. They typically are not re-sighted during a field season, suggesting that these whales may be passing through the area rather than remaining in the primary study area for long durations. Because the juveniles are spending more time in the study area than larger animals, they may be at greater risk for injury (Aschettino et al. 2018). A manuscript with details from the first three years of effort has recently been published in a special issue on the Impacts of Shipping on Marine Fauna in *Frontiers in Marine Science*. The manuscript is titled Satellite Telemetry Reveals Spatial Overlap between Vessel High-Traffic Areas and Humpback Whales (*Megaptera novaeangliae*) Near the Mouth of the Chesapeake Bay (Aschettino et al. 2020a).

For more information on this study, refer to the annual progress report for this project (Aschettino et al. 2020b).

2.2.3 VACAPES Outer Continental Shelf Break Cetacean Study

HDR has collaborated with the U.S. Navy to conduct marine mammal surveys near Naval Station Norfolk, Joint Expeditionary Bases-Little Creek and Fort Story, and Naval Air Station Oceana Dam Neck Annex, and within the W-50 MINEX zone since 2012 (Engelhaupt et al. 2016). However, limited survey effort has occurred farther offshore of the Virginia coast—in the VACAPES OPAREA near the continental shelf break. Therefore, there are limited data and information on how offshore species, including beaked whales, endangered fin and sperm whales, and other large baleen whales utilize the deeper waters of this region. Vessel surveys for the VACAPES Outer Continental Shelf Cetacean Study were initially conducted from April 2015 through June 2016 in association with the Mid-Atlantic Humpback Whale Monitoring project (Aschettino et al. 2016) and became a dedicated study in July 2016 (Engelhaupt et al. 2017), followed by a second dedicated year of surveys through all of 2017 (Engelhaupt et al. 2018) and a third year through all of 2018 (Engelhaupt et al. 2019). The goal of this study is to determine the seasonal occurrence, movement patterns, site fidelity, behavior, and ecology of cetaceans in VACAPES OPAREA offshore waters. During the vessel surveys, researchers utilize a combination of techniques including focal follows, photo-

ID, biopsy sampling, unmanned aircraft systems, and satellite-linked telemetry tags. Activities conducted during the 2019 field season are summarized below and detailed in Engelhaupt et al. 2020.

Survey Effort

HDR conducted 14 offshore vessel surveys in 2019, covering 4,637 km of trackline. Surveys were conducted at least once per month in all months except April and July, 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

Totals of 239 marine mammal sightings and 18 sea turtle sightings were recorded during vessel surveys (**Figure 25**). Twelve cetacean taxa were identified: unidentified pilot whale (*Globicephala* sp.) (*n*=86), common bottlenose dolphin (*n*=43), common dolphin (*n*=38), fin whale (*n*=15), Risso's dolphin (*n*=9), sperm whale (*n*=7), Atlantic spotted dolphin (*n*=7), humpback whale (*n*=4), short-finned pilot whale (*n*=4), striped dolphin (*n*=4), True's beaked whale (*n*=2), Sowerby's beaked whale (*n*=1), and Cuvier's beaked whale (*n*=1). In addition, there were 18 sightings of unconfirmed species: unidentified dolphin (*n*=11), unidentified large whale (*n*=4), unidentified cetacean (*n*=1), unidentified *Mesoplodon* beaked whale (*n*=1), and unidentified beaked whale (*n*=1). Two sea turtle taxa were identified: loggerhead turtle (*n*=15) and leatherback turtle (*n*=3).

As expected, sightings of deep-diving species, including sperm whales, pilot whales, and beaked whales, were concentrated near and offshore of the continental shelf break and in the Norfolk Canyon area. Baleen whale sightings were recorded both on and offshore of the shelf, though a greater proportion occurred offshore in 2019 compared to 2018. Coverage during 2019 continued to include more time in waters deeper than 1,500 m than in preceding seasons, focusing on locating priority deep-diving sperm whales and beaked whales. Dolphin species were sighted throughout the core study and transit areas, and sea turtles were only sighted over the shelf. 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.

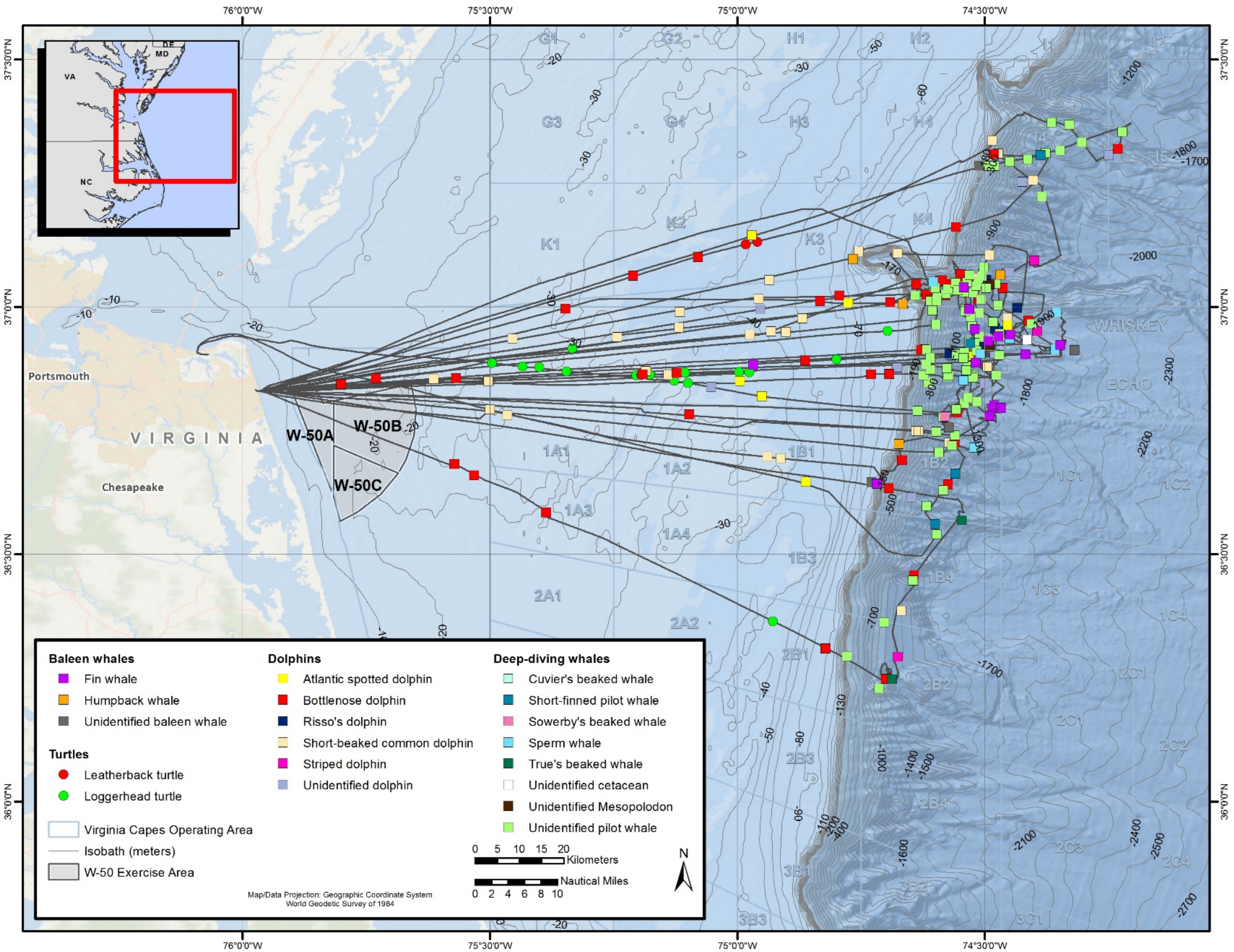

Figure 25. All tracklines and sightings of marine species for field work conducted in 2019.

Photo-ID

Photo-ID images were collected during 163 of the 239 marine mammal sightings. Baleen, sperm, and beaked whale images were added to HDR's existing catalogs, which now contain 83 fin whales, 10 minke whales, 6 North Atlantic right whales, 2 sei whales, 89 sperm whales, 8 Sowerby's beaked whales, and one Cuvier's beaked whale. Of the 83 identified fin whales, 13 (15.7 percent) have been re-sighted; 7 (8.4 percent) of them during different years ranging from 247 to 355 days between first and last sightings. Locations of all re-sighted fin whales were over the continental shelf inshore of the 200-m depth contour. Twelve of the 89 identified sperm whales (13.5 percent) were sighted on more than one day, ranging from 9 to 428 days between sightings. All 12 re-sighted sperm whales were photographed at least once within or offshore of Norfolk Canyon; 7 of those 12 were in those waters for all documented sightings. There have been no re-sightings of any of the identifiable Sowerby's beaked whales. Duke University compared the Cuvier's beaked whale ID to their existing catalog but no matches were found. Humpback whale images were incorporated into the existing nearshore catalog (see Aschettino et al. 2019), adding 4 new whales. Images of other odontocete species have been archived for future processing.

Biopsy Samples

Five biopsies were collected from sperm whales, and one was collected from a humpback whale. The humpback whale sample was added to those collected during the nearshore humpback survey effort, and the sperm whale samples are currently being processed. Gender results from 2017 and 2018 sperm whale samples show 3 females and 10 males, but no 2019 results are available at the time of this summary.

Tagging

Eight satellite tags were deployed in 2019: 7 on sperm whales and 1 on a humpback whale (**Table 15**). The humpback tag data will be included in the nearshore humpback reports (Aschettino et al. 2020b) and therefore have been excluded from this summary. Tag duration ranged from 7.2 to 32.2 days (mean=15.2) for sperm whales. Maximum distance from initial tagging location ranged from 82 to 918 km (mean=283.4), and mean distance from tagging locations for each tagged individual ranged from 38 to 360 km (mean=125.6). The SPOT-6 tags provided locations only and SPLASH-10 tags recorded dive depths and duration in addition to providing locations. Maximum dive depth ranged from 1,119 to 1,887 m, and maximum dive duration ranged from 49 to 57 min.

Locations from satellite-tagged sperm whales showed movements through multiple U.S. Navy OPAREAS, mostly along the continental shelf break and beyond the slope. Movements varied, with most individuals showing limited movement from their initial tagging location in the VACAPES OPAREA (e.g., **Figures 26 and 27**), and others moving greater distances to the north or east, generally along the continental shelf edge and slope. Movements ranged north through the Atlantic City and Narragansett Bay OPAREAs with one individual crossing into Canadian waters before the tag stopped transmitting. None of the 2019 tagged whales moved south to the Cherry Point OPAREA waters as in previous years.

Table 15. Satellite tag deployments on sperm whales during 2019.

Animal ID	Tag Type	Deployment Date	Last Transmission Date	Tag Duration (Days)
HDRVAPm038	SPLASH-10	08-Mar-19	20-Mar-19	11.1
HDRVAPm061	SPOT-6	08-Mar-19	24-Mar-19	15.6
HDRVAPm065	SPLASH-10	08-Mar-19	22-Mar-19	13.2
HDRVAPm082	SPLASH-10	27-Jun-19	07-Jul-19	9.4
HDRVAPm086	SPLASH-10	05-Aug-19	13-Aug-19	7.2
HDRVAPm087	SPOT-6	05-Aug-19	29-Sep-19	32.2
HDRVAPm088	SPOT-6	05-Aug-19	23-Aug-19	17.5

Fieldwork and data-analysis efforts for this project are ongoing. Results continue to show a high diversity of marine mammal species including deep-diving odontocete species, in the study area, which is an important high-use area for U.S. Navy training and testing activities. The sighting of an ESA-listed blue whale in 2018 during this study was the first documented off the coast of Virginia and a manuscript with details of the sighting was submitted in September 2019 to *Marine Biodiversity Records* and is currently in review. A detailed analysis of movement and dive data for both fin and sperm whales is ongoing, with results showing similarities and variability within and between individuals of each species. The dive data from the first satellite-monitored location dive behavior tag to be deployed on a Sowerby's beaked whale have provided valuable insight with respect to the behavior of this highly cryptic species that is potentially at higher risk of influence from anthropogenic noise. Further analysis of these data has been presented at the World Marine Mammal Conference in 2019 (Engelhaupt et al. 2019) and a manuscript is in preparation. Providing a more detailed understanding of both fine- and medium-scale foraging ecology of sperm and beaked whales continues to be the priority during FY 2020–2021 surveys. As additional surveys are conducted and tags are deployed on multiple species across all four seasons, we expand our knowledge of marine mammal and sea turtle occurrence and habitat use in this high-use U.S. Navy training range.

For more information on this study, refer to the annual progress report for this project (Engelhaupt et al. 2020).

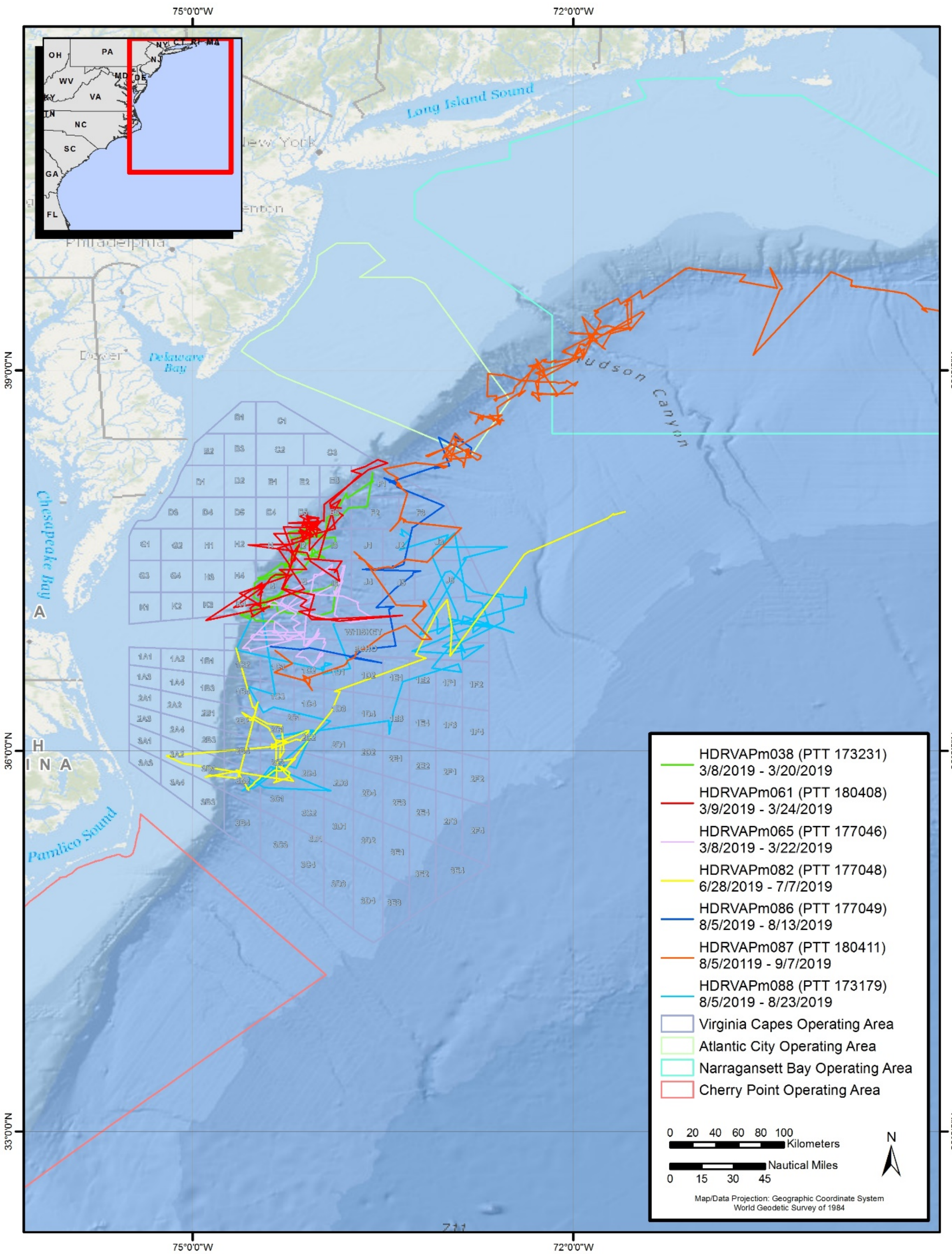

Figure 26. Tag tracks of all sperm whales tagged during 2019.

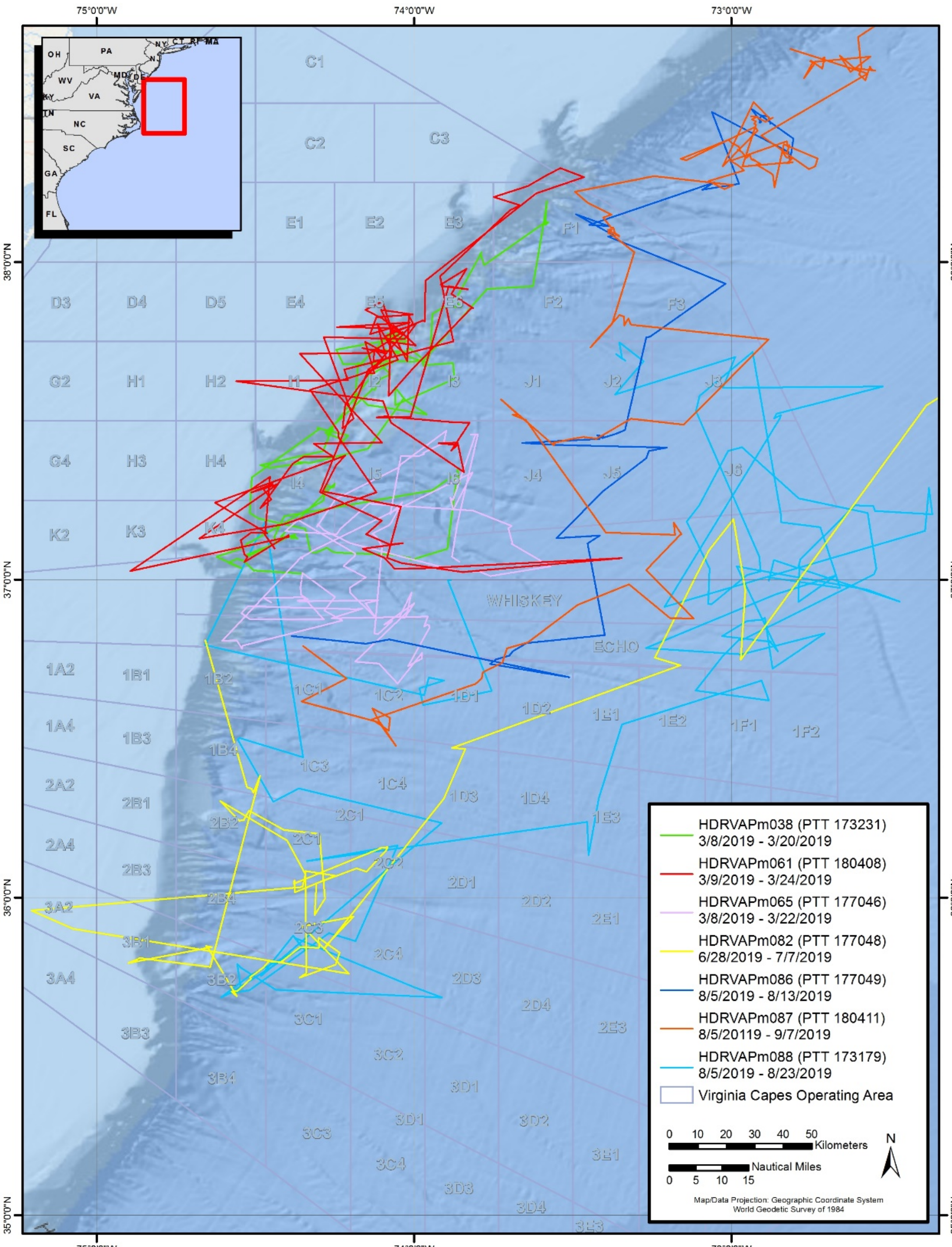

Figure 27. Tag tracks of all sperm whales tagged during 2019, zoomed to show more detail of the movement of multiple whales that stayed close to tag-deployment location in VACAPES OPAREA.

2.2.4 Pinniped Tagging and Tracking in Virginia

Since the passage of the MMPA in the U.S. in 1972, and as amended (16 United States Code § 1361 14 et seq.), both harbor seal and gray seal populations have grown in the Northwest Atlantic Ocean (Hayes et al. 2019). Both species are year-round coastal inhabitants in eastern Canada and New England, and occur seasonally in the mid-Atlantic United States between September and May (Hayes et al. 2019). Harbor seals migrate to northern areas for pupping and mating in the spring and summer, and return to more southerly areas in the fall and winter. Grey seal pupping typically occurs in winter between January and February, followed immediately by mating once pups are weaned. The newly weaned pups occasionally disperse south and west of the pupping beaches beginning in the spring. Within the last decade, harbor seals have been observed returning seasonally to haul-out (resting) locations in coastal Virginia, and gray seals occasionally are observed there as well (Jones et al. 2018).

The Navy regularly engages in training, testing, and in-water construction activities in coastal Virginia and Chesapeake Bay (**Figure 28**) in order to maintain Fleet readiness and structural integrity of military installations. The lower Chesapeake Bay and coastal areas of Virginia represent one of the busiest hubs of naval activity on the East Coast and host numerous pierside facilities, installations, vessel, shipyards, and in-water training ranges. Seals seasonally inhabiting and transiting through these areas could be impacted by the use of active sonars and explosives, vessel traffic and movement, dredging, pile driving, and other activities.

Navy biologists have been researching seal occurrence in and around the Chesapeake Bay since 2013, and conducting systematic haul-out counts in the region since 2014 (see **Section 2.1.1.3**) Results from these surveys indicate that seals arrive in the area in the fall and depart in the spring (Rees et al. 2016). However, our understanding of seal movements, habitat use, haul-out patterns, and dive behavior in Virginia waters is still extremely limited. In order to assess the potential impacts on seals from Navy activities, mitigate potentially harmful interactions, and obtain appropriate authorizations to maintain environmental compliance, it is important to have a better understanding of seal distribution and behavior in these areas. Although visual haul-out studies are useful for estimating the minimum number of animals present on land at various times of the year, telemetry studies are needed to characterize seals' at-sea movements, habitat use, and dive behavior, as well as the environmental variables that may influence their distribution patterns.

Now in its third field season as of winter 2019-2020, this study sought to establish the feasibility of using satellite tags to better understand seals' residency time in Virginia waters, their local habitat utilization patterns, and their migratory destinations in the spring. The information gathered from this effort will provide valuable baseline data needed for the future assessment of harbor seal movements and site fidelity along the U.S. Eastern Seaboard.

The capture site is located on the Eastern Shore of Virginia, where seals haul out between fall and spring. The Eastern Shore haul-out area has several discrete haul-out sites (5 main locations within the marsh, which can further be broken down into a total of 9 smaller sites) where seals have been observed (Jones et al. 2020). These haul-outs are in a tidal salt marsh, consisting of muddy banks and vegetation, which is subject to tidal influx. The seals are often seen hauled out in areas with little to no vegetation, or where existing vegetation has been flattened by either the tide or the animals' weight. Seal captures followed a similar protocol as described by Jeffries et al. (1993). Seals are captured using a seine net and 3 small flat-bottomed vessels with outboard motors. Seals are brought onshore after entering the capture net adjacent to haul-out site(s).

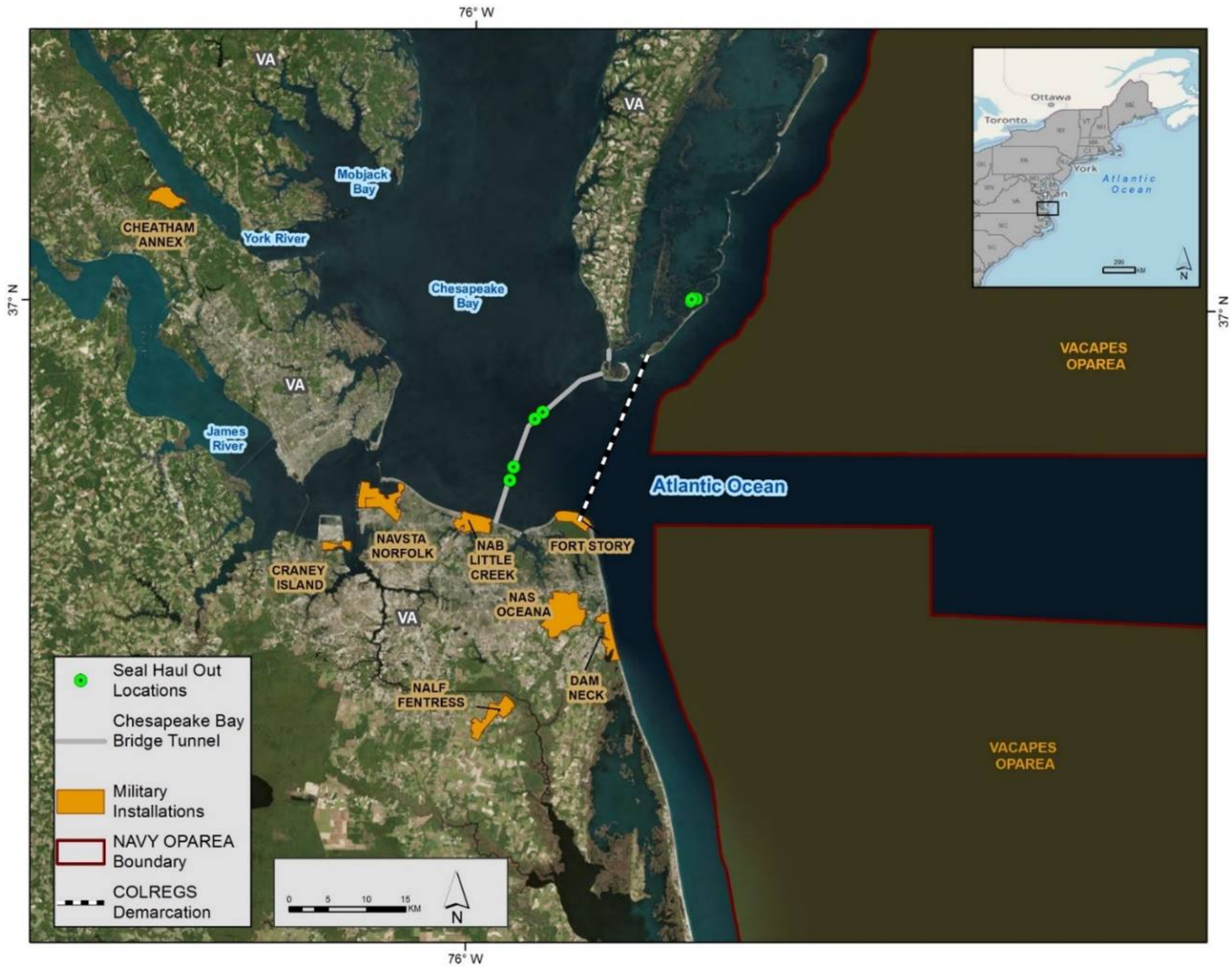

Figure 28. Seal haul-out locations in lower Chesapeake Bay and coastal Virginia, showing the Virginia Capes Range Complex (VACAPES) and sonar training areas. COLREGS = collision regulations; OPAREA = Operating Area.

Seven seals were captured during the first year of the study (Ampela et al. 2019). Plans for the 2019 season included tagging up to 17 harbor seals, with a combination of SPOT and two types of SPLASH tags, using the same methods as the previous year. However, due to a number of environmental, logistical, and anthropogenic factors, no seals were captured in 2019.

There were two 5-day fieldwork windows in 2019 (one in January and one in February), both of which posed unique challenges. Field work was planned for January 2019 in order to have tags on animals as early as possible to maximize the duration of data collection. The weather conditions were not ideal during this field work window, with winds blowing from the North (N), Northeast (NE), or Northwest (NW) almost every day, and therefore directly at the haul out locations from the open ocean. This likely discouraged seals from hauling out at the preferred capture location, and reduced the number of animals observed overall. The January field work window also coincided with the end of snow goose-hunting season and therefore one of the busiest hunting weeks, so there were audible distant gunshots across the marsh and an increase in vessel traffic in the area. The seals seemed more alert and responsive to human disturbances than they typically were during previous observations and any seals that were initially hauled out quickly flushed into the water as the field team approached. Ultimately, the capture net was not deployed during this fieldwork window.

The February 2019 fieldwork window had more promise due to the increase in seals utilizing the area, and the hunting season being over. However, the weather remained poor, with winds from the N or N/NE for the first half of the window. There were West winds for the second half of the field work window, which did allow for slightly better working conditions. Wind speeds were high, ranging from 14-25 knots with gusts from 15-27 knots throughout the entire fieldwork window (recent observational data suggest that N, NE and West winds are not ideal for capture and tagging operations if winds are above 14 knots). Additionally, the seals were hauling out at a different site than the previous season, which added logistical difficulties because the bottom of the inlet/creek at these locations was more variable and deeper at high tide, which prevented the lead line of the net from reaching bottom. The new haul out site provided the seals with a better view of approaching boat traffic, which allowed them to return to the water quicker. The capture net was deployed four times over the course of the fieldwork window. None of the net deployments resulted in captures due to the seals quickly flushing from the haul out before the net could be fully deployed, as well as issues with the net configuration, which did not allow it to deploy correctly.

Table 16. A summary of the number of seals hauled out and environmental data for all tagging field days during the 2018-2019 season.

Date	Haul-out Site Surveyed	Number of Seals	Max Wind Speed (kt)	Max Wind Gust (kt)	Wind Direction	Min Air Temp (°F)	Max Air Temp (°F)
10-Jan-19	A - E	0	14	n/c	W/NW	32	39
11-Jan-19	A - E	0	14	n/c	N/NNW	30	39
12-Jan-19	A - E	0	17	n/c	N/NE	35	42
13-Jan-19	A - E	0	25	n/c	N/NE	36	44
9-Feb-19	A - E	0	24	31	N	24	42
10-Feb-19	C	65	14	17	NE/E	22	40
11-Feb-19	C	25	18	22	NE/E	35	41
12-Feb-19	C	10	17	25	W	40	54
13-Feb-19	E	30	22	25	W	35	51
13-Feb-19	B	12	22	25	W	29	52

Key: n/c = data not collected; kt = knots; °F = degrees Fahrenheit

The first two years of the study helped refine our understanding of how environmental factors influence seal haul-out behavior and therefore capture success. Weather and tidal data will influence the schedule for the 2020 fieldwork window. Additionally, modifications will be made to the net configuration to ensure proper deployment.

2.2.5 Sea Turtle Tagging—Chesapeake Bay and Coastal Virginia

Researchers from the Virginia Aquarium & Marine Science Center 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 foraging behavior of loggerhead, green (*Chelonia mydas*), and Kemp's ridley turtles in this region. Research methods include the use of satellite telemetry to characterize broad-scale movement patterns and the use of both satellite- and acoustic-telemetry data to characterize the occurrence of turtles in specific areas of interest to the U.S. Navy. This dataset will assist the U.S. Navy in identifying seasonal areas where cheloniid sea turtles are likely to occur in order to support environmental planning and compliance efforts.

A total of 129 turtles were released with satellite transmitter and/or VEMCO acoustic tags (51 satellite, 90 acoustic) from 2013 through 2018 (**Table 17**). See Barco et al., 2017 and Barco et al., 2018 for details of how turtles were acquired as well as tagging procedures. Telemetry data for loggerheads has been previously analyzed to estimate local home range and assess foraging behavior (Barco et al., 2017), as well as a home range and preliminary foraging analysis for Kemp's ridley turtles (manuscript submitted). Additional analyses are currently being finalized to develop state-space switching models (SSM) and habitat models for both loggerhead and Kemp's ridley turtles in the Chesapeake Bay. This work is expected to be published in 2021.

Table 17. Summary of all tags deployed on turtles 2013-2018.

	Loggerhead (Cc)			Kemp's ridley (Lk)			Green (Cm)			TOTAL	
	Total	VEMCO	Satellite	Total	VEMCO	Satellite	Total	VEMCO	Satellite	VEMCO	Satellite
2013	11	11	6	1	1	0	2	2	0	14	6
2014	7	7	5	16	16	3	2	2	0	25	8
2015	15	7	7	21	14	7	1	1	0	22	14
2016	0	0	0	4	0	4	0	0	0	0	4
2017	0	0	0	21	11	10	1	1	0	12	10
2018	0	0	0	26	16	9	1	1	0	17	9
TOTAL	**33**	**25**	**18**	**89**	**58**	**33**	**7**	**7**	**0**	**90**	**51**

Key: Cc=*Caretta caretta* (loggerhead); Lk=*Lepidochelys kempii* (Kemp's ridley); Cm=*Chelonia mydas* (green)

2.3 Behavioral Response

2.3.1 Atlantic Behavioral Response Study

The Atlantic Behavioral Response Study (Atlantic-BRS) was initiated following extensive planning discussions with researchers and U.S. Navy personnel to transition experimental methods previously developed under the Southern California Behavioral Response Study (SOCAL-BRS), funded primarily by the U.S. Navy's Living Marine Resources (LMR) program, as well as the Office of Naval Research (ONR). For the past three years, a research collaboration of scientists from Duke University, Southall Environmental Associates (SEA), Cascadia Research, and the University of St. Andrews has conducted strategic tag deployments and controlled exposure experiments (CEEs) on beaked and pilot whales off the coast of Cape Hatteras, North Carolina. This collaboration has had unprecedented success in tagging high-priority beaked whales and conducting CEEs with both operational mid-frequency active sonar (MFAS) systems from Navy surface vessels (e.g. SQS-53C-equipped combat vessels) as well as experimental sound sources simulating these systems. This report describes the objectives, field methods and results, and analyses conducted to date. Most focus here is on accomplishments from the 2019 field season and response analyses largely conducted on data collected in 2017 and 2018 (Southall et al 2018; 2019) as detailed analyses of the 2019 field data are still ongoing.

Most previous studies have either used short-term, high-resolution acoustic tag sensors to measure fine-scale behavior in response to calibrated metrics of experimental noise exposure, or coarser-scale, longer-term measurements of movement and diving behavior associated with incidental exposures during sonar training operations. This study is unique in bringing both approaches together and building on previous experience with both tag types for focal species within the same area. Specifically, the overall design involves expanding the temporal and spatial scales of previous BRS efforts by combining short-term, high-resolution acoustic archival tags (DTAGs) providing short-term (hours) but very high-resolution movement and calibrated acoustic data, and satellite-linked, time-depth recording tags (SLTRDs, i.e. "sat tags") providing much longer-term (weeks-months) data on movement and increasingly better resolution dive data, simultaneously deployed on multiple individuals of focal species in the same CEEs.

The overall research objective is to provide direct, quantitative measurements of marine mammal behavior before, during, and after known exposures to MFAS signals in order to better describe behavioral response probability in relation to key exposure variables (e.g. received sound level, proximity, animal behavioral state). These measurements will have direct implications for and contributions to more informed assessments of the probability and magnitude of potential behavioral responses of these species. Results will be directly applicable to the Navy in meeting their mandated requirements to understand the impacts of training and testing activities on protected species, as well as to regulatory agencies in evaluating potential responses within regulatory contexts.

Several key categories of behavioral responses are being evaluated, including potential avoidance of sound sources that influence habitat usage, changes in foraging behavior, and changes in social behavior. While the overall experimental approach using CEEs and comparing exposure among conditions before, during, and after noise exposure is not uncommon, several methodological parameters (e.g., tag types and configuration settings, nominal target exposure levels) differ slightly among species given known variability in their life history, baseline behavior, and presumed (from previous observations and studies in other areas) sensitivity to noise exposure. As in previous studies, explicit monitoring and mitigation protocols have been established and followed in conducting CEEs in order to meet experimental objectives and ensure compliance with both permit authorizations and ethical standards. Further, experimental objectives, field work accomplishments, and planned effort are regularly communicated transparently to interested stakeholders through periodic compliance reporting, progress updates, and presentations and discussions in scientific and general audience fora.

Details of the experimental design, analytic approach, and field logistics can be found in Southall et al. 2020.

2.3.1.1 Field Effort

Atlantic-BRS field effort in 2019 consisted of two phases. Phase 1 occurred in spring 2019 with five sessions over the course of May and June. Phase 2 occurred in summer 2019 with another five sessions in July and August. Overall, 21 satellite tags were deployed on focal species (**Tables 18-19** - 16 on Cuvier's beaked whales, and 5 on short-finned pilot whales). A total of four CEE sequences were conducted (**Table 20**), all of which were full-simulated source MFAS events due to the unavailability of U.S. Navy warships. The simulated CEEs were conducted on nine of the 21 satellite tagged animals, and all nine were Cuvier's beaked whales.

Phase I (Spring 2019) Accomplishments

- Successful deployment of 9 of satellite tags (8 beaked whales; 1 pilot whale).
- Two successful CEEs with simulated MFAS CEEs. Both were conducted at or near higher target RLs specified for 2019.
- Novel observations of potential social group disruption in beaked whales, with individuals with known sighting history in same social group subsequently sighted apart following CEE.
- Sustained efforts to relocate sat-tagged animals in the field using goniometer detections. This significantly increases chances of subsequent tag deployments, improves animal pseudo-tracks by providing high confidence surface locations, and results in many photo-ID resights to evaluate group composition and social interactions. These developments proved very important on multiple levels.
- Greatly improved satellite-transmitting tag dive data thanks to earlier progress in tag deployment strategies to reduce/eliminate gaps in satellite tag data and to improve temporal resolution on diving and behavioral data. Successfully collected continuous dive data for two-week periods, strategically covering CEE periods, as designed.

Phase II (Summer 2019) Accomplishments

- Successful deployment of 12 satellite tags (8 beaked whales; 4 pilot whales).
- Successful deployment and recovery of two DTAGs (both beaked whales; 1 very short).
- First successful deployment of DTAG on beaked whale in a group with long-term satellite tag reporting position and continuous dive data. Numerous methodological implications including first-ever CEE on animals together and being measured on multiple temporal, spatial scales of resolution.
- Successful completion of two full-duration simulated MFAS source CEEs.
- Sustained success in relocating tagged whales for resights, photo-ID, and group composition.

- Sustained success in collecting continuous, full time series dive data at 5-min resolution.
- Significant new insights into social behavior of Cuvier's beaked whales, with CEE conducted on group with three simultaneously tagged beaked whales. Major implications for response analyses and novel observations of potential social responses to MFAS exposure.

Table 18. Satellite tag deployments for Cuvier's beaked whales for 2019 Atlantic-BRS field efforts.

Species[1]/Tag ID	Deployment Date	Tag Duration (days)	Dive Data Steams	Deployment Latitude (°N)	Deployment Longitude (°W)
ZcTag082	5/11/2019	53	5-min time series	35.5216	74.7619
ZcTag083	5/11/2019	40	5-min time series	35.5734	74.7486
ZcTag084	5/23/2019	44	5-min time series	35.5318	74.7276
ZcTag085	5/27/2019	41	5-min time series	35.6930	74.7464
ZcTag086	5/28/2019	14	5-min time series	35.5957	74.7301
ZcTag087	6/2/2019	21	5-min time series	35.6000	74.7255
ZcTag088	6/2/2019	44	5-min time series	35.6091	74.7234
ZcTag089	6/2/2019	28	5-min time series	35.5780	74.7342
ZcTag090	7/29/2019	16	5-min time series	35.5932	74.7469
ZcTag091	7/29/2019	14	5-min time series	35.6193	74.7494
ZcTag092	7/30/2019	41	5-min time series	35.5359	74.7259
ZcTag093	7/30/2019	25	5-min time series	35.5398	74.7284
ZcTag094	7/30/2019	3	5-min time series	35.5909	74.7411
ZcTag095	8/12/2019	38	5-min time series	35.6509	74.7385
ZcTag096	8/12/2019	44	5-min time series	35.6474	74.7357
ZcTag097	8/12/2019	37	5-min time series	35.6301	74.7412

Table 19. Satellite tag deployments for pilot whales during Atlantic-BRS field efforts in 2019.

Species[1]/Tag ID	Deployment Date	Tag Duration (days)	Dive Data Steams	Deployment Latitude (°N)	Deployment Longitude (°W)
GmTag223	5/8/2019	1	Behavioral categorical	35.6876	74.7749
GmTag224	7/28/2019	32	Behavioral categorical	35.8364	74.8316
GmTag225	7/28/2019	11	Behavioral categorical	35.8532	74.8162
GmTag226	7/28/2019	25	Behavioral categorical	35.8479	74.8103
GmTag227	7/28/2019	10	Behavioral categorical	35.8560	74.8108

Table 20. CEEs conducted during 2019 Atlantic-BRS field efforts.

CEE ID	Date	CEE Type	Focal whales	CEE duration (minutes)	CEE source latitude (°N) at CEE start	CEE source longitude (°W) at CEE start
19-01	15-May-19	Simulated MFAS	Zc82; Zc83	7*	35.40	74.76
19-02	7-June-19	Simulated MFAS	Zc89; Zc86	30	35.42	74.81
19-03	6-August-19	Simulated MFAS	Zc19_218a; Zc93 (in same group)	30	35.60	74.76
19-04	19-August-19	Simulated MFAS	Zc95; Zc96; Zc97 (in same group)	30	35.79	74.78

Key: CEE = controlled exposure experiment; MFAS = mid-frequency active sonar; Zc = Cuvier's beaked whale; * = preliminary shut-down of simulated MFAS source due to permit requirements for marine mammals (common bottlenose dolphins) swimming within 200 m of active source at near full power.

The full 2019 annual progress report for this project (Southall et al. 2020) includes a complete synthesis of each CEE conducted with standardized tables and figures for each. These include: (1) metadata summaries; (2) planning RL modeling (where applicable), (3) modeled positions from satellite-tag locations for individuals exposed during each CEE using several methods; and (4) dive records for satellite tagged whales during CEEs; and (5) DTAG quick-look summaries for applicable CEEs. Examples of these figures for CEE #19-01 can be seen in **Figures 29** through **32**.

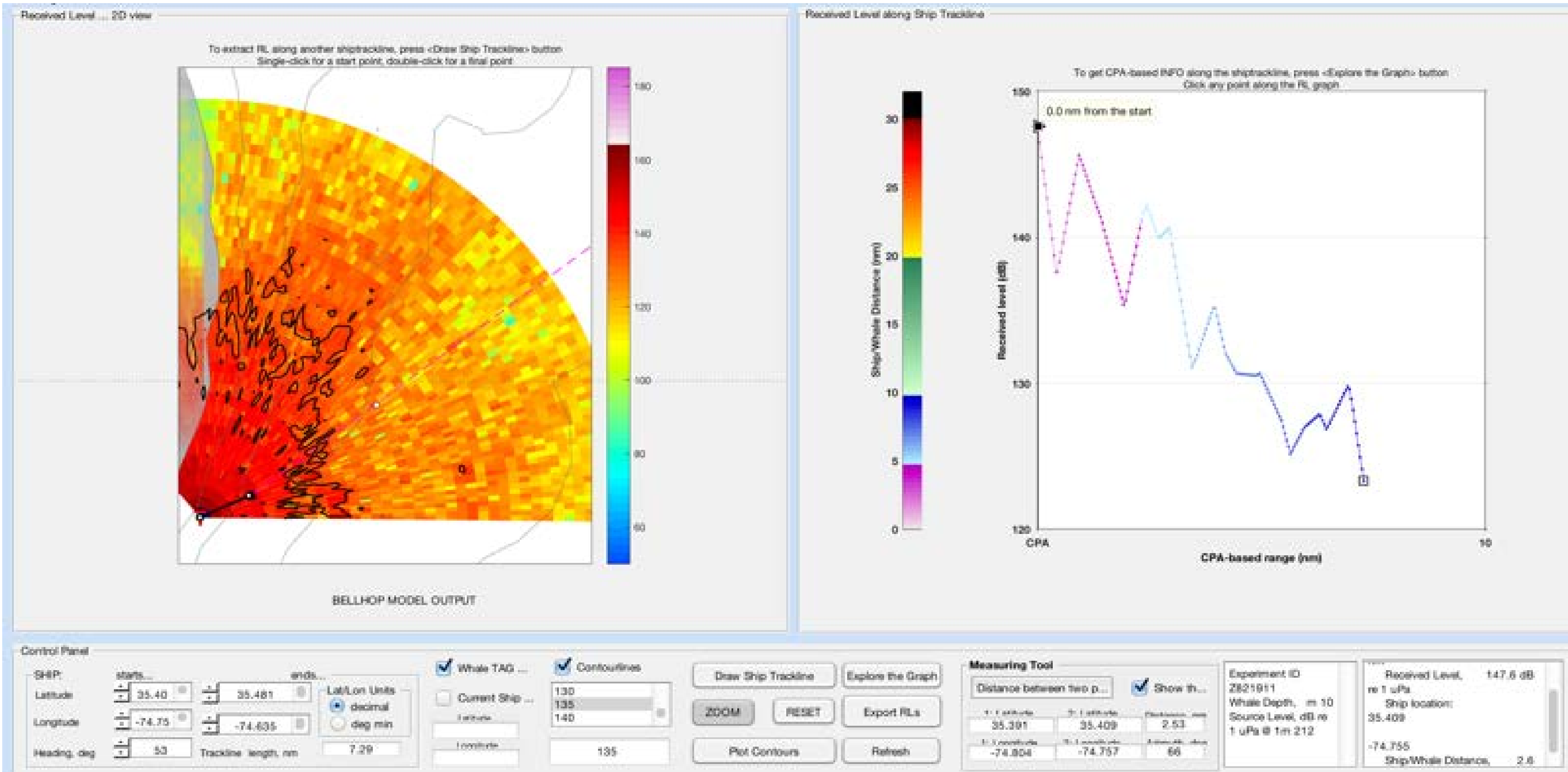

Figure 29. Received level model prediction at 10-m depth for focal beaked whale Zc82 for estimated start position of Atlantic-BRS CEE# 19-01. Modeled received level at this depth and estimated position was 147.6 decibels.

NOTE: These RL (received level) model prediction plots were generated using the Naval Postgraduate School sound propagation tool used in the field to estimate received levels for animals at known/estimated tag location with a MFAS source positioned at a strategic location (small white circle in left plots). Right panels show modeled RLs at different positions along tracks. For simulated MFAS CEEs (as here) where the source is not moving under power (drifting), this is indicated as the closest point of approach for the model estimate. Model runs are shown for different focal animals (where appropriate) and different animal depths in the water column, based on species and location differences.

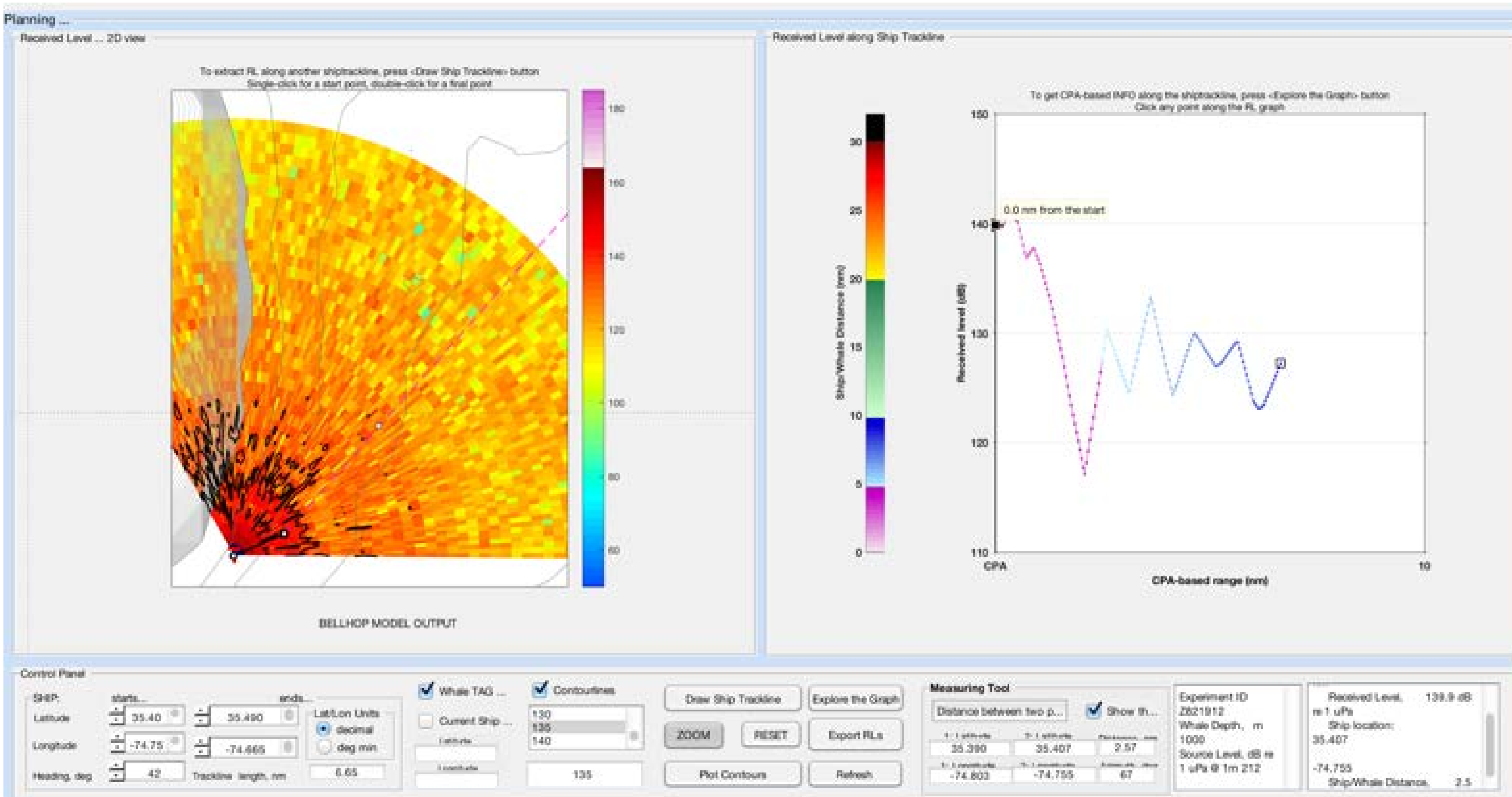

Figure 30. Received level model prediction at 1000-m depth for focal beaked whale Zc82 for estimated start position of Atlantic-BRS CEE# 19-01. Modeled received level at this depth and estimated position was 139.9 decibels.

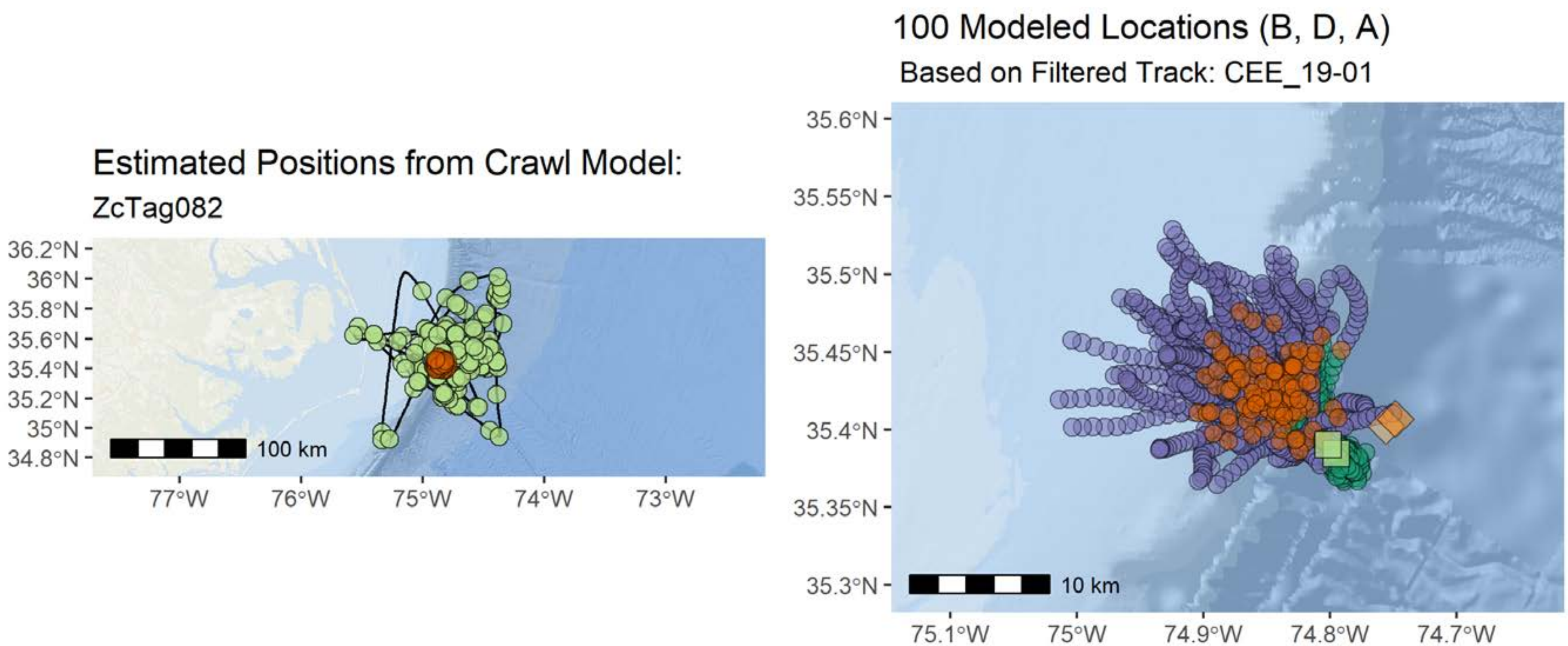

Figure 31. Estimated surface positions for focal whale Zc 82 before, during, and after Atlantic-BRS CEE# 19-01.

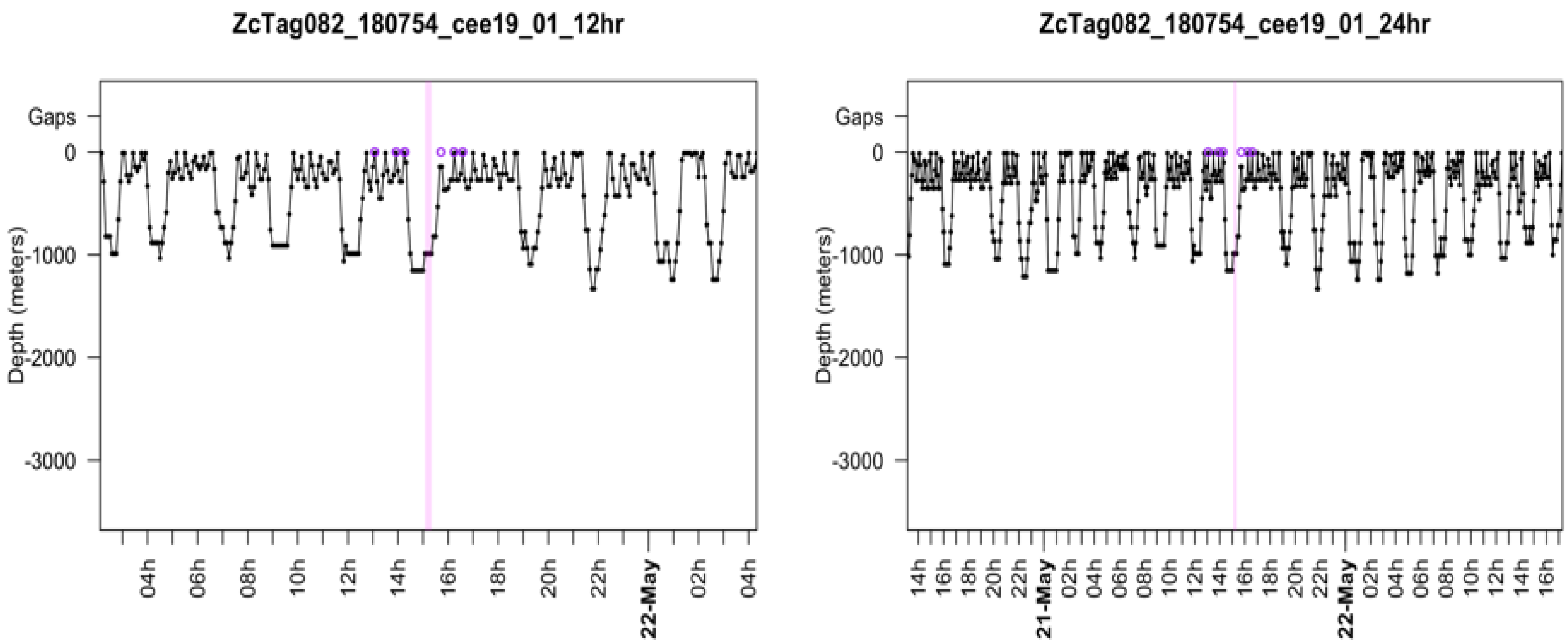

Figure 32. Available dive data for focal beaked whale Zc82 before, during, and after Atlantic-BRS CEE# 19-01. The pink bar shows the time of simulated MFAS transmission.

2.3.1.2 Preliminary Results

The 21 satellite tags deployed on beaked whales (*n*=16) and pilot whales (*n*=5) recorded individual movement and diving data for 582 total days. This is in addition to 57 tags (27 beaked whales; 30 pilot whales) deployed in 2017 and 2018, making the collective effort off Cape Hatteras, in addition to the baseline satellite tag deployments conducted ahead of the Atlantic-BRS project, the largest set of baseline data on high-priority Cuvier's beaked whales currently available anywhere in the world. The collective dataset now includes many tens of thousands of hours of data both prior to and following either of the CEE types conducted. These data augment previously collected baseline data in serving as the foundation against which potential fine-scale behavioral responses can be analyzed.

While analyses are ongoing and will include assessments across many exposures, including those obtained from the three years of fieldwork to date and subsequent efforts, responses observed in 2019 CEEs were among the clearest and strongest documented within some individuals. These included avoidance responses, changes in diving behavior, and some of the first indications of changes in social interactions as a function of MFAS exposure.

Avoidance responses of focal individuals on the order of 10 or more km from pre-CEE areas over periods of hours were apparent in the field within multiple CEEs (#2019-02, #2019-03, and #2019-04). Individuals at greater ranges than focal whales generally remained and focal individuals eventually returned to the core areas where they were observed before CEEs, notably beaked whales tagged and observed in what are clearly high-use areas off Cape Hatteras near the HARP deployment sites. Changes in diving behavior included what appear to be extended dive durations during MFAS CEEs (e.g., nearly 2 hour dive in #2019-02 focal individual (ZcTag89) and shallower ascent phases were observed; these are consistent with some previous CEEs with Cuvier's beaked whales in the SOCAL-BRS effort. Additionally, because of the simultaneous DTAG (Zc19_218a) and satellite tag (ZcTag93) deployments within the same social group, we are able to quantify fine-scale aspects of movement and energetic responses during the strong avoidance responses seen during and following the CEE (#2019-03). Finally, given our success in tagging multiple individuals within the same social groups and following, photographing, and tracking individuals and groups over time, we now have some initial insights into possible disruption of social interactions during and following CEEs. We observed both what appear to be splitting of social groups during or just following MFAS exposure (CEE#2019-02) and apparent changes in multi-individual diving synchrony over hours and days following another CEE (#2019-04). It is important to note that sample sizes are limited at this point and that these should be seen as preliminary findings requiring both additional analysis and additional replication.

Quantitative analyses of behavioral changes within and between animals are underway and definitive conclusions about the nature and magnitude of avoidance, diving/foraging, and social responses to simulated and (especially) actual MFAS sources will require additional analyses and exposure-response data collection. Efforts are progressing with both horizontal-avoidance and dive-response analyses for beaked and pilot whales looking at responses within and across many individuals. The BRS team is approaching these analyses first from the perspective of the simulated MFAS sources given that so many more individuals have been included, and at more representative/higher RLs, than for CEEs with real ships. While the latter are clearly the priority as stated, an additional number of real-ship CEEs (with an objective of four including 4 to 6 beaked whales and some smaller number of pilot whales) will need to be conducted to complete those analyses. While the team would like to retain the option for additional CEEs with simulated MFAS for the 2020 field season, they have begun to develop a response paper for at least beaked whales using existing analytical methods. These analyses are ongoing, and will be influenced to some degree by the ongoing developments described previously. However, considerable progress has been made in the individual analytical approaches.

The team has also conducted additional detailed analysis for the individual exposed during the most successful Navy-ship CEE (Zc69) conducted in 2018 using these existing methods. Examples of these analyses, as a means of demonstrating the kinds of results being generated and an interesting possible larger-scale avoidance response, are provided in **Figure 33** and **Figure 34**. Beaked whale Zc69 was one of the first individuals for which series tag settings and high-resolution (5-minute) dive data were obtained continuously for a focused two-week period. During this period, spanning 25 May to 7 June, this whale was tracked, resighted multiple times, and monitored during four CEE sequences.

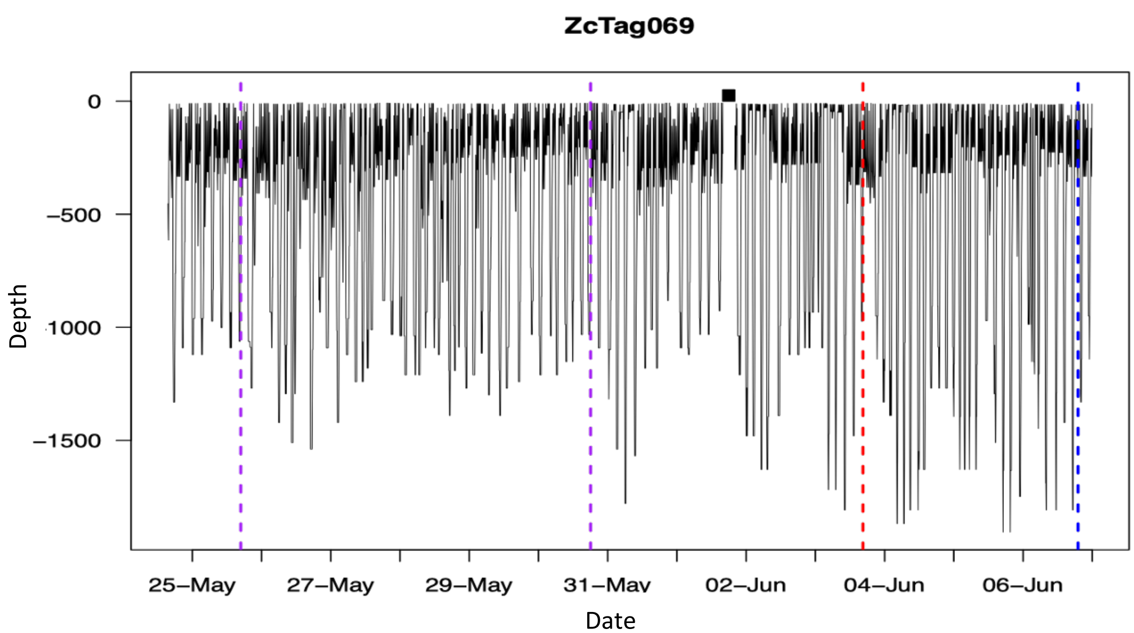

Figure 33. Complete dive record for Zc69. Purple lines denote exposure during simulated MFAS CEEs (#s 2018_02 and 2018_03), the red line denotes an exposure to a real Navy vessel (USS *NITZE*) CEE (#2019_04), and the blue line denotes a control CEE (#2018_05).

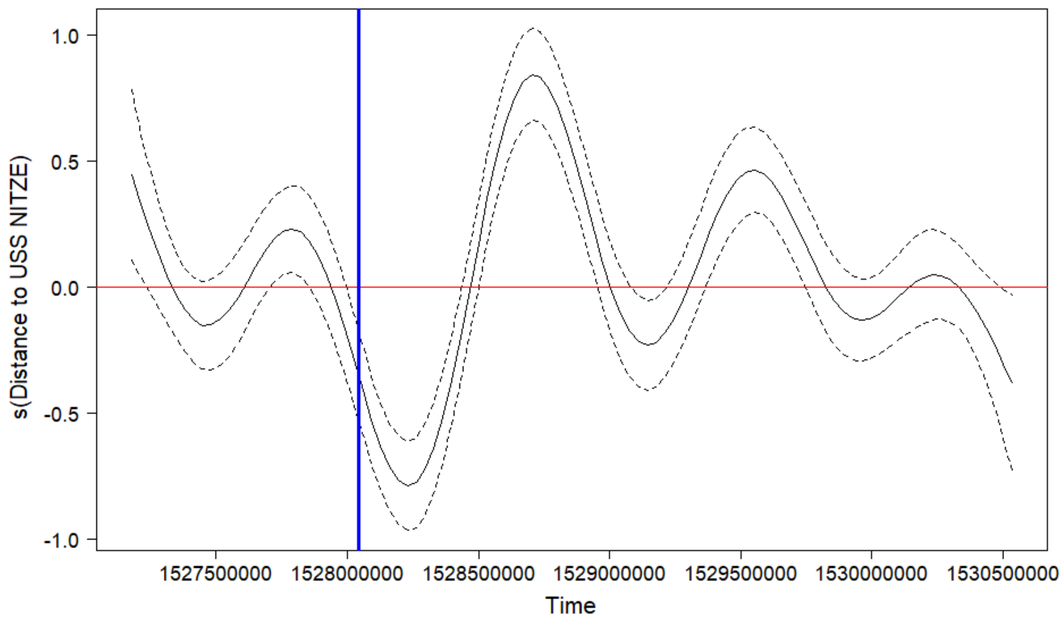

Figure 34. Horizontal avoidance analysis for Zc69 before demonstrating strong avoidance of the core habitat area during and just following CEE #2018_04 with the USS *NITZE* (indicated by the blue line).

2.3.1.3 Overall Assessment and Recommendations for 2020 Effort

The Atlantic-BRS team was extremely successful in deploying satellite tags (*n*=21, including 16 highest-priority beaked whales). Further, these deployments occurred within focused tagging windows preceding designated CEE windows and included high-resolution dive data from series tag settings. This resulted in concentrated periods of high-quality gapless movement and dive data centered on experimental windows. These strategic deployments meant that there were focal beaked whales (and in some cases pilot whales) available for inclusion in CEEs during focal periods, and that each individual was generally included and exposed for a single CEE. These modifications and continued success in re-locating previously tagged whales for data acquisition and focal follows, were substantial improvements using lessons learned in earlier field efforts.

Opportunities to coordinate with Navy ships during 2019 were unfortunately unavailable. Ships were identified for at least two windows of both field periods (spring and summer), but changes in their operational schedules and maintenance issues meant they were ultimately unavailable. As planned for within the experimental design, the secondary option of a simulated MFAS source was successfully used for CEEs during all scheduled periods.

Four CEEs were conducted during the 2019 field season, a smaller number conducted than during 2018. However, because of the strategic approach to deploy tags ahead of specified CEE periods, maximizing the extent of higher-resolution dive data, and seeking to maximize the number of tagged whales included in each CEE, there was effectively as much or more high-quality data collected during CEEs than in either of the two previous field seasons. Further, given the efforts to relocate previously tagged whales, the team was able to both satellite-tag multiple individuals within the same group and to relocate tagged individuals to either re-tag the same individual with a different tag type or to tag other individuals in the same group.

While these analyses are ongoing and will include assessments across many exposures, including those obtained from the three field seasons to date, responses observed in 2019 CEEs were among the clearest and strongest documented within some individuals. Some of these responses were apparent in the field with animals moving many miles in rapid fashion, as well as quantitative measurements of high-energy response behavior and localized avoidance. Nearly all individuals generally remained or returned to the core areas where they were observed before CEEs, notably beaked whales tagged and observed in what are clearly high-use areas off Cape Hatteras near the HARP deployment sites. However, several individuals moved tens or more miles away from these areas following CEEs. While quantitative analyses of behavioral changes within and between animals are underway, the CEE results from 2019 provide the clearest and strongest kinds of response data obtained to date in this or any prior sonar-related BRS. It is recommended that the modified and improved field methods concentrating on fewer CEEs with more tagged individuals developed for 2019 be continued for CEEs in focused periods for both species. Of greatest priority is to obtain additional operational Navy vessel CEEs for target RLs similar to those evoking strong responses in simulated MFAS CEEs.

Please refer to the annual progress report for detailed information on 2019 fieldwork, preliminary results from 2017–2018, and ongoing analyses (Southall et al. 2020).

2.3.2 Assessment of Behavioral Response of Humpback Whales to Vessel Traffic

In the western North Atlantic, humpback whales feed in high-latitude summer foraging grounds off the east coast of the United States and Canada before migrating to Caribbean breeding grounds in winter (Katona and Beard 1990, Barco et al. 2002, Stevick et al. 2006). Since the early 1990s, juvenile humpback whales have been documented feeding in winter in coastal waters of the mid-Atlantic states (Swingle et al. 1993). The abundance of humpback whales in the North Atlantic is increasing (Stevick et al. 2003), but there are high levels of mortality in mid-Atlantic states (Barco et al. 2002). Since January 2016, more than 100 humpback whale strandings have occurred along the U.S. East Coast, causing NMFS to declare an unusual mortality event for humpback whales in 2017 (https://www.fisheries.noaa.gov/national/marine-life-distress/2016-2020-humpback-whale-unusual-mortality-event-along-atlantic-coast). One-third of these strandings occurred in the mid-Atlantic, and although only roughly half of the whales were able to be examined post-mortem at all, over half of those that were examined showed evidence of human-activity related mortality (ship strikes or entanglement).

The U.S. Navy has supported research on humpback whales near Virginia Beach since 2014 as part of the Mid-Atlantic Humpback Whale Monitoring Project. Satellite-tracking data from this project show that the distribution of these animals overlaps significantly with shipping channels (Aschettino et al. 2019). One live and three dead whales with evidence of ship strikes were observed in the 2016/2017 field season. Given the unusual mortality event, the large number of ship-related injuries, and the high spatial overlap with shipping channels, it is essential to understand the behavior of these animals around ships at the entrance of Chesapeake Bay.

Humpback whales in Virginia Beach are constantly exposed to ships. As recently as 2017, Hampton Roads (Virginia) was the 9th busiest port in the U.S. and Baltimore (Maryland) was the 14th busiest (https://www.bts.gov/content/tonnage-top-50-us-water-ports-ranked-total-tons). Both ports are reached via the shipping lanes that pass through the mouth of the Chesapeake Bay at Virginia Beach, making these shipping lanes extraordinarily busy. This frequent exposure to ships could cause animals to become habituated to ship approaches and, therefore, perhaps less responsive. Habituation to vessel traffic has been documented by baleen whales in Cape Cod (Watkins 1986). However, some types of abrupt, startling sounds may lead to sensitization, or an increased sensitivity to the noise (Götz and Janik 2011). Humpback whales remain in the Virginia Beach area for days to months, and have been re-sighted over multiple years (Aschettino et al. 2019). This suggests that the disturbance from repeated ship exposures is not causing long-term displacement but may put the whales at heightened risk of being struck, given multiple encounters. Theoretically, animals are more likely to remain in good foraging areas even if they are risky, because the potential to be gained from productive foraging outweighs the heightened risk (Christiansen and Lusseau 2014). Therefore, responses may be short-lived and subtle, and require fine-scale sampling to detect. Understanding the behavior of these animals around ships is critical to developing measures to reduce the risk of ship strike mortality and promote the recovery of this population.

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

DTAGs were deployed on humpback whales in conjunction with focal follows of behavior of the tagged whales. These tags provide the opportunity to study the whales' three-dimensional movement and reactions to the sound of vessel approaches. The acoustic recorders on the DTAGs collect information on the acoustic profile of the nearby large vessels, including the received levels of sound at the animal and the frequency characteristics of the ship noise. Kinematic parameters recorded by the tag are used to categorize animal behavioral states (foraging, traveling, other) and measure direct avoidance responses. At each surfacing during the focal follows, behavioral state, distance and bearing (to recreate the whale's track), and estimated distance to the nearest ship were recorded. The DTAGs were programmed to record for 4 to 6 hours per day, allowing for multiple ship approaches per animal, and facilitated collection of synoptic behavioral observations. The aim was to deploy a single tag each day, unless a tag detaches from the whale early.

AIS data were utilized to collect additional information on vessels, including size, speed, and course of the focal vessel and other ships in the area. Photo-ID images of the focal whale and its associates during the focal follow and biopsy samples were also collected. Photo-ID images will be shared with colleagues from HDR and contributed to regional catalogs. Biopsy samples will be contributed to the sample collection curated by HDR. Efforts were made to coordinate DTAG deployments with individuals previously tagged with longer-term satellite-linked tags (SPOT or SPLASH) to provide days to weeks of movement and behavior data, providing additional context for the high-resolution, short-term DTAG deployments. Ideally, individuals would carry both types of tag simultaneously.

Seven days of suction-cup tagging effort were conducted in the Virginia Beach shipping lanes in the 2018/19 season, totaling 556 km during 46 hours of survey effort (**Table 21**). Surveys were conducted in BSS ranging from 2 to 4.

Table 21. Vessel survey effort during suction-cup tagging in the Virginia Beach shipping lanes study area in 2018/19.

Date	Beaufort Sea State	Distance surveyed (km)	Survey Time (hrs:min)	At Sea Time (hrs:min)	Platform
6-Jan-2019	2-4	106.8	7:20	7:54	R/V *R.T. Barber*
8-Jan-2019	2-4	72.5	5:46	7:30	R/V *R.T. Barber*
12-Jan-2019	2-3	75.0	6:03	6:38	R/V *R.T. Barber*
16-Jan-2019	2-4	95.4	7:27	7:33	R/V *R.T. Barber*
17-Jan-2019	3-4	46.7	2:44	3:18	R/V *R.T. Barber*
18-Jan-2019	2-3	118.5	7:18	7:44	R/V *R.T. Barber*
7-Mar-2019	2-3	41.2	9:15	10:17	R/V *R.T. Barber*

Humpback whales were sighted on 13 occasions totaling 16 whales (**Table 22, Figure 35**). Single animals were the most common (10 of 13 sightings), followed by pairs. No whales were observed in groups larger than two animals.

Table 22. Humpback whale sightings observed during suction-cup tagging in the Virginia Beach shipping lanes study area in 2018/19.

Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Group Size	Tags Deployed
6-Jan-2019	14:40	36.8953	75.9286	1	–
6-Jan-2019	16:21	36.9463	75.9893	1	–
6-Jan-2019	19:03	36.9312	75.9689	1	–
6-Jan-2019	20:30	36.8142	75.8852	2	–
8-Jan-2019	15:50	36.9524	75.9198	2	mn19_008a
12-Jan-2019	14:44	36.8861	75.9448	1	–
12-Jan-2019	16:08	36.9161	75.9204	1	–
12-Jan-2019	16:41	36.9379	75.9346	1	–
12-Jan-2019	17:10	36.9680	75.9600	1	–
12-Jan-2019	19:13	36.9612	75.9496	1	mn19_012a
12-Jan-2019	16:29	36.9203	75.9371	2	–
12-Jan-2019	19:42	36.8856	75.8776	1	–
7-Mar-2019	13:14	36.9369	75.9847	1	mn19_066a

Three DTAGs were deployed on humpback whales during the 2018-19 season (**Table 23, Figure 36**). Two tags attached well and remained on the animal for a period of several hours (2.3 and 6.5 hours), while one was removed within 10 minutes by the animal (data from this tag will not be used for analyses). Depth profiles show a maximum of 10 m (mn19_008a) and 25 m (mn19_066a); most dives for animal mn19_008a were to 4–6 m while mn19_066a dove deeper, typically between 10 and 20 m (**Figure 37, Figure 38**). The animal tagged on 8 January (mn19_008a) was in a group of two; these animals surfaced synchronously or nearly synchronously for the majority of the focal follow. Fine-scale analyses of the acceleration data are ongoing. The animal tagged on 7 March (mn19_066a) had been tagged a few days earlier by HDR Inc., with a FastLoc GPS tag. Positions obtained from the GPS tag facilitated locating the animal for acoustic tagging. This animal remained within the shipping lanes for the entire DTAG tag deployment. Several large ships passed near the animal during the deployment, including a dredge directly in its path, which caused the animal to change course for one surfacing.

Table 23. Suction-cup tag information from deployments on humpback whales in the Virginia Beach shipping lanes study area in 2018/19.

Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Tag Type	Tag ID	Duration (hrs:min)
8-Jan-2019	17:37	36.9854	75.9013	DTAG	mn19_008a	2:17
12-Jan-2019	19:18	36.9612	75.9496	DTAG	mn19_012a	0:10
7-Mar-2019	15:12	36.9610	75.9806	DTAG	mn19_066a	6:29

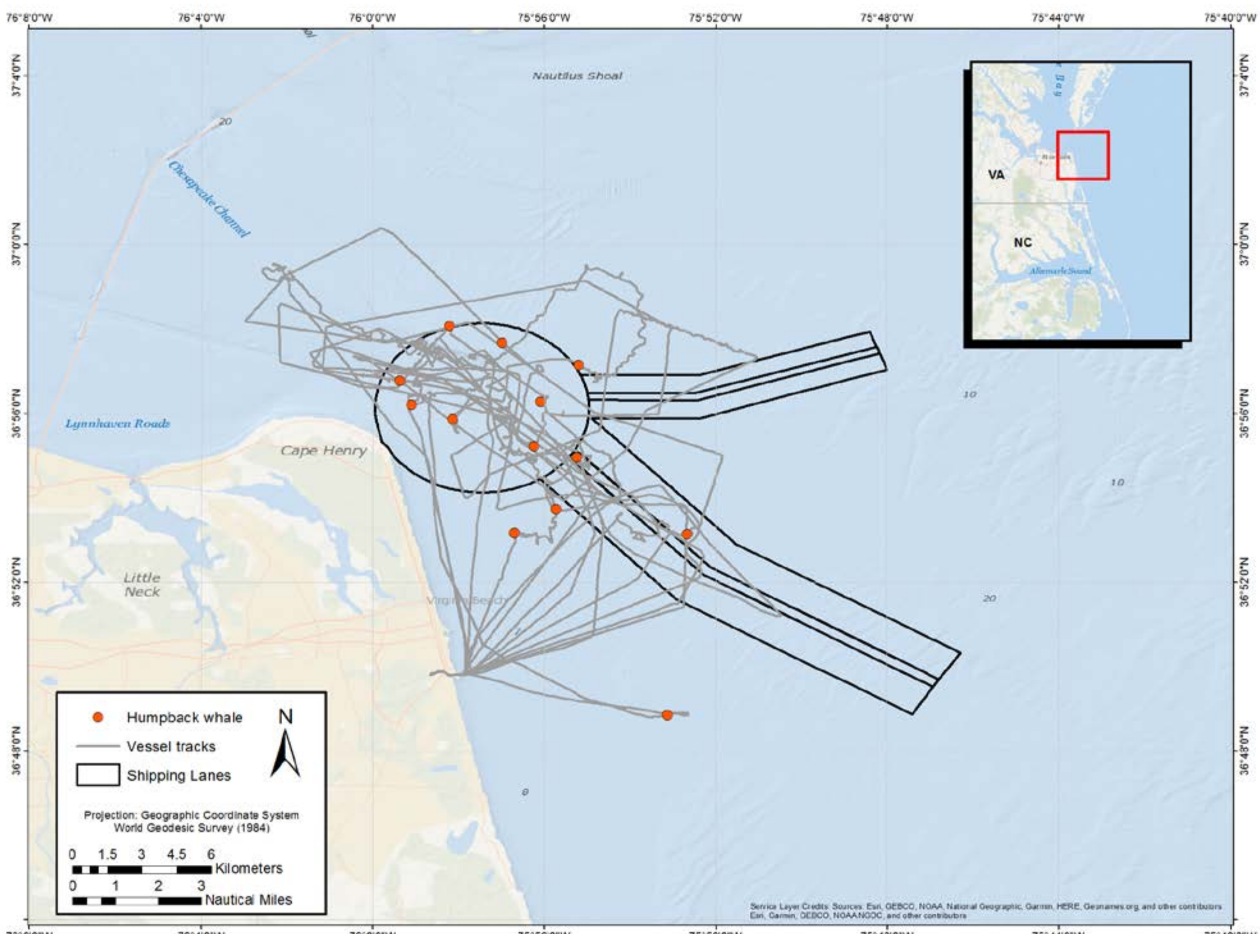

Figure 35. Survey tracks and locations of all sightings during humpback whale suction-cup tagging effort in the Virginia Beach shipping lanes study area in 2018/19.

Focal-follow data were collected for the duration of both the 8 January and the 7 March tag deployment. Data are currently being processed, including using the animal's distance and bearing from the research vessel and the research vessel's GPS track to recreate the animals' positions.

AIS data were collected from the Research Vessel (R/V) *Barber* during both tag deployments to determine the locations of all large ships during the focal follow. These data are being decoded. Distance and bearing estimates collected by the team for other vessels in the vicinity also are being processed to obtain positions of small boats that were not transmitting AIS. Finally, the SeaLink Advanced Analytics system was used to recreate large-ship tracks using AIS and radar (**Figure 42**). There were considerably more ships near the animal during the tag deployment on 7 March compared to 8 January. A comparison of these methods will be completed before planning begins for the next field season to determine redundancies and accuracy of the systems.

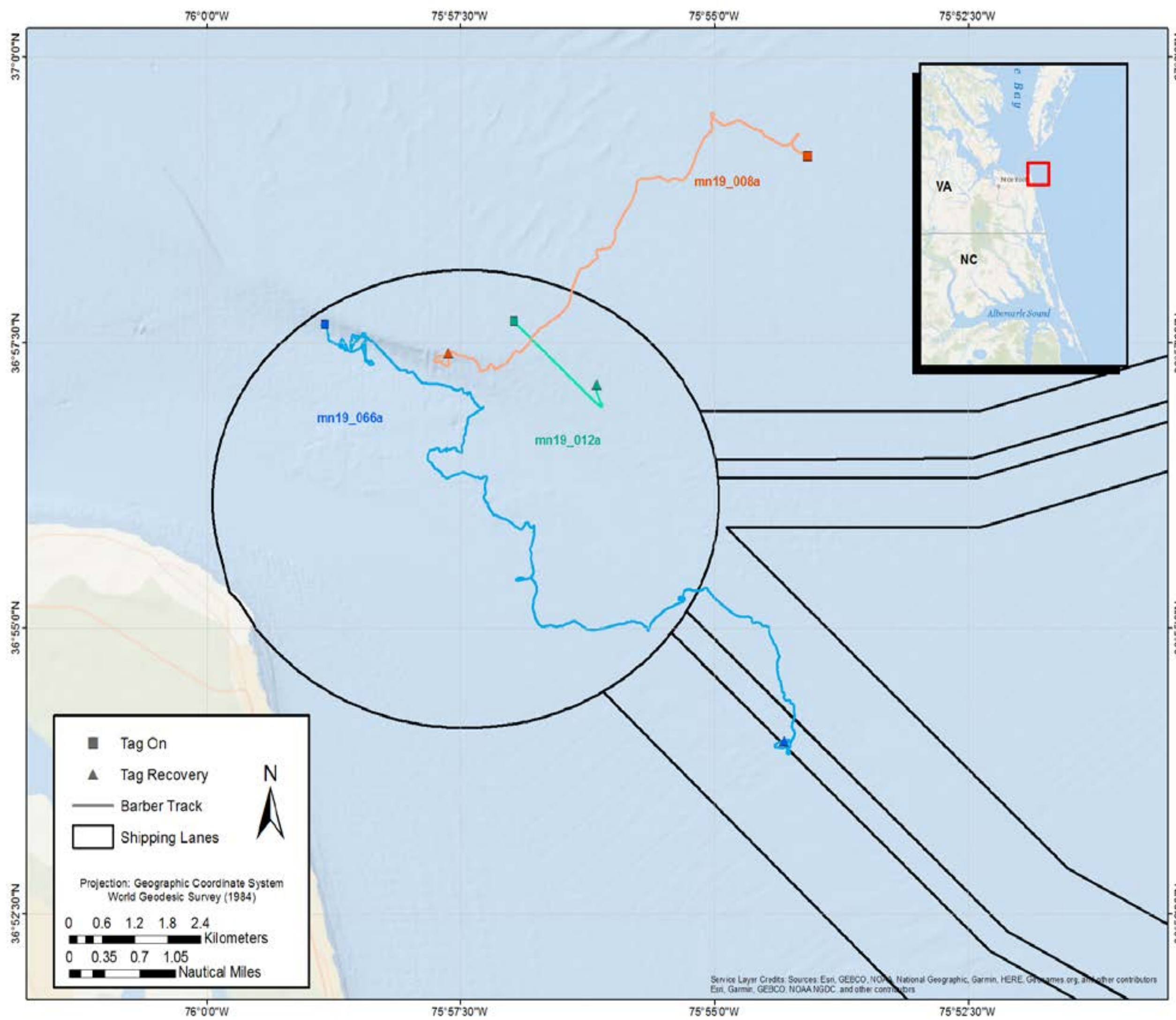

Figure 36. Tagging location and tag recovery location for all three DTAG deployments in the Virginia Beach shipping lanes study area in 2018/19. Each colored line represents the R/V *Barber*'s track during the focal follow of the animal.

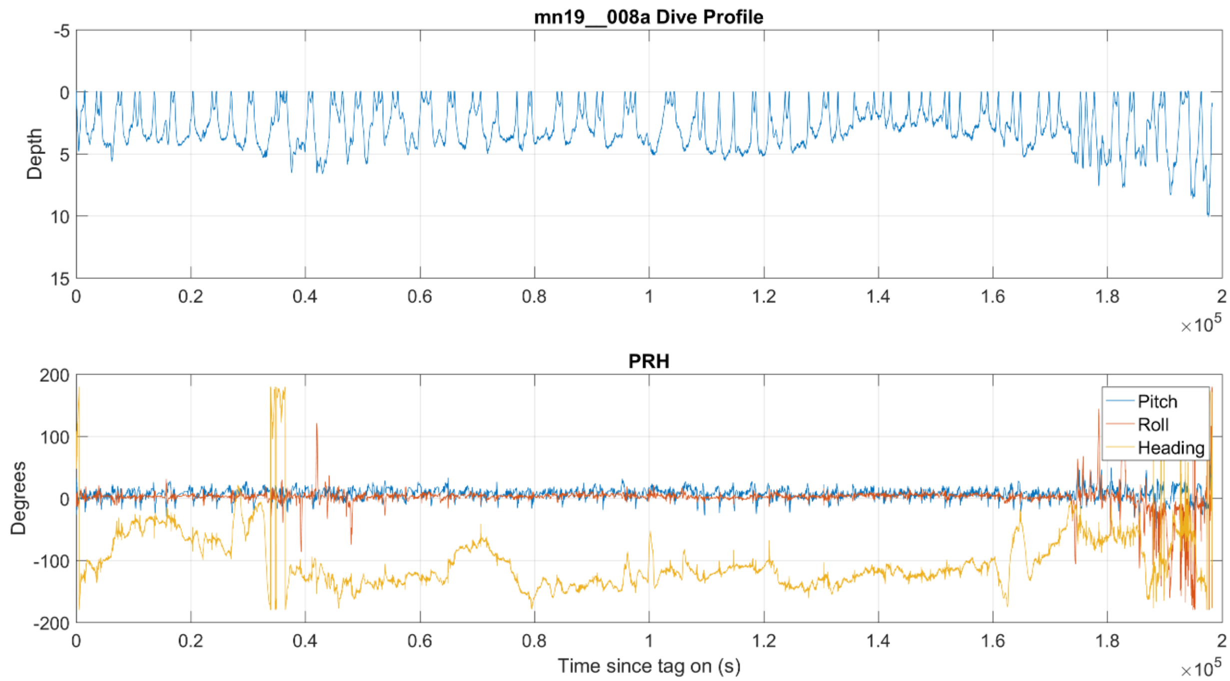

Figure 37. Dive depth profile and accelerometry metrics (pitch, roll, and heading) for tagged animal mn19_008a.

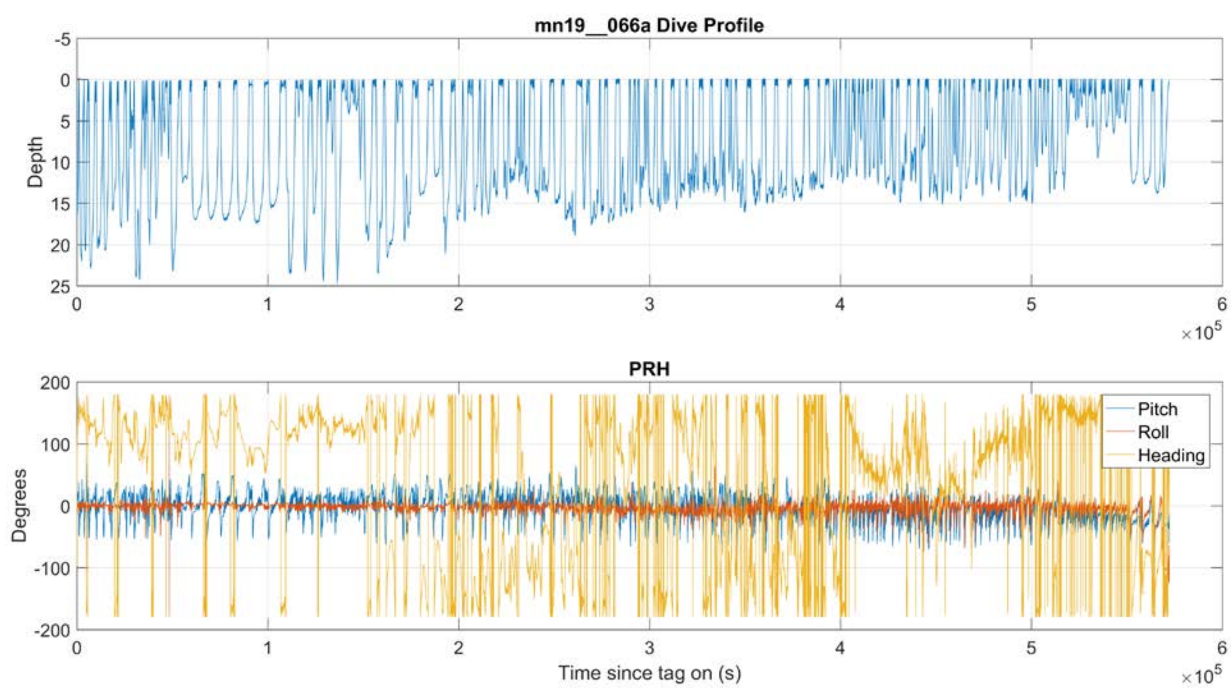

Figure 38. Dive depth profile and accelerometry metrics (pitch, roll, and heading) for tagged animal mn19_066a.

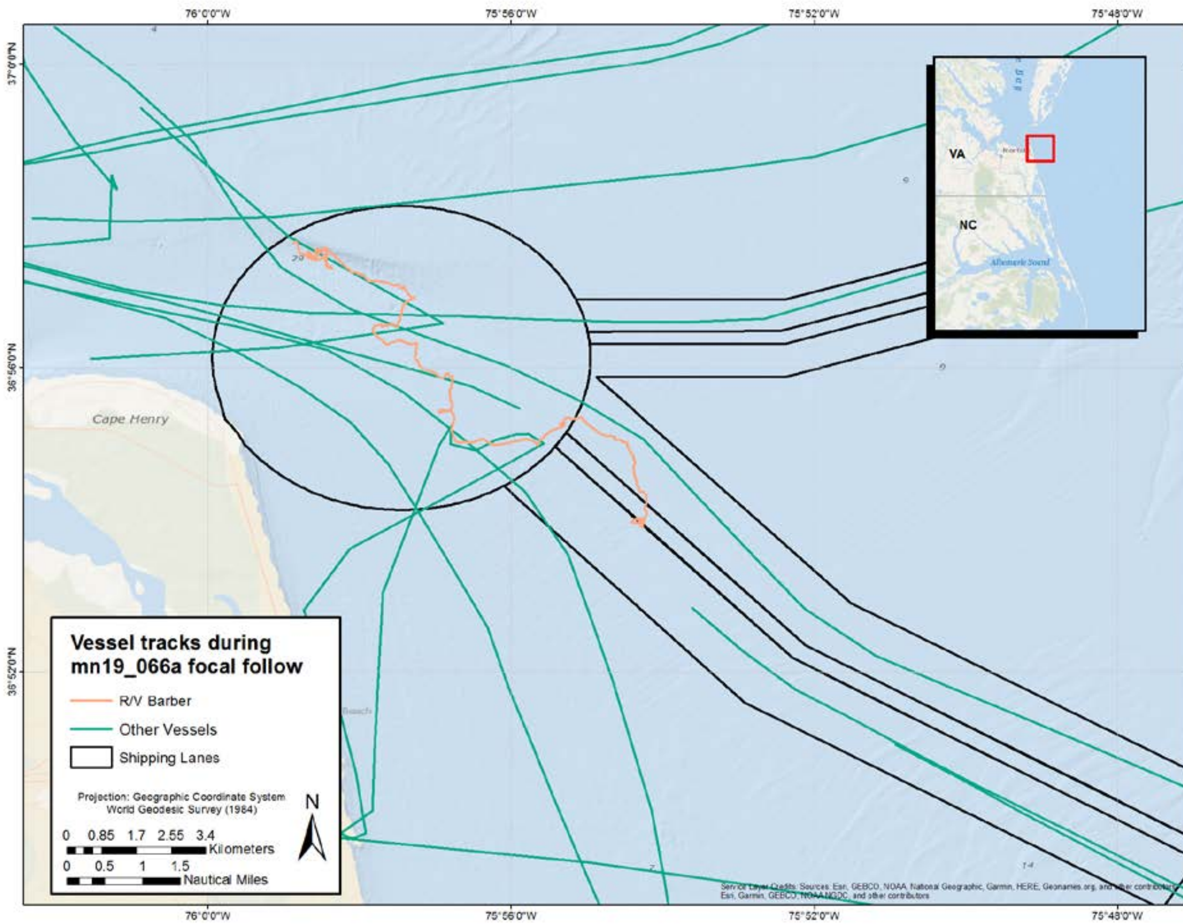

Figure 39. Ship tracks during the tag deployment of tagged animal mn19_066a. The R/V *Barber* (travelling near the animal for the duration) is shown in red while the other ships are shown in green. Ship locations included are those that overlap in time with any point on the tag record. Proximity or crossing tracks do not indicate that the ship and animal were in the same location at the same time.

The low sample size during this year of the project precludes conclusions about humpback whale responses to ships in this area. However, this pilot project allows for validation of methods and the development of analytical tools to process and analyze the data. Analytical tools currently being developed and streamlined include the following:

- conversion of animal distance and bearing from research vessel into latitude/longitude positions
- decoding AIS data into ship positions and time stamps
- acoustically detecting ship approaches on tag records (which will also allow for analysis of previous tag records with no focal follows)
- tools to deconstruct high-resolution accelerometer and magnetometer data into biologically meaningful movement metrics, such as turning rates and overall body acceleration.

Additional fieldwork will be conducted during the winters of 2019/20 and 2020/21 to increase the sample size of tagged whales for analysis. Priorities in 2020 include extending tag deployment durations (including overnight tag deployments when weather allows) and deploying DTAGs on whales equipped with satellite tags deployed by HDR Inc. The aim is that this approach will: (1) improve the accuracy of location estimates for whales that are part of the vessel-response project and (2) provide fine-scale information on the diving behavior of satellite-tagged whales. Both of these projects will contribute to ongoing efforts to understand the behavior of juvenile humpback whales in the Virginia Beach area and to better understand risk factors and develop potential mitigation measures for ship strikes.

For more information on this project, please refer to the 2019 annual progress report (Shearer et al. 2020).

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SECTION 3 – DATA MANAGEMENT

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

3.1 Data Standards

The U.S. Navy MSM program requires that all acquired data be maintained for ready dissemination to U.S. Navy environmental planners, analysts, and researchers, and formatted to ensure compatibility with existing marine databases (HDR 2014). Starting in 2013, the U.S. Navy developed a MSM Data Standard applicable to visual 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 the National Oceanic and Atmospheric Administration'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.

3.2 Survey Data Collection and Management Toolkit (COMPASS)

The U.S. Navy identified the need for development of a survey data-collection system that fully meets U.S. Navy's MSM Data Standard. The objectives were to streamline data-collection procedures, minimize manual data-management requirements, and increase the standardization and repeatability of data-collection efforts. In response to this need, HDR has developed a survey toolkit called *COMPASS (Cetacean Observation and Marine Protected Animal Survey Software). COMPASS* is designed to be an integrated survey data-collection and data-management system to facilitate work conducted during MSM surveys. The *COMPASS* survey toolkit integrates current mobile and web technologies to allow efficient real-time collection, processing, reporting, and delivery of marine species data. The toolkit includes 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 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.

The mobile App runs on the Apple iPad® platform and 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) (**Figures 40-41**). 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.

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. 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. After the survey is completed and the data are synced to a central database server, primary access to the survey data occurs through a web-based interface to facilitate QC review and editing.

The *COMPASS* source code and a complete user guide is publically available for use. For more information on the development and features of COMPASS, refer to the previous annual progress report (Richlen et al. 2019) as well as the COMPASS landing page.

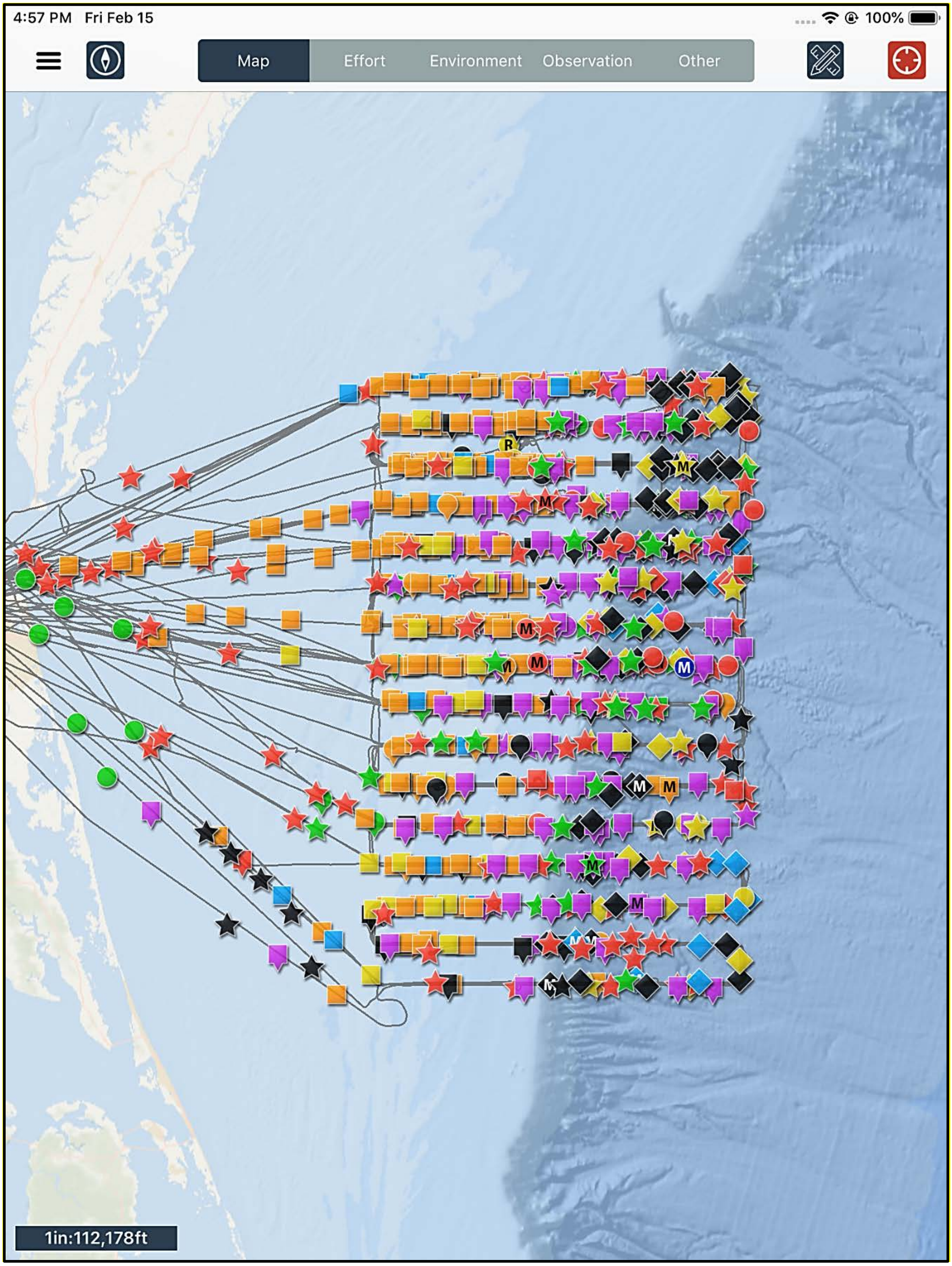

Figure 40. Screenshot from *COMPASS* field App showing tracklines and sightings made during aerial survey efforts. Different custom symbols indicate sightings, symbols with 'R' indicate resightings, symbols with 'M' indicate multi-species, and gray lines show trackline effort.

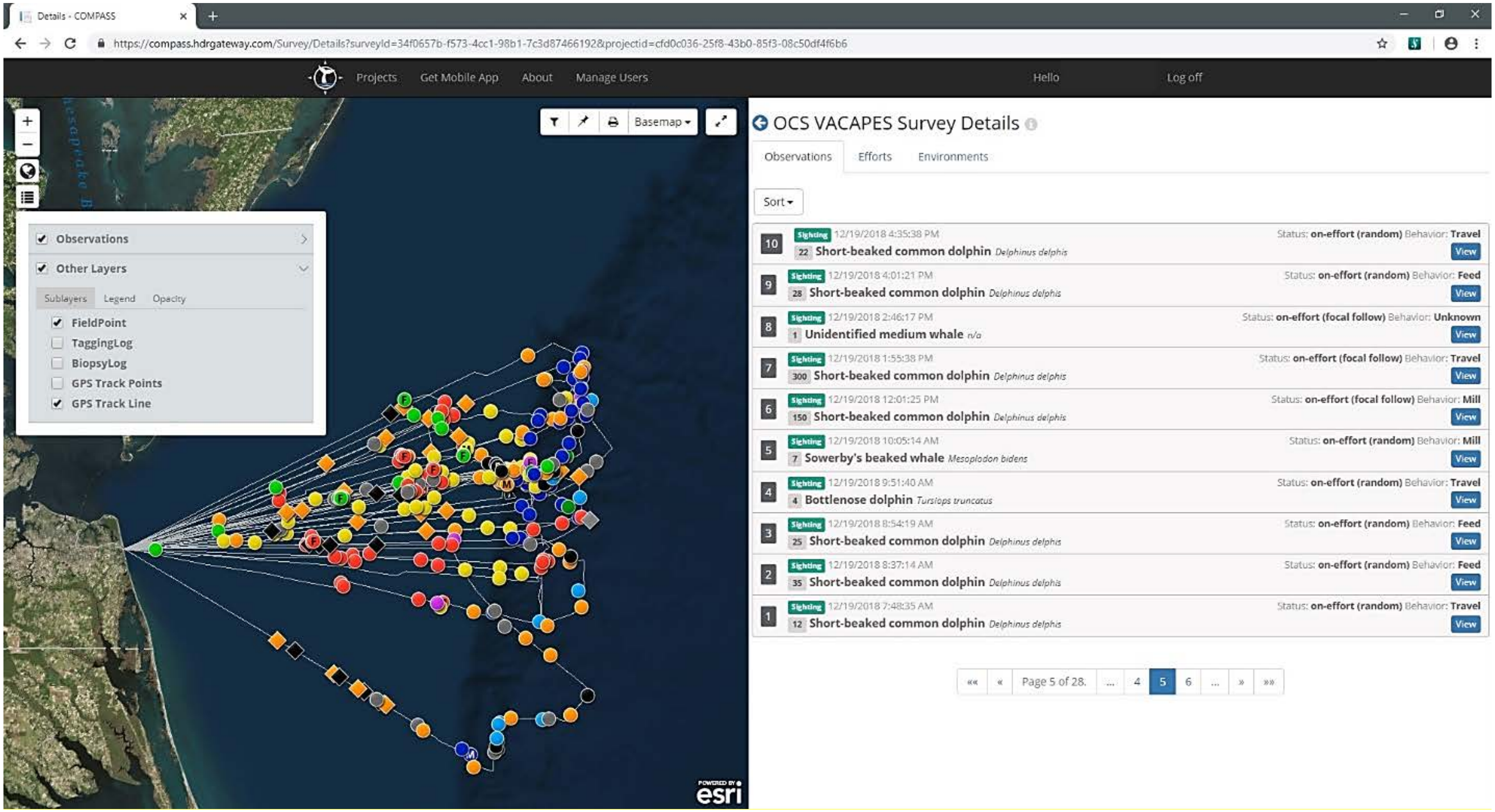

Figure 41. Screenshot from *COMPASS* web portal showing tracklines and sightings made during vessel surveys supporting the VACAPES OCS project. The left side of the screen is the map of sighting data and filtering options for the display and map output. The right side of the screen shows the sighting data that can be sorted, filtered, and edited for the survey.

3.3 Data Archiving and Access

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

The U.S. Navy MSM data-management team effectively disseminates data to facilitate information sharing among stakeholders, and to advance the general knowledge of marine species distribution and behavior. This information dissemination is achieved in part by the delivery of U.S. Navy MSM visual survey data to the OBIS-SEAMAP database, an interactive online archive for marine mammal, sea turtle, seabird, and selected fish data. Researchers worldwide contribute datasets to Duke University's Marine Geospatial Ecology and Marine Conservation Ecology Laboratories, which maintain OBIS-SEAMAP. The U.S. Navy provides all MSM survey data to OBIS-SEAMAP to contribute to the knowledge of global patterns of marine species distribution and biodiversity. Once these datasets are provided to OBIS-SEAMAP and have been through a review process, the information is published on the U.S. Navy data provider page. In 2019, 15 new datasets from 7 Fleet-funded Atlantic and Pacific projects were submitted to OBIS-SEAMAP.

In addition to visual survey data, animal telemetry data collected from tagging studies are provided to a variety of publically-available databases, including movebank.org, seaturtle.org, and the Animal Telemetry Network Data Assembly Center.

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SECTION 4 – ADAPTIVE MANAGEMENT AND STRATEGIC PLANNING PROCESS

4.1 Adaptive Management

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

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

4.2 Strategic Planning Process

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

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

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

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

- Integrated Comprehensive Monitoring Program top-level goals
- Scientific Advisory Group recommendations
- Integration of regional scientific expert input
- Ongoing AMR dialog between NMFS and the 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 24** summarizes U.S. Navy MSM projects currently underway in the Atlantic for 2020–2021. 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 24. Summary of monitoring projects in the Atlantic for 2020–21.

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, HDR Inc. **Timeline**: Ongoing since 2017 **Funding**: FY16 – $35K, FY17 – $1.25M, FY18 – $1.4M, FY19 – $1.4M	• Evaluate behavioral responses by marine mammals exposed to Navy training and testing activities	**Field work ongoing** • Technical progress reports available – 2017–2019 • Multiple publication manuscripts in prep • Multiple publications available
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-linked tags **Performing Organizations**: Duke University, Woods Hole Oceanographic Institution, Cascadia Research Collective **Timeline**: Ongoing since 2013 **Funding**: FY12 – $275K, FY13 – $250K, FY14 – $510K, FY15 – $520K, FY16 – $420K, FY17 – transitioned under Atlantic BRS	• Determine what populations of marine mammals are exposed to Navy training and testing activities • Establish the baseline behavior (foraging, dive patterns, etc.) of marine mammals where Navy training and testing activities occur • Evaluate behavioral responses by marine mammals exposed to Navy training and testing activities	**Field work ongoing** • Technical progress reports available – 2013–2018 • Transitioned to Atlantic BRS in 2017 • Beaked whale diving publication available
Title: Mid-Atlantic Continental Shelf Break (VACAPES) 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-linked tags, high-resolution dive tags **Performing Organizations**: HDR, Inc. **Timeline**: Ongoing since 2015 **Funding**: FY15 – $75K, FY16 – $645K, FY17 – $0, FY18 – $321K, FY19 – $357K	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Establish the baseline habitat uses and movement patterns of marine mammals where Navy training and testing activities occur • Establish the baseline behavior (foraging, dive patterns, etc.) of marine mammals where Navy training and testing activities occur	**Field work ongoing** • Technical progress reports available – 2016–2019 • Focus on sperm whale diving and feeding ecology in 2020–21

Project Description	Intermediate Scientific Objectives	Status
Title: North Atlantic Right Whale Monitoring **Location**: Mid-Atlantic and Southeast calving grounds **Objectives**: *Current* - Assess seasonal distribution in the Mid-Atlantic region. *Previous* - Assess behavior of right whales in coastal waters of the Southeast calving grounds, including rates of travel of individuals, dive behavior, and rates of sound production; **Methods**: Autonomous underwater gliders equipped with passive acoustic monitoring capabilities and near real-time reporting. Short-term non-invasive suction cup attached multi-sensor acoustic recording tags with Fastloc GPS; **Performing Organizations**: Woods Hole Oceanographic Institution, Duke University, Syracuse University, **Timeline**: Ongoing since 2014 **Funding**: FY13 – $335K, FY14 – $390K, FY15 – $505K, FY16 – $390K, FY17 – $278K, FY18 – $268K, FY19 – $214K	• 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	**Fieldwork ongoing** • DTag deployments on SE calving grounds 2014–17 • Technical progress reports available – 2014–2017 • 2019 - shift focus to occurrence in Mid-Atlantic • 2018-21 autonomous glider deployments in Mid-Atlantic • Multiple publications 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-linked tags **Performing Organizations**: HDR, Inc. **Timeline**: Ongoing since 2015 **Funding**: FY14 – $320K, FY15 – $260K, FY16 – $370K, FY17 – $325K, FY18 – $0, FY19 – $250K	• Establish the baseline habitat uses and movement patterns of marine mammals where Navy training and testing activities occur • Establish the baseline behavior (foraging, dive patterns, etc.) of marine mammals where Navy training and testing activities occur	**Fieldwork ongoing** • Technical progress reports available – 2014–19 • Peer-reviewed publication • Vessel response component added winter of 2018–19
Title: Behavioral Response of Humpback Whales to Vessel Traffic **Location**: Chesapeake bay and Nearshore Mid-Atlantic **Objectives**: Understand the behavioral response of humpback whales to approaching vessels in the shipping channels at the mouth of the Chesapeake Bay. **Methods**: Dtags, satellite-linked tags, and focal follow observational methods **Performing Organizations**: Duke University, HDR Inc. **Timeline**: 2018–21 **Funding**: FY19 – $95K	• Establish the baseline behavior (foraging, dive patterns, etc.) of marine mammals where Navy training and testing activities occur • Evaluate behavioral responses of marine mammals exposed to Navy training and testing activities	**Fieldwork ongoing** • Pilot project - February 2019 • 2019 technical progress report available

Project Description	Intermediate Scientific Objectives	Status
Title: Mid-Atlantic Humpback Whale Catalog **Location**: Northwest Atlantic **Objectives**: Establish a centralized collaborative humpback whale photo-id catalog for the mid-Atlantic and southeast regions to support management and environmental planning **Methods**: Photo-ID **Performing Organizations**: Organizations: Virginia Aquarium & Marine Science Center Foundation, Duke University **Timeline**: 2017–2019 **Funding**: FY16 – $106K, FY17 – $74K, FY18 – $75K	Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur	**Finalization – spring 2020** • Stakeholder workshop report available • Technical progress reports available – 2016–2018 • Online catalog application available spring 2020
Title: Lower Chesapeake Bay Sea Turtle Tagging and Tracking **Location**: Lower Chesapeake Bay **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**: Tagging - satellite, GPS, and acoustic telemetry **Performing Organizations**: Virginia Aquarium and Marine Science Center Foundation, NAVFAC Atlantic, CheloniData LLC **Timeline**: 2013–2019 **Funding**: FY13 – $180K, FY14 – $195K, FY15 – $70K, FY16 – $183K, FY17 – $103K, FY18 – $0, FY19 – $28K	• Estimate the density of marine mammals and sea turtles in Navy range complexes and in specific training areas • Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to Navy training and testing activities	**Fieldwork complete** • Technical progress reports available – 2013–2018 • Loggerhead analysis complete • Loggerhead publication in prep • Final Kemp's Ridley analysis underway • Kemp's Ridley publication in prep
Title: Pinniped Tagging and Tracking in Virginia **Location**: Lower Chesapeake Bay (Hampton Roads) **Objectives**: Document habitat use, movement and haul-out patterns of seals in the Hampton Roads region of Chesapeake Bay and coastal Atlantic Ocean **Methods**: Photo-ID, tagging **Performing Organizations**: NAVFAC Atlantic, Naval Undersea Warfare Center, The Nature Conservancy, Atlantic Marine Conservation Society, Virginia Aquarium & Marine Science Center Foundation, HDR Inc. **Timeline**: 2017–2021 **Funding**: FY16 – $40K, FY17 – $164K, FY18 – $46K, FY19 – $468K	• Estimate the density of marine mammals and sea turtles in Navy range complexes and in specific training areas • Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to Navy training and testing activities	**Fieldwork ongoing** • Technical progress report available – 2017–18 • Final field work tentatively planned for winter 2020–21

Project Description	Intermediate Scientific Objectives	Status
Title: Haul Out Counts and Photo-Identification of Pinnipeds in Chesapeake Bay, Virginia **Location**: Chesapeake Bay **Objectives**: Document seasonal occurrence, habitat use, and haul-out patterns of seals **Methods**: Visual surveys, photo-ID **Performing Organizations**: NAVFAC Atlantic **Timeline**: 2015–2021 **Funding**: FY15 – $52K, FY16 – $57K, FY17 – $7K, FY18 – $29K, FY19 – $62K	• 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	**Fieldwork ongoing** • Technical progress reports available – 2016–2019 • Final field work planned for winter 2020–21
Title: Occurrence of Bryde's Whales in Northeastern Gulf of Mexico **Location**: Northeastern Gulf of Mexico **Objectives**: Assess seasonal and occurrence of Bryde's whales in the Northeastern Gulf of Mexico **Methods**: Passive acoustic monitoring **Performing Organizations**: NOAA-NMFS Southeast Fisheries Science Center **Timeline**: 2019–2022 **Funding**: FY18 – $78K, FY19 – $395K	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Establish the baseline vocalization behavior of marine mammals where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to Navy training and testing activities	**New start 2019** • 2019 technical progress report available
Title: Jacksonville Vessel Surveys and Tagging **Location**: Jacksonville Range Complex (USWTR) **Objectives**: Assess occurrence, habitat associations, and stock structure of marine mammals and sea turtles in key areas of Navy range complexes **Methods**: Vessel visual surveys, satellite-linked tags, biopsy sampling, photo-ID **Performing Organizations**: Duke University, HDR, Inc. **Timeline**: 2020–22 **Funding**: FY18 – $261K, FY19 – $62K	• Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur • Determine what populations of marine mammals are exposed to Navy training and testing activities • Evaluate trends in distribution and abundance of populations that are regularly exposed to Navy training and testing activities	**Fieldwork to resume in 2020** • Transitioned from small vessel baseline surveys • Focus on photo ID, tagging, and M3R species verification support
Title: Baseline Monitoring for Marine Mammals in the East Coast Range Complexes – Passive Acoustics **Location**: Virginia Capes, Cherry Point, and Jacksonville Range Complexes **Objectives**: Assess occurrence, habitat associations, density, stock structure, and vocal activity of marine mammals in key areas of Navy range complexes **Methods**: Passive acoustic monitoring **Performing Organizations**: Duke University, Scripps Institute of Oceanography **Timeline**: 2007–2019 **Funding**: FY13 – $780K, FY14 – $800K, FY15 – $680K, FY16 – $596K, FY17 – $426K, FY18 – $299K, FY19 – $303K	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Establish the baseline vocalization behavior of marine mammals where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to Navy training and testing activities	**HARP deployments ongoing** • Current focus – Norfolk Canyon, Hatteras, Jacksonville • Technical progress report series available • Analysis focus shifted to Shelf Break Species Acoustic Ecology in 2019

Project Description	Intermediate Scientific Objectives	Status
Title: Acoustic Ecology of Northwest Atlantic Shelf Break Species **Location**: Northwest Atlantic **Objectives**: Assess seasonal and spatial, acoustic niches, and anthropogenic drivers of distribution throughout the Northwest Atlantic shelf break region **Methods**: Passive acoustic monitoring **Performing Organizations**: NOAA-NMFS Northeast Fisheries Science Center **Timeline**: 2019–2022 **Funding**: FY18 – $143K, FY19 – $145K	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Establish the baseline vocalization behavior of marine mammals where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to Navy training and testing activities	**New start 2019** • 2019 technical progress report available
Title: Marine Mammal Monitoring on Navy Ranges (M3R) **Location**: Jacksonville USWTR **Objectives**: TBD **Methods**: Passive acoustic monitoring **Performing Organizations**: NUWC Newport **Timeline**: 2020– **Funding**: TBD	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Establish the baseline vocalization behavior of marine mammals where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to Navy training and testing activities	**New start 2020** • Initiate data collection and species verification tests

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APPENDIX A

RECENT PUBLICATIONS AND PRESENTATIONS RESULTING FROM AFTT-RELATED MONITORING INVESTMENTS

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

Ampela, K.A., M.L. DeAngelis, G.G. Lockhart, R.A. DiGiovanni Jr., J. Bort Thornton, D. Rees, P.H. Thorson, D. Jones, S. Hayes, K. Murray, A. Wilke, Z. Poulton, M. Killmon, B. Lusk, S. Barco, A. Costidis, A. McNaughton, R. Boettcher, G. T. Waring. 2019. The first successful satellite-tag deployment on wild-captured harbor seals in Virginia, USA. Poster presentation, World Marine Mammal Conference. 9-12 December 2019. Barcelona, Spain.

Aschettino, J., D. Engelhaupt, A. Engelhaupt, and J. Bell. 2019. Re-sight occurrence and frequency of satellite tagged humpback, fin, and sperm whales off Virginia, USA. Poster presentation, World Marine Mammal Conference. 9-12 December 2019. Barcelona, Spain.

Aschettino, J.M., D.T. Engelhaupt, A.G. Engelhaupt, A. DiMatteo, T. Pusser, M.F. Richlen, and J.T. Bell. 2020. Satellite telemetry reveals spatial overlap between vessel high-traffic areas and humpback whales (*Megaptera novaeangliae*) near the mouth of the Chesapeake Bay. Frontiers in Marine Science 7: 121.

Cioffi, W.R., N.J. Quick, H.J. Foley, D.M. Waples, Z.T. Swaim, J.M. Shearer, D.L. Webster, A. Friedlaender, B. Southall, R.W. Baird, D. Nowacek, and A. Read. 2019. Extreme synchrony in diving behavior of Cuvier's beaked whales (*Ziphius cavirostris*) off Cape Hatteras, North Carolina. Oral presentation, World Marine Mammal Conference. 9-12 December 2019. Barcelona, Spain.

Cotter, M.P., S. Coates, T. Pusser, and J.T. Bell. 2019. Aerial surveys for protected marine species around Norfolk Canyon, Virginia, USA. Poster presentation, World Marine Mammal Conference. 9-12 December 2019. Barcelona, Spain.

Engelhaupt, D., A. Engelhaupt, J. Aschettino, and J. Bell. 2019. Diving behavior and movements of a Sowerby's beaked whale tagged near Norfolk Canyon. Oral presentation, World Marine Mammal Conference. 9-12 December 2019. Barcelona, Spain.

Engelhaupt, D.E, T. Pusser, J.M. Aschettino, A.G. Engelhaupt, M.P. Cotter, M.F. Richlen, and J.T. Bell. 2020. Blue whale (*Balaenoptera musculus*) sightings off the coast of Virginia. *Marine Biodiversity Records* 13: 6.

Parks, S.E., D.A. Cusano, S.M. Van Parijs, and D.P. Nowacek. 2019. North Atlantic right whale (*Eubalaena glacialis*) acoustic behavior on the calving grounds. *Journal of the Acoustical Society of America* 146: EL15-EL21.

Parks, S.E., D.A. Cusano, S.M. Van Parijs, and D.P. Nowacek. 2019. Acoustic crypsis in communication by North Atlantic right whale mother-calf pairs on the calving grounds. *Biology Letters* 15: 20190485.

Quick, N.J., W.R. Cioffi, C. Harris, S. DeRuiter, B. Southall, and A. Read. 2019. More than metronomes: Variation in diving behaviour of Cuvier's beaked whales (*Ziphius cavirostris*). 2019. Oral presentation, World Marine Mammal Conference. 9-12 December 2019. Barcelona, Spain.

Schick, R., M. Bowers, S. DeRuiter, A. Friedlaender, J. Joseph, T. Margolina, D. Nowacek, and B. Southall. 2019. Accounting for positional uncertainty when modeling received levels for tagged cetaceans exposed to sonar. Oral presentation, World Marine Mammal Conference. 9-12 December 2019. Barcelona, Spain.

Shearer, J.M., N.J. Quick, W.R. Cioffi, R.W. Baird, D.L. Webster, H.J. Foley, Z.T. Swaim, D.M. Waples, J.T. Bell, and A.J. Read. 2019. Diving behaviour of Cuvier's beaked whales (*Ziphius cavirostris*) off Cape Hatteras, North Carolina. *Royal Society Open Science* 6: 181728.

Southall, B., W.R. Cioffi, N.J. Quick, R. Schick, D. Nowacek, D.L. Webster, Z.T. Swaim, H.J. Foley, D.M. Waples, C. Harris, L. Thomas, T. Margolina, J. Joseph, M. Bowers, A. Friedlaender, K. Southall, S. DeRuiter, J. Wisse, J.M. Shearer, and A. Read. 2019. Atlantic behavioral response study – Responses of Cuvier's beaked whales and short-finned pilot whales to military sonar off Cape Hatteras, North Carolina, USA. Oral presentation, World Marine Mammal Conference. 9-12 December 2019. Barcelona, Spain.

Watwood, S., E. Jacobson, C. Oedekoven, N. DiMarzio, K. Dolan, J. Fayton, P. Hulton, L. Thomas, and D. Moretti. 2019. Behavioral response function for Cuvier's beaked whales on a Navy training range. Oral presentation, World Marine Mammal Conference. 9-12 December 2019. Barcelona, Spain.

Wisse, J., A. Boggs, H.J. Foley, Z.T. Swaim, D.M. Waples, A. Read, and D. Nowacek. 2019. Baseline variation of steroid hormones in short-finned pilot whales (*Globicephala macrorhynchus*). Oral presentation, World Marine Mammal Conference. 9-12 December 2019. Barcelona, Spain.

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

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