Marine Species Monitoring for the U.S. Navy's Atlantic Fleet Training and Testing (AFTT) – 2022 Annual Report

Prepared For and Submitted To

National Marine Fisheries Service

Office of Protected Resources

Prepared by

Department of the Navy

In accordance with 50 Code of Federal Regulations § 216.245(e)

July 2023

Citation for this report is as follows:

DoN (Department of the Navy). 2023. *Marine Species Monitoring for the U.S. Navy's Atlantic Fleet Training and Testing (AFTT) — 2022 Annual Report*. U.S. Fleet Forces Command, Norfolk, Virginia. July2023.

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From left to right:

Post-tagging release of a juvenile female harbor seal (*Phoca vitulina*) instrumented with a depth-sensing SPLASH tag at the Eastern Shore of Virginia. Photograph taken by Deanna Rees (Naval Facilities Engineering Systems Command, Atlantic) taken under National Marine Fisheries Service Scientific Research Permit No. 21719.

North Atlantic right whale (*Eubalaena glacialis*) #4180 and her calf, observed off Currituck National Wildlife Refuge, North Carolina, during a mid-shelf baleen whale survey; photographed by Jessica Aschettino (HDR, Inc.), taken under National Marine Fisheries Service Scientific Research Permit No. 21482, issued to Dan Engelhaupt (HDR, Inc.).

A DTAG is deployed on a Cuvier's beaked whale (*Ziphius cavirostris*) during the Atlantic Behavioral Response Study off Cape Hatteras, North Carolina; photographed by Kate Sutherland (Duke University), taken under National Marine Fisheries Service Scientific Research Permit No. 19903, issued to Andy Read (Duke University).

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ACRONYMS AND ABBREVIATIONS

°N	degrees North
°W	degrees West
AFTT	Atlantic Fleet Training and Testing
AMAPPS	Atlantic Marine Assessment Program for Protected Species
AMR	Adaptive Management Review
AMSEAS	Atlantic Marine Conservation Society
ATN DAC	Animal Telemetry Network data assembly center
AUTEC	Atlantic Undersea Test and Evaluation Center
BIW	Bath Iron Works
BRS	behavioral response study
CAS	continuously active sonar
CBBT	Chesapeake Bay Bridge-Tunnel
CEE	controlled exposure experiment
CI	confidence interval
cm	centimeter(s)
CNO	Chief of Naval Operations
CS-SVM	Class-Specific Support Vector Machine
dB	decibel(s)
dB re 1 µPa	decibels referenced to a pressure of 1 microPascal
DMON	digital acoustic monitoring instrument
DoN	Department of the Navy
DPS	distinct population segment
DTAG	digital acoustic tag
EAR	Ecological Acoustic Recorder
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FL	fork length
GOM	Gulf of Mexico
GPS	Global Positioning System
HARP	High-frequency Acoustic Recording Package
ICMP	Integrated Comprehensive Monitoring Program
IHA	Incidental Harassment Authorization
JAX	Jacksonville
JSWTR	Jacksonville Shallow Water Training Range
kg	kilogram(s)
kHz	kilohertz
km	kilometer(s)
km^2	square kilometer(s)
LiDAR	Light Detection and Ranging
LOA	Letter of Authorization
M3R	Marine Mammal Monitoring on Navy Ranges
m	meter(s)
MAHWC	Mid-Atlantic Humpback Whale Photo-ID Catalog
MARU	Marine Autonomous Recording Unit
ME DMR	Maine Department of Marine Resources
MFAS	mid-frequency active sonar
MINEX	Mine-neutralization Exercise
MMM	Maine Maritime Museum
MMoME	Marine Mammals of Maine
MMPA	Marine Mammal Protection Act
MSM	Marine Species Monitoring
NAHWC	North Atlantic Humpback Whale Catalog
NARW	North Atlantic right whale

NBATH	Northern bath Iron Works
NEFSC	Northeast Fisheries Science Center
nm	nautical mile(s)
NMFS	National Marine Fisheries Services
NMSDD	Navy Marine Species Density Database
NOAA	National Oceanic and Atmospheric Administration
NSWC	U.S. Naval Surface Warfare Center
NUWCDIVNPT	Naval Undersea Warfare Center Division Newport
OBIS-SEAMAP	Ocean Biogeographic Information System-Spatial Ecological Analysis of Megavertebrate Populations
OEIS	Overseas Environmental Impact Statement
ONR	Office of Naval Research
OPAREA	Operating Area
PAM	passive acoustic monitoring
photo-ID	photo-identification
PMRF	Pacific Missile Range Facility
PTT	platform transmitter terminal
RHIB	rigid-hulled inflatable boat
RL	received level
RMS	root mean square
R/V	research vessel
SE	standard error
SEA	Southall Environmental Associates Inc.
SEFSC	Southeast Fisheries Science Center
SLTDR	satellite-linked, time-depth recording tag
SP	Sutherland/Patteson
SPOT	Smart Position and Temperature
SOAR	Southern California Anti-Submarine Warfare Range
sUAS	small unmanned aerial systems
UME	unusual mortality event
UNCW	University of North Carolina at Wilmington
U.S.	United States
USFFC	U.S. Fleet Forces Command
USS	U.S. Ship
UTC	Coordinated Universal Time
VACAPES	Virginia Capes

SECTION 1 – INTRODUCTION

This report contains a summary of marine species monitoring (MSM) projects funded by the United States (U.S.) Navy within the Atlantic Fleet Training and Testing (AFTT) study area during 2022 as described in the AFTT Final Environmental Impact Statement/Overseas Environmental Impact Statement Phase III (EIS/OEIS) (DoN 2018). The U.S. Navy supports monitoring for a variety of protected marine species in compliance with the Letters of Authorization (LOA) (NMFS 2018a, 2019a, 2019b), Biological Opinions (NMFS 2018b, 2019c), and Final Rules (NMFS 2019d, 2020) issued under the Marine Mammal Protection Act of 1972 (MMPA) and the Endangered Species Act of 1973 (ESA) for training and testing within the AFTT study area.

Section 2 of this report summarizes monitoring progress and results for each MSM project, with additional data and details in the bullets below.

- Detailed technical reports for the individual MSM projects are provided as supporting documents to this report (Alvarez et al. 2023; Ampela et al. 2023; Aschettino et al. 2023; DeAngelis et al. 2023; Engelhaupt et al. 2023; Jones and Rees 2023; Rafter et al. 2022; Guins et al. 2023; Shearer et al. 2023; Soldevilla et al. 2023; Southall et al. 2023; Van Parijs et al. 2023; Waples and Read 2023) and are available on the U.S. Navy's MSM web portal. Each individual technical report is linked directly from the corresponding subsection.
- A summary of current monitoring projects for 2022–23 is provided in **Appendix A**.
- Publications and conference presentations for 2022 from U.S. Navy-funded work are listed in **Appendix B** by author last name.

1.1 Background

The AFTT study area includes at-sea components of the range complexes as well as training and testing ranges within the western North Atlantic Ocean and encompasses the Atlantic Coast of North America and the Gulf of Mexico (**Figure 1**). The AFTT study area covers approximately 2.6 million square nautical miles of ocean area and includes designated U.S. Navy operating areas (OPAREA) and special use airspace. The AFTT study area also includes portions of Narragansett Bay, lower Chesapeake Bay, St. Andrew Bay, and pier-side locations where sonar maintenance and testing occur. The U.S. Navy's range complexes that fall within the AFTT study area include the following and are depicted on **Figure 1**:

- Northeast Range Complex
- Virginia Capes (VACAPES) Range Complex
- Navy Cherry Point Range Complex
- Jacksonville (JAX) Range Complex
- Key West Range Complex
- Gulf of Mexico Range Complex

In order to authorize the incidental taking of marine mammals under the MMPA, the National Marine Fisheries Services (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 an 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 by NMFS for the AFTT study area includes terms and conditions for continued monitoring within this region.

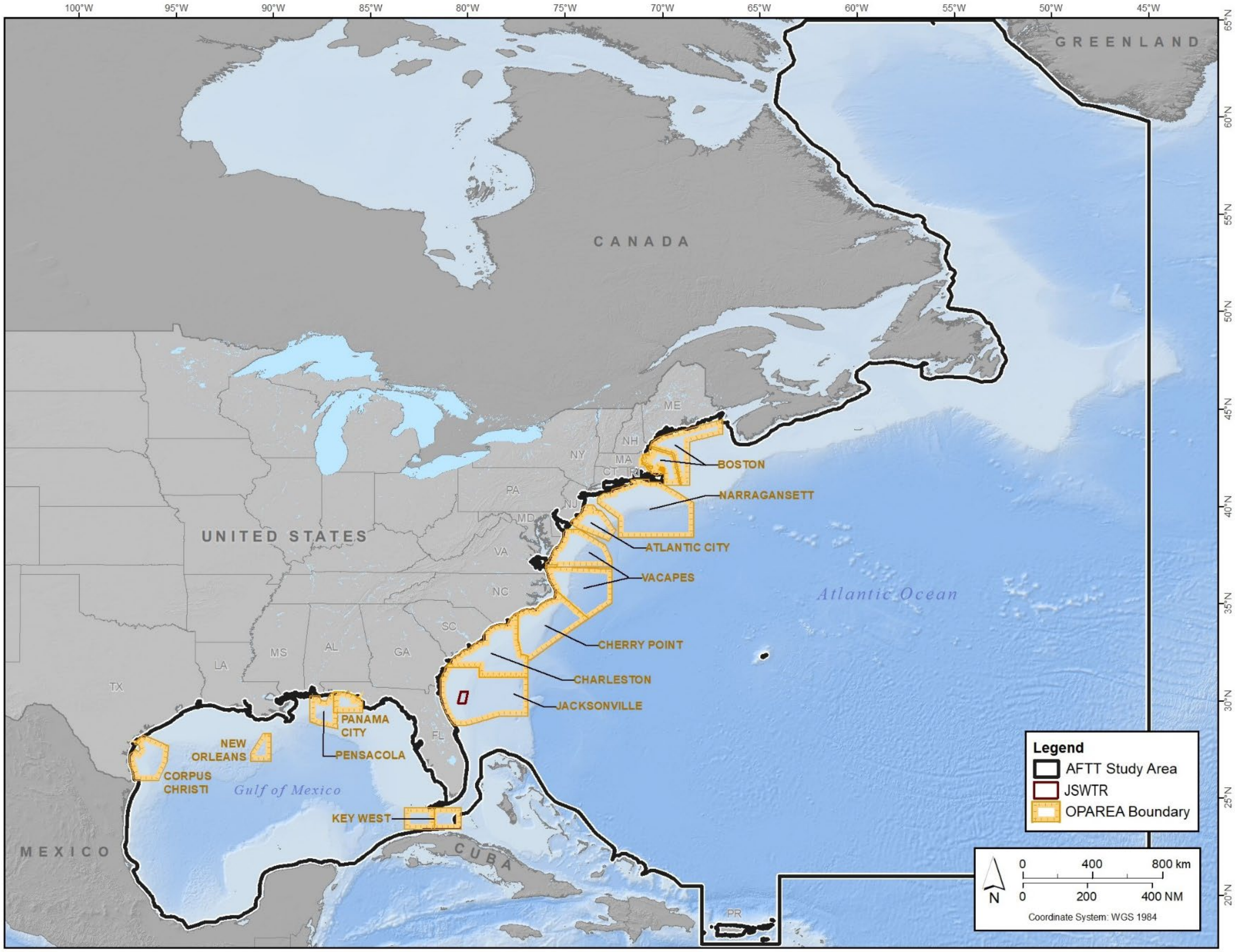


Figure 1. Atlantic Fleet Training and Testing study area.

The U.S. Navy has invested nearly $50 million (**Table 1**) in compliance-monitoring activities within the AFTT study area since 2009. Additional information regarding the program is available on the U.S. Navy's MSM Program website. This 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.

Table 1. Annual funding for the U.S. Navy's Marine Species Monitoring Program in the Atlantic Fleet Training and Testing study during Fiscal Years 2009–2022.

Fiscal Year (01 October–30 September)	Funding
2009-2013	$15,330,000
2014	$3,311,000
2015	$3,700,000
2016	$3,845,000
2017	$3,383,000
2018	$3,476,000
2019	$4,187,000
2020	$4,022,000
2021	$4,240,000
2022	$4,175,000
Total	**$49,469,000**

In addition to the compliance monitoring program for 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) Environmental Readiness Program's Living Marine Resources Program support coordinated Science and Technology as well as Research and Development programs focused on understanding the effects of sound on marine mammals, including physiological, behavioral, ecological, and population-level effects. These programs currently fund several significant ongoing projects relative to potential operational impacts on marine species within some U.S. Navy range complexes.

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 2010) and serves as a planning tool to focus monitoring priorities pursuant to ESA and MMPA requirements, and coordinate monitoring efforts across regions based on a set of common objectives. Although the ICMP does not identify specific research questions or projects, it provides a flexible, scalable, and adaptable framework within the context of adaptive-management and strategic planning. The ICMP is evaluated through the Adaptive Management Review (AMR) process to 1) assess overall progress, 2) provide a matrix of goals and objectives, and 3) make recommendations for refinement and evolution of the monitoring program's focus and direction. This process includes 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 modifications are warranted to address monitoring goals.

Using an underlying conceptual framework incorporating a progression of knowledge from occurrence to exposure/response, and ultimately consequences, the U.S. Navy developed the Strategic Planning Process (DoN 2013) as a tool to help guide the investment of resources to most efficiently address ICMP goals. Intermediate Scientific Objectives form the basis of evaluating, prioritizing, and selecting new monitoring projects or investment topics. The Strategic Planning Process will continue to shape the future of the U.S. Navy's MSM Program and 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).

Additional information and background on the ICMP and Strategic Planning Process can be found on the U.S. Navy's MSM web portal.

1.3 Report Objectives

This report presents the progress, accomplishments, and results of U.S. Navy MSM projects within the AFTT study area in 2022 and has two primary objectives:

1. Summarize findings from the U.S. Navy-funded marine mammal and sea turtle monitoring conducted within the AFTT study area during 2022, 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 MSM. These initiatives continue to shape the evolution of the U.S. Navy MSM Program for 2023 and beyond, improve understanding of the occurrence and distribution of marine mammals and sea turtles within the AFTT study area, and improve understanding of their exposure and response to sonar and explosives training and testing activities.

Appendix A summarizes U.S. Navy MSM investments within the Atlantic for 2022 and projects continuing in 2023. Additional details regarding these projects as well as data, reports, and publications can be accessed through the U.S. Navy's MSM web portal as they become available.

SECTION 2 – MARINE SPECIES MONITORING ACTIVITIES

The predecessor to AFTT monitoring began in 2007 with a data-collection program supporting the development of an Undersea Warfare Training Range initially planned for Onslow Bay off the coast of North Carolina. That initial monitoring program was heavily focused on visual line-transect surveys and passive acoustic monitoring (PAM) for the purpose of establishing a robust understanding of protected species distribution and occurrence. The baseline occurrence work eventually expanded to several additional study sites and formed the basis of the current monitoring program for AFTT. These long-term study areas now serve to support more recent projects involving the tagging and tracking of multiple species of cetaceans (**Section 2.2**), as well as behavioral response studies (**Section 2.3**).

Although standard line-transect visual surveys are no longer a significant component of monitoring for AFTT, work on occurrence, distribution, population and social structure continues and is threaded throughout many of the current projects as an important component of understanding the consequences of exposure to training and testing activities on individuals, stocks, and populations.

2.1 Occurrence, Distribution, Population, and Social Structure

Small vessel-based monitoring in 2022 incorporated multi-disciplinary methods, including photo-identification (photo-ID), biopsy sampling, unmanned aerial vehicle observations, and satellite tagging. While passive acoustic monitoring was also a cornerstone of the monitoring program through much of the first decade of study, the focus has been shifting away from pure baseline data collection in recent years, with efforts being directed more toward species-specific studies and broader ecological analyses. A summary of accomplishments and results from visual and PAM efforts for the reporting period is presented in the following subsections.

2.1.1 Visual Methods

2.1.1.1 Photo-identification Analysis off Cape Hatteras, North Carolina

As a component to supplement the Atlantic Behavioral Response Study (BRS; **Section 2.3.1**), Duke University continued photo-ID fieldwork within the Cape Hatteras study area during 2022 to confirm species, identify individuals, and conduct follow-up monitoring of satellite-tagged animals. These matching analyses build upon established photo-ID catalogs and photographs previously collected within other AFTT monitoring and study areas, including Jacksonville, Florida, and Onslow Bay, North Carolina.

Digital photographs were obtained from seven cetacean species, with most taken of Cuvier's beaked whales (*Ziphius cavirostris*) and short-finned pilot whales (*Globicephala macrorhynchus*), the two primary focal species of the Atlantic BRS. Other cetacean species for which photographs were taken include sperm whales (*Physeter macrocephalus*), Atlantic spotted dolphins (*Stenella frontalis*), Clymene dolphins (*Stenella clymene*), Risso's dolphins (*Grampus griseus*), and common bottlenose dolphins *(Tursiops truncatus*) (herein referred to as the bottlenose dolphin) (**Table 2**). 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 the images were cropped and placed into a folder for each sighting.

Table 2. Cetacean sightings with numbers of photo-Identification images collected for species within the Cape Hatteras study area in 2022.

Species	Common Name	Number of Sightings	Number of Photo-ID Images
Globicephala macrorhynchus	Short-finned pilot whale	71	4,720
Grampus griseus	Risso's dolphin	2	189
Physeter macrocephalus	Sperm whale	1	25
Stenella clymene	Clymene dolphin	1	1
Stenella frontalis	Atlantic spotted dolphin	7	625
Tursiops truncatus	Bottlenose dolphin	60	772
Unidentified beaked whale	Unidentified beaked whale	2	2
Unidentified dolphin	Unidentified dolphin	4	3
Unidentified odontocete	Unidentified odontocete	2	13
Ziphius cavirostris	Cuvier's beaked whale	74	9,010
Total		**224**	**15,360**

Images of 110 newly identified animals were added to existing photo-ID catalogs of short-finned pilot whales, Risso's dolphins, sperm whales, Atlantic spotted dolphins, bottlenose dolphins, and Cuvier's beaked whales (**Table 3**). Additionally, 38 new photo-ID matches were made within the short-finned pilot whale and Cuvier's beaked whale catalogs. A bottlenose dolphin that was sighted twice in 2013 was also re-sighted in September 2021, 9 years after its initial sighting; this is the longest re-sight for this species off Cape Hatteras. To date, photo-ID catalogs for 11 species have been assembled within the Cape Hatteras study area, across multiple AFTT monitoring projects, which include almost 2,200 distinct individuals, with 619 individuals re-sighted across all species (**Table 3**).

Table 3. Summary of all images collected during fieldwork within the Cape Hatteras study area in 2022 showing number of new identifications, photo-ID catalog sizes, number of new re-sights, and total re-sights to date.

Species	New Images Collected	New IDs	Catalog Size	New Re-sights	Re-sights To Date
Balaenoptera physalus	0	0	1	0	0
Delphinus delphis	0	0	46	0	1
Globicephala macrorhynchus	4,720	36	1,375	7	476
Grampus griseus	189	6	47	0	6
Kogia sp.	0	0	1	0	0
Megaptera novaeangliae	0	0	2	0	0
Physeter macrocephalus	25	1	29	0	1
Stenella clymene	1	0	3	0	0
Stenella frontalis	625	9	42	0	0
Tursiops truncatus	772	9	369	0	18
Ziphius cavirostris	9,010	49	283	31	117
Total	**15,360**	**110**	**2,198**	**38**	**619**

Short-finned Pilot Whales

Thirty-six new identifications and 7 new re-sightings were added to the short-finned pilot whale catalog in 2022. The current re-sight rate of short-finned pilot whales is 35 percent, comparable to the rate documented in 2021. More than 200 short-finned pilot whales have been seen on three or more occasions, and 14 animals have been re-sighted more than six times. More than 100 short-finned pilot whales have been biopsied within the study area between 2006 and 2022, and the sex of 95 whales has been determined from analysis of these samples, with 69 males and 26 females sampled to date.

Individual short-finned pilot whales have been documented returning to the Cape Hatteras area over extended periods. Almost 120 pilot whales have records of 5 or more years between their first and last sightings, and 23 individuals have histories that span 10 or more years (**Table 4**). Three of these 23 whales were satellite-tagged, and 3 others were biopsied (1 male, 2 females). These long-term photo-ID records demonstrate that both male and female short-finned pilot whales exhibit strong, but intermittent, site fidelity to the Cape Hatteras area. Additionally, a new, long-term re-sighting was found during this period. Gma_1-065 was first seen in May 2008; it was re-sighted in July 2010, again in October 2022 when it was accompanied by a calf (**Figure 2**). This 14-year period represents the longest-term re-sighting of a short-finned pilot whale off Cape Hatteras. The 36 newly identified short-finned pilot whales added to the Hatteras photo-ID catalog were systematically compared to catalogs for this species from Onslow Bay, North Carolina, and JAX, Florida, but no new matches were made between the study areas. Four pilot whales were previously matched between the Cape Hatteras and Onslow Bay study areas. Gma_8-165 was seen in Onslow Bay, in a group of 40 short-finned pilot whales in August 2007, and re-sighted and satellite-tagged (GmTag209) within the Cape Hatteras area 11 years later, in August 2018. Three other short-finned pilot whales were also photographed with Gma_8-165 in both sightings. These four photo-ID matches are the only short-finned pilot whale matches documented between the Cape Hatteras and Onslow Bay catalogs. To date, no matches have been made between the Cape Hatteras and JAX catalogs.

Table 4. Frequency distribution of the number of years between first and last sightings of photo-identified short-finned pilot whales within the Cape Hatteras study area.

Number of Years Between First and Last Sighting	Number of Individuals
Less than 1	132
1 to 2	49
2 to 3	45
3 to 4	63
4 to 5	69
5 to 6	17
6 to 7	20
7 to 8	43
8 to 9	14
9 to 10	1
10 to 11	13
11 to 12	7
More than 12	3
Total	**476**

Figure 2. **Photographs of Gma_1-065 in May 2008 (top), July 2010 (middle), and October 2022 (bottom).**

Four short-finned pilot whales off Cape Hatteras were equipped with Digital Acoustic Recording Tags (DTAGs) in 2022; one was matched to the study's photo-ID catalog. Gma_8-072 was first photographed in October 2015 and tagged in October 2022 (**Figure 3**). No pilot whales were satellite-tagged during the 2022 field season.

HDR researchers also collected and provided images of short-finned pilot whales during their fieldwork within the Norfolk Canyon study area in 2021 and 2022 (**Table 5**). Approximately 1,100 images were graded for photographic quality and animal distinctiveness, and all images of sufficient quality and distinctiveness were then sorted by individual within each sighting. The best image for each individual was then compared to the existing Norfolk photo-ID catalog. Fifteen new individuals were added to the Norfolk short-finned pilot whale catalog (**Table 6**). No new re-sightings occurred in the Norfolk pilot whale catalog; as reported last year, 10 short-finned pilot whales were re-sighted by HDR researchers during their fieldwork from 2015 through 2022. Short-finned pilot whales in the Norfolk catalog were compared to those in the Cape Hatteras short-finned pilot whale catalog, which contains 1,375 individuals. One new match was made between the two areas, adding to the 43 previous matches. M-047 was seen off Cape Hatteras in May 2015 and was re-sighted 7 years later off Norfolk. Thus, 15 percent (44 of 295) of pilot whales observed within the Norfolk Canyon have also been photographed within Cape Hatteras. Comparing the two catalogs provides additional long-term re-sighting information: 13 of the pilot whales were seen within Cape Hatteras from 2007 to 2009, but not observed again until they were photographed within the Norfolk Canyon area from 2015 onward. The new Norfolk pilot whale IDs were compared to short-finned pilot whale catalogs from Onslow Bay, North Carolina, and JAX, Florida, but did not make any matches.

Table 5. Number of sightings of short-finned pilot whales and number of images collected by year within the Norfolk Canyon area.

Year	Number of Sightings	Number of Photo-ID Images
2021	2	198
2022	9	882
Total	**11**	**1,080**

Table 6. Catalog sizes for short-finned pilot whales within the Norfolk Canyon area, including the original 2015–2019 catalog and individuals added during recent photo-ID efforts.

Species	2015–2019 Catalog	2020–2021 Catalog	2021–2022 New IDs	Current Catalog Size	New Re-sights	Total Re-sights
Globicephala macrorhynchus	230	280	15	295	0	10

Comparisons are still in progress between two catalogs of short-finned pilot whale photographs collected from researchers and volunteers working around Martinique and Guadeloupe Islands in the Caribbean contributed by Dr. Jeremy Kiszka of Florida International University. The Caribbean catalog was compared to the short-finned pilot whale catalogs from JAX, Florida; Onslow Bay, North Carolina; and Cape Hatteras, North Carolina. Several potential matches occurred between the sites, but they could not be confirmed due to poor photographic quality.

Figure 3. Photographs of Gma_8-072 in October 2015 (top) and October 2022, when it was equipped with a DTAG (bottom).

Both Caribbean catalogs were compared to a catalog of short-finned pilot whales that was created from images taken during research cruises conducted by National Oceanic and Atmospheric Administration (NOAA) scientists within the GOM and contributed by Keith Mullin of the Southeast Fisheries Science Center (SEFSC). Several potential matches were made, and images were circulated to Jeremy Kiszka, Andrew Read, and Kim Urian; however, all agreed that the matches could not be confirmed, either due to poor photographic quality or minimal animal distinctiveness. In the coming year, the plan is to finish comparisons between the Caribbean catalogs and the catalog of short-finned pilot whales off Norfolk, Virginia. The study hopes to receive further image contributions from Dr. Jeremy Kiszka from the Caribbean, including whales harvested for human consumption within St. Vincent.

Linkages between pilot whales within the Caribbean and those inside the U.S. Exclusive Economic Zone are important because short-finned pilot whales are still harvested in St. Vincent and elsewhere within the Caribbean. Sophie Hanson, an undergraduate at Duke University, completed an honors thesis looking at the genomics of short-finned pilot whales using biopsy samples collected from the Caribbean nations of St. Vincent and the Grenadines (n = 17); JAX, Florida (n = 7); and Cape Hatteras, North Carolina (n = 36). She used single nucleotide polymorphisms to infer genetic differentiation or similarity. These results support the hypothesis that genetic population connectivity occurs between short-finned pilot whales in St. Vincent, Florida, and North Carolina (Hanson 2022).

Cuvier's Beaked Whales

Forty-nine new identifications were added to the Cuvier's beaked whale photo-ID catalog during 2022, and 31 new re-sights were made (both within and between years). The current re-sight rate for Cuvier's beaked whales within the Cape Hatteras area is 41 percent; an increase from 36 percent in 2021. To date, 81 of the 117 (69 percent) matched Cuvier's beaked whales have been seen across multiple years, and 47 of those have been re-sighted more than 3 years after the initial observation (**Table 7**). This is a notable increase over last year's photo-ID results, when only 28 whales had been sighted over more than a 3-year period.

Table 7. Frequency distribution of the number of years between first and last sightings of photo-identified Cuvier's beaked whales within the Cape Hatteras study area.

Number of Years Between First and Last Sighting	Number of Individuals
Less than 1	39
1 to 2	20
2 to 3	11
3 to 4	20
4 to 5	17
5 to 6	4
6 to 7	2
7 to 8	2
More than 8	2
Total	**117**

Eight Cuvier's beaked whales were tagged in 2022 as part of the Atlantic BRS; two of those individuals were matched to the photo-ID catalog:

- *Zca_027r* was initially observed in 2015; it was re-sighted in August 2018 and October 2020 and was finally satellite-tagged (ZcTag129) in June 2022; this individual is an adult male (**Figure 4**).
- *Zca_065* was initially observed in August 2018 without a calf and seen again the following year in August 2019 with a moderately distinctive calf (Zca_148r). She was re-sighted in July 2021 with an apparently new calf (Zca_120); both had prominent scars that likely came from a shark. She and her second calf were re-sighted in June 2022, and she was satellite-tagged (ZcTag130) (**Figure 5**).

Individual *Ziphius* were observed associating in the same groups over periods of days to weeks, but long-term social associations are still uncommon. Previously, only two instances were documented of a long-term association. The first was an adult male/adult female pair satellite-tagged in the same group in May 2016 (ZcTag046 and ZcTag047, respectively) and seen together again in June 2017. A second long-term association involved two adult males tagged in the same group of three in August 2018 (ZcTag071 and ZcTag072, respectively) and photographed together in a group of six in August 2020. Both whales were encountered again later that year, but in different groups. During this reporting period, a third long-term association that involved two adult males was documented: Zca_056 and Zca_035 were satellite-tagged in separate groups in August 2018 (ZcTag072 and ZcTag076, respectively) and were re-sighted together in August 2020 and August 2021.

The photographic histories of individual whales continue to improve the understanding of the demographics of *Ziphius* within the Cape Hatteras study area. Of particular interest is estimating calving intervals of individual females and the survival of calves in the post-dependency period; a sufficient number of images of distinctive calves is beginning to make this analysis feasible (**Table 8**). For example, Zca_102 was seen with its mother (Zca_101) several times throughout the 2020 field season (**Figure 6**). Zc_120 was first photographed with its mother in July 2021; at the time, it was classified as a young-of-the year animal. As mentioned previously, the pair was re-sighted in June 2022, and the mother was satellite tagged (ZcTag130; **Figure 7**); ZcTag130 had a prior calf that was also distinctive (Zca_148r). Additionally, Zca_067 was seen in August 2018 with a distinctive calf; she was re-sighted in June 2022 without the calf. If these distinctive calves can be re-sighted, this will be the study's first information about movements and associations of juvenile goose-beaked whales. It is hoped that continuing to observe these distinctive calves will provide insight into the age at which calves separate from their mothers and facilitate estimating calving intervals for adult females in this population.

Table 8. Identifications and sighting histories of distinctive goose-beaked whale calves.

Calf ID	Sighting Date(s)
Zca_068	August 2018
Zca_141r	July 2019
Zca_148r	August 2019
Zca_183r	August 2020
Zca_102	August 2020, October 2020
Zca_120	July 2021, June 2022, August 2022

Figure 4. Photographs of Cuvier's beaked whale individual Zca_027r, initially sighted in 2015, resighted in 2018 (top) and 2020, and satellite-tagged in 2022 (ZcTag129; bottom).

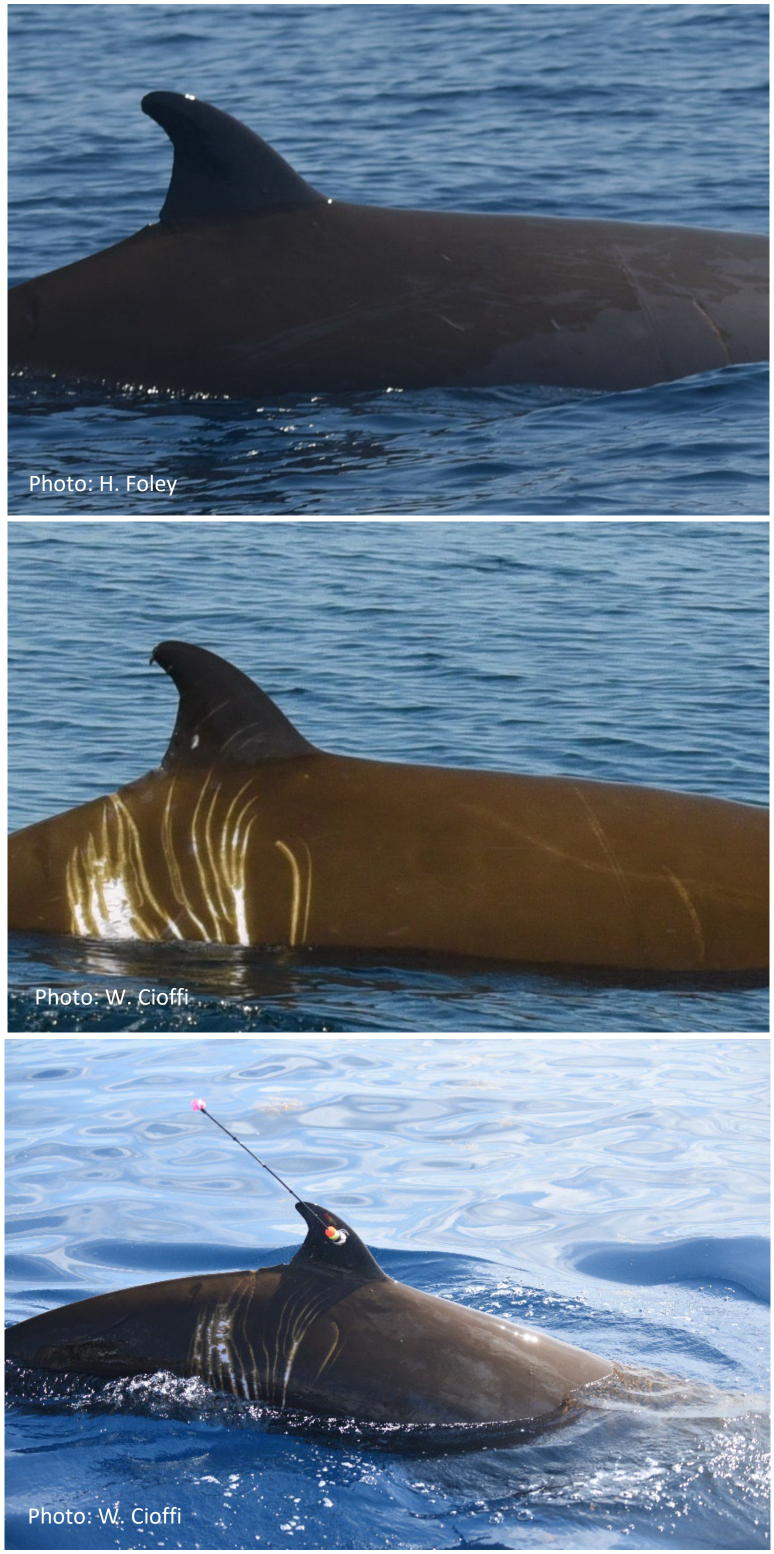


Figure 5. Photographs of Cuvier's beaked whale individual Zca_065, initially sighted in 2018 (top), re-sighted in 2019 and 2021 (middle), and satellite-tagged in 2022 (ZcTag130; bottom).

Figure 6. Photograph of Zca_102, the calf of Zca_101, in August 2020.

Figure 7. Photograph of Zca_120, the calf of Zca_065 (ZcTag130), in July 2021.

Biopsy samples are continuing to be collected from Cuvier's beaked whales off Cape Hatteras to assign sex to animals that lack erupted teeth or extensive scarring—the two characteristics used to identify adult males. Analysis of these samples will also provide important information on genetic relationships among individuals, effective population size, and biochemical markers of diet and stress. To date, 38 biopsy samples of *Ziphius* have been collected.

During this reporting period, Ali Pagliery, a Duke undergraduate student, examined the scarring density of individual animals of known sex. She used photographs taken at the time of biopsy to quantify the percent of scarring in a defined region below the dorsal fin of each whale, following the methods developed by Coomber et al. (2022). She found that females (n = 9 with sex assigned from molecular analysis of biopsy samples) had scarring densities ranging from 0 to 3.1 percent, while males (n = 29) had scarring densities ranging from 0 to 34.7 percent (**Table 9**). Twenty of the 29 males also had photographs of the head and face taken at the time of biopsy. These can be used to classify the animals as adult males if erupted teeth are present. All known subadult males (without erupted teeth) had scarring densities of 5 percent or less; while all adult males, except for one, had scarring densities of 5 percent or greater. When the nine males without photographs of the head or face are included, it seems likely that most of those can be classified into an age class, simply based on their scarring density. These results will be used in the future to classify animals in the catalog that lack head photographs but possess high scarring densities as adult males.

Three additional catalogs have been created for *Ziphius* from images collected by other researchers and scientists, and the study's images of whales are being compared with these catalogs **(Table 10**). To date, nine matches have been made between the four catalogs; the study's three longest-term re-sightings are derived from these inter-catalog comparisons. University of North Carolina at Wilmington (UNCW) M-003 was first photographed by the aerial survey team off Cape Hatteras in August 2014. The study then photographed the whale in 2015, 2019, 2020, and finally in June 2022, when it was seen for the first time with a calf, confirming that this individual is an adult female. This female acquired few, if any, new scars in 8 years. Sutherland/Patteson (SP) M-003 was photographed by Kate Sutherland in May 2004 south of Cape Hatteras, and the study tagged it 15 years later in July 2019 (ZcTag090); this whale is an adult male. It is believed that this is the longest-term re-sighting record of a Cuvier's beaked whale within the Northwest Atlantic. SP M-004 was originally photographed by Kate Sutherland in July 2010; it was sighted off Cape Hatteras 10 years later and tagged in August 2020 (ZcTag108). Another inter-catalog match made during this reporting period was HDR M-001, which was photographed in August 2020, and then photographed by HDR in August 2022 off Norfolk, Virginia. Occasional movements have also been documented between Cape Hatteras and Norfolk Canyon from the study's large sample of satellite-tagged whales. These comparisons are increasing knowledge regarding the long-term and long-distance movements of this population (**Figure 8**).

The study's sighting histories of individual whales will contribute to a meta-analysis of Cuvier's beaked whale demography funded by ONR and coordinated by Erin Falcone and Greg Schorr. The goal of this collaborative project is to compare vital rates of Cuvier's beaked whales across populations that experience varying exposure to military sonar. Pigmentation and scarring-density metrics will be applied to images from each population in a uniform manner, allowing the study to classify individual whales according to age classes (calf, adult, or juvenile) and, in some cases, sex. Estimation of vital rates for each population will require age- and sex-linked life-history data from a large sample of individual animals. It is important to have adequate samples of photo-ID data from each region; the Cape Hatteras photo-ID catalog is the largest in this dataset and will be an important contribution to this analysis.

Table 9. Identification codes, percent scarring, and genetic sex of biopsied goose-beaked whales within the defined region of interest.

Biopsy Identification	Percent Scarring	Genetic Sex
HJF_20_007	0.0	Female
ZTS_15_015	0.0	Male
ZTS_18_012	0.0	Male
ZTS_21_016	0.0	Female
ZTS_15_017	0.1	Female
HJF_21_006	0.3	Male
ZTS_13_031	0.3	Female
ZTS_21_019	0.6	Female
HJF_21_004	0.6	Male
HJF_21_007	0.6	Male
HJF_21_010	0.8	Female
ZTS_21_020	1.0	Male
ZTS_21_014	1.1	Male
AJR_18_001	1.4	Female
HJF_21_011	1.4	Male
ZTS_21_021	1.5	Female
HJF_21_003	1.6	Male
HJF_21_005	2.0	Male
HJF_21_009	2.5	Male
HJF_18_004	3.1	Female
HJF_20_010	4.0	Male
ZTS_21_015	4.1	Male
HJF_20_009	4.6	Male
ZTS_21_018	4.9	Male
WRC_21_002	5.0	Male
HJF_20_005	5.1	Male
ZTS_18_011	6.1	Male
HJF_21_008	7.2	Male
WRC_21_003	10.5	Male
HJF_21_002	10.6	Male
HJF_20_006	14.4	Male
WRC_21_004	16.9	Male
ZTS_21_017	19.5	Male
HJF_18_002	19.6	Male
ZTS_13_032	21.0	Male
HJF_18_003	22.2	Male
ZTS_17_004	33.6	Male
HJF_18_001	34.7	Male

Table 10. Number of images in each Cuvier's beaked whale catalog and years when the images were collected.

Catalog Descriptor[a]	Catalog Location	Years Images Collected	Number of Individuals
UNCW	Cape Hatteras, North Carolina Aerial Surveys	2012–2017	51
SP	South of Cape Point, North Carolina	2003–2018	25
HDR	Norfolk, Virginia	2019–2022	3
DUML	Cape Hatteras, North Carolina	2007–2022	283

[a] UNCW= University of North Carolina at Wilmington catalog made from aerial surveys; SP= Sutherland/Patteson catalog from seabirding trips south of Cape Point; HDR= HDR catalog from research trips in Norfolk, Virginia; DUML= Duke University Marine Lab catalog from research trips off Cape Hatteras

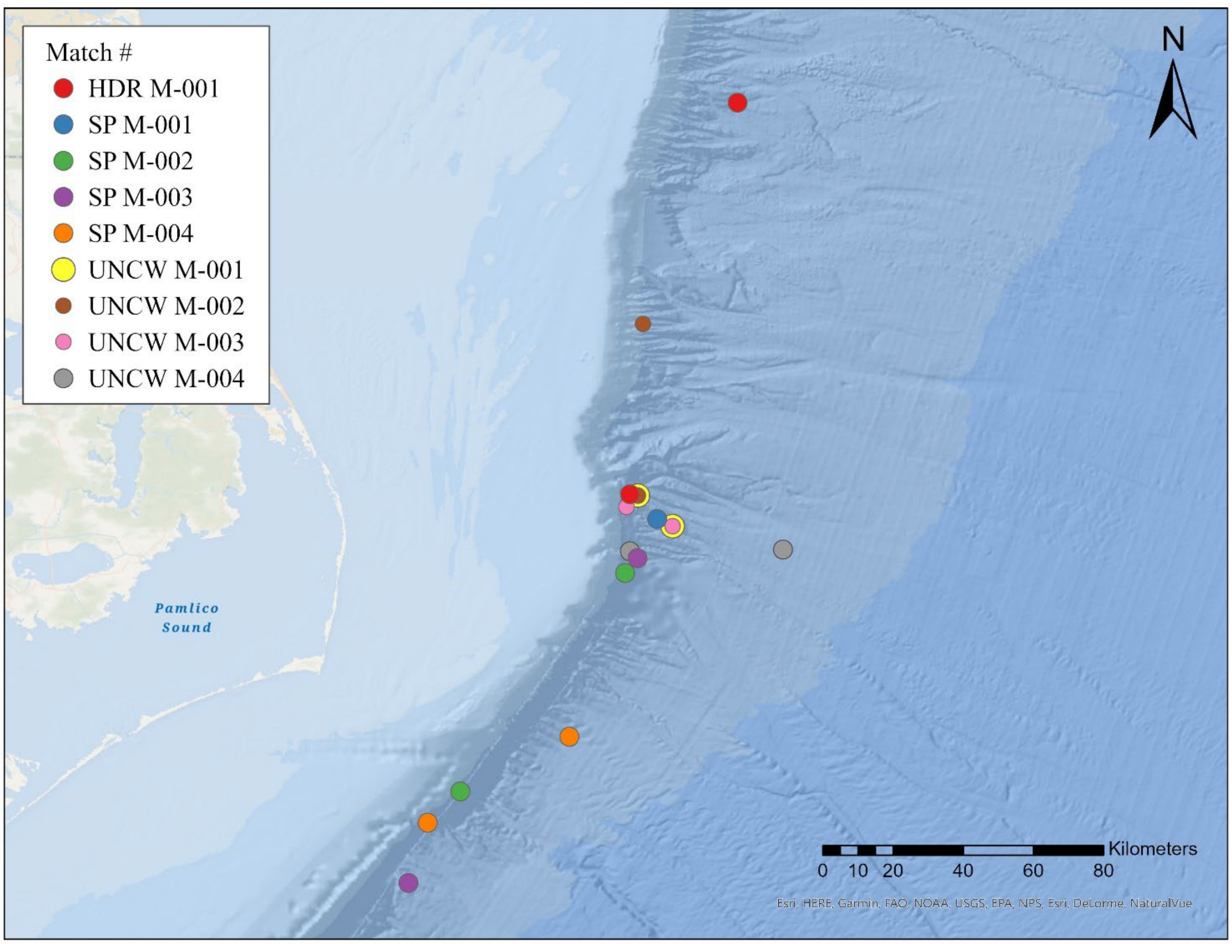


Figure 8. Map of sighting locations of Cuvier's beaked whales matched between the Duke University catalog and three external catalogs (HDR = HDR catalog from Norfolk, Virginia; SP = Sutherland/Patteson catalog from south of Cape Point; UNCW = University of North Carolina at Wilmington catalog from aerial surveys).

Satellite Tagging

To date, 80 satellite tags have been deployed on 79 short-finned pilot whales off Cape Hatteras, and 31 of these (39 percent) have been re-sighted. Most of these re-sightings occurred within the same field season, but 12 (39 percent) have been re-sighted across multiple years after being tagged. Ninety-six satellite tags have been deployed on 92 Cuvier's beaked whales from 2014 through 2022, and 64 of these animals (67 percent) have been re-sighted. Many re-sightings occurred within the same field season, but 32 of the re-sighted whales (50 percent) were photographed at least a year after tagging. 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, few instances of long-term damage to the dorsal fin of tagged animals occurred, and most individuals appear to be well-healed.

Several re-sightings of satellite-tagged short-finned pilot whales occurred during the 2022 field season. GmTag134 and GmTag135 were tagged in the same group in October 2015, along with four other pilot whales; all six were seen together in June 2018, and all were photographed in the same group 7 years after their initial sighting, in October 2022. GmTag201 was tagged in May 2018 and re-sighted once in June 2018, but it was not seen again until August 2022, when it was photographed. The tag and all hardware had been shed, leaving only two well-healed scars at the tag location. A Cuvier's beaked whale, ZcTag106, was satellite-tagged in August 2020. It was re-sighted several times during that field season and was seen again in July 2021 and October 2022. Photographs show that the tag was shed by 2021, leaving well-healed scars that diminished over the year, based on photographs from 2022. ZcTag115 was satellite-tagged in July 2021; it was re-sighted several months later, in September 2021, and the tag had already been shed, leaving several small scars. This is the first documentation of a functioning satellite tag being shed within the deployment field season.

In 2022, four Cuvier's beaked whales were re-sighted for the first time since they were satellite-tagged. As documented in previous years (Waples and Read 2022), *Ziphius* in the study population show various effects of satellite-tagging. ZcTag079 was satellite-tagged in 2018 and not re-sighted until August 2022; the photographs are of marginal quality, but it appears that a single piece of hardware remains in the dorsal fin. ZcTag114 and ZcTag122 were tagged in July and August 2021, respectively, and were re-sighted in June and August 2022, respectively; both whales had shed their tags and all hardware, and had only well-healed scars remaining. Finally, ZcTag121 was tagged in July 2021 and was re-sighted several more times during the 2021 field season, then was re-sighted again in June 2022; the satellite tag was still in the dorsal fin, although the tag was no longer transmitting.

For more information regarding this study, refer to the annual progress report for this project (Waples and Reed 2023).

2.1.1.2 Jacksonville Vessel Surveys

The JAX OPAREA was one of the original study sites in the early years of the monitoring program focused on establishing baseline occurrence from 2009 through 2017 (Foley et al. 2019). More recently, vessel-based visual surveys were conducted in May and December 2022 to assist with the implementation of the Marine Mammal Monitoring on Navy Ranges (M3R) passive acoustic system in conjunction with the Naval Undersea Warfare Center, Division Newport (see **Section 2.1.2.4**). Vessel-based monitoring activities on the Jacksonville Shallow Water Training Range (JSWTR) supported the M3R system by validating species detections made by the hydrophone array, as well as conducting photo-ID and biopsy sampling, at the JAX study area in 2022.

Surveys were conducted on both the Research Vessel (R/V) *Richard T. Barber* (in May) and the R/V *Shearwater* (in December) **(Table 11** and **Figure 9)**. Vessel surveys were conducted for 6 days within the JAX study area and 1 day during transits from and to Beaufort, North Carolina, in 2022, totaling 478 kilometers (km), or 78.25 hours, of survey effort (**Table 11**). These surveys were conducted in Beaufort sea states 1 to 6 and covered the JSWTR site (**Figure 9** and **Figure 10**), as well as shelf and pelagic waters between Florida and North Carolina during transit.

Table 11. Vessel survey effort within the Jacksonville study area in 2022.

Date	Beaufort Sea State	Distance Surveyed (km)	Survey Time (hours:minutes)	At-Sea Time (hours:minutes)
14-May-22	1–2	69.0	6:31	10:58
15-May-22	2	54.7	6:22	12:00
16-May-22	4	25.0	3:13	7:54
18-May-22	3	74.0	6:29	11:11
12-December-22	3–4	101.1	9:15	24:00
13-December-22	4–5	82.0	9:44	24:00
14-December-22	4–5	72.2	9:35	24:00

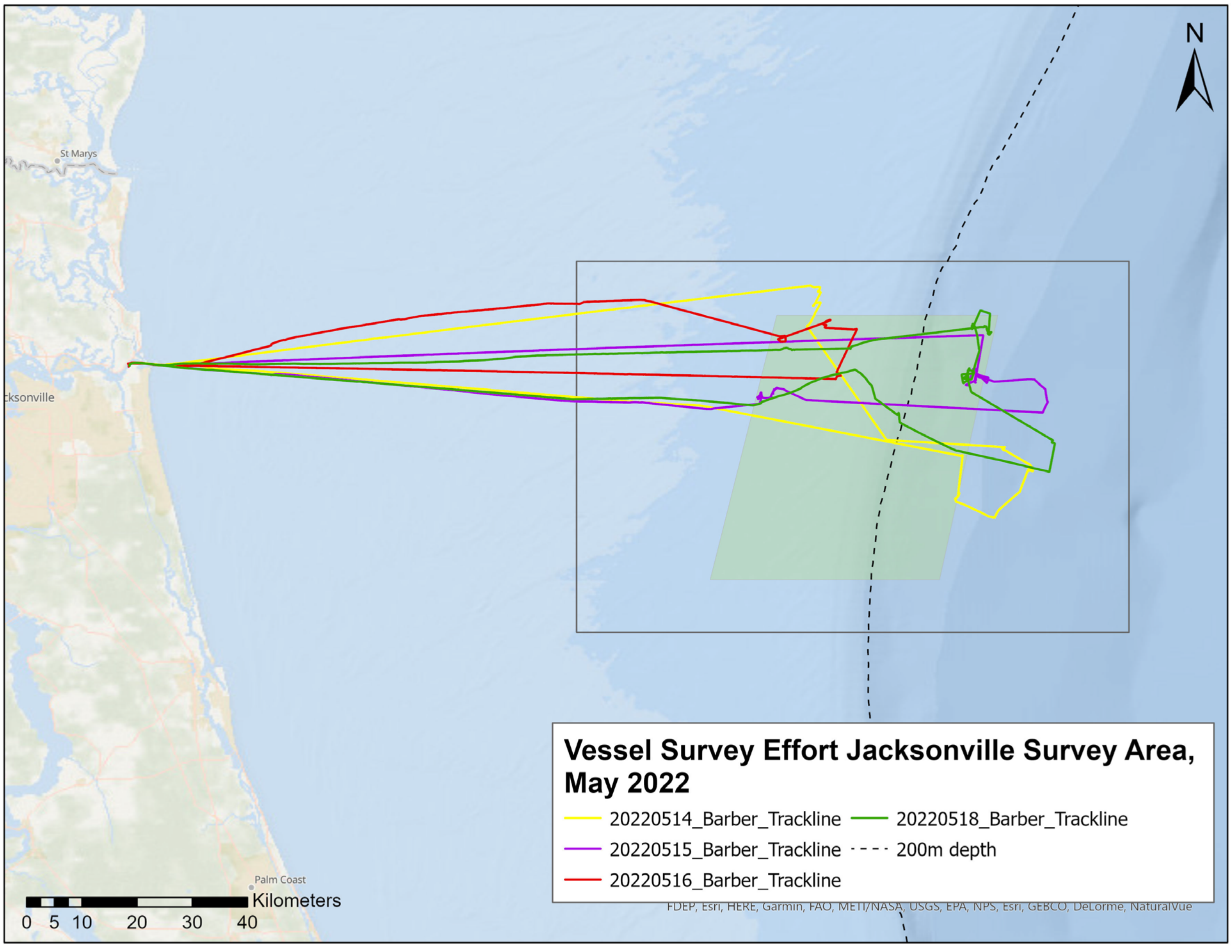


Figure 9. Vessel survey effort for May 2022 in the JAX OPAREA. The gray rectangle is the JAX study area, and the green shaded parallelogram encompasses the JSWTR.

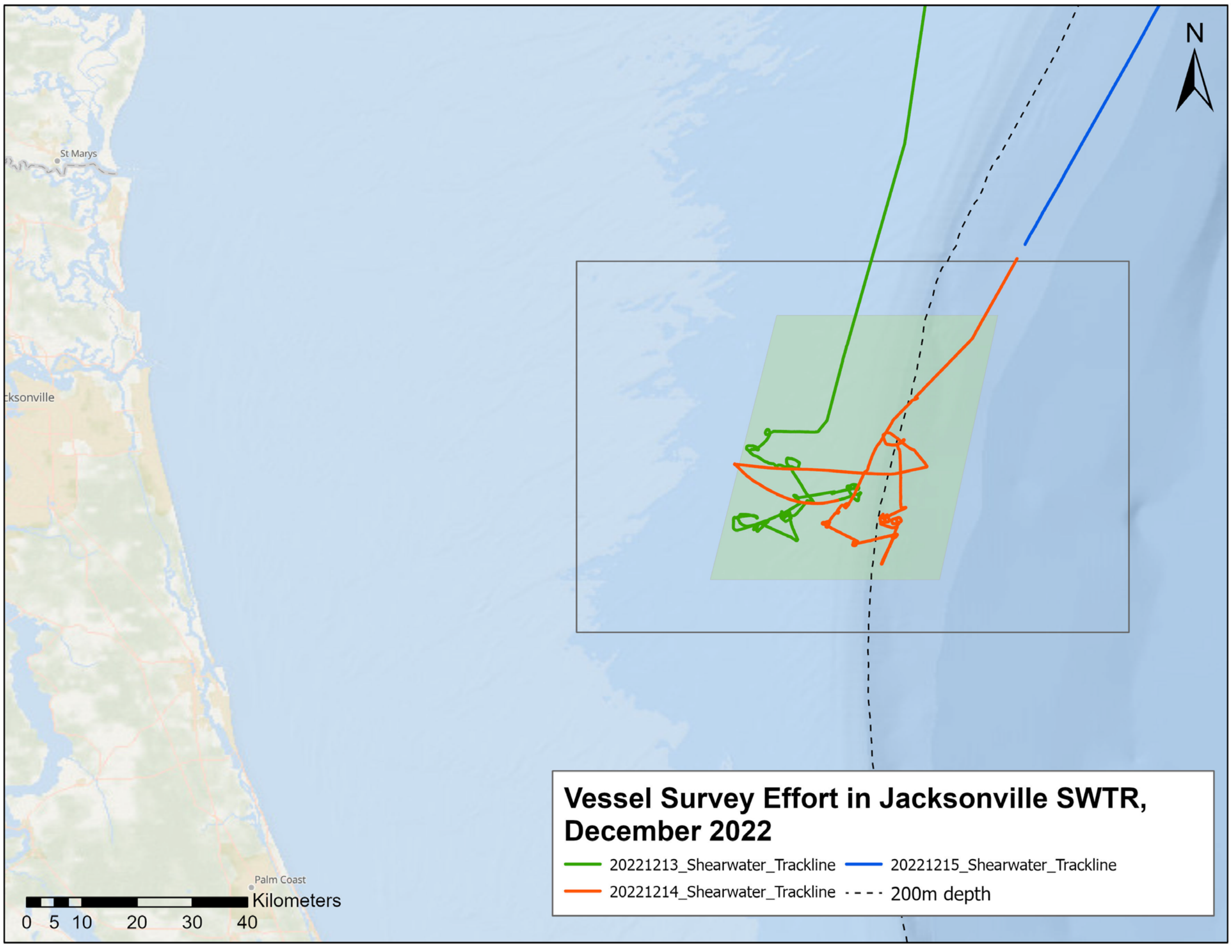


Figure 10. Vessel survey effort for December 2022 in the JAX OPAREA. The gray rectangle is the JAX study area, and the green shaded parallelogram encompasses the JSWTR.

Thirty-four cetacean sightings were recorded, and most (85.3 percent) comprised two species: Atlantic spotted dolphins (n = 8) and common bottlenose dolphins (n = 21). One sighting occurred of a dolphin group that was not identified to species. Seven sightings of seven loggerhead sea turtles (*Caretta caretta*) were observed. Consistent with observations in previous years, Atlantic spotted dolphins were restricted to shallow shelf waters, while common bottlenose were found both on the shelf and offshore of the continental shelf break (**Figure 11**).

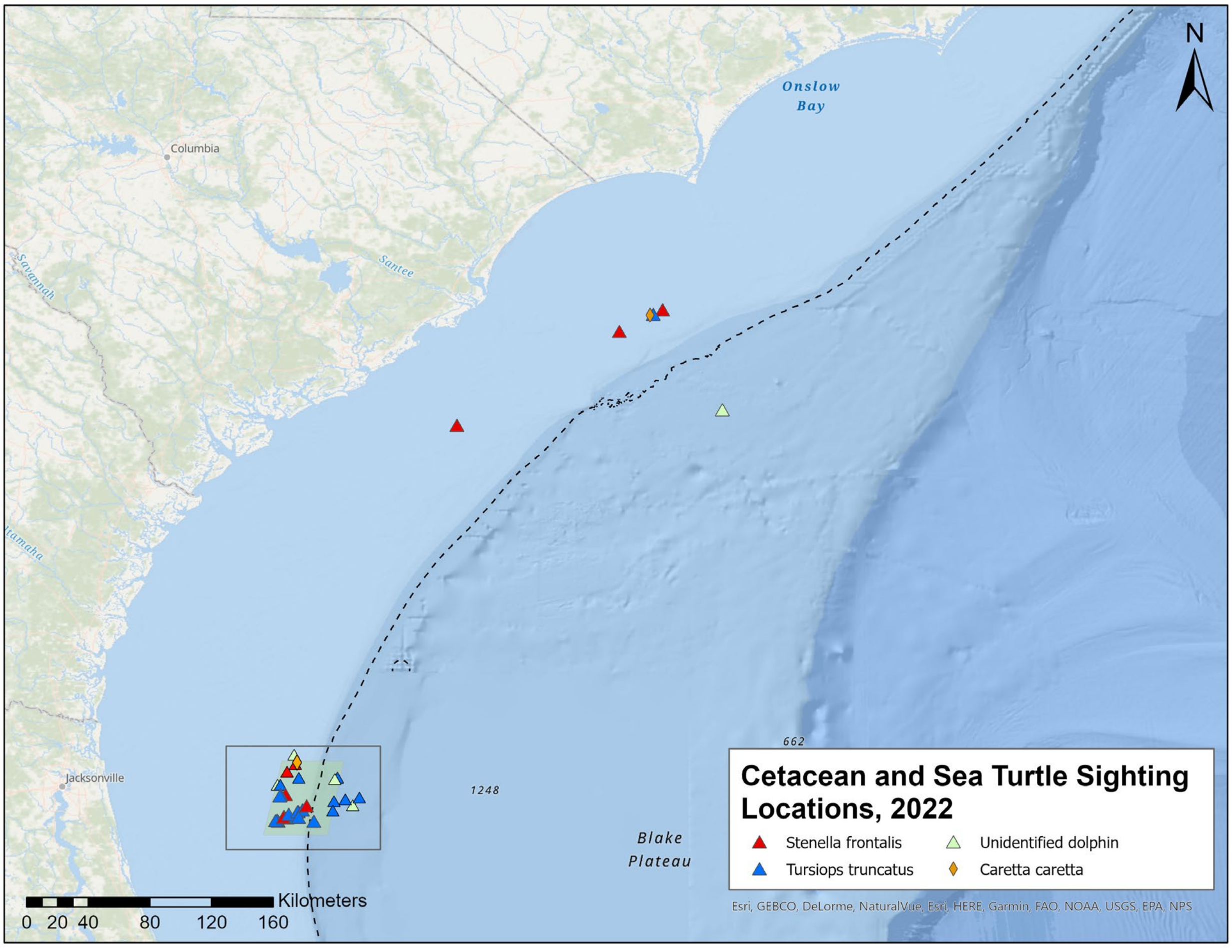


Figure 11. Distribution of cetacean and sea turtle sightings recorded in 2022. The gray rectangle is the JAX study area, and the green shaded parallelogram encompasses the JSWTR.

Satellite tagging was attempted in collaboration with Jessica Aschettino from HDR Inc., but the study team did not encounter any target species during this trip. Five biopsy samples were collected from bottlenose dolphins in the JAX survey area (**Figure 12**). Voucher specimens of these samples are archived at the Duke University Marine Laboratory in Beaufort, North Carolina. Researchers investigated genetic variation between the coastal and pelagic ecotypes of bottlenose dolphins that occupy distinct habitats and engage in different patterns of diving behavior.

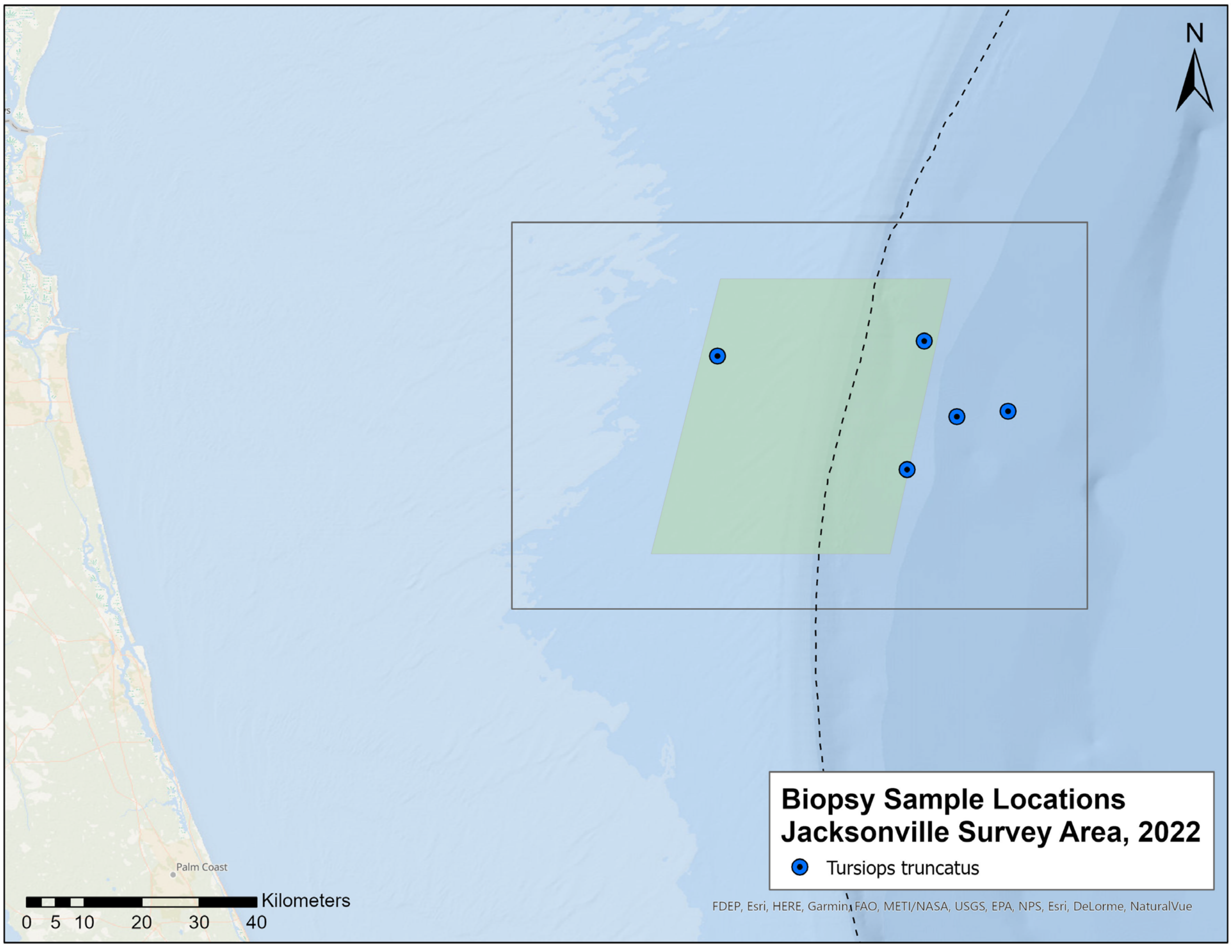


Figure 12. Locations of biopsy samples collected within the JAX study area in 2022.

To improve understanding of population structures in and between these groups, genome-wide genetic variation was investigated using restriction site-associated DNA sequencing. Whole-genome resequencing (approximately 10x coverage) was performed on four individuals from each of the three populations (inshore, coastal, and offshore), significantly increasing genetic resolution at the gene level. Analysis of Next Generation Sequencing Data was used to calculate nucleotide diversity (π) for sliding windows of 5 kilobase at 1 kilobase intervals, providing a genome-wide view of genetic diversity at an incredibly high resolution. First, the study team determined if offshore populations are the most genetically diverse. Second, the team scanned the genome for regions where inshore populations contained more variation than offshore populations, indicating potential targets of positive selection. Lastly, the team visualized nucleotide diversity in windows around candidate genes from the genome-wide scan for outlier genes related to hypoxia. Nucleotide diversity was highest in offshore populations and lowest in inshore populations. Windows of high nucleotide diversity exist across all three populations, but the highest distribution and lowest density are found offshore.

For additional details and information on this study, please refer to the annual progress report for this project (Alvarez et al. 2023).

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

Harbor seals (*Phoca vitulina*) and gray seals (*Halichoerus grypus atlantica*) are year-round coastal inhabitants in eastern Canada and New England and occur seasonally in the mid-Atlantic U.S. between September and May (Hayes et al. 2022). Until 2018, NMFS Stock Assessment Reports (SARs) indicated that the gray and harbor seal populations range from Labrador to New Jersey, with scattered sightings and strandings reported as far south as North Carolina for gray seals and Florida for harbor seals (Hayes et al. 2018). Other researchers have reported that harbor and gray seal distributions along the U.S. Atlantic coast appear to be expanding or shifting (den Heyer et al. 2021; DiGiovianni et al. 2011, 2018; Johnston et al. 2015). The range expansion of harbor seals may be due to rapid growth of gray seal populations in Canada and the northeastern U.S., which could be causing the displacement of harbor seals at haul-out sites due to physical interference or competitive exclusion (Cammen et al. 2018; Pace et al. 2019; Wood et al. 2019). Within the last decade, harbor seals have been observed returning seasonally, from fall to spring, to haul-out locations in coastal Virginia, and gray seals are occasionally observed during the winter, but not on a consistent basis (Ampela et al. 2023; Jones and Rees 2022). More recent stock assessments now indicate the southern extent for the harbor seal population range is North Carolina. However, the geographic range for the gray seal population remains the same (Hayes et al. 2022).

In 2014, the U.S. Navy initiated a study to investigate seal presence at select haul-out locations within the lower Chesapeake Bay and coastal waters of Virginia, which are important areas to U.S. Navy training and testing activities. Haul-out counts and photo-ID methods are being used to acquire a better understanding of the seals' seasonal occurrence, habitat use, and haul-out patterns within this area. This study continues to provide valuable baseline information for the future assessment of seal movement, site fidelity, and abundance within the mid-Atlantic region.

For the 2021/2022 field season, systematic vessel-based counts of all seal species were conducted at two different survey areas (**Figure 13**): 1) within lower Chesapeake Bay along the Chesapeake Bay Bridge-Tunnel (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 composed of five main haul-out locations. Haul-out surveys started in November and ended in May to ensure the documentation of seal arrival and departure for the 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). An unmanned aircraft system (i.e., drone) was also used at the Eastern Shore survey area to help improve count data collected during vessel-based point counts. 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. An experimental approach for estimating abundance was also attempted using seal count data for the 2016–2022 field seasons from the CBBT and Eastern Shore survey areas as well as satellite telemetry data on harbor seal activity in Virginia waters (Ampela et al. 2023). For the abundance estimates, a total mean seal count for the study area was produced for each season and combined with a telemetry correction factor that was based on the mean proportion of time that tagged seals spent ashore (Huber et al. 2001; Thompson et al. 1997).

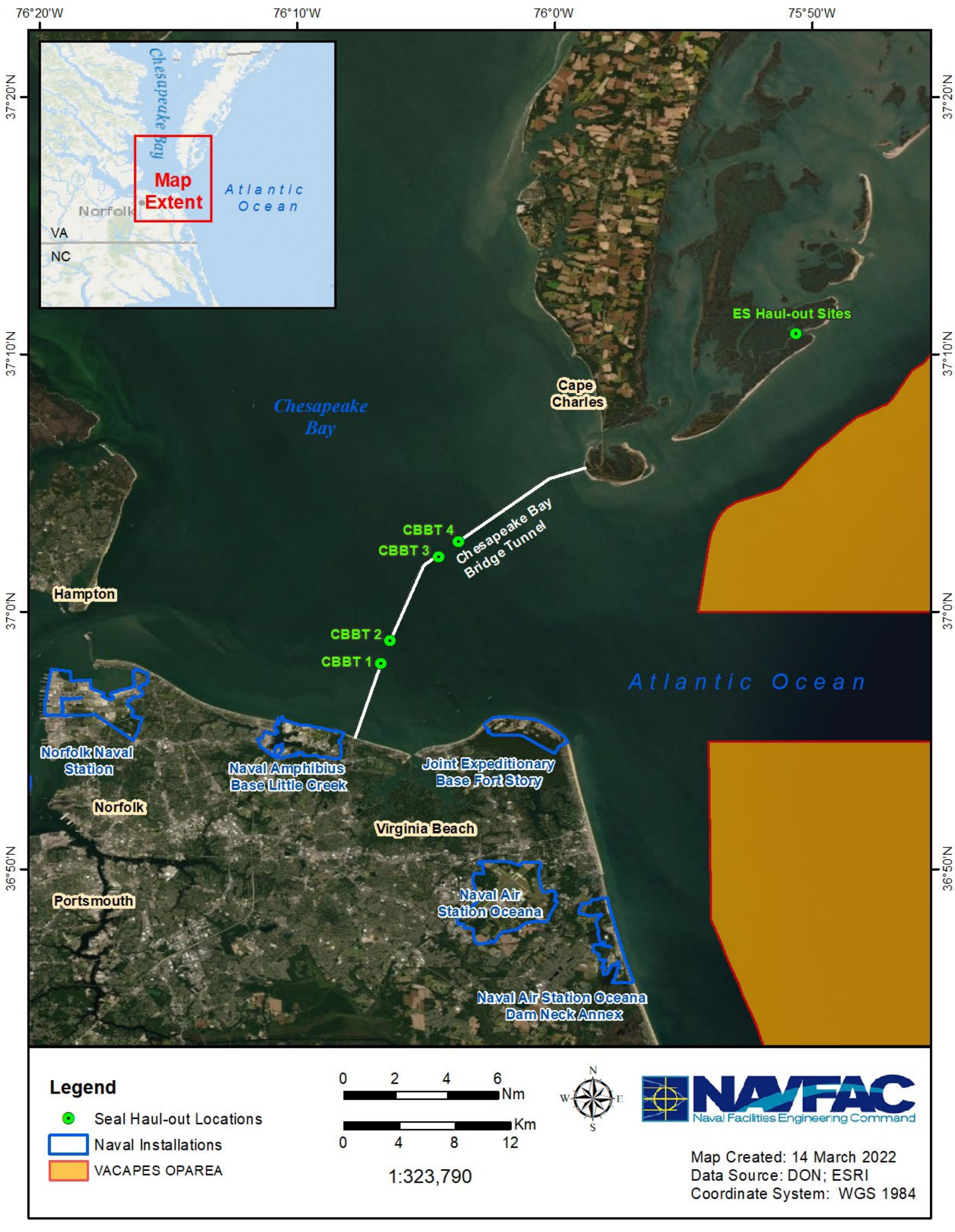


Figure 13. Chesapeake Bay Bridge Tunnel (CBBT) and Eastern Shore (ES) haul-out locations and their proximity to U.S. Naval installations.

Haul-out Count Results

For the 2021/2022 field season at the CBBT survey area, 12 survey days were completed between 2 November 2021 and 25 April 2022. Overall, 98 seals in total (combined in-water and hauled-out) were sighted across the four CBBT haul-out locations, with more seals observed at CBBT 3 (n = 44) and CBBT 4 (n = 50). Seals were observed on 10 of the 12 (83.3 percent) survey days. The total daily number of seals counted per survey day ranged from 0 to 25 seals, with the highest count recorded in March. For the Eastern Shore survey area, 13 survey days were completed between 2 November 2021 and 6 May 2022. Seals were observed on 9 of the 13 (69.2 percent) survey days, with a total of 143 seal sightings recorded for the season. The total daily number of seals counted ranged from 0 to 45 individuals per survey day, with the highest counts recorded in January and February. Seals were observed hauled out at two of the five main haul-out sites.

As of the end of the 2021/2022 field season, 122 survey days have been conducted across eight field seasons (2014–2022) at the CBBT survey area. Seals have been consistently recorded from mid-November to April. For the Eastern Shore survey area, 71 survey days have been conducted across six field seasons (2016–2022), and seals have been recorded from early November to early April. The majority of seals observed at both survey areas were harbor seals. Gray seals have been occasionally sighted during the winter at both survey areas, although not on a consistent annual basis. For the CBBT, gray seal sightings were recorded for the 2014/2015 (n = 1), 2015/2016 (n = 2), and 2020/2021 (n = 1) field seasons. For the Eastern Shore, gray seal sightings were recorded for the 2017/2018 (n = 1), 2018/2019 (n = 2), 2019/2020 (n = 1), and 2020/2021 (n = 4) field seasons; one gray seal was sighted off effort during the 2021/2022 season.

Since the start of the study in 2014, a fluctuation in seal presence has been observed for the CBBT survey area, with an increasing trend in average and maximum seal count from 2014 to 2018, followed by a decrease from 2018 to 2020 (**Table 12**). For the 2020/2021 season, seal presence appeared to rebound, with an increase in average seal count as well as maximum seal count for a single survey day. A slight decrease in these summary statistics were observed for the 2021/2022 season. A similar fluctuation in seal presence was observed for the Eastern Shore survey area, with an increase in average and maximum seal count from 2016 to 2018 and again for the 2019 to 2022 field seasons (**Table 13**). Some of the lowest total, maximum, and average seal counts for the CBBT and Eastern Shore survey areas were reported for the 2018 to 2020 seasons as well as the 2021/2022 season. Additionally, a statistically significant difference (F_{stat} = 2.75, p = 0.012) was observed between the average seal counts across the eight field seasons (2014 to 2022) for the CBBT survey area. The drop in maximum and average seal count for the 2018 to 2020 seasons as well as the 2021/2022 season for the Eastern Shore survey area was not as substantial compared to the CBBT for these seasons, and the difference between average seal counts across six field seasons (2016 to 2022) was not statistically different (F_{stat} = 0.43, p = 0.82).

Table 12. Seasonal survey effort (number of survey days), 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 (days)	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
2019–2020	6	29	5	9
2020–2021	11	137	12	32
2021–2022	10	98	10	25

Table 13. Seasonal survey effort (number of survey days), 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 (days)	Seal Counts		
		Total	Average	Maximum
2016–2017	7	105	15	24
2017–2018	8	197	25	69
2018–2019	11	160	15	66
2019–2020	9	157	17	39
2020–2021	12	219	18	44
2021–2022	9	143	16	45

Photo-Identification and Abundance Estimation Results: CBBT and Eastern Shore Combined

For the 2021/2022 field season, 45 harbor seals were uniquely identified: 15 (33 percent) were new individuals to the catalog, and 30 (67 percent) were re-sightings of individuals that were identified from previous field seasons (**Figure 14**). After reviewing all images from the 2015 to 2022 seasons, 170 harbor seals and 1 gray seal were uniquely identified. Of the 170 harbor seals, 88 (52 percent) were observed only once, and 82 (48 percent) were determined to be present within the study area on more than one occasion across the seven field seasons, indicating at least some degree of seasonal site fidelity within lower Chesapeake Bay and coastal Virginia waters. More than half of the identified harbor seals (56 percent) have been sighted at only the CBBT survey area, with a smaller percentage (35 percent) sighted at only the Eastern Shore survey area. Sixteen harbor seals were re-sighted at both survey areas on separate survey days within and across seasons. These results indicate that harbor seals make localized movements throughout the region during their seasonal occupancy and that while some seals may be using a particular haul-out site within a given season, others may use multiple haul-out sites within a season.

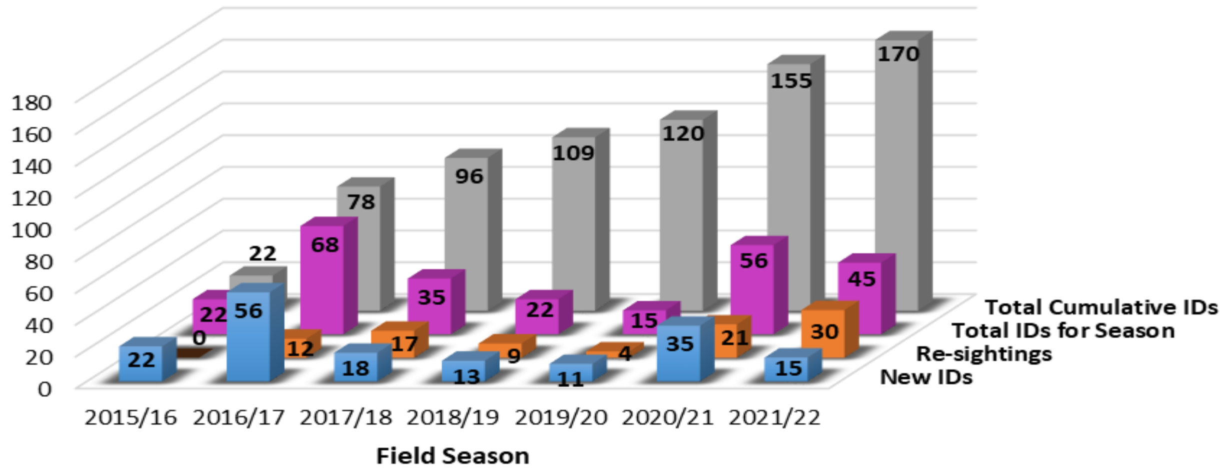


Figure 14. Harbor seal identifications over seven field seasons (2015–2022). The purple bars indicate the total number of IDs for a season, orange bars indicate the number of re-sightings (i.e., those IDs that were seen in previous seasons), blue bars indicate the number of new IDs added to the catalog, and gray bars indicate the total number of cumulative unique IDs.

A population abundance for harbor seals was estimated for the study area using mark-recapture data and the Lincoln-Peterson model. The estimated average abundance across all seven seasons (2015–2022) was 198 individuals. Abundance estimates were also calculated for each field season from 2015 to 2022 using the mark-recapture data, as well as from 2016 to 2022 using a telemetry correction factor approach that incorporated seal count and satellite telemetry data (Ampela et al. 2023; Huber et al. 2001; Thompson et al. 1997). Abundance estimates produced from the mark-recapture data ranged from 81 (95 percent confidence interval [CI]: 44.14–117.19) to 242 (95 percent CI: 91.35–392.65) individual harbor seals (**Figure 15**). The estimates calculated using the telemetry correction factor were slightly higher in comparison for most seasons and ranged from 124 (95 percent CI: 0-270.66) to 252 (95 percent CI: 84.46-420.34) individual harbor seals (**Figure 15**). The margin of error was larger for the abundance estimates produced using the telemetry correction factor approach; potentially due to small sample sizes for both count and telemetry data for this type of calculation. A fluctuation in abundance estimates occurred across seasons for both approaches and regression analysis results indicate there is not a statistically significant trend in population abundance. Therefore, there is reason to believe that the population of animals using the lower Chesapeake Bay and Eastern Shore may be relatively stable.

Haul-out counts and photo-ID data collection have continued for the 2022/2023 field season at both the CBBT and Eastern Shore survey areas. For more information on the Virginia seal haul-out count visual surveys, please see the annual progress report (Jones and Rees 2023), and visit the project profile page.

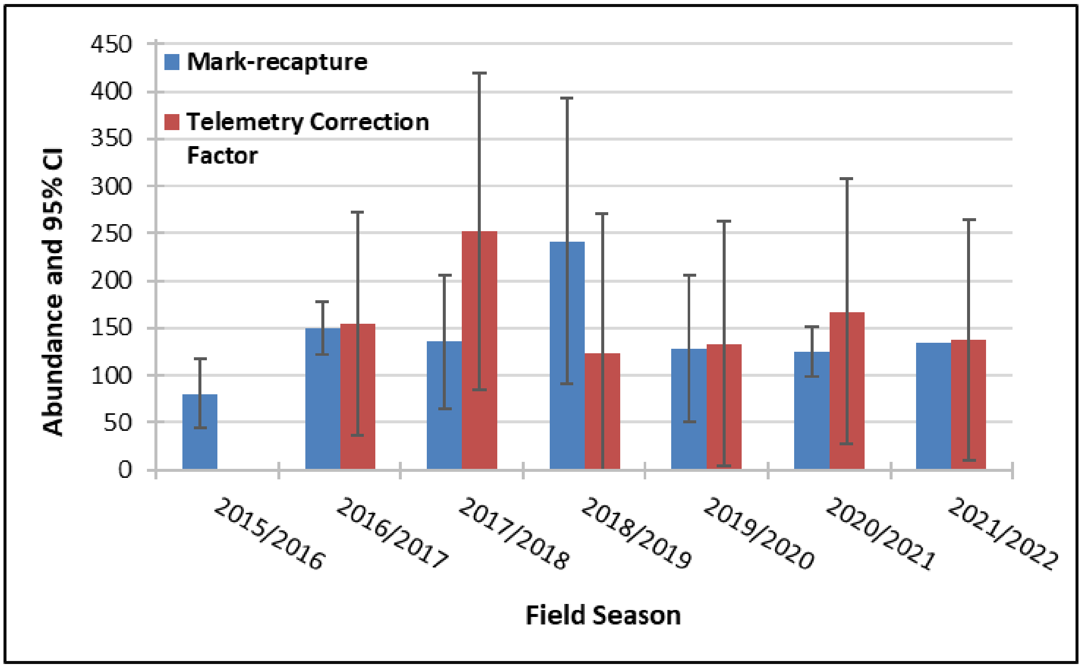


Figure 15. Total abundance estimates and 95 percent confidence intervals (CIs) for the combined CBBT and Eastern Shore survey areas, calculated from the mark-recapture and telemetry correction factor approaches for the 2015–2022 field seasons. There is no 2015/2016 estimate for the telemetry correction factor approach because surveys at the Eastern Shore did not start until the 2016/2017 season.

Time-lapse Camera Monitoring

The visual survey haul-out counts discussed above are currently limited by resources and study design to twice per month, and survey scheduling is dependent on weather, available daylight hours, and marine conditions. These limitations have resulted in a paucity of information during certain times of the day (e.g., sunrise/sunset) and in adverse weather conditions (e.g., rain, high winds, sea states greater than Beaufort 3). Trail cameras are cost effective tools for collecting large amounts of data in a way that limits or eliminates impacts to the animals as compared to traditional visual surveys (Wearn and Glover-Kapfer 2019; Koivuniemi et al. 2016) and are especially effective for monitoring wildlife in remote locations. With the use of trail cameras, it is possible to simultaneously sample multiple haul-out areas for extended periods of time, with relatively low personnel demands and limited disturbance to the seals.

Camera trap surveys consist of one or multiple cameras that are set to capture animals in or moving through an area. Camera traps can either be set to take a photograph when motion is detected, or to operate in a time-lapse mode to take photographs at a set time interval. For this project, cameras were placed at multiple locations covering most of the known haul-out sites at two survey areas in southeastern Virginia and were operated in time-lapse mode.

Objectives for this study are 1) to improve the understanding of local and seasonal haul-out patterns, and the numbers of seals hauled out during daylight hours; 2) to investigate any haul-out patterns in relation to environmental factors; and 3) to investigate differences between vessel-based surveys and time-lapse camera data collection. The data and results from this effort will further improve the assessment of potential impacts from the Navy including training and testing activities, installation construction (e.g., pile driving), and vessel-transiting as required under the Marine Mammal Protection Act and National Environmental Policy Act for Commander, U.S. Fleet Forces Command (USFF) and Commander, Navy Installations Command in the region. These data may also provide important baseline information for the assessment of potential future impacts from climate change or other anthropogenic activities.

To date, the study team has completed three seasons (2019/2020, 2020/2021, and 2021/2022), with a fourth (2022/2023) in progress. Three different trail camera models were used in this study. Model selection was site specific and based on the need for wireless capability and camera network linking (for remote sites), or image quality (for sites where cameras had to be placed at a distance from the haul-out site). The ability to link to a wireless network in order to send photographs remotely, and the ability to link cameras to a single wireless account was important for the ES survey area, given the remoteness of the area and close proximity of the haul-out sites to one another. At the CBBT survey area, high image quality was critical in order to capture seals at greater distances from the camera installation locations to the haul-out sites (approximately 100-130 m or 328-427 ft).

During 2019/2020 the cameras were installed from November through April at the Eastern Shore survey area and January through April at the CBBT survey area. In 2020/2021 and 2021/2022, the duration of camera deployment at both locations was extended to October through May. Cameras were placed at the two highest-use areas at the CBBT and at all known haul-out locations at the Eastern Shore. Images were recorded in time-lapse mode, at a frequency of every 15 minutes, during daylight hours only; however, they were not synced to take images simultaneously.

Images were reviewed for the presence of seals in the water or hauled out, and vessels. While images from the camera surveys are not of high enough quality to identify seals to species in most cases, the vessel surveys can be relied upon to provide the frequency of harbor versus gray seals visiting the survey areas. In addition to the presence of seals hauled out and in the water, images were reviewed for the presence of vessels. The Timelapse Image Analysis system and the Timelapse2 program (Greenberg 2021a, 2021b), was used to count, mark and record the number of seals or vessels. (**Figure 16**). Timelapse2 includes built in features that simplify the visual examination, encoding, and recording the data from each image, including custom data recording template set-up, automatic extraction of image data (e.g., file name, date, and time taken), persistent seal marking, automatic counting of marks as identified by the user developed template, automated batch time correction, and image review tools (e.g. magnifier, play forward and reverse, pan/zoom tools, and image enhancement) (Greenberg 2021b).

The total number of camera recording days (total days minus camera failure days), total images captured, the date the first and last seals were seen (seal occupancy season), seal haul-out count average (number of seals hauled out divided by the number of images with seals hauled out) and the sightings summaries for all three seasons season are shown in **Table 14** for the ES survey area and **Table 15** for the CBBT survey area. Seal haul-out count occurrences at the ES survey area totaled 48,784 during the 2019/2020 season, 54,066 during the 2020/2021 season, and 60,963 during the 2021/2022 season. At the CBBT survey area there were 5,690 seal haul-out count occurrences during the 2019/2020 season, 10,555 during the 2020/2021 season, and 14,144 during the 2021/2022 season.

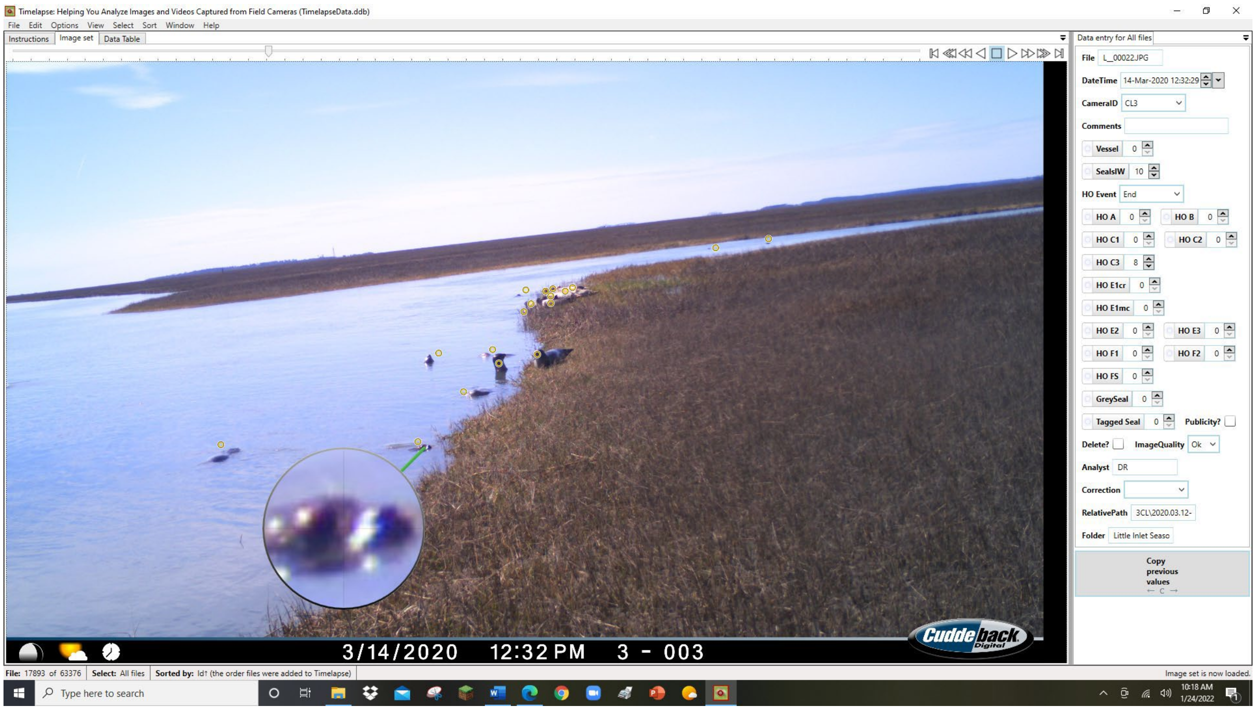


Figure 16. Screenshot of Timelapse Image Analysis workspace. Counted seals are marked by yellow circles, the magnifier feature is shown near the front of the image and the customizable data template at the right.

Table 14. Camera trap effort summary for the ES survey area during the occupancy season.

Season	Camera Recording Days	Images	First Seal Recorded	Last Seal Recorded	Haul-out Average	Days Seals Hauled-out	Percent of Days Hauled-out	Days Seals Present[a]	Percent of Days Present
2019/2020	169	59,679	4 Nov	20 Apr	9.78	135	75.8	149	83.7
2020/2021	208	75,120	30 Oct	25 May	7.65	164	76.9	189	88.2
2021/2022	193	69,125	15 Oct	28 Apr	10.21	143	67.7	173	81.9

[a] Seals present=seals hauled-out or in the water.

Table 15. Camera trap effort summary for the CBBT survey area during the occupancy season

Season	Camera Recording Days	Images	First Seal Recorded	Last Seal Recorded	Haul-out Average	Days Seals Hauled-out	Percent of Days Hauled-out	Days Seals Present[a]	Percent of Days Present
2019/2020[b]	112	11,309	8 Jan	28 Apr	3.88	63	55.8	92	81.4
2020/2021	187	22,053	30 Oct	22 May	5.08	80	37.9	139	65.9
2021/2022	153	19,278	20 Oct	1 May	6.82	94	46.1	146	71.6

[a] Seals present=seals hauled-out or in the water.

Seal count averages (number of seals hauled out and in the water divided by the number of images with seals) by season and month for the ES survey area are shown in (**Figure 17**) and for the CBBT survey area in (**Figure 18**).

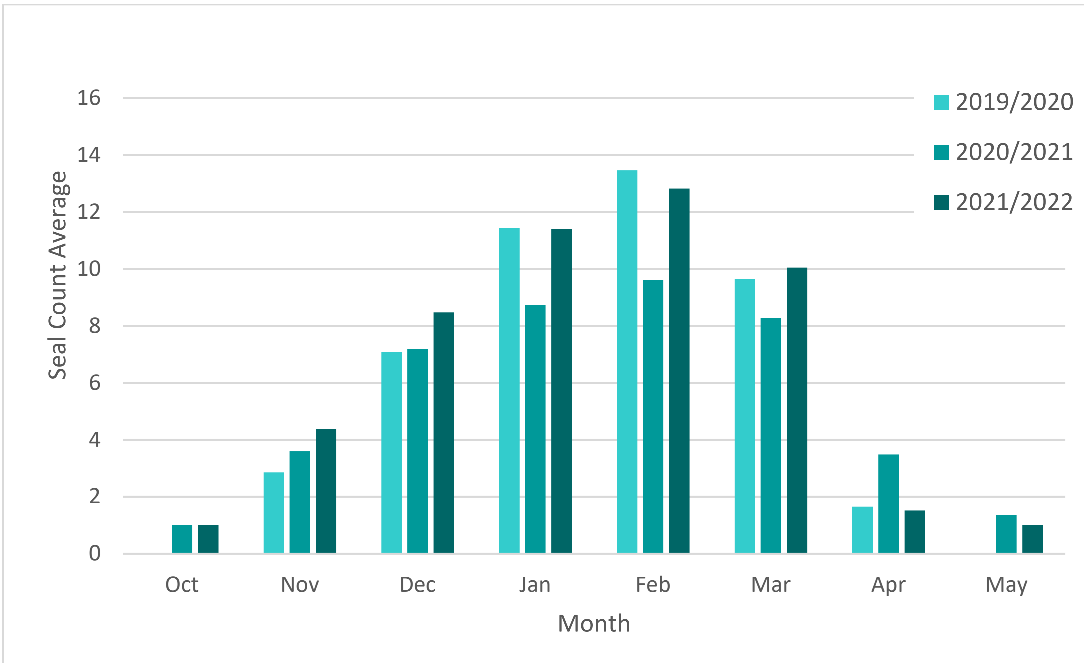


Figure 17. Average seals counted by month at the ES survey area.

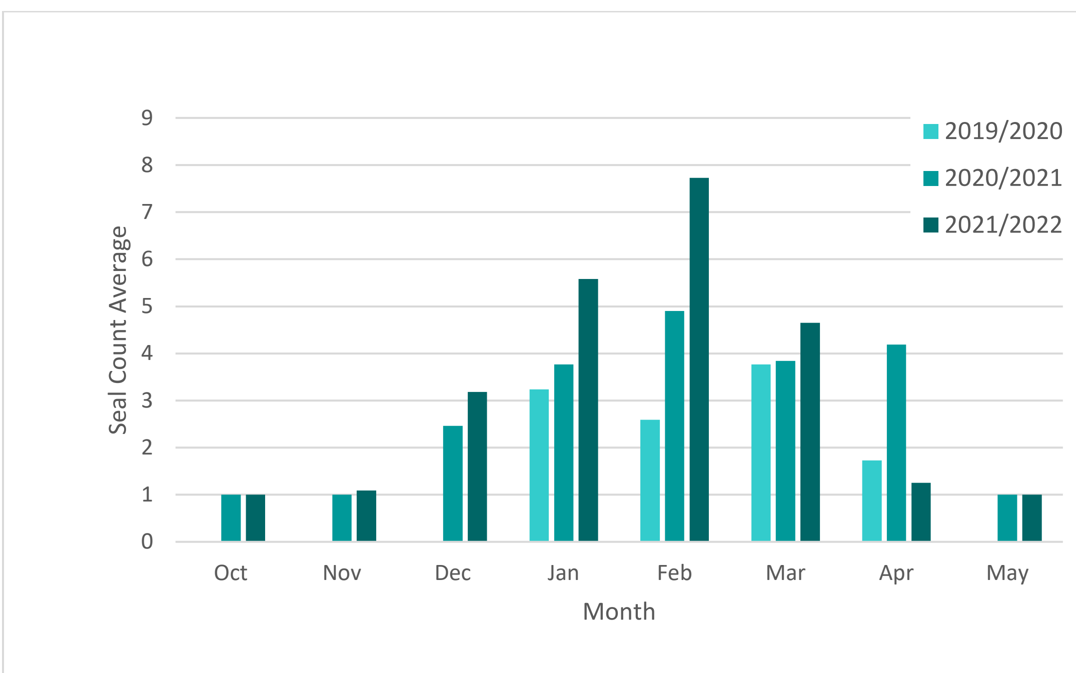


Figure 18. Average seals counted by month at the CBBT survey area.

A comparison of environmental factors to hauled out seals was completed for the 2019/2020, 2020/2021, and the 2021/2022 seasons and is available in Guins et al. (2023).

A comparison of counts from cameras to vessel surveys was completed for the 2019/2020, 2020/2021, and the 2021/2022 seasons to determine if the counts yielded similar results and if camera counts could be a useful proxy for vessel counts in the future, given the high cost, weather dependency, labor intensity, and the seal disturbance potential of vessel counts. Several differences were identified including observation duration (continuous for vessel surveys), impact to behavior (seals often flush into the water in response to approaching vessels), and better ability to observe obscured animals and behavior from vessel surveys.

A comparison of counts to vessel presence as a potential factor of disturbance was completed for the 2019/2020, 2020/2021, and the 2021/2022 seasons. During the 2019/2020 season vessels were captured in 0.7 percent of all images taken at the ES survey area (444 images) and 19.40 percent of all images taken at the CBBT survey area (1,104 images). Vessels were photographed on 49 out of 178 of the survey days at the Eastern Shore, and 54 out of 113 of the survey days at the CBBT survey area. Most of the vessels recorded at the Eastern Shore survey area were from research efforts. During the 2020/2021 season, vessels were captured in 0.35 percent of all images taken at the ES survey area (267 images) and 10.93 percent of all images taken at the CBBT survey area (2,424 images). Vessels were photographed on 72 out of 212 of the survey days at the Eastern Shore survey area. Vessels were photographed on 112 out of 211 of the survey days at the CBBT survey area. During the 2021/2022 season, vessels were captured in 0.65 percent of all images taken at the Eastern Shore survey area (501 images) and 10.2 percent of all images taken at the CBBT survey area (2014 images). Vessels were photographed on 78 out of 211 of the survey days at the Eastern Shore survey area. Vessels were photographed on 112 out of 204 of the survey days at the CBBT survey area.

For more information on the Virginia seal camera survey work, including details of analyses conducted, please see the annual progress report (Guins et al. 2023), or visit the project profile page.

2.1.1.4 Mid-Atlantic Humpback Whale Catalog

Humpback whales (*Megaptera novaeangliae*) 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. The Mid-Atlantic Humpback Whale Photo-ID Catalog (MAHWC) is a collaborative, integrative platform that provides a broad-scale and high-quality tool that can be used 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. This project contributes to the overall community effort to help monitor the West Indies Distinct Population Segment (DPS) and complements existing U.S. Navy MSM efforts (Mid-Atlantic Humpback Whale Monitoring and Mid-Atlantic Continental Shelf Break Cetacean Study).

The overarching goal of this project is to facilitate exchange of information among researchers who have been involved in humpback whale photo-ID efforts over the last 40 years in the North Atlantic. These efforts can also serve to support assessment of human impacts (e.g., injuries from entanglement or watercraft), body condition, and behavior (e.g., foraging). Longitudinal mark-recapture data can also serve as a non-invasive mechanism to investigate and detect changes in patterns of humpback whale occurrence, inter-annual variation, and changes in distribution and phenology over time. Survey effort and opportunistic sightings of humpback whales in the mid-Atlantic and Southeastern U.S. have increased substantially in the past few years. To integrate data from a multitude of sources more effectively, both current and historical, a streamlined process for submissions, management, and access is necessary. Additionally, 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 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.

Developmental work in 2022 included updating key fields, and re-linking data and images to take advantage of automated uploading procedures that were developed for other catalogs on the OBIS-SEAMAP platform, as well as integrating an Application Programming Interface to assist with matching between the MAHWC and the large repository of online images available on HappyWhale, a global archive of sighting data that includes state-of-the-art image processing algorithms. Additionally, curator instructions and protocols required updating and testing.

The rollout of the final catalog is currently slated for summer 2023, and a stakeholder workshop will be held to introduce contributors to the new features and capabilities. Data from the catalog have also been included in a publication authored by Danielle Brown (Rutgers University) with several MAHWC collaborators as authors (Brown et al. 2022).

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. Additionally, the M3R 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 MSM and interactions with training and testing activities.

All current and past deployments of PAM devices—including High-frequency Acoustic Recording Packages (HARPs); Slocum G3 ocean gliders; Marine Autonomous Recording Units (MARUs); Autonomous Multichannel Acoustic Recorders; Ecological Acoustic Recorders; automated click detectors (CPODs); SoundTraps, and autonomous real-time acoustic detection buoys—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 conducted PAM using HARPs as part of the original multi-disciplinary monitoring effort for Onslow Bay from 2007 to 2013, expanding into the JAX OPAREA from 2009 to 2019, Cape Hatteras from 2012 to 2020, and Norfolk Canyon from 2014 to 2022 (**Figure 19**). The primary objective of all deployments was to determine species distributions and document spatiotemporal patterns of cetaceans across areas of interest.

The final single-channel HARP deployment was retrieved at the Norfolk Canyon site in May 2022 (Rafter et al. 2022). The HARP metadata explorer provides a filterable summary of all previous deployments as well as links to associated technical reports. Data from deployments has been contributed to a broad collaborative analysis of North Atlantic shelf break species (see **Section 2.1.2.2**) and results from analyses are incorporated into NOAA's Passive Acoustic Cetacean Mapper. For more information on the HARP program, refer to the primary literature publications using data from previous HARP deployments (Stanistreet et al. 2016; Davis et al. 2017; Hodge et al. 2018).

Deployment details for each site are shown in **Table 16** through **Table 18**. 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.

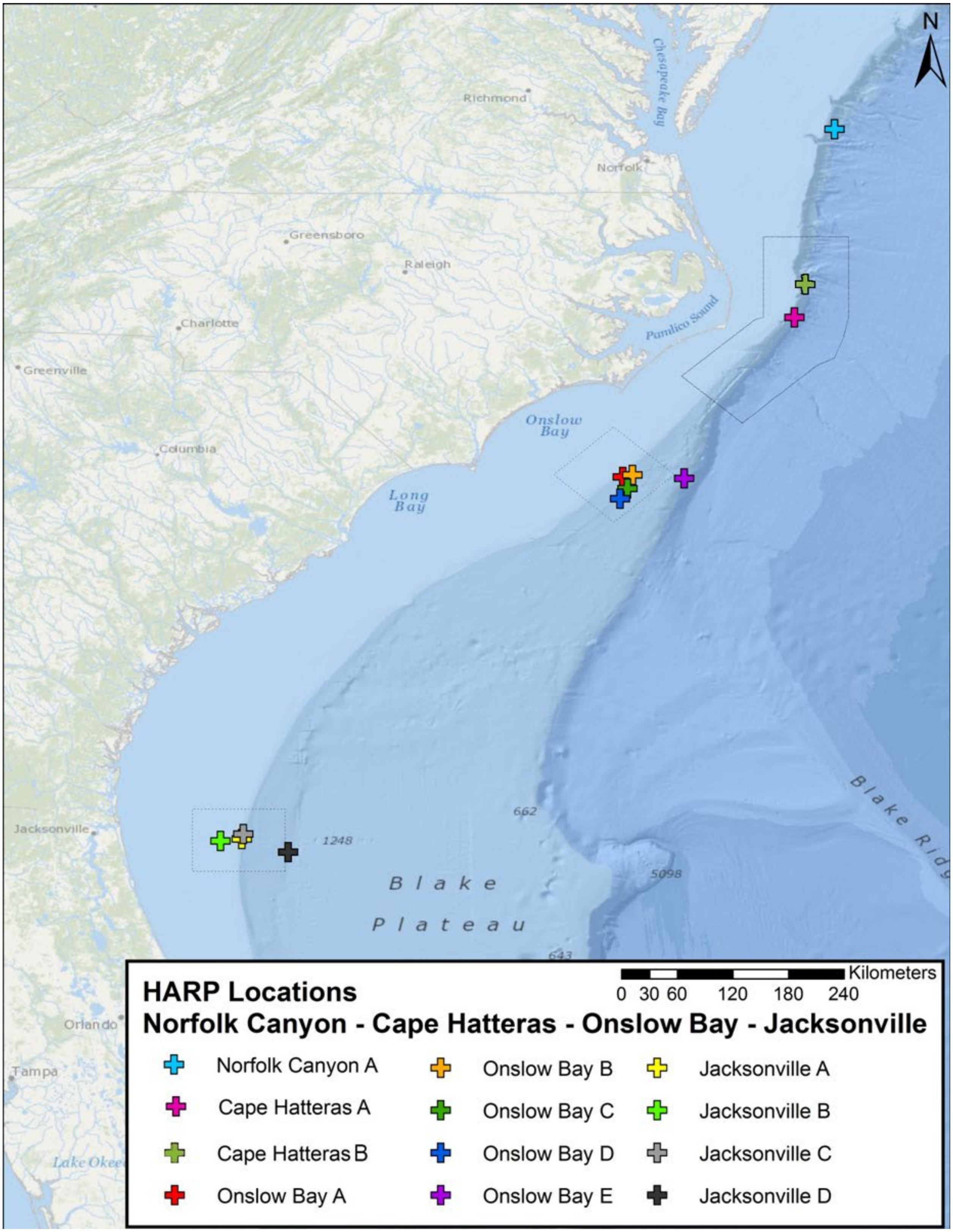


Figure 19. Location of HARP deployment sites within Norfolk Canyon, Cape Hatteras, Onslow Bay, and JAX study areas.

Table 16. All HARP deployments within JAX.

Site	Deployment Date	Retrieval Date	Recording Start Date	Recording End Date	Latitude (°N)	Longitude (°W)	Depth (m)	Sampling Rate (kHz)	Duty Cycle
11D	23-Aug-14	02-Jul-15	23-Aug-14	22-May-15	30.1506	79.7700	806	200	Continuous
12D	02-Jul-15	26-Apr-16	03-Jul-15	04-Nov-15	30.1489	79.7711	800	200	Continuous
13D	26-Apr-16	25-Jun-17	26-Apr-16	25-Jun-17	30.1518	79.7702	736	200	Continuous
14D	25-Jun-17	26-Jun-18	25-Jun-17	26-Jun-18	30.1527	79.7699	740	200	Continuous
15D	26-Jun-18	15-Jun-19	26-Jun-18	15-Jun-19	30.1522	79.7710	740	200	Continuous
16D	15-Jun-19	14-Jun-21	15-Jun-19	30-Jun-20	30.155	79.771	735	200	Continuous

Key: °N = degrees North; °W = degrees West; kHz = kilohertz; m = meter(s).

Table 17. All HARP deployments at the Norfolk Canyon site.

Site	Deployment Date	Retrieval Date	Recording Start Date	Recording End Date	Latitude (°N)	Longitude (°W)	Depth (m)	Sampling Rate (kHz)	Duty Cycle
01A	19-Jun-14	07-Apr-15	19-Jun-14	05-Apr-15	37.1662	74.4669	982	200	Continuous
02A	30-Apr-16	30-Jun-17	30-Apr-16	28-Jun-17	37.1652	74.4666	968	200	Continuous
03A	29-Jun-17	02-Jun-18	29-Jun-17	02-Jun-18	37.1674	74.4663	950	200	Continuous
04A	02-Jun-18	19-May-19	02-Jun-18	18-May-19	37.1645	74.4659	1,050	200	Continuous
05A	19-May-19	01-Mar-21	19-May-19	8-May-20	37.1645	74.4659	1,050	200	Continuous
06A	29-Jun-21	20-May-22	29-Jun-21	19-Sept-21	37.1645	74.4659	1,050	200	continuous

Key: °N = degrees North; °W = degrees West; kHz = kilohertz; m = meter(s).

Table 18. All HARP deployments at the Cape Hatteras site.

Site	Deployment Date	Retrieval Date	Recording Start Date	Recording End Date	Latitude (°N)	Longitude (°W)	Depth (m)	Sampling Rate (kHz)	Duty Cycle
02A	09-Oct-12	29-May-13	09-Oct-12	09-May-13	35.3406	74.8559	970	200	Continuous
03A	29-May-13	08-May-14	29-May-13	15-Mar-14	35.3444	74.8521	970	200	Continuous
04A	08-May-14	06-Apr-15	09-May-14	11-Dec-14	35.3467	74.8480	850	200	Continuous
05A	06-Apr-15	29-Apr-16	07-Apr-15	29-Jan-16	35.3421	74.8572	980	200	Continuous
06A	29-Apr-16	09-May-17	29-Apr-16	06-Feb-17	35.3057	74.8776	1,020	200	Continuous
HAT_B_01_01	09-May-17	25-Oct-17	09-May-17	25-Oct-17	35.5837	74.7492	1,118	200	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	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	Continuous
HAT_B_02_02_C4	28-Jun-17	Lost-at-sea	28-Jun-17	N/A	35.5793	74.7569	1,040	200	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	Continuous
HAT_B_03_01	25-Oct-17	01-Jun-18	25-Oct-17	01-Jun-18	35.5835	74.7431	1,117	200	Continuous
HAT_B_04_01	01-Jun-18	13-Dec-18	01-Jun-18	13-Dec-18	35.5897	74.7476	1,350	200	Continuous
HAT_B_04_02_C4	01-Jun-18	13-Dec-18	N/A	N/A	35.5851	74.7515	1,175	200	Continuous
HAT_B_04_03_C4	01-Jun-18	13-Dec-18	01-Jun-18	13-Dec-18	35.5905	74.7628	1,078	200	Continuous
HAT_B_05_01	13-Dec-18	18-May-19	14-Dec-18	18-May-19	35.5897	74.7476	1,350	200	Continuous
HAT_B_06_01	18-May19	24-Oct-19	18-May-19	24-Sep-19	35.5844	74.7479	1,120	200	Continuous
HAT_B_05_02_C4	17-May-19	24-Oct-19	17-May-19	N/A	35.5805	74.7455	1,217	200	Continuous
HAT_B_05_03_C4	17-May-19	24-Oct-19	17-May-19	N/A	35.5848	74.7415	1,227	200	Continuous
HAT_B_07_01	24-Oct-19	01-Mar-21	25-Oct-19	29-Oct-20	35.5826	74.7501	1,100	200	Continuous

Key: °N = degrees North; °W = degrees West; m = meter(s); kHz=kilohertz; N/A=not available.

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

More than 25 species of cetaceans use the shelf break regions of the U.S. eastern seaboard, including several endangered and acoustically sensitive species such as beaked whales. Understanding patterns in species distribution, and the anthropogenic and environmental drivers that may impact their distribution, are critical for appropriate management of marine habitats. To better understand patterns in species distribution and vocal activity, NOAA's Northeast Fisheries Science Center (NEFSC) and Scripps Institution of Oceanography collaboratively deployed long-term HARPs at eight sites along the western North Atlantic shelf break. This work was conducted from 2015 to 2019, with financial support from the Bureau of Ocean Energy Management. Similarly, the U.S. Navy has been acoustically monitoring the shelf break region with HARPs at three to four sites since 2007. Together these combined efforts bring the total to 11 recording sites spanning the U.S. eastern seaboard, from New England to Georgia.

Data from earlier HARP recorders have been analyzed in multiple previous studies (e.g., Davis et al. 2017; Stanistreet et al. 2017, 2018). This project focuses on analyses of more recent datasets collected from 2015 to 2019. The focus of the 2022 efforts were to finalize species occurrence analyses, including reclassifying beaked whale species using improved classification neural network algorithms, applying frameworks to assess impacts of sonar and seismic noise on the acoustic ecology and acoustic behavior of protected species, and developing ecological approaches for exploring species niche and co-occurrence across shelf break areas.

Work conducted in 2022 was aimed at advancing the analytical components for these key objectives:

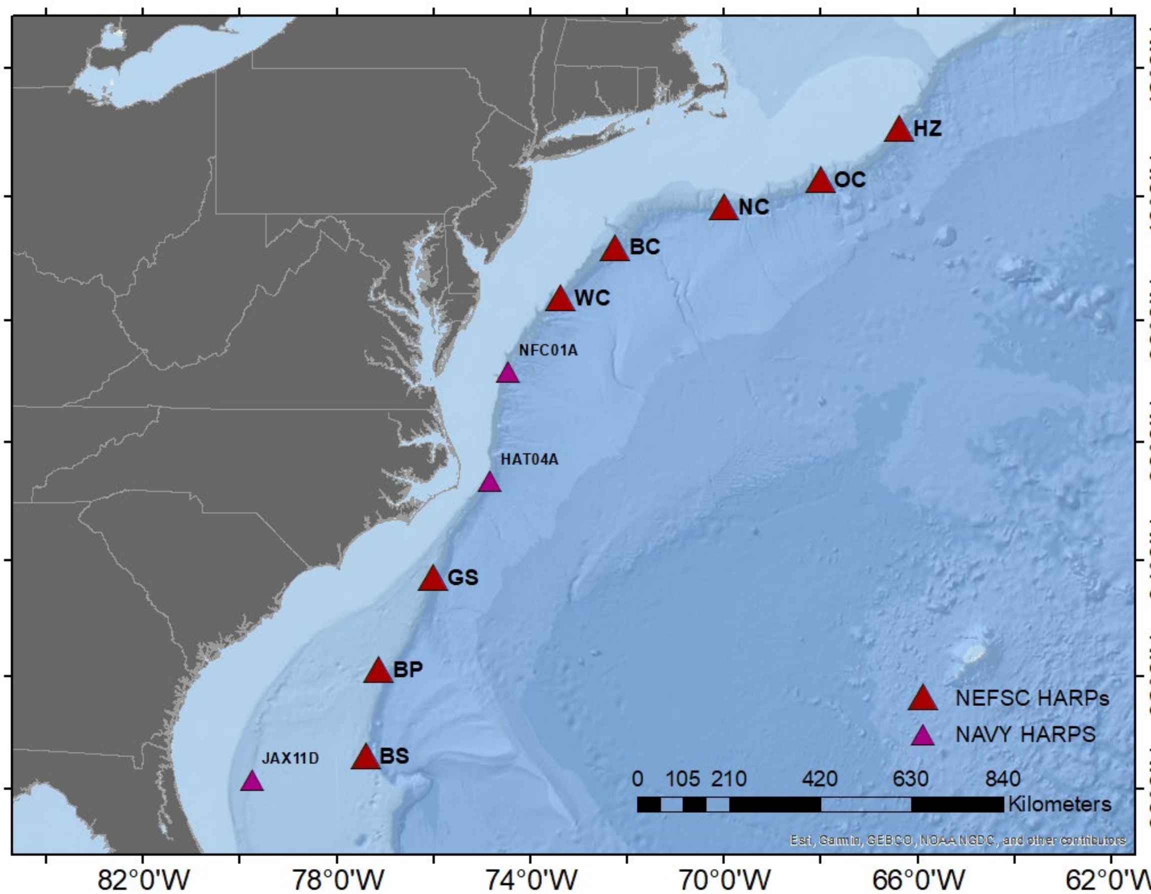
- Finalize and reapply the automated neural network classification for beaked whales
- Continue the analysis on the effects of anthropogenic noise on beaked whale vocal activity
- Compare and contrast two passive acoustic monitoring methodologies—towed array and shelf-break HARPs—with regards to beaked whale temporal and spatial presence and diving behavior
- Assess patterns of richness and composition of marine mammal communities through ecological gradients in acoustic data across the shelf break

Continuous passive acoustic recordings have been collected at 11 sites by the NEFSC and U.S. Navy along the Atlantic continental shelf break of the U.S. beginning as early as 2015. The sites deployed starting in 2015 include Heezen Canyon, Oceanographer Canyon, Nantucket Canyon (three northernmost sites), Norfolk Canyon, Cape Hatteras, and JAX (U.S. Navy deployments). These were expanded in 2016 to include Wilmington and Babylon Canyons north of Cape Hatteras as well as Gulf Stream, Blake Plateau, and Blake Spur south of Cape Hatteras. (**Table 19; Figure 20**). Each HARP was programmed to record continuously at a sampling rate of 200 kilohertz (kHz) with 16-bit quantization, providing an effective recording bandwidth from 0.01 to 100 kHz. Further details of HARP design are described in Wiggins and Hildebrand (2007).

Table 19. HARP deployment sites and recording details for data analyzed from 2015 through 2019.

Site	Recording Start Date	Recording End Date	Recorder Depth (m)
Heezen Canyon (HZ)	June 2015	May 2019	845–1,090
Oceanographer Canyon (OC)	April 2015	May 2019	450–1,100
Nantucket Canyon (NC)	April 2015	June 2019	890–977
Babylon Canyon (BC)	April 2016	May 2019	997–1,000
Wilmington Canyon (WC)	April 2016	May 2019	974–1,000
Norfolk Canyon (NFC)	April 2016	May 2019	950–1,050
Hatteras (HAT)	April 2016	May 2019	980–1,350
Gulf Stream (GS)	April 2016	June 2019	930–953
Blake Plateau (BP)	April 2016	May 2019	940–945
Blake Spur (BS)	April 2016	June 2019	1,000–1,005
Jacksonville (JAX)	April 2016	June 2019	736–750

Key: m = meter(s)



Key: BC = Babylon Canyon; BP = Blake Plateau; BS = Blake Spur; GS = Gulf Stream; HAT = Hatteras; HZ = Heezen Canyon; JAX = Jacksonville; NC = Nantucket Canyon; NFC = Norfolk Canyon; OC = Oceanographer Canyon; WC = Wilmington Canyon

Figure 20. HARP deployment sites for data analyzed from 2015 through 2019.

Applying Improved Automated Classification for Beaked Whales

The volume of data generated from the 11 recording sites during 2015–2019 presented a challenge for classification of beaked whales to the species level, as it requires expertise and time to manually label echolocation clicks. The purpose of this effort was to design a system to streamline and automate the process of detecting and classifying beaked whale echolocation clicks using deep-learning neural networks. The classification pipeline consisted of multiple steps targeted to efficiently detect beaked whales, often challenging to detect when other species dominate the soundscape. The steps included: 1) a generic detector to detect clicks above a received-level threshold, 2) a discrimination phase to remove dominant non-beaked whale detections, 3) an unsupervised learning to derive clusters of distinct click types based on similarities in the spectral shape, and 4) a trained deep neural network to classify clusters of echolocation clicks based on spectral shape, interclick interval, and click duration.

These steps were finalized and described in detail in Van Parijs et al. 2022. This improved automated classification approach was then re-run through all Atlantic shelf break data. Expert analysts reviewed the clicks classified by the neural network in the program DetEdit (Solsona-Berga et al. 2020) to confirm their classification. Additionally, the classification pipeline was tested on a small dataset of two months of data from 2016 to compare classification results where data were previously manually labeled.

Assessing Effects of Anthropogenic Noise on Beaked Whale Vocal Activity

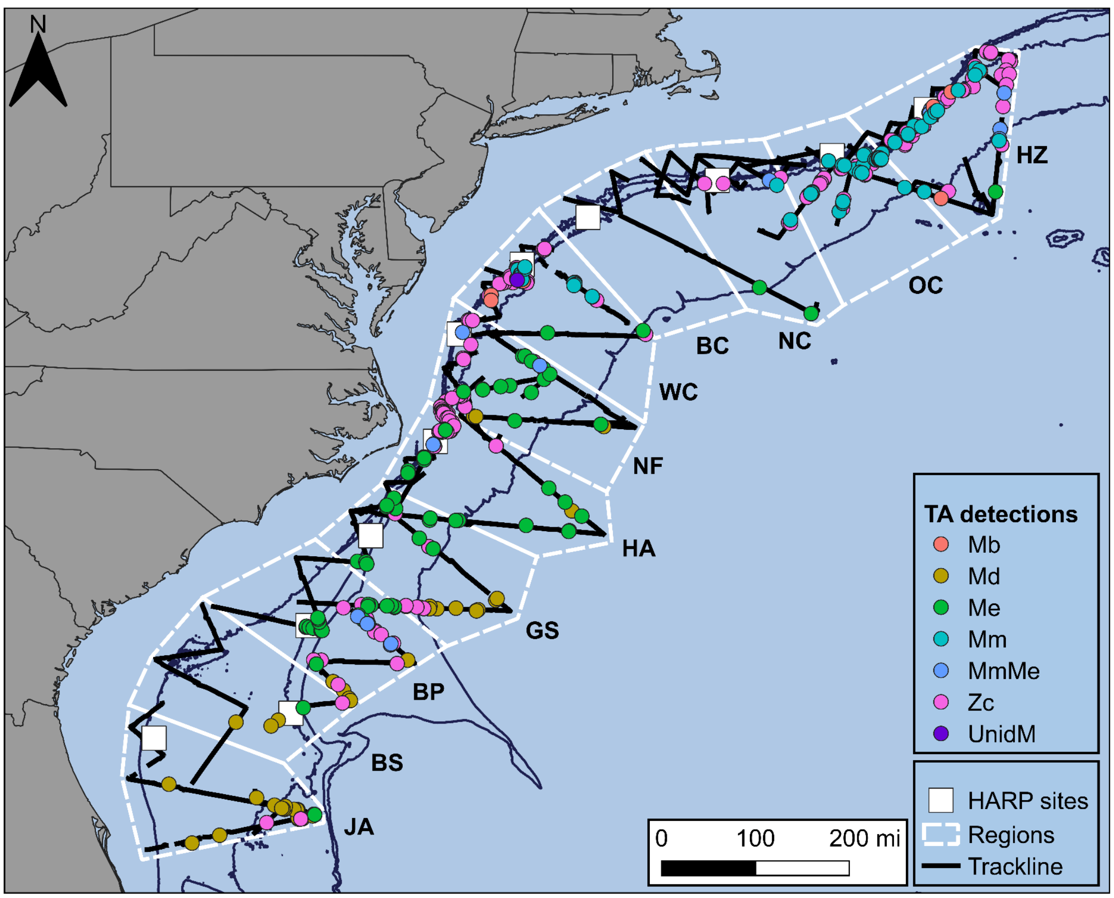
The goal for this component of the project is to refine a statistical approach to investigate the potential impacts of mid-frequency active sonar (MFAS) on beaked whale acoustic activity in the western North Atlantic. The analyses include data for several species of beaked whales for acoustic behavioral response to sonar operations in areas with varying naval activity. The relationship between MFAS and the acoustic behavior of beaked whales is complex and requires the inclusion of natural temporal and spatial variability in click densities (e.g., caused by species or population-level seasonality, habitat preference, the behavioral context of echolocating, and individual variability). For this part of the project, analyses focus on the HARP sites, as presence of MFAS is higher there than at other locations.

The proposed statistical analysis to investigate impact entails presence/absence-level decisions in 1-minute segments, which requires beaked-whale data to be classified to a finer resolution of at least 1-minute granularity. The previous classification methodology included a clustering method that had a significant proportion of false detections and false classifications, which needed to be addressed. Therefore, for this reporting period, the majority of the effort was focused on the refinement of the species-specific classifier. While current effort was focused on evaluating classification of beaked whale species provided by the neural network using the program DetEdit, progress has been made on the statistical analysis of the sonar impact on a preliminary dataset with a high probability score of matching species labels provided by the neural network.

Three species of beaked whales were studied during this preliminary analysis at the three U.S. Navy sites, in particular Sowerby's (*Mesoplodon bidens*), Gervais' (*Mesoplodon europaeus*), and Cuvier's beaked whales. Generalized estimating equations were used to model relationships between the three species of beaked whales' click presence, temporal covariates, and MFAS covariates. Only site HAT (Hatteras) had enough presence of Gervais' and Cuvier's beaked whales to create a model that could summarize the relationship of MFAS to these two species of beaked whales. The probability of detecting both species of beaked whales continued to increase at HAT with increasing time since cessation of sonar use up to about a month, and maximum peak-to-peak received levels were negatively related to the probability of detecting both species of beaked whales at levels above 110 decibels referenced to a pressure of 1 microPascal (dB re 1 µPa). This analysis was presented at the 7th International Meeting on the Effects of Sound in the Ocean on Marine Mammals in Beaufort, North Carolina, March 2022 ("Impact of Mid-Frequency Active Sonar on Beaked Whales documented by Passive Acoustic Monitoring").

Comparing and Contrasting Two Methodologies—Towed Array and Shelf-break HARP Data Sets—with Regards to Beaked Whale Temporal and Spatial Presence, and Diving Behavior

A comprehensive East coast Atlantic Marine Assessment Program for Protected Species (AMAPPS) stock assessment survey took place during the summer months of June to August 2016, concurrent with the shelf-break HARP recordings. The towed-array survey provides large-scale spatial information on beaked whale presence and acoustic behavior, while the shelf-break HARP bottom-mounted recorders provide detailed temporal coverage. These two datasets were combined to explore how they can jointly provide data to improve understanding of species distributions. Eleven HARPs and two towed-array surveys were analyzed covering 1 July to 31 August 2016, with the coverage area divided into 11 regions each containing one HARP (see **Figure 21**).



Key: BC = Babylon Canyon; BP = Blake Plateau; BS = Blake Spur; GS = Gulf Stream; HA = Hatteras; HZ = Heezen Canyon; JA = Jacksonville; Mb = *Mesoplodon bidens*; Md = *Mesoplodon densirostris*; Me = *Mesoplodon europaeus*; Mm = *Mesoplodon mirus*; NC = Nantucket Canyon; NF = Norfolk Canyon; OC = Oceanographer Canyon; TA = towed array; WC = Wilmington Canyon; Zc = *Ziphius cavirostris*

Figure 21. HARP locations and vessel transect lines with towed array detections for data collected from 1 July to 31 August 2016.

Comparisons between detections from HARPs and towed-array site showed consistency in the percent of minutes present across several regions. However, there were several periods when either the towed array only or the HARP recorder only detected a given species. This is likely due to the large spatial coverage of the array, traversing both slope and abyssal waters, but also not remaining in a location for a long period of time. This demonstrates that combining these methods are better at providing an accurate representation of species presence, while individually they have the potential to miss the occurrence of certain species. The extended spatial coverage from the towed arrays was also able to show that all species occurrence extended into deeper waters beyond the HARP sites. In particular, Blainville's (*Mesoplodon densirostris*) and Gervais' extended significantly beyond the shelf break (**Figure 21**).

Assessing Patterns of Richness and Composition of Marine Mammal Communities through Ecological Gradients in Acoustic Data across the Shelf Break

Assessing patterns of richness and composition of marine animal communities through ecological gradients such as latitude and depth over time are of primary importance in conservation biology as these can provide important warning signs of environmental change, which can aid in designing new management and conservation measures. Fast and reliable methods are required for biodiversity assessments to determine and compare species richness patterns that can be applied in both accessible and remote habitats. The goal for this component of the project is to apply ecological species modeling (as described in Van Opzeeland and Hillebrand 2020) and acoustic niche approaches (Van Opzeeland and Boebel 2018; Weiss et al. 2021) to the large acoustic data set to apply new techniques for understanding species ecology, community structure, and acoustic niche interactions between multi-species groups throughout the shelf break data.

Details on the results from this work in 2022 can be found in Van Parijs et al. 2023.

2.1.2.3 Rice's Whale Occurrence within the Northeastern Gulf of Mexico

The Rice's whale (*Balaenoptera ricei*; formerly Gulf of Mexico Bryde's whale) is estimated to have a population size of 51 individuals in U.S. waters (Garrison et al. 2020) and was listed as endangered under the ESA in 2019 (84 *Federal Register* 15446, 87 *Federal Register* 8981). The majority of modern sightings occur within waters between the 100- and 400-meter (m) isobaths within an area near the De Soto Canyon off northwestern Florida (Soldevilla et al. 2017; Rosel et al. 2021). This primary distribution area is defined as the Rice's whale core habitat (Rosel and Garrison 2022). Occurrence patterns from long-term PAM over the 2010–2018 period and from summer and fall visual surveys during 2018 and 2019 indicate that the whales are found year-round within the core 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. Many of these activities, including U.S. Navy readiness training and testing, and Eglin Air Force Base activities, overlap with the whales' core habitat. Understanding seasonal distribution and density of Rice's whales throughout the core habitat will improve understanding of potential impact of human activities in this area, improve the accuracy and precision of impact assessments, and assist in developing effective mitigation measures as needed.

To improve management of human-based activities in the core habitat of these endangered whales, the SEFSC began deploying a sparse array of 17 PAM units concurrent with one long-term HARP in May 2021. The PAM moorings are being deployed in two lines of nine units each to nearly completely cover the core habitat (**Figure 22**) over a nearly 2-year period to improve understanding of seasonal and interannual distribution, movement patterns, and habitat use. The moorings use SoundTrap ST500 STDs, calibrated long-term recorders capable of continuously recording underwater sound in the 20 Hertz to 48 kHz frequency range, including

Rice's whale calls and ambient noise, for up to 6 months. Additionally, the study leverages a long-term HARP being deployed by the SEFSC, Scripps Institution of Oceanography, and collaborators, at the De Soto Canyon site in the core Rice's whale habitat over the August 2020 to July 2025 period. At this site, they have been continuously recording ambient noise and other acoustic events in the 10 Hertz to 100 kHz frequency range since 2010 to monitor the impacts of the Deepwater Horizon oil spill and subsequent restoration activities on cetaceans. Together with the sparse array of SoundTraps, these PAM deployments provide the necessary data to understand seasonal distribution and density of Rice's whales.

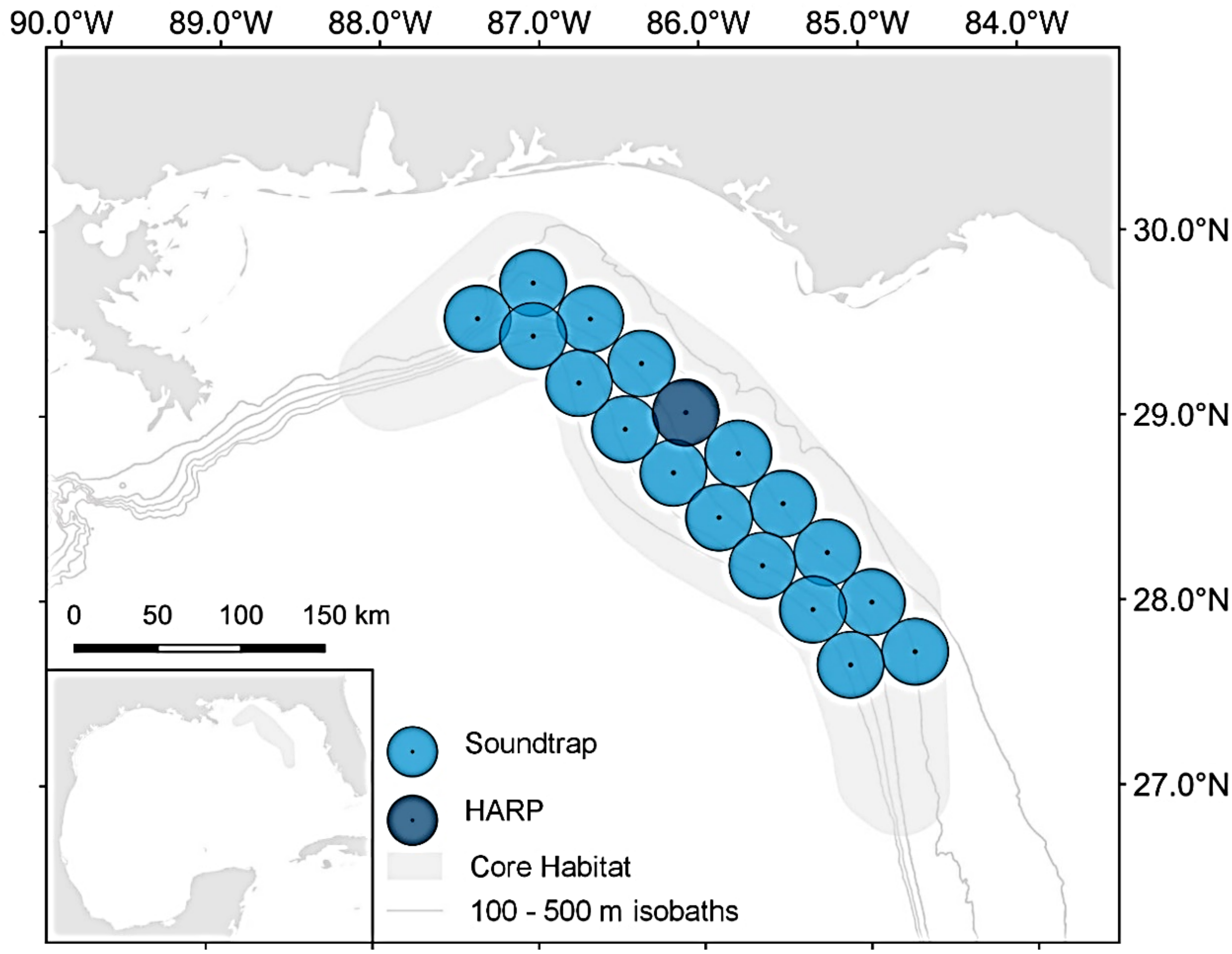


Figure 22. Historic long-term PAM station in the Rice's whale core habitat since 2010 (HARP) and 2021–2023 PAM stations (SoundTraps). The NMFS core habitat of Rice's whales is indicated.

During 2022, data analyses were begun on the SoundTrap recordings (November 2021 to September 2022) as well as the concurrently deployed De Soto Canyon HARP recordings (August 2021 to June 2022). Automated spectrogram cross-correlation detectors for the downsweep-sequence and long-moan calls, developed under an earlier phase of this work, were run on all recordings. Given the critically endangered status of this species, automated detector thresholds are intentionally set low to minimize missed detections at the cost of increased false positive detections, and a subsequent manual validation step is conducted to remove false positive detections. This semi-automated process is both more efficient and consistent than a complete manual detection process and more accurate than a fully automated process. Across the 15 moorings recovered from the November 2021 to April 2022 period, there were 1,835 instrument-days of recordings, 530,834 Rice's whale long-moan calls detected, and 67,712 Rice's whale downsweep sequences detected. The validation process has been completed for long-moan calls from 13 of the 15 moorings, yielding a total of 183,102 true and 24,566 possible long-moan call detections out of 405,212 auto-detections validated to date. During the November 2021 to April 2022 period, true detections of Rice's whale long-moans occurred at all 13 of the manually validated sites, ranging from 368 to 50,695 calls per site. Similar to the May to September 2021 data, higher numbers of detections occurred at the inshore sites. Manual validation results indicate false detection rates for the long-moan detector vary by site and over time within sites, with higher false-positive rates at offshore sites compared to inshore sites, and at the two southernmost sites near the Tampa shipping lane. High levels of seismic airgun activity during this deployment led to higher false-positive rates. Across the 13 validated sites, the daily occurrence of Rice's whale long-moan calls varied by site as well, with calls present on 29 to 99 percent of days per site over the November 2021 to April 2022 period. Across the 13 moorings recovered from the April to September 2022 period, there were 1,624 instrument-days of recordings. Data storage hard-drives purchased during periods of supply chain issues caused by the COVID-19 pandemic have had a high rate of failure. Corrupted data were successfully recovered from all 13 sites, and are currently undergoing decompression, decimation, and automated detection-processing steps.

Planned work for the remainder of the project includes completing validations and statistical analyses from the three deployments. The manual validation process will be completed for long-moans on data from the remaining three sites and for downsweep sequences at all sites from the second deployment, and the detectors will be run and validated on the SoundTrap data from the third deployment. Additionally, ambient noise analyses, monthly occurrence mapping, and evaluation of diel and seasonal changes in call occurrence and ambient noise impacts on call detection will be conducted. A manuscript will be drafted following completion of data analyses from the NOAA-funded fourth deployment. Finally, data collected during this project are being leveraged under NOAA-funded projects to acoustically track calling Rice's whales throughout the core habitat and to evaluate feasibility of using spatially explicit capture-recapture methods for density estimation.

Additional details on the work conducted over the past year is available in Soldevilla et al. 2023.

2.1.2.4 Marine Mammal Monitoring on Navy Ranges

The Marine Mammal Monitoring on Navy Ranges (M3R) program began in 2000, with the development of a system to use the bottom-mounted hydrophones of the U.S. Navy's test and training ranges to detect, classify, localize, and monitor marine mammals in real-time by listening for their vocalizations. Each of the ranges has 100 to 200-plus widely spaced hydrophones, and the systems consist of rack-mounted computer nodes and monitoring displays connected with Gigabit networks. The M3R system is currently installed at the Atlantic Undersea Test and Evaluation Center (AUTEC), Southern California Anti-Submarine Warfare Range (SOAR), Pacific Missile Range Facility (PMRF), and JSWTR. The M3R program collects continuous archive data and periodic recordings from each of these ranges and uses these data, along with field tests, for collaborative studies on marine mammal behavior, distribution, abundance, foraging, and habitat use; for understanding the effects of U.S. Navy activities on the long-term health of the populations; and for the development of detection, classification, localization, and density-estimation algorithms.

The M3R system was installed at JSWTR in December 2019, initially connected to hydrophones installed on the northern half of the range (Phase I), and later connected to the southern hydrophones in December 2022. JSWTR has 223 active hydrophones mounted at depths ranging from 35 to 355 m over a span of 2,000 square kilometers (km^2) (**Figure 22**), making it the largest M3R system to date. In contrast to the AUTEC, PMRF, and SOAR deep-water ranges on which the M3R system is deployed, JSWTR is a shallow-water range that is likely to have different species present than those typically found on the deep-water ranges.

The M3R system runs nearly continuously year-round, archiving data from all range hydrophones simultaneously in real-time, when there are no range activities that would preclude its operation. Detection, classification, and localization reports are stored to binary archive files for later playback and analysis. The M3R system employs three detector/classifiers: a Fast Fourier Transform-based detector, a Class-Specific Support Vector Machine (CS-SVM) detector/classifier, and a Blainville's beaked whale foraging click matched filter (Jarvis et al. 2008). The CS-SVM classifier currently has six classes at JSWTR: Blainville's beaked whale foraging and buzz clicks, Cuvier's beaked whale foraging and buzz clicks, sperm whale clicks, and 'generalized dolphin' clicks.

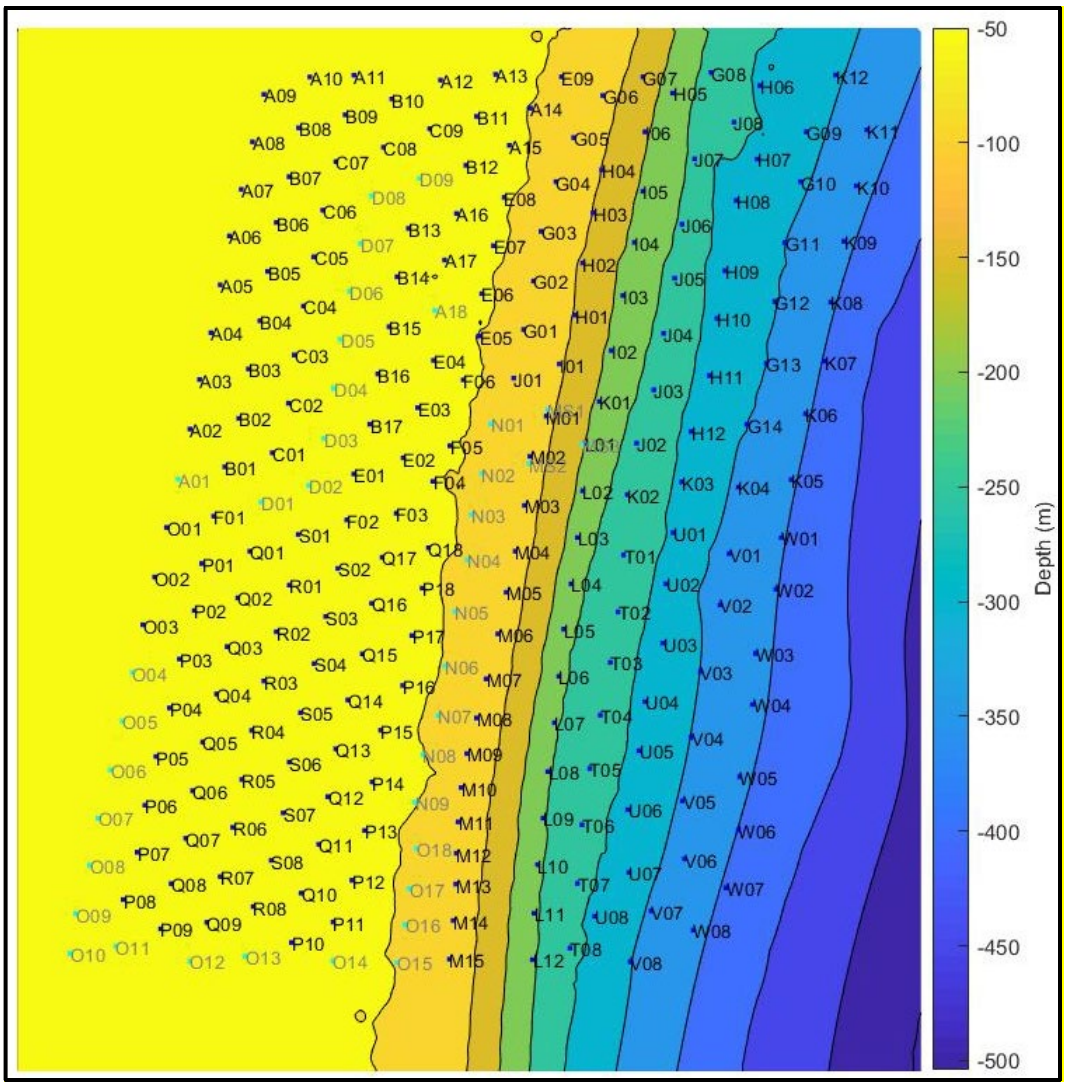


Figure 23. Hydrophone range at JSWTR with bathymetry. Inactive hydrophones have gray labels.

The M3R team conducted species-verification trials in May and December 2022 in collaboration with Duke University and HDR, Inc. During these trials, NUWC personnel used the M3R PAM displays to look for species of interest, and direct the on-water team to the locations of the animals via satellite phone texts. Upon locating the animals, the field team verified the species; collected behavioral and environmental data; took photographs for their photo-ID catalogs; took biopsy samples; and potentially deployed satellite tags. The focal species for these efforts were:

1. Short-finned pilot whales (*Globicephala macrorhynchus)*
2. Bottlenose dolphins (*Tursiops truncatus*)
3. Atlantic spotted dolphins (*Stenella frontalis*)
4. Risso's dolphins (*Grampus griseus*)
5. Rough-toothed dolphins (*Steno bredanensis*)

The first 2022 species verification test occurred 14 to 18 May (**Table 20**). During this effort, two of the focal species were identified. This included three visually verified groups of bottlenose dolphins and one visually verified group of Atlantic spotted dolphins. Duke University was able to collect four biopsies from the bottlenose dolphin groups.

Table 20. May 2022 field effort: species acoustically identified with the M3R system at JSWTR.

Species		Number of Acoustic Detections Logged	Number of Acoustic Detections Directed	Number of Acoustic Detections Visually Verified	Number of Biopsies
Common Name	Scientific Name				
Bottlenose dolphin	*Tursiops truncatus*	8	4	3	4
Atlantic spotted dolphin	*Stenella frontalis*	1	1	1	0
Unidentified dolphin	Delphinidae sp.	31	8	0	0

The second 2022 species verification test occurred 13 to 14 December (**Table 21**). During this effort, two of the focal species were identified. This included eight visually verified groups of bottlenose dolphins and one visually verified group of Atlantic spotted dolphins. Unfortunately, poor weather conditions made biopsy sampling impossible.

Table 21. December 2022 field effort: species acoustically identified with the M3R system at JSWTR.

Species		Number of Acoustic Detections Logged	Number of Acoustic Detections Directed	Number of Acoustic Detections Visually Verified	Number of Biopsies
Common Name	Scientific Name				
Bottlenose dolphin	*Tursiops truncatus*	8	8	8	0
Atlantic spotted dolphin	*Stenella frontalis*	1	1	1	0
Unidentified dolphin	Delphinidae sp.	52	8	0	0

An opportunistic monitoring trip was also conducted for three days in February 2022. The focus of the trip was to record acoustic data for the development of a suite of North Atlantic right whale (NARW: *Eubalaena glacialis*) classifiers. Broadband recordings of the northern portion of the range were taken continuously. An M3R analyst monitored opportunistically for this species as well as any other baleen whales that could be used as a confusion species when training the classifiers. The goal is to deploy a suite of NARW classifiers where confidence in positive detections is increased by the number of classifiers in agreement.

2.1.2.5 Autonomous Real-time Detection Buoy

The autonomous real-time reporting passive acoustic detection buoy (**Figure 24**) deployed by Woods Hole Oceanographic Institute off the coast of Cape Hatteras, North Carolina, in October 2021 experienced technical issues with the mooring line, causing it to break free and drift away in the Gulf Stream in July 2022. A new buoy was deployed in September 2022 at a location to the northwest to be farther from the Gulf Stream (thereby reducing flow noise as well) and to de-conflict with shipping lanes. The buoy has the ability to detect and classify whale vocalizations using a digital acoustic monitoring instrument (DMON) and sophisticated analysis software to listen for whales as well as send notifications and data to researchers in near-real time.

Figure 24. DMON buoy deployed off the coast of Cape Hatteras, North Carolina.

Sensor data from the buoy are relayed to shore and posted on the project's publicly accessible website at Robots4Whales. The DMON is programmed with the Low-frequency Detection and Classification System (Baumgartner and Mussoline 2011; Baumgartner et al. 2013) and is capable of detecting humpback, fin (*Balaenoptera physalus*), sei (*Balaenoptera borealis*), and NARWs. Detection data are transmitted in near real time to shore where they are reviewed daily by trained analysts, and the results posted on the project website, distributed to interested parties by automated email messages, made available for display on WhaleMap, and integrated into NOAA's Passive Acoustic Cetacean Mapper.

Of the four baleen whale species monitored, humpback and fin whales were the most commonly detected through July 2022 (**Figure 25**). NARWs were also relatively commonly detected from December through February. This buoy had similar mooring line issues to the previous deployment and stopped working in December 2022; it is expected to be redeployed in early 2023.

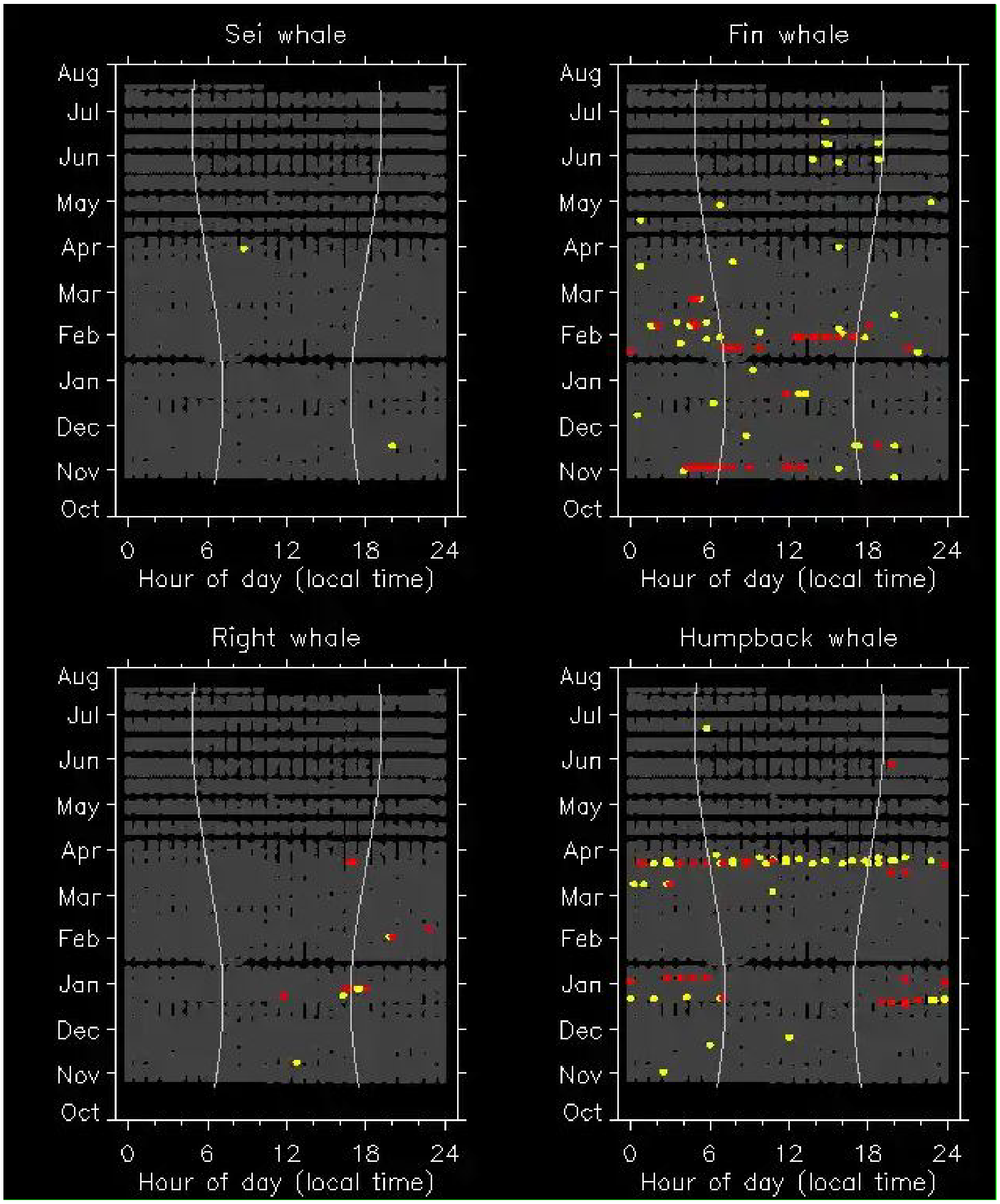


Figure 25. Diel plot showing detections (yellow = possible, red = confirmed) of baleen whales from October 2021 through July 2022.

2.1.2.6 SoundTrap Deployment in the Mid-Atlantic

In collaboration with NOAA Northeast Fisheries Science Center, a two sets of SoundTraps were deployed to monitor for the presence of North Atlantic right whales within the western Mid-Atlantic. Three units were deployed off the coast of Delaware in July, and three were deployed off southeast Virginia in the Coastal Virginia Offshore Wind energy area (**Figure 25)**. This contributes to a multi-agency effort to build out a broader regional long-term PAM network covering the continental shelf break from Maine to Georgia. These archival PAM systems will be serviced and re-deployed approximately every 6 months. Analysis of the data will be performed by NEFSC staff and results incorporated into NOAA's Passive Acoustic Cetacean Mapper.

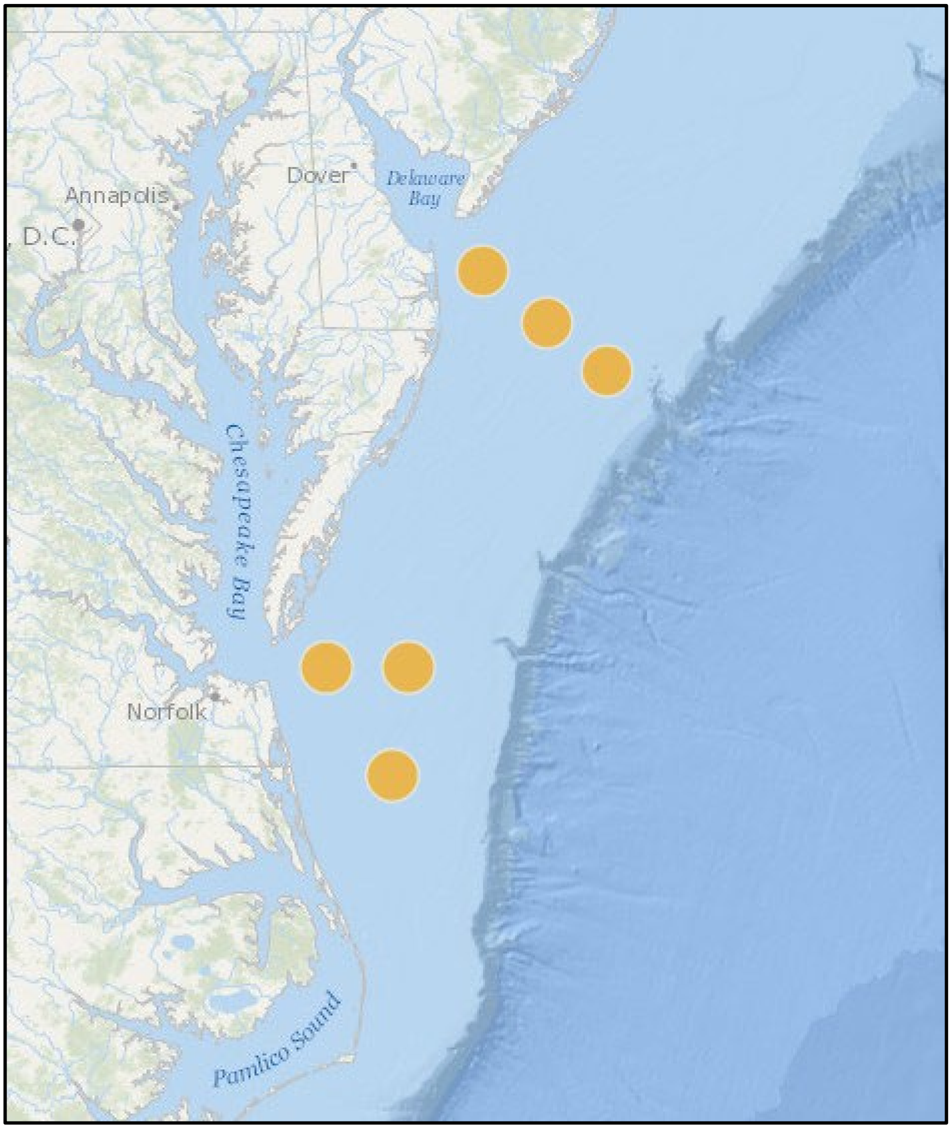


Figure 26. Locations of SoundTrap deployments in June and July 2022.

2.2 Tagging Studies

During the 2022 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**), and pinnipeds (**Section 2.2.4**) in support of AFTT monitoring requirements.

2.2.1 Tagging of Deep-Diving Odontocete Cetaceans

In 2022, tagging activities were conducted off the coast of Cape Hatteras in association with the Atlantic BRS (**Section 2.1.1.1**). These deployments built on the Deep Divers project that began in 2013 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). The 2022 study year constituted the sixth year of directly supporting the Atlantic BRS with a continued focus on the distribution and ecology of Cuvier's beaked whales and short-finned pilot whales. Satellite tagging has provided information on the spatial use and diving behavior of deep-diving odontocetes over the medium term (i.e., weeks to months) (Baird et al. 2018). Shorter-term dive data (i.e., hours to days) can be collected using DTAGs, and longer-term movement information (i.e., months to years) can be collected using photo-ID techniques (see **Section 2.1.1.1**).

During June through August 2022, the sixth year of field effort was completed in support of the Atlantic BRS (**Section 2.3.1**). Satellite-tag deployments were conducted by a researcher from Bridger Consulting Group in coordination with the Atlantic BRS team aboard Duke University vessels. The goal of this study was to deploy satellite tags prior to scheduled controlled exposure experiments (CEEs) on the two primary species: Cuvier's beaked whale (highest priority) and short-finned pilot whale (second priority). This section summarizes the satellite-tag data, focusing on large-scale spatial use by 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, eight satellite tags were deployed on Cuvier's beaked whales (**Table 22, Figure 27** and **Figure 28**). One DTAG was successfully deployed on a Cuvier's beaked whale during the 2022 field effort (**Table 23**). It collected data before, during, and after the successful single MFAS CEE conducted with an operational U.S. Navy 53C sonar on the U.S. Ship (*USS) Farragut*.

Table 22. Summary of satellite tag deployments during Atlantic BRS field efforts in 2022.

Species/ Tag ID	Deployment Date	Deployment Latitude (°N)	Deployment Longitude (°W)	Dive Data Streams	Tag Duration (days)
ZcTag128_DUML	06/21/22	35.6560	74.7486	5-min time series	8
ZcTag129_DUML	06/21/22	35.6462	74.7548	5-min time series	76
ZcTag130_DUML	06/30/22	35.6461	74.7237	5-min time series	76
ZcTag131_DUML	08/03/22	35.7150	74.6052	5-min time series	11
ZcTag132_DUML	08/03/22	35.6946	74.5853	5-min time series	74
ZcTag133_DUML	08/05/22	35.6300	74.7061	5-min time series	68
ZcTag134_DUML	08/05/22	35.6282	74.7024	5-min time series	41
ZcTag135_DUML	08/05/22	35.6197	74.6305	5-min time series	27

Key: ID = identification; min = minute; °N = degrees north; °W = degrees west; Zc = *Ziphius cavirostris* (Cuvier's beaked whale).

Table 23. DTAG deployments for Cuvier's beaked whales during Atlantic BRS field efforts in 2022.

Tag ID[a]	Deployment Date	Deployment Latitude (°N)	Deployment Longitude (°W)	Baseline or CEE Number	Tag Duration (hours)	Recovered?
Zc22_219a	8/7/22	35.6178	74.7244	CEE #2022_03	23.7	Yes

Key: ID = identification; °N = degrees north; °W = degrees west; Zc = *Ziphius cavirostris* (Cuvier's beaked whale).

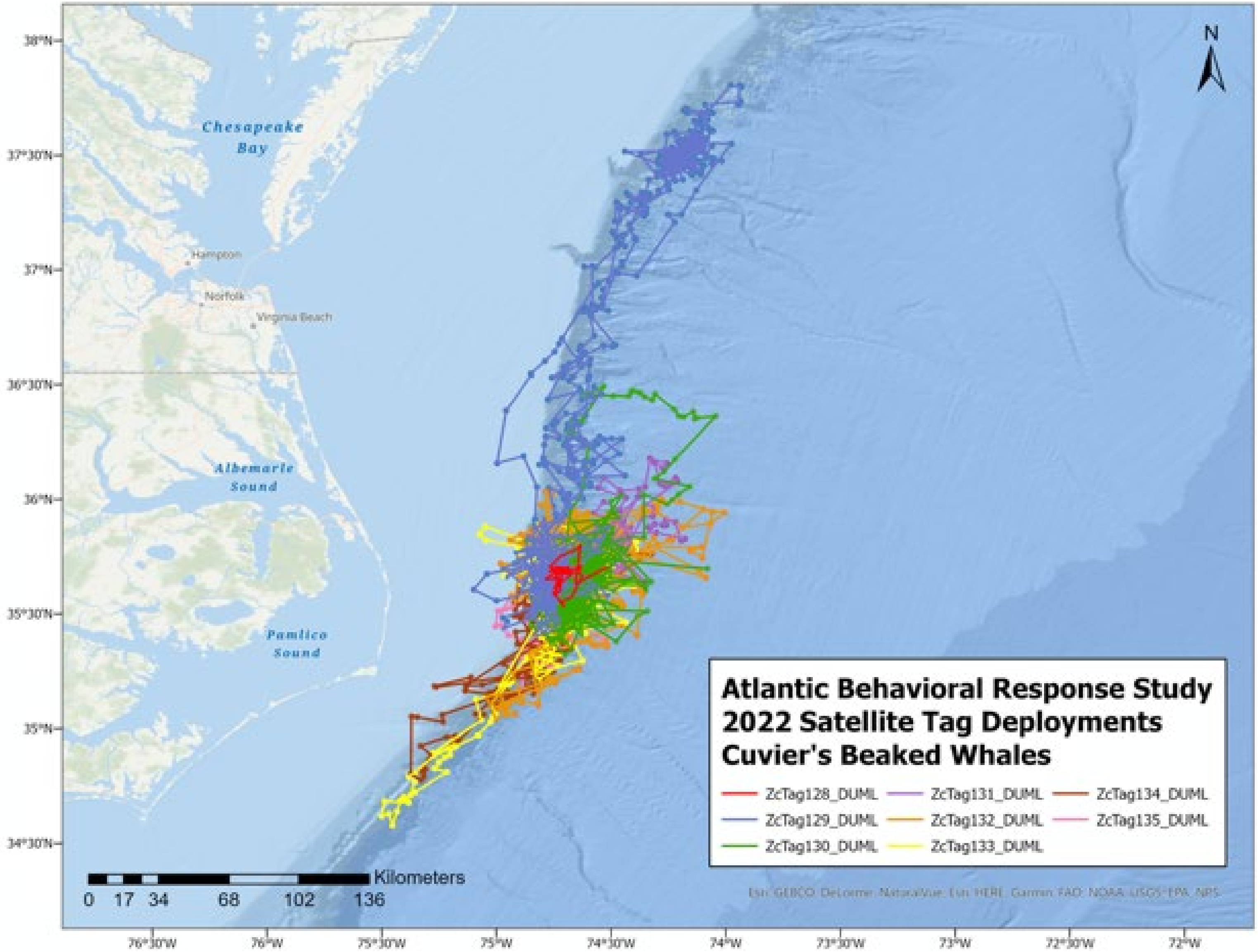


Figure 27. Douglas-filtered Argos positions and tracklines for all eight Cuvier's beaked whale satellite-tag deployments in 2022.

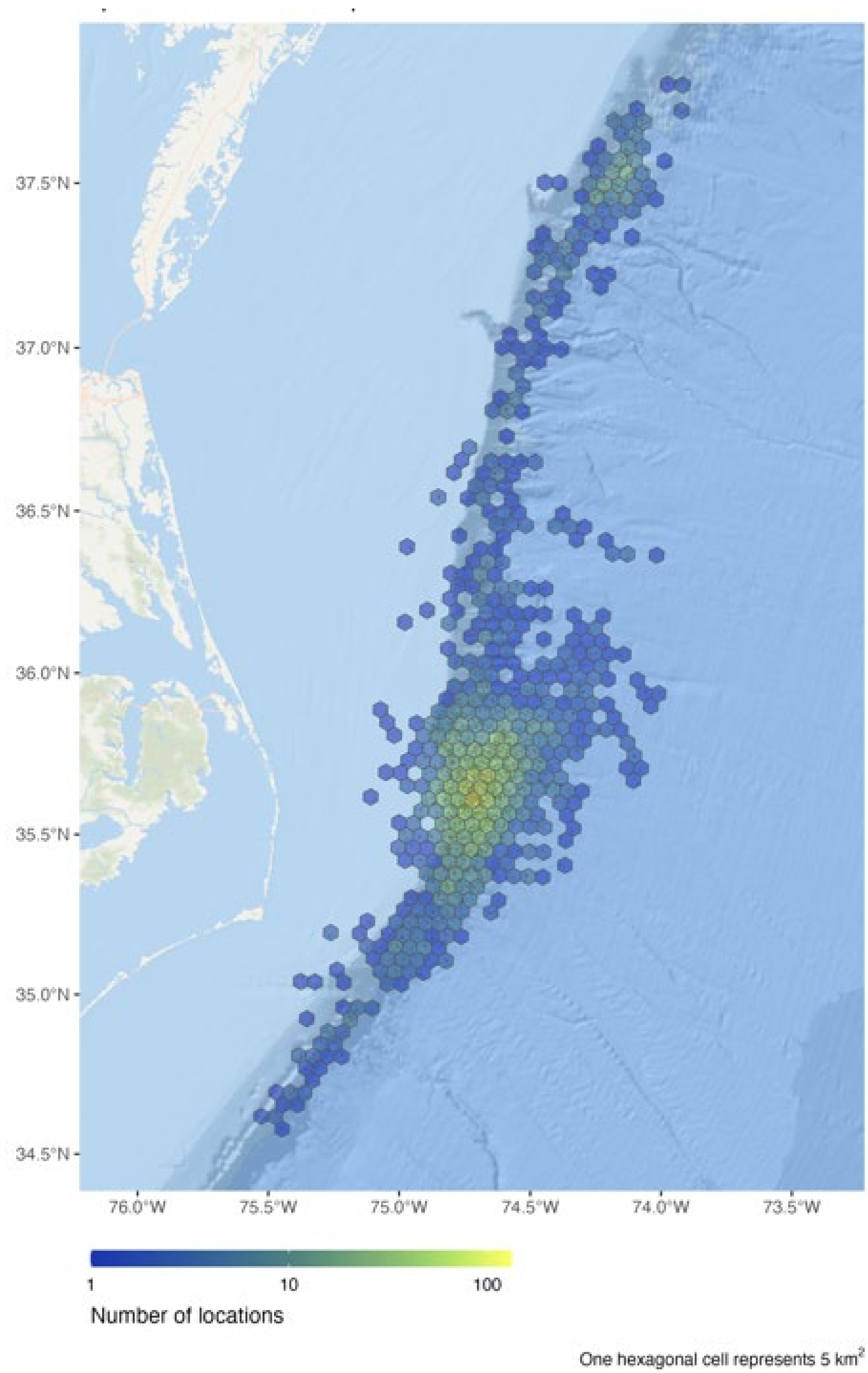


Figure 28. Douglas-filtered Argos locations for all 2022 Cuvier's beaked whales aggregated in 5-km² hexagonal grid cells.

2.2.2 Mid-Atlantic Nearshore and Mid-Shelf Baleen Whale Monitoring

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 via the Mid-Atlantic Humpback Whale Monitoring Project (Aschettino et al. 2023). Vessel surveys focused on photo-ID, biopsy sampling, and tagging using medium-resolution satellite tags and high-resolution suction-cup tags, as well as the use of a small unmanned aerial systems (sUAS) for length and body condition assessments. These baseline data are critical for assessing the potential for disturbance to humpback whales in this part of the mid-Atlantic. Data on other baleen whale species were also collected opportunistically, although relatively little information exists on how other species of baleen whales, including endangered fin and North Atlantic right whales, use the central waters of the AFTT.

PAM results from autonomous gliders and MARUs confirm that humpback, fin, sei, minke (*Balaenoptera acutorostrata*), and NARWs regularly use the continental shelf waters off the coasts of Virginia and North Carolina (Stanistreet et al. 2016; Salisbury et al. 2018; Baumgartner 2019). Acoustic detections are supported by visual sighting data collected by the Atlantic Marine Assessment Program for Protected Species (AMAPPS aerial and vessel surveys (NEFSC and SEFSC 2012, 2013) as well as previously funded U.S. Navy aerial and vessel surveys (Mallette et al. 2018).

Fin whales, considered a strategic stock given their ESA status, appear to show a reliable pattern of occurrence near or over the continental shelf break throughout VACAPES (Hayes et al. 2022; Mallette et al. 2018). Led by researchers from HDR Inc., satellite-monitored tags deployed between 2016 and 2021 on fin whales within VACAPES show both localized and extensive movements over all areas of the continental shelf (Engelhaupt et al. 2017, 2018, 2019; Aschettino et al. 2018, 2021, 2022a). Confirmed sightings of critically endangered NARWs off Virginia have increased as coverage during the Mid-Atlantic Humpback Whale Project surveys has extended farther from the coastline in recent years (Aschettino et al. 2022b). Movements of satellite tagged NARWs show extensive use of the mid-shelf region to both the north and south of the primary study area (Aschettino et al. 2022b; A. Engelhaupt et al. 2022b). Although sightings of blue whales (*Balaenoptera musculus*) off Virginia are infrequent, they have now been documented during HDR, Inc. surveys in 2018 (Engelhaupt et al. 2019), 2019 (Cotter 2019), 2021 (A. Engelhaupt et al. 2022), and 2022. Argos location data from two satellite-tagged blue whales showed at least some movements through the shallow continental shelf waters (Lesage et al. 2017; D. Engelhaupt et al. 2020; Aschettino et al. 2022a).

Building upon the established long-term dataset, the Mid-Atlantic Nearshore and Mid-Shelf Baleen Whale Monitoring project expands the previous study area to encompass mid-shelf waters out to approximately 40 nautical miles (nm) from shore, where the diversity of baleen whale species increases. The goals of this study are to assist the U.S. Navy and regulatory agencies by addressing the following questions:

- What is the baseline ecology and behavior of baleen whales (including critically endangered NARWs, fin, humpback, sei, minke, and blue whales) within the study area?
- Do individual whales exhibit site-fidelity within specific regions of the U.S. Navy OPAREAs over periods of weeks, months, or years?
- What is the seasonal extent of baleen whale movements within and around U.S. Navy OPAREAs?
- Do baleen whales spend significant time within or primarily move through areas of U.S. Navy live-fire or Anti-Submarine Warfare training events?
- Are baleen whale movement patterns affected by U.S. Navy training exercises?

- Are baleen whales likely exposed to significant sound levels produced by vessel traffic and/or military training exercises using active sonar?

The humpback whale field season off Virginia Beach runs from approximately the end of October through March, typically concentrated between December and February, with smaller numbers of sightings occurring outside this timeframe. Since this project's inception in 2015, seven annual field seasons have occurred, beginning with collection of basic baseline information using photo–ID, focal follow, and biopsy sampling methods (Aschettino et al. 2015). Subsequently, the project has evolved to include deployment of satellite-linked telemetry and DTAGs; collaboration with researchers from Duke University to examine behavioral response of humpbacks to large vessels (see **Section 2.3.2**); photogrammetry using sUAS; and, most recently, an expansion into the mid-shelf region with the addition of other baleen whale species, including fin whales and NARWs.

2.2.2.1 Survey Effort

Twenty-eight vessel surveys were conducted between 14 November 2021 and 15 March 2022. Eleven of these surveys were considered nearshore, and 17 surveys were defined as mid-shelf. More than 213 hours of survey effort were completed and 3,432 km of trackline were covered (**Figure 29**). The 2022/2023 season began on 21 November 2022 and is still underway at the time of this report.

2.2.2.2 Sightings

In total, 78 baleen whale sightings occurred during the 2021/2022 season, including 64 humpback whale sightings composed of 98 individuals, 7 fin whale sightings composed of 10 individuals, 4 minke whale sightings composed of 5 individuals, and 3 NARW sightings composed of 5 individuals (**Figure 29**). Sightings of non-target species (i.e., bottlenose dolphins) were sometimes recorded but are not presented here.

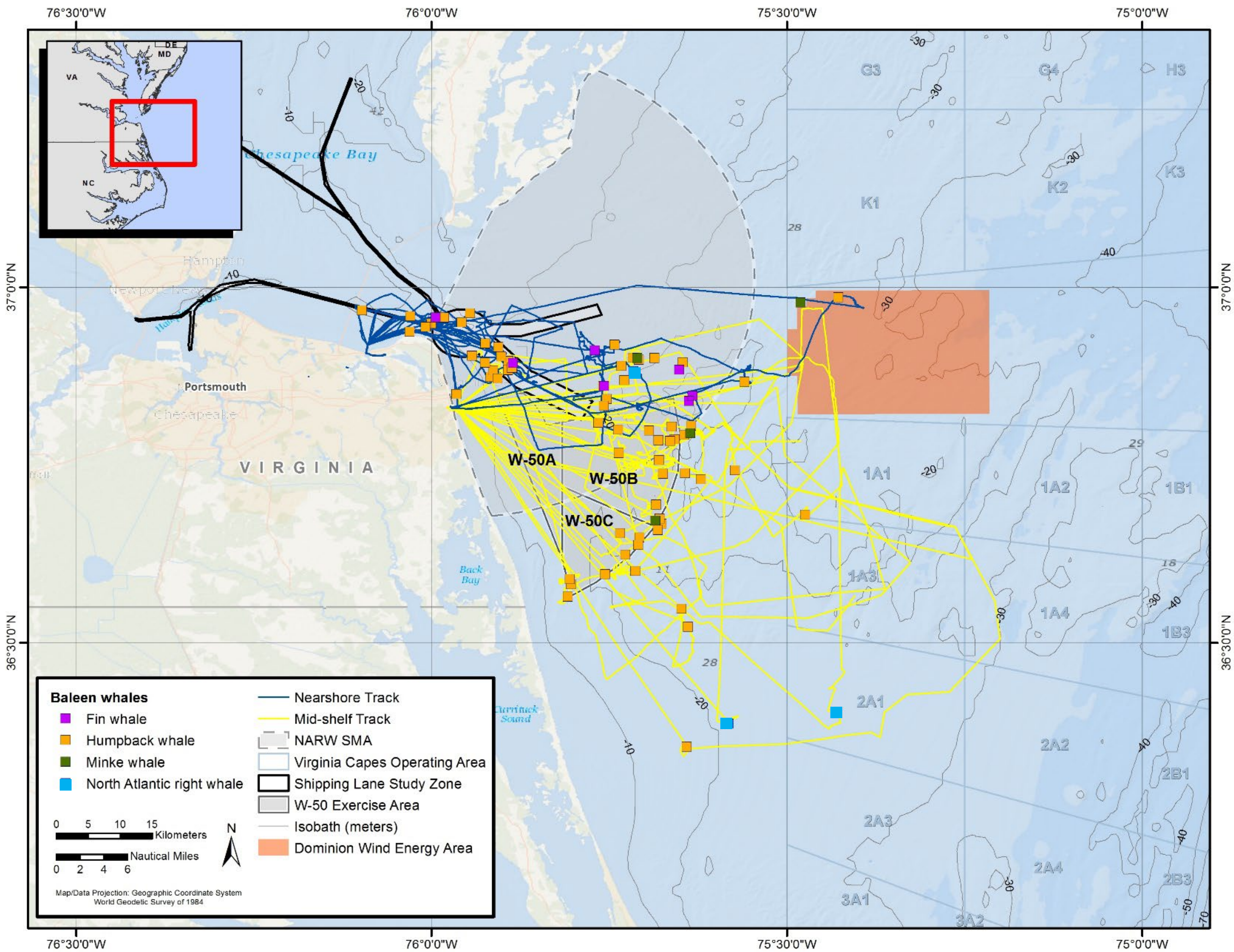


Figure 29. Nearshore survey tracks (gray) and mid-shelf survey tracks (yellow) with locations of all humpback (*n* = 64), fin (*n* = 7), minke (*n* = 4), and NARW (*n* = 3) sightings for the 2021/2022 field season.

2.2.2.3 Photo-identification

The 64 sightings of humpback whales included 98 total individuals and resulted in 54 unique humpback whales identified using dorsal fin and fluke images for the season. An additional four humpback whales were also seen during the Outer Continental Shelf Break Cetacean Study (see **Section 2.2.3**) surveys in January 2022 and are included in catalog results. Of the 57 total unique humpback whales seen during the 2021/2022 season, 26 (45.6 percent) were classified as sub-adults/adults based on their estimated size in the field; 15 (26.3 percent) were categorized as juveniles, 12 (21.1 percent) were classified as adults, 3 (5.3 percent) were classified as subadults, and 1 (1.8 percent) was classified as a large calf. Twenty (35.1 percent) of the 57 individuals were re-sights to HDR, Inc.'s catalog; 1 individual had not been seen since the 2014/2015 season (HDRVAMn008) and the remaining re-sights included individuals from each of the previous seven field seasons. The additional 37 whales were new individuals added to HDR, Inc.'s growing catalog, which, to date, has 245 unique humpback whales (inclusive of identifications added from the Outer Continental Shelf Break Cetacean Study; see **Section 2.2.3; Figure 30**). Twenty-two of the 57 humpback whales (38.6 percent) were seen on more than one occasion this season and 5 of those were seen on three or more occasions. This is up from the 2020/2021 season in which only four of the 31 (12.9 percent) humpback whales were seen on more than one occasion, and was more comparable to prior seasons (42.9 percent during 2019/2020; 44.7 percent during 2018/2019; 21.9 percent during 2017/2018; and 69.5 percent during 2016/2017).

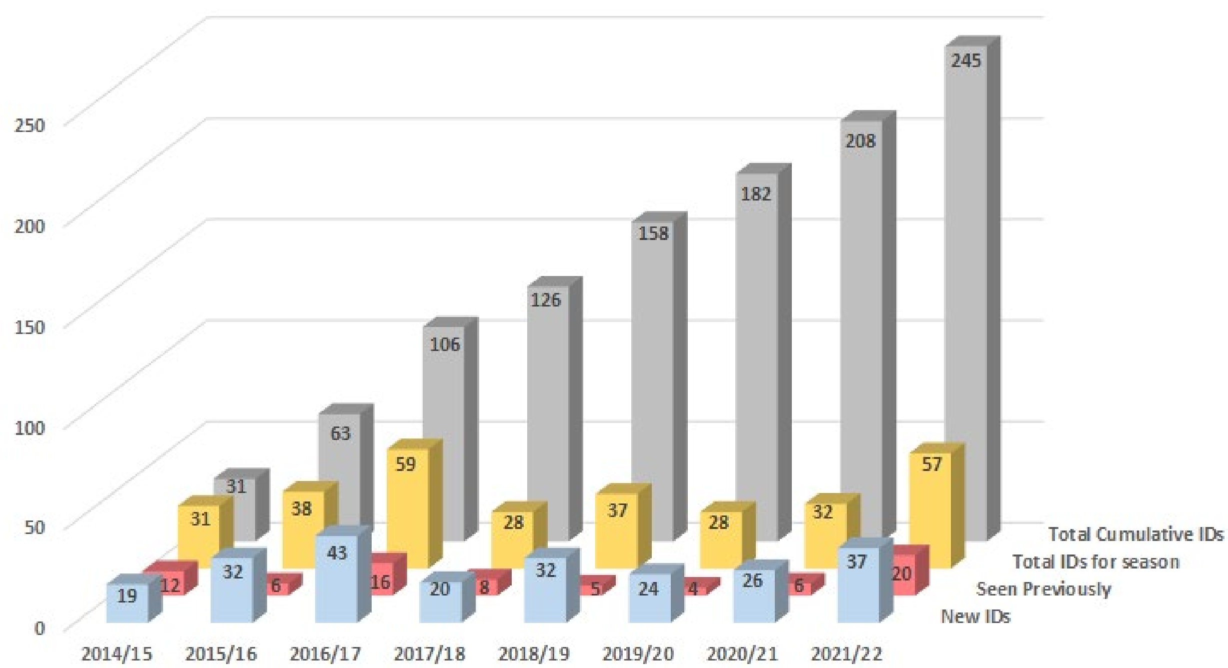


Figure 30. Humpback whale identifications over eight seasons within the Virginia study area: yellow bars = total number of IDs for each season; red bars = number of those IDs that were seen in previously seasons; blue bars = number of new IDs added to the catalog; gray bars = total number of cumulative unique IDs.

Beginning in December 2018, drone video was collected on numerous humpback whales. In the field, live video was used to assist the research team in assessing overall body condition, as well as during tagging attempts to maximize successful deployments. A DJI Phantom 4 Pro V2.0 drone was used to collect morphometric data. Data were typically collected at flight heights between 15 and 30 m, depending on the behavior of the focal animal during the time of the encounter. The drone collected 4K ultra-high-definition video at 30 frames per second. Measurements were using altitude data from the drone's stock barometer, although some error is expected with this method. Open-source software developed by researchers at Duke University (Torres and Bierlich 2020) was used to calculate lengths of 30 individual humpback whales (data from December 2018 through June 2020). Each of these whales has a unique identification in the HDR, Inc. humpback whale catalog and had previously been assigned an age-class based on subjective size assessments from the R/V platform. The measured humpback whales ranged in size from 6.9 to 10.1 m in total length, with a mean value of 8.5 m and a median length of 8.6 m. All whales that measured 9.8 m or greater (n = 6) had been classified as sub-adults or adults in the field. All but one of the whales that measured 8.7 m or less (n = 17) had been classified as juveniles in the field. Whales that ranged from 8.7 to 9.6 m (n = 7) were classified as either juvenile (n = 2), juvenile/sub-adult (n = 1), sub-adult (n = 3), or sub-adult/adult (n = 1) in the field. Following the methodology described in Dawson et al. (2017), the drone was recently retrofitted with a custom Light Detection and Ranging (LiDAR) altimeter. This upgrade increases the precision (to within 5 centimeters [cm]) and consistency of the sUAS altimetry measurements to minimize possible error in measured animal lengths. The photogrammetry techniques remain the same, however, with greater accuracy than the stock DJI barometer.

2.2.2.4 Biopsy Samples

Seven biopsy samples were collected from humpback whales during the 2021/2022 season and are awaiting analysis, along with samples collected during previous field seasons. Thirty-one samples (29 humpback and 2 fin whale samples) from 2014 to 2016 were previously 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). Significant differences occurred in both $\delta^{13}C$ and $\delta^{15}N$ values between the humpback and fin whales within the Virginia 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, it is likely that the humpback whales are feeding at a higher trophic level than the fin whales within this area (Waples 2017). Genetic analyses identified 14 female and 15 male humpback whales from these samples. No significant differences occurred in $\delta^{13}C$ values between male and female humpback whales, but females did have significantly lower $\delta^{15}N$ values than males, indicating that the diets of the two sexes may differ in this area (Waples 2017).

A total of 63 humpback whale samples (including duplicates of the samples provided for stable isotope analysis) was provided to the University of Groningen in the Netherlands for genetic analysis and integration into a larger North Atlantic humpback whale population study. Eight fin whale samples were also provided. Gender results show roughly equal sex ratios of humpback whales (32 males and 31 females) and a skewed gender ratio of 6:1 (males versus female) for fin whales (Bérubé and Palsbøll 2022). Genetic matching to the larger North Atlantic humpback whale catalog of more than 9,200 individuals showed that 18 samples matched to samples collected elsewhere along the eastern U.S. No duplicate humpback whale samples exist in the HDR, Inc. dataset. All samples matched 100 percent on all loci genotyped in both samples in each pair (i.e., no mismatching genotypes were detected). A single pair of duplicate samples was detected between two HDR, Inc. fin whale samples; however, none of the HDR, Inc. fin whale samples matched to the 1,789 samples contained in the North Atlantic fin whale genetic archive (Bérubé and Palsbøll 2022).

2.2.2.5 Tagging

Ten Argos-linked satellite tags were deployed on baleen whales during the 2021/2022 season. Nine tags were deployed on humpback whales: 1 SPOT-6 (Smart Position and Temperature), 2 SPLASH10-292, and 6 SPLASH10-F (**Table 24**). One SPLASH10-F tag was deployed on a NARW (**Table 25**). One SPLASH10-292 tag deployed on a humpback whale never transmitted. The remaining humpback tags transmitted between 2.7 and 13.3 days (mean = 6/.2 days) and the NARW tag transmitted 18.7 days. Whales tagged during this field season showed varied movement patterns, with some exclusively spending time within the primary study area and others moving out of the study area and farther offshore or to the north or south (**Figure 31** and **Figure 32**). Two individuals, *HDRVAMn163* and *HDRVAMn246*, primarily spent time at the mouth of the Chesapeake Bay and heavily used the shipping channels (24.7 and 45.8 percent of locations within shipping channels, respectively). Individuals who spent little to no time within shipping channels (*HDRVAMn012*, *HDRVAMn223*, *HDRVAMn225*, *HDRVAMn243*, *HDRVAMn251*, and *HDRVAMn233*) more heavily used the offshore region of the VACAPES OPAREA (**Figure 31**). The yearling NARW initially showed movement along the coastline to the south, before abruptly changing direction and heading back to the north; first along the coast but then moving out to deeper, continental shelf waters before the tag stopped transmitting approximately 40 km off Delaware Bay. This individual covered more than 2,200 km during the 18-day deployment (roughly 124 km/day) (**Figure 33**).

Eight of the satellite tags recorded information on dive depth and duration in addition to the Argos capabilities (**Table 26**). Seven humpback whale tags record a total of 4,519 dives. Mean dive depth ranged from 13.9 to 17.6 m with a maximum dive depth of 281 m by one individual. Mean dive durations ranged from 2.7 to 3.1 minutes. One NARW tag recorded a total of 1,770 dives. Mean dive depth was 20.2 m, and mean dive duration was 4.5 minutes.

Table 24. Satellite-tag deployments on humpback whales during the 2021/2022 field season.

Animal ID	Estimated Age Class	Tag Type	Argos ID	Deployment Date	Last Transmission Date	Tag Duration (Days)
HDRVAMn219	Adult	SPLASH10-292	177355	21-Nov-21	N/A	—
HDRVAMn223	Adult	SPLASH10-292	183916	1-Dec-21	4-Dec-21	2.7
HDRVAMn225	Adult	SPOT-6	177042	4-Dec-21	11-Dec-21	6.2
HDRVAMn233	Adult/ Sub-adult	SPLASH10-F	208691	17-Dec-21	21-Dec-21	3.8
HDRVAMn012	Adult	SPLASH10-F	208692	19-Jan-22	24-Jan-22	4.2
HDRVAMn243	Adult/ Sub-adult	SPLASH10-F	221008	19-Jan-22	26-Jan-22	6.7
HDRVAMn163	Juvenile	SPLASH10-F	201569	31-Jan-22	13-Feb-22	13.3
HDRVAMn251	Juvenile	SPLASH10-F	201570	9-Feb-22	14-Feb-22	4.2
HDRVAMn246	Juvenile	SPLASH10-F	201571	10-Feb-22	19-Feb-22	8.7

Key: ID = identification; N/A = not available

Table 25. Satellite-tag deployments on North Atlantic right whales during the 2021/2022 field season.

Animal ID	Age Class	Tag Type	Argos ID	Deployment Date	Last Transmission Date	Tag Duration (Days)
Calf of 3232	Yearling	SPLASH10-F	208687	21-Feb-21	11-Mar-22	18.7

Key: ID = identification

Table 26. Summary of dive data collected from all tagged baleen whales during the 2021/2022 season.

Animal ID	Species	Argos ID	No. Dives Logged	Mean Dive Depth (m)	Max Dive Depth (m)	Mean Dive Duration (mm:ss)	Max Dive Duration (mm:ss)
HDRVAMn223	Humpback whale	183916	255	16.9	22.0	02:58	06:05
HDRVAMn233	Humpback whale	208691	370	17.6	26.0	03:07	08:47
HDRVAMn012	Humpback whale	208692	405	14.4	29.0	03:04	08:29
HDRVAMn243	Humpback whale	221008	500	16.5	281.0	02:42	05:37
HDRVAMn163	Humpback whale	201569	1434	13.9	32.0	02:46	06:31
HDRVAMn251	Humpback whale	201570	495	16.1	33.0	03:04	05:41
HDRVAMn246	Humpback whale	201571	1060	15.3	33.0	02:51	05:27
Calf of 3232	NARW	208687	1,770	20.2	94.0	04:29	12:45

Key: ID = identification; Max = Maximum; m = meter(s); mm:ss = minutes:seconds

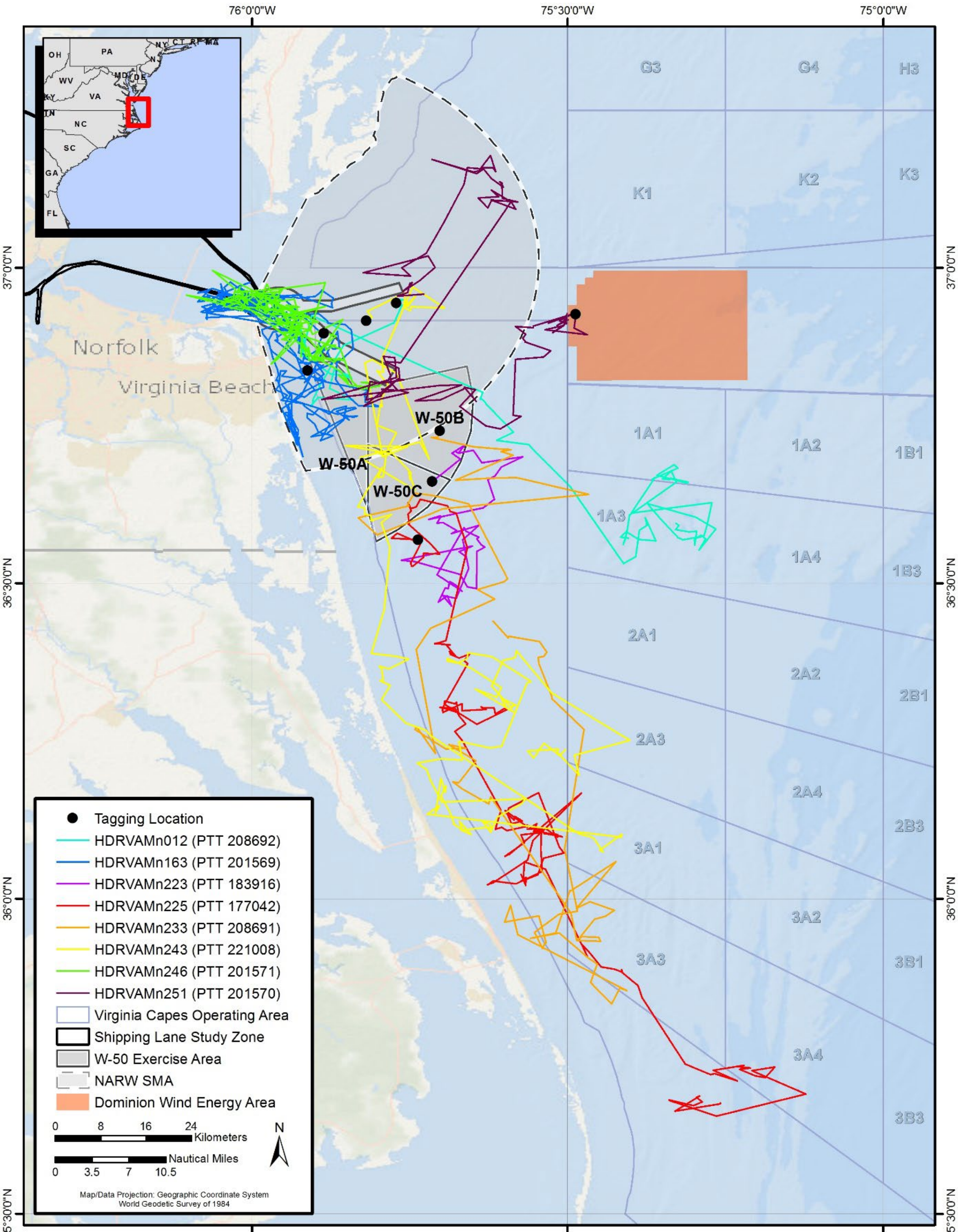


Figure 31. Argos trackline for all humpback whales (*n* = 8) tagged during the 2021/2022 field season.

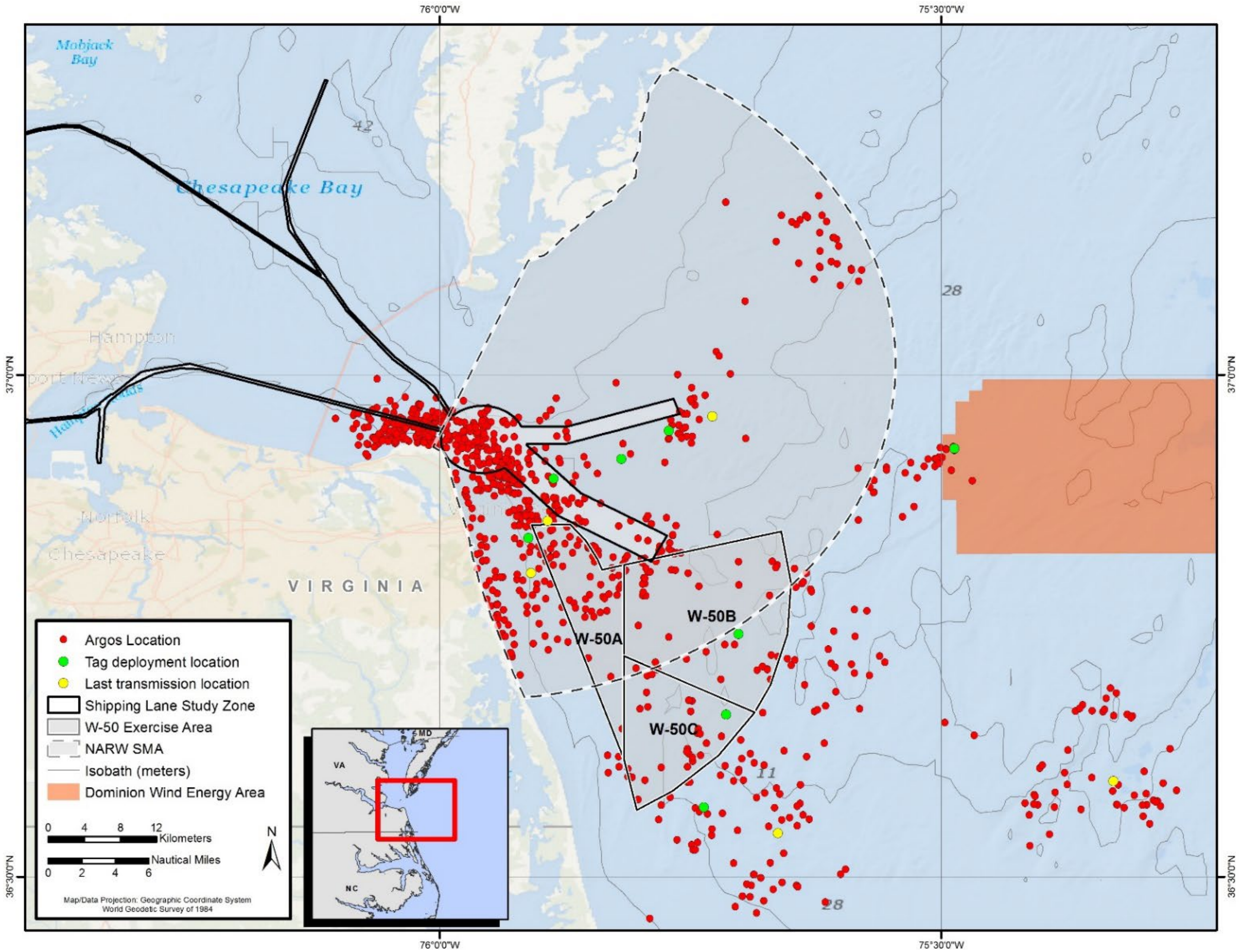


Figure 32. Filtered locations of all humpback whale Argos locations within the immediate vicinity of shipping channels at the mouth of Chesapeake Bay from tag deployments (*n*=8) during the 2021/22 field season

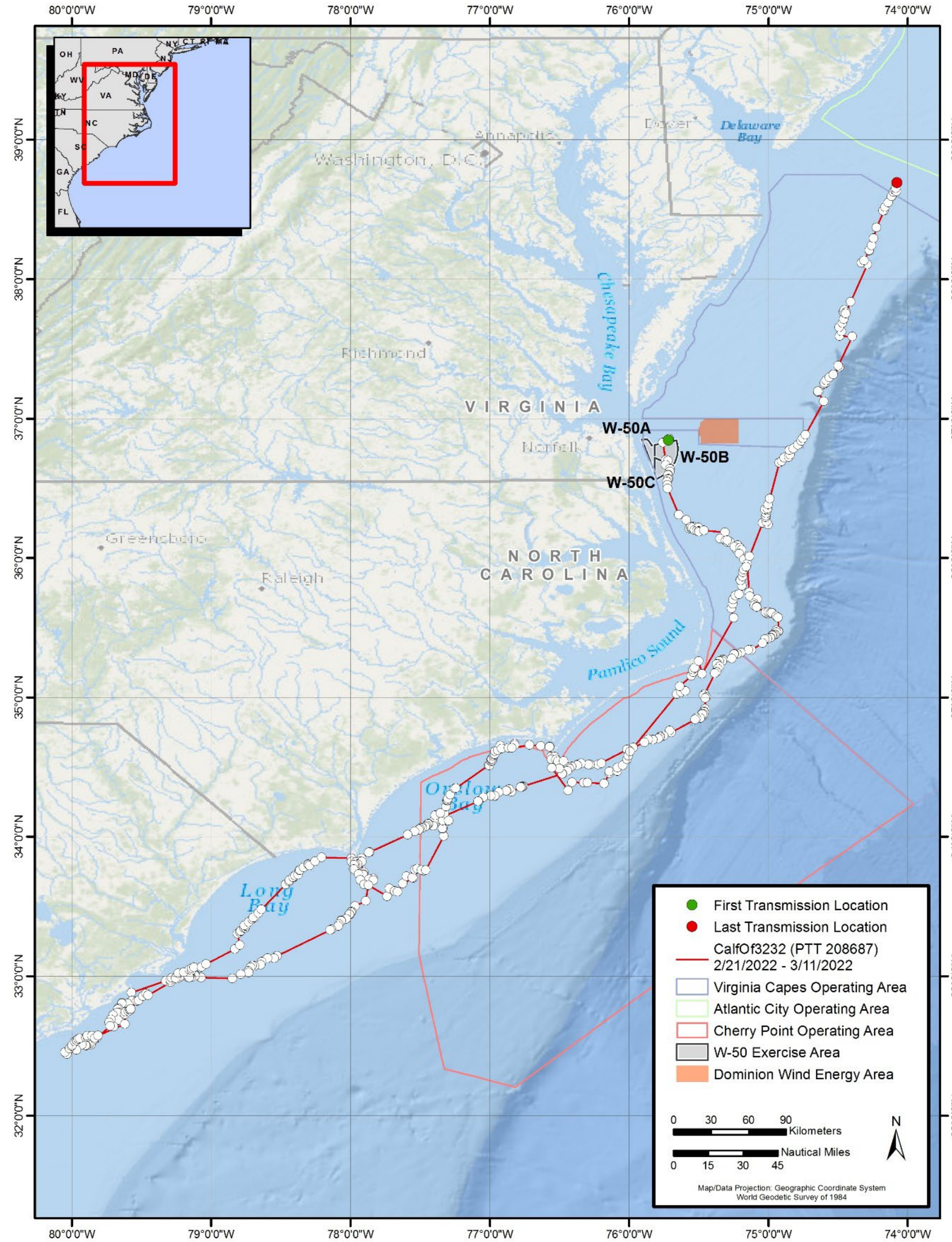


Figure 33. Argos locations and trackline of the North Atlantic right whale 'Calf of 3232' tagged during the 2021/2022 field season.

In January 2019, Duke University researchers initiated a concurrent tagging project on whales around the shipping lanes within the Chesapeake Bay study area. This study continued into the 2020/2021 and 2021/2022 field seasons. High-resolution 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**. In November 2020, HDR, Inc. also incorporated the use of DTAGs into their existing projects. The goal was to deploy tags on individuals within the mid-shelf region to learn more about their foraging and fine-scale dive behavior within these areas. Two DTAGs were deployed on humpbacks whale during the 2021/2022 season (**Table 27**; **Figure 34**); however, one tag broke on impact and was not recovered. The recovered tag recorded 805 minutes of data and was deployed in association with a SPLASH10-F satellite tag (**Table 27**).

Table 27. DTAG deployment on a humpback whale during the 2021/2022 field season.

Animal ID	Species	DTAG Number/ Deployment ID	Deployment (GMT)	Depth at Tagging (m)	Tag off Animal (GMT)	Tag Duration (min)
HDRVAMn219	Humpback	321 / mn21_325a[a]	2021-Nov-21 15:26	13	Unknown	—
HDRVAMn012	Humpback	321 / mn21_351a	2021-Dec-17 17:18	20	2021-Dec-18 06:43	805

Key: ID = Identification; GMAT = Greenwich Mean Astronomical Time; m = meter(s); min = minute(s)
[a] Tag broke on impact and not recovered

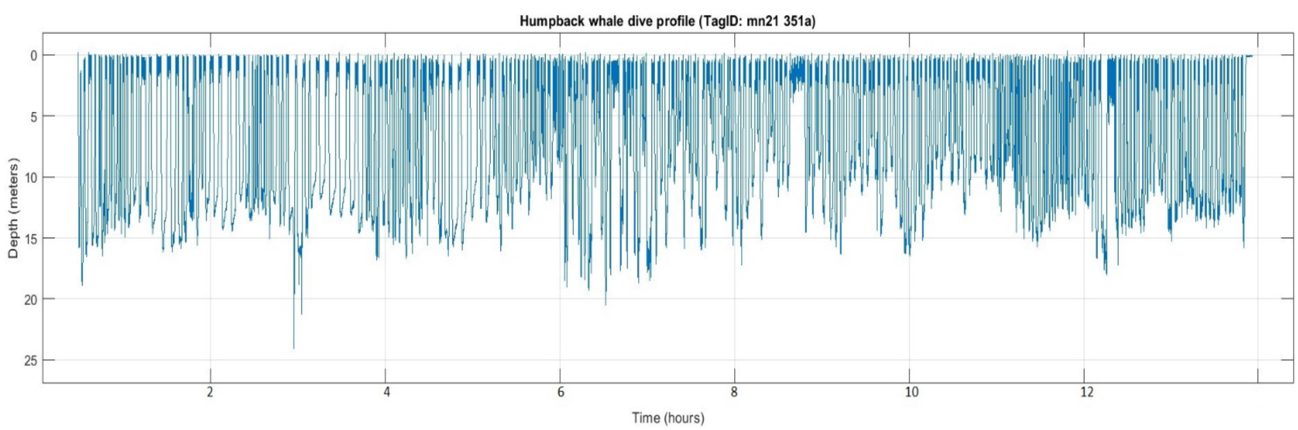


Figure 34. Dive profile for humpback whale HDRVAMn012 (DTAG *mn20_351a*).

2.2.2.6 Discussion

Data analyses for this study are ongoing. Results to-date indicate some site fidelity to the study area for humpback whales over a period of days to weeks and some returning to the area in subsequent seasons. As the project has evolved to push effort farther offshore into the mid-shelf region, the estimated age class of individual humpback whales has shifted from primarily juveniles (in previous years) to older age-classes, as seen during the 2021/2022 season. A high level of occurrence within the shipping channels continues to be prevalent for animals using the nearshore waters; these are important high-use areas for both the U.S. Navy and commercial traffic. Further effort into the mid-shelf region has shown that another subset of animals is also spending time in or near the W-50 Mine Neutralization Exercise (MINEX) zone and the broader offshore VACAPES OPAREA, where they are presumably within the hearing range of underwater detonation training exercises. Use of the Dominion Wind Energy Area, approximately 27 miles off the coast of Virginia, will be of interest in the coming years as the wind farm grows from the two turbines (currently) to 176 turbines. Vessel interactions within the overall study area remain a concern for humpback and other baleen whales. Nearly 10 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 2017, NMFS declared an Unusual Mortality Event (UME) 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 UME investigation process remains ongoing. Additionally, an UME for NARWs was also declared in 2017, with 97 instances of mortalities, serious injuries, and morbidity, primarily from rope entanglements and vessel strikes. The first vessel-related death of a NARW in 2023 occurred in Virginia Beach and highlights the potential for injuries and fatalities in this area.

For more information regarding this study, refer to the annual progress report for this project (Aschettino et al. 2023).

2.2.3 VACAPES Outer Continental Shelf Cetacean Study

Since 2012, HDR has collaborated with the U.S. Navy to conduct marine mammal surveys near Naval Station Norfolk, Joint Expeditionary Bases-Little Creek and Fort Story, and Naval Air Station Oceana Dam Neck Annex, and within the W-50 MINEX zone (Engelhaupt et al. 2016). However, limited survey effort has previously occurred farther offshore of the Virginia coast—within the VACAPES OPAREA near the continental shelf break. Therefore, limited data and information exists regarding how offshore species, including beaked whales, endangered fin and sperm whales, and other large baleen whales use 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 subsequently became a dedicated project in July 2016 (Engelhaupt et al. 2017). The goal of this study is to determine the seasonal occurrence, movement patterns, site fidelity, behavior, and ecology of cetaceans within VACAPES OPAREA offshore waters. During the vessel surveys, researchers use a combination of techniques, including focal follows, photo-ID, biopsy sampling, unmanned aircraft systems, and satellite-linked telemetry tags. Activities conducted during the 2022 field season are summarized below and detailed in Engelhaupt et al. 2023.

2.2.3.1 Survey Summary

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 to more than 2,000 m. HDR, Inc. conducted 11 offshore vessel surveys during 2022, covering 3,304 km of trackline.

One-hundred-five marine mammal sightings and 3 sea turtle sightings were recorded during vessel surveys in 2022 (**Figure 35**). Ten cetacean taxa were identified (in order of decreasing frequency): common bottlenose dolphin (*n* = 26), pilot whale (*n* = 22), common dolphin (*n* = 22), sperm whale (*n* = 11), Risso's dolphin (*n* = 9), fin whale (*n* = 5), humpback whale (*n* = 5), blue whale (*n* = 2), Cuvier's beaked whale (*n* = 1), and True's beaked whale (*Mesoplodon mirus*; *n* = 1). Additionally, there was one sighting of an unidentified beaked whale. One sea turtle species was identified: loggerhead turtle (*n* = 3). Given the study's focus on priority species that do not include pilot whales, the overlapping range of both short-finned and long-finned pilot whales (*Globicephala melas*) within the study area, and the challenge of identifying the genus *Globicephala* down to species from a distance, most pilot whale groups were classed as unidentified pilot whales.

Sightings of deep-diving species, including sperm whales and pilot whales, were again concentrated beyond the shelf break and into deeper offshore waters during 2022 surveys, though some sperm and pilot whale sightings were inside Norfolk Canyon near the shelf break. Baleen whales were encountered both over the shelf and beyond the shelf break as during previous years of this study, but the majority of fin whale sightings were beyond the shelf break. A sighting of four blue whales milling within 5 km of each other was of particular importance; such an aggregation has not been documented previously in this study. Dolphin species were sighted throughout the core study and transit areas, similar to previous years, and only three loggerhead sea turtle sightings were recorded, all over the continental shelf.

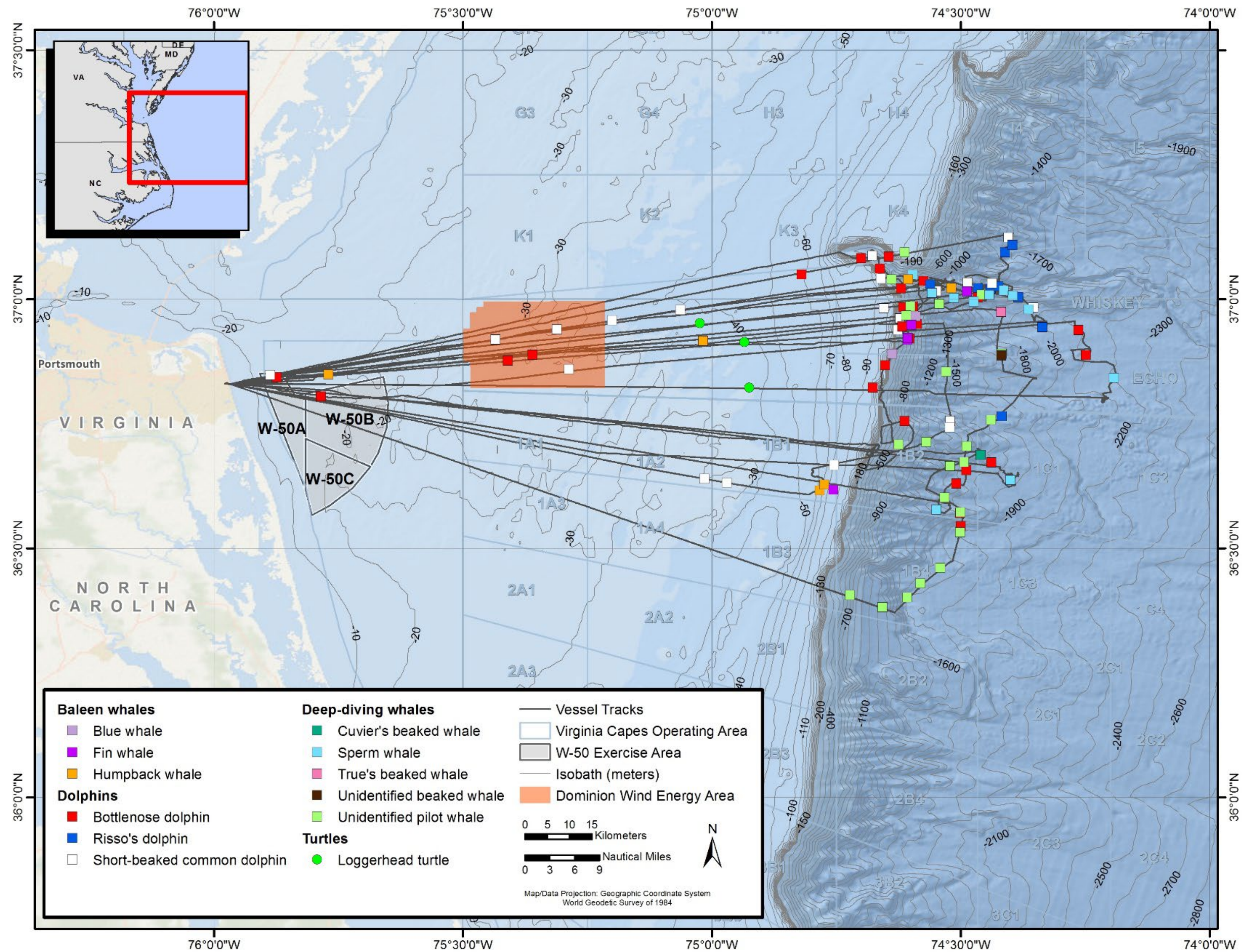


Figure 35. All tracklines and sightings of marine species for OCS field work conducted in 2022.

2.2.3.2 Photo-ID

Photo-ID images were collected during 41 of the 105 marine mammal sightings. Baleen and sperm whale images were added to HDR, Inc.'s existing catalogs, which now contain 272 humpback whales (**Section 2.2.2**), 113 fin whales, 22 NARWs, 10 minke whales, 2 sei whales, 7 blue whales, 129 sperm whales, 8 Sowerby's beaked whales, 5 Cuvier's beaked whales, and 3 True's beaked whales. Of the 113 identified fin whales, 16 (14.2 percent) have been re-sighted; 11 (9.7 percent) of them during different years ranging from 248 to 2,204 days between first and last sightings. All fin whale resightings have been over the continental shelf inshore of the 100-m depth contour. Nineteen of the 129 identified sperm whales (14.7 percent) were sighted on more than 1 day, ranging from 1 to 1,402 days between first and last sightings. Three of the sperm whales photographed in 2022 were sighted previously in this study, one first documented in June 2017 and two during May 2018. Photo-ID images of the four identified blue whales were sent to Mingan Island Cetacean Study colleagues, who attempted to match it to their North Atlantic blue whale catalog and found no matches. The humpback whale photographs were added to HDR, Inc.'s humpback whale catalog, which is summarized in that project's report (Aschettino et al. 2023; see **Section 2.2.2** of this report). Pilot whale photographs that are collected have been shared with Duke University; 2021 and 2022 images processed added 15 individuals to the Norfolk catalog, including 1 new match to the Cape Hatteras catalog (see Waples and Read 2021, 2022, 2023; see **Section 2.1.1.1** of this report). The updated total of matches between Virginia and North Carolina remains 15 percent (44 of 295).

2.2.3.3 Biopsy Samples

Four biopsies were collected from sperm whales and processed at Oregon State University along with three samples collected in 2021. Results show two females and five males. One biopsy was also collected from a blue whale, which is being stored for processing at a later date.

2.2.3.4 Tagging

Six satellite tags were deployed on sperm whales in 2022; all were SPLASH-10 tags, which collect location and dive depth/duration information (**Table 28**). Tag duration ranged from 8.7 to 17.2 days (mean = 11.5 days). Maximum distance from initial tagging location ranged from 38 to 312 km (mean = 190.9 km), and mean distance from tagging locations for each tagged individual ranged from 21 to 189 km (mean = 103.7 km). Maximum dive depth ranged from 1,247 to 1,855 m, and maximum dive duration ranged from 56 to 69 minutes.

Satellite-tagged sperm whales showed movements through multiple U.S. Navy OPAREAS, mostly along the continental shelf break and beyond the slope. Movements of four tagged sperm whale individuals remained within the VACAPES OPAREA for the duration of the tag transmissions. Two other tagged sperm whale individuals moved along the continental shelf break, one to the north (but still within the VACAPES OPAREA) and then back to the south through the Cherry Point OPAREA, and the other individual initially farther to the north (through the Atlantic City OPAREA) and then within Hudson Canyon at the edge of the Narragansett Bay OPAREAs before turning back south (**Figure 36**).

One blue whale was also tagged with a SPLASH-10F tag, with a transmission duration of 0.7 day. Due to the short duration, locations from the tagged blue whale show little movement all within 4.8 km of the tagging (**Figure 37**). Maximum dive depth was 237 m and maximum dive duration was 8.9 minutes.

Table 28. Satellite tag deployments for all species during OCS field work in 2022.

Animal ID	Species	Tag Type	Deployment Date	Last Transmission Date	Tag Duration (Days)
HDRVAPm114	Sperm whale	SPLASH10-F	16-Mar-22	25-Mar-22	8.9
HDRVAPm115	Sperm whale	SPLASH10-292B	21-Apr-22	09-May-22	17.2
HDRVAPm117	Sperm whale	SPLASH10-292B	23-Apr-22	02-May-22	8.7
HDRVAPm118	Sperm whale	SPLASH10-292B	30-May-22	10-Jun-22	10.5
HDRVAPm119	Sperm whale	SPLASH10-292B	30-May-22	13-Jun-22	13.4
HDRVAPm121	Sperm whale	SPLASH10-292B	29-Jun-22	10-Jul-22	10.5
HDRVABm006	Blue whale	SPLASH10-F	21-Oct-22	22-Oct-22	0.7

Key: ID = Identification

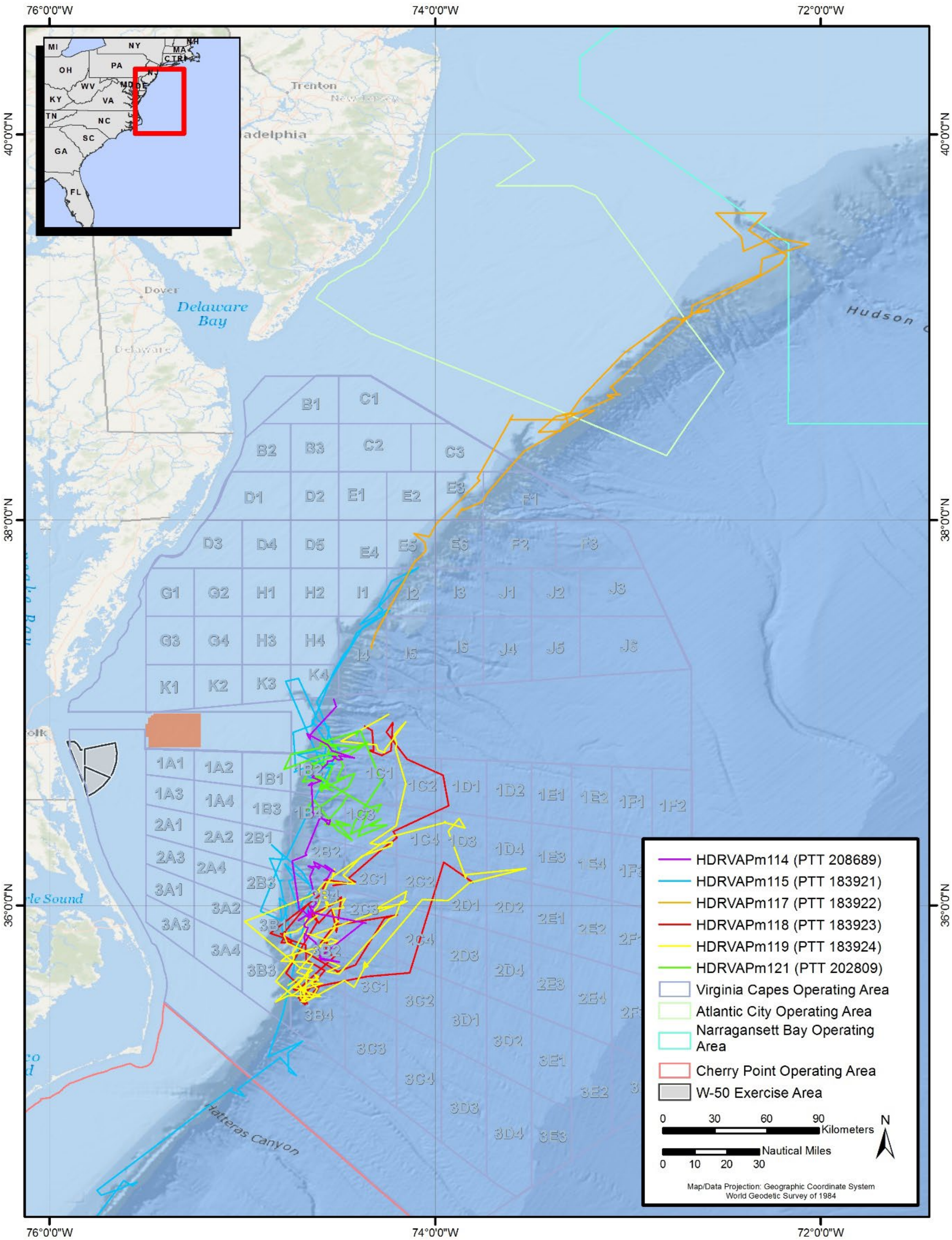


Figure 36. Tracks of all sperm whales tagged during OCS field work in 2022.

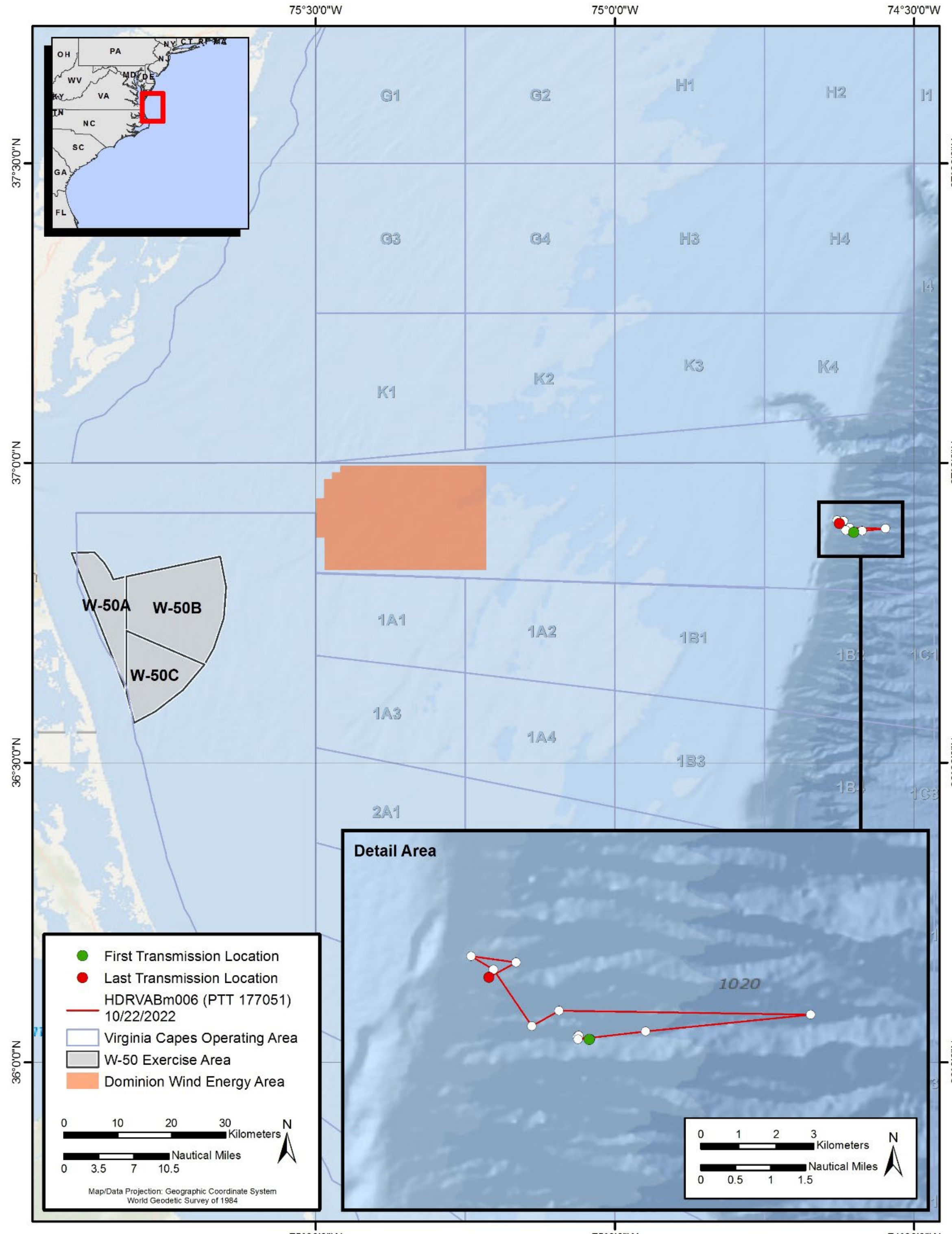


Figure 37. Filtered locations (white dots) and track of blue whale HDRVABm006 over 0.7 day.

The planned incorporation of DTAGs into this project saw its first successful deployment on a sperm whale in April 2022. Three DTAGs were deployed in total, all on sperm whales, with recordings lasting 199, 281, and 132 minutes (**Table 29**). These data are still being analyzed; however, dive-depth profiles for all individuals are shown below (**Figure 38**).

Table 29. DTAG deployments on sperm whales during 2022.

Animal ID	DTAG Number/ Deployment ID	Deployment (GMT)	Depth at Tagging (m)	Tag off Animal (GMT)	Tag Duration (mins)
HDRVAPm117	321 / pm22_113a	2022-Apr-23 15:36	1,228	2022-Apr-23 18:55	199
HDRVAPm119	321 / pm22_150a	2022-May-30 16:02	1,947	2022-May-30 20:41	281
HDRVAPm116	346 / pm22_189a	2022-Jul-08 14:56	1,778	2022-Jul-08 17:08	132

Key: ID = Identification; GMAT = Greenwich Mean Astronomical Time; m = meter(s); min = minute(s)

Fieldwork and data-analysis efforts for this project are ongoing and continue to yield positive progress. Survey results show a high diversity of marine mammal species, including deep-diving sperm whales and Cuvier's, True's, and Sowerby's beaked whales, as well as ESA-listed baleen whales, including blue and fin whales, within this high-use U.S. Navy training and testing activity area. As the study has continued, coverage has been adapted to better describe the occurrence of the species most at risk of long-term consequences from potential anthropogenic interactions. The documentation of a group of blue whales and satellite tagging of one individual during 2022 has added to the limited knowledge of the movements of this ESA-listed species within Virginia waters, supporting the previously published records of sightings off Virginia (D. Engelhaupt et al. 2020, 2022). Continued steps for the project toward providing a more detailed understanding of fine-scale foraging ecology of sperm whales have been made in 2022, with the addition of DTAG deployments on deep-diving sperm whales. Although photo-ID requires a multi-year commitment to accumulate sufficient data to produce meaningful contributions towards understanding site-fidelity and ultimately population consequences, the steady increase of matches of fin whales on the continental shelf across years provides evidence of site-fidelity displayed by an ESA-listed species whose movements are not well understood in this region. The importance of the Norfolk Canyon and surrounding waters to ESA-listed sperm whales is also becoming evident through individual re-sightings, group structure (including those with calves), tagged whale movements, and dive behavior. With every new survey conducted and each tag deployed on multiple species across seasons, the study team expands their knowledge of marine mammal and sea turtle occurrence and habitat use within this important U.S. Navy training range.

For more information on this study, refer to the annual progress report for this project (Engelhaupt et al. 2023).

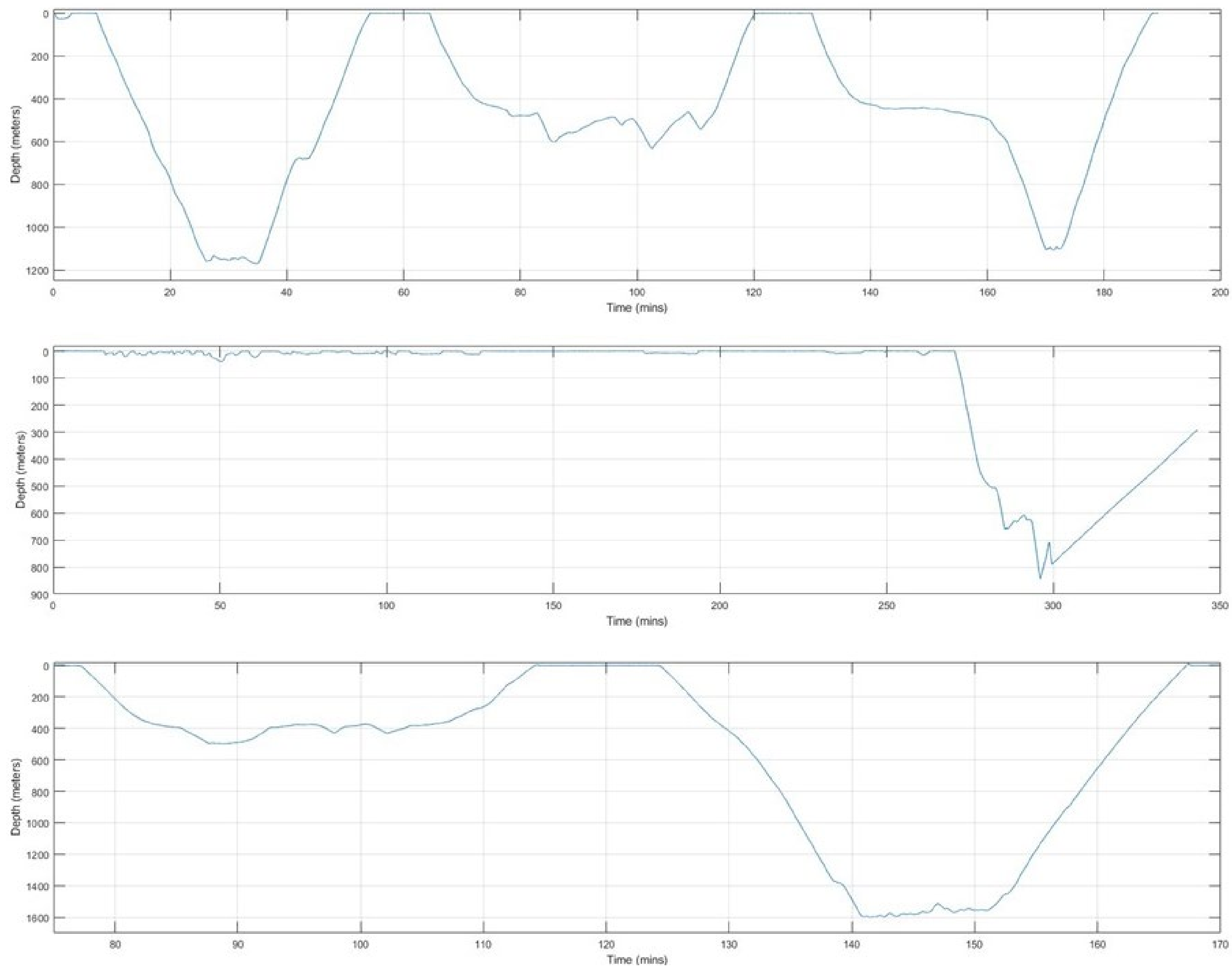


Figure 38. Dive-depth profile (m) for sperm whales, DTAG pm22_113a (top), DTAG pm22_150a (center), and DTAG pm22_189a (bottom). The uniform depth change after 300 minutes for pm22_150a is after the tag released from the whale. Note that the X and Y axes are different scales for each individual.

2.2.4 Pinniped Tagging and Tracking in Southeast Virginia

Since the passage of the MMPA in the U.S. in 1972 (16 U.S. Code § 1361 14 et seq.), the harbor seal population has grown in the northwest Atlantic Ocean (Hayes et al. 2022). Harbor seals are year-round inhabitants of the coastal waters of eastern Canada and Maine (Katona et al. 1993) and occur seasonally along the coasts from southern New England to Virginia from September through late May (Hayes et al. 2021). Harbor seals in the mid-Atlantic region undertake seasonal migrations to northern areas for pupping and mating in spring and summer, and return to more southerly areas in fall and winter (Ampela et al. 2021; Hayes et al. 2022). Within the last decade, harbor seals have been observed returning seasonally to haul-out (resting) locations in coastal Virginia, and one to a few gray seals are occasionally observed during the winter, but not on a consistent basis (Jones and Rees 2023).

U.S. Navy biologists have been researching seal occurrence within and around Chesapeake Bay since 2013. Systematic counts have been conducted since 2014, and time-lapse trail cameras have recorded counts since 2019 (see **Section 2.1.1.3**). Results from these surveys indicate that seals arrive in the area in fall and depart in spring (Jones and Rees 2023). However, 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 U.S. 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 studies (haul out counts and photo-ID) are useful for estimating the minimum number of animals present on land at various times of the year and local abundance, tagging 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. This is the goal of the Pinniped Tagging and Tracking study. 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 (**Figure 39**), where seals haul out between fall and spring. The Eastern Shore haul-out area has several discrete haul-out sites (five main locations within the marsh, which can further be broken down into a total of nine smaller sites) where seals have been observed (Jones and Rees 2023). These sites are located in a tidal salt marsh consisting of muddy banks and vegetation, which is subject to tidal influx.

Seal captures followed a similar protocol as described by Jeffries et al. (1993). Seals were captured in the water adjacent to haul-out site(s) using a modified seine net and two or three small flat-bottomed vessels with outboard motors, and brought onshore after being secured in the capture net.

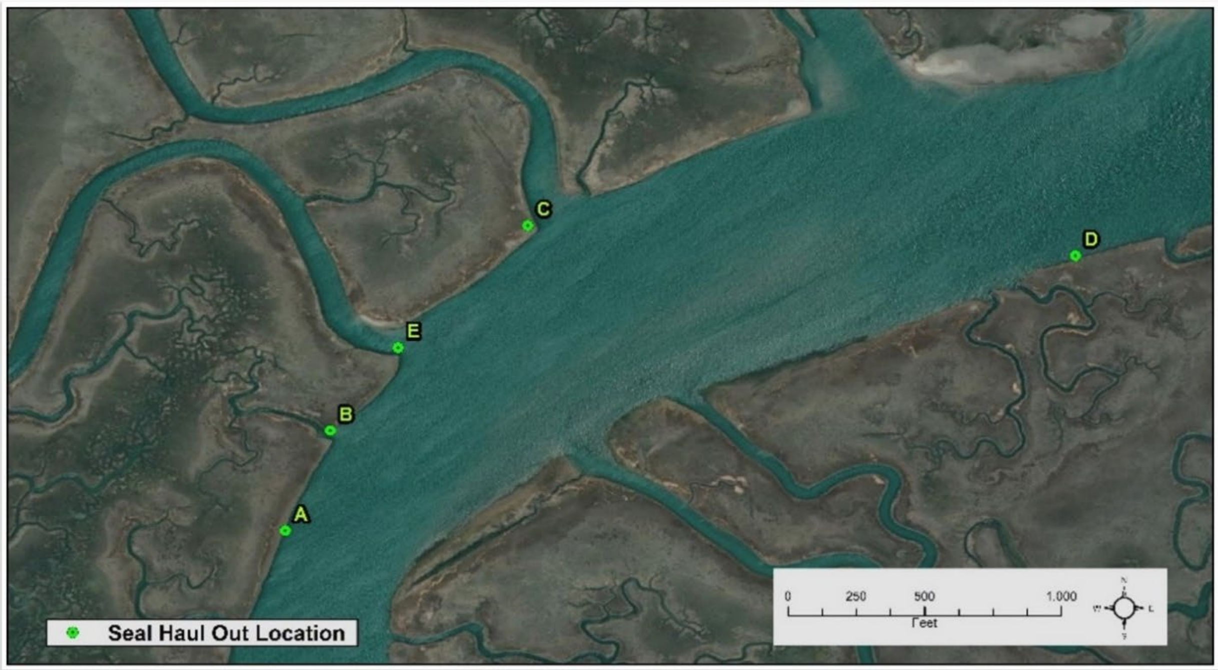


Figure 39. Aerial photo of five established seal haul-out locations on the Eastern Shore of Virginia.

Vinyl AllflexTM livestock ear tags were attached to the seal's left and right hind flipper webbing. These flipper tags featured unique identifiers specific to this study and are used for purposes of individual identification if resighted as they potentially stay attached for multiple years. Each seal was also instrumented with a Global Positioning System (GPS)-enabled depth-sensing satellite tag that provided location accuracy of up to 20 m, designed for tracking fine-scale horizontal movements as well as vertical (dive) movements. Satellite tags were glued directly to the seals' fur on the head or shoulder area (depending on the size of the animal) using DevconTM 20845 High Strength 5-Minute Epoxy. The tags are designed to fall off during the annual molt in July, following the May to June breeding season. A suite of biological samples was also collected from each animal in accordance with NMFS Scientific Research Permit number 21719.

Nine harbor seals were captured and tagged in 2018 and 2020, and another five harbor seals were captured and tagged in 2022, for a total of 14 tags deployed to date as part of this study (**Table 30**; Figure 40). No seals were tagged in 2019 due to several environmental and logistical factors, and fieldwork was not conducted in 2021 due to the COVID-19 pandemic. Over 17 months of telemetry data composed of more than 29,000 individual records from these tagged seals has been uploaded to the Animal Telemetry Network data assembly center. Tag data included the animals' horizontal and vertical (i.e., depth) position, location class, and sensor type. Detailed metadata are also available, including taxonomic information, attribute definitions, data quality and processing steps, and spatial bounds of the data. All five seals tagged in 2022 (one adult female, four juvenile males) were instrumented with GPS-enabled, non-depth-sensing satellite tags (SPLASH10-BF). Satellite tag data were analyzed to investigate seals' use of marine and coastal habitat to include haul-out behavior and a comparison of in-water temperatures and seal in-water behavior, and to create maps of their transits and haul-out locations.

Table 30. Summary of seals tagged in 2018, 2020, and 2022.

Date Tagged	Animal ID	Satellite Tag PTT #	Date of Last Transmission	VEMCO Tag #	Length (cm)	Girth (cm)	Weight (kg)	Sex	Estimated Age
04-Feb-18	1801	166450	23-May-18	15249	102	80	29.0	Male	Juvenile[a]
04-Feb-18	1802	166449	29-Jun-18	N/A	153	118	90.4	Male	Adult
04-Feb-18	1803	166451	06-May-18	15251	129	99	58.8	Female	Juvenile[a]
04-Feb-18	1804	166452	26-May-18	15252	143	119	74.8	Female	Adult
06-Feb-18	1805	166453	09-Apr-18	15253	121	97	49.8	Female	Juvenile[a]
06-Feb-18	1806	173502	22-Jun-18	N/A	149	116	82.2	Female	Adult
06-Feb-18	1807	173503	26-Apr-18	15250	93	77	24.8	Female	YOY[b]
26-Feb-20	2001	177411	12-July-20	N/A	95	80	26.1	Female	Juvenile[a]
02-Mar-20	2002	177410	10-Jun-20	N/A	130	88	47.0	Male	Juvenile[a]
07-Feb-22	2260	178255	8-Jun-22	N/A	119	85	40.6	Male	Juvenile[a]
08-Feb-22	2261	178256	17-Jun-22	N/A	155	116	102.0	Female	Adult
09-Feb-22	2262	178257	18-July-22	N/A	146	114	81.0	Male	Juvenile[a]
15-Feb-22	2263	178258	4-Jun-22	N/A	115.5	85	38.0	Male	Juvenile[a]
15-Feb-22	2264	177412	25-May-22	N/A	121.5	89.5	47.1	Male	Juvenile[a]

Key: cm = centimeters; ID = Identification; kg = kilogram(s); N/A = not available; PTT = platform transmitter terminal; YOY = young of the year

[a] Juvenile = 2–4 years old

[b] YOY = up to 1.5 years old

Seals tagged in 2022 were tracked for an average of 123 days and spent an average of 37 days (30 percent of time tracked) in Virginia waters. The last tagged seal to leave Virginia waters headed north on 10 April 2022; all other tagged seals departed Virginia waters in March. Each seal showed distinct individual differences in their use of the coastal environment while in Virginia waters. Each seal made between 5 and 17 trips to and from the capture site, which ranged from between 8 to 232 km and lasted from 3 hours to 6 days. Some seals used Chesapeake Bay while others did not, and at least one seal never made a trip offshore. The mean in-water temperature recorded by the five 2022 tags while seals were in Virginia waters was 8.95 degrees Celsius (standard deviation = 3.01). All five seals also showed roughly similar temporal haul-out patterns while in Virginia (February––April timeframe) with the majority most likely to haul out between 04:00 and 12:00 local time.

Seals tagged in 2022 showed a broadly similar spatial extent of seasonal movements as seals tagged in previous years (Ampela et al. 2019, 2021). In all 3 years, tagged seals traveled as far north as coastal Maine, and used similar haul-out areas in coastal New York and New England, indicating that tagged seals are using established haul-out sites over time. For the majority of tagged seals, the haul-out sites in New York and southern New England appeared to be stop-overs during the northward migration (**Figure 41**). Haul out sites in coastal New Jersey and Cape Cod Bay were only used in 2022 and 2020, respectively.

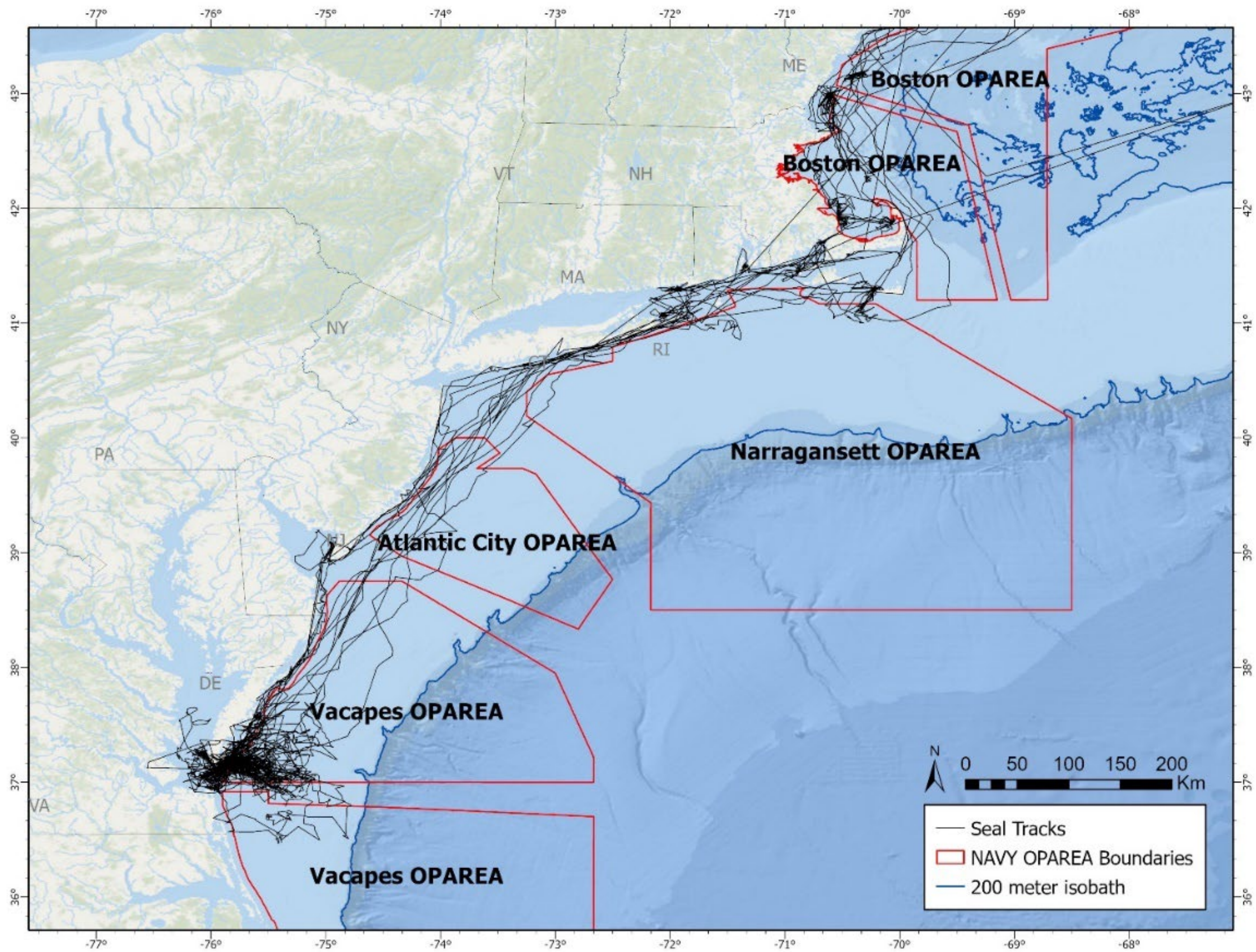


Figure 40. Reconstructed tracks of all 14 seals tagged in coastal Virginia from 2018 through 2022 (maximum tag duration = 160 days) in relation to U.S. Navy OPAREAs.

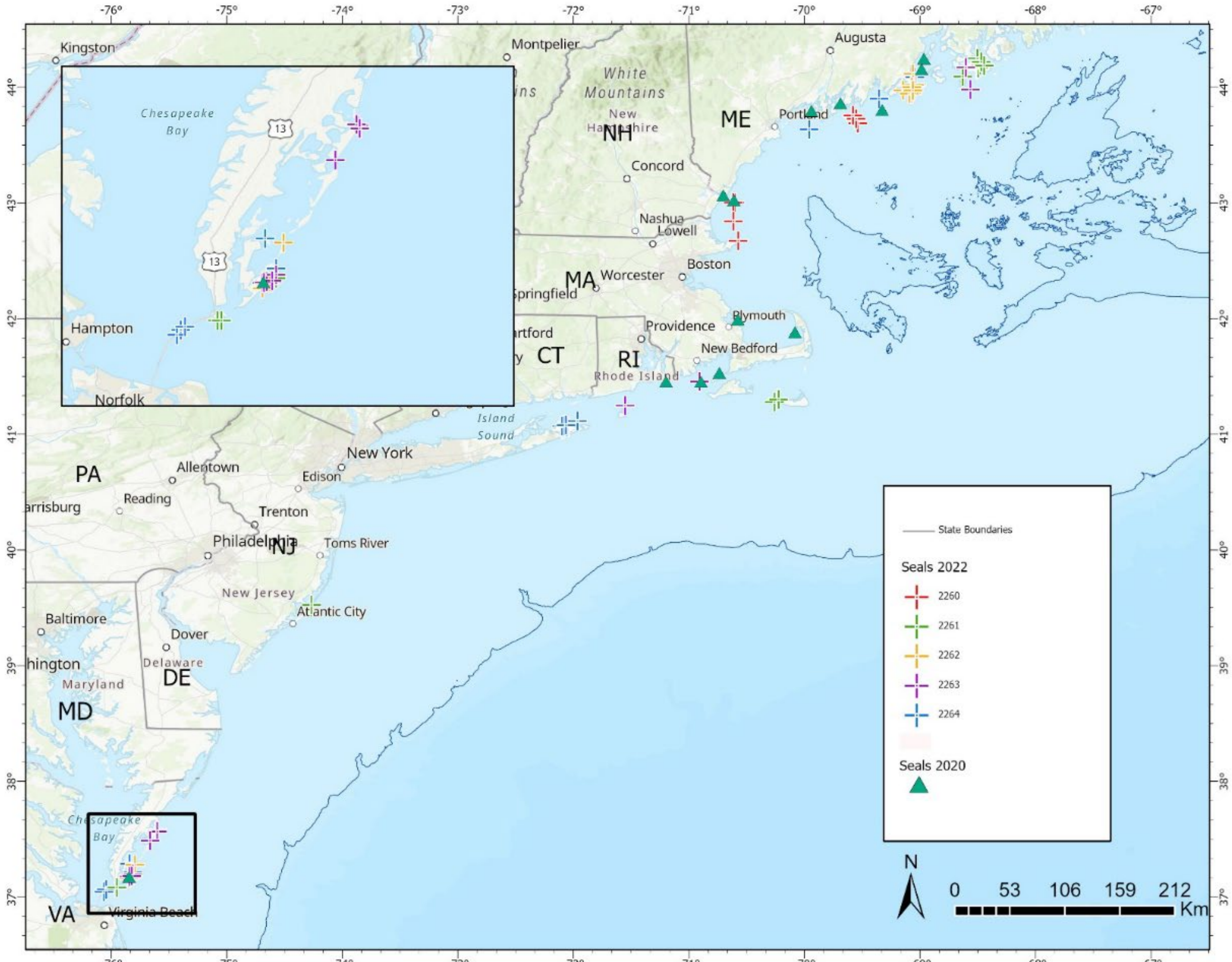


Figure 41. Haul-out locations for the five seals tagged in 2022, compared to the two seals tagged in 2020. Haul-out areas are based on Fastloc® GPS locations classified as "hauled out."

Filtered location data were used to generate utilization distributions and calculate 50 percent and 95 percent habitat use isopleths for each tagged seal (Calenge 2006). The resulting isopleths were overlaid to create relative habitat use maps. Cumulatively, all five seals tagged in 2022 had a 95 percent habitat-use isopleth and 50 percent isopleth (core habitat) that extended as far north as coastal Maine. Animals tagged in 2022 used nearshore waters (between 3 and 10 nm) more often, which resulted in a smaller area of use for these animals compared to animals tagged in 2020. When looking at the cumulative habitat use for all 14 seals, only small portion of the 50 percent isopleths overlapped with the VACAPES OPAREA. Tagged seals had a 95 percent likelihood of being in the lower Chesapeake Bay and using the waters around the mouth of Chesapeake Bay. The 95 percent isopleths did overlap with the VACAPES OPAREA, with a concentration at the western edge of the northern half of the VACAPES OPAREA. The 95 percent isopleths also extended to the southern half of the VACAPES OPAREA offshore of North Carolina. Overall, tagged seals spent a cumulative 669 days in Virginia waters; on 158 of these days (24 percent), satellite tags reported locations within the VACAPES OPAREA.

The 14 harbor seals tagged to date as part of this study represent a variety of age classes and overall have an even sex ratio (7:7). Phocid seals use coastal and marine habitats differently depending on age, sex, and breeding status (Breed et al. 2006, 2009, 2011). While the sample size from this study is still too small to understand how these factors may influence harbor seals' habitat use within and near areas of interest to the U.S. Navy, the information gathered to date has already improved our understanding of the demography of harbor seal movements along the Eastern Seaboard. Results from this study have demonstrated that adult harbor seals make long-distance seasonal movements through the mid-Atlantic and Gulf of Maine, however, it is believed that the majority of seals moving into southern New England and mid-Atlantic waters are subadults and juveniles (Hayes et al. 2022). Based on morphometric measurements, 9 of the 14 seals tagged during this study were estimated to be juveniles, 1 was estimated to be a young-of-the-year pup, and 4 were estimated to be adults.

Harbor seal populations around the world are generally considered to be non-migratory, staying within approximately 50 km of their natal area (Bjørge et al. 1995; Frost et al. 1996; Swain et al. 1996; Ogilvie et al. 2009; Ross et al. 2013; NOAA Fisheries 2022). However, results from this and other tagging studies in the U.S. have documented regular, long-distance (greater than 900 km) seasonal movements (Womble and Gende 2013), which could reasonably be viewed as migratory behavior. Observed movements of seals, such as those tagged in this study, could represent a gradual recolonization of previous habitat prior to near-extirpation by humans (e.g., Wood et al. 2011) and/or exploration of new, suitable habitat, versus a true migratory pattern. If this is the case, then long-distance movements of these seals would be expected to diminish over time and for harbor seals to remain closer to their natal areas, possibly establishing pupping sites farther south along the Eastern Seaboard. The influence of climate change on oceanographic conditions and prey distribution is also likely to drive the distribution and habitat use of Atlantic harbor seals. In addition, it should be noted that individual differences play a significant role in the habitat use and seasonal movements of phocid seals, as shown by this study.

For more information on this study, please refer to the 2021–2022 annual progress report for this project (Ampela et al. 2023).

2.3 Behavioral Response

2.3.1 Atlantic Behavioral Response Study

The Atlantic-BRS was conceived, designed, adapted, and applied through a collaboration building on historical and ongoing U.S. Navy-funded studies under their Marine Species Monitoring Program. It uses a combination of novel multi-scale tagging approaches for baseline monitoring and behavioral response studies at multiple temporal and spatial scales for key marine mammal species, primarily Cuvier's beaked whales and, secondarily, short-finned pilot whales, off the coast of Cape Hatteras, North Carolina. The project advances approaches developed from previous BRS field and analytical work supported by the U.S. Navy's Living Marine Resources program and Office of Naval Research. It is the first systematic effort to quantify sonar exposure and behavioral responses of priority marine mammal species to military sonar using CEEs off the U.S. Atlantic coast.

The Atlantic-BRS was collaboratively designed and strategically adapted by an experienced multi-institutional team. CEE methods involve MFAS—successfully coordinated with operational SQS-53C from U.S. Navy vessels—using strategically deployed, complementary tag sensors on many individuals simultaneously. The project is ongoing but nearing completion of the current approach and methodology focused on MFAS, and continues to add to the largest and most comprehensive data set available for sonar exposure and response for one of the highest-priority marine mammal species for the U.S. Navy, Cuvier's beaked whales.

By design, 2022 included both strategically focused field efforts and intensive analysis. A single extended field period lasted from mid-summer to fall, with tags deployed in appropriate weather windows ahead of anticipated U.S. Navy vessel availability. Building on earlier field seasons of this project (see Southall et al. 2018, 2019, 2020, 2021, 2022), Atlantic-BRS field operations included two control CEEs focused on single tagged individuals, and achieved the primary objective of conducting one CEE with operational MFAS in coordination with the *USS Farragut* (DDG 99) and a large number of tagged beaked whales (n = 8). This CEE strategically included a multi-scale experimental design with a focal individual tagged with a satellite-transmitting tag; a focal individual with a short-term, high-resolution archival tag; and multiple non-focal individuals at variable ranges from an operational MFAS source with long-term pre-exposure data. This CEE completed the dataset for operational MFAS of the conventional lower duty cycle variety.

The overall objective is to directly measure exposure and behavioral responses to U.S. Navy MFAS and quantify behavioral response probability in relation to key exposure variables (e.g., received sound level, proximity, and animal behavioral state). These measurements have and will directly contribute to more informed assessments of the probability and magnitude of potential behavioral responses of these species. These data support the U.S. Navy in meeting their mandated requirements to assess the impacts of training and testing activities on protected species, specifically regarding baseline behavior and exposure-response, and by providing sufficiently large sample sizes to begin addressing exposure consequences, thus directly addressing focal areas for the U.S. Navy's MSM Program.

Previous studies have used short-term, high-resolution acoustic tag sensors to measure fine-scale behavior in response to experimentally controlled noise exposure. Others have used coarser-scale, longer-term measurements of movement and diving behavior associated with incidental exposures during sonar training operations. This study brings both approaches together, applying experience with different tag types and experimental approaches. Notably, the study team has expanded the temporal and spatial scales of previous BRS by combining short-term, high-resolution acoustic archival tags (or DTAGs) that provide short-term (hours) but very high-resolution movement and calibrated acoustic data with satellite-linked, time-depth recording tags that provide much longer-term (weeks to months) data on movement and increasingly higher resolution dive data, which are simultaneously deployed on multiple individuals of focal species in the same CEEs. Strategically specified categories of potential behavioral responses are evaluated using a variety of adaptive and cutting-edge methods, namely: 1) potential avoidance of sound sources that influence habitat usage; 2) changes in foraging behavior; and 3) changes in social behavior.

The 2022 study year represented an important milestone in the overall research program. It was determined prior to the season that a sufficient sample size for simulated MFAS CEEs had been obtained and that one additional CEE with operational vessel MFAS, provided it was conducted with multiple individuals, would adequately round out the data set desired for a comparison of results. The field objective for 2022 was therefore to conduct a single, high-sample-size CEE with an operational vessel, allowing for as many additional control sequences as possible. A relatively intensive analytical emphasis was also planned given the progression of parallel U.S. Navy-funded analytical development and implementation. A brief synthesis of experimental methods is provided, as well as summarized results from the operational vessel MFAS CEE conducted during the 2022 field season. A synthesis of the peer-reviewed papers that have been or are in the process of being published is also provided.

Full details of the experimental design, analytic approach, and field logistics can be found in the 2022 annual progress report (Southall et al. 2023).

2.3.1.1 Field Effort

The Atlantic BRS field effort for 2022 mirrored successful earlier approaches, with fieldwork occurring during a single window spanning early summer through early autumn. Based on a combination of weather conditions and U.S. Navy vessel availability, a small boat-based team (n = 4) aboard the R/V *Barber,* an 8-m aluminum-hulled vessel, conducted advanced deployment of satellite tags. The field crew transited offshore daily when sea conditions were suitable, located animals, deployed tags, and collected photo-ID and other data from groups. During periods in which DTAG deployments and CEEs were attempted, a research crew of approximately six individuals worked from the fast catamaran R/V *Shearwater* along with, in reasonable conditions, the R/V *Barber* (with a crew of four, as above). The R/V *Shearwater* served as an excellent elevated tag tracking and visual observation platform before, during, and after CEEs. These vessels were generally involved in tag deployment and CEE efforts, as well as in re-sighting and biopsy sampling of focal individuals; thereafter, they were augmented by contracted private fishing vessels as needed.

Overall, eight satellite tags were deployed, all on Cuvier's beaked whales, one of the two focal species of the Atlantic BRS (along with short-finned pilot whales). Please refer to **Section 2.2.1** of this report for more details on the tagging component of this project. One DTAG was deployed on a Cuvier's beaked whale and collected data before, during, and after the successful single MFAS CEE conducted with an operational Navy 53C sonar on the *USS Farragut*.

Controlled Exposure Experiments

Three CEE sequences were conducted during the Atlantic-BRS 2022 field effort. This included two control (no sonar) CEEs focused on single tagged individuals and one successful, complete, operational Navy SQS/53C MFAS CEE (primary 2022 objective) with two focal (one sat tag, one DTAG) and six non-focal whales (**Table 31**).

Table 31. CEEs conducted during 2022 Atlantic-BRS field efforts.

CEE ID	Date	CEE Type	Focal Whales	Non-focal Whales	CEE Duration (min)	Start CEE Source latitude (°N)	Start CEE source longitude (°W)
#2022_01	8/4/22	CONTROL	ZcTag129	ZcTag130 ZcTag131 ZcTag132	30	37.4736	74.2399
#2022_02	8/5/22	CONTROL	ZcTag131	ZcTag129 ZcTag131 ZcTag132	30	35.8362	74.4400
#2022_03	8/7/22	Operational MFAS	ZcTag135; Zc22_219a	ZcTag129 ZcTag130 ZcTag131 ZcTag132 ZcTag133 ZcTag134	60	35.4740	74.4710

Key: ID = identification; min = minute; °N = degrees north; °W = degrees west; Zc = *Ziphius cavirostris* (Cuvier's beaked whale).

Short narrative summaries for each of the two control sequences (**Table 32** and **Table 33**) and comprehensive synthesis of the operational MFAS CEE (#2022_03; see **Table 34**) are provided in the tables. The full 2022 annual progress report for this project (Southall et al. 2023) includes a complete synthesis of each CEE conducted, with standardized tables and figures for each. These include: 1) metadata summaries, 2) planning received level (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. Sequential positioning (**Figure 42**) and actual start and end positions for *USS Farragut* for Atlantic-BRS CEE #2022_03 are shown in **Table 35**.

Table 32. Metadata summary for Atlantic-BRS (CONTROL) CEE #2022_01

CEE # 2022_01	
Date:	**04 August 2022**
Type:	**CONTROL** (no MFAS)
Signal parameters:	*n/a* Positioned R/V Shearwater as done during simulated source CEEs for pre, exposure, and post-exposure phase.
Start time (UTC):	12:30
Start lat/lon (source):	37.4736; -74.2399
End time (UTC):	13:00 (30 min exposure duration matched to simulated MFAS)
End lat/lon (source):	37.4763; -74.2429
Beaked whales tagged during CEE:	(n=1) – **ZcTag129** (focal sat tag animal); Note: ZcTag130, ZcTag131, ZcTag132 had active tags during this CEE but were > 100 km away
Pilot whales tagged:	none
Estimated Range (start CEE):	1.8 km (1 nm) @ start
Modeled Max RL:	*n/a* since no MFAS transmission, but model runs at surface and depth with post hoc positions from 131.2-141.5 dB RMS if transmissions had occurred

CEE #2022_01 - Narrative Summary
At the point in the 2022 field season when this CEE occurred, two whales had been tagged and tracked for nearly two months, while several additional tags had been deployed the previous day. Given the location of these tags and poor weather forecast in the primary research area, the research team in the field on the *R/V Shearwater* focused on ZcTag129 who was far to the north (near Washington Canyon) both to resight it and obtain recent positional data and to conduct a focused control CEE. Given the timing in the tag sequence, data were limited to XY positional data (and thus analyses of potential avoidance behavior) without diving data. There were three other tagged whales (ZcTag130, ZcTag131, and ZcTag132) during this period but they were over 100 km from the CEE location and not deemed effectively part of this CEE. Note: no RHIBs were tracking during this control sequence given conditions and locations. *R/V Shearwater* located and tracked the focal tagged whale, which alone as seen and photographed before and after the CEE in normal tracking and positioning approaches. *R/V Shearwater* was positioned ~1nm from last surface series prior to the control 'exposure' sequence. The focal whale (ZcTag129) was located easily following the CEE in the general area and with no obvious change in behavioral state.

Key: dB RMS = decibels root mean square; n/a = not available; RHIB = rigid-hulled inflatable boat; Zc = *Ziphius cavirostris* (Cuvier's beaked whale)

Table 33. Metadata summary for Atlantic-BRS (CONTROL) CEE #2022_02

CEE # 2022_02	
Date:	**05 August 2022**
Type:	**CONTROL** (no MFAS)
Signal parameters:	*n/a* Positioned R/V Shearwater as done during simulated source CEEs for pre, exposure, and post-exposure phase.
Start time (UTC):	16:55
Start lat/lon (source):	35.8362; -74.4400
End time (UTC):	17:25 (30 min exposure duration matched to simulated MFAS)
End lat/lon (source):	35.8420; -74.410
Beaked whales tagged during CEE:	(n=3) – **ZcTag131** (focal sat tag animal); ZcTag130, ZcTag132 (non-focal sat tags). Note: ZcTag129 was active during this CEE but >100 km away
Pilot whales tagged:	none
Estimated Range (start CEE):	1.8 km (1 nm) @ start
Modeled Max RL:	*n/a* since no MFAS transmission, but model runs at surface and depth with post hoc positions from 126.5-140.7 dB RMS if transmissions had occurred

CEE #2022_02 - Narrative Summary
Given the location of tagged whales in the study area and excellent weather forecast the R/V Shearwater had returned from the previous day CEE very far north. The team was supporting the R/V Barber in locating and identifying candidate groups for tagging; three additional tags were deployed later this day. A control CEE focused on ZcTag131 which was in a group of four whales resighted with high confidence over four surface series to obtain recent positional data and conduct a focused control CEE. XY positional and dive data were obtained. Two other (non-focal) tagged whales (ZcTag130 and ZcTag132) were in the general area during this period; ZcTag 129 was over 100 km from the CEE location and not deemed effectively part of this CEE. Note: no RHIBs were tracking during this control sequence given conditions and locations. *R/V Shearwater* located and tracked the focal tagged whale group, which was photographed before and after the CEE in normal tracking and positioning approaches. *R/V Shearwater* was positioned ~1nm from the focal group at the last surface series prior to the control 'exposure' sequence. The group and focal whale ZcTag131 were located easily following the CEE in the general area and with no obvious change in behavioral state

Key: dB RMS = decibels root mean square; n/a = not available; RHIB = rigid-hulled inflatable boat; Zc = *Ziphius cavirostris* (Cuvier's beaked whale)

Table 34. Metadata summary for Atlantic-BRS CEE #2022_03

CEE # 2022_03	
Date:	**07 August 2022**
Type:	**Operational MFAS Source: *USS FARRAGUT*** (DDG99)
Signal parameters:	Two sequential CP/CW waveforms 0.5-second (sec) duration each with 0.1 sec separation for total ping series 1.1 sec duration
Start time (UTC):	17:10
Start lat/lon (source):	35.483; -74.500
End time (UTC):	18:11 (61 min exposure duration matched to other operational MFAS)
End lat/lon (source):	35.605; -74.7317
Beaked whales tagged during CEE:	(n=8) – **ZcTag135** (focal sat tag animal); Zc22_219a (focal DTAG animal); ZcTag129, ZcTag130, ZcTag131, ZcTag132, ZcTag133, ZcTag134 (non-focal sat tags).
Pilot whales tagged:	none
Estimated Range (start CEE):	13.4 nm @ start for focal whale ZcTag135 13.0 nm @ start for focal whale Zc22_219a (was with ZcTag135 before CEE but not @ start)
Modeled Max RL:	Focal whale ZcTag135: 140.9 dB RMS @ 10m; 140.4 dB RMS @900m Focal whale Zc22_219a: 139 dB RMS @ 10m; 137.3 dB RMS @1400m (note: measured max RL on DTAG for Zc22_219a = 139.3 dB RMS)

CEE #2022_03 - Narrative Summary
For the current CEE, there were a total of eight beaked whales tagged, including two focal whales. This included Zc22_219a, tagged with a DTAG ~3.5h before the CEE, and ZcTag135 tagged with a satellite-transmitting position and depth sensor tag deployed two days earlier. Both focal animals were tracked with on-water visual observations at the time of the CEE from separate vessels. Six other tagged whales (Zcs 129-134) had been tagged from as long as six weeks to as few as two days prior to the CEE. Zcs129 and 130 were transmitting just positions at the time of the CEE (but had some of the longest pre-CEE baseline data of any Atlantic-BRS CEEs) while Zcs131-134 were transmitting both positions and dive data. Offshore conditions on the day of the CEE were suitable for small boat operations and the RHIB *R/V Barber* deployed the DTAG and tracked Zc22_219a before, during, and after the CEE and collected passive acoustic data from a calibrated hydrophone at known locations. A separate charter vessel was used to track Zc135 and collect additional data from other incidentally exposed whales. The Atlantic-BRS chief scientist coordinated through shore-based Fleet Forces Command colleagues, facilitating coordination with the USS FARRAGUT that was ultimately communicated to verify start and end of operations in the field via VHF radio. As designed for the 2022 field season for the Atlantic-BRS effort, this included a large number of whales tagged during an event with an operational sonar with precise and complete requested ship support, tags of both types deployed and successfully recovered, and an optimal spatial configuration of focal and incidental whales. Focal whales were predicted to have been exposed in the experimental target range of 110-140 dB RMS at ranges of ~10-15 nm with incidental whales occurring at variable ranges out to ~60 nm with RLs of ~90-130 dB RMS.

Key: CP/CW = chaotic phase/continuous wave; dB RMS = decibels root mean square; min = minute(s); RHIB = rigid-hulled inflatable boat; sec = second(s); VHF = very high frequency; Zc = *Ziphius cavirostris* (Cuvier's beaked whale)

Table 35. Sequential positioning and actual start/end positions for *USS Farragut* for Atlantic-BRS CEE #2022_03.

Position Request for *USS Farragut*	Description	Latitude (°N)	Longitude (°W)	Heading
1	Nominal initial posit	36.033	74.583	Not specified
2	5 Aug 1300 EDT (~48h pre) based on centroid from multiple prop model runs for in situ sightings and known locations for five tagged whales	36.000	74.500	185
3	6 Aug 1300 EDT (~24h pre) based on centroid from multiple higher quality Argos posits for three tagged whales [note: study team provided both a possible northern starting location and a contingency southern track based on projected vessel location on 7 Aug]	Northern: 36.000 Southern: 35.483	Northern: 74.500 Southern: 74.500	Northern: 185 Southern: 351
4	7 Aug 1100 EDT: Final requested start position – settled on southern start with northerly track based on *USS Farragut* location and timing; retained 24h pre location but modified requested course	35.483	74.500	357
5	Actual start position and course from *USS Farragut* navigation	35.474	74.471	358

Key: °N = degrees north; °W = degrees west; EDT = Eastern Daylight Time; h = hour.

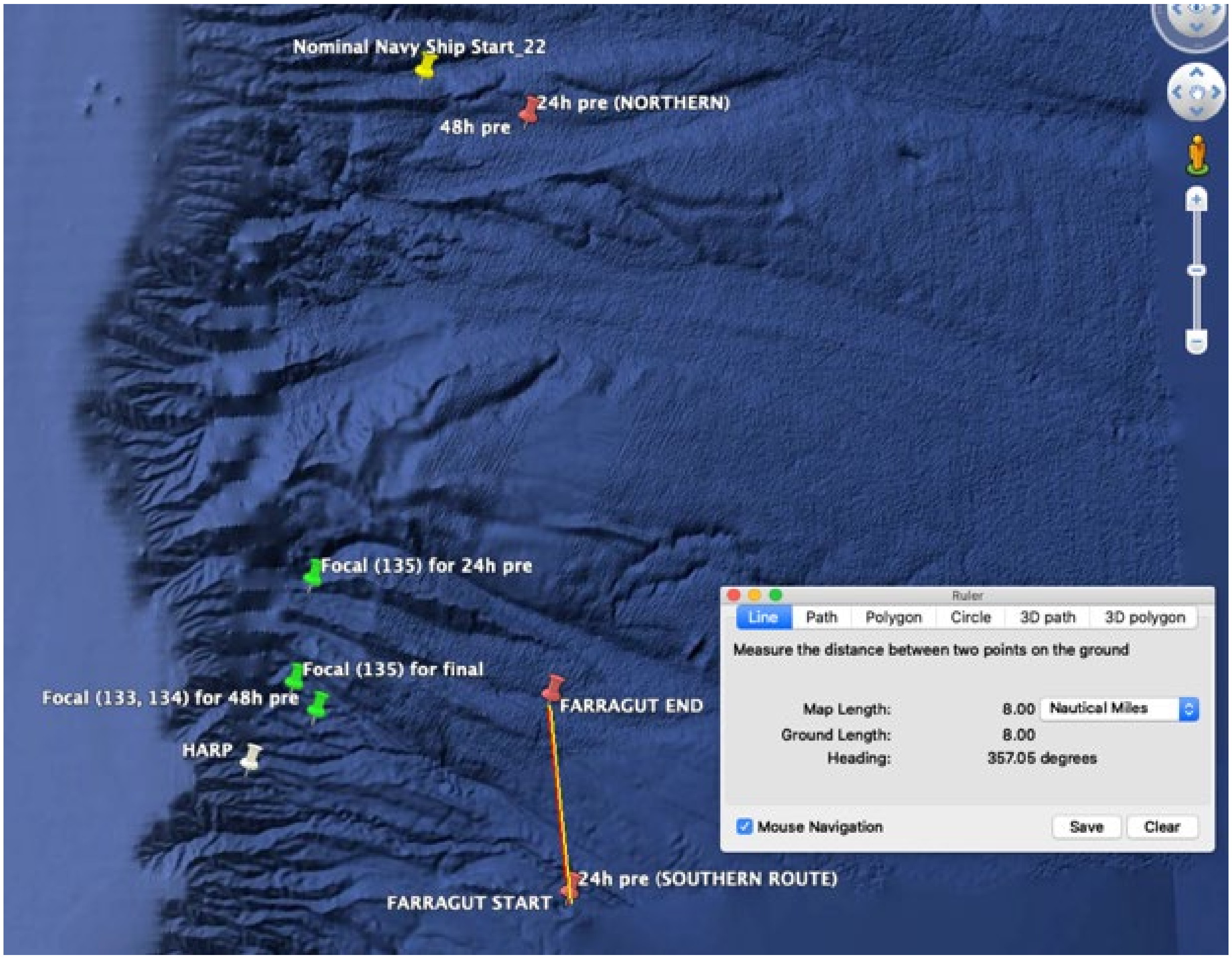


Figure 42. Sequential requested *USS Farragut* start positions shown relative to focal animal centroid or actual position estimates used in RL model estimates. See Table 35 for descriptions.

Summary of 2022 Field Effort: Accomplishments and Assessment

Accomplishments:

- Successful deployment of eight satellite tags on Cuvier's beaked whales.
- Successful deployment, data collection, and recovery of a long-sought overnight DTAG on a Cuvier's beaked whale within a social group including another satellite-tagged beaked whale.
- Two successful control CEEs using simulated MFAS CEE design for avoidance analysis integration.
- Successful CEE with operational U.S. Navy vessel, using full-scale SQS-53C MFAS. conducted with eight Cuvier's beaked whales (seven satellite-transmitting tags (all with Argos positions, one with time series dive data, one in focal follow and one with DTAG in focal follow). All eight were within target RL range for this species (120 to 140 decibels).
- Continued success with research platform *R/V Shearwater* augmented by chartered fishing vessels. Highly successful in locating and tracking animals, including successful overnight tracking.

- Sustained efforts to relocate satellite-tagged animals in the field using goniometer detections, increasing chances of subsequent tag deployments, improving animal pseudotracks by providing high confidence surface locations, and resulting in many photo-ID re-sights to evaluate group composition, social interactions, and biopsy samples.

Assessment of Field Approach:

- Field teams were adaptive, resilient, and dedicated in working through some of the worst conditions experienced in a decade of field effort during June and July. Outstanding conditions during a very small window in early August enabled the majority of success in tagging and completion of CEEs.
- Continued success in locating and tagging Cuvier's beaked whales, such that no second-priority pilot whales were tagged in 2022.
- Sustained success using advance planning and support as well as close coordination among members of the research team and the U.S. Fleet Forces Command (USFFC) team. This included substantial challenges for the Navy team given the different approach in 2022 of scheduling multiple vessels with the intention of conducting only one CEE based on a combination of available tagged animals and workable weather. While expected, the Atlantic-BRS team belaying requests for coordination with scheduled Navy ships was a new development for the study team's coordination. This was extremely well-managed and communication by the USFFC team to Navy fleet operators, as was the CEE that was ultimately coordinated in an adaptive. When this CEE was conducted, land-land and at-sea coordination between research and operational vessels was very successful, including specific fine-tuning on timing requested by the BRS field team and accomplished by the *USS Farragut*.
- Following a series of challenges and failures in VHF radio transmissions and sensor systems with prior DTAGs, the strategically targeted deployment ahead of the MFAS CEE (#2022_03) was successful in all aspects. Data were collected for the entire 24-hour period, including acoustic and overnight dive data, and detachment and transmissions were fully as planned to allow relatively easy recovery.
- Sustained high-quality satellite-transmitting tag dive data thanks to earlier progress in tag programming 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 2-week periods, strategically covering CEE periods, as designed. Long-duration (up to 76 days) function of tags in reporting Argos positions was again experienced, potentially due to improved batteries in SPLASH tags.
- Due to challenging sighting and tagging conditions, only a single Fastloc satellite tag (SPLASH-10F) was deployed in a test configuration that was designed to assess the feasibility of collecting simultaneous FastGPS and time-series depth messages. This tag performed well below expectation probably due to a low (non-optimal) deployment location on the animal. This instrument only uplinked five unique FastGPS messages before ceasing all uplinks after 17 days. For these reasons, future deployments are recommended to increase the sample size of Fastloc tags and develop a better understanding of their average performance and limitations.

2.3.1.2 Analytical Developments, Results, Publications, and Presentations

Readers are referred to Section 3.1 of the 2020 Atlantic-BRS annual report (Southall et al. 2021) for extensive details on data analyses and visualization that continue to be applied in the presentation and publication of results.

As the Atlantic-BRS project has progressed, it is consistently producing peer-reviewed publications both directly through the project and in collaboration with the ONR-funded Double Mocha effort, which developed analytical tools and methods that are now being applied to Atlantic-BRS. A summary of papers that are published, in review, or in advanced stages of development is included in **Table 36**; direct links to publications are provided where available.

Table 36. Atlantic BRS publications and manuscripts in review or advanced stages of preparation.

Category	Nominal Title/Subject	Lead Author (Institution)	Status
Baseline behavior	Diving behaviour of Cuvier's beaked whales (*Ziphius cavirostris*) off Cape Hatteras, North Carolina	Shearer (Duke)	Published
Methodology – technology	Mind the gap – Optimising satellite tag settings for time series analysis of foraging dives in Cuvier's beaked whales	Quick (Duke)	Published
Methodology – technology	Accounting for positional uncertainty when modeling received levels for tagged cetaceans exposed to sonar	Schick (Duke)	Published
Baseline behavior	Aerobic dive limits in Cuvier's beaked whales	Quick (Duke)	Published
Methodology – technology	Continuous-time discrete-state modeling for deep whale dives	Hewitt (Duke)	Published
Baseline behavior	Residency and movement patterns of Cuvier's beaked whales (*Ziphius cavirostris*) off Cape Hatteras, North Carolina, USA	Foley (Duke)	Published
Baseline behavior	Extreme synchrony in diving behaviour of Cuvier's beaked whales (*Ziphius cavirostris*) off Cape Hatteras, North Carolina	Cioffi (Duke)	Published
Methodology – technology	Monte Carlo testing to identify behavioral responses to exposure using satellite tag data	Hewitt (Duke)	Published
Methodology – technology	Time-discretization approximation enriches continuous-time discrete-space models for animal movement	Hewitt (Duke)	Published
Methodology – technology	Varying-Coefficient Stochastic Differential Equations with Applications in Ecology	Michelot (St. Andrews)	Published
Methodology – technology	Continuous-time modelling of behavioural responses in animal movement	Michelot (St. Andrews)	In review
Methodology – technology	Trade-offs in telemetry tag programming for deep-diving cetaceans: data longevity, resolution, and continuity	Cioffi (SEA)	Published
Methodology – technology	Detecting changes in foraging behavior in Cuvier's beaked whales exposed to sonar using coarse resolution data	Glennie (St. Andrews)	Final preparation
Baseline behavior	More than metronomes: variation in diving behavior of Cuvier's beaked whales (*Ziphius cavirostris*)	Quick (Duke)	Final preparation
Baseline behavior	Shallow night intervals in *Ziphius cavirostris*	Cioffi (Duke)	Final preparation
CEE exposure-response	Behavioral responses of Cuvier's beaked whales to simulated mid-frequency active military sonar off Cape Hatteras, NC	Southall (SEA)	In preparation

Category	Nominal Title/Subject	Lead Author (Institution)	Status
Methodology – technology	Estimating RLs and horizontal avoidance with dynamic covariates in exposed animals	Schick (Duke)	In preparation
Baseline behavior	Possible orientation behavior in Ziphius	Quick (Duke)	In preparation
CEE exposure-response	Behavioral responses of Cuvier's beaked whales operational mid-frequency active military sonar off Cape Hatteras, NC	Southall (SEA)	In preparation
Baseline physiology	Baseline variation of steroid hormones in short-finned pilot whales (*Globicephala macrorhynchus*)	Wisse (Duke)	In preparation
Disturbance exposure-response	Measuring stress responses in short-finned pilot whale biopsies: are field methods confounding our data?	Wisse (Duke)	In preparation

Key: SEA = Southall Environmental Associates Inc.

2.3.1.3 Overall Assessment and Recommendations

The following summarizes the accomplishments and general assessments for the 2022 field effort:

- Overall, the 2022 field season was the most challenging field conditions in more than a decade of tagging efforts in the Cape Hatteras location. Success relied on a great deal of patience, persistence, and dedication from the field team.
- Despite challenges, eventual successful deployment of a large number (n = 8) of tags on high-priority Cuvier's beaked whales and a collection of tens of thousands of hours of movement and diving behavior and movement. No secondary-priority pilot whales were tagged given the success with beaked whales.
- Strategic objectives focused parallel efforts on an intense analytical push to complete analyses for simulated MFAS CEE results and successful completion of a single CEE coordinated with an operational U.S. Navy vessel MFAS.
- Successful coordination and adaptive planning with USFFC colleagues to accomplish a complete and as-designed CEE with the *USS Farragut*. Strategic objectives and a selective approach to conduct one successful CEE with many whales this season also required patience, communication, and adaptability on the Navy side. This was achieved with sustained coordination and effort with U.S. Navy personnel working with vessels ahead of their deployment and close, real-time communication of times and locations of possible coordination using shore-based personnel from both the Atlantic-BRS and U.S. Navy teams. Data requested from U.S. Navy vessels was provided in a complete, timely, and unclassified manner. A coordinating and planning briefing between the Atlantic-BRS and U.S. Navy teams in Norfolk, Virginia, was a useful and positive interaction in terms of situational awareness and planning.
- Target RLs for Cuvier's beaked whales were achieved at approximately 110 to 140 dB RMS for focal whales in the operational vessel MFAS CEE. Model estimates based on post hoc location and diving behavior for focal whales were very similar to measured, calibrated RLs from DTAG deployments. These target levels were achieved at realistic operational ranges (10 to 50 nm) with focal and non-focal Cuvier's beaked whales. Some, but not all, exposed whales showed clear changes in movement and diving patterns, similar to those observed previously with simulated MFAS sources at closer range (2 to 3 nm), based on field observations and initial analysis of data collected.
- Satellite tag deployment settings were maintained as developed in earlier years with very positive results. Many of the 2022 tags again achieved greater duration deployments for returning Argos position data in addition to up to three weeks of focused, high-resolution, continuous time series dive data.
- Continued efforts to apply and improve methods of receiving signals from satellite tags using an Argos goniometer remained essential in tracking and relocating tagged individuals many times to obtain photographs and biopsy samples as well as locate other individuals for tagging attempts.
- Extensive progress in publications and many presentations at the Effects of Sound in the Ocean on Marine Mammals and other recent conferences have been made in terms of baseline behavior and methodological advances, including tag settings, RL modeling, and new behavioral response methods.

Future effort and recommendations include:

- Analytical tools have been developed and applied to the simulated MFAS CEE data set and the associated publication is well along. This paper will be submitted by summer 2023 and will be followed thereafter with common analytical methods by a subsequent paper focusing on operational Navy vessel CEEs. With the strategically focused single CEE in 2022, the data set for operational MFAS sources is of comparable magnitude. Data have been processed but effort remains to replicate all analyses and complete the second paper. This will occur in parallel with additional field effort.
- Field efforts in 2023 will pivot to the use of continuously active sonar (CAS). While it is important that experimental methodologies remain as similar as possible in terms of contextual and logistical aspects of field operations, tag settings/types, and others, some modifications will be required. Planning discussions have occurred and are ongoing. An experimental plan summarizing the approach will be provided at or following the April program review meeting and discussed with the U.S. Navy. Coordination with Navy vessels should be maintained using identical approaches as in previous seasons.
- The combination of satellite tags (with series settings for Cuvier's beaked whales) and DTAG deployments should be maintained, with additional effort to simultaneously deploy DTAGs within groups with satellite-tagged individuals.
- Further deployments of the study team's remaining Fastloc satellite tags are recommended for the next season to assess their feasibility as well as optimize configurations and settings. The study team will assess the performance of these tags to increase movement model precision around exposures while retaining an ability to uplink simultaneous dive data. In addition, the team will attempt to use these Fastloc tags to calibrate a functional relationship between distance and signal strength of boat-based Argos Goniometer receptions, which could be used to increase the precision of movement modeling across all tags with these receptions.
- Field efforts to locate tagged animals with validated locations using goniometer detections, visual observations, and photo-ID should be maintained before and after CEEs.

Please refer to the annual progress report for detailed information on 2022 fieldwork, preliminary results from 2017 to 2021, and ongoing analyses (Southall et al. 2023).

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 U.S. and Canada before migrating to Caribbean breeding grounds in winter (Katona and Beard 1990; Barco et al. 2002; Stevick et al. 2006). Juvenile humpback whales have been observed feeding in mid-Atlantic coastal waters during the winter since the early 1990s (Swingle et al. 1993). Since January 2016, more than 178 humpback whale strandings have occurred along the U.S. East Coast, causing NMFS to declare an Unusual Mortality Event for humpback whales in 2017 (still ongoing as of April 2023). Over half of these strandings occurred in the mid-Atlantic region, and although only approximately half of the whales were able to be examined post-mortem, 40 percent of those showed evidence of human interaction (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. 2020). One live and three dead whales with evidence of ship strikes were observed during the 2016/2017 field season. Given the UME, the large number of ship-related injuries, and the high spatial overlap with shipping channels, it is essential to understand the behavior of these animals around ships at the entrance of Chesapeake Bay.

Humpback whales near Virginia Beach are constantly exposed to ships. As recently as mid-2021, Hampton Roads (Virginia) was the sixth busiest port in the U.S., and Baltimore (Maryland) was the sixteenth busiest port in the U.S. Both ports are reached via the shipping lanes that pass through the mouth of 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 be 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 within the Virginia Beach area for days to months, and have been re-sighted over multiple years (Aschettino et al. 2021). This suggests that the disturbance from repeated ship exposures is not causing long-term displacement, but this may put humpback whales at a heightened risk of being struck, given multiple encounters. Theoretically, animals are more likely to remain within 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 may 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 the Gulf of Maine sub-population of the West Indies DPS.

In other areas, humpback whales have low responses to anthropogenic sounds 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 risks 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 in a recovering population.

The objective of this work is to build upon the ongoing Mid-Atlantic Humpback Whale Project (**Section 2.2.2**) by deploying high-resolution DTAGs to measure humpback whale responses to close ship approaches. The following questions are being addressed:

1. Do humpback whales respond to ship approaches, and if so, which behavioral or movement parameters change?
2. Which aspects of a ship approach (including the ship's acoustic and behavioral characteristics) elicit which types of responses?
3. Does the behavioral context of the animal (foraging/non-foraging) affect the probability of responding to a ship approach?

DTAGs were deployed seasonally on humpback whales within the coastal waters off Virginia Beach, less than 20 km from shore, in conjunction with focal follows, since 2019. 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 also collected information regarding the acoustic profile of the nearby large vessels, including the RLs 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, and other) and measure direct avoidance responses. At each surfacing, during the focal follows, behavioral state, distance and bearing, and estimated distance to the nearest ship were recorded. The DTAGs were programmed to record either for 4 to 6 hours per day or set for an overnight attachment before detaching, allowing for multiple ship approaches per animal and facilitating the collection of synoptic behavioral observations. The aim was to deploy a single tag each day, unless a tag detached from the whale early.

Automatic Identification System data (which includes information about the ship's identity, GPS location, course, speed, size, and cargo, among others) were used to collect additional information about vessels, including the size, speed, and course of the focal vessel and other ships within the area. Photo-ID images of the focal whale and its associates were collected during the focal follow, and biopsy samples were also collected. Photo-ID images were shared with HDR, Inc. and researchers, and added to regional catalogs. Biopsy samples were contributed to the sample collection curated by HDR, Inc. Efforts were made to coordinate DTAG deployments with individuals previously tagged with longer-term satellite-linked tags 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 tags simultaneously.

Nine days of suction-cup tagging effort were conducted within the Virginia Beach shipping lanes during the 2022 season, totaling 538 kilometers during 60.3 hours of survey effort (**Table 37**). Surveys were conducted in Beaufort Sea States ranging from 1 to 4.

Table 37. Vessel survey effort during suction-cup tagging within the Virginia Beach shipping lanes study area in 2022.

Date	Beaufort Sea State	Distance Surveyed (km)	Survey Time (hours:minutes)	At-sea Time (hours:minutes)
13-January-2022	1–2	30.6	6:35	6:47
18-January-2022	1–4	45.4	7:11	7:48
24-January-2022	2	55.6	6:43	7:08
25-January-2022	1–2	31	8:26	8:51
2-February-2022	3	23.6	2:49	3:12
8-February-2022	1–2	57.4	5:07	5:39
9-February-2022	1–2	135.2	7:57	8:40
10-February-2022	2–4	92.6	10:08	10:41
11-February-2022	2–4	66.7	5:23	5:39

Humpback whales were sighted on 19 occasions, totaling 22 whales, with 2 re-sights of previously tagged whales (**Table 38, Figure 43**). Single animals were the most common (16 of 19 sightings), with three pairs of animals.

Table 38. Humpback whale sightings during suction-cup tagging within the Virginia Beach shipping lanes study area in 2022.

Date	Time (UTC)	Latitude °N	Longitude °W	Group Size	Tags Deployed
13-January-22	16:28	36.85584	75.89747	1	0
13-January-22	17:54	36.87573	75.92175	1	0
13-January-22	19:40	36.87701	75.88760	1	0
18-January-22	21:04	36.87379	75.88122	1	0
25-January-22	14:45	36.90749	75.91213	1	mn22_025a
25-January-22	15:18	36.91229	75.92542	1	0
2-February-22	15:23	36.88419	75.97200	1	0
8-February-22	17:52	36.78156	75.95267	1	0
8-February-22	21:14	36.89000	75.90167	1	0
8-February-22	21:24	36.88127	75.90909	1	0
9-February-22	14:07	36.75273	75.90409	1	mn22_040a
9-February-22	19:02	36.94295	75.95523	1	0
9-February-22	19:16	36.95257	75.96744	2	0
9-February-22	19:22	36.95041	75.97831	1	0
9-February-22	21:23	36.73230	75.93204	1	mn20_040a *resight
10-February-22	14:27	36.88033	75.87837	2	mn22_041a
10-February-22	18:42	36.90026	75.90922	1	mn22_041b
11-February-22	12:52	36.86856	75.89703	1	mn21_041b *resight
11-February-22	16:41	36.90289	75.91410	2	0

Key: mn = *Megaptera novaeangliae*; °N = degrees north; UTC = Coordinated Universal Time; °W = degrees west

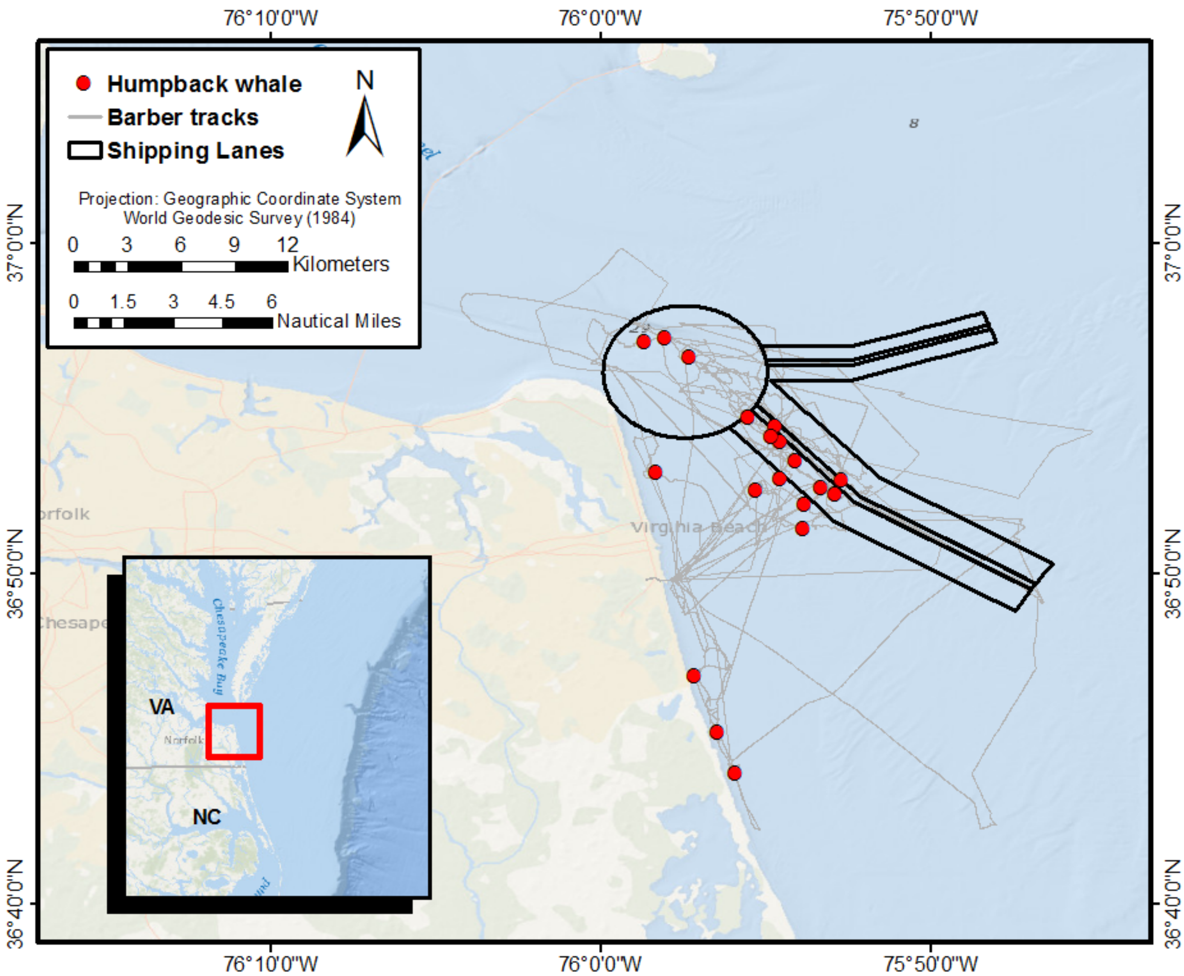


Figure 43. Survey tracks and locations of all humpback whale sightings during suction-cup tagging effort within the Virginia Beach shipping lanes study area in 2022.

Four DTAGs were deployed (**Table 39**; **Figure 44** through **Figure 46**); two of those were on animals that were already carrying satellite-transmitting tags deployed by HDR, Inc. One DTAG was not recovered, and two deployments were made with DTAGs that also contained a Fastloc GPS receiver. One of these deployments (*mn22_040a*) was tagged very near shore in shallow water; this animal had no dives deeper than 4 m for the first 9 hours of deployment and did not forage. Foraging lunges were present on two of the three recovered tag records.

Two of the three animals with recovered tags in 2022 exhibited clear foraging lunges, although at lower rates than animals tagged in previous years (**Figure 47** and **Figure 48**). The only animal with data that extended into the nighttime hours did not forage. Lunges averaged 10.9 m depth, with the deepest at 14.7 m depth (**Table 40**). Lunges were relatively horizontal, with median pitch during the lunge ranging from -21 (head down) to +29 (head up) degrees and roll ranging from -39 (right) to +28 (left) degrees (**Table 40**).

All three animals showed rolling behavior that might indicate foraging events. The study team measured the same parameters for these events as for regular lunges, as well as the absolute maximum and minimum rolls performed during a lunge by the animal (**Table 41**). Rolls can be performed in either direction, so these summary statistics do not necessarily capture the full picture of the animal's motion.

Fewer rolling events occur than regular lunges (*n* = 10 rolling lunges, versus *n* = 30 regular lunges). Pitches were still relatively horizontal. Median rolls were also low, but the range of absolute rolls during individual lunges was from -180 to +179 degrees. Therefore, the animals were rolling in different directions, averaging out the median roll.

Table 39. Suction-cup tag deployments on humpback whales within the Virginia Beach shipping lanes study area in 2022.

Date	Time (UTC)	Latitude °N	Longitude °W	Tag Type	Tag ID	Duration (hour:minutes)
25-January-22	18:04	36.94586	75.95108	DTAG/Fastloc	Mn22_025a	3:39
9-February-22	14:28	36.76070	75.94497	DTAG/Fastloc	Mn22_040a	11:40
10-February-22	15:41	36.89021	75.88011	DTAG	Mn22_041a	0:57
10-February-22	19:10	36.89986	75.90898	DTAG	Mn22_041b	Not recovered

Key: Mn = *Megaptera novaeangliae*; °N = degrees north; UTC = Coordinated Universal Time; °W = degrees west

Table 40. Lunge characteristics from lunges recorded from humpbacks tagged off the coast of Virginia Beach, Virginia, in 2022.

Tag ID	Total Number of Lunges	Depth (meters) Median (max)	Median Pitch during Lunge (degrees) Median (range)	Median Roll during Lunge (degrees) Median (range)
mn22_025a	21	10.1 (13.8)	-3.9 (-21.0 to 29.2)	-1.2 (-38.6 to 27.5)
mn22_040a	0	N/A	N/A	N/A
mn22_041a	9	13.2 (14.7)	-2.4 (-9.2 to 17.7)	2.2 (-11.0 to 7.9)

Key: ID – Identification; Mn = *Megaptera novaeangliae*; N/A = not available; max = maximum

Table 41. Characteristics of rolling lunges recorded from humpbacks tagged off the coast of Virginia Beach, Virginia in 2022.

Tag ID	Total Number of Rolling Lunges	Depth (meters) Median (max)	Median Pitch during Lunge (degrees) Median (range)	Median Roll during Lunge (degrees) Median (range)	Absolute Roll (min:max)
mn22_025a	7	7.3 (12.4)	6.2 (-7.5 to 23.2)	20.0 (-70.9 to 106.9)	-180:172
mn22_040a	1	1.5	-13.0	92.8	174
mn22_041a	2	14.1 (14.9)	15.9 (11.2 to 20.6)	-12.1 (-9.5 to -14.6)	-180: -178.5

Key: ID – Identification; Mn = *Megaptera novaeangliae*; max = maximum; min = minimum

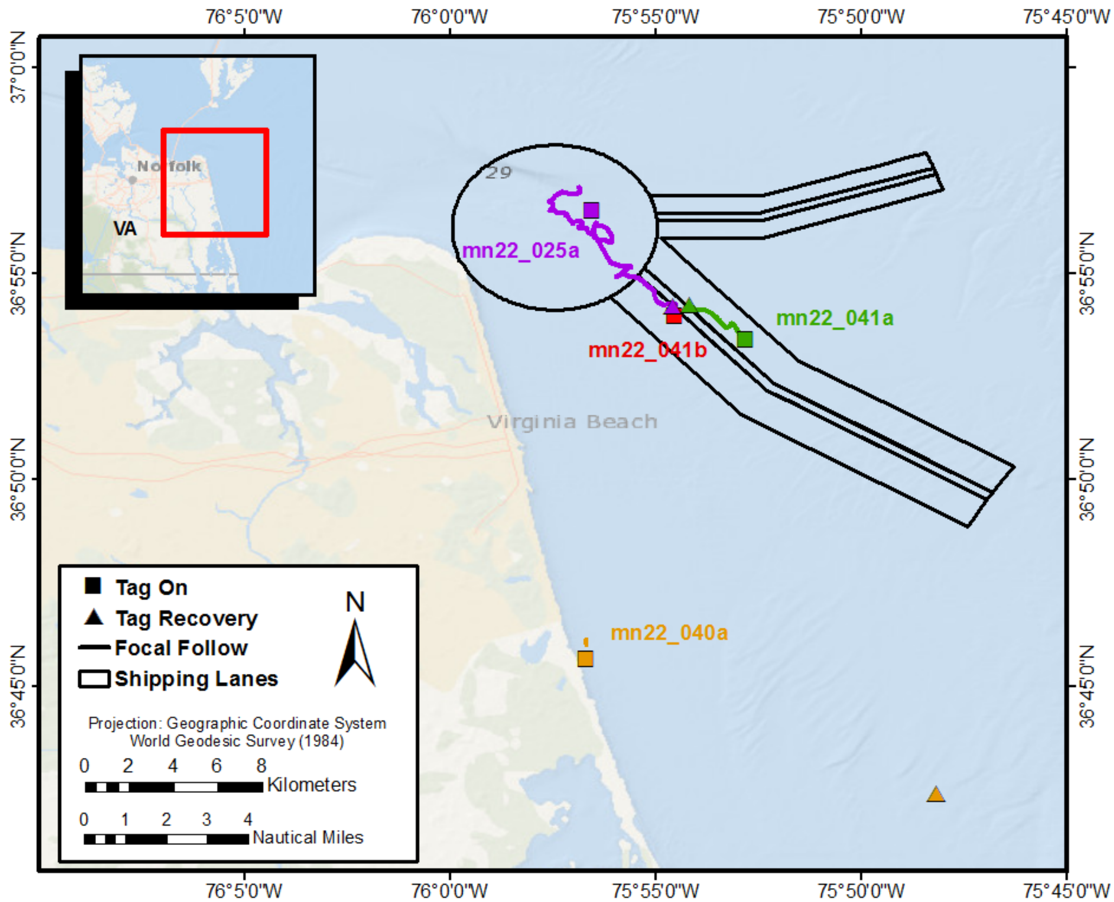


Figure 44. Tagging location and tag recovery location for all suction-cup deployments within the Virginia Beach shipping lanes study area in 2022. Each colored line represents the *R/V Barber's* track during the focal follow of the animal.

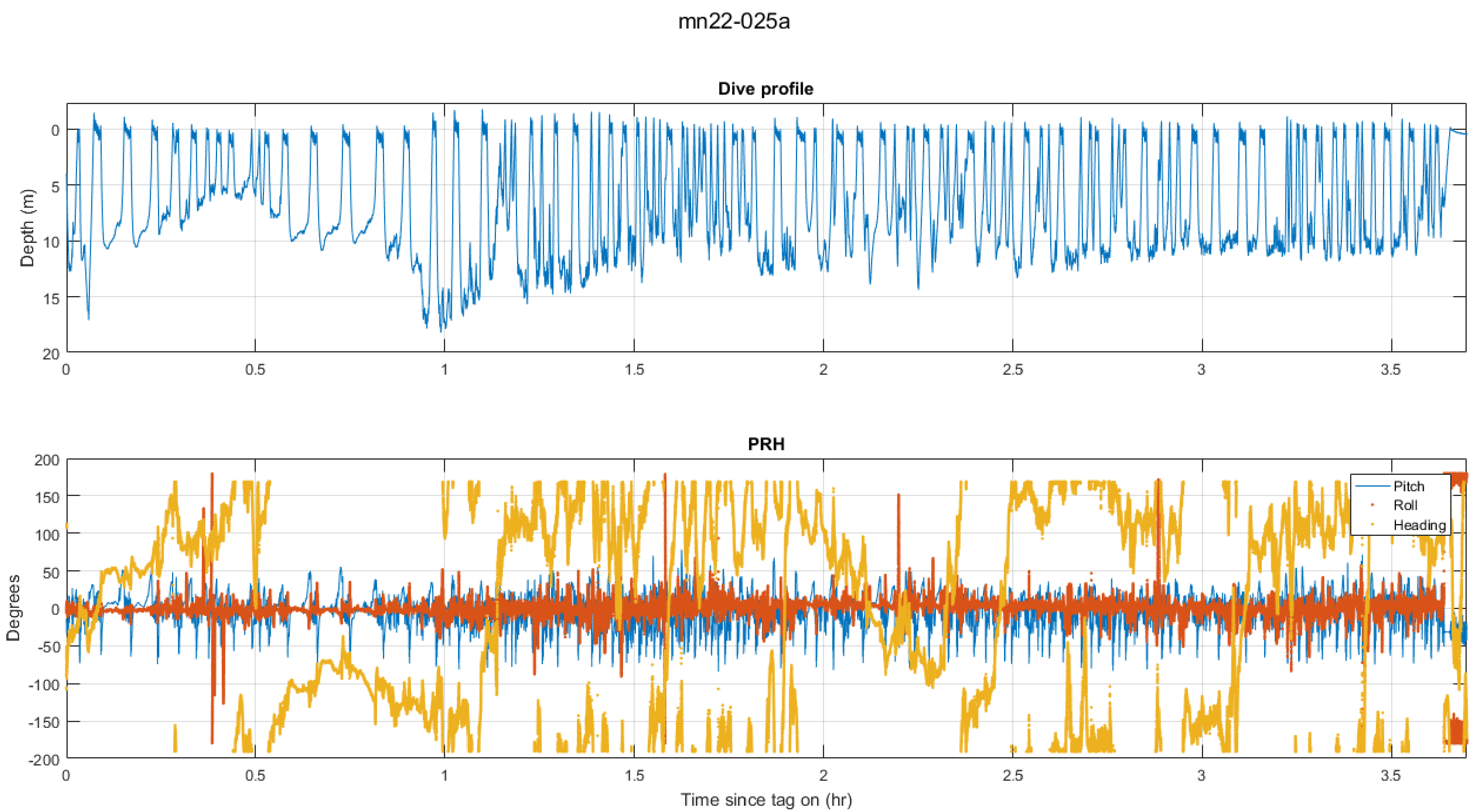


Figure 45. Dive-depth profile (top) and accelerometry metrics (bottom; pitch, roll, and heading) for tagged animal mn22_025a.

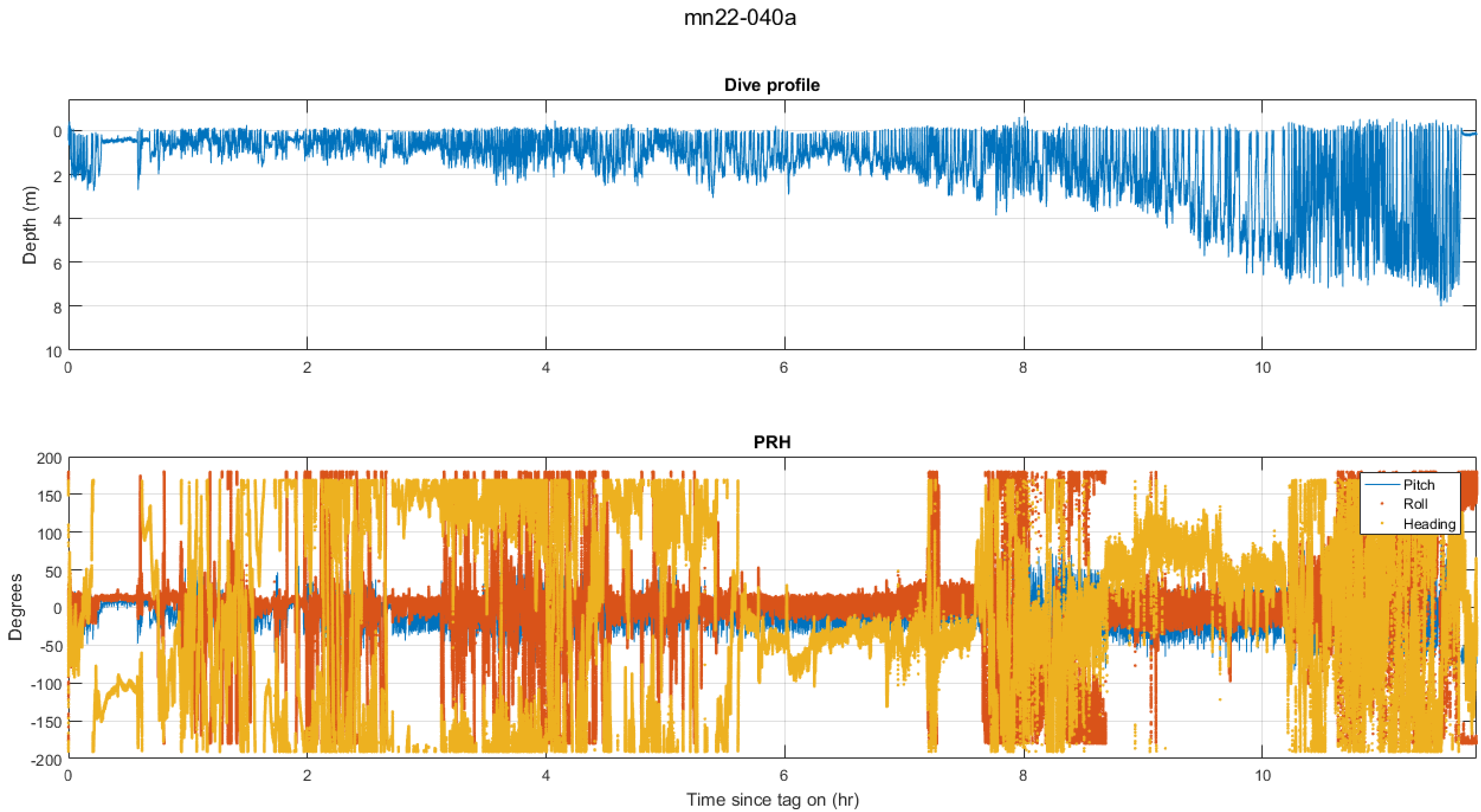


Figure 46. Dive-depth profile (top) and accelerometry metrics (bottom; pitch, roll, and heading) for tagged animal mn22_040a.

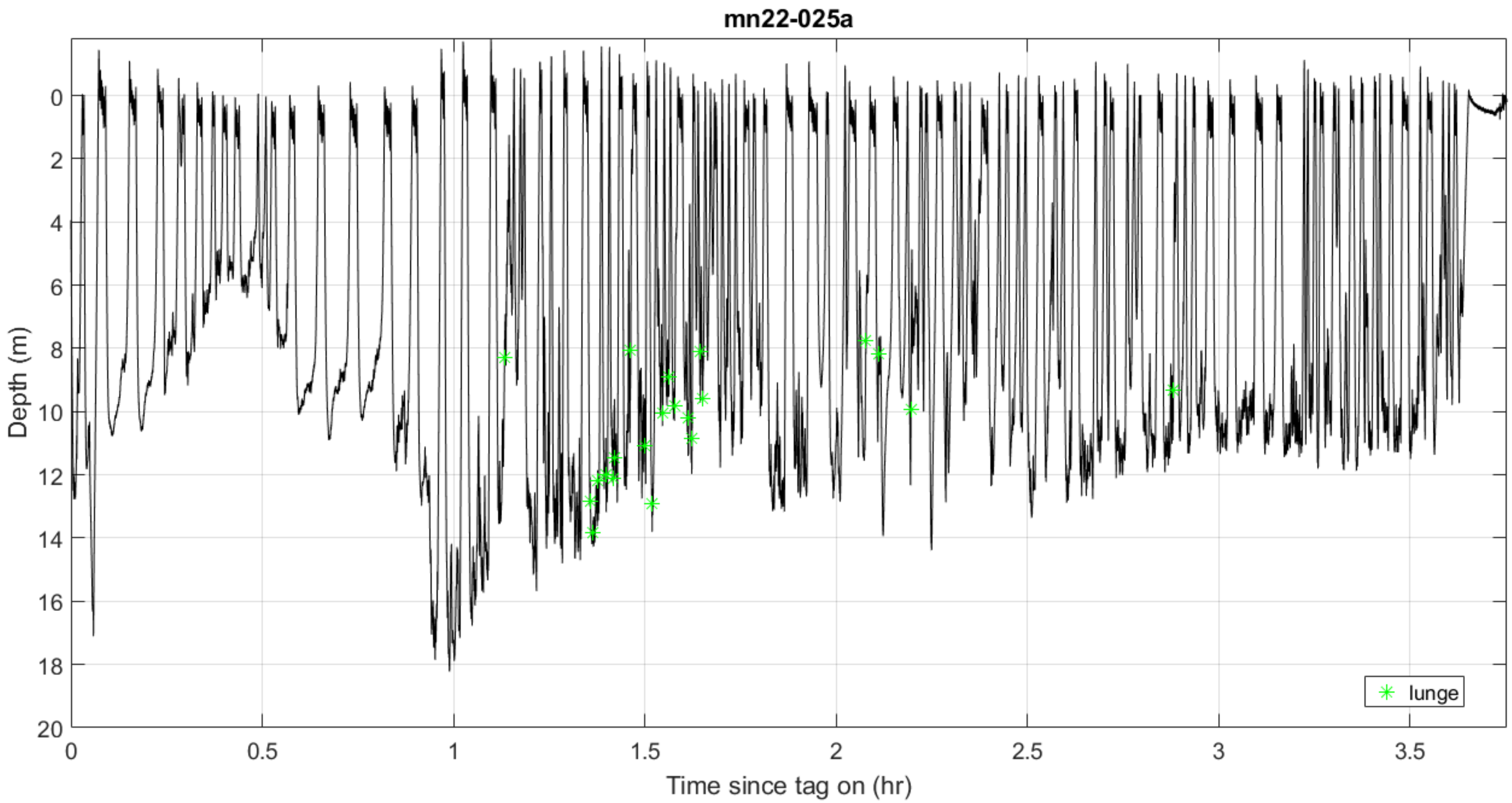


Figure 47. Dive profile for mn22_025a with lunges overlaid (green stars). The shaded area indicates nighttime hours.

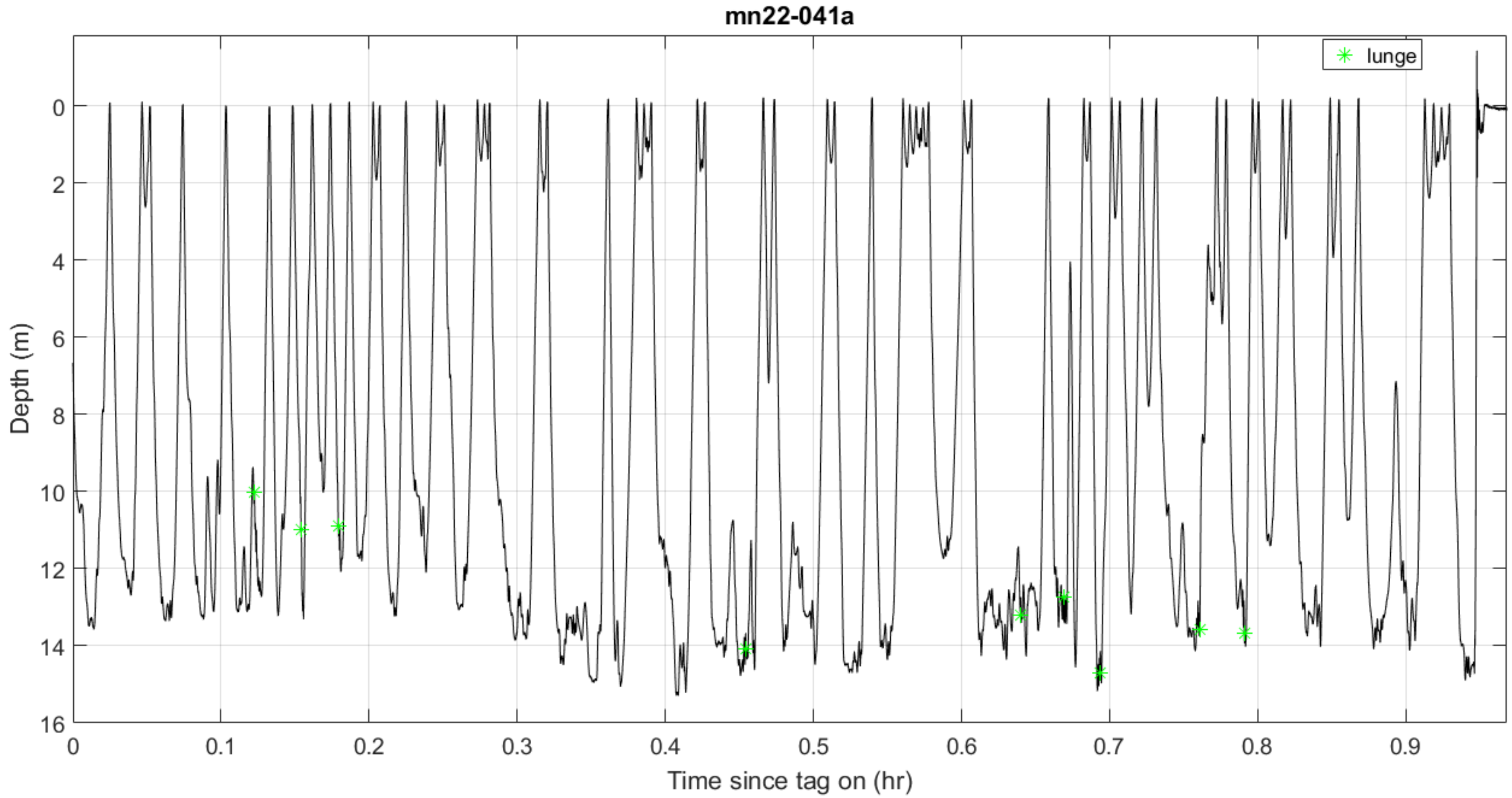


Figure 48. Dive profile for mn22_041a with lunges overlaid (green stars). The shaded area indicates nighttime hours.

Efforts in 2022 built on previous years of research within this area; the study team deployed four additional tags on humpback whales near the Virginia Beach shipping lanes. Two of the three tagged whales showed foraging behavior with similar depths and orientations to those from tags previously deployed within this area. As cessation of foraging is often considered a response to disturbance, identifying the presence and frequency of foraging events contributes to the understanding of humpbacks' responses to ships and highlights the importance of this area as a winter-feeding ground for these animals. The study team's future work will combine the lunge data from these DTAGs with the synoptic satellite-tag locations collected by HDR, Inc. and available high-resolution bathymetry data to determine whether animals are foraging near the seafloor or within the water column, as well as their exact foraging locations relative to the shipping lanes.

During the 2022 season, researchers focused their analysis on foraging behavior from all tags deployed to date in this project. The study team quantified foraging rates and kinematic behaviors for regular lunges and rolling events and identified potential diel patterns in foraging lunges. The study team will include this analysis in a manuscript currently being prepared for submission to a journal this year. In the coming year, the study team will also continue to refine the correlation between distance to the nearest vessel from the focal follows and the received noise level on the tags. If the team can predict the ship's distance from the RL with accuracy, they can estimate ship distances from portions of the tag record without focal follows. Finally, the study team will use concurrent satellite-tag and DTAG records from double-tagged animals to predict foraging behavior on longer-duration satellite tags using information from the high-resolution DTAGs.

The team also refined foraging lunge detection from accelerometry data streams and flow noise and worked on development of several analytical tools this year, including:

- *Tools to deconstruct high-resolution accelerometer and magnetometer data into biologically meaningful movement metrics, such as turning rates and overall body acceleration.*
- *Refinement of the ship distance/received level regression to increase predictive power*
- *A combination of DTAG records with concurrent satellite records to make predictions about foraging behavior in lower-resolution, longer-duration satellite tag records*

Fieldwork is currently being conducted during the 2023 season (January through March) to increase the number of tagged whales with ship approaches for analysis. Fieldwork will consist of acoustic prey mapping using the EK80 active acoustic system on the R/V *Shearwater*. The study team will map prey density within and outside the shipping lanes at multiple times of day to assess spatial and diurnal variation in prey density. This work will inform the analysis of humpback foraging behavior and help to predict their vulnerability to ship encounters. The study team will not conduct tagging during the 2023 season but will conduct prey mapping around animals tagged by HDR, Inc. if those tag deployments occur while the R/V *Shearwater* is within the area. The fieldwork and analyses will focus on contributing to ongoing efforts to understand the behavior of juvenile humpback whales within the Virginia Beach area, understand risk factors, and develop potential mitigation measures for ship strikes.

For more information on this project and details of the analyses, please refer to the 2022 annual progress report (Shearer et al. 2023).

2.3.3 Pinniped Behavioral Response Study

The two most common seals that inhabit coastal and offshore areas along the U.S. East Coast are harbor seals (*Phoca vitulina*) and gray seals (*Halichoerus grypus*). Some individuals have been documented traveling more than 800 km from Maine to North Carolina, overlapping with several of the U.S. Navy's ranges, thereby exposing them to a variety of Navy and other anthropogenic activities. Since 2018, the NEFSC, the Naval Undersea Warfare Center Division Newport (NUWCDIVNPT), the Atlantic Marine Conservation Society (AMSEAS), and Marine Mammals of Maine (MMoME), collectively referred to as the Team, have partnered to capture and satellite tag gray and harbor seals to study their movements and health status. To date, telemetry data have been collected on 32 juvenile gray seals (2019–2022) and 23 harbor seals (2018–2022). Based on this telemetry work, the movements of both harbor and gray seals overlap with two of the Navy's Living Marine Resources priority geographic regions in the Atlantic (Boston and VACAPES OPAREAs) and established and proposed wind-farm areas.

The Naval Undersea Warfare Center Division Newport (NUWCDIVNPT proposed to capture and tag harbor and gray seals along the U.S. East Coast to establish a baseline and then carry out a behavioral response study using controlled exposure experiments with simulated underwater sounds from military training and testing activities, such as sonar and pile driving, to determine if pinnipeds exhibit a response.

There are three phases to approach this research. The purpose of Phase I was to conduct a pilot study to inform the development of a multi-year program to measure baseline behavior and determine how human sounds, including active sonar signals, affect pinnipeds. The purpose of Phase II was to continue the collection of baseline behavioral information and design the behavioral response component. Finally, CEEs would be conducted during Phase III.

The three objectives for Phase I are: 1) to assess the feasibility of conducting aerial surveys between New York and Rhode Island; 2) to coordinate aerial surveys with ground, boat, and remote-camera surveys within the survey area; and 3) to assess the feasibility of capturing and tagging harbor and gray seals in southern New England and New York. The Team from NUWC, AMSEAS, NMFS, and MMoME conducted harbor and gray seal aerial surveys (New York to Rhode Island), seal captures to deploy satellite tags (New York), camera surveys (Rhode Island), and in-person observations (New York and Rhode Island).

In winter/spring 2021, the Team tagged seven harbor seals and one gray seal off Long Island, New York. The harbor seals traveled as far south as the southern border of New Jersey, but eventually all made their way to Maine by summer. The gray seal traveled as far as Nova Scotia and exploited offshore waters primarily off New England. This movement by the gray seal is consistent with the telemetry tracks from gray seal pups in Murray et al. (2021). Aerial surveys were conducted three times during the 2020–2021 season, and a new haul out site was observed, which further added to the information collected to establish a baseline. In addition to employing a systematic in-person monitoring protocol at known haul-out sites, particularly those that might be candidates for capture and tagging, the use of remote (trail) cameras proved to be an efficient and cost-effective method to gather information than what could be conducted with only site visits. Cameras have been used successfully in numerous studies of terrestrial animals (O'Connell et al. 2010), but only a few, in comparison, have been used to study pinnipeds (Gucu et al. 2009; Koivuniemi et al. 2016; Øren et al. 2018).

The aim of Phase II, which began during the 2022 field season, is to continue collecting behavior data to understand the physical or biotic factors that influence the movement and foraging tactics of harbor and gray seals; the amount of time seals spend in specific areas, paying particular attention to Navy OPAREAS;

and the anthropogenic risks (e.g., noise-producing military activities) seals potentially encounter within nearshore and offshore areas. The tasks for Phase II of this research project included: 1) continue aerial surveys to document harbor and gray seal haul outs within the Narragansett Bay OPAREA; 2) coordinate aerial surveys with ground and remote-camera surveys; 3) deploy satellite tags on harbor and gray seals during the late fall through early spring; and 4) assess satellite-tag data collected from tags deployed on pinnipeds, authorized under the NMFS research permit (NMFS permit number 21719).

Due to poor weather conditions and COVID-19 impacts, the 2022 capture and tagging season was shortened, although the Team participated in capture and tagging efforts in Virginia (**Section 2.2.4**) in February, and successfully captured and tagged three harbor seals in New York in March. In-person counts, and remote-camera efforts continued throughout the field season with the use of two trail cameras with cell phone capabilities and a third camera that took photographs at 10-minute intervals.

NUWC intends to deploy up to 10 additional satellite tags to evaluate diving, haul-out, and foraging behavior to establish a baseline, and will be concurrently testing a prototype accelerometer tag to quantify behavioral states in preparation for controlled exposure experiments in the future. Additionally, NMFS and AMSEAS plan to deploy an additional 15 satellite tags each in association with other projects. Collectively, these additional 40 tags will contribute to establishing a robust baseline dataset to provide necessary context for assessment of potential behavioral responses during Phase III of the project.

For details of the work conducted during Phases I and II of this project, see NUWC Newport 2023.

2.4 Sturgeon Monitoring

2.4.1 Atlantic and Shortnose Sturgeon Monitoring in the Lower Kennebec River

This telemetry monitoring study was initiated in May 2021 to collect year-round occurrence data for Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and shortnose sturgeon (*Acipenser brevirostrum*) in the lower Kennebec River, Maine (from north of Bath Iron Works [BIW] to Fort Popham), and also to collect data during recurrent U.S. Navy testing activities. This study also implemented monitoring stations offshore of Popham Beach to capture coastal movements of sturgeon and other species, including white sharks (*Carcharodon carcharias*). Offshore stations form a curtain between Fox-Seguin Islands and the Jackknife Ledge Dredge Disposal area.

Project objectives are: 1) monitor sturgeon activity in the proximity of Bath Iron Works; 2) document coastal movements of fish offshore from Popham Beach: sturgeon, striped bass, white sharks, and other species designated as highly migratory species by NOAA (tuna, sharks, swordfish [*Xiphias gladius*]); 3) monitor year-round presence and migration of Atlantic sturgeon in the lower Kennebec River; 4) monitor year-round presence and migration of shortnose sturgeon in the lower Kennebec River; and 5) add additional acoustically tagged species to the Kennebec River system. Collaborators on this project include the State of Maine Department of Marine Resources (ME DMR), University of Maine, U.S. Geological Survey, Portsmouth Navy Yard, and University of Maryland Center for Environmental Science. Data collected from this study will help to understand sturgeon movement patterns in and out of the Kennebec River basin and identify new overwintering or spawning areas and coastal movements between river systems (i.e., Penobscot, Piscataqua, Merrimack). Additionally, the project will provide data for sturgeon transiting past BIW, which will facilitate effective management of dredge windows and minimize the impact of dredging on migrating or feeding sturgeon.

As of December 2022, 16 year-round telemetry monitoring stations exist from Courthouse Point in Dresden to Fort Popham (including one in the Eastern River), and 5 stations are offshore (**Figure 49**). ME DMR and NUWCDIVNPT co-maintain seven of the in-river stations. Downloads of telemetry stations occur twice a year. In the river, the array has detected both species of sturgeon, American shad (*Alosa sapidissima*), and striped bass (*Morone saxatilis*). Offshore data includes detects for species of sturgeon, striped bass, American shad, white sharks, and Atlantic bluefin tuna (*Thunnus thynnus*).

Although some actively transmitting sturgeon tags in the Kennebec River have not expired, 40 Atlantic sturgeon ranging from 57 to 168 cm fork length (FL) and 23 shortnose sturgeon ranging from 54 to 87 cm FL were captured in June, July, and October 2022. All fish were tagged with Passive Integrated Transponder (PIT) tags- , measured, weighed, and had fin clips taken and preserved for future genetic analysis. A borescope was used to sex animals when possible. Additionally, 61 of these fish were acoustically tagged with surgically implanted transmitters (VEMCO Innovasea, V16 and V13) to increase the population of tagged fish within the Kennebec River.

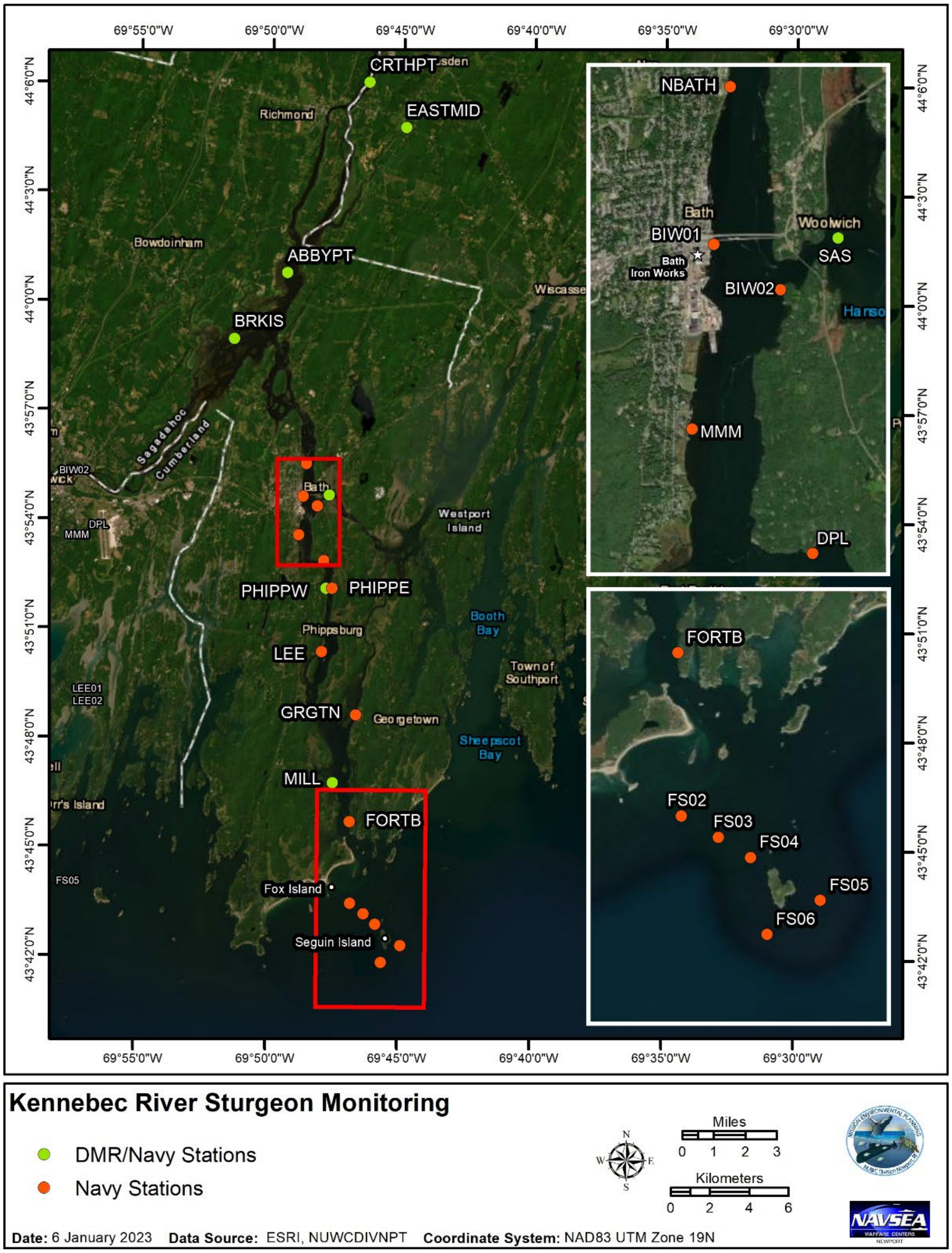


Figure 49. Array map showing the location of Navy and ME DMR monitoring stations in the lower Kennebec River basin.

2.4.1.1 Data Summary through October 2022

Through October 2022, 48,202 detections were recorded across all stations (**Table 42**). Of those detections, the vast majority (*n* = 40,166) were Atlantic sturgeon, followed by striped bass (*n* = 4,887), Atlantic bluefin tuna (*n* = 1,248), and white shark (*n* = 1,048). However, the frequency of tag observations should not be interpreted as a proxy for population distribution or abundance, as the proportion of tagged individuals for each species is not equivalent. For example, an increasingly high percentage of white sharks along the US Atlantic coast are tagged, while only a very small percentage of the American shad population is tagged.

Table 42. Detections of fish through October 2022 tagged with VEMCO acoustic transponders.

Species	River	Ocean
Atlantic sturgeon	36387	3779
Shortnose sturgeon	675	54
White shark	0	1048
Striped bass	4887	61
Atlantic bluefin tuna	0	1248
American shad	33	30

For sturgeon, the highest frequency of observations and unique number of individuals detected was at riverine stations beginning at Maine Maritime Museum (MMM), and including North-BIW, BIW1, BIW2, and MMM, during May and June (**Figure 50**). Station NBATH had the highest number of unique individuals, with an average of up to 21 unique Atlantic sturgeon documented during June. Atlantic sturgeon were recorded nearly each day at some of these stations during May, indicating residential/feeding rather than strictly transitory behavior. Overall, the abundance of Atlantic sturgeon detections upriver was higher in early spring/summer (April through June) and lower in the summer (July/August). Toward the early fall (September), the overall number of fish observed declined, and the prevalence shifted towards southern stations (FORTB, MILL) and offshore.

Total detections for shortnose sturgeon were much lower than Atlantic sturgeon, though differences are likely reflective of current active tags within the region. The highest number of detections were recorded at similar stations as those observed for Atlantic sturgeon, ranging from DPL to NBATH in April and May. Shortnose sturgeon were not detected on fixed river stations outside these months. However, active monitoring with a VEMCO hydrophone in October through December 2022 revealed that shortnose sturgeon tagged earlier in that year (June through August) were observed at known over-wintering locations in the river (e.g., near Swan Island). Several tags also were documented as far north as Lockwood for the first time in winter months. Twenty-three additional shortnose sturgeon tagged in the Kennebec River during 2022 will provide more data for this species for comparison, in addition to numerous tagged in the Merrimack River.

Overall counts and frequency of Atlantic sturgeon at offshore stations are unsurprisingly lower, with the highest counts at these stations occurring during June through September, with notable detections also recorded during April. Offshore detections likely represent data for fish moving in and out of the system during those months (**Figure 50**). No sturgeon were detected on any station during December and January, and were only observed at offshore stations during February and March, an indication that sturgeon do not appear to be using the area around BIW during those winter months. Additional tags released in 2022 will provide further data on these trends.

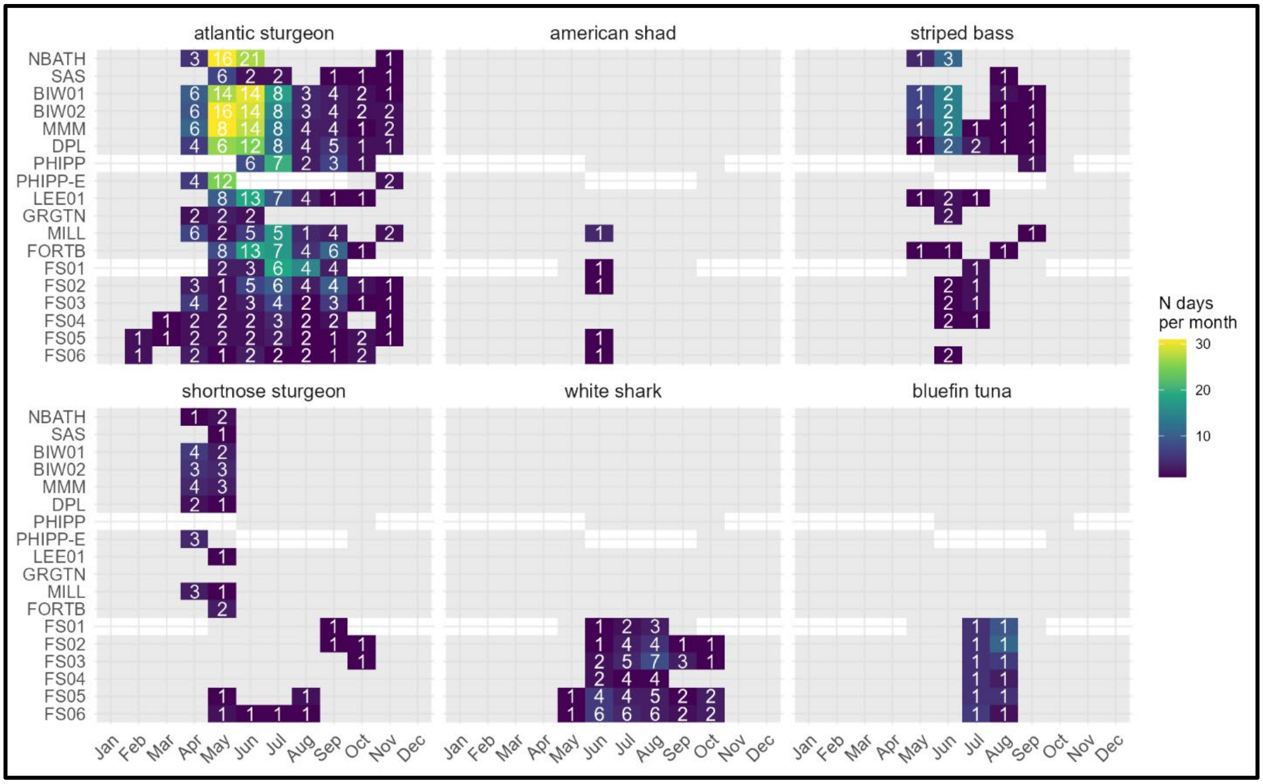


Figure 50. Species detected at each station during the monitoring period May 2021–October 2022, showing the number of days per month with detections (color coded) and median number of unique individuals (the white numbers). Current numbers of actively tagged fish are not uniform across species, so results can be used to infer presence and seasonality, but not relative abundance of species. (Note: unshaded cells represent months with no coverage for that station).

2.4.2 Distribution of Gulf Sturgeon within the Panama City Testing Range

Gulf sturgeon (*Acipenser oxyrinchus desotoi*) were ESA-listed as threatened in 1991. From spring to fall, adults undergo a prolonged period of fasting in rivers before transiting to marine foraging areas, which are linked to reproductive success and key to the recovery of this species. Improving the limited understanding of marine habitat requirements is emphasized in the Gulf Sturgeon Recovery Plan (USFWS and GSMFC 1995), which highlights the need for multi-year tracking studies. The U.S. Naval Surface Warfare Center (NSWC) Panama City Division Testing Range overlaps extensively with Gulf Sturgeon Critical Habitat, as well as adjacent areas where Gulf sturgeon are believed to occur, and information on the spatial and temporal patterns of habitat use is needed.

Thirty Gulf sturgeon had previously been implanted with acoustic transmitters (VEMCO Ltd. V-16-6H) during 2021 (see Fox et al. 2000 for surgical procedures). An acoustic receiver array was also deployed within the NSWC Panama City Testing Range to monitor for these transmitters as well as transmitters deployed for other projects (in Gulf Sturgeon and other species) in fall 2021. This array consisted of 30 VEMCO Acoustic Release and 46 VEMCO Transmitting Receivers, and was maintained until mid-May 2022. During that time, 33 transmitters were detected, including those implanted in species other than Gulf sturgeon (bull shark [*Carcharhinus leucas*], devil ray [*Mobula mobular*], crevalle jack [*Caranx hippos*], Kemp's ridley turtle [*Lepidochelys kempii*], and white shark).

Initial analyses of the detections from the 2021/2022 field season receiver array guided changes to the array configuration for 2022/2023. Namely, most Gulf sturgeon detections were nearshore and within the eastern portion of the study area. To increase receiver density and maximize detections of Gulf sturgeon, the most offshore receivers where no Gulf sturgeon were detected were relocated between the northern-most line of receivers and the coast. Additionally, Acoustic Release receivers were used strategically to reduce potential loss as well as ease deployment and recovery. These receivers were deployed in October 2022 and serviced in January 2023. Thirteen Gulf sturgeon from the Choctawhatchee River were detected 9,152 times within the GOM during the 2022/2023 field season, with an additional 72 transmitters detected on the receiver array, many of which are expected to be Gulf sturgeon from other river systems such as the Apalachicola, Suwanee, Yellow, or Blackwater Rivers. The majority of Gulf sturgeon detections remained close to shore, with no confirmed detections beyond seven km (**Figure 51**).

In November 2022 and March 2023, 14 REMUS 100 Autonomous Underwater Vehicle missions were conducted in search of Gulf sturgeon within the northeastern portion of the study area, where the highest number of Gulf sturgeon were detected during the first field season. The REMUS 100 was equipped with an acoustic receiver as well as side-scan sonar to image individuals along the mission path (**Figure 52**). In addition to the sampling missions, two range-test missions were conducted within the test range to collect data on maximum detection distances; this included the traditional transmitting receiver as well as an enhanced porotype mobile receiver supplied by Innova Sea.

The current acoustic-receiver array will be maintained through May 2023. After retrieval and download of the array, species identity for unknown transmitters will be confirmed provided they are shared through I-tag or the Gulf Sturgeon Recovery Database. During the third and final year of the study, the current large-scale array will be concentrated into a finer-scale array within the test range. This consolidation should help in identifying important habitats and key features for Gulf sturgeon during their winter foraging season. Additionally, it will enable the assessment of seasonal use patterns within the NSWC Panama City Test Range at a finer resolution.

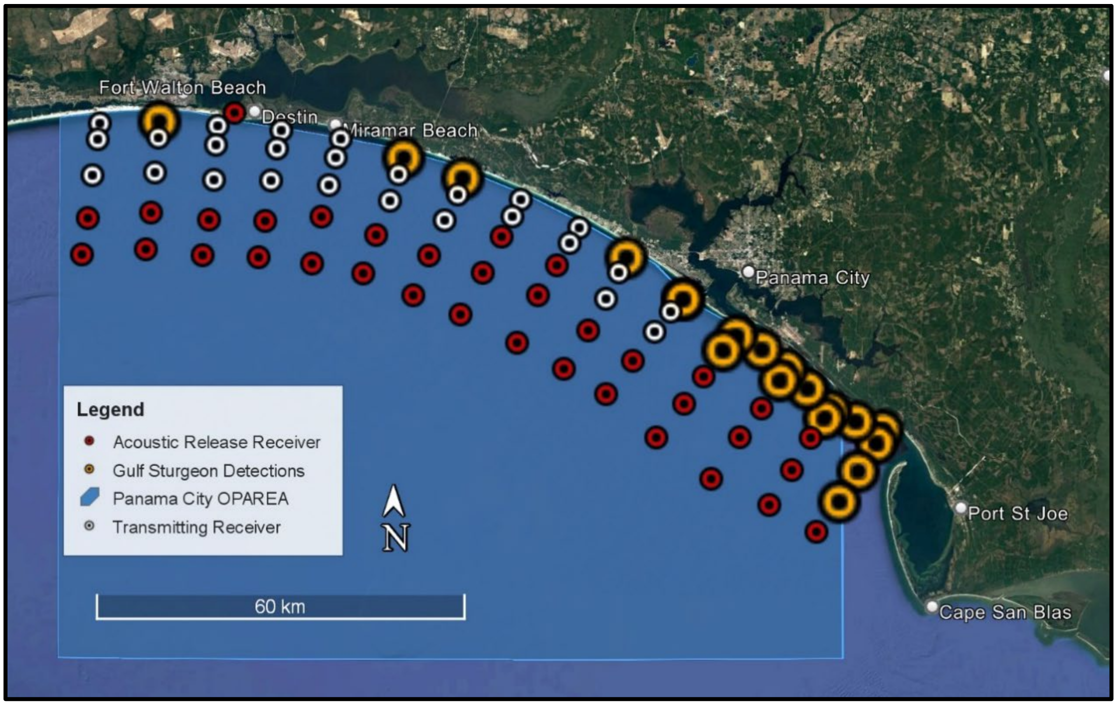


Figure 51. Acoustic receiver locations with detections of Gulf sturgeon in the NSWC Panama City Division Testing Range in the second field season (white = transmitting receivers, red = Acoustic Release receivers, orange = detections of Gulf sturgeon).

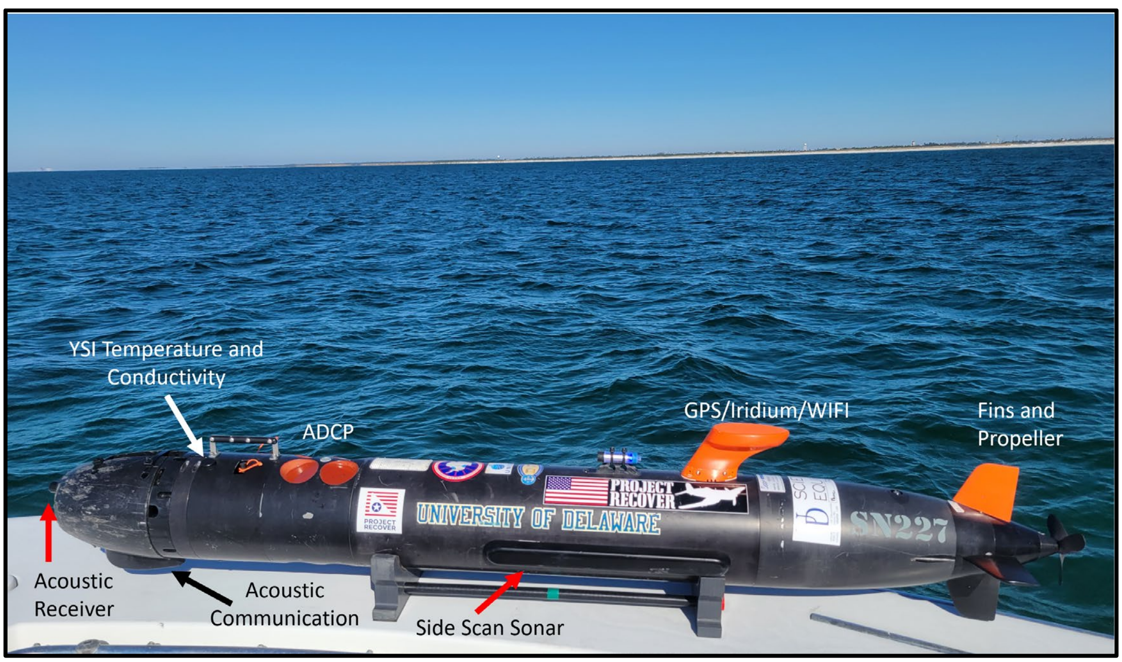


Figure 52 REMUS 100 Autonomous Underwater Vehicle used to detect Gulf sturgeon with an acoustic telemetry receiver, and also equipped with side-scan sonar, , and environmental sensors.

2.5 Ice Exercise Monitoring

The U.S. Department of the Navy was issued an Incidental Harassment Authorization (IHA) on 4 February 2022 under Section 101(a)(5)(D) of the MMPA (16 U.S. Code 1371(a)(5)(D)). The IHA authorized take incidental to 2022 Ice Exercise (ICEX) activities in the Arctic Ocean and was valid from 4 February through 30 April 2022. The IHA contained two reporting requirements:

1. *The holder of this Authorization is required to submit a draft report on all monitoring conducted under the IHA.*

Within the camp, the Camp Safety Watch was tasked specifically to monitor for marine mammals using a visual camera and a thermal imaging camera; each with pan, tilt, and zoom capability, as well as the naked eye. During the construction of the ice camp (prior to a dedicated Camp Safety Watch being in place) and during demobilization of the camp (after the Camp Safety Watch was disbanded), personnel still maintained a marine-mammal lookout within the camp and during every movement between the camp and the runways. Additionally, a dedicated marine-mammal watch was assigned to all field parties (i.e., any activity outside the immediate vicinity of the ice camp). PAM was conducted during all submarine activities, and mitigation was not required to be enacted. **Table 43** provides the cumulative hours of monitoring effort for marine mammals and total observations of marine mammals (note, none were observed).

Table 43. Monitoring Effort during ICEX 22.

Activity	Hours	Marine Mammal Observations
Camp Buildup	36	0
Camp Demobilization	48	0
Camp Safety Watch	84	0
Field Parties	125	0
Total Hours and Observations	**293**	**0**

2. *The Navy must analyze any declassified underwater recordings collected during ICEX 22 for marine mammal vocalizations and report that information to NMFS, including the types and natures of sounds heard (e.g., clicks, whistles, creaks, burst pulses, continuous, sporadic, strength of signal) and the species or taxonomic group (if determinable). This information must be submitted to NMFS with the 2023 annual AFTT declassified monitoring report.*

The ice camp supporting ICEX22 was operational from 28 February to 20 March 2022. During this time, the ice floe upon which the camp was built shifted from approximately 199 miles northeast of Deadhorse, Alaska, to 185 miles northeast of Deadhorse, Alaska. At the beginning of the camp build, a major breakup of ice within the Beaufort Sea caused multiple fractures to propagate through the first-year and multi-year ice at Camp Queenfish. The conditions were severe enough that personnel were evacuated from the camp and returned to Prudhoe Bay, and a second ice floe was then selected and the camp was built again. The time lost during demobilization of the first camp, pioneering for a second camp, and rebuilding meant that some of the research projects did not occur. One project was the under-ice recording conducted by Naval Post Graduate School. Therefore, no recordings to analyze for seal vocalizations exist.

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APPENDIX A

SUMMARY OF MONITORING PROJECTS IN THE ATLANTIC FOR 2022–2023

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Appendix A: Summary of Monitoring Investments in the Atlantic for 2022–2023

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, DTAGs, satellite tags **Performing Organizations**: Duke University, Southall Environmental Associates, University of St. Andrews, Bridger Associates, Calvin College, HDR Inc. **Timeline**: 2017–2023 **Funding**: FY16 – \$35K, FY17 – \$1.25M, FY18 – \$1.4M, FY19 – \$1.4M, FY20 – \$1.3M, FY21 – \$1.25M, FY22 - \$1.3M	• Evaluate behavioral responses by marine mammals exposed to Navy training and testing activities	**Field work ongoing** • Mid-frequency active sonar CEEs completed 2022 • Continuously active sonar CEEs begin 2023 • Technical progress reports available – 2017–2022 • Tagging data available - Animal Telemetry Network • Multiple peer-reviewed publications and manuscripts in prep or review
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, Bridger Consulting, HDR Inc. **Timeline**: Ongoing since 2013 – began supporting Atlantic BRS in 2017 **Funding**: FY12 – \$275K, FY13 – \$250K, FY14 – \$510K, FY15 – \$520K, FY16 – \$420K, FY17+ funded 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 • Tagging field work continues under Atlantic BRS • Tagging data - Animal Telemetry Network • Multiple peer-reviewed publications
Title: Mid-Atlantic Offshore Cetacean Study (VACAPES) **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., Kimora Solutions **Timeline**: 2015–2023 **Funding**: FY15 – \$75K, FY16 – \$645K, FY17 – \$0, FY18 – \$321K, FY19 – \$357K, FY20 – \$371K, FY21 – \$430K, FY22 - \$530K	• 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 – 2016–2022 • Sperm whale diving and feeding ecology focus beginning 2021 • Peer-reviewed publications • Sighting data – OBIS-SEAMAP • Tagging data – Animal Telemetry Network

Project Description	Intermediate Scientific Objectives	Status
Title: North Atlantic Right Whale Monitoring, Conservation, and Protection **Location**: Mid-Atlantic **Objectives**: Assess seasonal occurrence, habitat use, behavior and movements in the Mid-Atlantic region; Contribute to conservation and protection range-wide **Methods**: Passive acoustics, visual surveys, UAS and focal follow observations, suction-cup tags, satellite-linked telemetry tags **Performing Organizations**: HDR, Inc., Woods Hole Oceanographic Institution, Duke University, Kimora Solutions **Timeline**: 2014–2023 **Funding**: FY13 – $535K, FY14 – $640K, FY15 – $755K, FY16 – $540K, FY17 – $528K, FY18 – $518K, FY19 – $464K, FY20 – $615K, FY21 – $450K, FY22 – $450K	• 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 2014–2017 • Opportunistic visual monitoring, satellite-linked tagging, and suction-cup tag deployments in Mid-Atlantic beginning 2021 • Autonomous PAM glider deployments (2018–20), fixed auto-reporting PAM buoy off Cape Hatteras (2021–23), Mid-Atlantic SoundTrap deployments (2022–23) • Multiple peer-reviewed publications available • Sighting data - WhaleMap **Annual financial support to SE Early Warning System surveys** **Participation on NE and SE recovery plan implementation teams**
Title: Mid-Atlantic Nearshore & Mid-shelf Baleen Whale Monitoring **Location**: Mid-shelf VACAPES Range Complex **Objectives**: Assess occurrence, habitat use, and baseline behavior of baleen whales in the mid-Atlantic region **Methods**: Visual surveys, UAS and focal follow observations, photo-ID, biopsy sampling, satellite-linked telemetry tags **Performing Organizations**: HDR, Inc., Kimora Solutions **Timeline**: 2021–2023 **Funding**: FY22 – $420K	• 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 report available – 2022 • Spin-off from nearshore humpback monitoring project in 2021 • Tagging data – Animal Telemetry Network • Sighting data – OBIS-SEAMAP
Title: Mid-Atlantic Humpback Whale Monitoring **Location**: Nearshore VACAPES Range Complex **Objectives**: Assess occurrence, habitat use, and baseline behavior of humpback whales nearshore to SE Virginia and Chesapeake Bay **Methods**: Visual surveys, UAS and focal follow observations, photo-ID, biopsy sampling **Performing Organizations**: HDR, Inc., Kimora Solutions **Timeline**: 2015–2023 **Funding**: FY14 – $320K, FY15 – $260K, FY16 – $370K, FY17 – $325K, FY18 – $0, FY19 – $250K, FY20 – $157K, FY21 – $320K, FY22 – $150K	• 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 – 2014–2022 • Vessel response component added winter of 2019 • Focus on continuation of photo-ID and morphometric assessments beginning in 2022 • Peer-reviewed publications • Tagging data – Animal Telemetry Network • Sighting data – OBIS-SEAMAP

Project Description	Intermediate Scientific Objectives	Status
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 telemetry tags, and focal-follow observational methods **Performing Organizations**: Duke University, HDR Inc. **Timeline**: 2018–2023 **Funding**: FY19 – $95K, FY20 – $75K, FY21 – $80K, FY22 – $80K	• 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** • Technical progress reports available – 2019–2022
Title: Pinniped Tagging and Tracking in Virginia **Location**: Lower Chesapeake Bay & Virginia Eastern Shore **Objectives**: Document habitat use, movement and haul-out patterns of seals in the Hampton Roads region of Chesapeake Bay and coastal Atlantic Ocean **Methods**: Satellite-linked telemetry tags **Performing Organizations**: NAVFAC Atlantic, NAVFAC Northwest, Naval Undersea Warfare Center, The Nature Conservancy, Atlantic Marine Conservation Society, Virginia Aquarium & Marine Science Center Foundation, HDR Inc. **Timeline**: 2017–2023 **Funding**: FY16 – $40K, FY17 – $164K, FY18 – $46K, FY19 – $468K, FY20 – $200K, FY21 – $79K, FY22 – $290K	• 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 completion anticipated in 2023** • Technical progress report available – 2017–2022 • Field work resumed winter 2022 • Tagging data – Animal Telemetry Network
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, The Nature Conservancy, HDR Inc. **Timeline**: 2015–2023 **Funding**: FY15 – $52K, FY16 – $57K, FY17 – $7K, FY18 – $29K, FY19 – $62K, FY20 – $40K, FY21 – $50K, FY22 – $93K	• 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 – 2016–2022 • Time-lapse camera traps incorporated in 2019

Project Description	Intermediate Scientific Objectives	Status
Title: Time-lapse Camera Surveys of Pinnipeds in Southeastern Virginia **Location:** Lower Chesapeake Bay and Virginia Eastern Shore **Objectives:** Document seasonal occurrence, habitat use, and haul-out patterns of seals **Methods:** Remote time-lapse camera traps, photo-ID **Performing Organizations**: NAVFAC Atlantic, The Nature Conservancy **Timeline:** 2019–2023 **Funding:** FY19 – $15k, FY20 – $18K, FY21 – $11K, FY22 – $34K	• 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	**Data collection and analysis ongoing** • Technical progress reports available – 2019–2022
Title: Pinniped Behavioral Response Study [1] **Location:** Northeast U.S. (New York and Rhode Island) **Objectives:** Document habitat use, haul-out patterns, and baseline behavior of seals, assess behavioral response of seals to training and testing activities **Methods:** Remote time-lapse camera traps, visual surveys, satellite-linked telemetry tags **Performing Organizations**: Naval Undersea Warfare Center, Atlantic Marine Conservation Society, National Marine Fisheries Service, Marine Mammals of Maine **Timeline:** 2020–2023 **Funding:** $350k	• 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** • Technical progress report available – 2020–2022
Title: Occurrence of Rice's Whales in the Gulf of Mexico [1] **Location**: Northeastern Gulf of Mexico **Objectives**: Assess seasonal and occurrence of Rice's whales in the Northeastern Gulf of Mexico **Methods**: PAM **Performing Organizations**: NOAA-NMFS Southeast Fisheries Science Center **Timeline**: 2019–2023 **Funding**: FY18 – $78K, FY19 – $395K, FY20 – $250K, FY22 – $59K	• 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	**Data collection and analysis ongoing** • Technical progress reports available – 2019–2022 • 2020 data collection delayed due to COVID-19 pandemic • Data collection to be complete in 2023 • Publication planned based on final analysis results

[1] Funded by Naval Sea Systems Command

Project Description	Intermediate Scientific Objectives	Status
Title: Baseline Monitoring for Marine Mammals in the East Coast Range Complexes – Passive Acoustics **Location**: Virginia Capes, Cherry Point, and Jacksonville Range Complexes **Objectives**: Assess occurrence, habitat associations, density, and vocal activity of marine mammals in key areas of Navy range complexes **Methods**: Passive acoustics **Performing Organizations**: Duke University, Scripps Institute of Oceanography **Timeline**: 2007–2022 **Funding**: FY13 – $780K, FY14 – $800K, FY15 – $680K, FY16 – $596K, FY17 – $426K, FY18 – $299K, FY19 – $303K, FY20 – $231K	• 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 complete in 2022** • Technical progress report series available • Multiple peer-reviewed publications available • Data contributed to collaborative broad scale ecological analysis efforts at NOAA-NEFSC • Data archiving at NCEI initiated
Title: Acoustic Ecology of Northwest Atlantic Shelf Break Species and Effects of Anthropogenic Noise Impacts **Location**: Northwest Atlantic **Objectives**: Assess seasonal and spatial occurrence, acoustic niches, and anthropogenic drivers of distribution throughout the Northwest Atlantic shelf break region **Methods**: Passive acoustics **Performing Organizations**: NOAA-NMFS Northeast Fisheries Science Center **Timeline**: 2019–2023 **Funding**: FY18 – $143k, FY19 – $145K, FY20 – $145K, FY21 – $150K, FY22 – $150K	• 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	**Analysis ongoing** • Technical progress reports available – 2019–2022 • Multiple peer-reviewed publications available
Title: Atlantic Marine Assessment Program for Protected Species (AMAPPS) **Location:** Northwest Atlantic (Maine to Florida) **Objectives:** Assess the abundance, distribution, ecology, and behavior of marine mammals, sea turtles, and seabirds throughout the U.S. Atlantic **Methods:** Visual surveys, passive acoustics, tagging **Performing Organizations:** NOAA Fisheries Northeast and Southeast Fisheries Science Centers **Timeline:** 2010–2023 **Funding:** $250K annually	• 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	**Ongoing** • AMAPPS I – 2010–2014 • AMAPPS II – 2015–2019 • AMAPPS III – 2020–2024

Project Description	Intermediate Scientific Objectives	Status
Title: Jacksonville Shallow Water Tracking Range **Location**: Jacksonville SWTR **Objectives**: Assess occurrence, habitat associations, and stock structure of marine mammals and sea turtles in key areas of Navy range complexes, acoustic detection species verifications **Methods**: Passive acoustics (M3R), visual surveys, satellite-linked tags, biopsy sampling, photo-ID **Performing Organizations**: Duke University, HDR, Inc., NUWC Newport **Timeline**: 2020–2023 **Funding**: FY18 – $261K, FY19 – $62K, FY20 – $97K, FY21 – $304K FY22-$116K	• 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 • 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	**Field work ongoing** • Transitioned from small vessel baseline surveys • Field work resumed in 2021 with new M3R component • Current focus on photo-ID, tagging, and M3R species verification support
Title: Distribution of Gulf Sturgeon in the Panama City Testing Range [1] **Location**: NSWC Panama City Testing Range **Objectives**: Assess Gulf Sturgeon distribution and habitat use **Methods**: Acoustic tagging **Performing Organizations**: University of Delaware, Delaware State University **Timeline**: 2021–2023 **Funding:** FY21 – $177K, FY22 – $149K	• Assess the occurrence and distribution of Threatened and Endangered species in Navy range complexes and in specific training and testing areas • Establish the baseline habitat uses and movement patterns of threatened and Endangered species where Navy training and testing activities occur	**Data collection in progress** • Field work initiated in October 2021
Title: Lower Kennebec River Sturgeon Monitoring [1] **Location**: Bath Iron Works and Lower Kennebec River **Objectives**: Assess Atlantic and shortnose sturgeon distribution and habitat use **Methods**: Acoustic tagging **Performing Organizations**: NUWC Div. Newport, Maine Department of Natural Resources, U.S. Geological Survey, PSNY, University of Maryland **Timeline**: 2021–2023	• Assess the occurrence and distribution of Threatened and Endangered species in Navy range complexes and in specific training and testing areas • Establish the baseline habitat uses and movement patterns of threatened and Endangered species where Navy training and testing activities occur	**Data collection in progress** • Field work initiated in May 2021

Key: DTAG = digital acoustic tag; FY = Fiscal Year; BRS = behavioral response study; VACAPES = Virginia Capes; PAM = passive acoustic monitoring; UAS = Unmanned Aerial Systems; photo-ID = photo identification; NAVFAC = Naval Facilities Engineering Systems Command; USWTR = Undersea Warfare Training Range; M3R = Marine Mammal Monitoring on Navy Ranges; NOAA = National Oceanic and Atmospheric Administration; NMFS = National Marine Fisheries Service; NUWC = Naval Undersea Warfare Center; PSNY = Portsmouth Navy Yard; TBD = to be determined

[1] Funded by Naval Sea Systems Command

APPENDIX B

2022 PUBLICATIONS AND PRESENTATIONS RESULTING FROM AFTT-RELATED MONITORING INVESTMENTS

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Appendix B: 2022 Publications and Presentations Resulting from AFTT-related Monitoring Investments

Publications

Brown, D.M., J. Robbins, P.L. Sieswerda, C. Ackerman, J.M. Aschettino, S. Barco, T. Boye, R. A. DiGiovanni Jr., K. Durham, A. Engelhaupt, A. Hill, L. Howes, K.F. Johnson, L. Jones, C.D. King, A.H. Kopelman, M. Laurino, S. Lonergan, S.D. Mallette, M. Pepe, C. Ramp, K. Rayfield, M. Rekdahl, H.C. Rosenbaum, R. Schoelkopf, D. Schulte, R. Sears, J.E.F. Stepanuk, J.E. Tackaberry, M. Weinrich, E.C.M. Parsons and J. Wiedenmann. 2022. Site fidelity, population identity and demographic characteristics of humpback whales in the New York Bight apex. *Journal of the Marine Biological Association of the United Kingdom* 102(1-2):157–165.

DiMatteo, A., G. Lockhart, and S. Barco. 2022. Habitat models and assessment of habitat partitioning for Kemp's ridley and loggerhead marine turtles foraging in Chesapeake Bay (USA). *Endangered Species Research* 47:91–107.

Engelhaupt, A., T.A. Jefferson, J.M. Aschettino, and J.T. Bell. 2022. Distribution, abundance and sighting patterns of multiple stocks of bottlenose dolphins (*Tursiops truncatus*) in coastal Virginia waters. *Journal of Cetacean Research and Management* 23(1):109–125.

Hewitt, J., A.E. Gelfand, N.J. Quick, W.R. Cioffi, B.L. Southall, S.L. DeRuiter, and R.S. Schick. 2022. Kernel density estimation of conditional distributions to detect responses in satellite tag data. *Animal Biotelemetry* 10(1):1–15.

Shearer, J.M., F.H. Jensen, N.J. Quick, A. Friedlaender, B. Southall, D.P. Nowacek, M. Bowers, H.J. Foley, Z.T. Swaim, D.M. Waples, A.J. Read. 2022. Short-finned pilot whales exhibit behavioral plasticity in foraging strategies mediated by their environment. *Marine Ecology Progress Series* 695:1–14.

Presentations

Ampela, K., R. DiGiovanni, M. DeAngelis, J. Bort, D. Rees, A. DiMatteo, and A. Wilke. 2022. At-sea Movements and Haul-out Behavior of Tagged Harbor Seals (*Phoca vitulina*) in their Newly Expanded Range off the Eastern United States. Presentation, 24th Biennial Conference on the Biology of Marine Mammals, West Palm Beach, Florida, 1–5 August 2022.

Aschettino, J., D. Engelhaupt, A. Engelhaupt, M. Cotter, and J. Bell. 2022. Movements and Dive Behavior of a Blue Whale Tagged off Virginia, USA. Presentation, 24th Biennial Conference on the Biology of Marine Mammals, West Palm Beach, Florida, 1–5 August 2022.

DeAngelis, M., E. Guzas, L. Marshall, T. Fetherston, R. Hesse, D. Perez, and E. Warner. 2022. Combining Spatial and Temporal Acoustic Datasets to Examine the Summer Presence of Beaked Whales Off the East Coast of the US. Poster, 24th Biennial Conference on the Biology of Marine Mammals, West Palm Beach, Florida, 1–5 August 2022.

Engelhaupt, D., A. Engelhaupt, J. Aschettino, M. Cotter, A. DiMatteo, and J. Bell. 2022. Going Up the Country - Detailed Tag Data Provides Critical Insight into a North Atlantic Right Whale's 17-day Journey North. Presentation, 24th Biennial Conference on the Biology of Marine Mammals, West Palm Beach, Florida, 1–5 August 2022.

Hewitt, J., A. Gelfand, N. Quick, and R. Schick. 2022. Identifying Vertical Avoidance Diving Behavior in Cuvier's Beaked Whales (*Ziphius cavirostris*) Using Long-Duration, Low-resolution Satellite Telemetry Devices. Poster, 24th Biennial Conference on the Biology of Marine Mammals, West Palm Beach, Florida, 1–5 August 2022.

Jones, D., D. Rees, J. Bort Thorton, and L. Busch. 2022. Investigating Site Fidelity and Seasonal Abundance of an Expanding Harbor Seal Population in the Mid-Atlantic. Poster, 24th Biennial Conference on the Biology of Marine Mammals, West Palm Beach, Florida, 1–5 August 2022.

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