U.S. Navy

MARINE SPECIES MONITORING PROGRAM

2023

ANNUAL REPORT

Atlantic

Marine species monitoring report for the U.S. Navy's Atlantic Fleet Training and Testing (AFTT)

June 2024


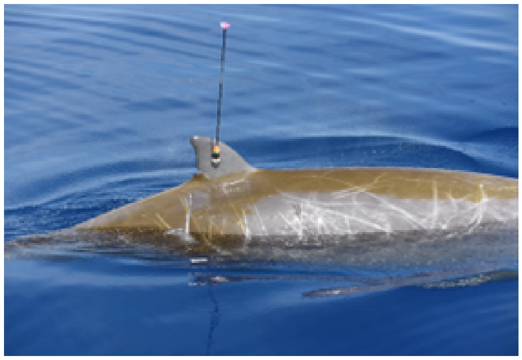


Photo credits from left to right:

Researchers approaching a pair of bubble-net feeding humpback whales (*Megaptera novaeangliae*) to deploy a suction cup tag during a vessel survey off Virginia Beach, Virginia. Photograph collected from a drone by Jessica Aschettino (HDR, Inc.), taken under National Marine Fisheries Service Scientific Research Permit No. 21482, issued to Dan Engelhaupt (HDR, Inc.).

A satellite tag is deployed on *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).

North Atlantic right whales (*Eubalaena glacialis*) #4130 (middle) and #4330 (top left), observed off Virginia Beach, Virginia, in a surface-active group during an aerial mid-shelf baleen whale survey; photographed by Todd Pusser (HDR, Inc.), taken under National Marine Fisheries Service Scientific Research Permit No. 21482, issued to Dan Engelhaupt (HDR, Inc.).

Marine species monitoring report for the U.S. Navy's Atlantic Fleet Training and Testing (AFTT)

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Science ⚓ Stewardship ⚓ Protection

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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
AUTEC	Atlantic Undersea Test and Evaluation Center
BIW	Bath Iron Works
BRS	behavioral response study
CAS	continuously active sonar
CATS	Customized Animal Tracking Solutions
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
DMON	digital acoustic monitoring instrument
DNN	deep neural network
DoN	Department of the Navy
DTAG	digital acoustic tag
DUML	Duke University Marine Lab
EDT	Eastern Daylight Time
EIS	Environmental Impact Statement
ENS	effective number of species
ESA	Endangered Species Act
FL	fork length
GMT	Greenwich Mean Time
GOM	Gulf of Mexico
GPS	Global Positioning System
HARP	High-frequency Acoustic Recording Package
ICMP	Integrated Comprehensive Monitoring Program
ID	identifier or identification number
JAX	Jacksonville
JSWTR	Jacksonville Shallow Water Training Range
kg	kilogram(s)
kHz	kilohertz
km	kilometer(s)
km^2	square kilometer(s)
LFDCS	Low-frequency Detection and Classification System
LiDAR	Light Detection and Ranging
LMR	Living Marine Resources
M3R	Marine Mammal Monitoring on Navy Ranges
m	meter(s)
MarEcoTel	Marine Ecology and Telemetry Research
MAHWC	Mid-Atlantic Humpback Whale Photo-ID Catalog
Max	maximum
ME DMR	Maine Department of Marine Resources
MFAS	mid-frequency active sonar
Min	minute(s)
MINEX	Mine-neutralization Exercise
MMM	Maine Maritime Museum
MMoME	Marine Mammals of Maine

MMPA	Marine Mammal Protection Act
mm:ss	minutes:seconds
MSM	Marine Species Monitoring
N/A or n/a	not available or not applicable
NARW	North Atlantic right whale
NBATH	Northern Bath Iron Works
NEAQ	New England Aquarium
NEFSC	Northeast Fisheries Science Center
nm	nautical mile(s)
NMFS	National Marine Fisheries Services
No.	Number
NOAA	National Oceanic and Atmospheric Administration
NSWC	U.S. Naval Surface Warfare Center
NUWC	Naval Undersea 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
PAS	pulsed active sonar
photo-ID	photo-identification
PMRF	Pacific Missile Range Facility
PTT	platform transmitter terminal
RL	received level
R/V	research vessel
SAG	surface-active group
SBES	split beam echosounder system
SBU	Stony Brook University
SEA	Southall Environmental Associates Inc.
SEFSC	Southeast Fisheries Science Center
SMA	Seasonal Management Area
SOAR	Southern California Anti-Submarine Warfare Range
SP	Sutherland/Patteson
SPOT	Smart Position and Temperature
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
YOY	young of the year
Zc	*Ziphius cavirostris*

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SECTION 1 – INTRODUCTION

This report contains a summary of Marine Species Monitoring (MSM) investments funded by the United States (U.S.) Navy in 2023 within the Atlantic Fleet Training and Testing (AFTT) study area 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 Final Rule and Letters of Authorization (NMFS 2019) and Biological Opinion (NMFS 2018) issued under the Marine Mammal Protection Act of 1972 (MMPA) and the Endangered Species Act of 1973 (ESA) for training and testing activities within the AFTT study area.

Section 2 of this report summarizes monitoring progress and results for each project, with additional data and details as follows:

- Detailed technical reports for individual projects are provided as supporting technical documents to this report (Alvarez et al. 2024; Aschettino et al. 2024a; Aschettino et al. 2024b; Engelhaupt et al. 2024; NUWC Newport 2024; Shearer et al. 2024; Soldevilla et al. 2024; Southall et al. 2024; Van Parijs et al. 2024; Waples and Read 2024) and are available on the U.S. Navy's MSM web portal. Each individual technical report is also linked directly from the corresponding subsection.
- A summary of current monitoring investments for 2023–2024 is provided in **Appendix A**.
- Publications and conference presentations for 2023 from work funded under the monitoring program within the AFTT study area are listed in **Appendix B.**

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 (GOM) (**Figure 1**). The AFTT study area covers approximately 2.6 million square nautical miles (nm) of ocean area and includes designated U.S. Navy operating areas (OPAREAs) and special use airspace. The AFTT study area also includes portions bays, harbors, inshore waterways, ports, and pierside locations where military readiness activities occur. The U.S. Navy's range complexes that fall within the AFTT study area include the following and are depicted in **Figure 1**:

- Northeast Range Complex
- Virginia Capes (VACAPES) Range Complex
- Navy Cherry Point Range Complex
- Jacksonville (JAX) Range Complex
- Key West Range Complex
- GOM 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 a Letter of Authorization 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.

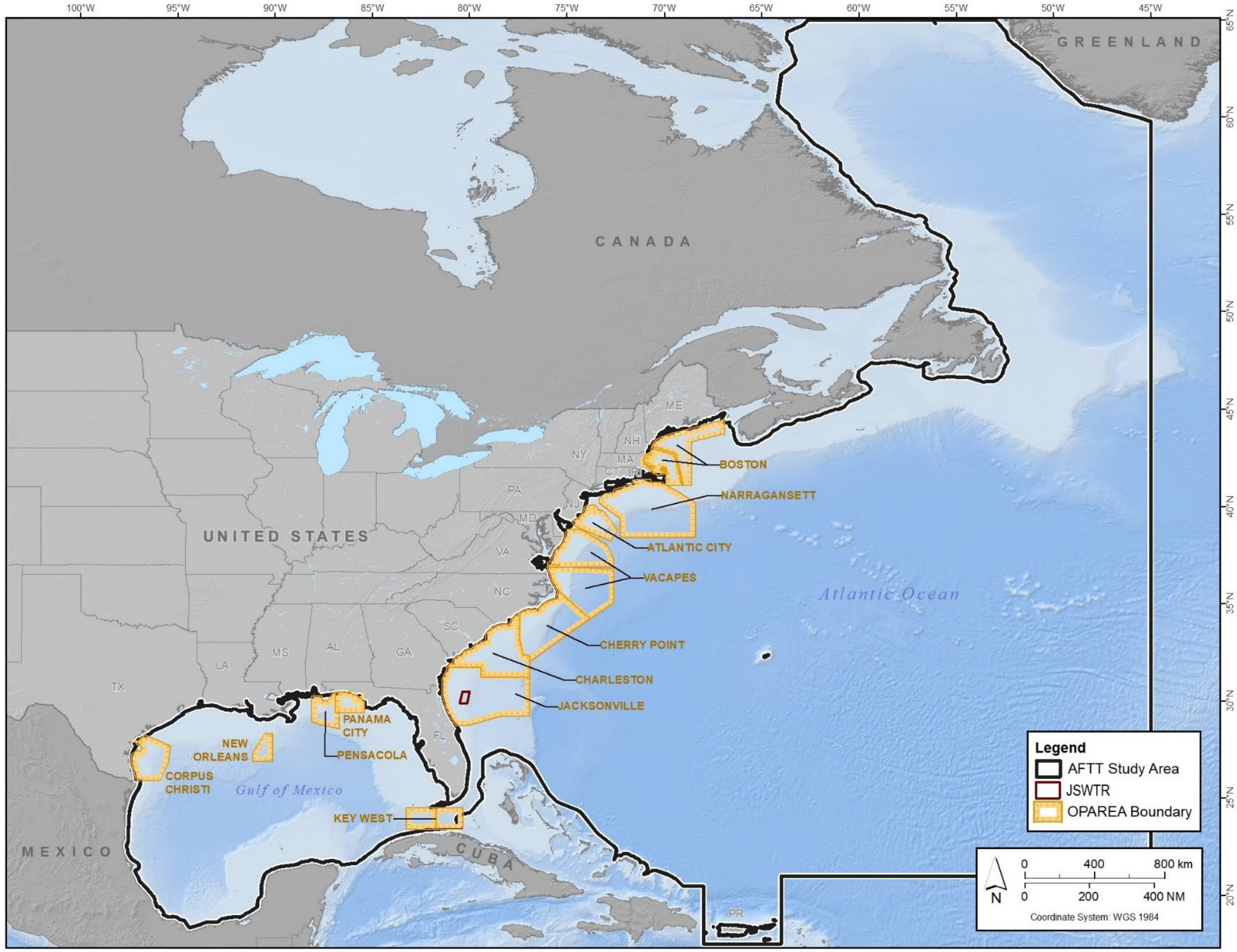


Figure 1. Atlantic Fleet Training and Testing study area.

The U.S. Navy has invested nearly $55 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 web portal. 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 within the Atlantic Fleet Training and Testing study area during Fiscal Years 2009–2023.

Fiscal Year (01 October–30 September)	Funding
2009–2013	$15,330,000
2014–2018	$17,715,000
2019	$4,187,000
2020	$4,022,000
2021	$4,240,000
2022	$4,175,000
2023	$4,690,000
Total	**$54,359,000**

In addition to the compliance monitoring program for training and testing activities, the Office of Naval Research (ONR) Marine Mammals and Biology Program supports basic and applied research and technology development related to understanding the effects of sound on marine mammals, including physiological, behavioral, ecological and population-level effects, and the Office of the Chief of Naval Operations (CNO) Environmental Readiness Program's Living Marine Resources (LMR) Program invests in projects supporting risk threshold criteria and impact assessment, analysis tools, and monitoring technology demonstrations. These programs each currently fund significant portfolios of ongoing projects relative to potential operational impacts on marine species with the primary goal of supporting U.S. Navy environmental planning and compliance.

1.2 Marine Species Research and Monitoring Strategic Framework

The initial structure for U.S. Navy's marine species monitoring efforts was developed in 2009 with the Integrated Comprehensive Monitoring Plan (ICMP). The intent of the ICMP was to provide an overarching framework for coordination of the U.S. Navy's monitoring efforts during the early years of the program's establishment. A Strategic Planning Process (DoN 2013) was subsequently developed and together with the ICMP framework serves as a planning tool to focus marine species monitoring priorities pursuant to ESA and MMPA requirements, and to coordinate monitoring efforts across regions based on a set of common objectives. Using an underlying conceptual framework incorporating a progression of knowledge from occurrence to exposure/response, and ultimately consequences, the Strategic Planning Process was developed as a tool to help guide the investment of resources to most efficiently address top-level objectives and goals of the monitoring program. Intermediate Scientific Objectives form the basis of evaluating, prioritizing, and selecting new monitoring projects or investment topics 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).

The Navy's marine species monitoring program investments are evaluated through the Adaptive Management Review (AMR) process to 1) assess overall progress, 2) review goals and objectives, and 3) make recommendations for refinement and evolution of the monitoring program's focus and direction. The marine species monitoring program has developed and matured significantly since its inception and now supports a portfolio several dozen active projects across a range of geographic areas and protected species taxa addressing both regional priorities (i.e., particular species of concern), and Navy-wide needs such as the behavioral response of beaked whales to training and testing activities.

A Research and Monitoring Summit was held in early 2023 to evaluate the current state of the Marine Species Monitoring Program in terms of progress, objectives, priorities, and needs, and to solicit valuable input from meeting participants including NMFS, MMC, and scientific experts. The overarching goal of the summit was to facilitate updating the ICMP framework for guiding marine species research and monitoring investments, and to identify data gaps and priorities to be addressed over the next 5 to 10 years across a range of basic research through applied monitoring. One of the outcomes of this summit meeting is a refreshed strategic framework, effectively replacing the ICMP, and continuing to provide coordination and synergy across the Navy's protected marine species investment programs with the collective goal of supporting improved assessment of effects from training and testing activities through development of first in class science and data.

1.3 Report Objectives

This report presents the progress, accomplishments, and results of U.S. Navy MSM projects within the AFTT study area during 2023 and has two primary objectives:

1. Summarize findings from the U.S. Navy-funded protected marine species monitoring conducted within the AFTT study area during 2023, 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. Provide an overview of monitoring initiatives and progress to support the ongoing AMR process, and evolution of the strategic framework for U.S. Navy marine species research and monitoring. These initiatives continue to shape the evolution of the U.S. Navy MSM Program for 2024 and beyond, improve understanding of the occurrence and distribution of protected marine species within the AFTT study area, improve understanding of their exposure and response to sonar and explosives training and testing activities, and ultimately inform us on the consequences of that exposure.

Appendix A summarizes U.S. Navy MSM investments within the Atlantic for 2023 and projects continuing in 2024. 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 projects involving the occurrence and distribution (**Section 2.1**) and ecology, behavior, and social structure (**Section 2.2**) of multiple species of cetaceans, as well as behavioral response studies (**Section 2.3**) and North Atlantic right whale *(*NARW*)* (*Eubalaena glacialis)* research within the Mid-Atlantic (**Section 2.4**).

Although standard line-transect visual surveys are no longer a significant component of monitoring for AFTT, work on occurrence, distribution, ecology, behavior, 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 and Distribution

2.1.1 Pinniped Monitoring 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 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-identification (photo-ID) methods are being used to acquire a better understanding of 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 2022/2023 field season, systematic vessel-based counts of all seal species were conducted at two different survey areas shown in **Figure 2**: 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 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 April 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.

2.1.1.1 Haul-out Count Results

For the 2022/2023 field season at the CBBT survey area, 12 survey days were completed between 4 November 2022 and 24 April 2023. Overall, 110 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 = 64) and CBBT 4 (n = 44) compared to CBBT 2 (n = 2) and CBBT 1 (n = 0). Of the 110 seals sighted, 108 were harbor seals and two were gray seals. 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 31 seals, with the highest count recorded in February. For the Eastern Shore survey area, 11 survey days were completed between 2 November 2022 and 11 April 2023. Seals were observed on 9 of the 11 (81.8 percent) survey days, with a total of 187 seal sightings recorded for the season. Of the 187 seal sightings, 185 were harbor seals and two were gray seals. The total daily number of seals counted ranged from 0 to 68 individuals per survey day, with the highest count recorded in January. Seals were observed hauled out at four of the five main haul-out sites.

At of the end of the 2022/2023 field season, 134 survey days have been conducted across nine field seasons (2014–2023) at the CBBT survey area. Seals have been consistently recorded from mid-November to April. For the Eastern Shore survey area, 82 survey days have been conducted across seven field seasons (2016–2023), 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), 2020/2021 (n = 1), and 2022/2023 (n = 2) 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), 2020/2021 (n = 4), and 2022/2023 (n = 2) field seasons; one gray seal was sighted off effort during the 2021/2022 season.

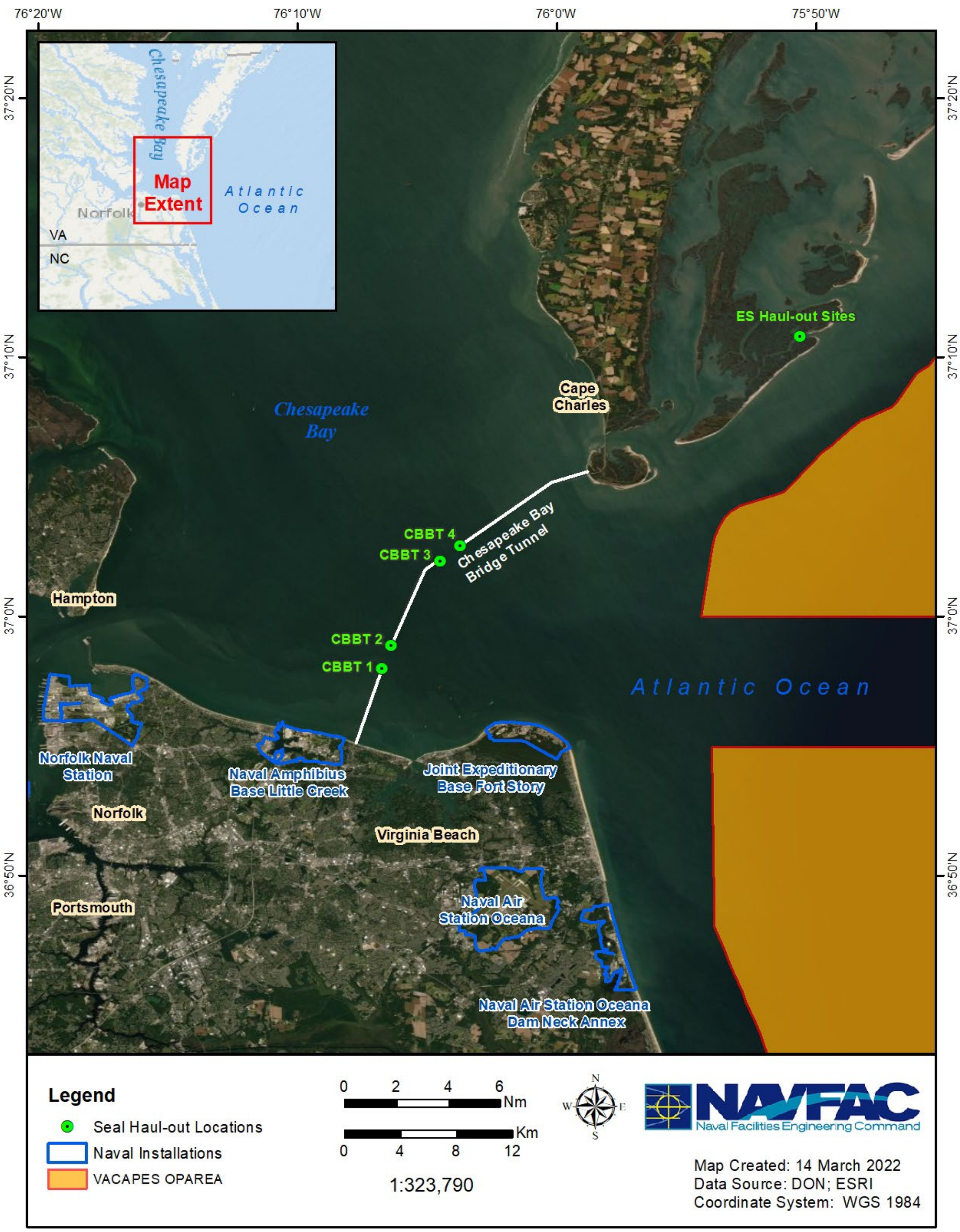


Figure 2. Chesapeake Bay Bridge Tunnel (CBBT) and Eastern Shore (ES) haul-out locations and their proximity to U.S. Naval installations.

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 2**). 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 and 2022/2023 seasons. 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 2023 field seasons (**Table 3**). 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 ($F_{stat} = 2.46$, $p = 0.018$) was observed between the average seal counts across the nine field seasons (2014–2023) 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 seven field seasons (2016–2023) was not statistically different ($F_{stat} = 0.38$, $p = 0.89$).

Table 2. 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.

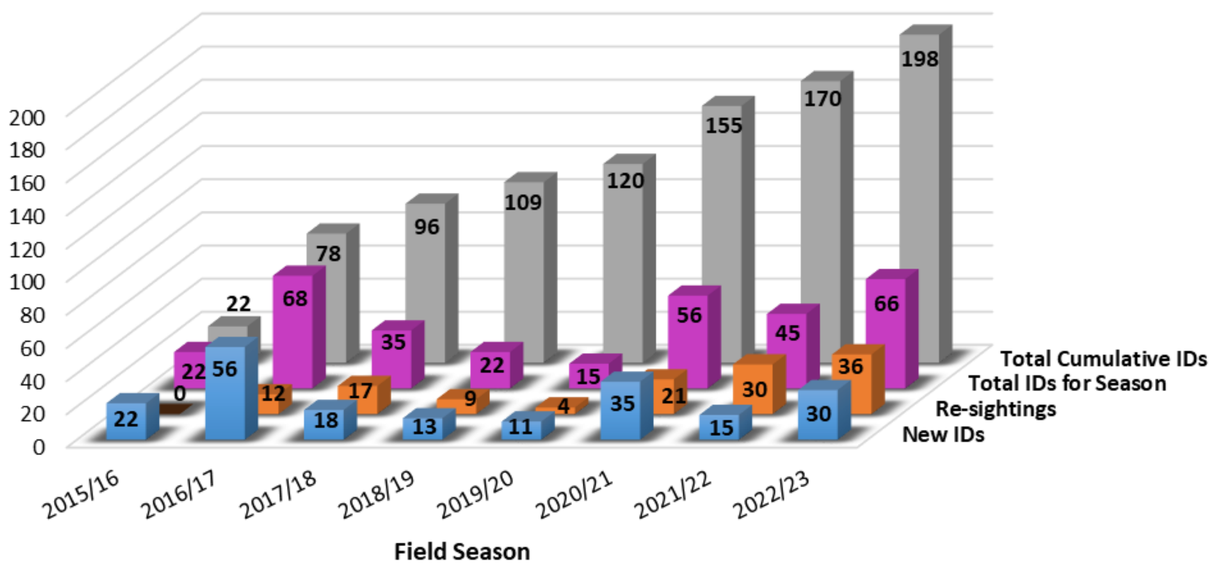
Field Season	"In Season" Survey Effort (days)	Seal Counts		
		Total	Average	Maximum
2014–2015	11	113	10	33
2015–2016	14	187	13	39
2016–2017	22	308	14	40
2017–2018	15	340	23	45
2018–2019	10	82	8	17
2019–2020	6	29	5	9
2020–2021	11	137	12	32
2021–2022	10	98	10	25
2022–2023	11	110	10	30

Table 3. 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
2022–2023	9	187	21	68

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

For the 2022/2023 field season, 66 harbor seals and three gray seals were uniquely identified. For the harbor seals, 30 (45 percent) were new individuals to the catalog, and 36 (55 percent) were re-sightings of individuals that were identified from previous field seasons (**Figure 3**). For gray seals, two were new individuals and one was a re-sighting of an individual that was first identified on 17 February 2021. After reviewing all images from the 2015 to 2023 seasons, 198 harbor seals and 4 gray seals were uniquely identified. Of the 198 harbor seals, 96 (48 percent) were observed only once, and 102 (52 percent) were determined to be present within the study area on more than one occasion across the eight field seasons, indicating a degree of seasonal site fidelity within the lower Chesapeake Bay and coastal Virginia waters. More than half of the identified harbor seals (53 percent) have been sighted at only the CBBT survey area, with a smaller percentage (36 percent) sighted at only the Eastern Shore survey area. Twenty-one 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.



Key: ID = identifier

Figure 3. Harbor seal identifications over seven field seasons since 2015. The purple bars indicate the total number of IDs for a season, orange bars indicate number of re-sightings (i.e., those IDs that were seen in previous seasons), blue bars indicate number of new IDs added to the catalog, and gray bars indicate 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 eight seasons (2015–2023) was 150 individuals. Abundance estimates were also calculated for each field season from 2015 to 2023 using the mark-recapture data; estimates 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 4**). A fluctuation in abundance estimates occurred across seasons. There was an overall increase from the 2015/2016 to 2018/2019 field seasons, with the exception of the 2017/2018 season, in which a decrease in abundance ($n = 135$ individuals) was observed. Abundance decreased after the 2018/2019 season but seemed to remain relatively stable from the 2019/2020 to 2021/2022 seasons, with a decrease in abundance for the 2022/2023 season (*n* = 85 individuals). 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.

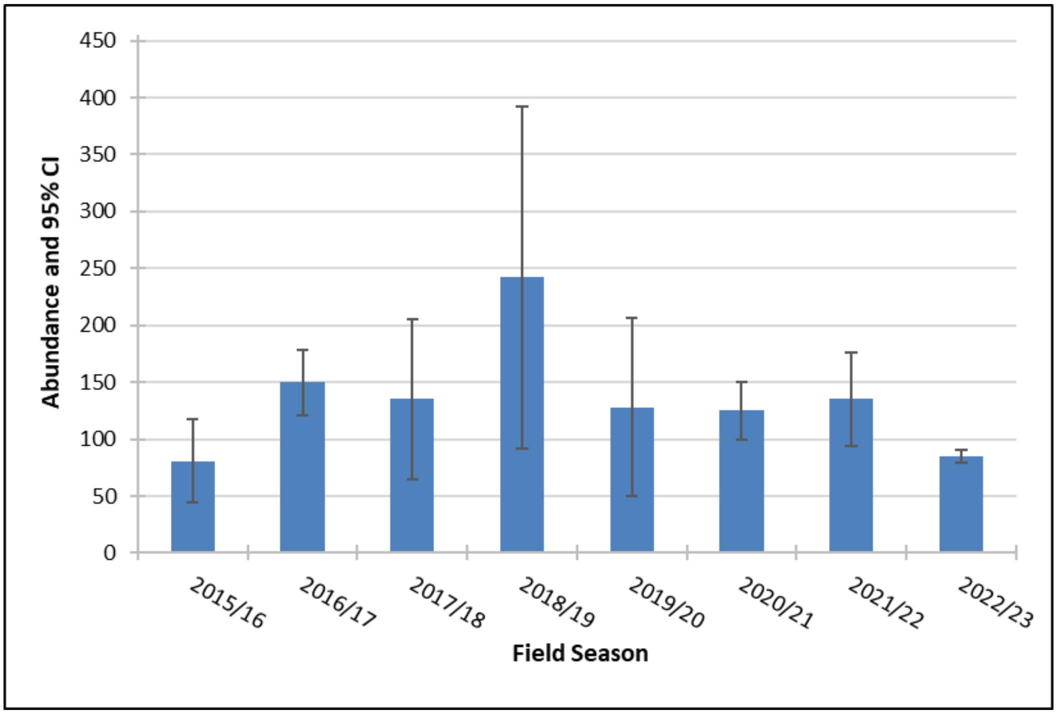


Figure 4. Total abundance estimates and 95 percent confidence intervals (CIs) for the combined CBBT and Eastern Shore survey areas, calculated from the mark-recapture approach for the 2015–2023 field seasons.

Haul-out counts and photo-ID data collection have continued for the 2023/2024 field season at both the CBBT and Eastern Shore survey areas. A technical progress report covering through the 2023/2024 field season will be available in late 2024. For more information on the Virginia seal haul-out count visual surveys, please visit the project profile page.

2.1.1.3 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 MMPA and National Environmental Policy Act for Commander, U.S. Fleet Forces Command (USFFC) 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 four seasons (2019/2020, 2020/2021, 2021/2022, and 2022/2023), with a fifth (2023/2024) in progress. 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 Eastern Shore survey area, given the remoteness of the area and close proximity of the haul-out sites to one another. Starting in 2023, wireless cameras were added to the CBBT survey area due to the high failure rate in the 2022/2023 season. Adding wireless cameras at CBBT allowed us to continually monitor camera performance.

During the 2021/2022 and 2022/2023 seasons, cameras were deployed from October to May at both the Eastern Shore and CBBT survey areas. 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. 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 5** shows the customizable data entry field (right) and the marks (yellow circles) on each counted seal. 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).

Camera trap effort and sighting summaries are shown in **Table 4** for the Eastern Shore survey area and **Table 5** for the CBBT survey area. Total seal counts for the 2021/2022 season were 60,959 at the Eastern Shore survey area and 14,144 at the CBBT survey area. During the 2022/2023 season, total seal counts were 59,551 at the Eastern Shore survey area and 15,461 at the CBBT survey area. Total counts indicate the total number of seals counted for the entire season in each image. Images were taken every 15 minutes; therefore, total counts are not to be interpreted as total number of seals at a site but are presented to provide relative haul-out use by site, and an index of haul-out activity.

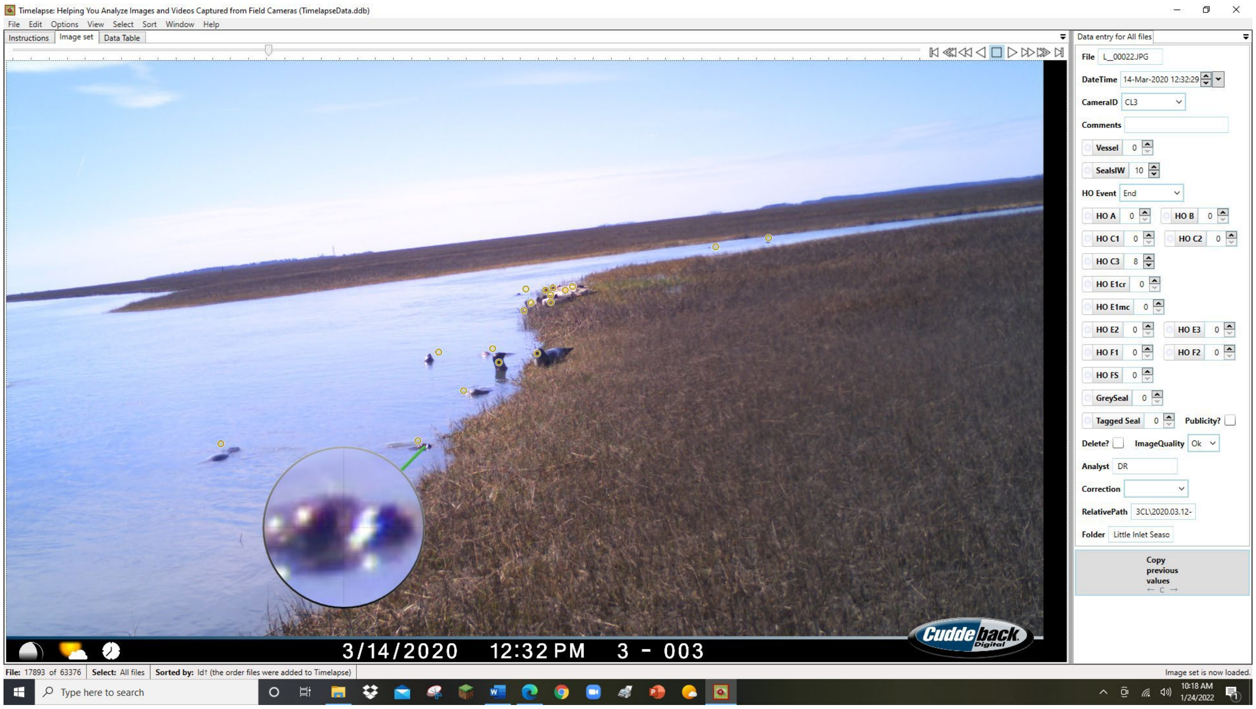


Figure 5. Screenshot of Timelapse Image Analysis workspace.

Table 4. Camera trap effort summary for the Eastern Shore survey area during the occupancy season.

Season	First Seal Recorded	Last Seal Recorded	Average Seals Hauled Out	% of Days Hauled-out	% of Days Present[a]
2019/2020	4-Nov-19	20-Apr-20	11.71	75.84	83.71
2020/2021	30-Oct-20	25-May-21	9.86	62.91	88.73
2021/2022	15-Oct-21	28-Apr-22	13.87	67.77	80.09
2022/2023	22-Oct-22	17-May-23	9.97	71.04	84.62

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

Table 5. Camera trap effort summary for the CBBT survey area during the occupancy season.

Season	Site	First Seal Recorded	Last Seal Recorded	Average Seals Hauled Out	% of Days Hauled-out	% of Days Present[a]
2019/2020[b]	CBBT3	8-Jan-20	28-Apr-20	4.34	30.97	72.56
	CBBT4	10-Jan-20	17-Apr-20	3.56	43.24	55.86
2020/2021	CBBT3	30-Oct-20	1-May-21	4.86	19.50	47.00
	CBBT4	4-Dec-20	22-May-21	5.19	32.23	56.39
2021/2022	CBBT3	20-Oct-21	16-Apr-22	5.33	23.08	64.34
	CBBT4	30-Nov-21	1-May-22	7.27	41.18	54.90
2022/2023	CBBT3	25-Oct-22	23-Apr-23	4.52	45.63	90.63
	CBBT4	25-Oct-22	31-Mar-23[c]	5.98	71.17	96.39

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

[b] Cameras were not installed until Jan 2020.

[c] No images were taken at CBBT4 after March 31, 2023, due to camera failure

During the 2021/2022 season, at the Eastern Shore study area, the seal average increased until the peak count in February, then began to decrease until the seals left the area (**Figure 6**). At the CBBT survey area, the seal average was much higher in February than in the other months (**Figure 7**). During the 2022/2023 season at the Eastern Shore survey area, the seal average increased until the peak count in January, then began to decrease until the seals left the area. Figure 6At the CBBT survey area, the months of January and February had the highest average before decreasing drastically in March.

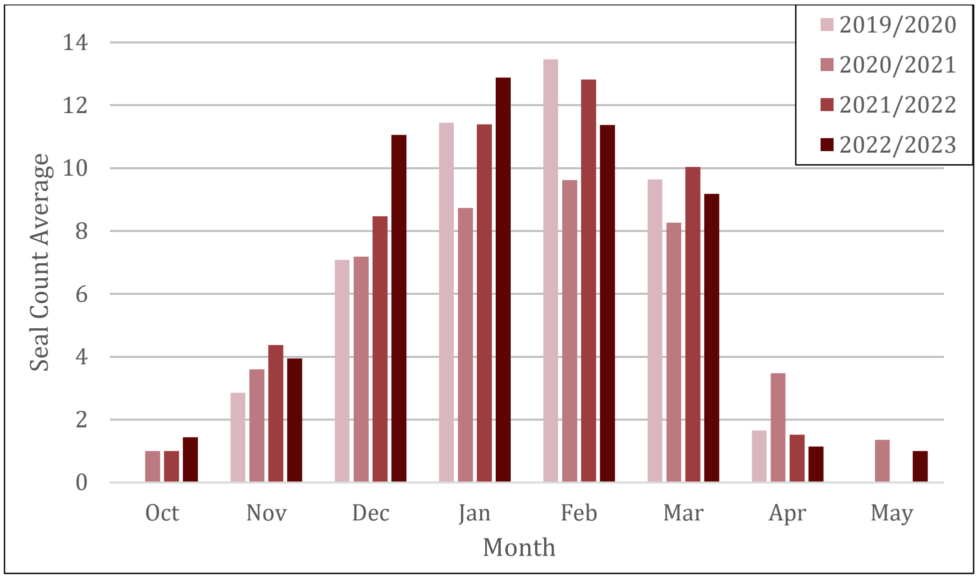


Figure 6. Average seals counted by month at the Eastern Shore survey area.

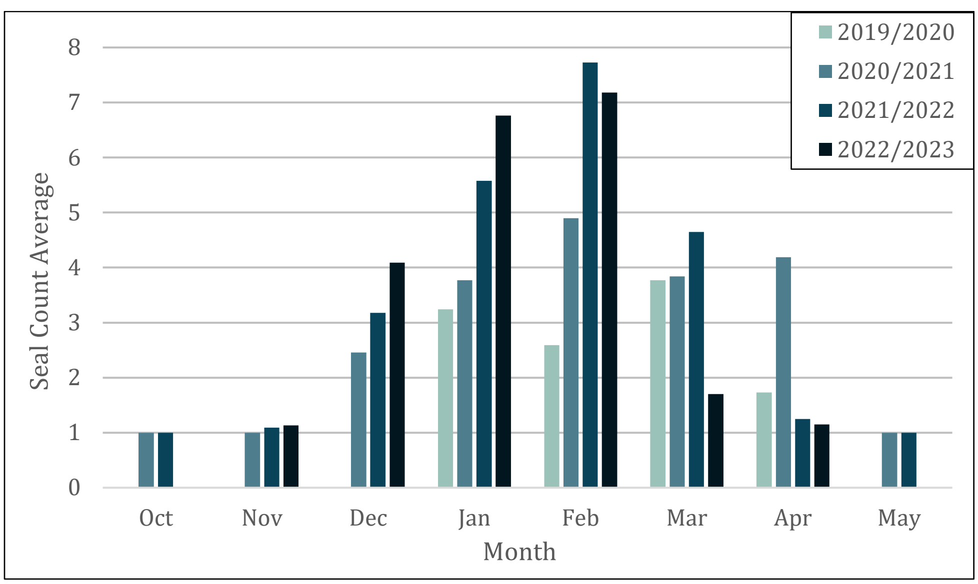


Figure 7. Average seals counted by month at the CBBT survey area.

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, 2021/2022 and the 2022/2023 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, 2021/2022, and 2022/2023 seasons. During the 2021/2022 season, vessels were captured on 35.5 percent of the survey days at the Eastern Shore survey area and 54.90 percent of the survey days at the CBBT survey area. During the 2022/2023 season, vessels were captured on 29.86 percent of the survey days at the Eastern Shore survey area and 51.38 percent of the survey days at the CBBT survey area. A technical progress report covering through the 2023/2024 field season will be available in late 2024. For more information on the Virginia seal camera survey work, including details of analyses conducted, please visit the project profile page.

2.1.2 Passive Acoustic Monitoring for Rice's Whale Occurrence in the Northeastern Gulf of Mexico

The Rice's whale (*Balaenoptera ricei*; formerly GOM 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 Southeast Fisheries Science Center (SEFSC) began deploying a sparse array of 17 PAM units concurrent with one long-term High-frequency Acoustic Recording Package (HARP) in May 2021. The PAM moorings were deployed in two lines of nine units each to nearly completely cover the core habitat (**Figure 8**) 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-kilohertz (kHz) frequency range, including Rice's whale calls and ambient noise, for up to 6 months. Additionally, the study leverages a long-term HARP 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.

During 2023, data analyses were completed 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.

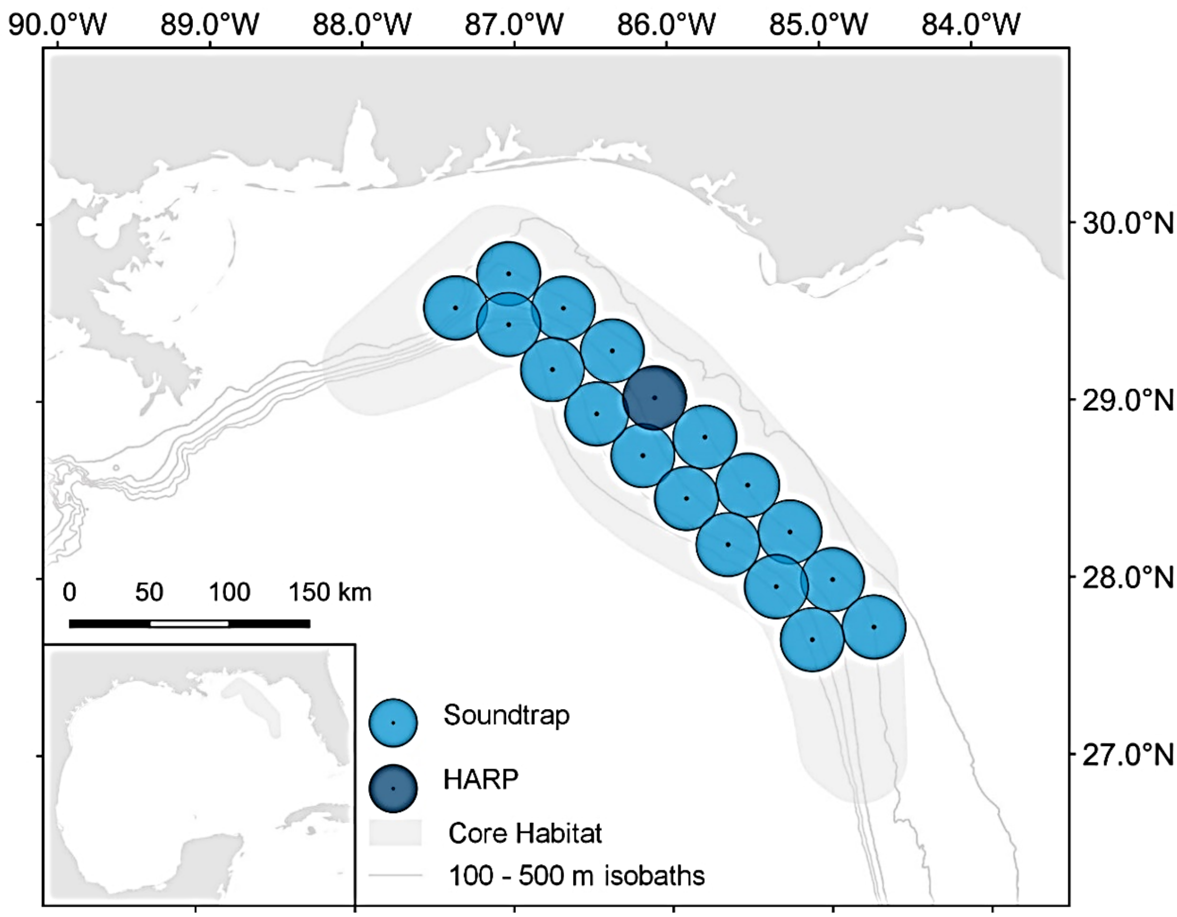


Figure 8. Historic long-term PAM station in the Rice's whale core habitat since 2010 (HARP) and 2021–2023 PAM stations (SoundTraps). The NMFS core habitat of Rice's whales is indicated.

Across the 15 moorings recovered from the November 2021 to April 2022 period, there were 1,835 instrument-days of recordings, 533,193 Rice's whale long-moan calls detected, and 67,712 Rice's whale downsweep sequences detected. The validation process for long-moan calls was completed on the remaining two of the 15 moorings, yielding a total of 250,122 true long-moan calls. The validation process for downsweep sequences was completed for all 15 sites, yielding a total of 10,989 true downsweep sequences. During this November 2021 to April 2022 period, true detections of Rice's whale long-moans occurred at 14 of the 15 sites, ranging from 368 to 53,884 calls per site, with call presence ranging from 29 to 97 percent of days. True detections of downsweep sequences occurred at 10 of the 15 sites, ranging from 18 to 3,148 calls per site, with call presence ranging from 1 to 62 percent of days.

A total of 11 moorings recovered from the April to September 2022 period yielded 1,552 instrument-days of recordings, 271,692 Rice's whale long-moan call detections, and 81,297 Rice's whale downsweep sequence detections. All calls were validated over the 11 moorings yielding a total of 124,521 true long-moan calls and 4,104 true downsweep sequences. During this April 2022 to September 2022 period, true detections of Rice's whale long-moans occurred at all 11 sites, ranging from 74 to 43,941 calls per site, with call presence ranging from 9 to 100 percent of days. True detections of downsweep sequences occurred at 8 of the 11 sites, ranging from 1 to 2,755 calls per site, with call presence ranging from 1 to 60 percent of days. The August 2021 to June 2022 HARP recordings yielded 285 days of recordings, 144,819 long-moan detections, and 24,295 downsweep sequence detections. The validation process yielded 103,338 true long moan calls and 3,771 true downsweep sequences, present on 99 percent and 40 percent of days, respectively. 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 these two deployment periods led to higher false-positive rates than seen in the first deployment.

Final statistical analyses and manuscript preparation are currently underway. These analyses and the manuscript will also include data from a fourth deployment funded by National Oceanic and Atmospheric Administration (NOAA). Additional leveraging is incorporating sound propagation modeling and ambient noise analyses to estimate detection ranges for normalizing call detections across sites and over time prior to evaluating seasonal trends. 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. (2024).

2.1.3 Atlantic and Shortnose Sturgeon Monitoring in the Lower Kennebec River

This telemetry monitoring study managed by the Naval Undersea Warfare Center Division Newport (NUWCDIVNPT) was initiated in May 2021 to collect year-round occurrence data for Atlantic sturgeon (*Acipenser oxyrhynchus*) and shortnose sturgeon (*A. oxyrhynchus*) in the lower Kennebec River (from north of Bath Iron Works [BIW] to Fort Popham), and to collect data during recurrent Naval activities. This study also implemented monitoring stations offshore of Popham Beach to capture coastal movements of sturgeon and other species, including white sharks. 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 BIW; 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); 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 acoustic tags to the population of sturgeon occurring in the Kennebec River system.

Collaborators on this project include 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 movement patterns in and out of the Kennebec basin, identify potentially new overwintering 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.

Although some actively transmitting sturgeon tags in the Kennebec region have not expired, 40 Atlantic sturgeon ranging from 57- to 168-centimeter (cm) fork length (FL) and 23 shortnose ranging from 54- to 87-cm FL were captured in June, July, and October 2022. To increase the population of tagged fish in the Kennebec, 61 of these fish were acoustically tagged with surgically implanted transmitters (VEMCO Innovasea, V16 and V13). As of December 2023, there are 15 year-round telemetry monitoring stations from Courthouse Point in Dresden to Fort Popham (including one in the Eastern River offshoot), and 5 stations offshore (**Figure 9**). Seven of the in-river stations are co-maintained by ME DMR (seasonal) and NUWCDIVNPT. Downloads of telemetry stations occur on a bi-annual basis. In river, the array has detected both species of sturgeon, American shad (*Alosa sapidissima*), and striped bass (*Morone saxitilis*). Offshore data for the project duration thus far includes detections for species of sturgeon, striped bass, white sharks (*Carcharodon carcharias*), and Atlantic bluefin tuna (*Thunnus thynnus*).

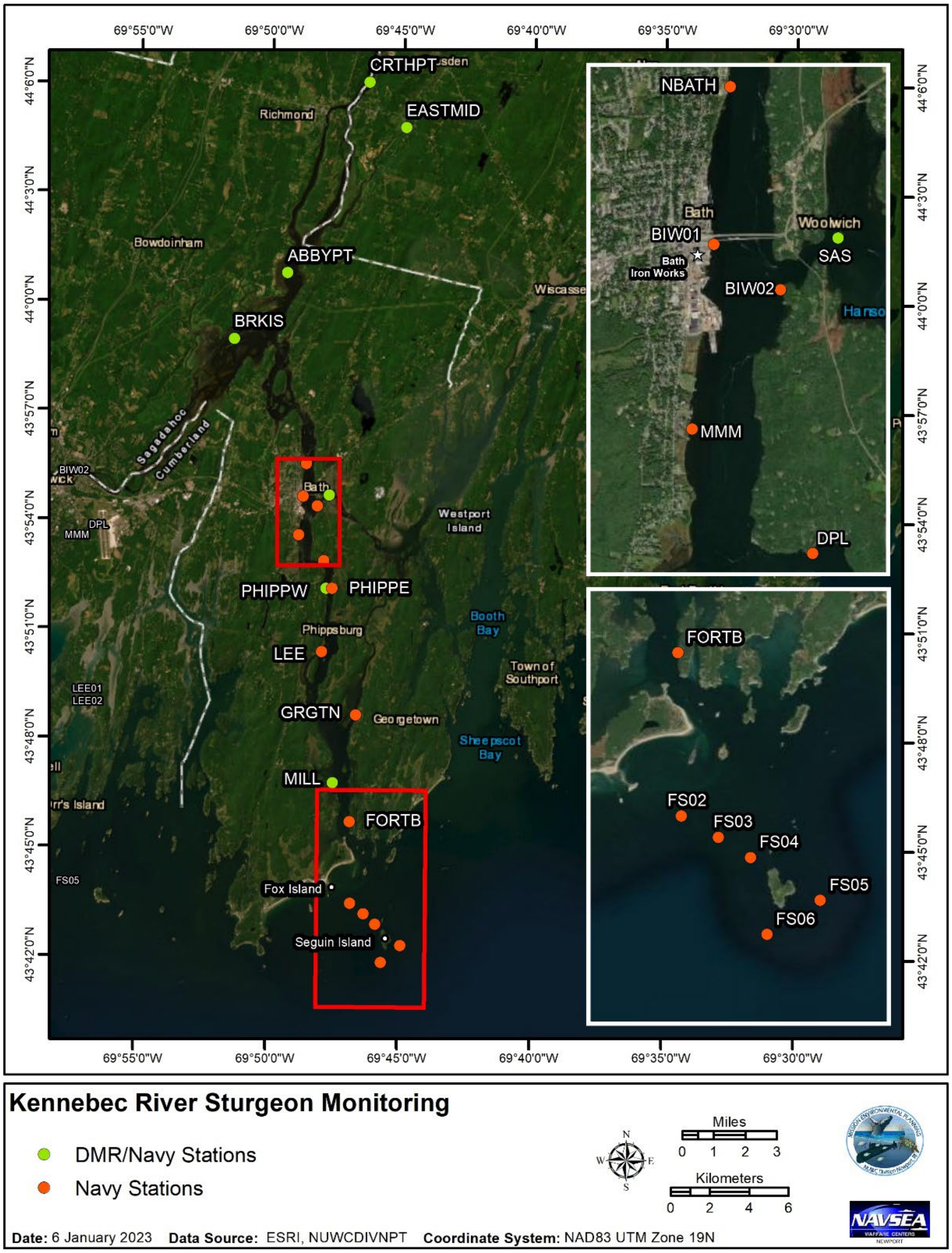


Figure 9. Array map showing the location of Navy and ME DMR monitoring stations in the lower Kennebec River basin extending to offshore Seguin Island

2.1.3.1 Data Summary for November 2022 – October 2023

For the time period representing the last 2 download cycles (November 2022 – October 2023), 779,984 detections were recorded across all stations (**Table 6**), including from 12 different projects (including the Naval Undersea Warfare Center [NUWC]). The addition of new-tagged fish to the system significantly increased the dataset in river. Of those detections, the vast majority (river: 731,770) were Atlantic sturgeon, followed by shortnose sturgeon (river: 24,924), striped bass (river: 2,565), and white shark (ocean: 849). 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 Atlantic sturgeon are tagged in the Gulf of Maine region, as compared with shortnose sturgeon. Notably, there were 19 unique white sharks detected that were tagged by Massachusetts Division of Marine Fisheries, an increasingly important dataset showing movements for this highly migratory species.

Table 6. Number of detections at river and ocean stations for each species across the study period (November 2022 – October 2023).

Species	Counts	River	Ocean
Atlantic sturgeon	Total Detections	731,770	3,758
	Unique Identifications	46	26
Shortnose sturgeon	Total Detections	24,924	0
	Unique Identifications	22	0
White shark	Total Detections	0	849
	Unique Identifications	0	19
Striped bass	Total Detections	2,565	578
	Unique Identifications	1	5

For Atlantic sturgeon, the highest frequency of observations and unique number of individuals detected was at riverine stations beginning at Maine Maritime Museum (MMM), including North Bath (NBATH), Bath Iron Works 1 (BIW1), Bath Iron Works 2 (BIW2) during May and June (**Figure 10**). These stations had up to 30 unique Atlantic Sturgeon documented in a single month. As with previous data, Atlantic sturgeon were recorded nearly each day at some of these stations during the month of May, indicating residential/feeding behavior rather than strictly transitory. Overall, the abundance of Atlantic sturgeon detections in this portion of the lower Kennebec was higher in early spring/summer (April – June) and lower in the summer (July – August). Toward the early fall (September), the overall number of fish observed declined on all stations in the lower Kennebec. In the winter months (December – March), the prevalence of detects was noticeable higher upriver on stations north of NBATH, with detects recorded for only one fish and only 1 day per month in February to March on stations from NBATH to MMM. These months represents that absolute lowest presence in the area around BIW and directly to the south.

Total detections for shortnose sturgeon were much lower than Atlantic, although differences are reflective of current active tags in the region. The highest amount of detections/individuals were recorded in similar months as those observed for Atlantic (April – June), although there was a fairly even spread ranging from DPL in the lower river to CRTHPT in the mid-river (**Figure 10**). Shortnose were not detected on stations in the lower Kennebec shown in **Figure 10** outside of April to August. The additional 23 tagged shortnose sturgeon in 2022 have provided insights on the important movements during the warmer months but also increased prevalence mid-river as compared to Atlantic sturgeon.

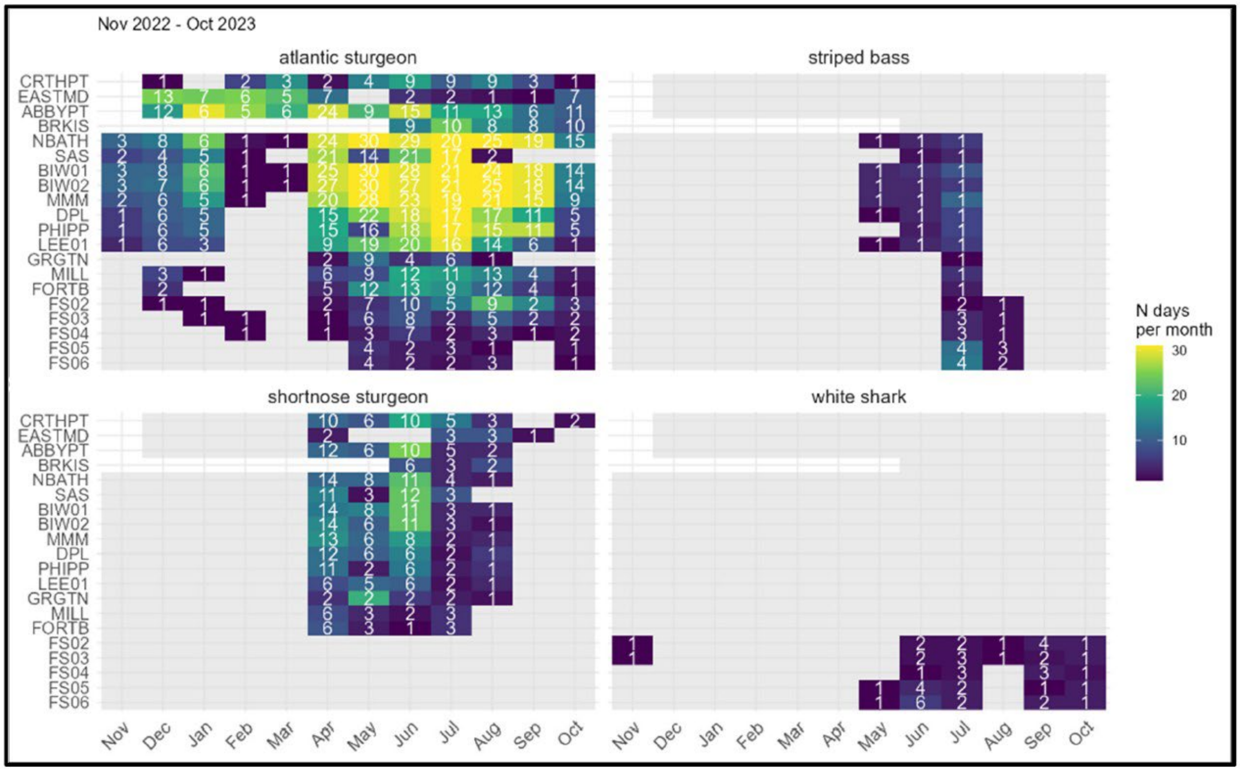


Figure 10. Species detected at each station during the monitoring period November 2022 – October 2023, showing the number of days per month with detections and median number of unique individuals (white numbers). Current numbers of actively tagged fish are not uniform across species, so results can be used to infer presence and seasonality, but not relative abundance of species. (Note: unshaded cells represent months with no coverage for that station).

Overall counts and frequency of Atlantic sturgeon at offshore stations are unsurprisingly lower, with highest counts at these stations occurring June through September with notable detections also recorded in April. Offshore detections likely represent data for fish moving in and out of the system during those months (**Figure 10**). No sturgeon were detected on any station offshore in November and March.

2.1.4 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 and will also assist in the Biological Assessment required under Section 7 of the ESA. 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). This array consisted of 30 VEMCO Acoustic Release and 46 VEMCO Transmitting Receivers and was maintained until mid-May 2022. In October 2022, a modified acoustic receiver array was deployed based on the findings from the first sampling season and included 37 VEMCO Acoustic Release and 43 VEMCO Transmitting Receivers. These modifications included moving the furthest offshore receivers to the nearshore environment where most Gulf sturgeon were detected. Additional receivers were also added to increase resolution in the northeast portion of the study area (**Figure 11**).

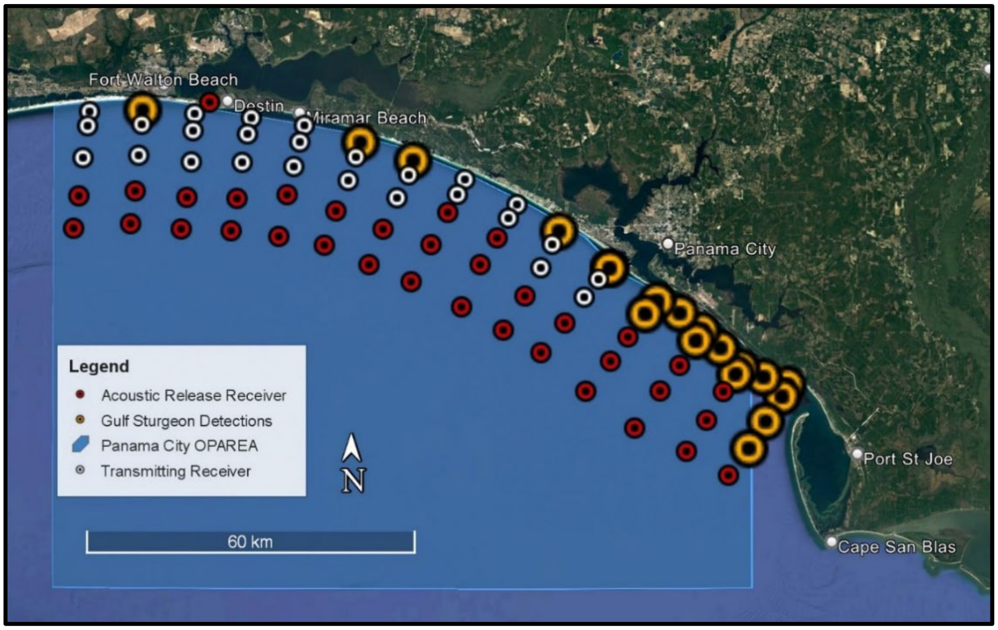


Figure 11. Acoustic receiver locations with detections of Gulf sturgeon in the NSWC Panama City Division Testing Range in the second field season (white = transmitting receivers, red = Acoustic Release receivers, orange = detections of Gulf sturgeon).

Fourteen 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. 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 year two acoustic receiver array was retrieved in May 2023. Of the 80 receivers deployed during year two of the project, one went missing between March and May. Initial results from that deployment showed that Gulf sturgeon were almost exclusively detected in the nearshore environment. Twenty-five of the 80 receivers detected sturgeon and 21 of those 25 were within 5 kilometers (km) of shore (**Figure 11, Figure 12**) which corresponds very closely to designated Gulf sturgeon critical habitat. To begin the third and final field season of this project, our array was reconfigured into a finer scale array to facilitate identifying important habitats, key use areas and seasonal patterns for Gulf sturgeon during their winter foraging season in the NSWC Panama City Test Range (**Figure 13**). This array was deployed in early October

2023 and will be maintained until at least May 2024. Twenty-five transmitters were deployed in adult Gulf sturgeon in the Choctawhatchee River on October 7 and 8, 2023 to increase sample sizes for this project. Also, in an attempt to image and locate Gulf sturgeon with and without transmitters in the Test Range, six REMUS 100 (equipped with a VEMCO receiver and a Marine Sonics ArcScout side scan sonar) missions were conducted between December 2023 and January 2024.

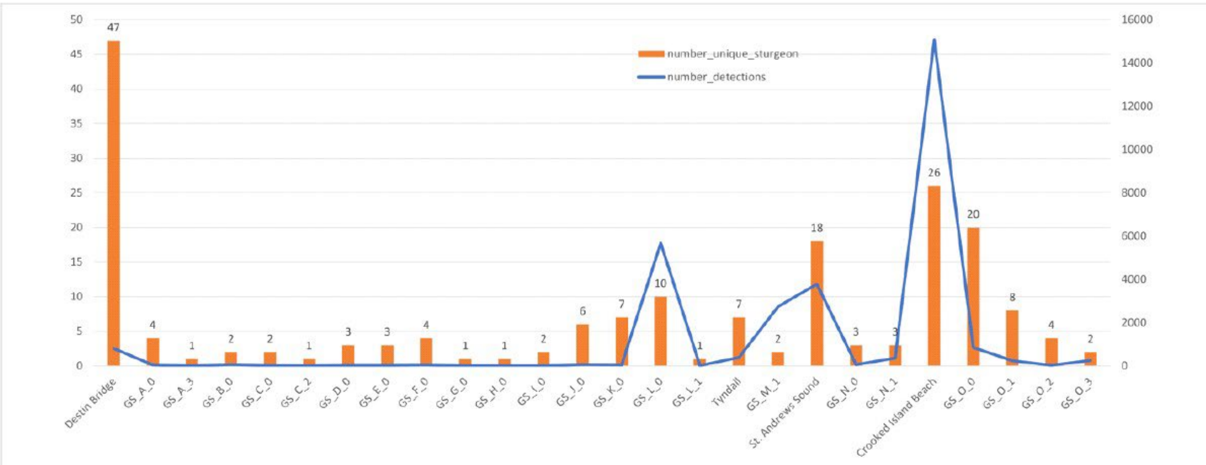


Figure 12. Total detections and number of unique telemetered Gulf sturgeon detected in the NSWC Panama City Division Testing Range. Station names ending with 0 are the closest line of receivers to shore followed by 1, 2, and 3. The x axis is labeled from west to east with the first station being located at Destin Pass inside the mouth of the Choctawhatchee Bay.

Figure 13. Deployment locations of passive acoustic receivers to monitor Gulf sturgeon in the NSWC Panama City Division Testing Range in the final field season (white = transmitting receivers, red = Acoustic Release receivers).

2.1.5 Jacksonville Shallow Water Training Range: Vessel Surveys and Visual Species-Verification Trials

2.1.5.1 Vessel Surveys

The JAX OPAREA was one of the original study sites during the early years of the monitoring program focused on establishing baseline occurrence from 2009 through 2017 (Foley et al. 2019). More recently, vessel-based surveys have been conducted to support visual species-verification trials and to assist with the implementation of the Marine Mammal Monitoring on Navy Ranges (M3R) passive acoustic system in conjunction with the NUWCDIVNPT (see **Section 2.1.5.2**). 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 2023.

Surveys were conducted on both the Research Vessel (R/V) *Richard T. Barber* (in October) and the R/V *Shearwater* (in February – March and December) (**Table 7**, **Figure 14**, **Figure 15**, **Figure 16**) by researchers from Duke University. Vessel surveys in 2023 were conducted for a total of 9 days within the JAX study area and 2 additional days during transits from and to Beaufort, North Carolina, totaling 1,481.5 km, and 69.75 hours, of survey effort (**Table 7**). These surveys were conducted in Beaufort sea states 1 to 7 and covered the JSWTR site (**Figure 14, Figure 15, Figure 16**), as well as shelf and pelagic waters between Florida and North Carolina during transit.

Table 7. Dates, distances, and durations surveyed during vessel surveys within the Jacksonville survey area in 2023.

Date	Beaufort Sea State	Distance Surveyed (km)	Survey Time (hours:minutes)	At-Sea Time (hours:minutes)	Platform
28-Feb-2023	3–4	Transit		4:57	R/V *Shearwater*
1-Mar-2023	1–4	75.59	7:19	24:00	R/V *Shearwater*
2-Mar-2023	3–4	39.90	4:22	14:27	R/V *Shearwater*
4-Mar-2023	3–4	213.11	7:02	17:17	R/V *Shearwater*
5-Mar-2023	3–4	208.44	10:28	24:00	R/V *Shearwater*
6-Mar-2023	3–4	160.79	10:55	24:00	R/V *Shearwater*
7-Mar-2023	3–5	Transit		21:02	R/V *Shearwater*
29-Oct-2023	3–4	23.15	1:56	9:38	R/V *R.T. Barber*
30-Oct-2023	2–4	77.23	4:01	11:22	R/V *R.T. Barber*
2-Dec-2023	6–7	Transit		16:59	R/V *Shearwater*
3-Dec-2023	4–6	394.17	4:25	22:45	R/V *Shearwater*
5-Dec-2023	3–5	117.73	6:31	17:37	R/V *Shearwater*
7-Dec-2023	2–3	58.59	4:36	16:45	R/V *Shearwater*
8-Dec-2023	2–3	113.00	8:10	24:00	R/V *Shearwater*
9-Dec-2023	2–4	Transit		15:18	R/V *Shearwater*

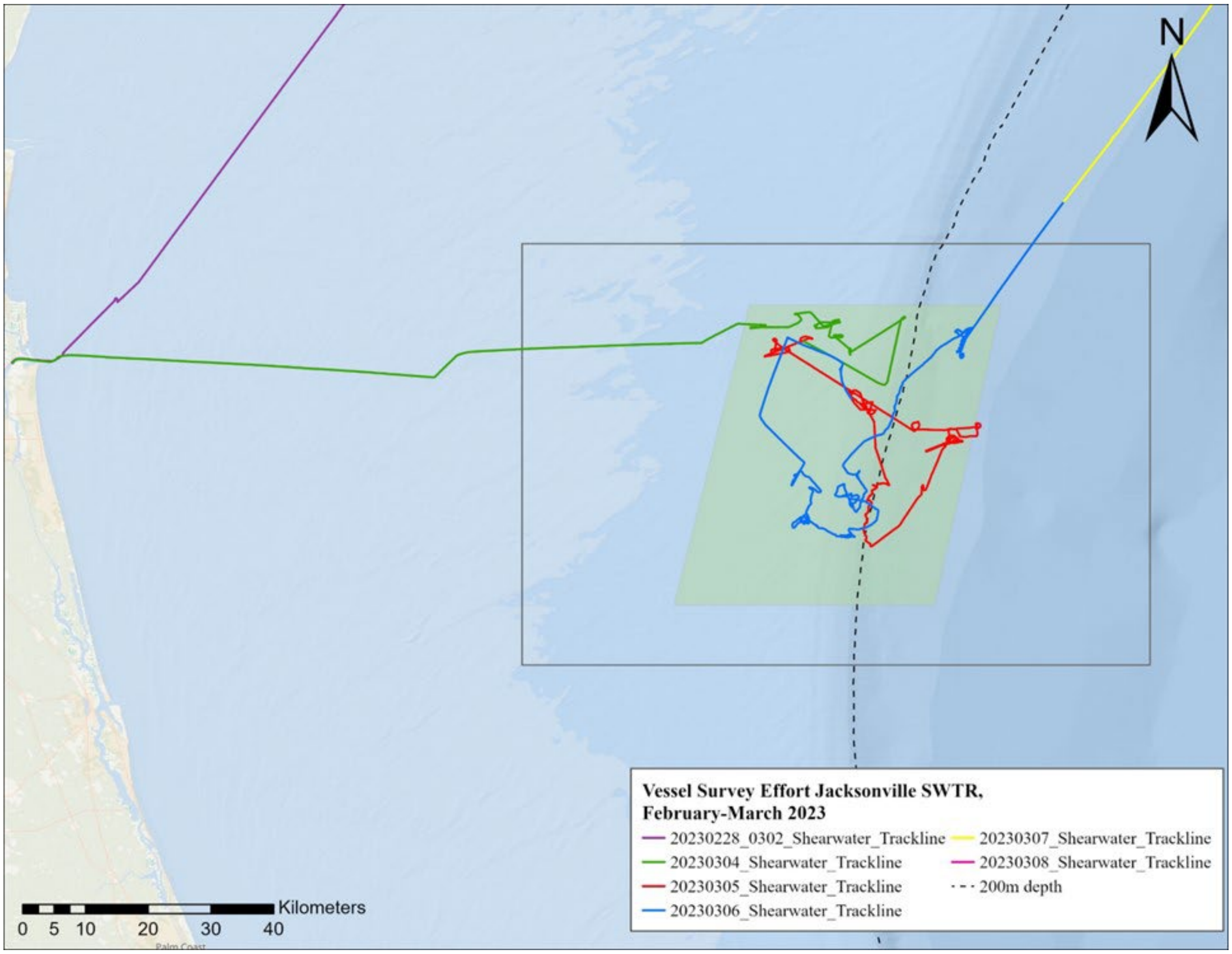


Figure 14. Vessel survey effort conducted by the R/V *Shearwater* for February- March 2023 within the JAX OPAREA. The gray rectangle is the JAX study area, and the green shaded parallelogram encompasses the JSWTR.

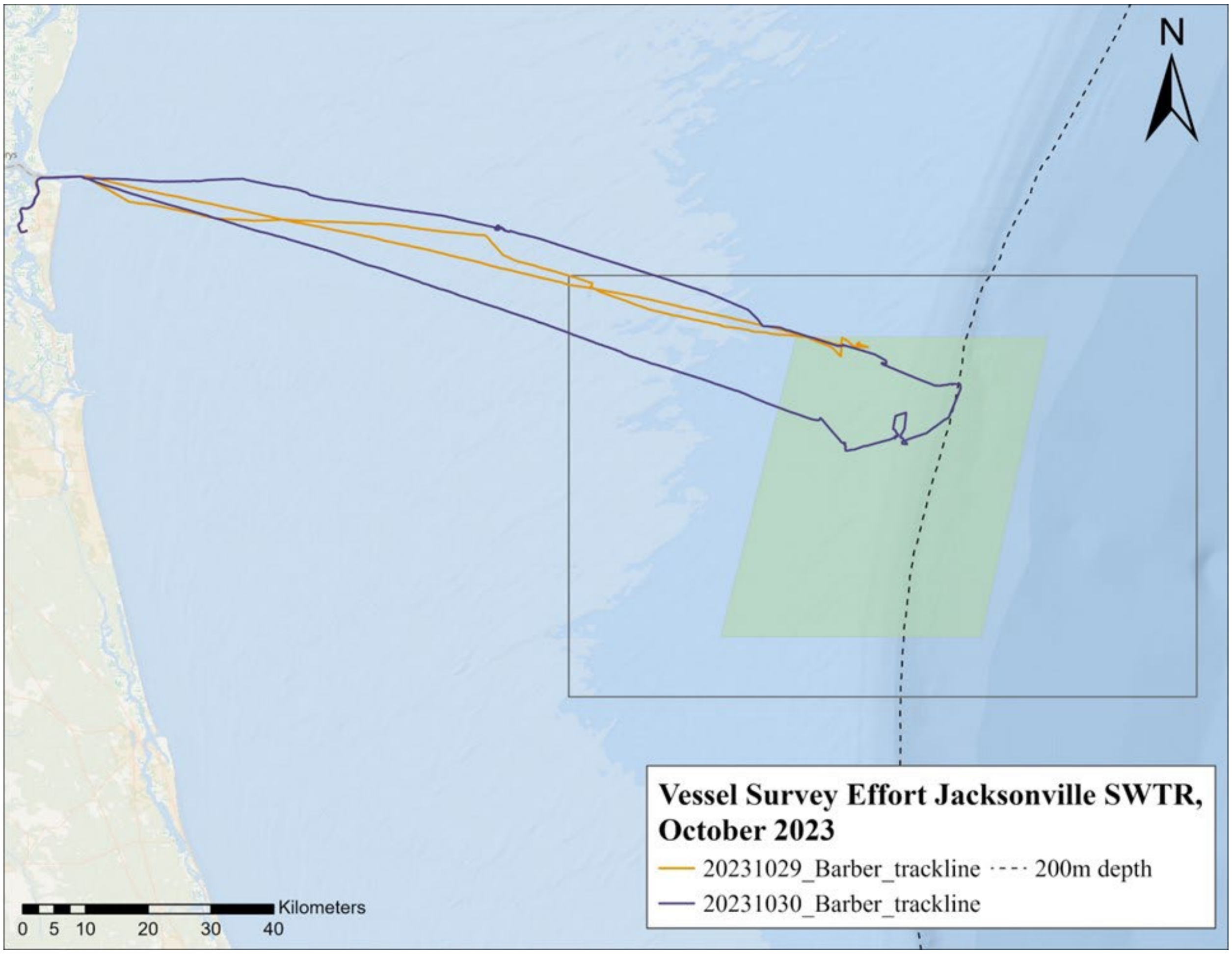


Figure 15. Vessel survey effort conducted by the R/V *Richard T. Barber* for October 2023 within the JAX OPAREA. The gray rectangle is the JAX study area, and the green shaded parallelogram encompasses the JSWTR.

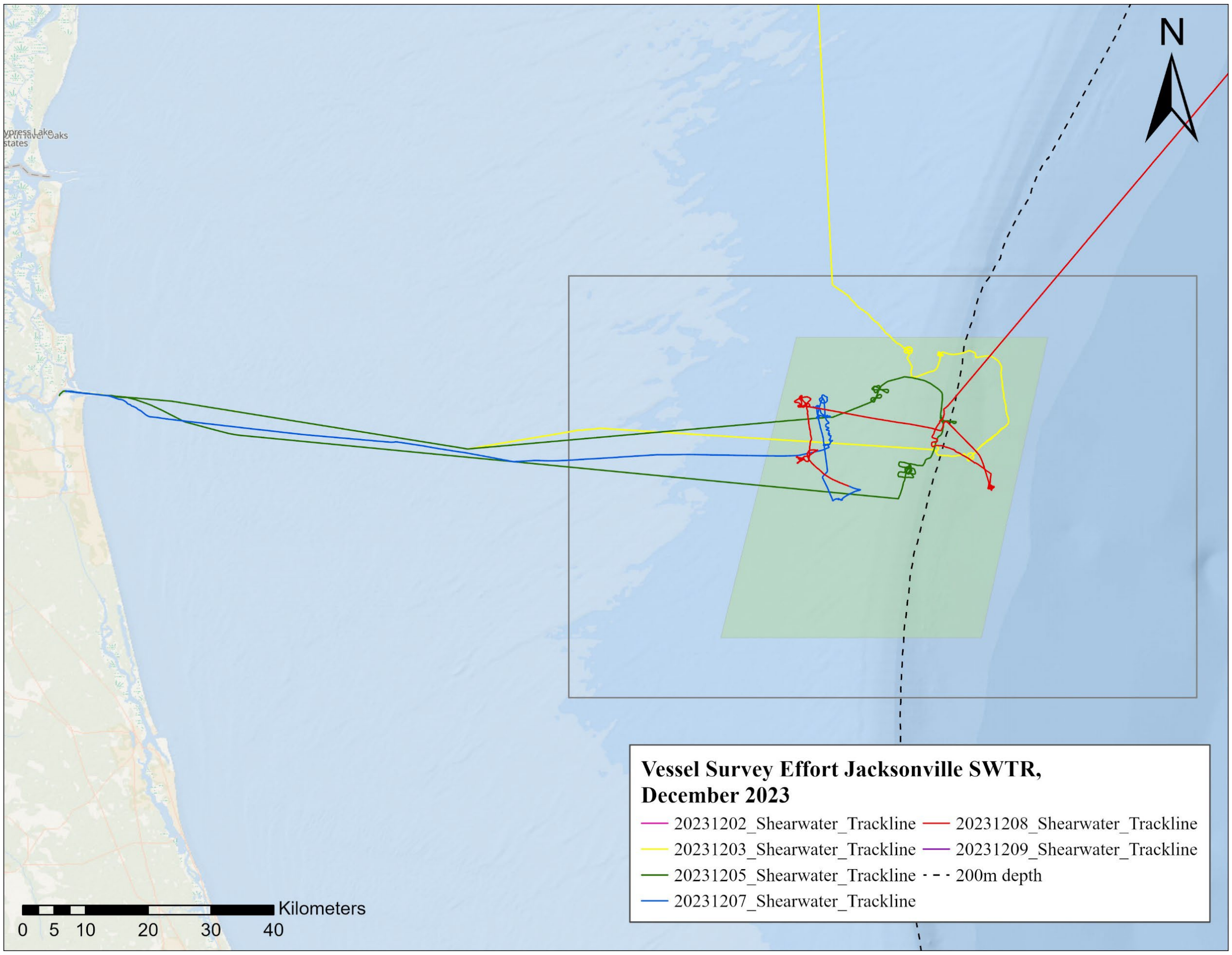


Figure 16. Vessel survey effort conducted by the R/V *Shearwater* for December 2023 within the JAX OPAREA. The gray rectangle is the JAX study area, and the green shaded parallelogram encompasses the JSWTR.

Forty cetacean sightings were recorded, and most (85 percent) comprised two species: Atlantic spotted dolphins (*Stenella frontalis)* (*n* = 19) and common bottlenose dolphins (*Tursiops truncatus)* (*n* = 15). A group of false killer whales (*Pseudorca crassidens*), a single minke whale (*Balaenoptera acutorostrata)*, and a group of rough-toothed dolphins (*Steno bredanensis)* were also observed, in addition to three unidentified dolphin sightings. Six sightings of loggerhead sea turtles (*Caretta caretta*) were also recorded. Consistent with observations in previous years, Atlantic spotted dolphins were restricted to shallow shelf waters, while common bottlenose dolphins were found both on the shelf and offshore of the continental shelf break (**Figure 17**). The false killer whales and minke whale were observed offshore of the shelf break (**Figure 17**). A new false killer whale catalog was created with 16 identified individuals. Photo-ID analysis identified 19 new Atlantic spotted dolphins, 12 new bottlenose dolphins, and 7 new rough-toothed dolphins, all of which have been added to existing catalogs. The minke whale did not have distinct markings for photo-ID.

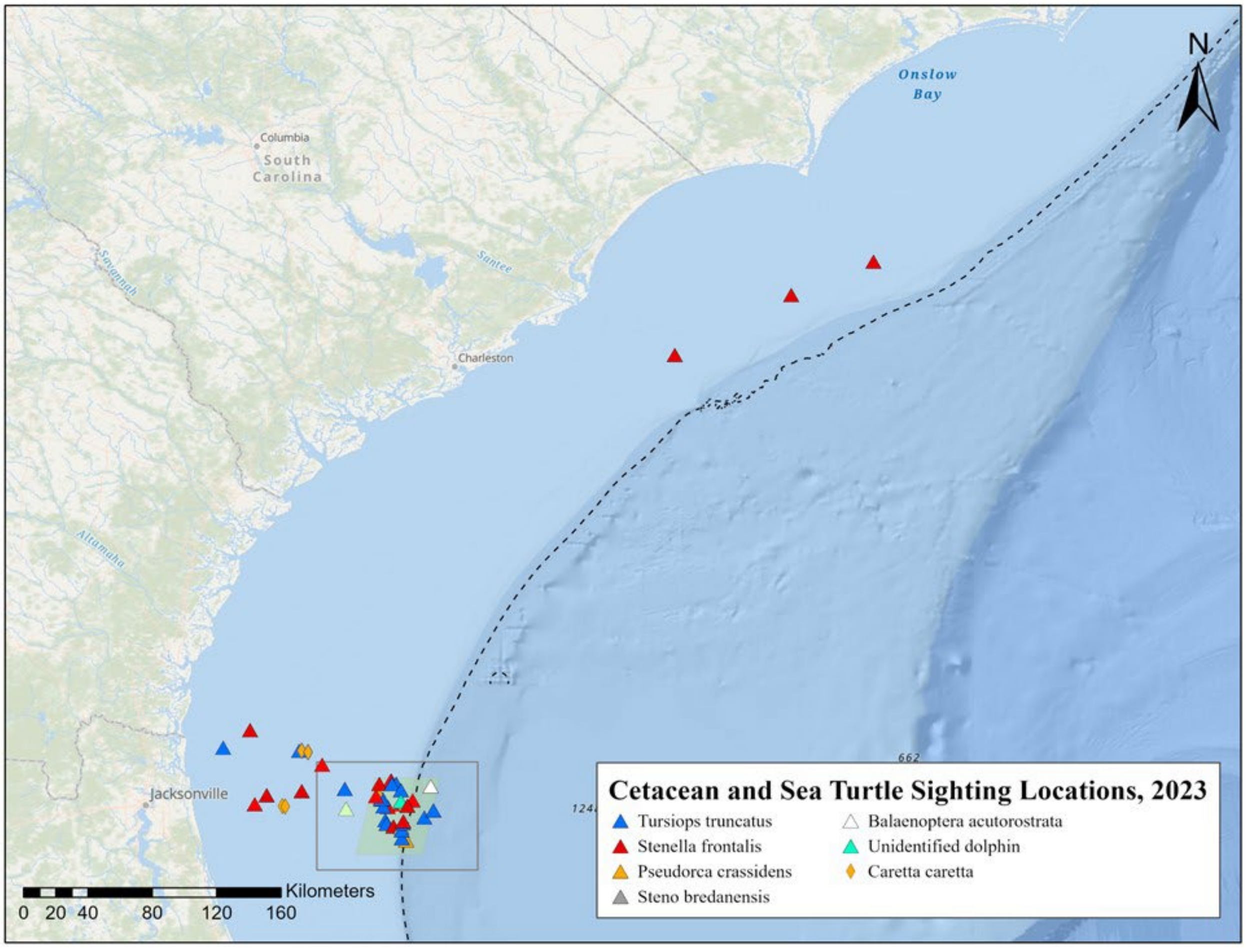


Figure 17. Distribution of cetacean and sea turtle sightings recorded during vessel surveys in 2023. The gray rectangle is the JAX study area, and the green shaded parallelogram encompasses the JSWTR.

Satellite tagging was attempted in collaboration with Jessica Aschettino from HDR, Inc. in October 2023, but no target species were encountered during this trip. One biopsy sample was collected from a bottlenose dolphin and three biopsy samples were collected from false killer whales in the JAX survey area in 2023 (**Figure 18**). Voucher specimens of these samples are archived at the Duke University Marine Laboratory (DUML) in Beaufort, North Carolina. The research team also used methods recently approved by NMFS and confirmed the efficacy of paintball marking as a minimally invasive, short-term aid to re-sighting and identification. Four bottlenose dolphins were temporarily marked with paintballs within the JAX survey area during 2023 (**Figure 19**).

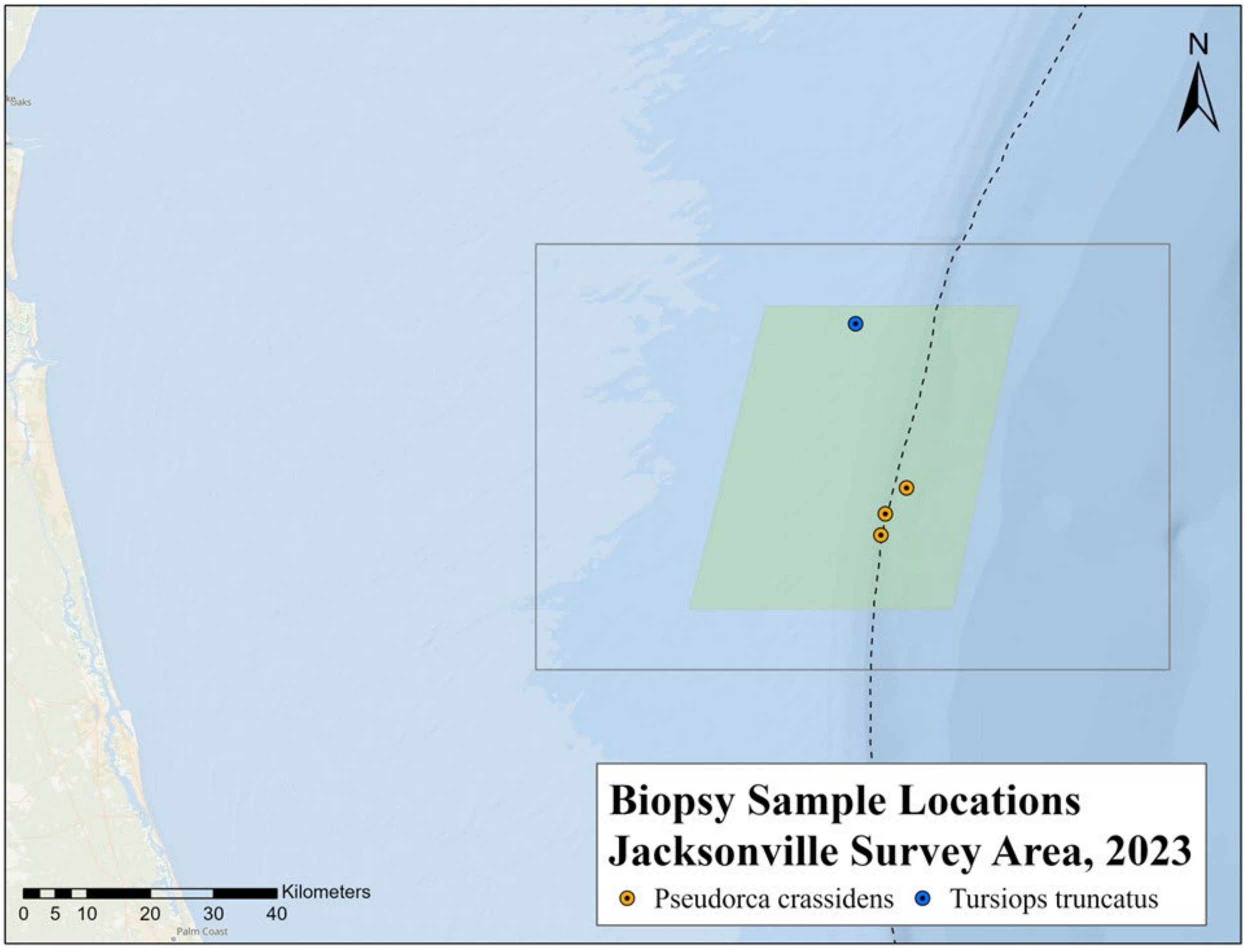


Figure 18. Locations of biopsy samples collected within the JAX study area during 2023.

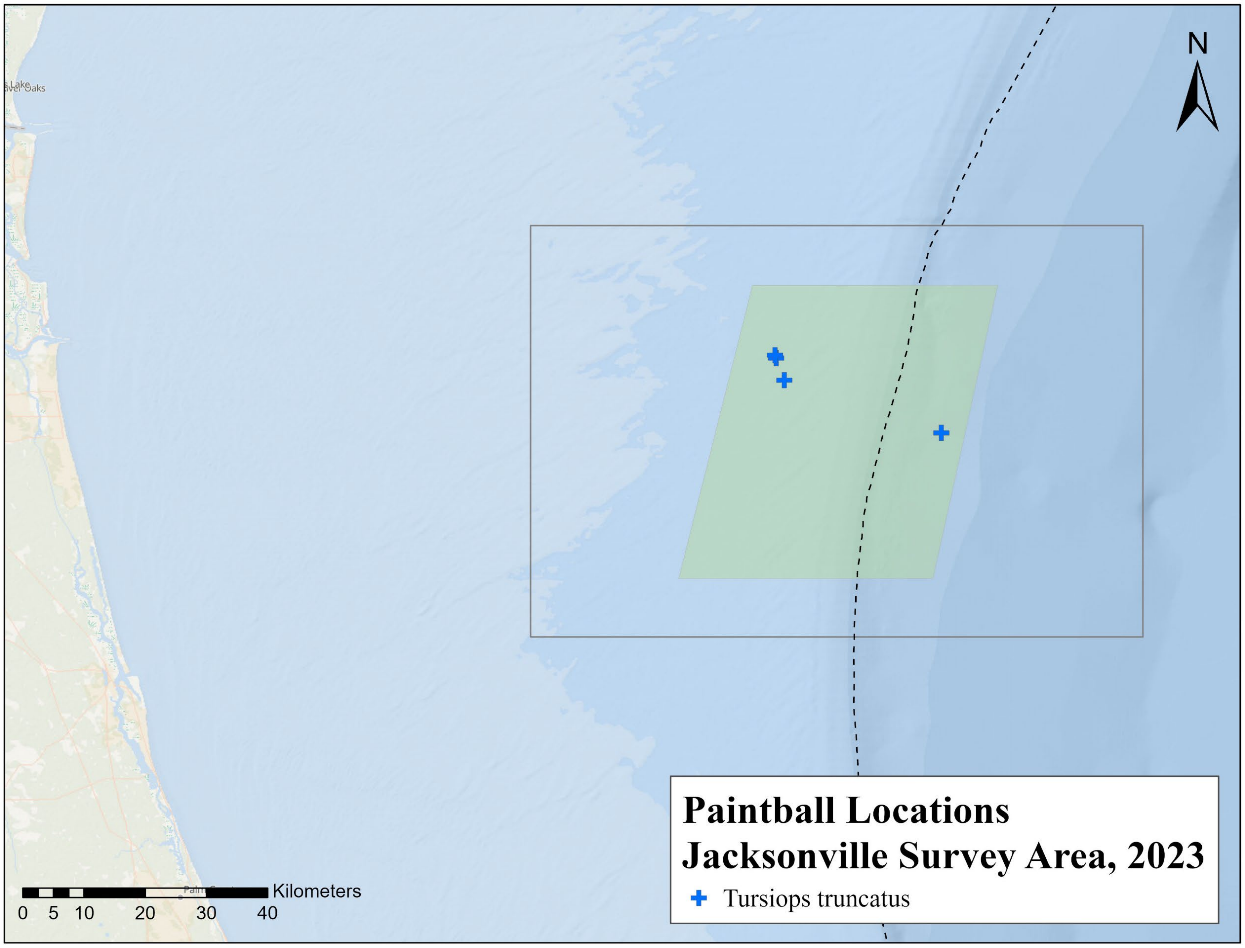


Figure 19. Locations of Tursiops marked with paintballs within the JAX survey area during 2023.

For additional details and information on this study, please refer to the annual progress report for this project (Alvarez et al. 2024).

2.1.5.2 Marine Mammal Monitoring on Navy Ranges (M3R)

The 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), JSWTR, and Canadian Forces Maritime Experimental and Test Ranges Nanoose Range. 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 25 to 255 m over a span of 2,000 square kilometers (km^2) (**Figure 20**), 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.

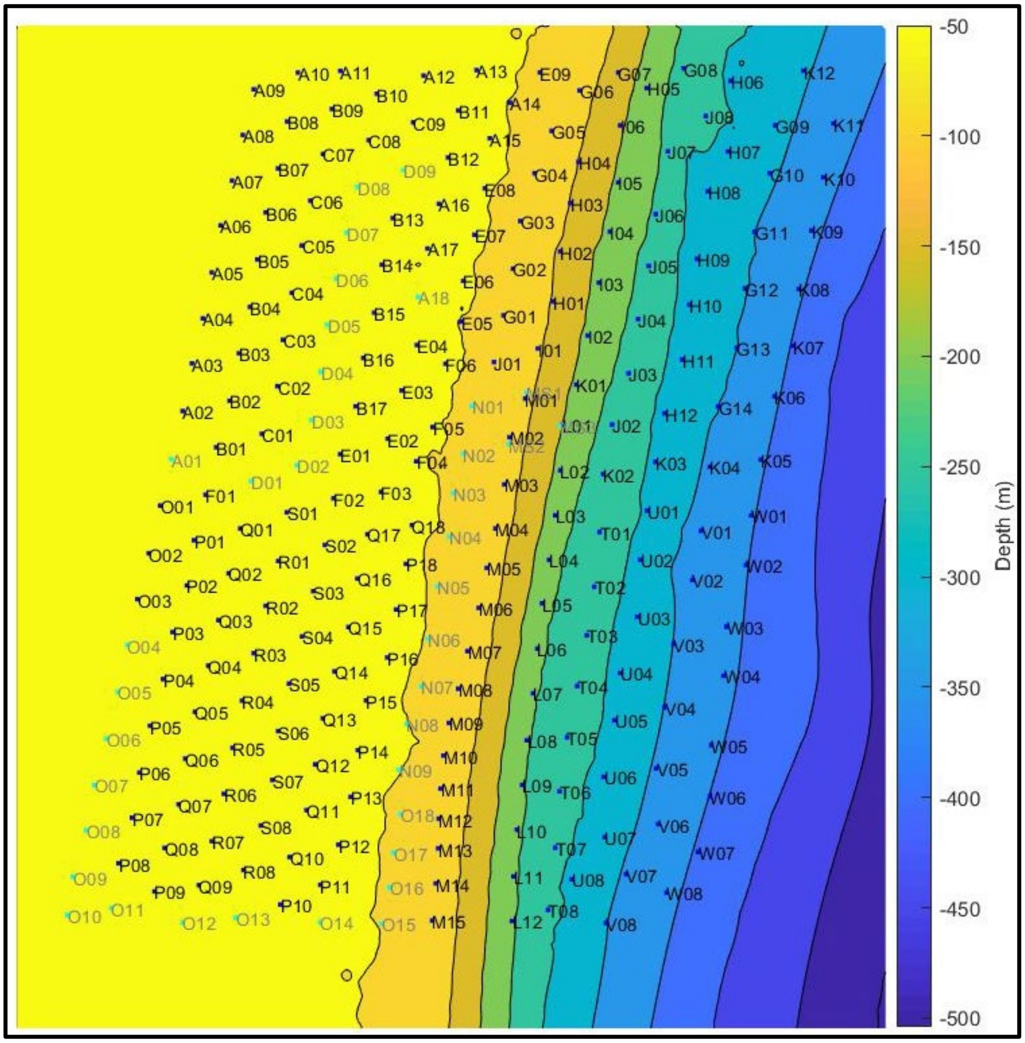


Figure 20. Hydrophone range at JSWTR with bathymetry. Inactive hydrophones have gray labels.

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 (*Mesoplodon densirostris*) 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, *Ziphius* (*Ziphius cavirostris*) foraging and buzz clicks, sperm whale (*Physeter macrocephalus*) clicks, and "generalized dolphin" clicks.

The M3R team conducted species-verification trials in March, October, and December 2023 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*)

During the three field sessions conducted in 2023, all five focal species were acoustically identified by M3R and three were visually verified by the on-water team: bottlenose dolphins, Atlantic spotted dolphins, and rough-toothed dolphins (**Table 8**).

Table 8. M3R acoustic detections and visual verifications at JSWTR in 2023.

Species		Number of Acoustic Detections Logged	Number of Acoustic Detections Directed	Number of Acoustic Detections Visually Verified
Common Name	**Scientific Name**			
Bottlenose dolphin	*Tursiops truncatus*	24	12	16
Atlantic spotted dolphin	*Stenella frontalis*	10	10	10
Risso's dolphin	*Grampus griseus*	6	2	0
Rough-toothed dolphin	*Steno bredanensis*	1	1	1
False killer whale	*Pseudorca crassidens*	2	1	1
Minke whale	*Balaenoptera acutorostrata*	2	1	1
Short-finned pilot whale	*Globicephala macrorhynchus*	18	2	0
Unidentified dolphin	*Delphinidae sp.*	210	14	0

2.1.6 Atlantic Marine Assessment Program for Protected Species

The Atlantic Marine Assessment Program for Protected Species (AMAPPS) is a comprehensive multi-agency research program in the U.S. Atlantic Ocean, from Maine to the Florida Keys. Its aims are to assess the abundance, distribution, ecology, and behavior of marine mammals, sea turtles, and seabirds throughout the U.S. Atlantic and to place them in an ecosystem context. This information can then provide spatially explicit information in a format that can be used when making marine resource management decisions and provide enhanced data to managers and other users by addressing data gaps that are needed to support conservation initiatives mandated under the MMPA, ESA, National Environmental Policy Act, and Migratory Bird Treaty Act. The program is a collaboration with NOAA Fisheries, Bureau of Ocean Energy Management, and U.S. Fish and Wildlife Service focused on developing models and tools to provide seasonal abundance estimates that incorporate environmental habitat characteristics for marine mammals, turtles, and seabirds in the western North Atlantic Ocean. These models rely on seasonal distribution and abundance data collected over multiple years using aerial and shipboard surveys. They also include dive pattern information from individually tagged turtles and detections from passive acoustic recording devices.

AMAPPS was initiated in 2010 (AMAPPS I – 2010–2014, AMAPPS II – 2015–2019, AMAPPS III – 2020–2024) and the U.S. Navy has been a consistent partner contributing financial support annually, as well as providing input on data gap needs to help direct data collection efforts. Data products and technical reports are available online: annual and final reports, and Marine Mammal Model Viewer.

2.2 Ecology, Behavior, and Social Structure

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

Since January 2015, HDR, Inc. has been monitoring humpback whales (*Megaptera novaeangliae*) 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. Vessel surveys have 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 drones for length and body-condition assessments. These baseline data are critical for assessing the potential for disturbance to humpback whales within this part of the mid-Atlantic. Data on other baleen whale species have also been collected opportunistically, although relatively little information exists on how other species of baleen whales, including endangered fin (*Balaenoptera physalus*) and NARWs, use this region.

PAM results from autonomous gliders and Marine Autonomous Recording Units confirm that humpback, fin, sei (*Balaenoptera borealis*), minke, and NARWs regularly use the continental shelf waters off the coasts of Virginia and North Carolina (Baumgartner 2019; Salisbury et al. 2018; Stanistreet et al. 2016). 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 (Cotter 2019; 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). Satellite-linked telemetry tags deployed on fin whales in the region by researchers from HDR, Inc. between 2016 and 2021 show both localized and extensive movements over all areas of the continental shelf (Aschettino et al. 2018, 2021, 2022a; Engelhaupt et al. 2017, 2018, 2019). 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, 2023a). Movements of satellite tagged NARWs show extensive use of the mid-shelf region both north and south of the primary study area (Aschettino et al. 2022b, 2023a; D. Engelhaupt et al. 2022). 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 (A. Engelhaupt et al. 2023a). Argos location data from two tagged blue whales showed at least some movements through continental shelf waters (Aschettino et al. 2022a; D. Engelhaupt et al. 2020; Lesage et al. 2017).

Building upon the long-term dataset established through ongoing monitoring of humpback whales, the Mid-Atlantic Nearshore and Mid-Shelf Baleen Whale Monitoring project expands the previous study area to encompass mid-shelf waters out to approximately 75 km 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 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 to be 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, nine 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 tags, digital acoustic tags (DTAGs), and Customized Animal Tracking Solutions (CATS) tags; collaboration with researchers from Duke University to examine behavioral response of humpbacks to large vessels (see **Section 2.2.2**); photogrammetry using drones; and, most recently, an expansion into the mid-shelf region with the addition of other baleen whale species, including fin whales and NARWs.

Since the field season spans calendar years from fall through spring, this report focuses on survey effort and observations made across late 2022 into early 2023.

2.2.1.1 Survey Effort/Summary

Twenty-four vessel surveys were conducted between 21 November 2022 and 06 March 2023. Five of these surveys were considered nearshore, and 19 surveys were defined as mid-shelf. More than 185 hours of survey effort were completed, and 3,379 km of trackline were covered (**Figure 21**). Eight aerial surveys were also flown in support of vessel field work between 22 November 2022 and 20 March 2023. One of these surveys was considered offshore and extended past the shelf break. More than 43 hours of survey effort were completed, and 7,484 km of trackline were covered (**Figure 22**).

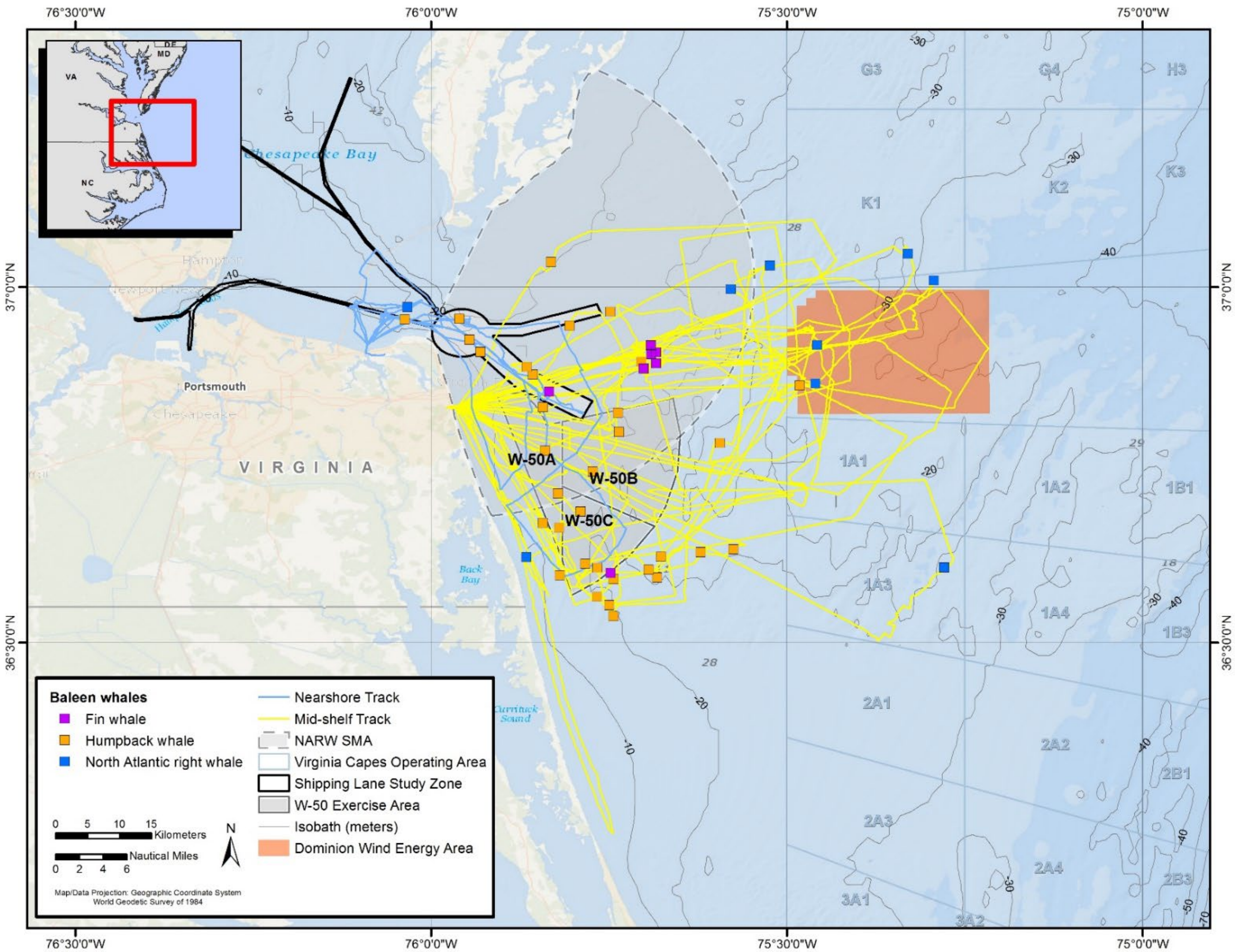


Figure 21. Nearshore (blue) and mid-shelf (yellow) vessel survey tracks, with locations of all humpback (*n* = 33), fin (*n* = 7), and North Atlantic right (*n* = 9) whale sightings for the 2022/2023 field season.

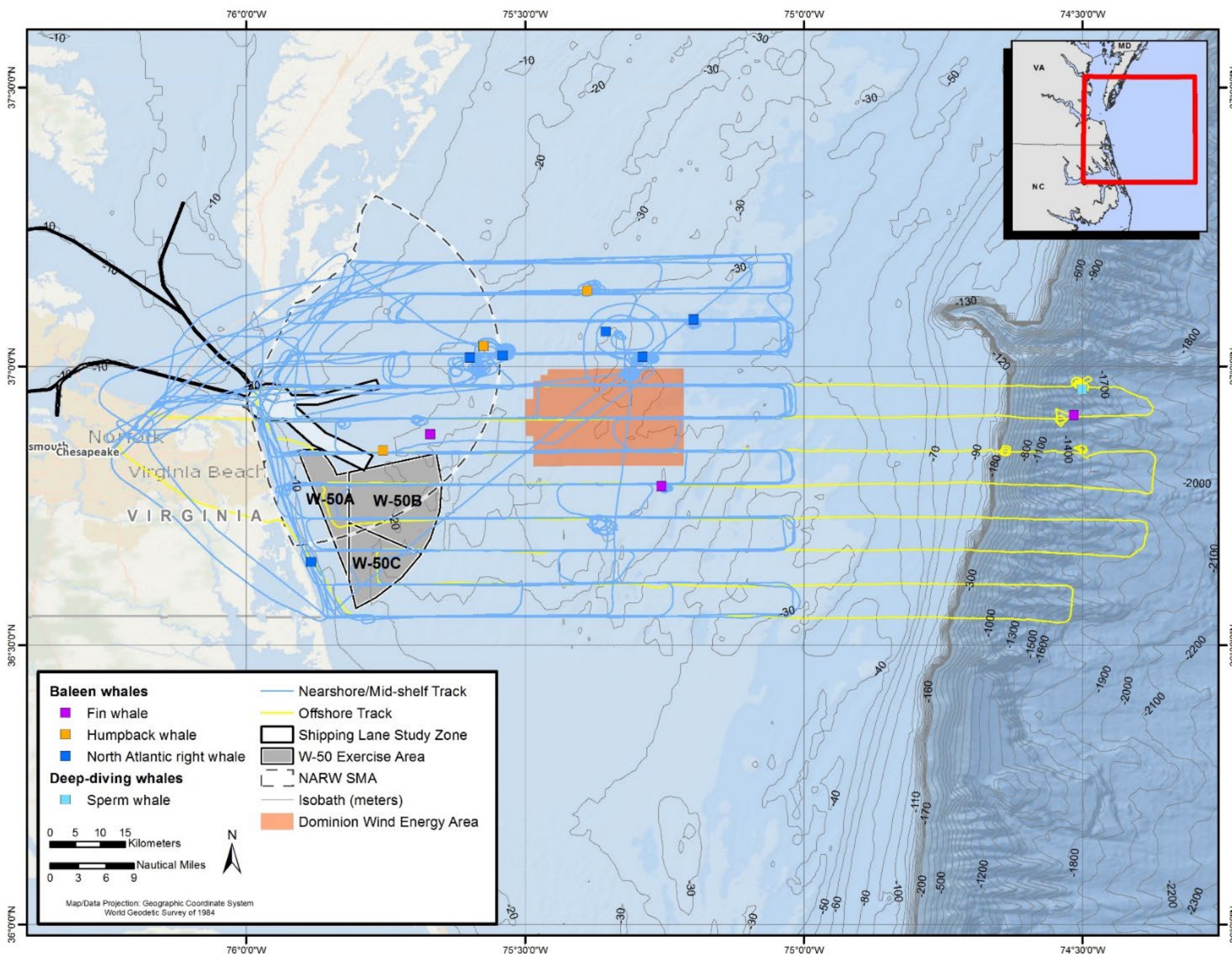


Figure 22. Aerial survey tracks (blue and yellow), with locations of all North Atlantic right (*n* = 6), fin (*n* = 3), humpback (*n* = 3), and sperm whale (*n* = 1) sightings for the 2022/2023 field season.

2.2.1.2 Sightings

In total, 49 baleen whale sightings occurred during vessel surveys in the 2022/2023 season, including 33 humpback whale sightings totaling 48 individuals, 7 fin whale sightings totaling 13 individuals, and 9 NARW sightings totaling 36 individuals (**Figure 21**). Sightings of non-target species (i.e., bottlenose dolphins) were sometimes recorded but are not presented here.

There were 12 baleen whale sightings during aerial surveys in the 2022/2023 season, including 3 humpback whale sightings totaling 3 individuals, 3 fin whale sightings totaling 4 individuals, and 6 NARW sightings totaling 18 individuals (**Figure 22**). Nine sperm whales were also seen on the single aerial survey conducted offshore in coordination with an offshore vessel survey. Sightings of non-target species (i.e., bottlenose dolphins, common dolphins (*Delphinus delphis*), Risso's dolphins (*Grampus griseus*), and a white shark (*Carcharodon carcharias*) were also recorded but are not presented here.

2.2.1.3 Tagging and Biopsy Samples

One biopsy sample was collected from a tagged humpback whale during the 2022/2023 season and is 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. A total of 63 humpback whale samples (including duplicates of the samples provided for stable isotope analysis [Waples 2017]) 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. and 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).

Two Argos-linked satellite tags were deployed on humpback whales during the 2022/2023 season: 1 SPOT-6 (Smart Position and Temperature), and 1 SPLASH10-F (**Table 9**). The tags transmitted 14.3 and 5.0 days, respectively. Whales tagged during this field season showed varied movement patterns. Sub-adult sized humpback whale HDRVAMn268 was tagged just outside the Mine-neutralization Exercise (MINEX) area and close to the Virginia-North Carolina border (**Figure 23**) and just over 2 weeks of location data were collected. This individual initially moved southward after tagging, with locations 0 to 12 nm from shore and moving 44 nm from the initial tagging location, just north of Oregon Inlet. After 11 days, HDRVAMn268 worked back to the north and into the primary study area, with locations in and around shipping channels at the mouth of Chesapeake Bay. This individual was re-sighted by the field team on 10 January 2024, and a CATS tag was deployed. Several days later, this individual moved northeastward before the tag stopped transmitting on 14 January 2024, 27 nm from shore within the VACAPES OPAREA.

Table 9. Satellite-tag deployments on humpback whales during the 2022/2023 field season.

Animal ID	Estimated Age Class	Tag Type	Argos ID	Deployment Date	Last Transmission Date	Tag Duration (Days)
HDRVAMn268	Sub-adult	SPOT6	233709	30-Dec-2022	13-Jan-2023	14.3
HDRVAMn278	Juvenile	SPLASH10-333F	201573	08-Feb-2023	13-Feb-2023	5.0

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

Juvenile humpback whale HDRVAMn278 was tagged at the mouth of Chesapeake Bay within the boundaries of the shipping lane study area (**Figure 23**). This individual was simultaneously double-tagged with a SPLASH10-F tag and CATS tag. At the time of tagging, Duke University was also working within the area, conducting prey mapping from the R/V *Shearwater*. This individual spent the entire 5 day duration of the tag either at the mouth of Chesapeake Bay or inside the bay, with locations as far west as the Hampton Roads Bridge Tunnel.

Figure 24 shows a zoomed-in view of both humpback whale tag locations during the 2022/2023 field season, focused on the nearshore study zone. As in previous years, a number of locations occurred within and around the shipping channels and at the mouth of Chesapeake Bay; however, given that only two tags were deployed, the impact from this figure is not as profound as during seasons when a higher number of tags were deployed. As in some previous seasons (e.g., Aschettino et al. 2018, 2020, 2021), Argos locations also occurred west of the CBBT. Locations were also reported to the east, west, and south of the NARW Seasonal Management Area (SMA), where vessel speed restrictions are in place seasonally.

One satellite tag recorded information on dive depth and duration in addition to the Argos capabilities (**Table 10**). This humpback whale tag recorded a total of 405 dives. Mean dive depth was 17.6 m, with a maximum dive depth of 31.0 m. Mean dive durations ranged from 2.7 to 3.1 minutes.

Table 10. Summary of dive depth and duration collected from the tagged humpback whale during the 2022/2023 field season.

Animal ID	No. Dives Logged	Mean Dive Depth (m)	Max Dive Depth (m)	Mean Dive Duration (mm:ss)	Max Dive Duration (mm:ss)
HDRVAMn278	405	17.6	31.0	02:43	04:49

Key: ID = identifier; Max = Maximum; mm:ss = minutes:seconds; No. = Number

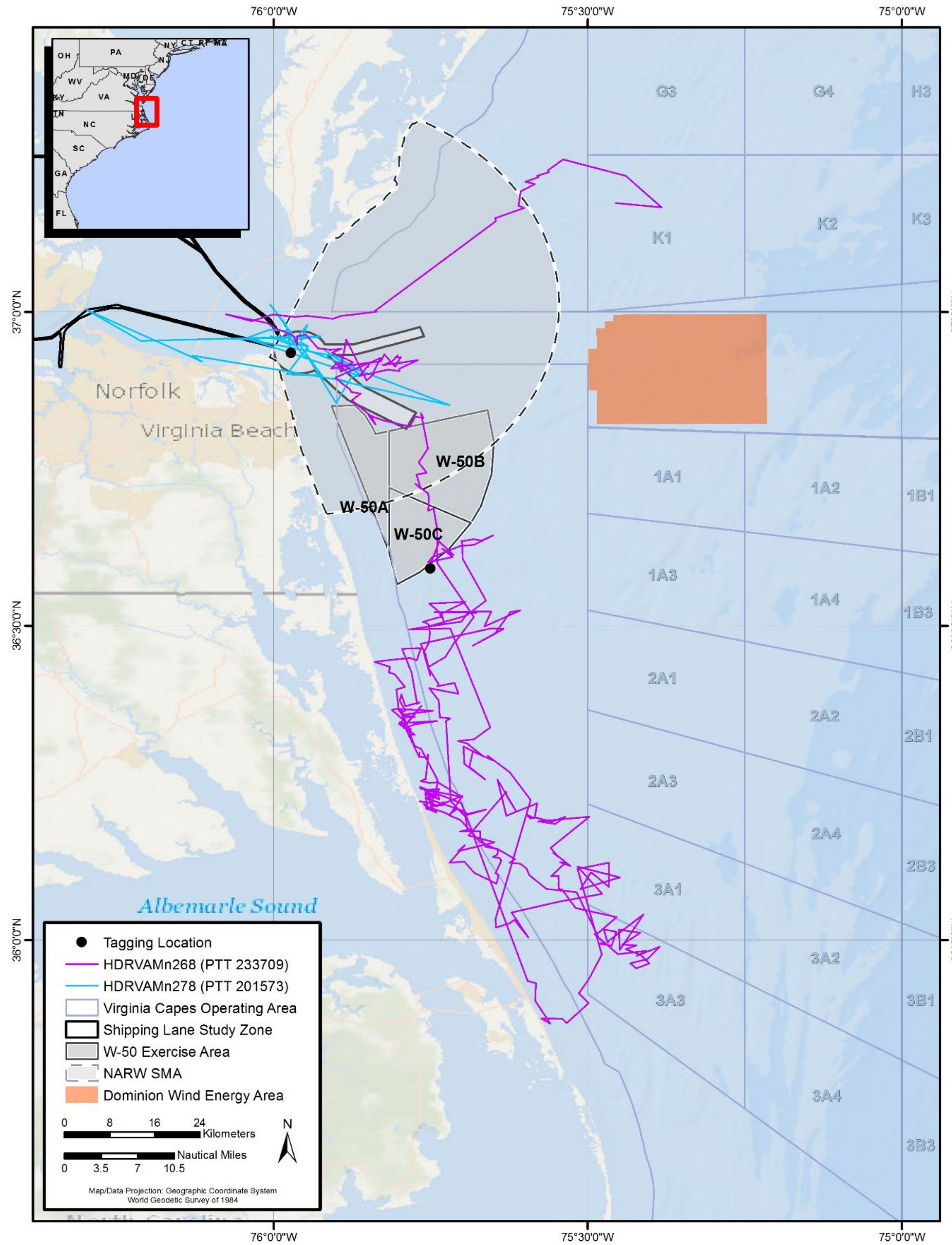


Figure 23. Argos tracks for all humpback whales tagged (n = 2) during the 2022/2023 field season.

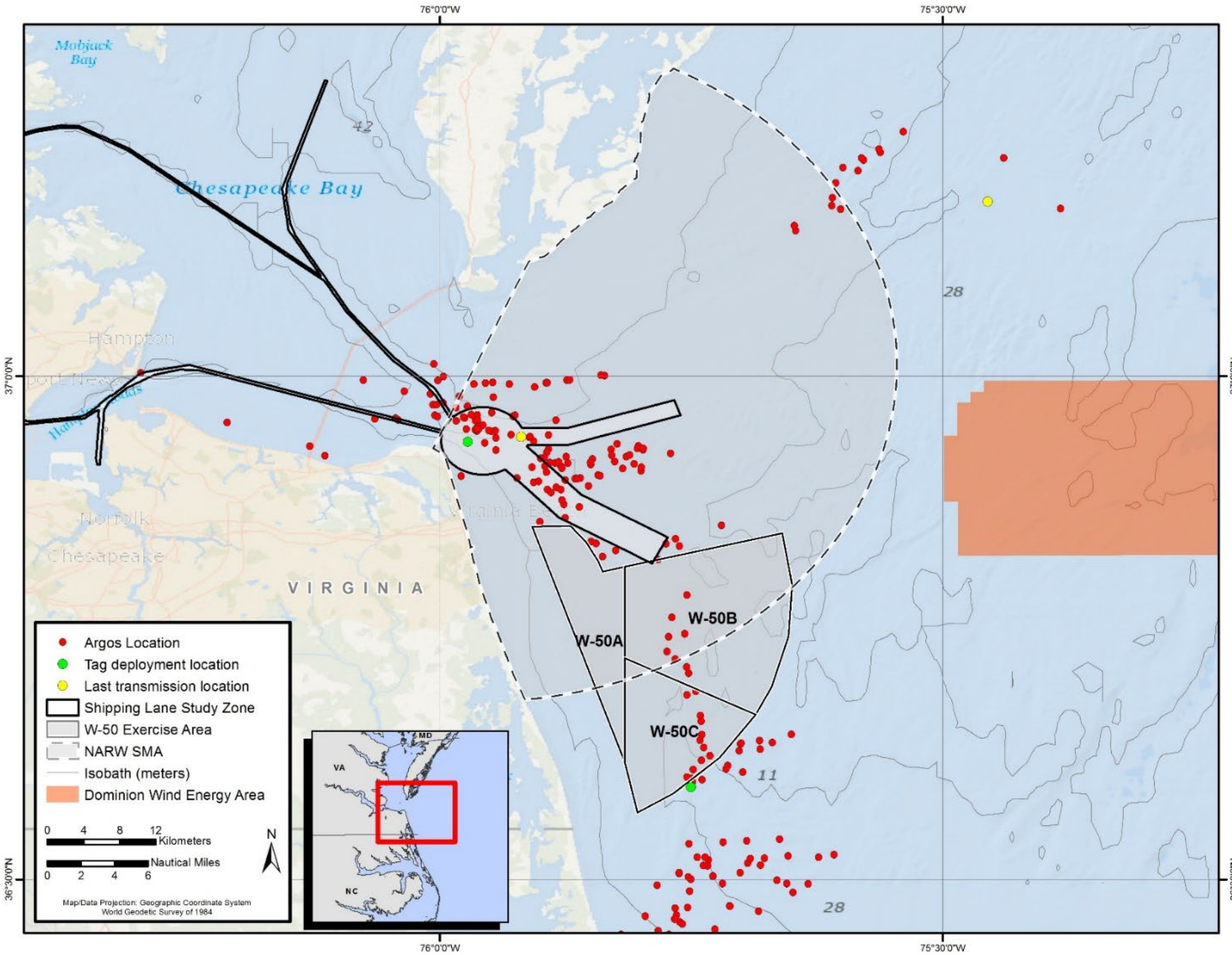


Figure 24. Filtered locations of all humpback whale Argos locations within the immediate vicinity of shipping channels at the mouth of Chesapeake Bay from tag deployments (n = 2) during the 2022/2023 field season.

Four CATS suction-cup tags were deployed during the 2022/2023 field season, two on humpback whales and two on NARWs (**Table 11**). The 22 November 2022 tag (eg221122-01) on right whale Eg #2605 "Smoke" collected more than 10 hours of three-dimensional movement, acoustic, and video data. Smoke was traveling with Eg #3503 "Caterpillar" (Right whales are on the move!) and unknown at the time, was pregnant and subsequently sighted with her new calf off the coast of St. Catherines Island, Georgia, almost 5 weeks later on 26 December 2023. **Figure 25** shows the location data, and **Figure 26** shows the dive profile for this tag. A preliminary audit for vocalizations was completed, but none were detected. Totals of 66 dives and 65 surfacing bouts were recorded during the tag's deployment (**Table 12**). Maximum dive depth ranged from 2.0 to 13.1 m (mean = 5.04 m) and dive duration ranged from 2.0 to 8.78 minutes (mean = 3.76 minutes) (**Table 12**).

Table 11. CATS deployments on baleen whales during the 2022/2023 field season.

Animal ID	Species	Number/ Deployment ID	Tag Type	Deployment (GMT)	Depth at Tagging (m)	Tag off Animal (GMT)	Tag Duration (min)
Eg #2605/ "Smoke"	North Atlantic right whale	eg221122-01	CATS	2022-Nov-22 21:05	11.3	2022-Nov-23 07:31	626
HDRVAMn268	Humpback whale	mn230110-01	CATS	2023-Jan-10 19:41	20.7	2023-Jan-11 11:06	864
Eg #3810	North Atlantic right whale	eg230129-01	CATS	2023-Jan-29 19:16	29.3	2023-Jan-29 19:39	23
HDRVAMn278	Humpback whale	mn230208-01	CATS	2023-Feb-08 17:04	18.9	2023-Feb-08 23:01	357

Key: ID = identifier; GMT = Greenwich Mean Time; min = minute(s)

Table 12. Summary of dive depth and duration data collected from CATS Tag eg221122-01.

Deployment ID	No. Dives Logged	Mean Dive Depth (m)	Max Dive Depth (m)	Mean Dive Duration (mm:ss)	Max Dive Duration (mm:ss)
Eg221122-01	66	5.04	13.1	3:46	8:47

Key: ID = identifier; mm:ss = minutes:seconds; No. = Number

Figure 27 and **Figure 28** show the dive profiles of mn230110-01 and eg230129-01, which collected data for 14 hours and 23 minutes, respectively. Tag eg230129-01 came off during surface-active behaviors between two individual whales. Files containing depth data for mn230208-01 were incomplete and are awaiting engineer help from the CATS team for conversion. Further analysis of all tag data is underway.

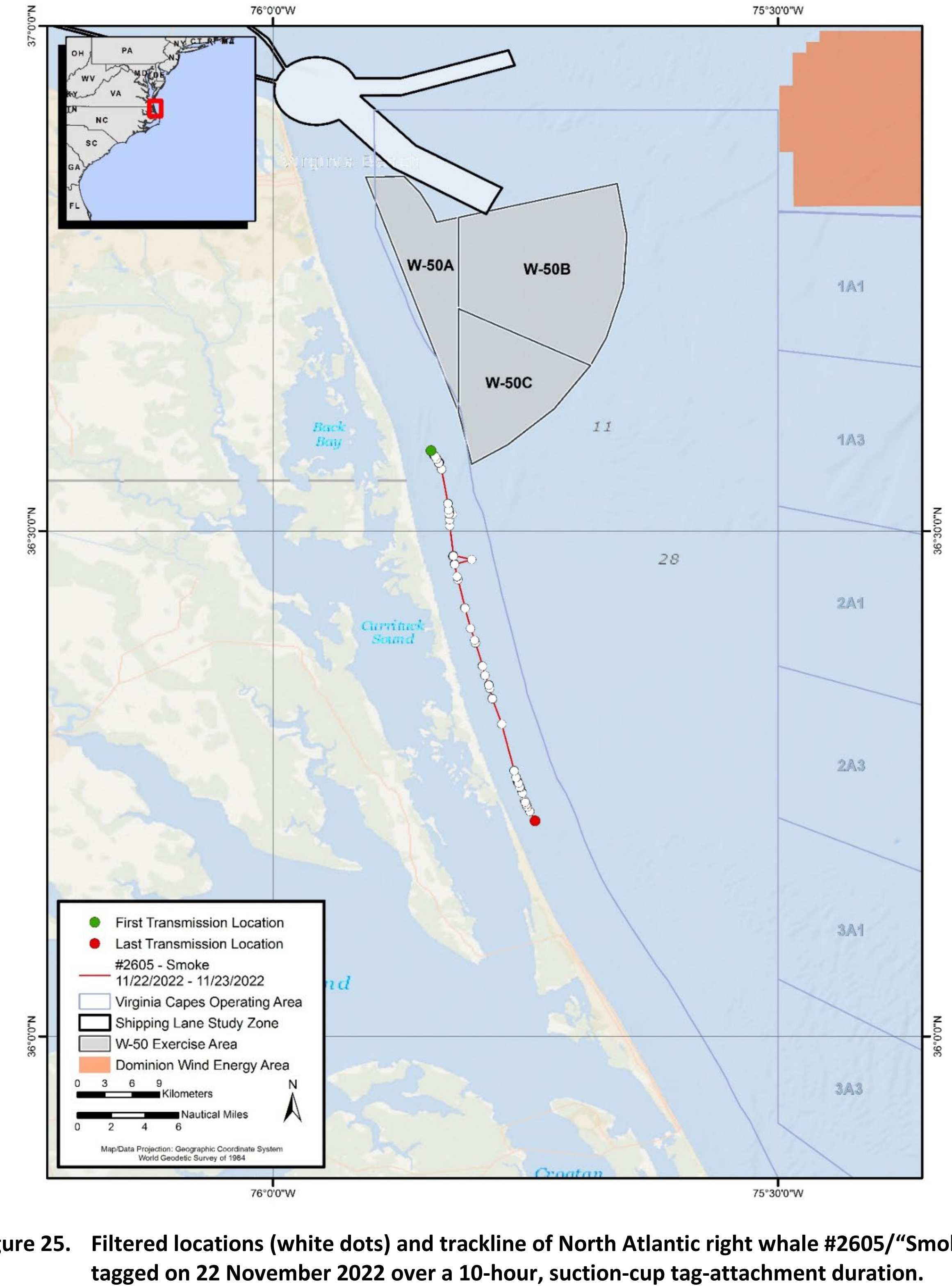


Figure 25. Filtered locations (white dots) and trackline of North Atlantic right whale #2605/"Smoke," tagged on 22 November 2022 over a 10-hour, suction-cup tag-attachment duration.

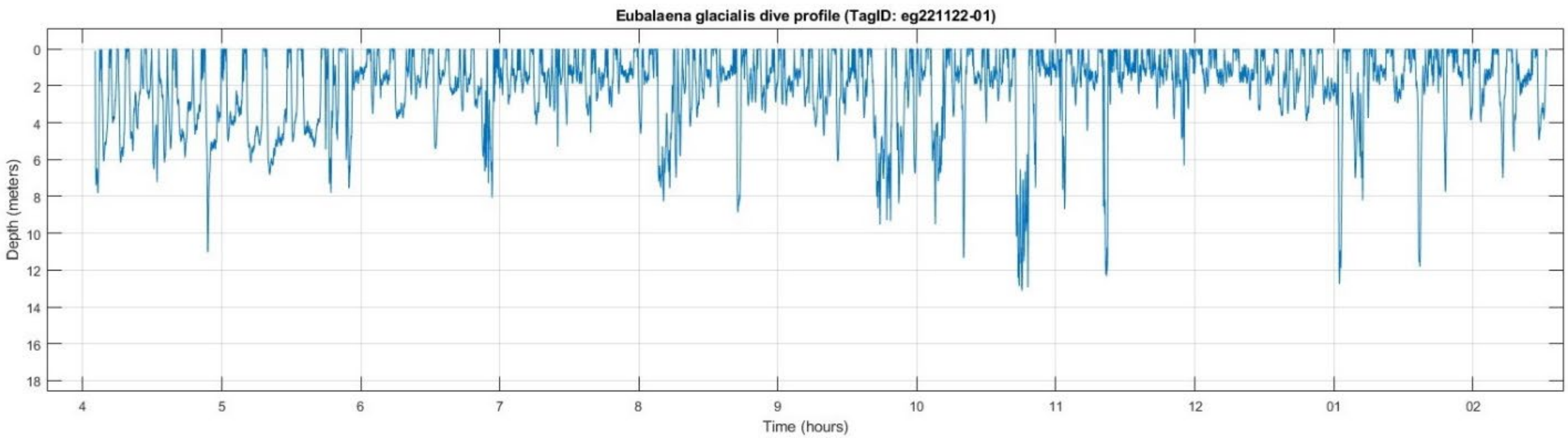


Figure 26. Dive-depth profile (in meters) for NARW #2605/"Smoke" (CATS eg221122-01).

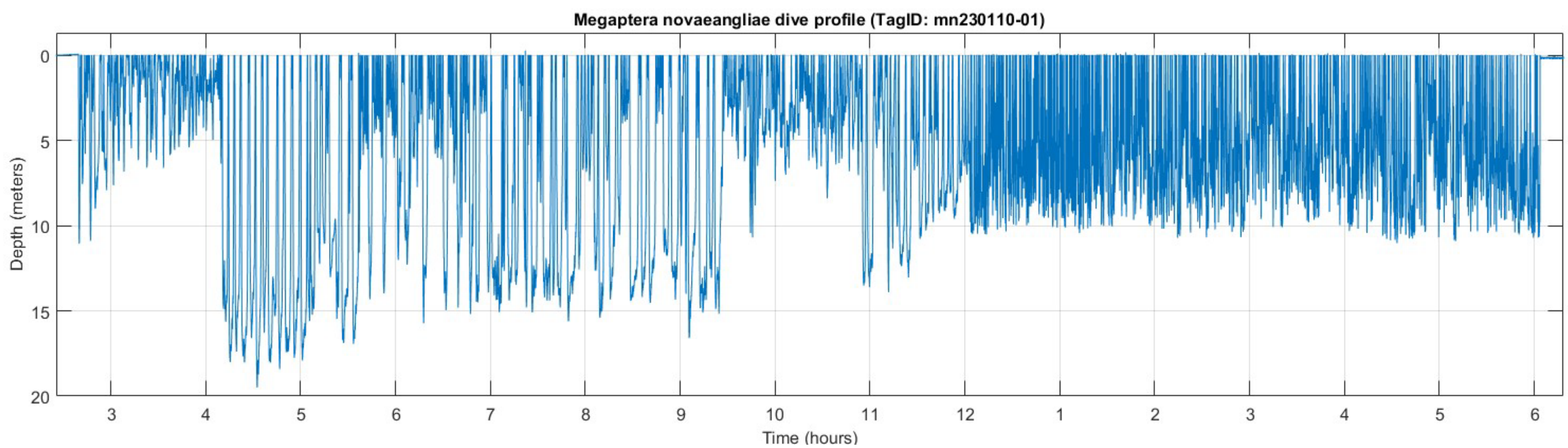


Figure 27. Dive-depth profile (in meters) for humpback HDRVAMn268 (CATS mn230110-01).

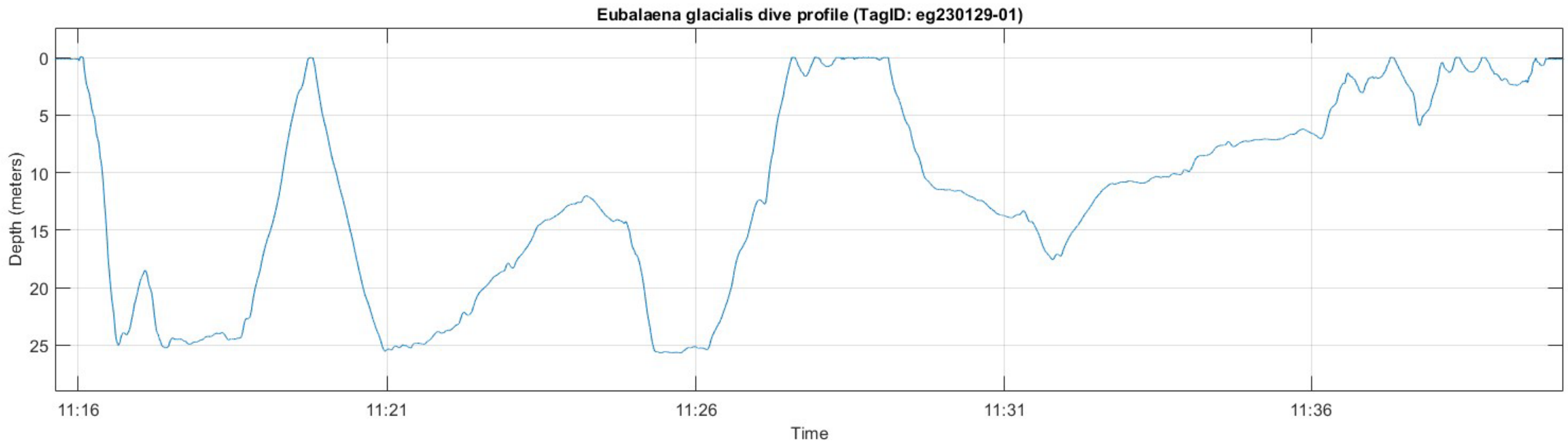


Figure 28. Dive-depth profile (in meters) for NARW #3810 (CATS eg230129-01).

2.2.1.4 Photo-identification and Mid-Atlantic Humpback Whale Catalog

Photo-identification – NARWs

The 36 NARWs observed during surveys resulted in 27 unique individuals identified during the 2022/2023 field season and included all age classes and both sexes. Four individuals were observed on 2 different days and three individuals were observed on 3 different days. One juvenile male, #4523/"Beaker," was seen previously within the study area in 2021 in addition to being observed on 3 different days during the 2022/2023 field season; the number of days between first and last sighting for this individual was 755. With the exception of adult female #2605/"Smoke" who was first seen with another adult female, #3503/"Caterpillar" in November 2022 then re-sighted with her new calf in March 2023 (Coming full circle – right whale mom returns with calf), all other re-sighted NARWs were parts of larger groupings of six to nine individuals engaged in either social or milling behavior. These larger groupings were observed within the study area between 24 January and09 February 2023, indicating that larger groups of NARWs were persistent in the study area for at a least a 2-week period. Also noteworthy is that of the nine sightings, only two occurred within the NARW SMA (**Figure 21**), where vessels larger than 65 feet are required to slow down to speeds of 10 knots or less from November through April. For additional information on NARWs in the Mid-Atlantic, see **Section 2.4** of this report and **Table 31** (in **Section 2.4.1**) for specifics on all aerial and vessel NARW sightings during the 2022/2023 field season.

Photo-identification – Humpback Whales

The 33 sightings of humpback whales included 48 total individuals and resulted in 36 unique humpback whales identified using dorsal fin and fluke images for the season (Aschettino et al. 2024b). An additional humpback whale was also seen during an Offshore Cetacean Study (see **Section 2.2.3**) survey in March 2023 (**Figure 29**). Of the 37 total unique humpback whales seen during the 2022/2023 season, 10 (27.0 percent) were classified as juveniles based on their estimated size in the field; 9 (24.3 percent) were categorized as sub-adults/adults, 8 (21.6 percent) were classified as adults, 5 (13.5 percent) were classified as subadults, and 1 (2.7 percent) was classified as a juvenile/sub-adult. Nine (24.3 percent) of the 37 individuals were re-sights to HDR, Inc.'s catalog; 1 individual had not been seen since the initial 2014/2015 season (HDRVAMn004) and the remaining re-sights included individuals from four of the previous eight field seasons. The additional 28 whales were new individuals added to HDR, Inc.'s growing catalog, which, to date, has 275 unique humpback whales (inclusive of identifications added from the Offshore Cetacean Study; see **Section 2.2.3; Figure 29**). Only 5 of the 37 humpback whales (13.5 percent) were seen on more than one occasion this season, and only 1 of those was seen on three or more occasions. This is down from most previous seasons (38.6 percent during 2021/2022; 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) but comparable to the 2020/2021 season (12.9 percent). To date, evidence of human interaction, either presumed line-entanglement scars or propeller scars, was apparent on at least 28 of the 275 (10.2 percent) cataloged humpback whales.

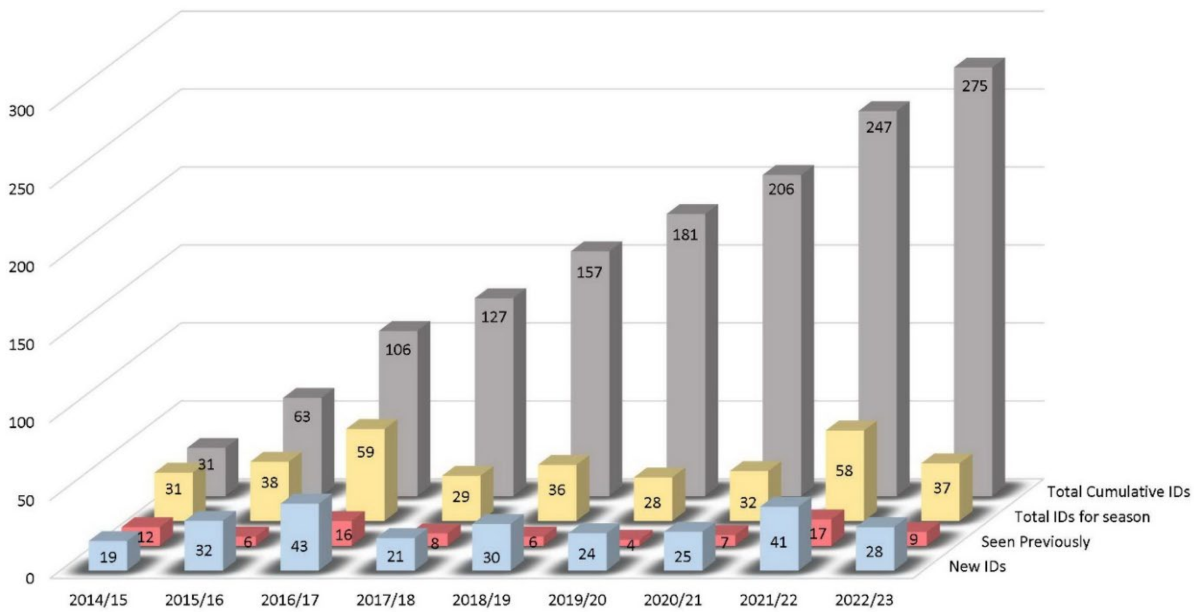


Figure 29. Humpback whale identifications over nine field seasons within the Virginia study area: yellow bars = total number of IDs for each season; red bars = number of those IDs that were seen in previous seasons; blue bars = number of new IDs added to the catalog; gray bars = total number of cumulative unique IDs.

Beginning in December 2018, drone video was collected from 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 used 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 research vessel. Following the methodology described in Dawson et al. (2017), the drone was recently retrofitted with a custom Light Detection and Ranging (LiDAR) altimeter (Lightware SF11). This upgrade increases the precision (to within 5 cm) and consistency of the drone 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.

Body length measurements were calculated for 43 individuals from drone footage collected between November 2021 and December 2022, and the lengths of 70 unique individuals have been calculated to date (Aschettino et al. 2023a). The body lengths for 10 of these 43 individuals had previously been calculated from earlier field seasons and were measured again. The best photograph was selected for each individual and image grading criteria from Christiansen et al. (2018) were applied. Twenty-five of these images met the grading criteria, and these individuals ranged from 9.35 to 13.93 m in total length (mean = 11.92 m; median = 11.91 m). All whales that measured less than 10 m had been classified as either juveniles, sub-adult/adult, or second-year calf in the field. All whales between 10 and 11 m were assigned either juvenile or sub-adult/adult. All whales over 11 m were classified as either sub-adult/adult or adult in the field.

Mid-Atlantic Humpback Whale Catalog

Humpback whales are the most common mysticete in the nearshore waters off the coast of Virginia (Mallette et al. 2017). Evidence of seasonal use, foraging, and site fidelity from photo-ID efforts suggest the mid-Atlantic provides important seasonal habitat for humpback whales (Barco et al. 2002; Swingle et al. 1993; Wiley et al. 1995). 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 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 vessel), 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 distribution and phenology over time. Survey effort and opportunistic sightings of humpback whales off 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 2023 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. All of HDR, Inc.'s humpback whale images and sighting records through the end of the 2022/2023 season have been updated in the database. All images have also been uploaded separately to Happywhale, which yielded 66 match records. Individuals were matched to various feeding grounds off the Northeastern U.S., Canada, and Iceland, as well as to breeding grounds off the Dominican Republic as well as the Turks and Caicos Islands. Matches continued to be made to other areas in the Mid-Atlantic, including Virginia, New York, and New Jersey.

2.2.1.5 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 during subsequent seasons. As the project has evolved to push efforts 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 2022/2023 season. Results continue to show site fidelity within the study area for many individuals and a high level of occurrence within areas that are heavily used by the U.S. Navy, commercial shipping, recreational and commercial fishing vessels, and future wind-energy areas.

Further efforts in the mid-shelf region have shown that another subset of animals is also spending time in or near the W-50 MINEX zone and the broader offshore VACAPES OPAREA, where they are presumably within the hearing range of underwater detonation training exercises. Use of the Dominion Wind Energy Area, approximately 27 nm 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 planned, with construction beginning in mid-2024. 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 near Virginia Beach and highlights the potential for injuries and fatalities in this area.

For more information regarding this study, refer to the annual progress reports for this project (Aschettino et al. 2024a, 2024b).

2.2.2 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 (Barco et al. 2002; Katona and Beard 1990; 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, 212 humpback whale strandings have occurred along the U.S. East Coast, causing NMFS to declare an UME for humpback whales in 2017 (still ongoing as of February 2024). One third of these strandings occurred within the mid-Atlantic region, and half of the whales that were able to be examined post-mortem showed evidence of human interaction (ship strikes or entanglement).

Satellite-tracking data from the Mid-Atlantic Humpback Whale Monitoring Project show that the distribution of these animals overlaps significantly with shipping channels (Aschettino et al. 2020). Within the Virginia Beach area, high rates of ship strikes have been reported, with 10 percent of cataloged whales showing evidence of ship-strike injuries (Aschettino et al. 2023a). Additionally, three animals added to the Mid-Atlantic catalog during winter 2016/2017 were later killed by collisions with ships (Aschettino et al. 2018). 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. Hampton Roads (Virginia) is the sixth busiest port in the U.S., and Baltimore (Maryland) is 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). Humpback whales remain within the Virginia Beach area for days to months, and have been re-sighted over multiple years (Aschettino et al. 2023a). 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 to oncoming vessels 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 this population.

The primary objective of this work is to build upon the ongoing humpback whale monitoring (**Section 2.2.1**) by deploying high-resolution DTAGs to measure humpback whale responses to close ship approaches. The following questions are 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?

During the first four field seasons of this project during the winters of 2019 to 2022, 15 DTAGs were deployed on individual whales and several of these individuals had accompanying satellite-telemetry tags deployed by HDR, Inc (Shearer et al. 2023). These tags provided the opportunity to study the whales' three-dimensional movement and reactions to the sound of vessel approaches. The fifth and final field season for this project began on 6 February 2023 and ended on 9 February 2023. No tags were deployed during the 2023 field effort. This season's effort concentrated on prey mapping using a split-beam, high-precision, scientific echosounder within the shipping lanes of the study area in order to determine regions of higher prey density in relation to the shipping channels and provide context to whales' spatial movements and behavior.

During acoustic surveys with scientific echosounders, high-frequency sound is propagated into the water column and reflected off organisms having differing density than the surrounding water. The echo or backscatter provides information about the density, depths, and spatial locations of organisms throughout the water column. The acoustic survey provides a non-invasive and non-destructive means to estimate areas of biomass hotspots to understand the spatial and temporal behavior of the potential prey field. Two separate surveys were designed for this field season: a systematic survey to map the main channel and a focused survey around a tagged whale.

The goal of the systematic survey was to map the prey fields in the main shipping channel south and east of the turning basin (**Figure 30**). This area was chosen due to overlap between the spatial positions of humpback whales satellite tagged in previous years by HDR, Inc. and consistent foraging within these areas detected during previous years' DTAG deployments. The survey encompassed areas both within and directly outside the shipping lanes in order to facilitate comparisons. To assess diurnal differences in prey distribution, the same tracklines were covered at different times. Line spacing for this survey was set at 250 m due to the time required to complete the full survey with overlapping data between night and day.

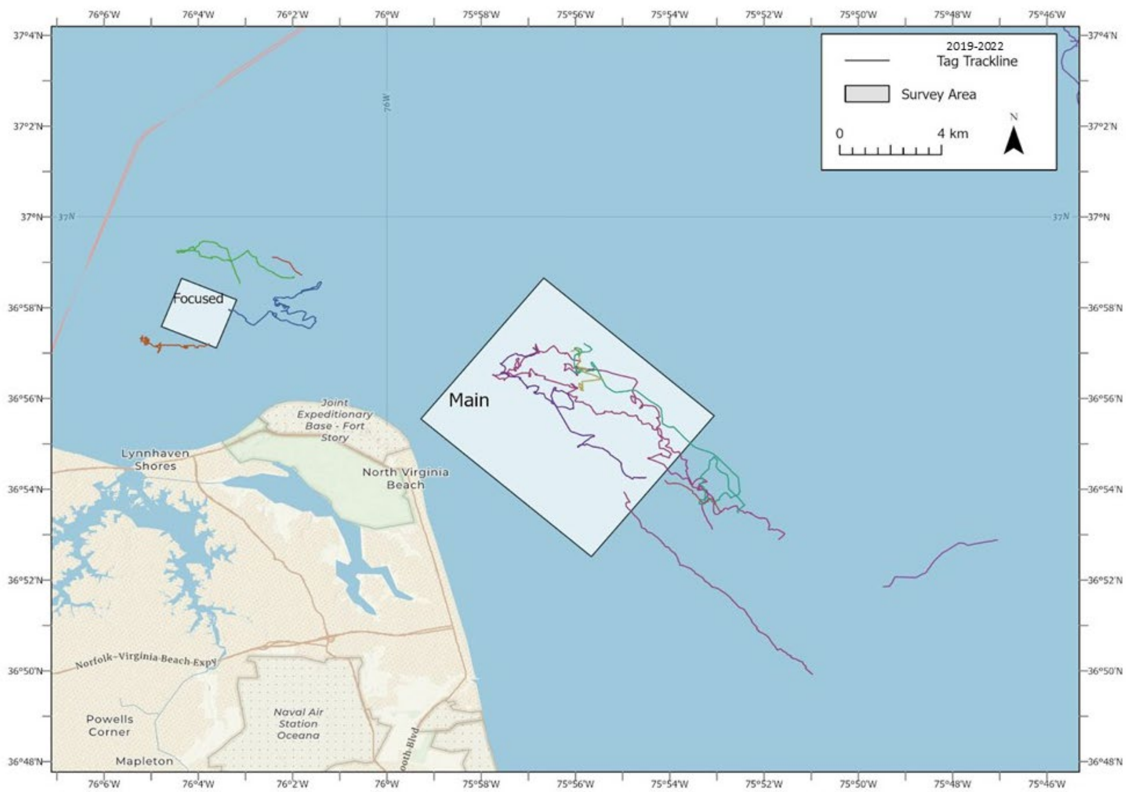


Figure 30. The light gray polygons represent the main and focused survey location inside the main shipping channel of the Virginia Beach inlet, with the multicolor lines representing the 2019–2022 DTAG data used in the survey design.

The focused survey was conducted near a tagged whale in order to compare the whale's behavior with *in situ* prey data. This required both a systematic grid survey in the vicinity of the tagged whale and a following survey during which the field team would communicate locations of the tagged whale to the vessel operator. The vessel operator would then survey in an irregular pattern over the last location of the tagged whale until the next sighting (**Figure 30**).

For all surveys, prey mapping of the water column was completed using a suite of hull-mounted Kongsberg split-beam echosounders (38 kHz, 70 kHz, 120 kHz) on the R/V *Shearwater*. Split beam echosounder systems (SBESs) rapidly transmit an acoustic ping that reflects off objects in the water column that have differing density than the surrounding water. The resulting echosounder data were paired with the ship's global positioning system (GPS; Furuno SC-33) to provide a high-resolution, geolocated sample of the full water column (**Figure 31**). SBES data were processed using Echoview v13 (Echoview Software Pty Ltd.). Bottom- and surface-tracking algorithms were developed to delineate the seabed and eliminate surface noise due to the sea state.

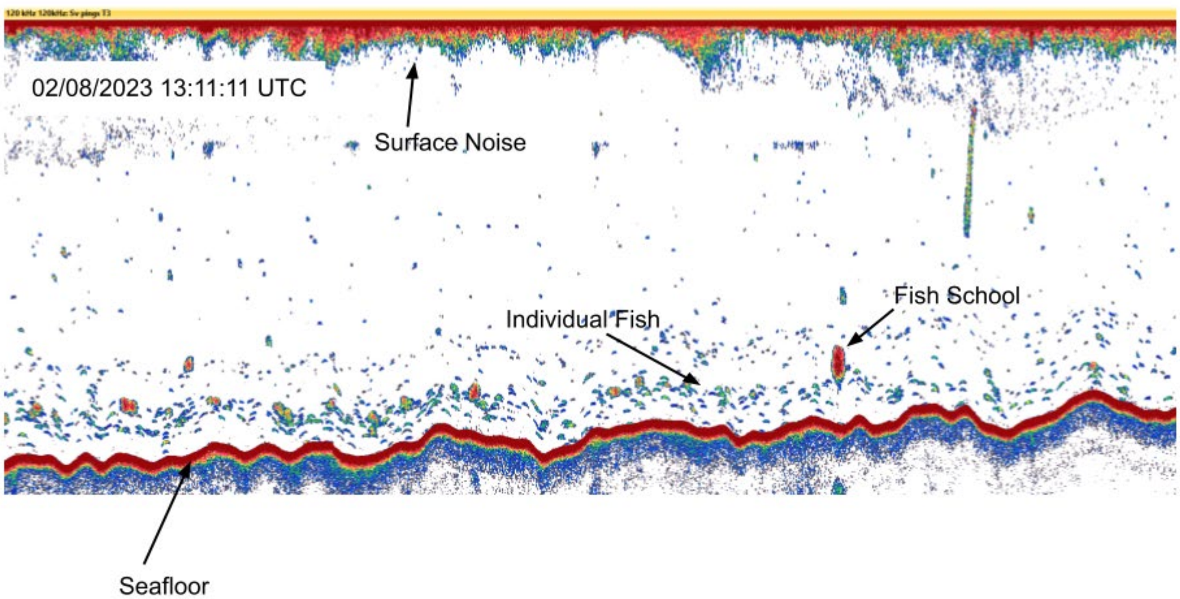


Figure 31. Example echogram describing the main features. Red represents strong echo returns and blue represents weak echo returns.

A total of 302 linear km of acoustic survey effort occurred during the 2-day cruise. This included 258 km surveyed in the main shipping channel (systematic survey, **Figure 32**) and 44 km of focused survey near a CATS-tagged humpback whale (**Figure 33**). Surveys were conducted during Beaufort Sea States 2–5. The beginning of the systematic survey in the main shipping channel was conducted in a Beaufort Sea State 5 (5- to 6-foot seas), which created data-quality issues over the first 12 hours until the sea state subsided.

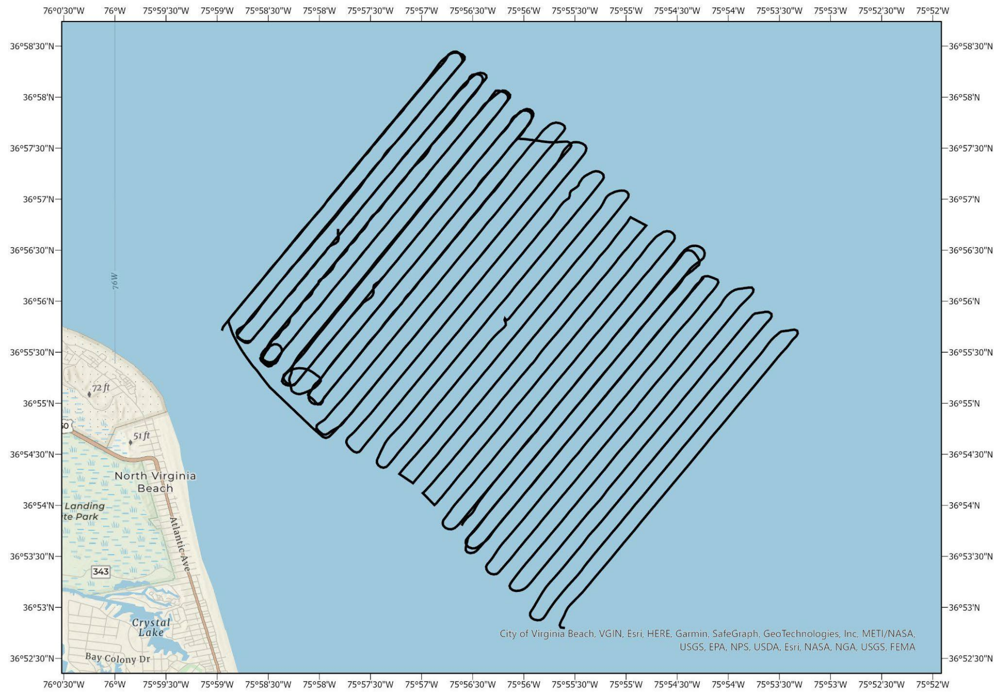


Figure 32. R/V *Shearwater* systematic echosounder survey tracks.

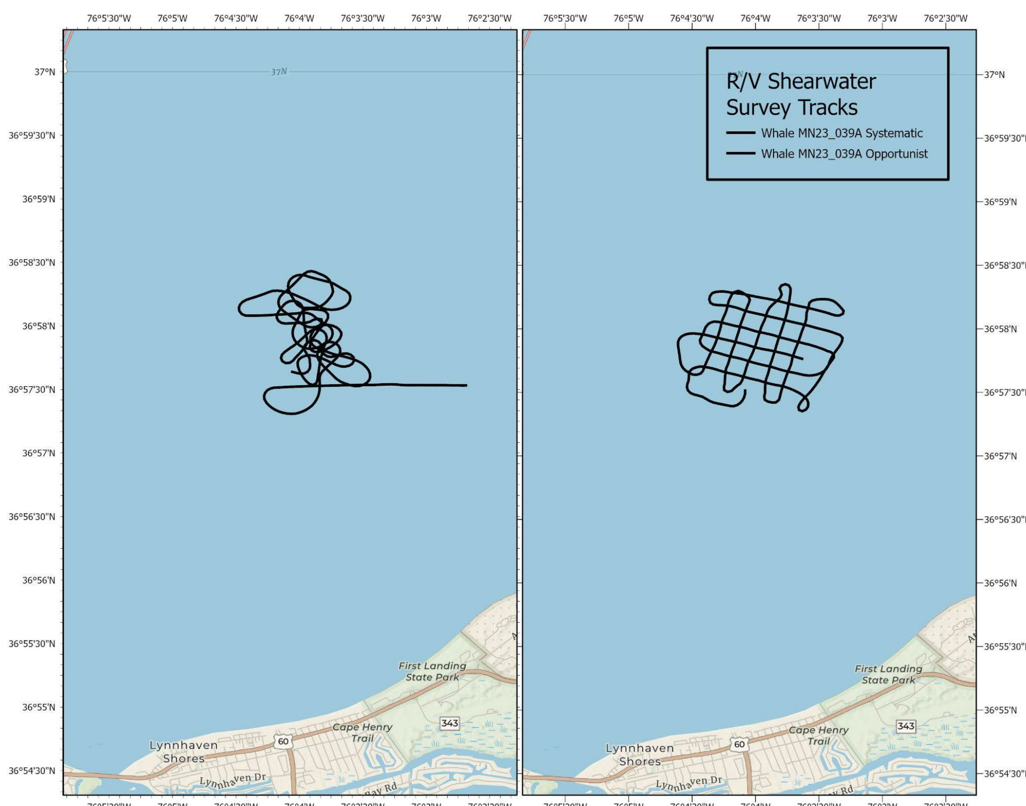


Figure 33. R/V *Shearwater* focused echosounder survey tracks.

The main survey revealed a scattering layer throughout the water column (**Figure 34**) relatively consistently over the full survey area, with higher density scattering layers found within the western and eastern portions of the survey area. The area of highest backscatter occurred within the northeastern corner of the survey area, near the location where the shipping lanes join the turning basin. Although whale tags were deployed during previous years and are not concurrent with this prey survey, the areas of higher prey density to the north and east roughly correspond to whale tracks that tended to stay on the northern side of the shipping lanes (**Figure 34**).

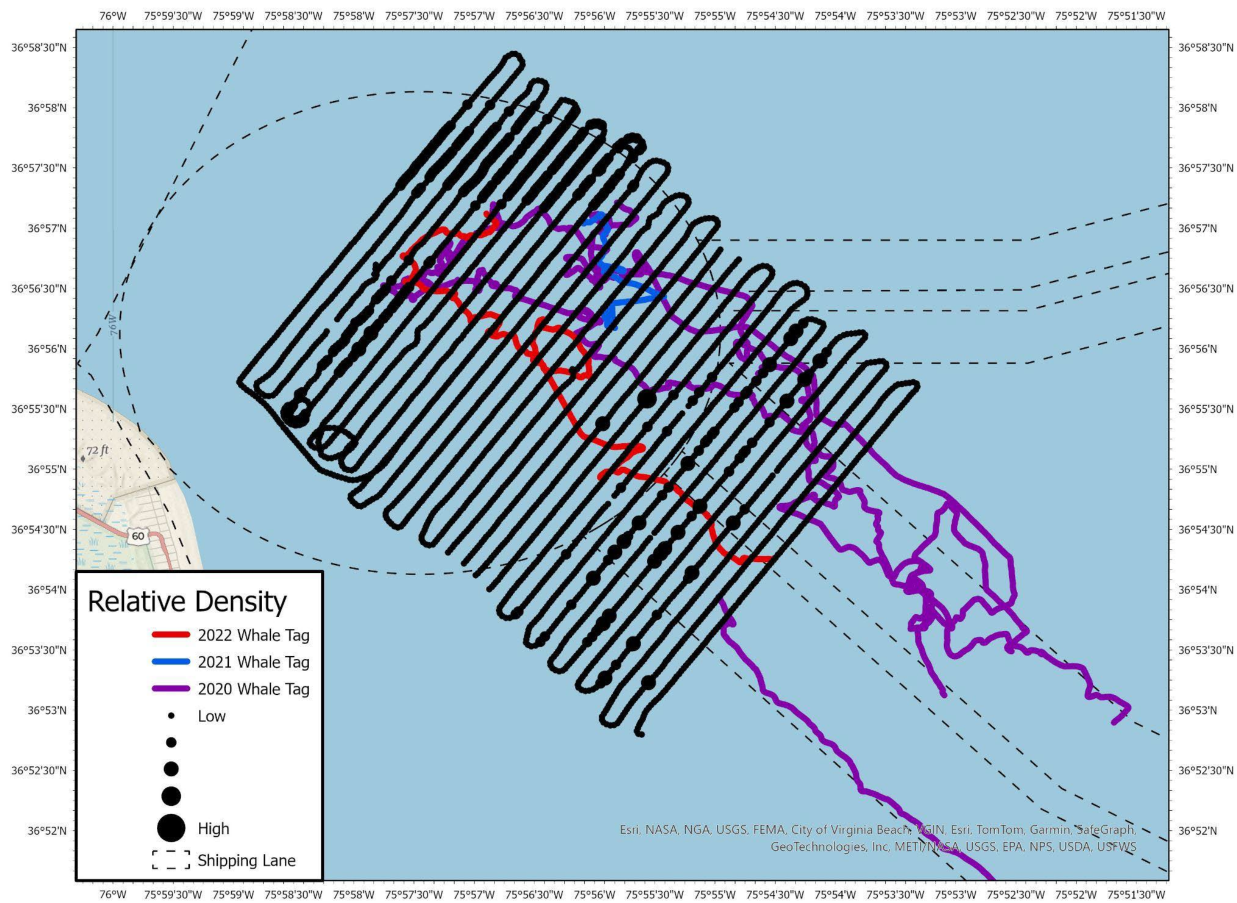


Figure 34. Survey tracklines for the main survey showing change in relative density across the survey area. Tracklines of whales tagged during previous years are overlaid on the survey lines.

The focused survey had complete spatial coverage of the area in which the whale was sighted during the survey (**Figure 35**). Areas of high backscatter density were found throughout much of the focused survey, particularly the survey following the whale's most recent position (**Figure 35**). Large fish schools were occasionally seen during the systematic grid survey (**Figure 36**).

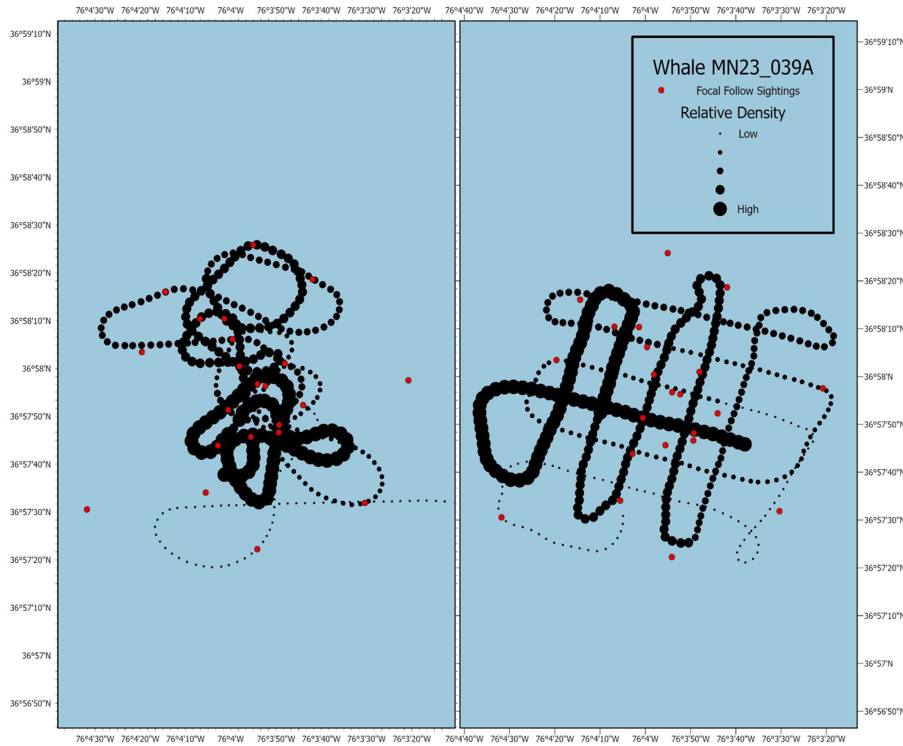


Figure 35. Focused survey tracklines for the survey (left) following whale mn23_039a and the systematic grid (right). Estimated whale positions are shown as red circles.

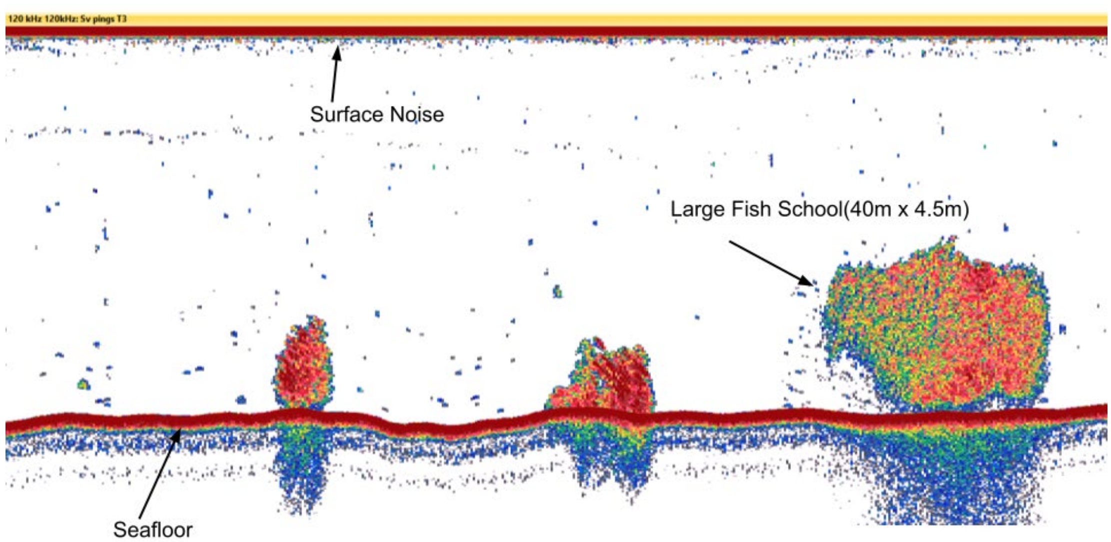


Figure 36. Large fish school seen during the systematic survey of whale mn23_39a.

The water column prey survey work conducted in 2023 supports previous years of research within this area that have documented high levels of foraging behavior in humpback whales tagged in and near the Virginia Beach shipping lanes. Although the primary goal of this work is to determine humpback responses to approaching ships, cessation of foraging behavior is likely to be both a response to disturbance and a potential predictor of how likely animals are to react to an approaching threat. As such, it is important to understand the prey fields within the area in order to provide context for the documented foraging behavior.

Two focused surveys were completed near a whale tagged with a CATS tag by HDR, Inc. (Aschettino et al. 2024a), including a systematic grid survey and a focal following survey. Prey density within the study area was not evenly distributed. Areas of high density were found throughout the systematic survey but were primarily concentrated to the northeastern side of the turning basin, and along the edges of the shipping channel, with lower densities within the middle and southwestern portions of the survey. Whales tagged during previous years followed a similar pattern of foraging near the edges of the shipping lanes. During the whale-follow survey, the tagged whale appeared to be actively foraging from focal follow observations. However, technical difficulties occurred during the tag offload, and the tag data are inaccessible at this time and not available to confirm foraging. High prey density, including large fish schools measuring up to 40 m by 4.5 m, were occasionally found during the whale-follow survey. This correlation between likely foraging behavior by the tagged whale and dense prey schools illustrates the likelihood of these whales foraging on patchy but dense prey resources within this area.

During 2023, foraging behavior from all tags deployed to date have been analyzed, including quantifying foraging rates, diel patterns, and kinematics. This manuscript is in review. The 2023 field season concluded the field effort portion of this project. Additional analyses are currently being conducted, including:

- Comparing prey survey results with known locations of foraging behavior from DTAG records to assess spatial and diel foraging patterns.
- Combining satellite tag locations, foraging lunges, and bathymetry data from animals tagged with both satellite tags and DTAGs to analyze fine-scale spatial context of foraging behavior (location in water column, use of shipping lanes)
- Analyzing behavioral responses to approaching ships, including foraging behavior cessation, water column use, and spatial avoidance.

These analyses will continue to contribute to ongoing efforts in order to understand the behavior of humpback whales within the Virginia Beach shipping lanes study area in order to develop potential mitigation measures for ship strikes.

For more information on this project and details of the analyses, please refer to the 2023 annual progress report (Shearer et al. 2024).

2.2.3 VACAPES Offshore Cetacean Study

HDR has collaborated with the U.S. Navy to conduct marine mammal surveys near Naval Station Norfolk, Joint Expeditionary Bases-Little Creek and Fort Story, and Naval Air Station Oceana Dam Neck Annex, and within the W-50 MINEX zone since 2012, (Engelhaupt et al. 2016). However, survey effort had not previously occurred farther offshore within the VACAPES OPAREA near the continental shelf break. Therefore, limited information existed regarding how offshore species, including beaked whales, endangered fin and sperm whales, and other baleen whales use the deeper waters of this region. Vessel surveys for the VACAPES Offshore Cetacean Study were initially conducted from April 2015 through June 2016 in association with the Mid-Atlantic Humpback Whale Monitoring project and subsequently became a dedicated project in July 2016. The goal of this study is to assess 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, drone photogrammetry, satellite-linked telemetry tags, and DTAGs or CATS tags. Activities conducted during the 2023 field season are summarized below and detailed in Engelhaupt et al. (2024).

The goals of this study are to assist the U.S. Navy and regulatory agencies with environmental planning and compliance by addressing the following questions:

- Which cetacean species occur within the VACAPES OPAREA off Virginia, and how does occurrence fluctuate seasonally?
- What are the baseline behaviors and ecological relationships of offshore cetaceans within the study area?
- Do individual cetaceans exhibit site fidelity within specific regions of the study area over periods of weeks, months, or years?
- What is the seasonal extent of cetacean movements within and around U.S. Navy VACAPES training range boxes?
- Do cetaceans spend significant time within or primarily move through areas of U.S. live-fire or Anti-Submarine Warfare training events?

2.2.3.1 Vessel Survey Effort/Summary

The study area is located approximately 90 to 160 km off the Virginia coast, encompassing regions of the outer continental shelf, shelf break, slope waters, and both Norfolk and Washington Canyons. Depth throughout the study area ranges from approximately 50 to 2,500 m. HDR, Inc. conducted 9 offshore vessel surveys during 2023, covering 2,727 km of trackline and over 107 hours of effort.

Seventy-four marine mammal sightings and 11 sea turtle sightings were recorded during vessel surveys in 2023 (**Figure 37**). Nine cetacean taxa were identified (in order of decreasing frequency): pilot whale (*Globicephala* sp.; *n* = 27), common bottlenose dolphin (*n* = 23), sperm whale (*n* = 8), common dolphin (*n* = 6), Atlantic spotted dolphin (*n* = 3), Risso's dolphin (*n* = 3), humpback whale (*n* = 2), blue whale (*n* = 1), and fin whale (*n* = 1). Two sea turtle species were identified: loggerhead turtle (*n* = 9) and leatherback turtle (*Dermochelys coriacea*; *n* = 2). Given the study's focus on priority species that do not include pilot whales, the overlapping range of both short-finned (*Globicephala macrorhynchus*) and long-finned pilot whales (*G. 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, unless the animals were closely approached and species could be identified.

Sightings of deep-diving species, including sperm and pilot whales, were again concentrated beyond the shelf break and into deeper offshore waters during 2023 surveys, similar to previous years. Baleen whales were encountered both over the shelf and beyond the shelf break, also similar to previous years. Dolphin species were sighted throughout the core study and transit areas, and with the exception of one loggerhead turtle, all sea turtle sightings were over the shelf.

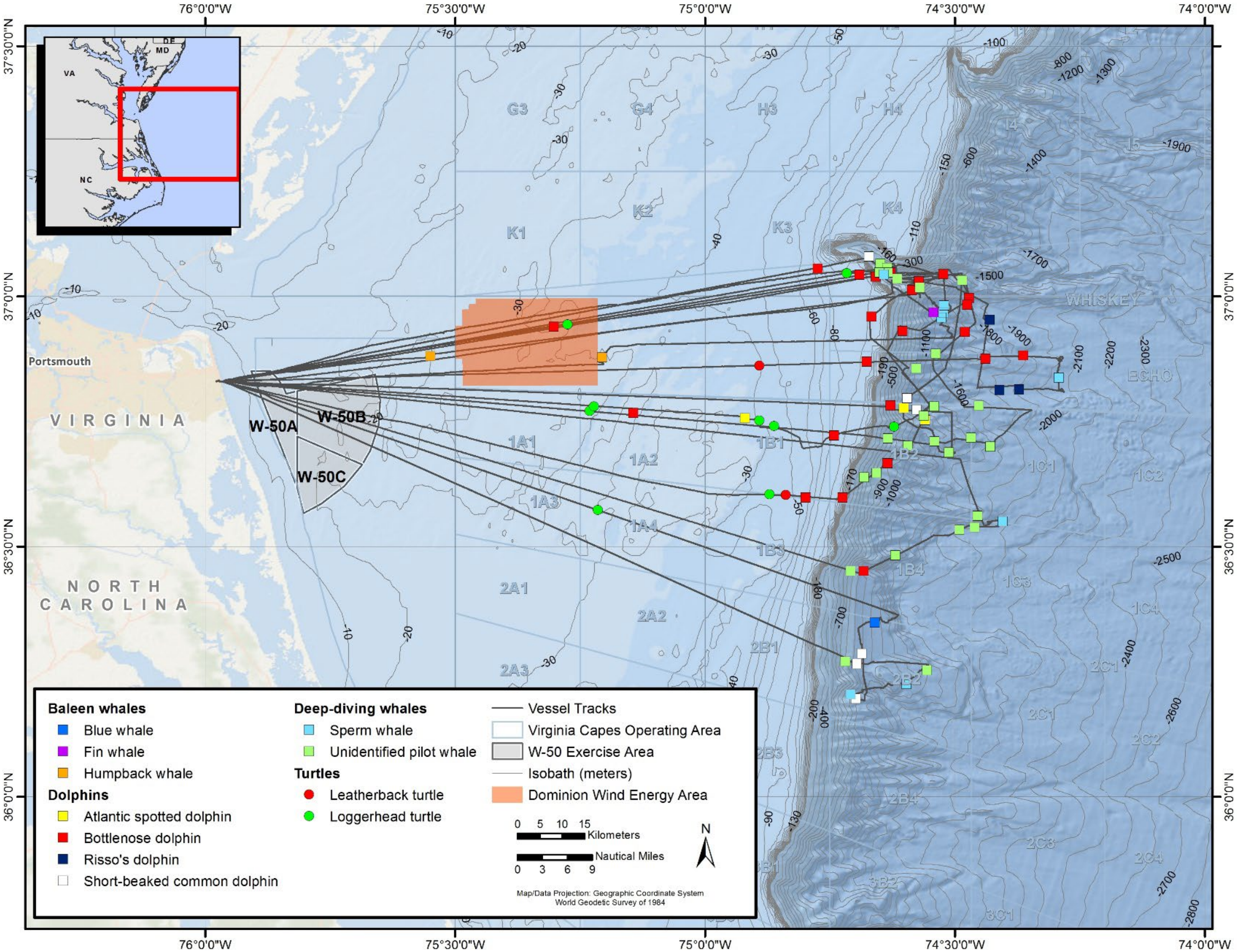


Figure 37. All tracklines and sightings of marine species during Offshore Cetacean Study fieldwork conducted during 2023.

2.2.3.2 Tagging and Biopsy Samples

Two biopsies were collected from sperm whales in 2023 and will be processed at Oregon State University. Prior to the 2023 field season, 27 unique sperm whale biopsy samples had been collected, of which 5 were determined to be female and 22 were determined to be male. Oregon State University was able to provide mitochondrial DNA results for 26 of these samples and included the three most common haplotypes: haplotype A (n = 16), haplotype B (n = 5), and haplotype C (n = 5).

Two satellite tags were deployed on sperm whales in 2023; both were SPLASH-10 tags, which collect location and dive depth/duration information (**Table 13**). Tag durations for sperm whales were 18.0 and 30.7 days. Maximum dive depths were 1,823 and 1,695 m, and maximum dive durations were 69 and 64 minutes.

Table 13. Satellite tag deployments for all species during Offshore Cetacean Study fieldwork during 2023.

Animal ID	Species	Tag Type	Deployment Date	Last Transmission Date	Tag Duration (Days)
HDRVAPm137	Sperm whale	SPLASH10	06-May-2023	24-May-2023	18.0
HDRVAPm138	Sperm whale	SPLASH10	06-May-2023	06-Jun-2023	30.7

Key: ID = identifier

Tagged sperm whales traveled up to 1,045 km from their initial tag deployment locations, and 39.1 and 8.2 percent of their locations were within the VACAPES OPAREA. Satellite-tagged sperm whales showed movements through multiple U.S. Navy OPAREAS, mostly along the continental shelf break and beyond the slope. One of the tagged sperm whales, HDRVAPm137, first moved southward and spent time within the Cherry Point OPAREA before turning back northward through VACAPES and Atlantic City OPAREAs and into the Narragansett Bay OPAREA for the last tag transmissions (**Figure 38**). The other tagged sperm whale, HDRVAPm138, moved northward throughout the tag duration along the continental shelf break through VACAPES, Atlantic City, and Narragansett Bay OPAREAs, and continued northward past Georges Bank before transmissions stopped (**Figure 39**).

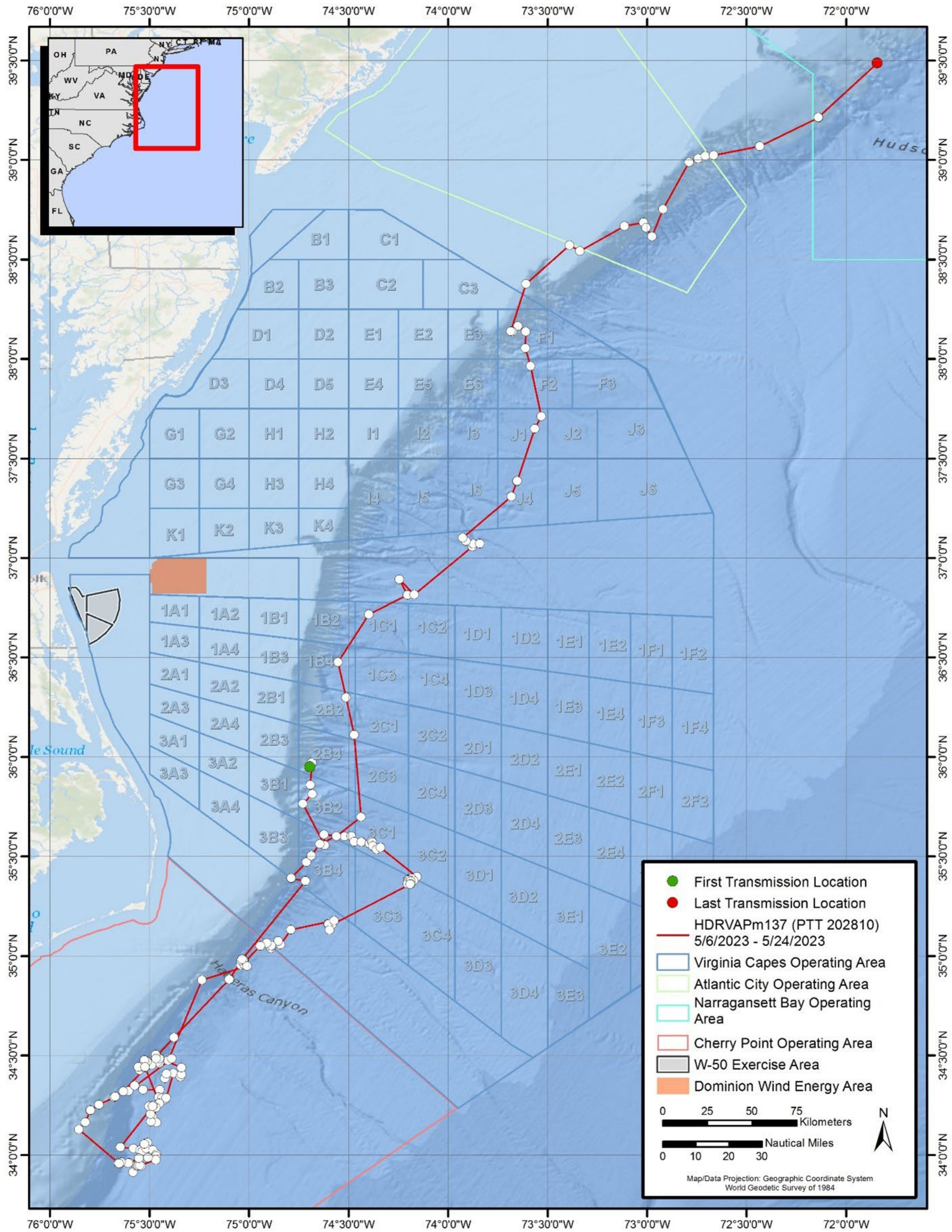


Figure 38. Filtered locations (white dots) and track of sperm whale HDRVAPm137 over 18.0 days.

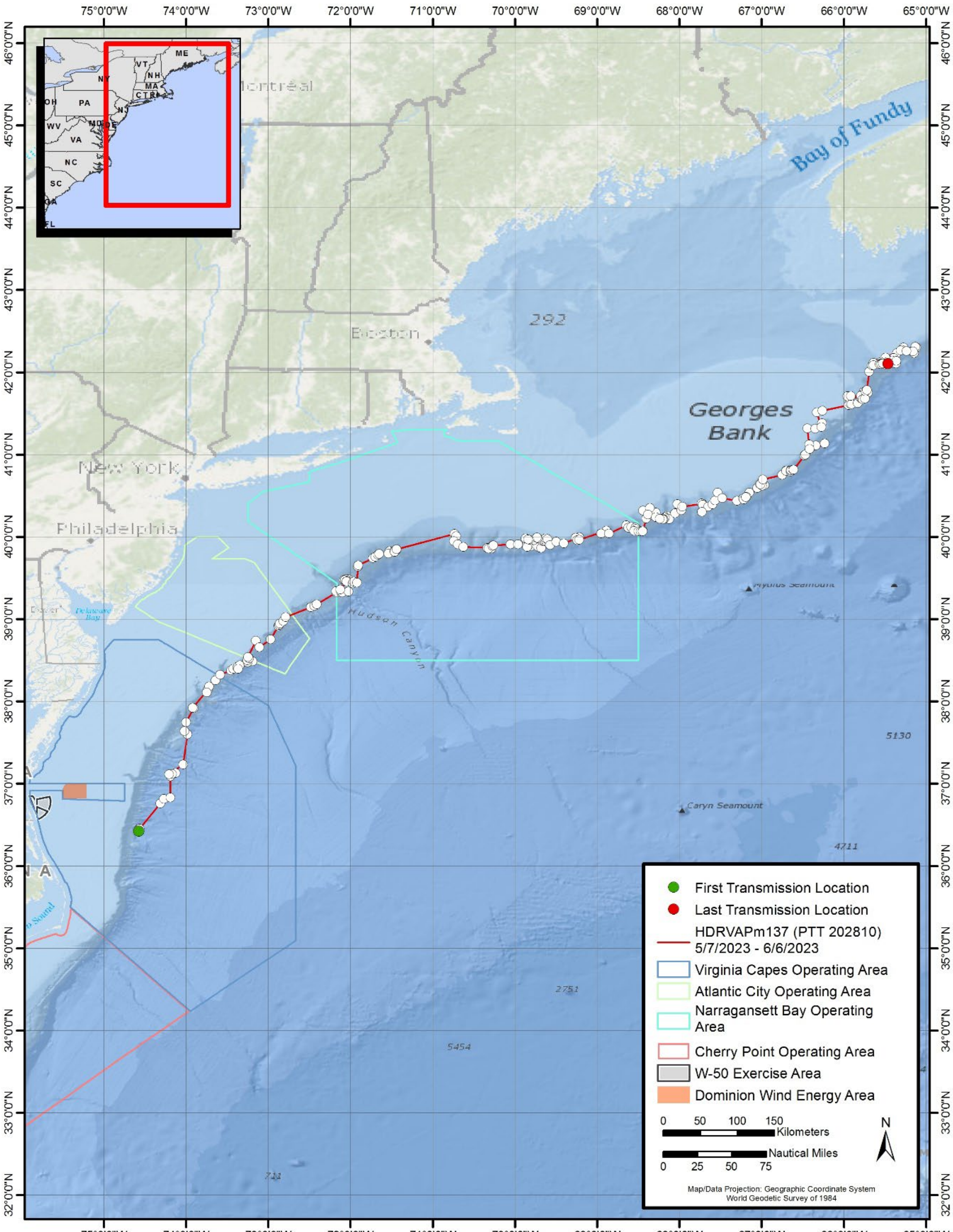


Figure 39. Filtered locations (white dots) and track of sperm whale HDRVAPm138 over 30.7 days.

No successful DTAG deployments occurred during 2023; however, analysis on the three DTAGs previously deployed on sperm whales during the 2022 season continued (**Table 14**). HDRVAPm117 dove three times during the tag deployment, with one dive close to 600 m and the other two dives to depths more than 1,000 m (**Figure 40**). An acoustic audit of these dive data showed sustained periods of clicking when at depths approximately 400 m and greater, and buzzes at the maximum depth of the dive bout. The tag on HDRVAPm119 was programmed for an overnight deployment but was released just over 300 minutes into the deployment (**Figure 41**). This individual remained at or near the surface for more than 4 hours before it dove, and the tag released before that dive was completed. This tag recorded codas that were produced by HDRVAPm119, as well as codas potentially produced by conspecifics. Codas were present for over 1.5 hours of the 4-hour surface event. HDRVAPm116 dove two times during the tag deployment, with the first dive to approximately 500 m and the second dive to nearly 1,600 m (**Figure 42**). Continuous clicking occurred during the first dive when deeper than 200 m and began again at the surface at the start of the second dive until nearing 900 m on the ascent. Buzzes were detected at the deepest part of the second dive, and codas were detected when the individual was at or near the surface.

Table 14. 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 (min)
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 = identifier; GMT = Greenwich Mean Time; min = minute(s)

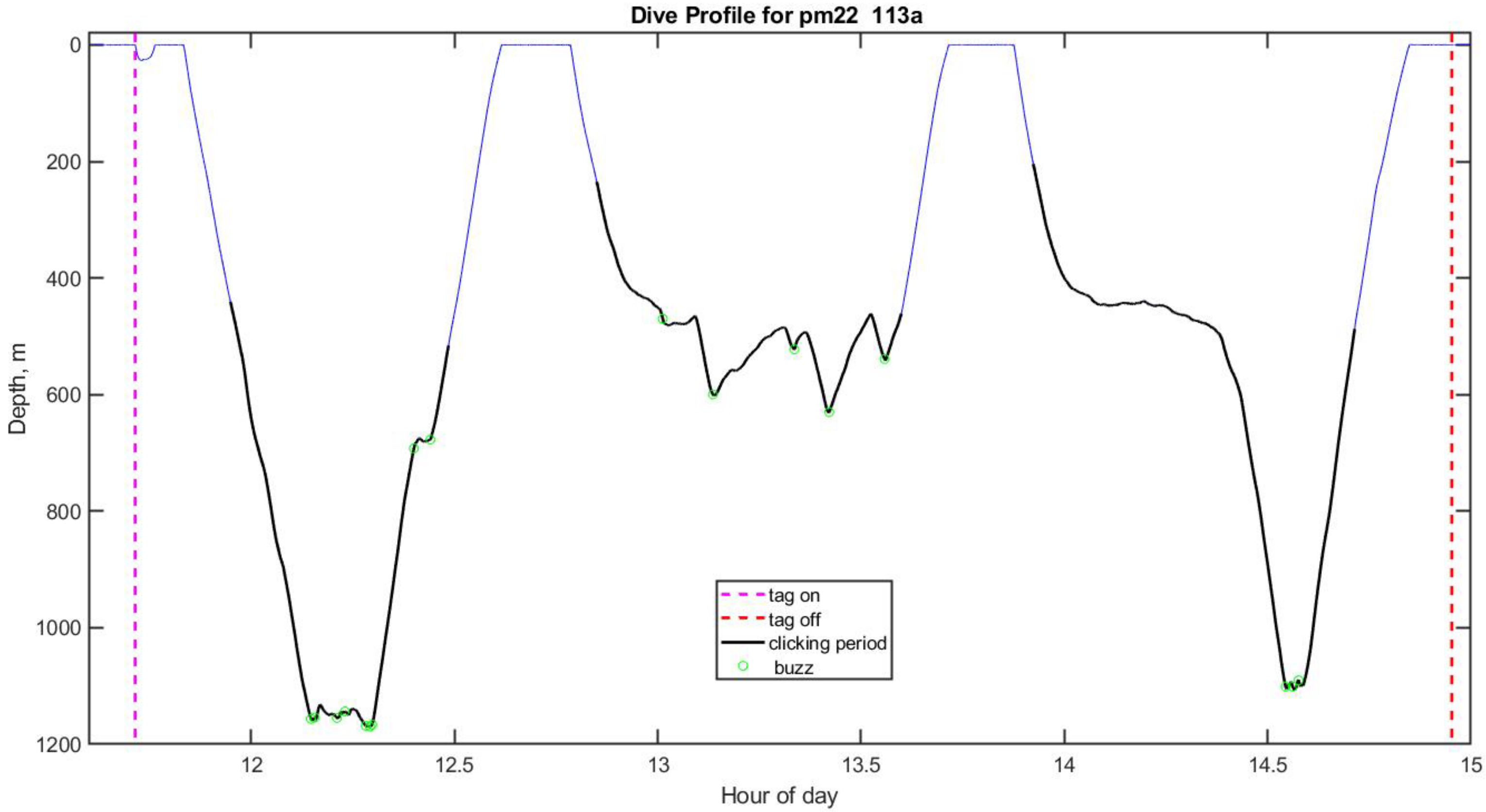


Figure 40. Acoustic audit results for DTAG dataset pm22_113a (HDRVAPm117) plotted with the dive profile. The black line indicates clicking, and the green circles indicate buzzing from the tagged animal. The pink dashed line marks the time the tag was on animal, and the red dashed line marks the time the tag was off animal.

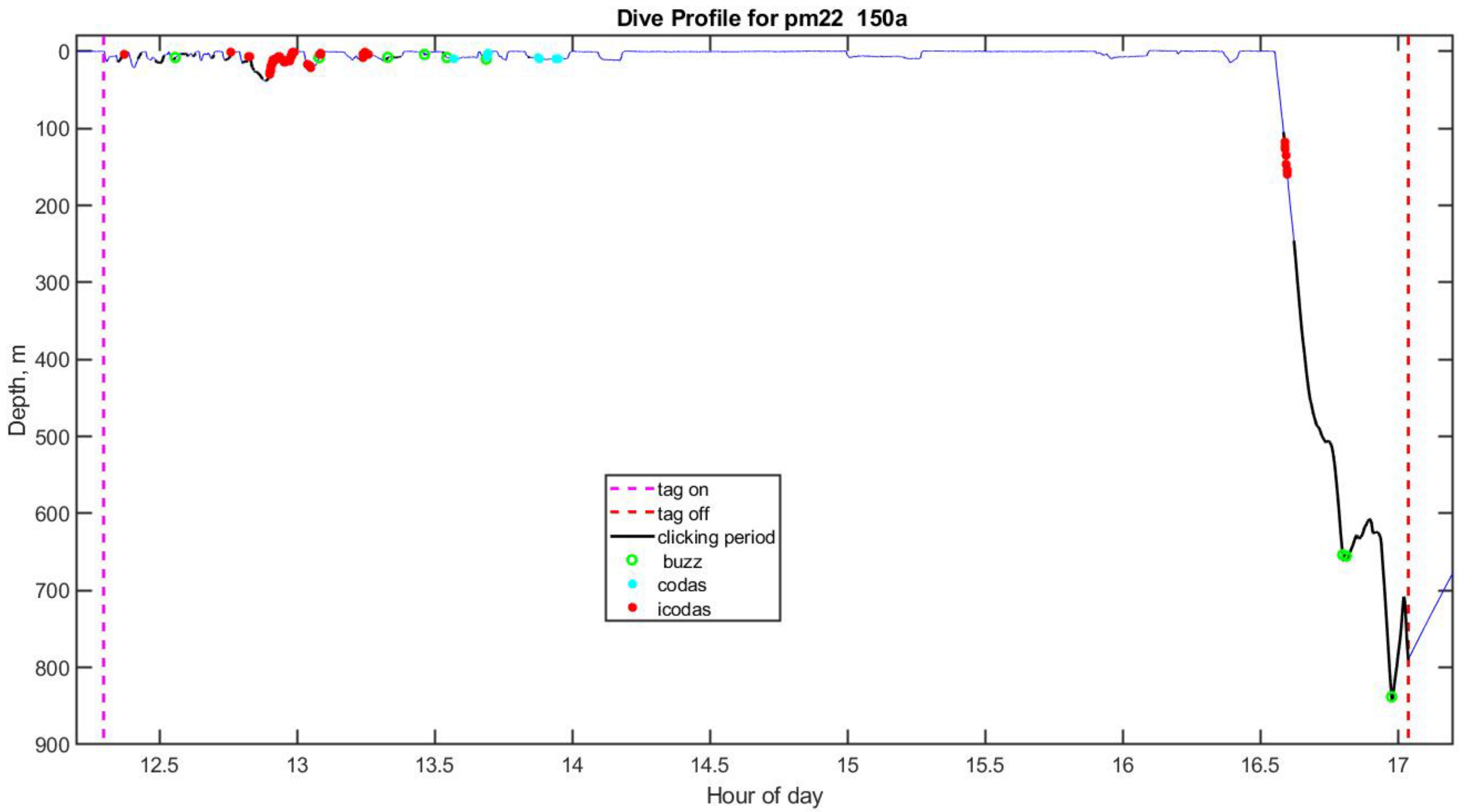


Figure 41. Acoustic audit results for DTAG dataset pm22_150a (HDRVAPm119) plotted with the dive profile. The black line indicates clicking, green circles indicate buzzing, blue circles are codas from the tagged animal, and red circles indicate codas that cannot be determined if they came from the tagged or other whales. The pink dashed line marks the time the tag was on animal and the red dashed line marks the time the tag was off animal.

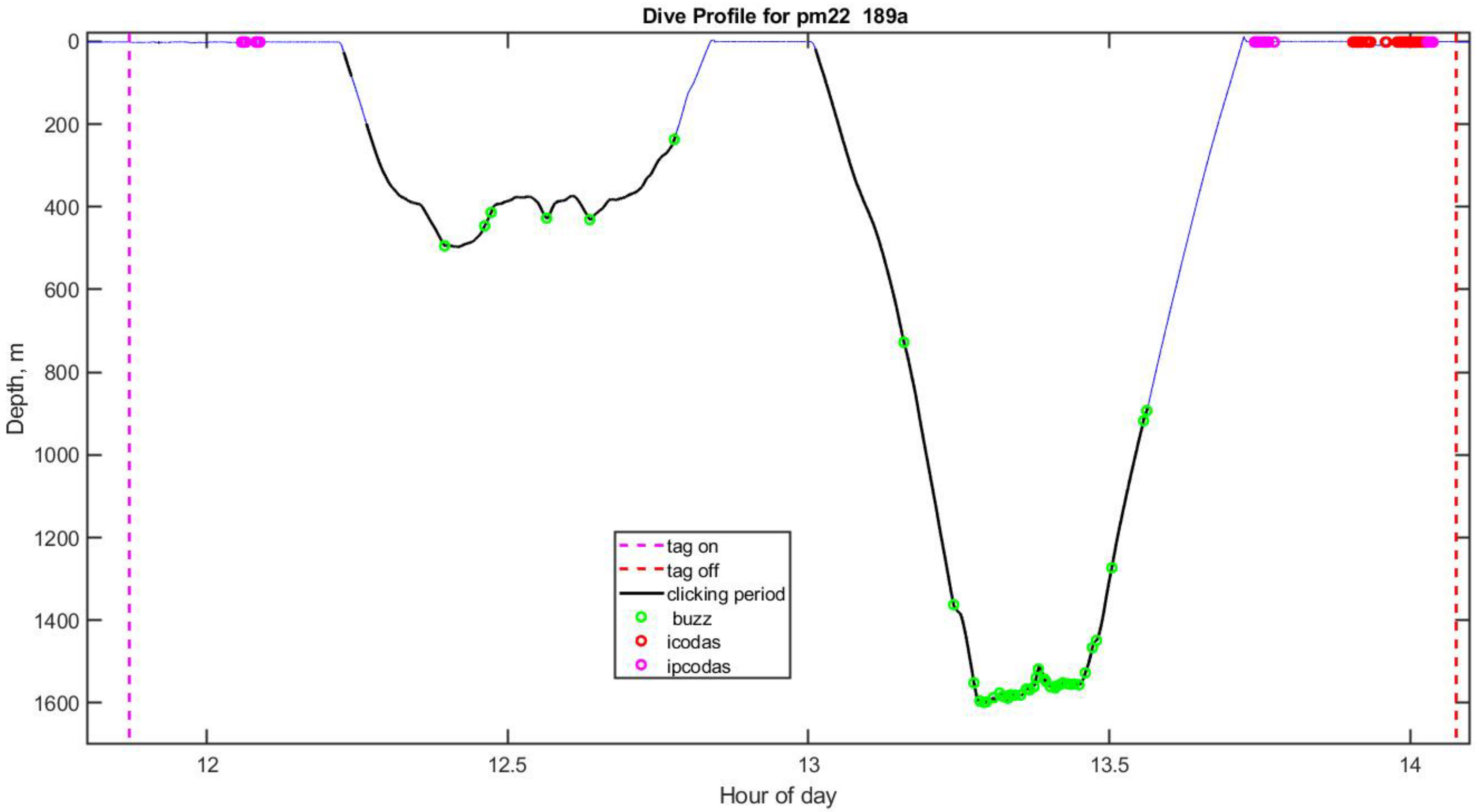


Figure 42. Acoustic audit results for DTAG dataset pm22_189a (HDRVAPm116) plotted with the dive profile. The black lines indicate clicking, green circles indicate buzzing, red circles indicate codas that cannot be determined if they came from the tagged individual or other whales, and pink circles indicate possible codas that cannot be determined if came from the tagged or other whales. The pink dashed line marks the time the tag was on animal and the red dashed line marks the time the tag was off animal.

2.2.3.3 Photo-identification

Photo-ID images were collected during 36 of the 74 marine mammal sightings. Baleen and sperm whale images were added to existing project catalogs, which now contain 275 humpback whales (**Section 2.2.1.4**), 118 fin whales, 46 NARWs (**Section 2.2.1.4** and **Section 2.4.1**), 10 minke whales, 2 sei whales, 8 blue whales, 141 sperm whales, 8 Sowerby's beaked whales (*Mesoplodon bidens*), 5 "*Ziphius*" (*Ziphius cavirostris*), and 3 True's beaked whales (*Mesoplodon mirus*). Of the 118 identified fin whales, 18 (15.3 percent) have been re-sighted; 14 (11.9 percent) of them during different years ranging from 248 to 2,530 days between first and last sightings.

Seventeen new sperm whales were identified and added to the catalog during 2023. Of the 141 identified whales, 22 (15.6 percent) were sighted on more than a single day, ranging from 1 to 2,185 days between the first and last sightings. Five of the sperm whales photographed during 2023 had been previously sighted during the study, with three first documented in 2017, one in 2019, and one in 2021. Drone video from April 2021 through July 2022 was analyzed to calculate the lengths of 18 individuals. Measured sperm whales ranged in size from 6.97 to 14.34 m in total length (mean = 10.17 m; median = 9.81 m).

Photo-ID images of the single blue whale were sent to Mingan Island Cetacean Study colleagues, who attempted to match it to their North Atlantic blue whale catalog and found no matches. Photographs of two humpback whales were added to the MAHWC, which is summarized in that project's report (Aschettino et al. 2024b; see **Section 2.2.1.4** of this report).

Pilot whale photographs through October 2023 have been shared with Duke University, which resulted in an additional 25 individuals added to the Norfolk catalog, including 1 re-sighting of an individual previously matched to the Cape Hatteras catalog (see **Section 2.2.4** of this report). The Norfolk catalog now contains 320 individual pilot whales, and the updated total of matches between Virginia and North Carolina remains 15 percent (47 of 320).

2.2.3.4 Discussion

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 *Ziphius*, 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. Continued steps for the project toward providing a more detailed understanding of fine-scale foraging ecology of sperm whales have been made during 2023 with the acoustic data analysis of DTAG deployments on deep-diving sperm whales. The importance of the Norfolk Canyon to sperm whales has also become evident through re-sightings and tagged whale movements. While photo-ID requires a multi-year commitment to accumulate sufficient data to produce meaningful contributions toward understanding site fidelity and ultimately population consequences of disturbance, the growth of multiple project catalogs continue to significantly add to the limited knowledge of multiple ESA-listed species within the region. Field efforts will continue to focus on the collection of movement, dive, foraging, and acoustic behavioral data of both sperm and beaked whales through DTAG deployments. The results of this multi-year effort continue to expand the knowledge of marine mammal and sea turtle occurrence and habitat use within the VACAPES OPAREA as well as provide detailed information needed to help mitigate potential effects from U.S. Navy training and testing activities.

For more information on this study, refer to the annual progress report for this project (Engelhaupt et al. 2024).

2.2.4 Photo-identification Analysis off Cape Hatteras, North Carolina

To supplement the Atlantic Behavioral Response Study (BRS; **Section 2.2.7.2**) Duke University continued photo-ID fieldwork within the Cape Hatteras study area during 2023 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 five cetacean species, with the most taken of *Ziphius cavirostris ("Ziphius")*, the primary focal species of the Atlantic BRS. Other cetacean species for which photographs were taken include short-finned pilot whales, sperm whales, and common bottlenose dolphins (**Table 15**). Additionally, digital photographs were taken of *Mesoplodon* species, and a new photo-identification catalog was created for this taxon within the Cape Hatteras area (**Table 15**).

Table 15. Cetacean sightings with numbers of photo-ID images collected for species within the Cape Hatteras study area during 2023.

Species	Common Name	Number of Sightings	Number of Photo-ID Images
Globicephala macrorhynchus	Short-finned pilot whale	20	543
Mesoplodon species	*Mesoplodon* species	7	1,575
Physeter macrocephalus	Sperm whale	2	54
Tursiops truncatus	Bottlenose dolphin	16	181
Unidentified odontocete	Unidentified odontocete	1	3
Unidentified *Ziphiid*	Unidentified *Ziphiid*	5	257
Ziphius cavirostris	Goose-beaked whale (*Ziphius*)	86	14,465
Total		**137**	**17,078**

Note: *Mesoplodon* species are known Mesoplodonts; Unidentified ziphiid may be either Mesoplodonts or *Ziphius*.

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.

Images of 50 newly identified animals were added to existing photo-ID catalogs of short-finned pilot whales, sperm whales, bottlenose dolphins, and *Ziphius* (**Table 16**). Additionally, 22 new photo-ID matches were made within the short-finned pilot whale and *Ziphius* catalogs. A bottlenose dolphin that was first sighted in September 2013 was re-sighted in October 2022, 9 years after its initial sighting; this is the second 9-year re-sight for this species off Cape Hatteras. To date, photo-ID catalogs for 12 taxa have been assembled within the Cape Hatteras study area, across multiple AFTT monitoring projects, which includes over 2,250 distinct individuals, with 644 individuals re-sighted across all species (**Table 16**).

Table 16. Summary of all images collected by species during fieldwork within the Cape Hatteras study area during 2023 showing number of new identifications, photo-ID catalog sizes, number of new re-sights, and total re-sights to date.

Species	New Images Collected	No. 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	543	13	1,388	4	480
Grampus griseus	0	0	47	0	6
Kogia species	0	0	1	0	0
Megaptera novaeangliae	0	0	2	0	0
Mesoplodon species	1,575	10	10	2	2
Physeter macrocephalus	54	1	30	0	1
Stenella clymene	0	0	3	0	0
Stenella frontalis	0	0	42	0	0
Tursiops truncatus	181	7	369	1	19
Ziphius cavirostris	14,465	29	312	18	135
Total	**16,818**	**60**	**2,251**	**25**	**644**

Key: ID = Identification Number; No. = Number

2.2.4.1 Short-finned Pilot Whales

Thirteen new identifications and four new re-sightings were added to the short-finned pilot whale catalog in 2023. The current re-sight rate of short-finned pilot whales is 35 percent, unchanged from 2022. 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. More than 120 pilot whales have records of 5 or more years between their first and last sightings, and 24 individuals have histories that span 10 or more years (**Table 17**). Three of these 24 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_7-225 was first seen in May 2008; it was re-sighted numerous times in 2015, again in 2018, and most recently in October 2022 (**Figure 43**). This is only the second time a 14-year re-sight has been found with the Cape Hatteras short-finned pilot whale catalog.

The 13 newly identified short-finned pilot whales added to the Cape Hatteras photo-ID catalog are in the process of being systematically compared to catalogs for this species from Onslow Bay, North Carolina, and Jacksonville, Florida. Four pilot whales were previously matched between the Cape Hatteras and Onslow Bay study areas. 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 Jacksonville catalogs.

Table 17. 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	46
8 to 9	14
9 to 10	1
10 to 11	13
11 to 12	7
More than 12	4
Total	**480**

Figure 43. Photographs of Gma_7-225 in May 2008 (top), October 2015 (middle), and October 2022 (bottom).

Images of short-finned pilot whales collected by HDR, Inc. during their fieldwork within the Norfolk Canyon study area in 2023 (Engelhaupt et al. 2024) were also contributed for analysis. Approximately 1,700 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. Twenty-five new individuals were added to the Norfolk short-finned pilot whale catalog (**Table 18**). One new re-sighting occurred in the Norfolk pilot whale catalog; to date, 11 short-finned pilot whales were re-sighted by HDR, Inc. researchers during their fieldwork from 2015 through 2023 (**Table 18**). The 25 new short-finned pilot whales in the Norfolk catalog were compared to those in the Cape Hatteras short-finned pilot whale catalog, which contains 1,388 individuals. Three new matches were made between the two areas, adding to the 44 previous matches. M-048 was seen off Cape Hatteras in May 2011 and was re-sighted more than 12 years later off Norfolk Canyon in October 2023, which is the longest re-sighting between the two areas (**Figure 44**). M-049 was seen off Cape Hatteras in May 2015 and was re-sighted off Norfolk Canyon in August 2023. M-050 was seen off Cape Hatteras in both May 2015 and August 2017, and was re-sighted for a third time in May 2023 off Norfolk Canyon. Thus, 14.7 percent (47 of 320) 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 Jacksonville, Florida, but did not make any matches.

Table 18. 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	2020–2022 Catalog	2022–2023 New IDs	Current Catalog Size	New Re-sights	Total Re-sights
Globicephala macrorhynchus	230	295	25	320	1	11

Stony Brook University researchers provided approximately 350 images of short-finned pilot whales collected in 2018 and 2019 during shelf-break surveys off New York. All images were graded for photographic quality and animal distinctiveness and were sorted by individual within each sighting. A new catalog was created for Stony Brook University and 14 identifications were added. Previously satellite-tagged short-finned pilot whales off Cape Hatteras frequently used this area off New York. Prior to the creation of this catalog, there was no photo-ID coverage existed this far north for short-finned pilot whales. All new individuals were compared to the Norfolk-HDR catalog and the Hatteras-DUML catalog, but no matches were found.

Comparisons have been completed of 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 catalogs were compared to the short-finned pilot whale catalogs from Jacksonville, 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 44. Photographs of M-048 in May 2011 off Cape Hatteras (top) and in October 2023 within the Norfolk Canyon area (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 NOAA scientists within the GOM provided by Keith Mullin of the SEFSC. Several potential matches were made, and images were circulated to Dr. 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. Comparisons between the Caribbean catalogs and the Norfolk catalog found no confirmed matches. The study hopes to receive further Caribbean image contributions from Dr. Jeremy Kiszka. 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.

2.2.4.2 *Ziphius*

Twenty-nine new identifications were added to the *Ziphius* photo-ID catalog during 2023, and 18 new re-sights were made (both within and between years). The current re-sight rate for *Ziphius* within the Cape Hatteras area is 44 percent; an increase from 41 percent in 2022. To date, 89 of the 135 (66 percent) matched *Ziphius* have been seen across multiple years, and 57 of those have been re-sighted more than 3 years after the initial observation (**Table 19**). This is an increase over last year's photo-ID results, when only 47 whales had been sighted over more than a 3-year period.

Table 19. Frequency distribution of the number of years between first and last sightings of photo-identified *Ziphius* within the Cape Hatteras study area.

Number of Years Between First and Last Sighting	Number of Individuals
Less than 1	46
1 to 2	22
2 to 3	10
3 to 4	16
4 to 5	19
5 to 6	11
6 to 7	6
7 to 8	2
8 to 9	1
More than 10	2
Total	**135**

Eleven *Ziphius* were tagged during 2023 as part of the Atlantic-BRS; two of those individuals were matched to the photo-ID catalog:

- *Zca_098* was initially observed in August 2020 when it was satellite-tagged (ZcTag102); it was re-sighted multiple times in August and September 2021 at which time the tag had been shed and a well-healed scar was present. It was re-sighted in August 2023, when it was satellite-tagged for a second time (ZcTag143); this individual is an adult male (**Figure 45**).
- *Zca_072* was initially observed in May 2019 and again in August 2021, when it was biopsied and genetically identified as a male but was classified as a subadult male due to lack of erupted teeth. It was re-sighted, and satellite tagged (ZcTag146) in August 2023; it still did not have erupted teeth at the time of tagging and remains classified as a subadult male. (**Figure 46**).

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 three 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. A third long-term association involving two adult males has also been 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. During this reporting period, an additional long-term association was documented between Zca_049, an adult male, and Zca_080r. Both individuals were photographed in the same group in May 2018 and were re-sighted together in June 2023. Zca-080r has not acquired any new rake marks over the 5-year sighting period and is likely an adult female (**Figure 47**). This would be the second time an adult male and adult female long-term association has been documented.

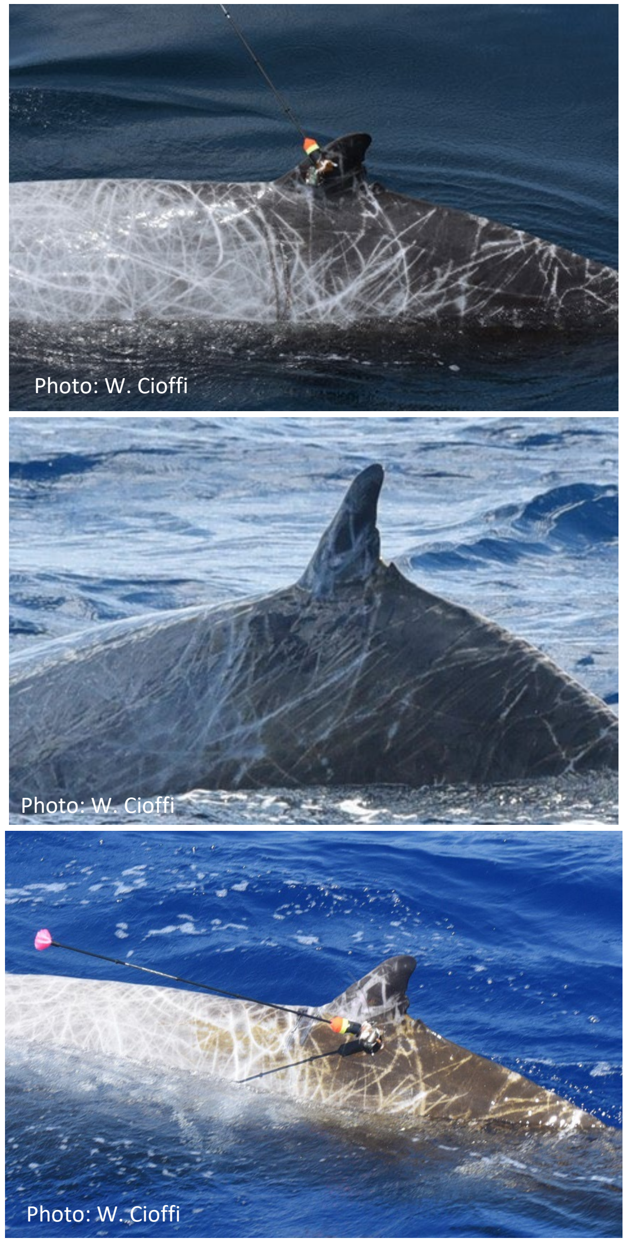


Figure 45. Photographs of Zca_098, initially satellite-tagged in August 2020 (ZcTag102; top), re-sighted multiple times in 2021 (middle), and satellite-tagged a second time in August 2023 (ZcTag143; bottom).

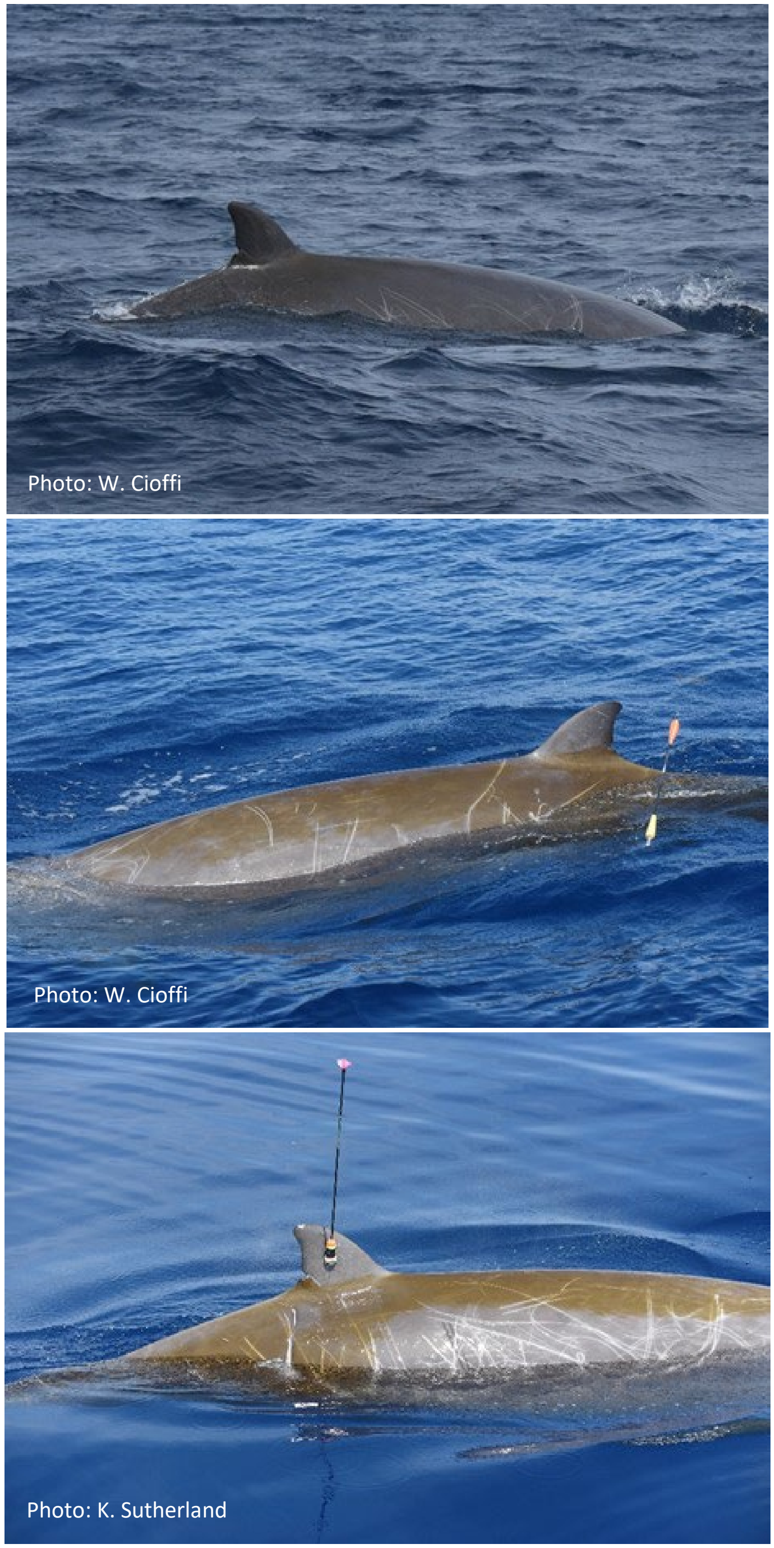


Figure 46. Photographs of Zca_072, initially sighted in May 2019 (top), re-sighted and biopsied in August 2021 (middle), and satellite tagged in August 2023 (ZcTag146; bottom).

Figure 47. Photographs of Zca_080r, initially sighted in May 2018 (top) and re-sighted in June 2023 (bottom). Note that few, if any, new scars have been accumulated over that period.

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 20**). 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 it was satellite tagged during the Atlantic BRS study 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 *Ziphius* 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). During this reporting period, a new inter-catalog match was made; SP M-005 was first sighted by Duke researchers in May 2019 and was re-sighted by Kate Sutherland and Brian Patteson in August 2023 (**Figure 48**). 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 49**).

Table 20. Number of images in each *Ziphius* catalog and years when the images were collected.

Catalog Descriptor[a]	Catalog Location	Years Images Collected	Number of Individuals
SP catalog	South of Cape Point, North Carolina	2003–2023	21
DUML catalog	Cape Hatteras, North Carolina	2007–2023	310
UNCW catalog	Cape Hatteras, North Carolina Aerial Surveys	2012–2017	51
NEAQ catalog	Northeast Canyons and Seamounts Marine National Monument Aerial Surveys	2017–2023	7
HDR catalog	Norfolk, Virginia	2019–2022	3
SBU catalog	New York Shelf Break, New York	2019	4

[a] SP= Sutherland/Patteson catalog from seabirding trips south of Cape Point; DUML= Duke University Marine Lab catalog from research trips off Cape Hatteras; UNCW= University of North Carolina Wilmington catalog made from aerial surveys; NEAQ=New England Aquarium Northeast Canyons and Seamounts Marine National Monument catalog from aerial surveys; HDR= HDR, Inc. catalog from research trips offshore Norfolk, Virginia; SBU= Stony Brook University catalog from research trips off the New York shelf break.

Two additional *Ziphius* catalogs were created during this reporting period. The New England Aquarium contributed images and sighting data of *Ziphius* collected during aerial surveys in the Northeast Canyons and Seamounts Marine National Monument from 2017 to 2023. Researchers from Stony Brook University contributed *Ziphius* images collected during vessel surveys along the New York shelf break in 2019. All images were assessed for photographic quality and animal distinctiveness and a new catalog was created for each of these research groups (**Table 20**). To date, six *Ziphius* catalogs in the Western North Atlantic have been created and will continue to be maintained.

Figure 48. Photographs of SP M-005, initially sighted in 2019 (top), and re-sighted in 2023 (bottom).

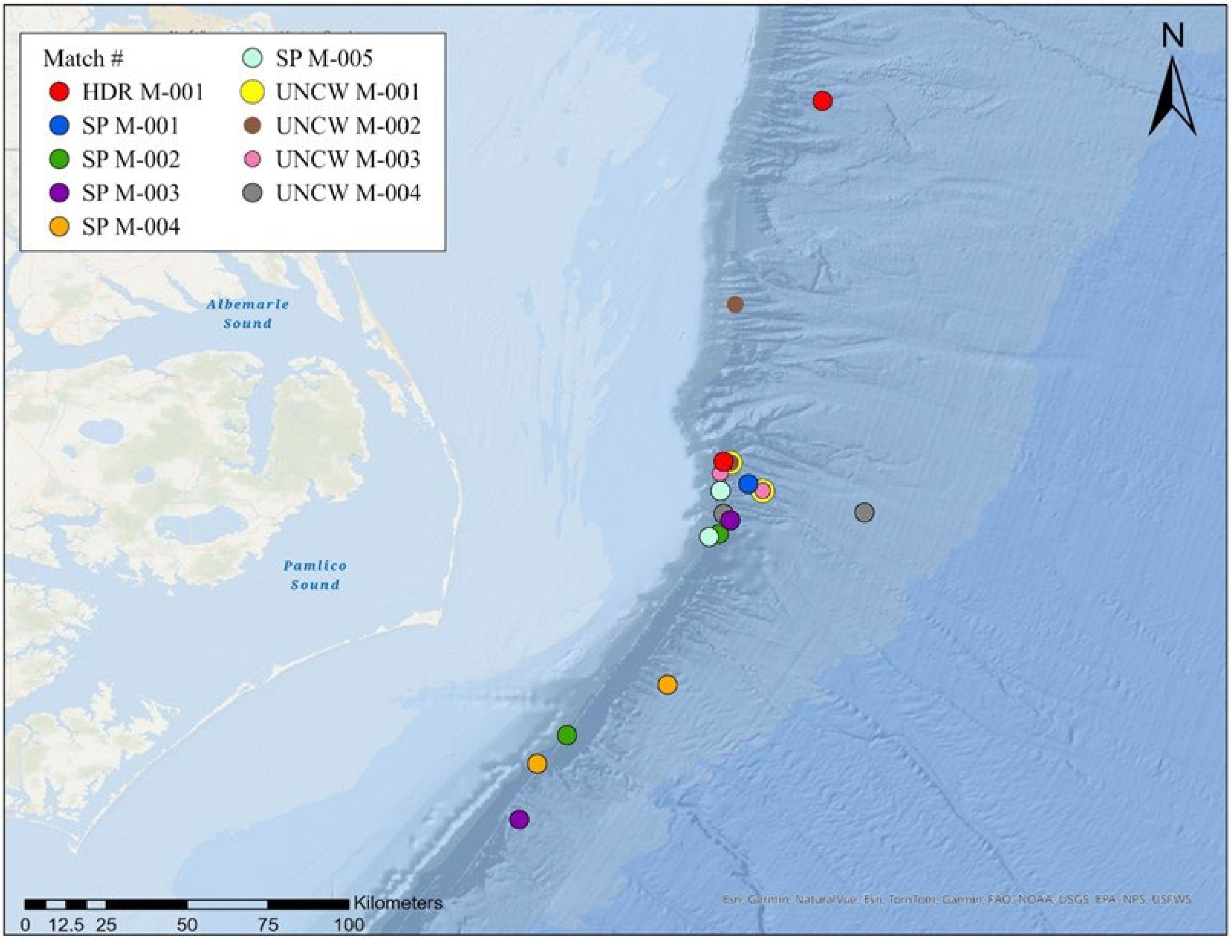


Figure 49. Map of sighting locations of Ziphius matched between the Duke University catalog and three external catalogs (HDR = HDR, Inc. catalog from Norfolk, Virginia; SP = Sutherland/Patteson catalog from south of Cape Point; UNCW = University of North Carolina at Wilmington catalog from aerial surveys).

The study's sighting histories of individual whales were contributed to a meta-analysis of *Ziphius* demography funded by ONR and coordinated by Erin Falcone and Greg Schorr from Marine Ecology and Telemetry Research (MarEcoTel). The goal of this collaborative project is to compare vital rates of *Ziphius* across populations that experience varying exposure to military sonar. Pigmentation and scarring-density metrics were 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 requires 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 is an important contribution to this analysis.

Once image processing was completed, age classes and sexes were assigned to individual whales in the Cape Hatteras catalog based on methods described in Coomber et al. (2016, 2022) (**Figure 50**). A combination of the documentation of erupted teeth and/or the presence of a calf along with scarring density values and pigmentation scores were used to classify many *Ziphius* that had previously been considered "unknown" in terms of age class or sex. The number of individuals in the catalog with an age class assignment increased from 156 to 242 (**Table 21**). Similarly, the number of individuals assigned a sex increased from 117 to 229 (**Table 22**). Even using these additional methods, however, many individuals in the catalog cannot be assigned a sex and/or age class. The methods developed by Coomber et al. (2016, 2022), particularly the scarring density threshold to assign age class and sex to *Ziphius* will continue to be applied to photographs acquired in the future.

Table 21. Age class assignments of individual *Ziphius* from DUML (based on photographs of males with erupted teeth and females with calves) versus assignments from MarEcoTel (based on photographs, scarring densities, and pigmentation characteristics).

Descriptor[a]	Adult	Subadult	Calf	Unknown	Total
DUML	110	1	5	156	272
MarEcoTel	182	55	5	30	272

a DUML = Duke University Marine Lab; MarEcoTel = Marine Ecology and Telemetry Research

Table 22. Sex assignments of individual *Ziphius* from DUML (based on photographs of males with erupted teeth, females with calves, and genetically identified animals from biopsies) versus assignments from MarEcoTel (based on photographs, biopsies, scarring densities, and pigmentation characteristics).

Descriptor[a]	Male	Female	Unknown	Total
DUML	98	19	155	272
MarEcoTel	133	96	43	272

[a] DUML = Duke University Marine Lab; MarEcoTel = Marine Ecology and Telemetry Research

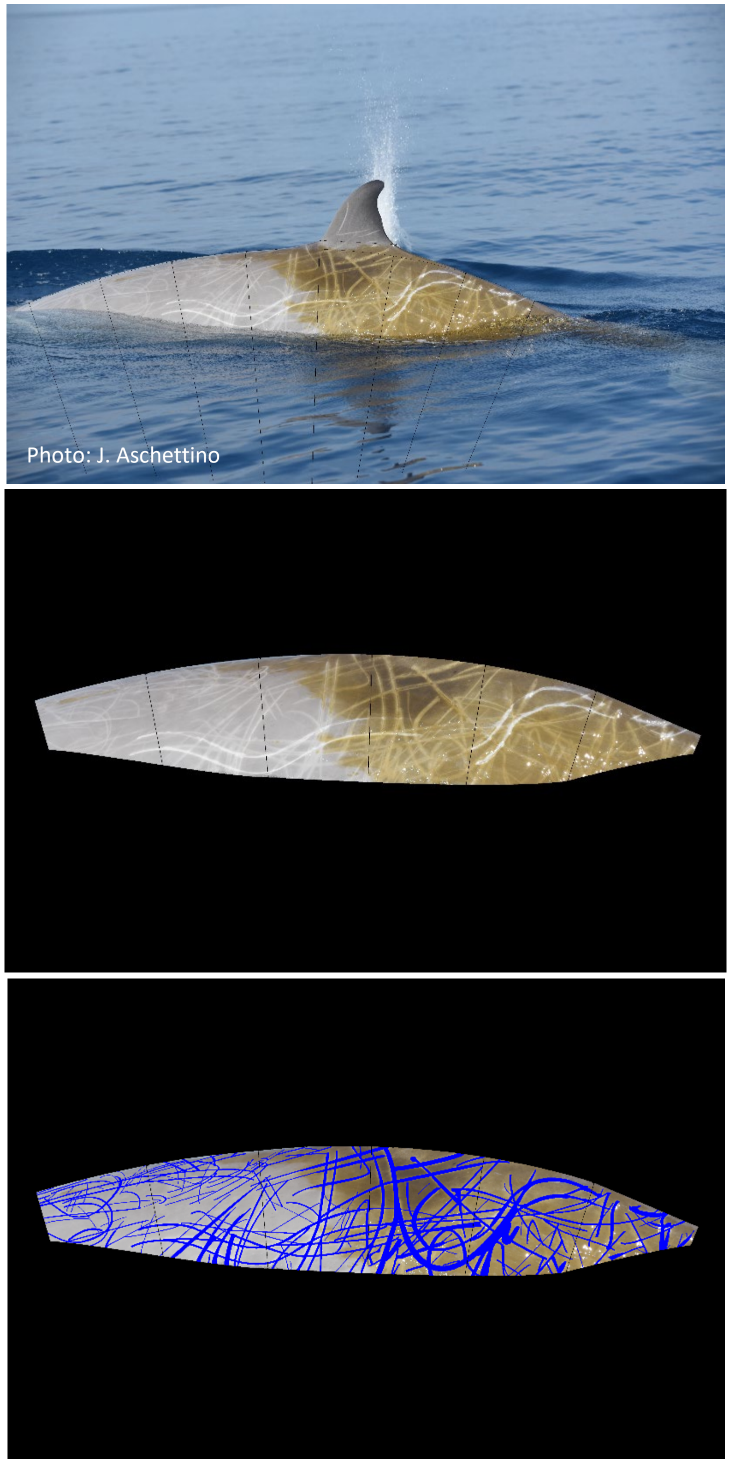


Figure 50. Photographs of Zca_063 with delineated Regions of Interest (top), with the background cleared around the Regions of Interest (middle), and with scars traced within Regions of Interest (bottom). All image processing was done using ImageJ software following the protocols written by Erin Falcone and Erin Keene (MarEcoTel), based on the methods developed by Coomber et al. (2016).

2.2.4.3 Satellite Tag Post-Deployment Monitoring

Photo-ID provides a useful means to document and assess the long-term effects of tagging on individual short-finned pilot and *Ziphius*. In general, few instances of long-term damage to the dorsal fin of tagged animals occurred, and most individuals appear to be well-healed. 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 tags have fallen off. There was very limited effort documenting short-finned pilot whales during the 2023 field season, with only 20 sightings and 543 photographs, and there were no re-sightings of any satellite-tagged short-finned pilot whales. A total of 107 satellite tags have been deployed on 101 individual *Ziphius* from 2014 through 2023, and 68 of these animals (67 percent) have been re-sighted. Many re-sightings occurred within the same field season, but 38 of the re-sighted whales (56 percent) were photographed at least 1 year after tagging.

A *Ziphius*, ZcTag108, satellite tagged in August 2020 was re-sighted several times during that field season and was seen again in October 2022 from the R/V *Shearwater,* but the quality of photographs was insufficient to evaluate the presence of the tag. The whale was photographed again in July 2023 and the images show that the tag had been completely shed, leaving well-healed scars on both sides of the dorsal fin. ZcTag054 and ZcTag056, both adult males, were satellite tagged in the same group in May 2017. Both were seen multiple times over the following years, and both were re-sighted, on the same day but in different groups, in 2023.

In 2023, three *Ziphius* were re-sighted for the first time since they were satellite tagged in previous years. ZcTag081 was tagged in August 2018 and not re-sighted until July 2023; the photographs are of marginal quality, but sufficient to determine that the tag and associated hardware had been shed, leaving a white scar at the tagging location. ZcTag132 was satellite tagged in August 2022 and re-sighted in July 2023; when the tag and all hardware had been shed, leaving several small scars. Finally, ZcTag096 was tagged in August 2019 and re-sighted and satellite tagged a second time in June 2021 (ZcTag112); there were no remains of the previous tag, only two small scars. It was re-sighed again in August 2023; the second tag and hardware had also been shed, leaving a second set of small scars remaining at the tagging site.

For more information regarding this study, refer to the annual progress report for this project (Waples and Read 2024).

2.2.5 Pinniped Tagging and Tracking in Southeast Virginia

U.S. Navy biologists have been researching seal occurrence within and around Chesapeake Bay since 2013 (Jones and Rees 2023). As part of a larger study involving haul-out counts and wildlife camera traps, satellite tagging was also utilized from 2018 to 2023 in order to characterize seals' at-sea movements, habitat use, and dive behavior, as well as the environmental variables that may influence their distribution patterns. The information from this effort provides valuable baseline data needed for the future assessment of harbor seal movements and site fidelity along the U.S. Eastern Seaboard. A total of 14 tags were deployed between 2018 and 2022 as part of this study (**Table 23**). 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. A tagging field session was undertaken in 2023, however no additional seals were captured or tagged.

Table 23. Summary of all seals tagged in 2018–2022.

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: ID = Identification Number; 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

Telemetry data from the 14 seals tagged from 2018–2022 have 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. No additional tagging field work is planned for Virginia at this time. For more information on this project including previous annual progress reports, see the project profile on the monitoring program's web portal.

2.2.6 Northeast Pinniped Monitoring

A telemetry and visual survey study managed by the NUWCDIVNPT was initiated in winter 2021 to collect data on harbor seals (*Phoca vitulina*) and gray seals (*Halichoerus grypus*) along the U.S. East Coast. The purpose of this field season's research was to collect baseline data to inform a proposed pinniped behavioral response study and continue long-term pinniped surveys, specifically in the Navy OPAREAS along the northwestern Atlantic coast. A summary of the data collected in previous field seasons can be found in NUWC Newport (2023).

The aim of the 2022/2023 field season was to continue to obtain data to measure baseline behavior 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, particularly in Navy OPAREAS. The tasks included: 1) Aerial surveys to document harbor and gray seal haul outs in the Narragansett Bay OPAREA (from New York to Rhode Island); 2) Ground and remote camera surveys; 3) Deployment of satellite tags on harbor seals during the late fall through early spring; and, 4) Analysis of satellite tag data collected from tags deployed on pinnipeds.

NUWCDIVNPT traveled to support a 12-day capture and tagging effort in Virginia organized the by Naval Facilities Engineering Systems Command Atlantic but no animals were successfully tagged during this effort. In addition, weather postponements during the remaining opportunities, resulted in zero harbor seals tagged during the 2022/2023 season for this project.

Aerial surveys were conducted in January, March, and August 2023. Since harbor and gray seals appear to be leaving their natal sites in Maine earlier, an aerial survey was conducted in August to determine how soon they arrive in locations south of Maine. No harbor seals were observed at known haul out sites in any areas south of Maine during August. Gray seals were observed at certain locations, where they are known to haul out year-round; however, the total number of animals observed was considerably lower than counts conducted during peak season.

These surveys flew at 600 feet and surveyed islands and any ledges or rocky areas where seals could haul out. The following haul out sites were surveyed: Moriches Bay, Shinnecock Bay, Montauk Point, Great Gull Island, Little Gull Island, Plum Island, Fort Tyler, Gardner's Island, and Sag Harbor, New York; and Block Island and Narragansett Bay, Rhode Island.

On each of the aerial survey days observers were also deployed to land-based haul out sites, in Narragansett Bay only to take ground counts to then compare with counts taken from the aerial survey photographs. This offered insight into the total number of animals actually hauled out on a site versus what is visible from a land-based vantage point and the number of animals potentially missed using one survey technique versus another. Details of these survey counts can be found in NUWC Newport (2024).

Similar to previous field seasons, there were three remote cameras set up at Naval Station Newport (NAVSTA) to monitor the harbor seal haul out located just offshore (**Figure 51**). One camera took pictures at 10-minute intervals and the two cellular-enabled cameras took motion-activated pictures. Half-way through the season, one of the cellular cameras failed and was replaced with an identical camera and setup. An extremely rare weather event occurred causing rainwater to enter into the cameras and all three were dismantled, dried, and replaced back at NAVSTA. However, by April, the quality of images coming from the cameras appeared compromised. All three were removed before the end of the season.

Photos are manually reviewed to estimate the number of seals hauled out, duration of haul out, presence/absence, and note any other factors that could influence seal behavior. In-person observations were conducted primarily on the predicted low tide as that is when the maximum amount of habitat is available for haul out. We combined the in-person observations with the remote camera counts to determine peak number of animals across the field seasons (**Figure 52**). In general, harbor seal peak numbers occur in March and then begin to rapidly dwindle in April. As we have seen from the tag data, April is when harbor seals depart their southerly haul out sites to return northward to Maine for pupping, breeding, and molting. Recently windfarm construction activity has begun with an increase in boat activity transporting equipment through Narragansett Bay. Harbor seals are exhibiting an increase in vigilant behavior and frequency of flushing events. The duration of haul out appears to also have changed, but not enough data has been collected at this time to determine whether this is significant.

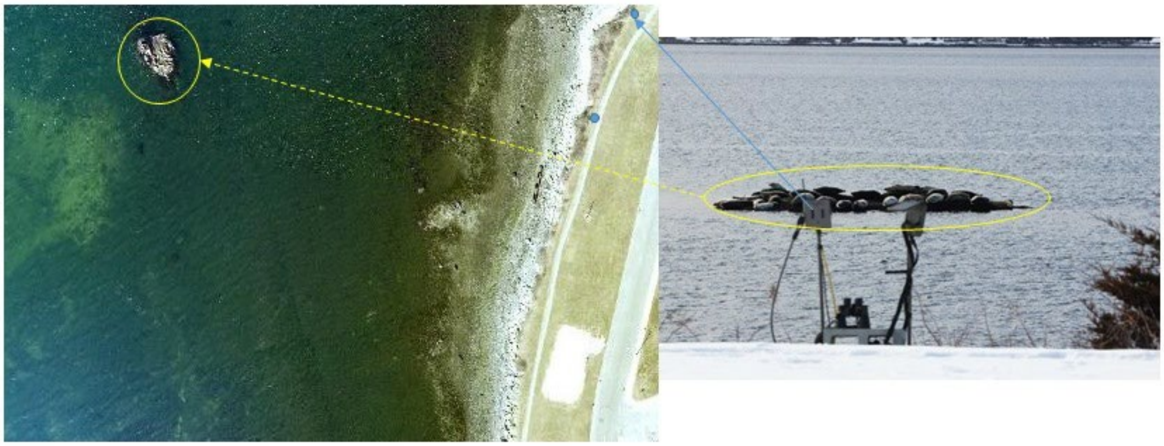


Figure 51. Camera set up at Naval Station Newport and Harbor Seal Haul Out

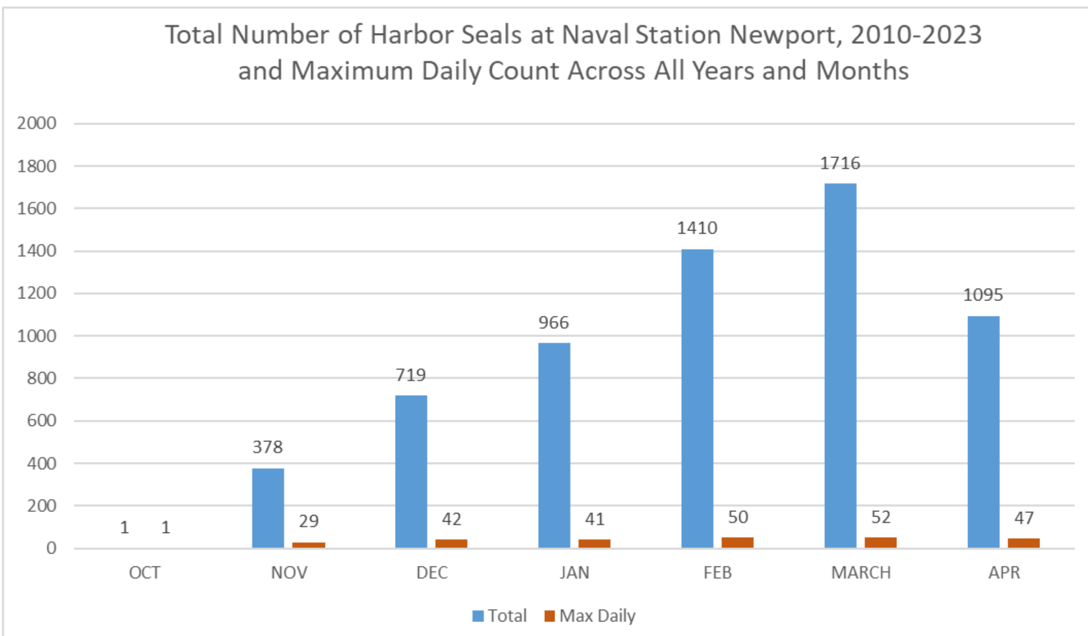


Figure 52. Total number of harbor seals at the Naval Station Newport haul out site from 2010–2023 from October–April. Includes maximum daily count across all years for each month.

2.2.7 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 acoustically monitored the shelf break region with HARPs at three to four sites from 2007–2019. Together these combined efforts bring the total to 11 recording sites spanning the U.S. eastern seaboard, from New England to Florida.

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 the datasets collected from 2015–2019. The focus of our efforts in 2023 have been to finalize projects for submission to peer-reviewed journals, and further develop community composition analysis techniques to explore dissimilarity and species co-occurrence across shelf break areas.

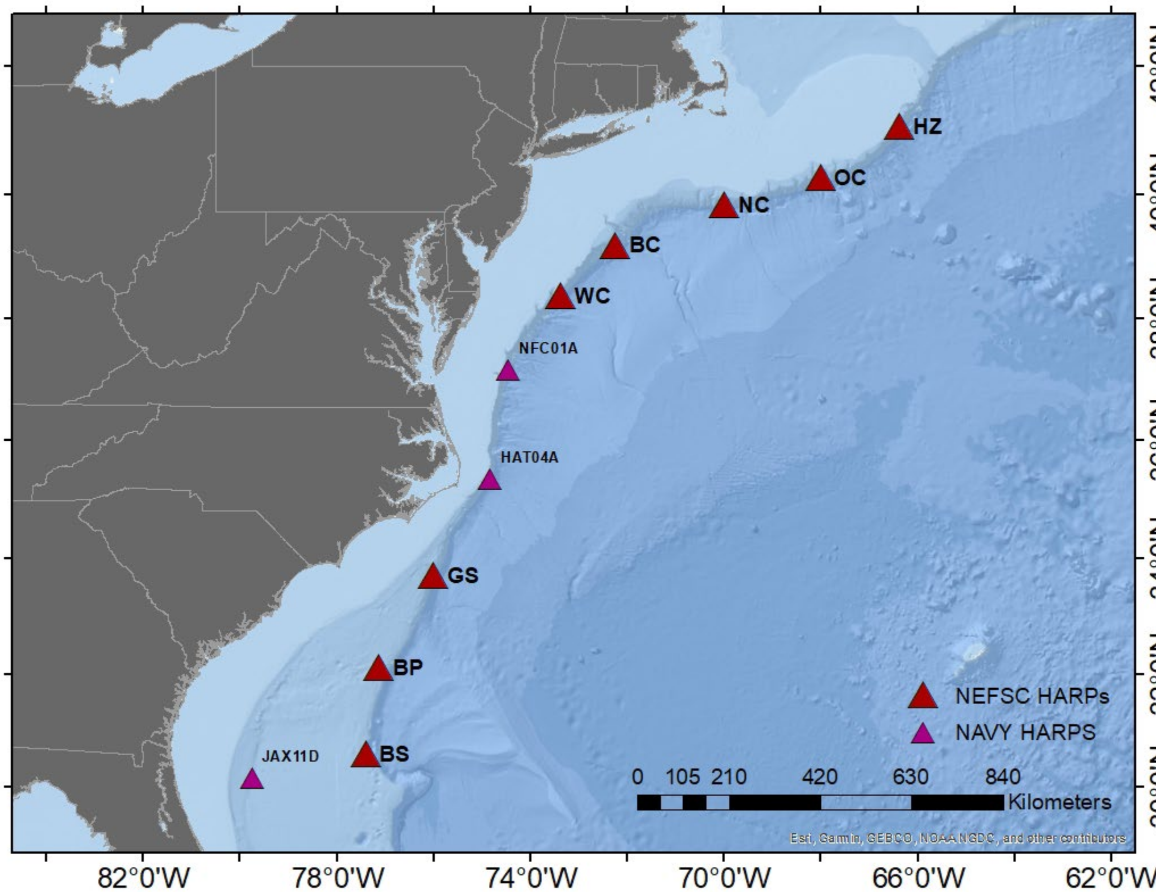
Work conducted in 2023 was aimed at finalizing components for these key objectives:

- Submit a manuscript describing the methodology of the beaked whale neural net classifier to be cited in future publications utilizing this approach
- Submit a manuscript comparing and contrasting two PAM methodologies—towed array and shelf break HARPs—concerning beaked whale temporal, spatial presence, and diving behavior
- Utilize passive acoustic data from 10 shelf-break environments to evaluate composition and dissimilarity of marine mammal community groups at different latitudes

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 24, Figure 53**). Each HARP was programmed to record continuously at a sampling rate of 200 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 24. 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 2015	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 2015	June 2019	736–750



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 53. HARP deployment sites for data analyzed from 2015 through 2019.

2.2.7.1 Analyses

Assessing patterns of richness and composition of marine animal communities through ecological gradients such as latitude and depth and 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 our large acoustic data set to apply new techniques for understanding species ecology, community structure and acoustic niche interactions between multispecies groups throughout the shelf break data.

Code was provided by Professor Hillebrand at the University of Bremen in Germany, and further developed to explore species richness and community dissimilarity, in addition to conditional inference trees and acoustic niche plots to explore baleen and odontocete species relationships over space (10 HARPs) and time (3 years: 2016–2019).

Additionally, multi-year patterns and trends were summarized for each species and site using a modified acoustic niche analysis to visualize when and where specific species are acoustically detected. The "acoustic niche" of each species is also visualized as approximate vocalization range for each species differentiates species that are low-frequency specialists (e.g., blue whales) from species that are high-frequency specialists (e.g., Gervais' beaked whale). In separating the acoustic presence of individual species, the acoustic niche analysis illustrates the species that comprise marine mammal communities at each site.

The primary aim for this analysis was to apply both our existing approaches to exploring niche level interactions within long term data sets within the shelf break marine mammal communities. The study team validated all sites for beaked whale presence at the daily scale using the output of the neural net dataset (Solsona-Berga et al. submitted) to a confidence threshold of 0.99. This report presents new results from data collected at 10 HARP sites between 2016 and 2019 as presented by Dr. Samara Haver as an invited speaker at the Ecological Society of America Special Session on Advancing Ecology and Conservation with Bioacoustics in August 2023 and in preparation for submission to a peer-reviewed ecology journal (**Figure 54, Figure 55)**.

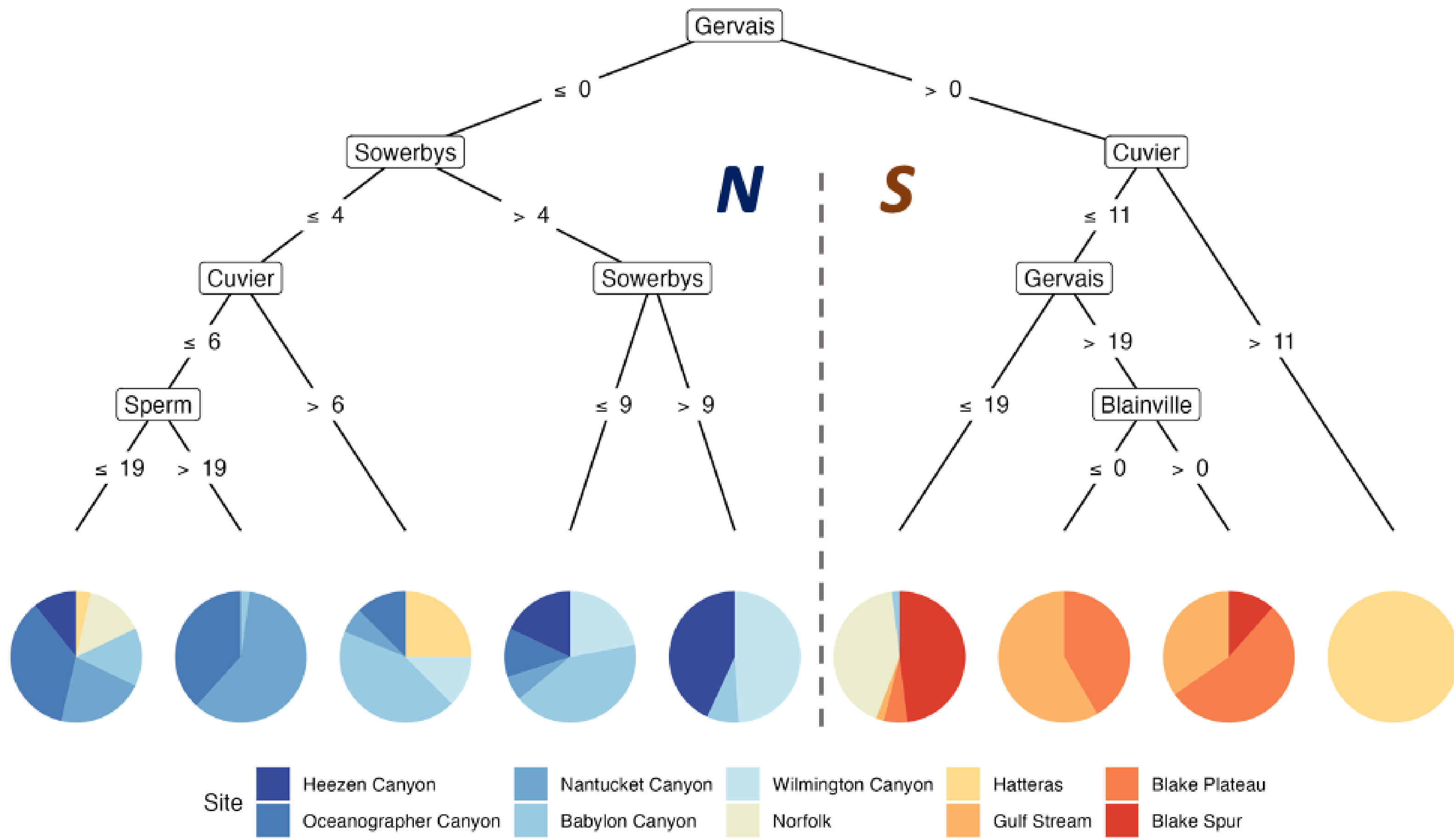


Figure 54. Conditional inference tree model results to compare the relative influence of certain species on community groups at different sites.

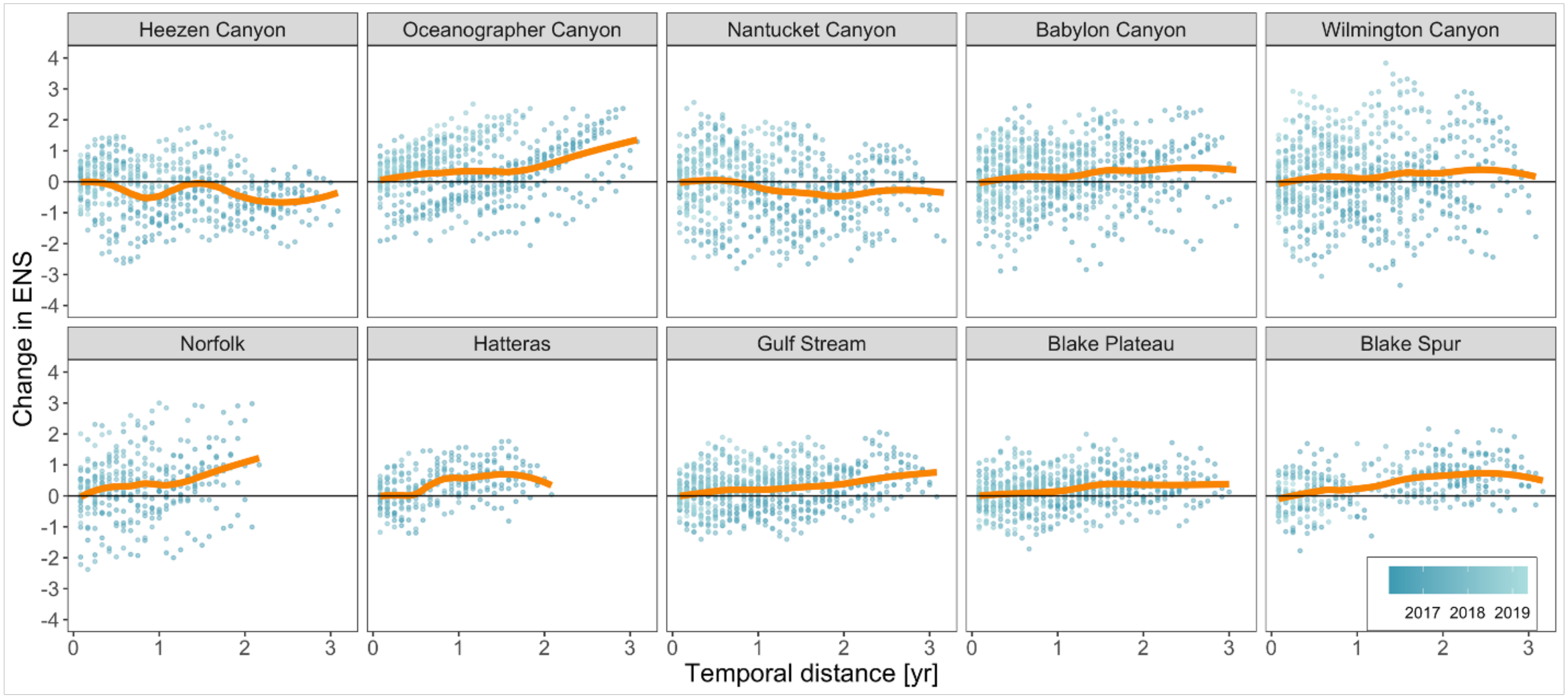


Figure 55. Variability in the effective number of species (ENS) detected at each site over time.

2.2.7.2 Manuscript Submissions

A methods paper describing the beaked whale neural net classifier built for North Atlantic HARP data was submitted to Methods in Ecology and Evolution, and is currently in review. Acoustic data from the 2016 HARP deployments were combined with passive acoustic data collected from a towed hydrophone array as part of the AMAPPS to examine niche partitioning of beaked whales in the western North Atlantic. This project was submitted to Marine Ecology Progress Series and is currently undergoing revisions. Abstracts for both submissions are provided below.

Machine learning with taxonomic family delimitation aids in the classification of rare and ephemeral beaked whale events in PAM

PAM is an essential tool for studying beaked whale populations. This approach can monitor elusive and pelagic species, but the volume of data it generates has overwhelmed researchers' ability to quantify species occurrence for effective conservation and management efforts. Automation of data processing is crucial, and machine learning algorithms can rapidly identify species using their sounds. Beaked whale acoustic events, often infrequent and ephemeral, can be missed when co-occurring with signals of more abundant, and acoustically active species that dominate acoustic recordings. Prior efforts on large-scale classification of beaked whale signals with deep neural networks (DNNs) have approached the class as one of many classes, including other odontocete species and anthropogenic signals. That approach tends to miss ephemeral events in favor of more common and dominant classes. A DNN method is described for improved classification of beaked whale species using an extensive dataset from the western North Atlantic. The study team demonstrates that by training a DNN to focus on the taxonomic family of beaked whales, ephemeral events were correctly and efficiently identified to species, even with few echolocation clicks. By retrieving ephemeral events, this method can support improved estimation of beaked whale occurrence in regions of high odontocete acoustic activity.

Niche partitioning of beaked whales in the western North Atlantic Ocean using passive acoustics

Beaked whales (family *Ziphiidae*) are cryptic, deep diving cetaceans found offshore. PAM of this family allows identification to species and is instrumental in expanding knowledge of their behavior, distribution, and habitat use. From 28 June to 25 August 2016, two broadscale shipboard surveys towed a hydrophone array in the western North Atlantic. Concurrently, 11 bottom-mounted recorders collected continuous passive acoustic data during July and August 2016 along the 1,000-m contour. Five beaked whale species (*Ziphius*, Gervais' [*Mesoplodon europaeus*], True's, Sowerby's, and Blainville's beaked whales) were present in both datasets. Beaked whales were commonly detected at the bottom-mounted sites (71 percent total days present), with sites off the United States' Mid-Atlantic Bight containing the greatest species diversity. Using the towed array, Blainville's and Gervais' were found in the Gulf Stream, True's were more commonly found in abyssal waters, and Sowerby's were more common on the continental slope. *Ziphius* were present throughout the survey area. Using multipath reflections, click depths were examined for 192 beaked whale events. Among three species tested (*Ziphius*, Gervais', and True's), only *Ziphius* were found to forage in proximity to the estimated seafloor depth. Combining these datasets expanded our understanding of these species' ranges, identified possible hotspots for True's and Gervais', and demonstrated the importance of placement for bottom-mounted instruments. This is the first study of its kind to provide a comprehensive view of how these whales exhibit niche partitioning over a large area and at depth.

For more information regarding this study, refer to the annual progress report for this project (Van Parijs et al. 2024).

2.3 Atlantic Behavioral Response Study

The Atlantic Behavioral Response Study (BRS) was conceived, designed, adapted, and applied through a collaboration building on historical and ongoing U.S. Navy-funded studies under their MSM 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 *Ziphius* 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 LMR program and Office of Naval Research Marine Mammals and Biology Program. It is the first systematic effort to quantify sonar exposure and behavioral responses of priority marine mammal species to military sonar using controlled exposure experiments (CEEs) off the U.S. Atlantic coast.

The Atlantic-BRS was collaboratively designed and strategically adapted by an experienced multi-institutional team. CEE methods previously concentrated on mid-frequency active sonar (MFAS)—successfully coordinated with operational SQS-53C from U.S. Navy vessels—using strategically deployed, complementary tag sensors on many individuals simultaneously. The project has yielded one of the largest and most comprehensive data sets available for sonar exposure and response for one of the Navy's highest-priority marine mammal species, *Ziphius*.

Building on earlier field seasons of this project, the 2023 field season marked a transition from CEEs using pulsed active sonar (PAS) MFAS signals to continuously active sonar (CAS). A single, extended field period lasted from summer to fall, with 11 tags deployed on beaked whales ahead of anticipated U.S. Navy vessel availability. Through sustained coordination and planning between the field team and USFFC, multiple CAS-capable vessels were identified and scheduled for possible coordination. An ill-timed engineering casualty restricted participation of the primary vessel with which the team had been closely coordinating in final preparation for a CAS CEE. A control (no MFAS) CEE was conducted adaptively given this development, yielding important behavioral data with which to contrast MFAS CEEs.

The overall project 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. The Atlantic-BRS project integrates both approaches by expanding the temporal and spatial scales of previous BRSs 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 focus of experimental studies using CEEs in previous field seasons has focused on PAS signals from both operational and simulated MFAS sources. Beginning in 2023, the Atlantic-BRS project is focusing on CAS, a different type of MFAS system in which similar frequency and modulation pattern signals are presented entirely or nearly continuously. There is interest in directly measuring and contrasting exposure and response from CAS stimuli with the large dataset obtained thus far with PAS signals. The project pivoted to CAS stimuli to begin to address these potential differences in exposure and response. The shift to focus on CAS was also done to address specified need topics identified by the U.S. Navy's LMR program, which is providing support funding for the program in coordination with the Fleet Monitoring Program. The team worked directly with the USFFC in Norfolk to extend previous, successful approaches used in coordinating PAS-capable U.S. Navy surface vessels to support CEEs as well as coordinate with and plan for CEEs with CAS-capable ships.

A brief synthesis of experimental methods is provided, as well as summaries of field efforts, tagging results and baseline data, and the results of the control (no-MFAS) CEE conducted adaptively in 2023. A summary and analysis of results using Fastloc® GPS sensors compared to previous tag approaches and settings as well as a synthesis of the peer-reviewed papers that have been or are in the process of being published are also provided.

Full details of the experimental design, analytic approach, and field logistics can be found in the 2023 annual progress report (Southall et al. 2024).

2.3.1 Field Effort

Atlantic-BRS field efforts for 2023 were spread adaptively based primarily on weather and potential Navy vessel availability across a single window spanning summer through early autumn. Field teams included a small boat-based team (4–5 individuals) aboard the R/V *Barber*—an 8-m, aluminum-hulled vessel—who conducted advanced deployment of satellite-transmitting tags as well as DTAGs during target windows. 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 when DTAG deployments and CEEs were attempted, a research crew of approximately 6 individuals worked offshore from the fast catamaran R/V *Shearwater* along with, in reasonable conditions and daylight hours, the R/V *Barber* (who maintained shore base of operations). The R/V *Shearwater* provides excellent, elevated, tag-tracking and visual-observation platforms before, during, and after CEEs. One or both vessels were involved in all 2023 tag deployments and CEEs, as well as re-sighting and biopsy sampling of focal individuals thereafter.

Overall, 11 satellite tags were deployed, all on *Ziphius*, 1 of the 2 focal species of the Atlantic BRS (along with short-finned pilot whales) (**Table 25, Figure 56, Figure 57**).

Table 25. Satellite tag deployments for *Ziphius* during Atlantic-BRS field efforts in 2023.

Species[a]/ Tag ID	Deployment Date	Deployment Latitude (°N)	Deployment Longitude (°W)	Dive Data Streams	Tag Duration (days)
ZcTag136_DUML	25-Jul-2023	35.6497	74.7225	5-min time series	68
ZcTag137_DUML	25-Jul-2023	35.5991	74.7219	5-min time series	61
ZcTag138_DUML	25-Jul-2023	35.6089	74.7430	5-min time series	19
ZcTag139_DUML	26-Jul-2023	35.7208	74.6589	5-min time series	29
ZcTag140_DUML	26-Jul-2023	35.7285	74.6515	5-min time series	8
ZcTag141_DUML	26-Jul-2023	35.6300	74.7061	5-min time series	5
ZcTag142_DUML	07-Aug-2023	35.6282	74.7024	5-min time series	67
ZcTag143_DUML[b]	07-Aug-2023	35.6197	74.6305	5-min time series	68
ZcTag144_DUML[b]	07-Aug-2023	35.6282	74.7024	5-min time series	39
ZcTag145_DUML[b]	21-Aug-2023	35.6282	74.7024	5-min time series	7
ZcTag146_DUML[b]	21-Aug-2023	35.6282	74.7024	5-min time series	70

Key: ID = Identification Number; °N = degrees North; °W = degrees West; min = minute(s)

[a] Zc = *Ziphius cavirostris*

[b] Fastloc® GPS tags

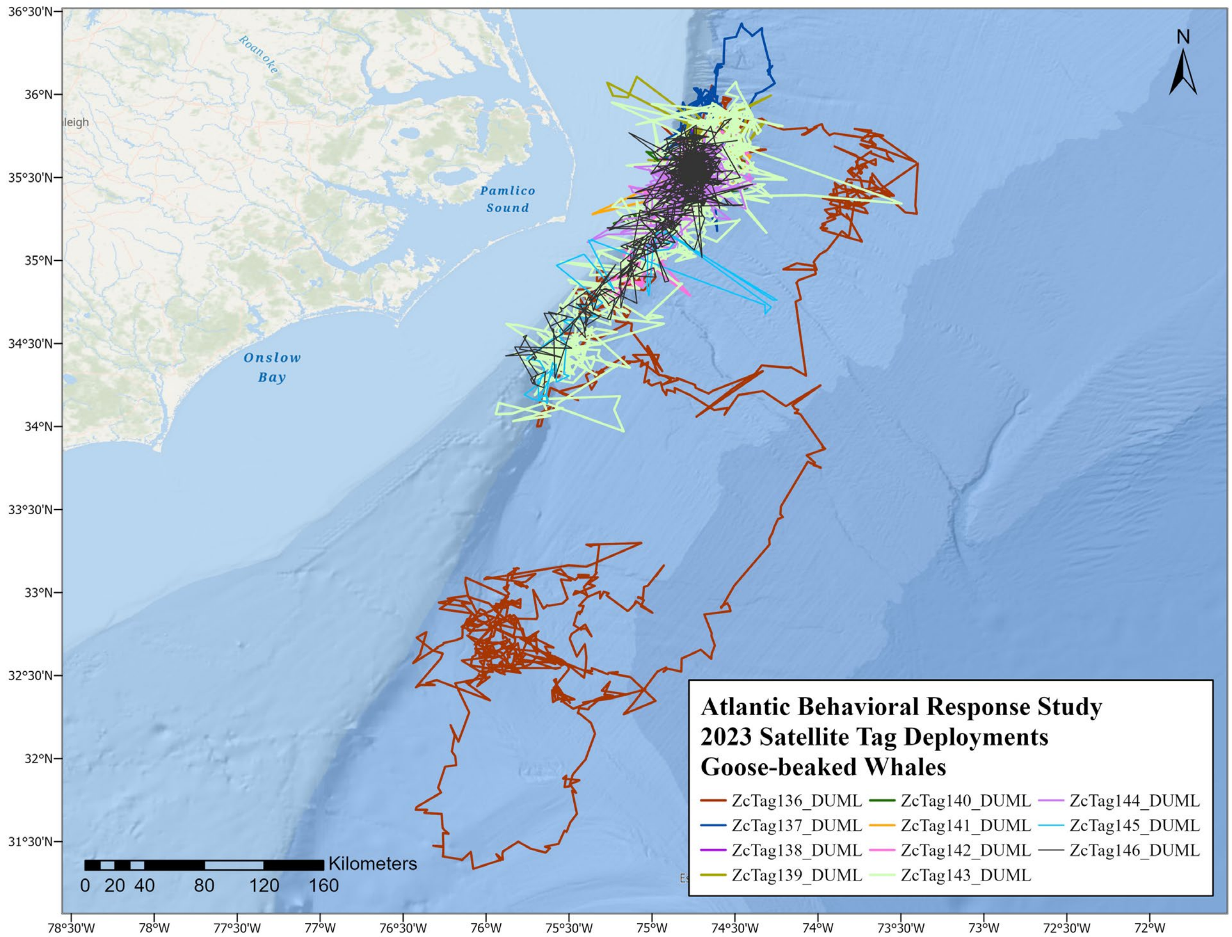


Figure 56. Filtered Argos position tracks for all (n = 11) beaked whales tagged during Atlantic-BRS field efforts in 2023.

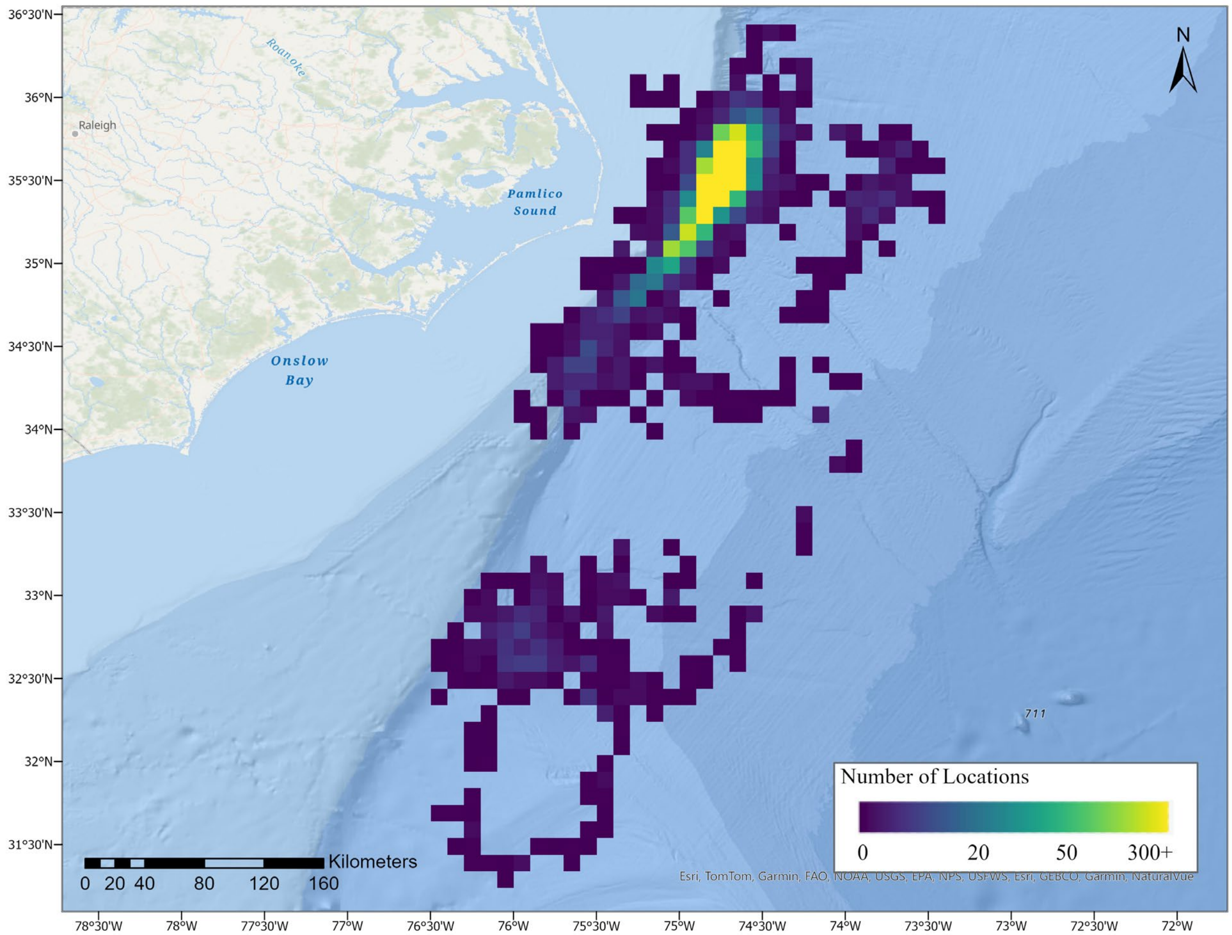


Figure 57. Filtered Argos locations for all (*n* = 11) beaked whales tagged during Atlantic-BRS field efforts in 2023 aggregated in 5-km^2 grid cells.

Summary of 2023 Field Effort: Accomplishments and Assessment

Accomplishments:

- Successful deployment of 11 satellite tags on *Ziphius*, including strategic deployment of four Fastloc® GPS tags, enabling a more systematic evaluation of these tags in the Atlantic-BRS context (identified as a specific objective in the 2022 annual report).
- Successful control CEE conducted using simulated MFAS CEE design from the R/V *Shearwater*.
- Obtained 6 biopsy samples.
- Continued success with research platform R/V *Shearwater.* 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:

- The combined team with USFFC successfully identified multiple capable and willing CAS-capable ships for participation with the Atlantic-BRS project in 2023 and succeeded in deploying many tags on the primary focal species. Unfortunately, the primary candidate vessel suffered an unrelated engineering casualty just prior to supporting the BRS project and was unavailable. Two other possible ships of opportunity were also unable to support the project focused on additional tagged whales later in the field season due to conflicting mission requirements.

- Field teams were adaptive in working through challenging conditions, especially again during June. Very good conditions again occurred during small windows in late July and early August enabled most of the success in tagging (11 tags in 4 field days). Advance discussions for 2024 field effort have included plans to shift field effort and requested Navy ship dates slightly later in the summer.
- Continued success in locating and tagging *Ziphius*, such that no second-priority pilot whales were tagged in 2023.
- Sustained high-quality dive data from satellite-transmitting tags due 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. The team successfully collected continuous dive data for up to 21-day periods, strategically covering CEE periods, as designed. Long-duration (up to 70 days) functioning of tags in reporting Argos positions was again experienced, likely due to improved batteries in SPLASH tags.

2.3.2 Controlled Exposure Experiments (CEEs)

One CEE sequence was conducted during the Atlantic-BRS 2023 field effort. As noted above, a dedicated CAS-capable ship (U.S. Ship [*USS] Winston S. Churchill*) was in coordination with the Atlantic-BRS team and was en route to support a MFAS (CAS) CEE when it experienced an engineering casualty. Given that the entire team and vessels were in place with four satellite-tagged whales, the decision was made to run a full control sequence. This was successfully conducted with two focal whales and two non-focal whales, all of which were tagged with satellite-transmitting SPLASH-10 tags (CEE #2023_01; see **Table 26**).

Table 26. CEEs conducted during Atlantic-BRS field efforts in 2023.

CEE ID	Date	CEE Type	Focal Whales	Non-focal Whales	CEE Duration (min)	Start CEE Source latitude (°N)	Start CEE source longitude (°W)
#2023_01	04-Aug-2023	CONTROL	ZcTag137 ZcTag138	ZcTag136 ZcTag139	30	35.7021	74.7129

Key: ID = identifier; min = minute; °N = degrees north; °W = degrees west; Zc = *Ziphius cavirostris* (*Ziphius*).

A narrative summary of the control CEE sequence is provided in **Table 27**. The full 2023 annual progress report for this project (Southall et al. 2024) includes a complete synthesis of the CEE conducted, with standardized tables and figures. These include: 1) a metadata summary, 2) planning received level (RL) modeling, 3) modeled positions from satellite-tag locations for individuals exposed during the CEE using several methods, and 4) dive records for satellite-tagged whales during the CEE. Sequential positioning for *USS Winston S. Churchill* for Atlantic-BRS CEE #2023_01 is shown in **Table 28** and **Figure 58**.

Table 27. Metadata summary for Atlantic-BRS (CONTROL) CEE #2023_01.

CEE # 2023_01	
Date:	**04 August 2023**
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):	13:37
Start lat/lon (source):	35.7021; -74.7129
End time (UTC):	14:17 (30 min exposure duration matched to simulated PAS MFAS)
End lat/lon (source):	35.7197; -74.7129
Beaked whales tagged during CEE:	(n=4) – **ZcTag137, 138** (focal sat tag animals); Non-focal whales: ZcTag136, 139
Estimated Range (start CEE):	2 km (1.2 nm) @ start
Modeled Max RL:	*n/a* since no MFAS transmission

CEE #2023_01 - Narrative Summary
Following the mechanical issue with the USS CHURCHILL ahead of the planned CAS MFAS CEE, and given that field teams and multiple tagged beaked whales were in place, a control CEE was conducted adaptively. Two tagged focal whales (ZcTag 137 and ZcTag 138) were being tracked from both research vessels in the same area. Two non-focal whales (ZcTag 136 and ZcTag 139) were also reporting tag data but not being tracked in the vicinity of the CEE location. The *R/V Shearwater* served as the mock CEE location and was positioned accordingly using RL modeling estimates used in previous MFAS controls matching PAS CEE parameters and durations. It was positioned approximately 2 km from the final confirmed location of ZcTag 138 accordingly and was floating and stationary with a mock sound source deployed for the 30-min duration of the control CEE. Both focal animals were observed by the *R/V Barber* 1.5-2h following the CEE.

Key: min = minute; n/a = not applicable; UTC = Coordinated Universal Time; Zc = *Ziphius cavirostris* (*Ziphius*)

Table 28. Sequential positioning for USS *Winston S. Churchill* ahead of Atlantic-BRS CEE #2023_01.

Position Request for *USS Winston S. Churchill*	Description	Latitude (°N)	Longitude (°W)	Heading
1	Nominal initial position (provided to ship weeks in advance)	35.9	74.5	Not specified
2	1 August 1200 EDT (approximately 72-hour pre-exposure) based on best estimate of ZcTag136 as nominal focal at that point	36.0	74.25	250
3	2 August 1200 EDT (approximately48-hour pre-exposure) based on best estimate of ZcTag136 as nominal focal at that point; three other whales further to west	36.0	74.35	230
4	3 August 1100 EDT: (approximately 24-hour pre-exposure) based on cluster of ZcTags137-139; pivoted to focus on this cluster based on ZcTag136 moving well east. This track was intended to cut the vessel between 136 to the east and the cluster near the shelf to the west.	35.92	74.52	203
5	4 August 0630 EDT: Final requested start position for *USS Winston S. Churchill.* Vessel was en route to this location when engineering casualty occurred.	35.95	74.36	205

Key: °N = degrees north; °W = degrees west; EDT = Eastern Daylight Time; Zc = *Ziphius cavirostris* (*Ziphius*)

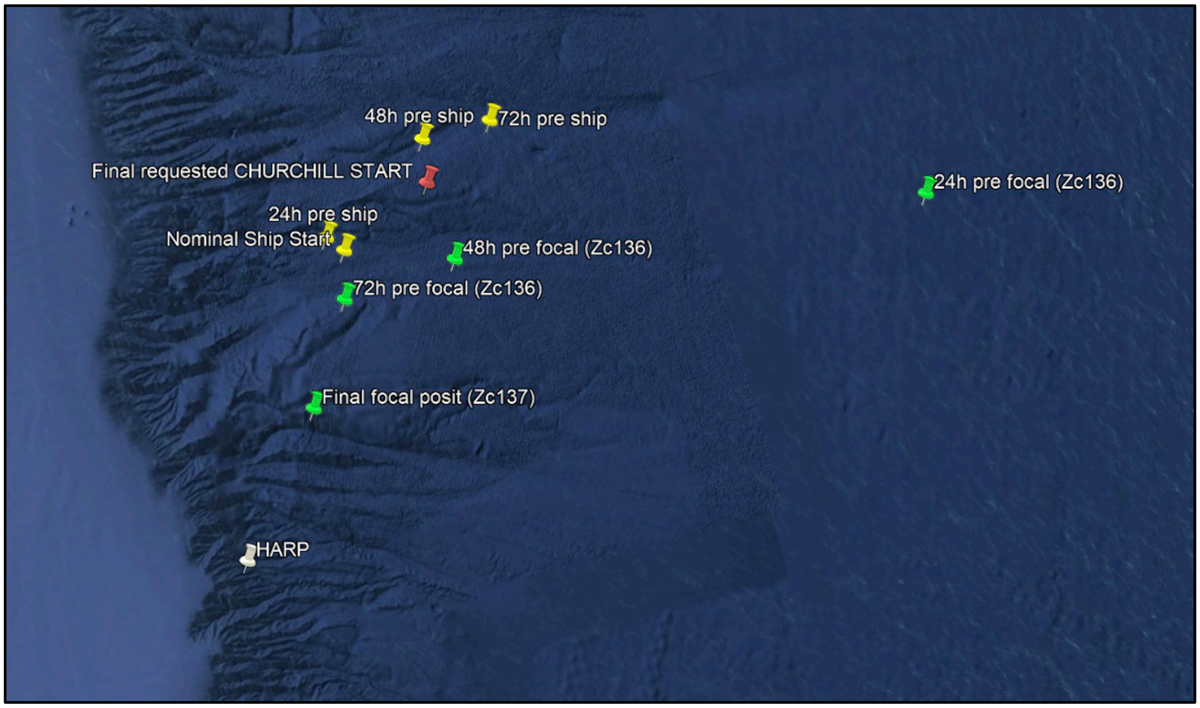


Figure 58. Sequential requested USS *Winston S. Churchill* start positions shown weeks to days in advance (yellow pins) as well as the final position (red pin) requested on the day of the planned CEE. Vessel positions are shown relative to focal animal position estimates (green pins) used in RL modeling and to inform the vessel position requests. See Table 28 for descriptions.

2.3.3 Results, Analytical Developments, 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 response analyses. A summary of papers that are published, in review, or in advanced stages of development is included in **Table 29**; direct links to publications are provided where available.

Table 29. 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) [Double Mocha]	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	Kernel density estimation of conditional distributions to detect responses in satellite tag data	Hewitt (Duke) [Double Mocha]	Published
Methodology – technology	Time-discretization approximation enriches continuous-time discrete-space models for animal movement	Hewitt (Duke) [Double Mocha]	Published
Methodology – technology	Varying-Coefficient Stochastic Differential Equations with Applications in Ecology	Michelot (St. Andrews) [Double Mocha]	Published
Methodology – technology	Continuous-time modelling of behavioural responses in animal movement	Michelot (St. Andrews) [Double Mocha]	Published
Methodology – technology	Trade-offs in telemetry tag programming for deep-diving cetaceans: data longevity, resolution, and continuity	Cioffi (SEA)	Published
Baseline behavior	Shallow night intervals in *Ziphius cavirostris*	Cioffi (Duke)	In preparation
CEE exposure-response	Behavioral responses of *Ziphius cavirostris* to simulated mid-frequency active military sonar off Cape Hatteras, NC	Southall (SEA)	Final preparation
Methodology – technology	Estimating RLs and horizontal avoidance with dynamic covariates in exposed animals	Schick (Duke)	Final preparation
Baseline behavior	Possible orientation behavior in *Ziphius*	Quick (Duke)	In preparation

Category	Nominal Title/Subject	Lead Author (Institution)	Status
CEE exposure-response	Behavioral responses of Cuvier's beaked whales to 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.

Fastloc® GPS Assessment

In 2023, four SPLASH10-F-333 Fastloc® GPS enabled tags were deployed to assess their utility for the Atlantic-BRS in simultaneously collecting high-resolution dive and position data on *Ziphius*. An additional tag was deployed in 2018 programmed only to collect and transmit Fastloc® GPS positions and no dive data. The five individuals tagged were ZcTag077_DUML, ZcTag143_DUML, ZcTag144_DUML, ZcTag145_DUML, and ZcTag146_DUML, the last four of which were during the 2023 field effort. All but ZcTag145_DUML and ZcTag146_DUML were attached to adult males. ZcTag146_DUML was attached to a male of unknown age, and ZcTag145_DUML was attached to an animal of unknown sex and age, but likely not an adult male. Two of the animals had been previously tagged: ZcTag077_DUML was attached to an animal that had also been tagged with ZcTag039, and ZcTag143_DUML was attached to an animal that also had been tagged with ZcTag102_DUML; however, the previous tags had both fallen off prior to the most recent tagging. ZcTag077_DUML, ZcTag143_DUML, and ZcTag144_DUML were all attached at or just below the base of the dorsal fin; ZcTag145_DUML was attached below the dorsal fin; and ZcTag146_DUML was attached in the center of the dorsal fin.

Tag ZcTag077_DUML, which was programmed to produce the greatest number of GPS positions, successfully transmitted 179 GPS positions over 23.7 days (approximately 7.6 positions per day). The four tags transmitting both time-series and GPS data did not perform as well, successfully transmitting only an average of 0.6 to 3.9 GPS positions per day. The worst performer was ZcTag145_DUML which also had the lowest deployment position on the animal, likely leading to lower average times when the radio could be active in air and higher rates of interrupted radio receptions or transmissions as the animal submerged. This tag also had a short deployment of only approximately 5.2 days. Given the location of the tag, it is possible the device was shed quickly. This animal will be a high priority for follow up in the next field effort to ascertain the condition of the tag deployment location on the body.

Receptions per day ranged from 22.5 to 57, which represents 8 to 20 percent ratio of transmissions to receptions, or that each message must be sent approximately 5 to 10 times to be received on a satellite for this cohort of tags. Data received on satellite that are correctly attributed to a platform transmitter terminal can still be corrupted and therefore unusable (**Figure 59**). These receptions are still helpful in estimating Argos position, but do not produce GPS or dive information. As expected, the poorest overall performing tag, ZcTag145_DUML, had the highest rate of corrupt messages, likely due to the low placement of the Argos antenna on the animal's body leading to interrupted transmissions.

The ability of the programming scheme to produce continuous stretches of time-series depth data which would be suitable for studying dive behavior responses to experimental stimuluses was assessed. Two of the 4 tags programmed to collect time-series data, ZcTag143_DUML (one data gap) and ZcTag146_DUML (no data gaps), produced suitable data. ZcTag144_DUML produced some data but was plagued with data gaps, and ZcTag145_DUML did not produce a meaningful amount of dive data. These differences were, in part, due to the height of the antenna on the animal. These two best performing tags also produced the fewest corrupt messages. Additionally, these were the longest duration tag deployments, giving enough time for data transmission to catch up with the queue of messages.

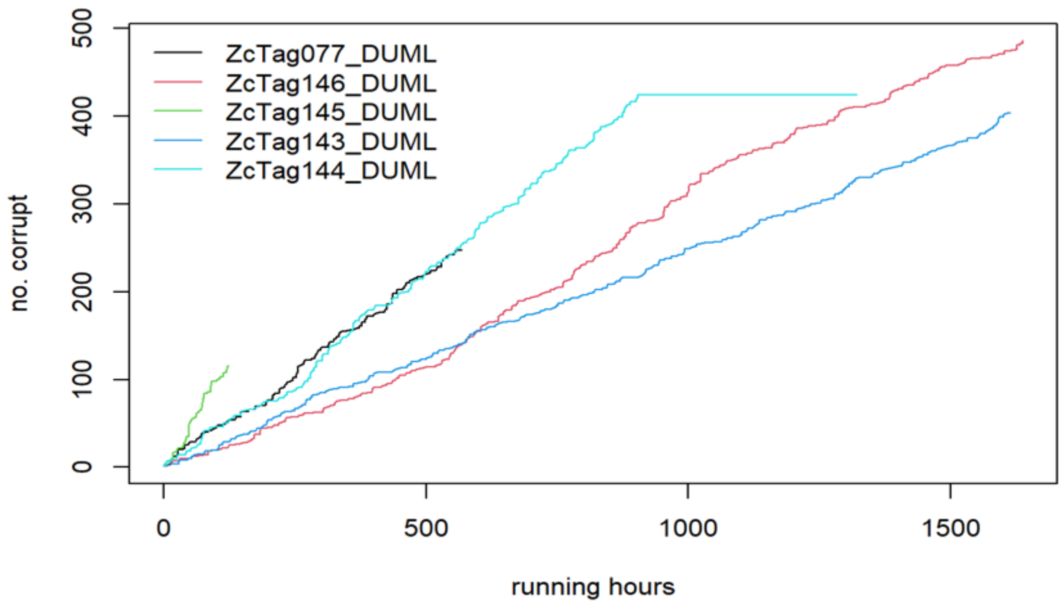


Figure 59. Accumulation of corrupt message receptions on the Argos system for FastGPS tags.

These results showed that it is possible to collect at least 14 days of near-continuous, 5-minute time-series depth data simultaneously with several GPS positions per day using tags with Fastloc® GPS. These GPS positions were sufficient to modestly decrease error and increase accuracy in fitted positions from a movement model. While these gains were relatively small (on the order of several km), they may be important in modeling finer-scale movement and yielding better RL estimates, which can vary substantially across small distances in the study site. The performance of these tags is sufficient to justify their continued use as a supplement to the existing tag configurations, though their utility in their impact on downstream analyses for the Atlantic-BRS, including RL estimation and horizontal avoidance detection will continue to be assessed (Schick et al., in prep.).

Given these pilot data, the programming can continue to be tuned to maximize the number of GPS positions received along with the duration and continuity of dive data. Field logistics during 2023 prevented the use of a shipboard receiver to intercept messages directly from the tag, which has been shown to increase message reception rates dramatically (Cioffi et al. 2023), but this can be subsequently implemented to further increase. Bandwidth limitation is an important issue for all tag configurations and especially for tags with Fastloc® GPS because of the additional data that is trying to transmit to satellite. An upcoming augmentation to the Argos satellite system may increase bandwidth by increasing the number of satellite passes for the study site.

2.3.4 Overall Assessment and Recommendations

The following summarizes the accomplishments and general assessments for the 2023 field effort:

- Field conditions proved challenging for the 2023 field season, particularly in the first month (June). This extends a longer-term pattern of fewer overall windows of ideal conditions, which require extended periods of adaptive effort to achieve research objectives.
- Successful deployment of a large number (*n* = 11) of tags on high-priority beaked whales and the collection of tens of thousands of hours of movement and diving behavior. Given this success, no second-priority pilot whales were tagged.
- Satellite-tag settings developed during earlier years remained consistent, with positive results. Many of the 2023 tags again achieved greater duration deployments for returning Argos position data as well as to up to 21 days of focused, high-resolution, continuous time series dive data.
- Dedicated and strategic deployment and evaluation of four Fastloc® GPS tags with a variety of associated outcomes and recommendations.
- Successful coordination and adaptive planning with USFF colleagues in scheduling and coordinating with multiple CAS-capable vessels for coordination. Unfortunately, several candidate vessels became unavailable in the days leading up to CEEs; the primary option that was en route to the study area with multiple tagged whales in good configurations to meet research objectives, experienced an engineering casualty just hours prior to the scheduled CEE.
- Despite setbacks with Navy ship availability, a successful control CEE using the PAS MFAS simulated source criteria was successfully conducted.
- Sustained success and continued enhancement of approaches for receiving data from satellite tags using goniometers. These approaches have proven essential in tracking and re-locating tagged individuals many times to obtain photographs and biopsy samples as well as locate other individuals for tagging attempts. They have also been proven to increase data magnitude and precision in ways that are demonstrably important in improving animal movement modeling and RL estimation (Schick et al., in prep.).
- Extensive progress in several publications in baseline behavior and methodological advances, and extensive effort in two forthcoming paper submissions for RL modeling (Schick et al., in prep.) and new behavioral response methods (Southall et al., in prep.).

Future effort and recommendations include:

- While efforts to coordinate with a CAS-capable ship in 2023 were regrettably unsuccessful given the poor timing of events described, it is important to note the continued success in coordination and planning as well as in terms of deploying many tags on the highest-priority species with extensive additional baseline and control data obtained. All the right plans and preparation for success with CAS CEEs were in place and maintaining field planning and logistics in similar manner is recommended. An experimental plan summarizing these approaches and status in planning will be provided at the March 2024 program review. Coordination with U.S. Navy vessels should be maintained using identical approaches as previous seasons through sustained and advance planning via USFFC.
- The combination of advance deployment of satellite tags in weeks to days ahead of CEEs and DTAG deployments in the day to hours ahead of CEEs should be maintained in the context of the multi-scale design. Priority should be given to simultaneously deploying DTAGs within groups with satellite-tagged individuals.
- Maintaining satellite-tag time-series settings as has been optimized for the Atlantic-BRS field site and objectives is recommended following extensive evaluation and assessment (see: Cioffi et al. 2023). Further deployments of the Fastloc® GPS satellite tags are also recommended for 2024 as a supplement to the study's existing tag configurations.
- Field efforts to locate tagged animals with validated locations using goniometer detections, visual observations, and photo-ID should be maintained as much as possible before and especially after

CEEs, given the substantial and demonstrated improvements in spatial movement data, RL model estimates, and other factors.

Please refer to the annual progress report for detailed information on 2023 fieldwork, preliminary results from 2017 to 2022, and ongoing analyses (Southall et al. 2024).

2.4 North Atlantic Right Whales

2.4.1 Aerial/Vessel Surveys and Tagging

Since 2015, HDR, Inc. researchers have been monitoring large whales off Virginia and North Carolina through non-systematic vessel surveys, aerial surveys, photo-ID, drones, and tagging (dart and suction cup) (see **Section 2.2.1** for additional details). Beginning in the winter 2022/2023 field season, there was increased effort to locate NARWs given their critically endangered status and the gap in knowledge for Mid-Atlantic waters. Between April 2018 and March 2023, there have been 20 sightings of NARWs off southern Virginia and northern North Carolina (**Table 30**; **Figure 60**; Aschettino et al. 2023b). Half of these sightings (*n* = 10) occurred during the 2022/2023 season, during which 27 unique individuals were documented (**Table 31**; Aschettino et al. 2024a). To date, 46 unique NARW's have been identified within the study area, of which 25 were male, 14 were female, and 7 were of unknown sex (Aschettino et al. 2023b). Group sizes ranged from 1 to 9 individuals (mean = 3). There were six occasions of NARW pairs: one adult female pair, two adult male/adult female pairs, and three cow/calf pairs (#1245/"Slalom" and calf (2022), #4180/"Dyad" and calf (2022), and #2605/"Smoke" and calf (2023)). There were six observations of single NARWs and eight observations of groups with three to nine individuals. Five of these larger groups were surface-active groups (SAGs), which were comprised of juveniles and adults of both genders (**Table 32**; A. Engelhaupt et al. 2023b). Aerial footage captured by drones has documented multiple observations of individuals in SAGs exhibiting both belly-to-belly and nonreproductive copulatory behaviors. Potential feeding and foraging events were also documented during 6 of the 20 sightings within the area, indicated by the observations of defecation, fluke-up dives, and open-mouth swimming behaviors.

Table 30. NARW sightings by season for all aerial and vessel surveys off southern Virginia and northern North Carolina during the winter seasons from 2017/2018 to 2022/2023.

Season	Number of Sightings	Number of Individuals	Unique IDs for Season
2017/2018	2	8	7
2018/2019	0	0	0
2019/2020	0	0	0
2020/2021	4	7	6
2021/2022	4	8	8
2022/2023	10	36	27

Key: ID = Identification Number

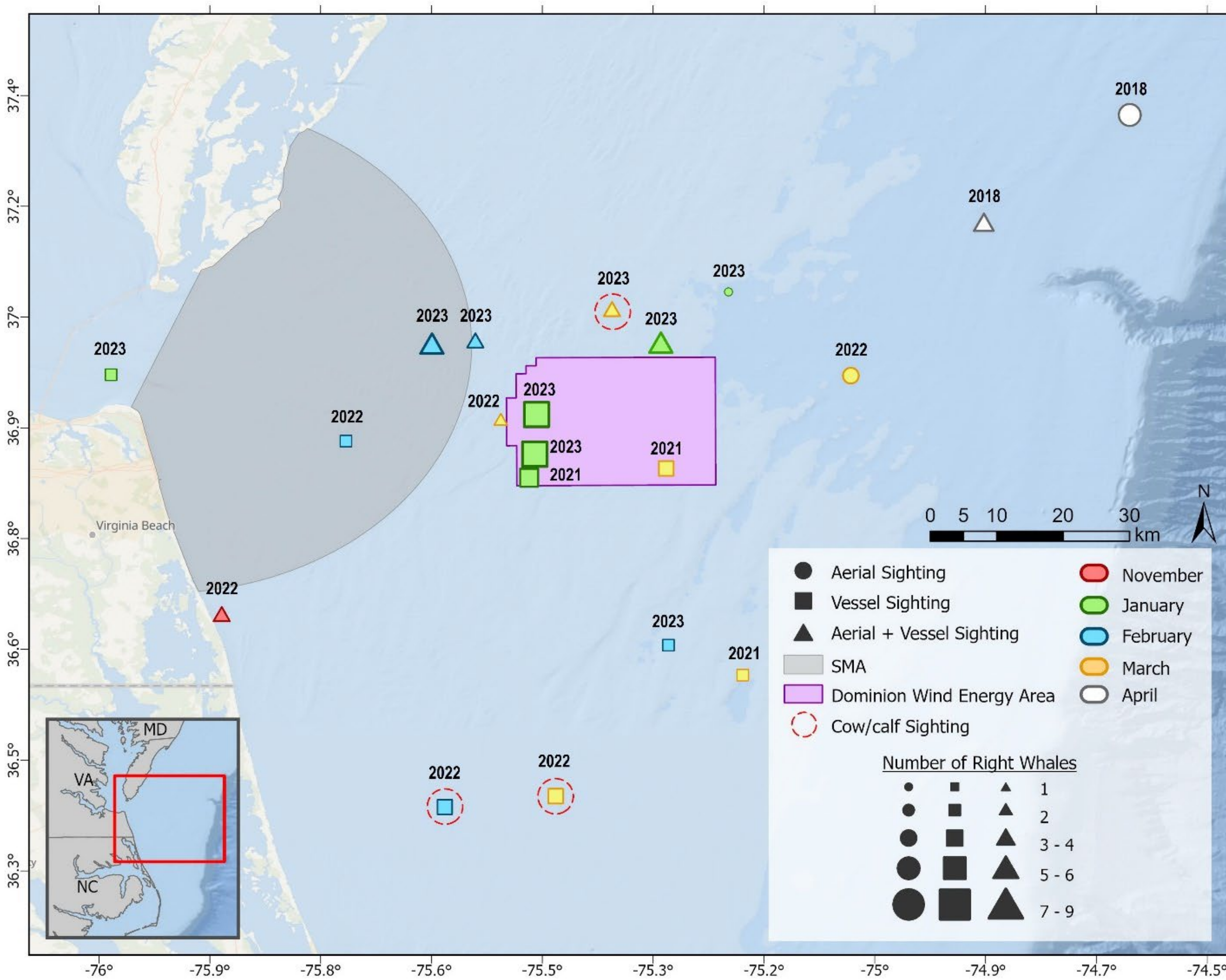


Figure 60. NARW sightings from aerial and vessel platforms collected off southern Virginia and northern North Carolina from 2018 to 2023.

Table 31. Summary of photo-identified NARWs from all platforms during the 2022/2023 field season, sorted by sighting date and animal ID.

Animal ID	Age Class	Sex	Group Size	Behavior	Sighting Date	Survey Type_ Sighting #	Sighting Latitude (°N)	Sighting Longitude (°W)	Unique Sighting Days
#2605	Adult	Female	2	Travel	22-Nov-2022	Aerial_s1	36.6492	75.8839	2
#2605	Adult	Female	2	Travel	22-Nov-2022	Midshelf_s5	36.6201	75.8662	2
#3503	Adult	Female	2	Travel	22-Nov-2022	Aerial_s1	36.6492	75.8839	1
#3503	Adult	Female	2	Travel	22-Nov-2022	Midshelf_s5	36.6201	75.8662	1
2022Calfof#2753	Yearling	Unknown	1	Travel	18-Jan-2023	Nearshore_s1	36.9719	76.0335	1
#1934	Adult	Female	1	Travel	24-Jan-2023	Aerial_s1	37.0838	75.1981	1
#3640	Adult	Male	6	Social/SAG	24-Jan-2023	Aerial_s4	37.0173	75.2895	1
#3810	Adult	Male	6	Social/SAG	24-Jan-2023	Aerial_s4	37.0173	75.2895	3
#3810	Adult	Male	6	Social/SAG	24-Jan-2023	Vessel_s2	37.0091	75.2938	3
#4610	Juvenile	Female	6	Social/SAG	24-Jan-2023	Aerial_s4	37.0173	75.2895	1
#4610	Juvenile	Female	6	Social/SAG	24-Jan-2023	Vessel_s2	37.0091	75.2938	1
#3120	Adult	Male	6	Social/SAG	24-Jan-2023	Aerial_s4	37.0173	75.2895	2
#3120	Adult	Male	6	Social/SAG	24-Jan-2023	Vessel_s2	37.0091	75.2938	2
#3701	Adult	Male	6	Social/SAG	24-Jan-2023	Aerial_s4	37.0173	75.2895	3
#3701	Adult	Male	6	Social/SAG	24-Jan-2023	Vessel_s2	37.0091	75.2938	3
#4612	Juvenile	Female	6	Social/SAG	24-Jan-2023	Aerial_s4	37.0173	75.2895	1
#4612	Juvenile	Female	6	Social/SAG	24-Jan-2023	Vessel_s2	37.0091	75.2938	1
#4523	Juvenile	Male	7	Social/SAG	29-Jan-2023	Midshelf_s3	36.8642	75.4600	3
#3810	Adult	Male	7	Social/SAG	29-Jan-2023	Midshelf_s3	36.8642	75.4600	3
#3701	Adult	Male	7	Social/SAG	29-Jan-2023	Midshelf_s3	36.8642	75.4600	3
#4540	Adult	Female	7	Social/SAG	29-Jan-2023	Midshelf_s3	36.8642	75.4600	1
#3541	Adult	Male	7	Social/SAG	29-Jan-2023	Midshelf_s3	36.8642	75.4600	1
#3301	Adult	Male	7	Social/SAG	29-Jan-2023	Midshelf_s3	36.8642	75.4600	1
#3579	Adult	Male	7	Social/SAG	29-Jan-2023	Midshelf_s3	36.8642	75.4600	1
#4523	Juvenile	Male	9	Mill	30-Jan-2023	Mishelf_s2	36.9039	75.4579	3
#3810	Adult	Male	9	Mill	30-Jan-2023	Midshelf_s2	36.9039	75.4579	3

Animal ID	Age Class	Sex	Group Size	Behavior	Sighting Date	Survey Type_ Sighting #	Sighting Latitude (°N)	Sighting Longitude (°W)	Unique Sighting Days
#3120	Adult	Male	9	Mill	30-Jan-2023	Midshelf_s2	36.9039	75.4579	2
#3701	Adult	Male	9	Mill	30-Jan-2023	Midshelf_s2	36.9039	75.4579	3
#3460	Adult	Male	9	Mill	30-Jan-2023	Midshelf_s2	36.9039	75.4579	1
#4991	Juvenile	Female	9	Mill	30-Jan-2023	Midshelf_s2	36.9039	75.4579	1
#4457	Juvenile	Male	9	Mill	30-Jan-2023	Midshelf_s2	36.9039	75.4579	1
#4020	Adult	Female	9	Mill	30-Jan-2023	Midshelf_s2	36.9039	75.4579	1
#4130	Adult	Male	9	Mill	30-Jan-2023	Midshelf_s2	36.9039	75.4579	1
#4523	Juvenile	Male	7	Social/SAG	07-Feb-2023	Midshelf_s2	37.0302	75.5308	3
#4991	Juvenile	Female	6	Social/SAG	07-Feb-2023	Aerial_s3	37.0161	75.5994	2
#4991	Juvenile	Female	7	Social/SAG	07-Feb-2023	Midshelf_s2	37.0302	75.5308	2
#4130	Adult	Male	6	Social/SAG	07-Feb-2023	Aerial_s3	37.0161	75.5994	2
#4130	Adult	Male	7	Social/SAG	07-Feb-2023	Midshelf_s2	37.0302	75.5308	2
#4191	Adult	Female	2	Mill	07-Feb-2023	Aerial_s1	37.0197	75.5406	1
#4191	Adult	Female	1	Mill	07-Feb-2023	Midshelf_s1	37.0302	75.5240	1
#4720	Juvenile	Unknown	6	Social/SAG	07-Feb-2023	Aerial_s3	37.0161	75.5994	1
#4720	Juvenile	Unknown	7	Social/SAG	07-Feb-2023	Midshelf_s2	36.9968	75.5787	1
#3845	Adult	Male	6	Social/SAG	07-Feb-2023	Aerial_s3	37.0161	75.5994	1
#3845	Adult	Male	7	Social/SAG	07-Feb-2023	Midshelf_s2	36.9968	75.5787	1
#4330	Adult	Male	2	Mill	07-Feb-2023	Aerial_s1	37.0197	75.5406	1
#4330	Adult	Male	6	Social/SAG	07-Feb-2023	Aerial_s3	37.0161	75.5994	1
#4330	Adult	Male	7	Social/SAG	07-Feb-2023	Midshelf_s2	36.9968	75.5787	1
#3997	Adult	Male	6	Social/SAG	07-Feb-2023	Aerial_s3	37.0161	75.5994	1
#3997	Adult	Male	7	Social/SAG	07-Feb-2023	Midshelf_s2	36.9968	75.5787	1
#1423	Adult	Unknown	1	Travel	26-Feb-2023	Midshelf_s1	36.6057	75.2792	1
#2605	Adult	Female	2	Mill	05-Mar-2023	Aerial_s1	37.0622	75.3556	2
#2605	Adult	Female	2	Travel	05-Mar-2023	Midshelf_s1	37.0432	75.3302	2
2022calfof#2605	Calf	Unknown	2	Mill	05-Mar-2023	Aerial_s1	37.0622	75.3556	1

Animal ID	Age Class	Sex	Group Size	Behavior	Sighting Date	Survey Type_ Sighting #	Sighting Latitude (°N)	Sighting Longitude (°W)	Unique Sighting Days
2022calfof#2605	Calf	Unknown	2	Travel	05-Mar-2023	Midshelf_s1	37.0432	75.3302	1

Key: °N = degrees North; °W = degrees West; ID = Identification Number

Table 32. All documented NARW surface-active groups seen during surveys off southern Virginia and northern North Carolina.

Date	Number of Individuals	Group Composition	IDs Present
13-Jan-2021	3	3 male (2 adult, 1 juvenile)	#2142, #3821, #4523
24-Jan-2023	6	2 female, 4 male (4 adult, 2 juvenile)	#3120, #3640, #3701, #3810, #4610, #4612
29-Jan-2023	7	1 female, 6 male (5 adult, 2 juvenile)	#3301, #3541, #3579, #3701, #3810, #4523, #4540
30-Jan-2023	9	2 female, 7 male (6 adult, 3 juvenile)	#3120, #3460, #3701, #3801, #4020, #4130, #4457, #4523, #4991
07-Feb-2023	7	1 female, 5 male, 1 unknown (3 adult, 4 juvenile)	#3845, #3997, #4130, #4330, #4523, #4720, #4991

Key: ID = Identification Number

During the 2021/2022 and 2022/2023 winter field seasons, four tags were deployed on NARWs. Three yearling NARWs were tagged with Wildlife Computers SPLASH10-F-333 dive/location dart tags (#5042, #5012, and #5132). A CATS tag was deployed on one pregnant female (#2605/"Smoke") (**Figure 61**). Dive depths and durations were assessed in relation to the maximum draft (15 m) of large ships transiting throughout the western Mid-Atlantic (D. Engelhaupt et al. 2023). Dives of dart-tagged yearling NARWs ranged from 5 to 94 m deep (mean = 19 m) and lasted for 2.0 to 20.6 minutes (mean = 5.4 minutes). While the majority of these dives, on average, exceeded the depths of vessel drafts, time spent at/near the surface or on the ascent/descent while diving still poses significant vessel-strike risks to individuals. During the 10.3-hour long CATS tag deployment, NARW #2605/"Smoke" spent 63 percent of her time in the upper 2 m of the water column, and 98 percent of her total time was in the upper 10 m of the 15-m vessel-strike zone (**Figure 61**). The CATS tag did not record any vocalizations by #2605/"Smoke" or her travel companion "Caterpillar," meaning they were undetectable by any real-time PAM systems.

This analysis, in addition to continued dedicated aerial and vessel survey effort, are helping to fill data gaps regarding the spatiotemporal use and behaviors of NARWs in the mid-Atlantic and highlight the importance of this area as more than just a migratory corridor.

For more information regarding this study, refer to the annual progress report for this project (Aschettino et al. 2024a) and **Section 2.2.1** of this report. Refer to Aschettino et al. (2023b) for further information on sightings and group composition, A. Engelhaupt et al. (2023b) for specifics on surface-active groups, and D. Engelhaupt et al. (2023) for dive tag data analysis.

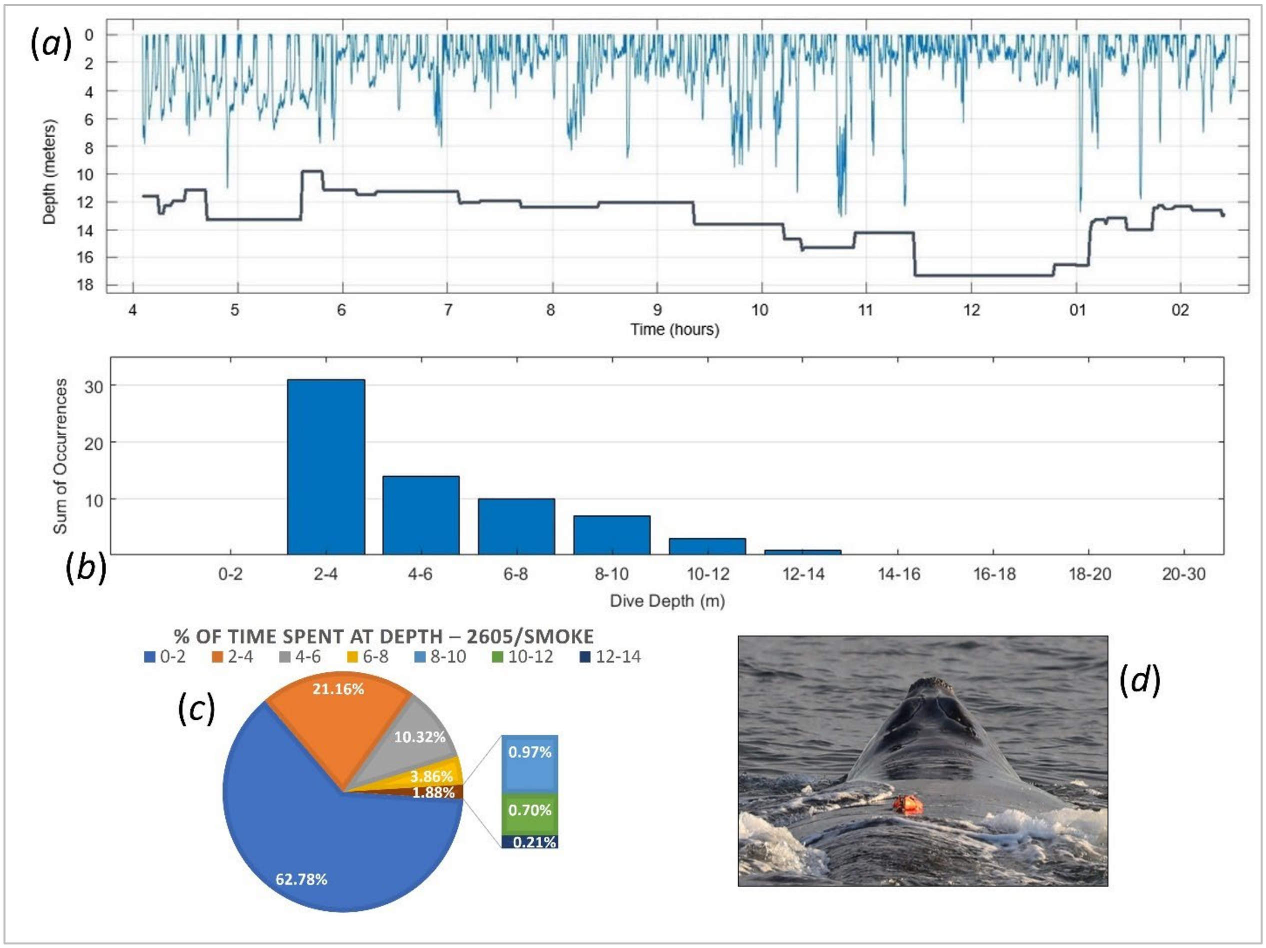


Figure 61. CATS tag analysis for NARW #2605/"Smoke": (a) dive depth profiles over the 10.3-hour tag deployment (~16:00–02:00 EST), solid black line under dives represents seafloor; (b) frequency histogram of dive depths in 2-m bins; (c) percent of time spent at each depth range (meters); (d) CATS tag on back of #2605/"Smoke."

2.4.2 Passive Acoustics

Autonomous Real-Time Detection Buoy

An autonomous real-time reporting passive acoustic detection buoy (**Figure 62**) was deployed by Woods Hole Oceanographic Institute off the coast of Cape Charles, VA, in September, 2023. 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.

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 (LFDCS; Baumgartner and Mussoline 2011; Baumgartner et al. 2013) and is capable of detecting humpback, fin, sei, 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 on WhaleMap, and integrated into NOAA's Passive Acoustic Cetacean Mapper.

Figure 62. DMON buoy deployed off the coast of Cape Charles, Virginia.

This buoy was strategically placed to complement the sound trap deployments (discussed below) as well as another real-time detection buoy deployed off southern Virginia by another organization, and to facilitate the HDR, Inc. field team efforts in the area. This location also falls within the jurisdiction of the New England/Mid-Atlantic branch of NOAA Fisheries; therefore, confirmed detections of North Atlantic right whales will trigger a temporary "slow zone" for vessels. Slow Zones are a voluntary program NOAA Fisheries uses to notify vessel operators to slow down to protect right whales—maintaining speeds of 10 knots or less can help protect right whales from vessel collisions. Under these programs, NOAA Fisheries provides maps and coordinates to vessel operators indicating areas where right whales have been detected. For a period of 15 days after a whale is detected, mariners are encouraged to avoid these areas or reduce speeds to 10 knots or less while transiting through these areas. Active Slow Zones can be found on NOAA's website as well as WhaleMap.

Of the four baleen whale species monitored, humpback and fin whales were the most commonly detected (**Figure 63**). NARWs were also relatively commonly detected from December through February. From October 2023 to February 2024, the Cape Charles buoy had 26 confirmed detections of North Atlantic right whales, which led to a slow zone in the area surrounding the buoy for a total of 135 days—nearly continuously from early November through the end of February. There were also 15 additional possible right whale detections that did not meet the criteria to be confirmed as "detected." Up to date daily detections are available at the project's page on Robots4Whales.

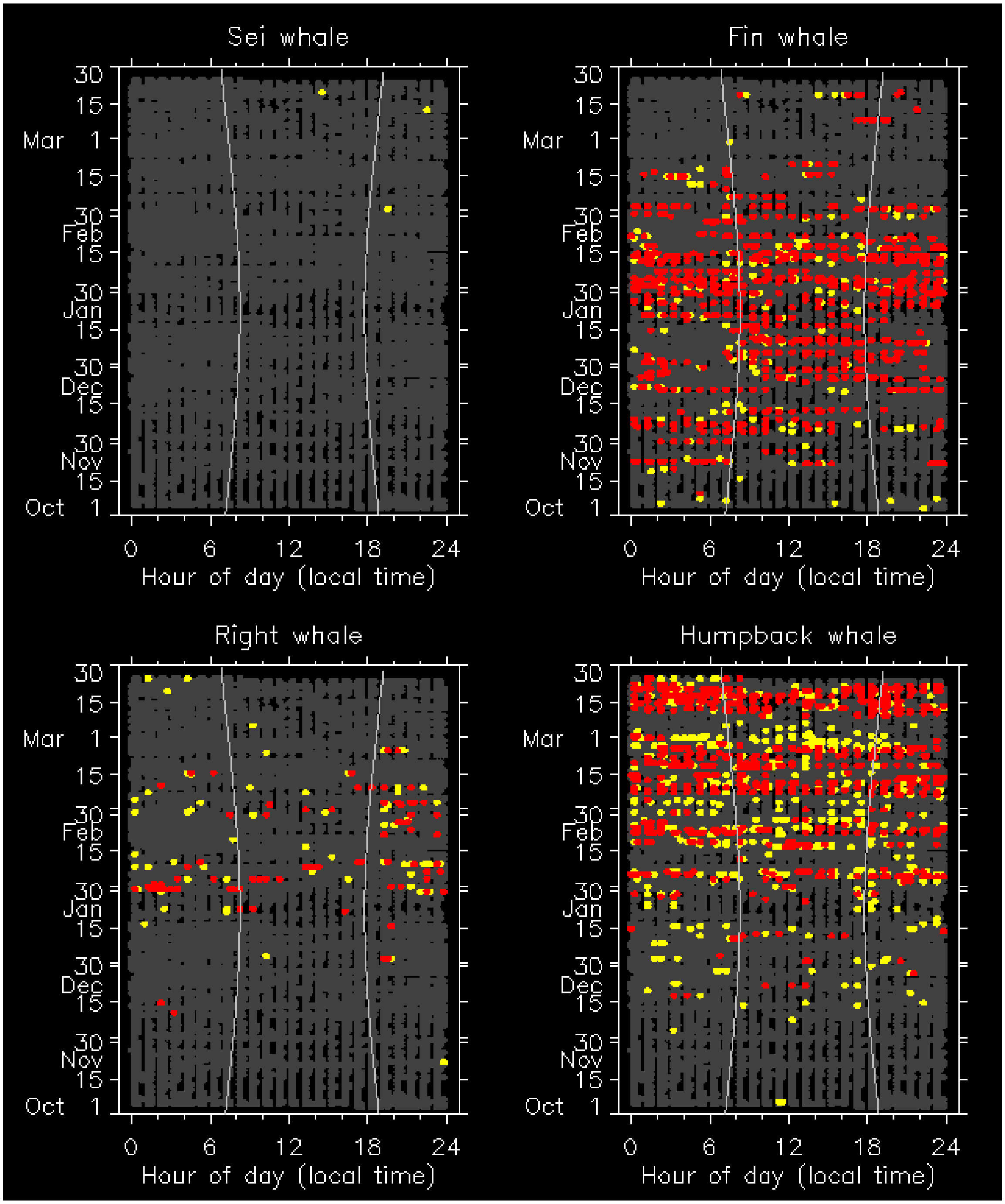


Figure 63. Diel plot showing detections (yellow = possible, red = confirmed) of baleen whales from the buoy deployed off the coast of Cape Charles, Virginia from October 2023 through April 2024.

Three sets of SoundTraps were deployed to monitor for the presence of NARWs within the western Mid-Atlantic in collaboration with NOAA NEFSC during 2023. This is an expansion of the two locations deployed in 2022, with a new array extending off eastern shore of Virginia, as well as one additional unit near the shelf break off of Virginia Beach (**Figure 64**). The units off the coast of Delaware and southeaster Virginia were serviced in January, June, and November, and the three new units off the eastern shore were deployed in October. 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 5-6 months. Current deployment status can be found on the monitoring program's PAM deployment viewer.

Analysis of the data is being performed by NEFSC staff and results incorporated into NOAA's Passive Acoustic Cetacean Mapper. All SoundTraps deployed from June 2022- June 2023 have been processed with the LFDCS and analyzed for daily presence for NARW upcalls, fin whale pulses, blue whale song, and sei whale downsweeps following the methods described in Davis et al. (2017) and Davis et al. (2020). If a day contained the required amount of detections for the call types specified, that species was logged as "detected". Only the first deployment off Virginia (three sites: CB01, CB02, and CB03) have been analyzed for humpback whales so far. **Figure 65** shows days each species was detected and confirmed present per site, with gray periods indicating either no data or no analysis (in the case of humpback whales) available.

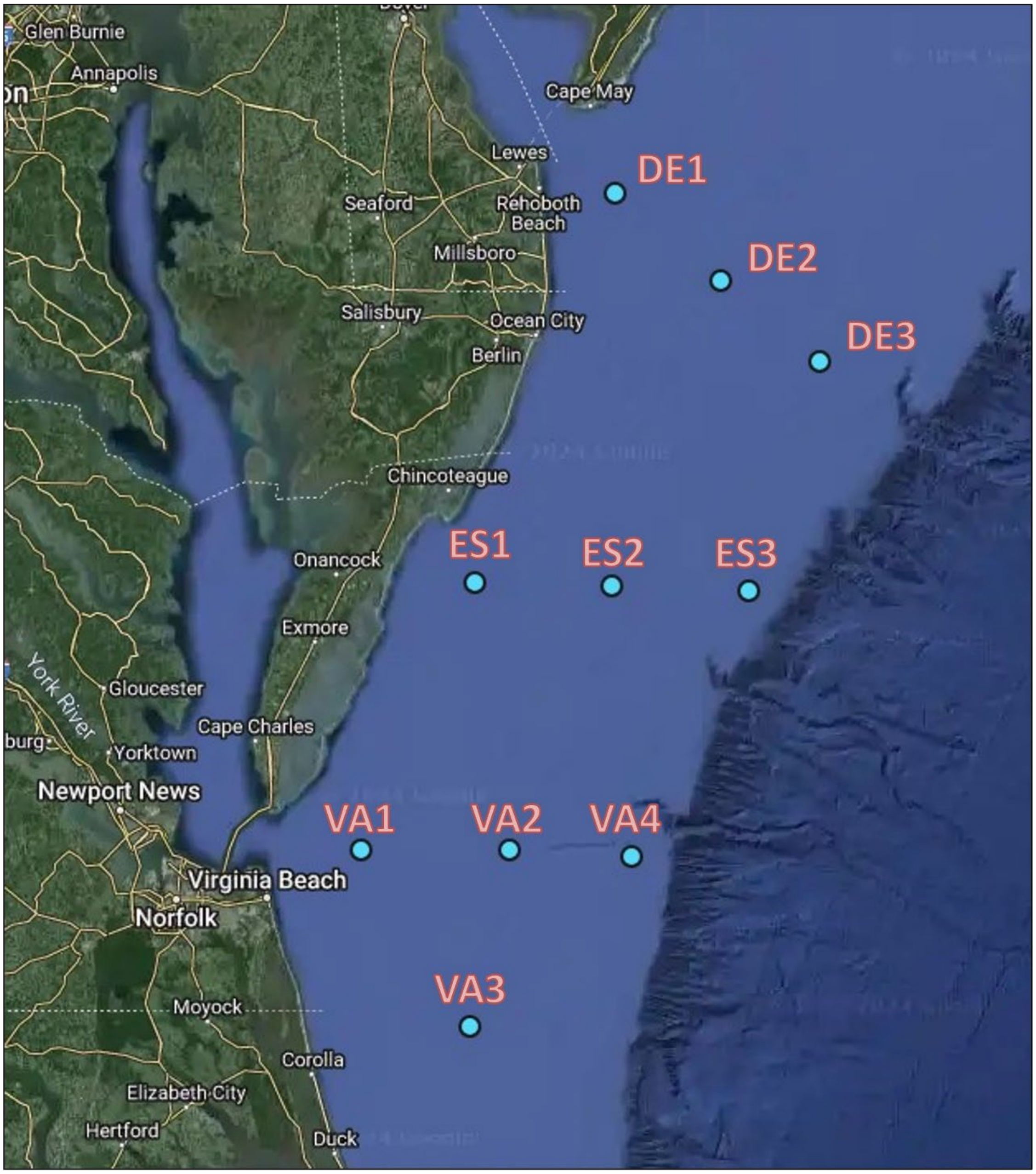


Figure 64. Locations of SoundTrap deployments during 2023.

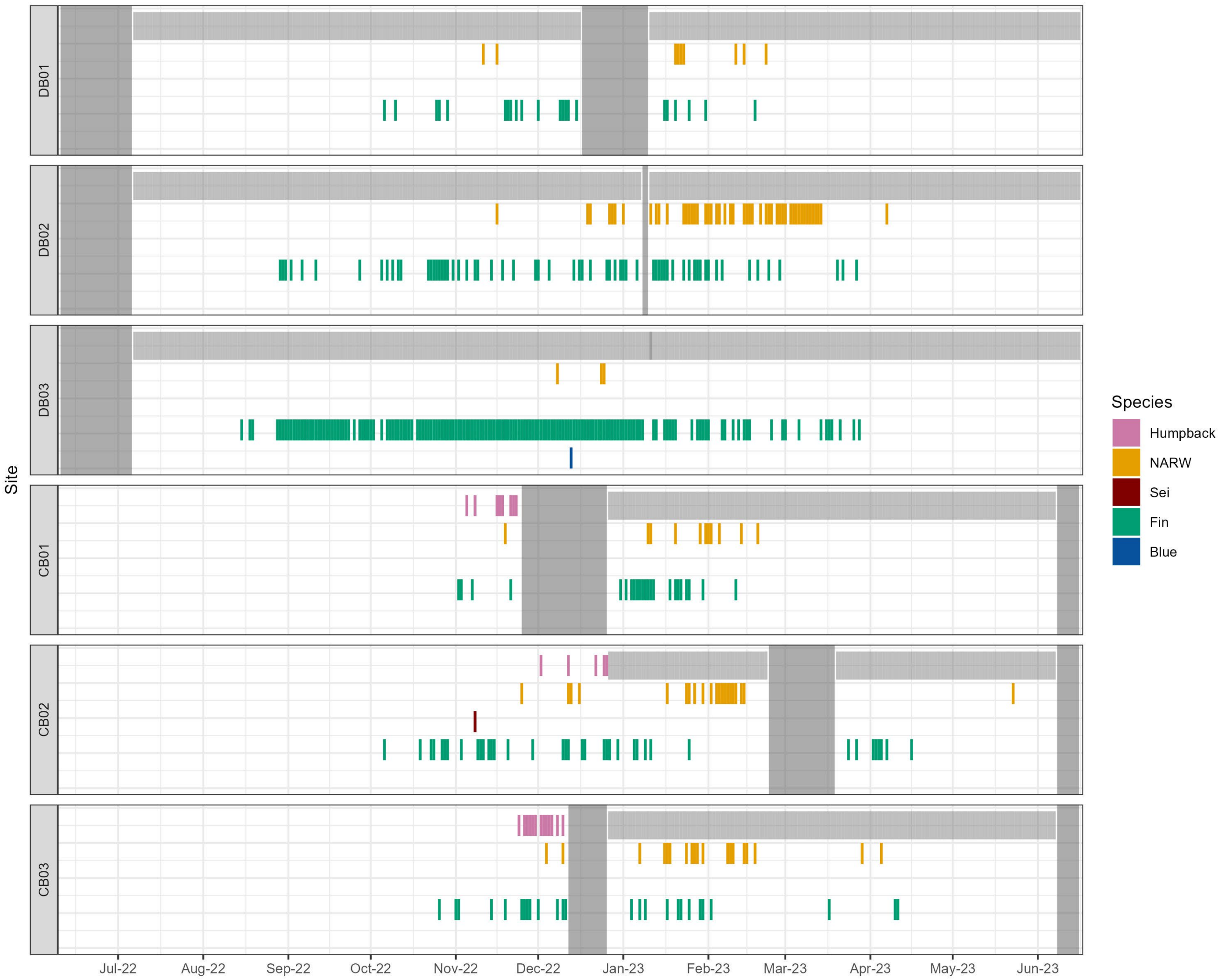


Figure 65. Daily confirmed detections of baleen whales from SoundTraps deployed from June 2022 to June 2023.

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APPENDIX A

SUMMARY OF MONITORING INVESTMENTS IN THE ATLANTIC FOR 2023–2024

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Appendix A: Summary of Monitoring Investments in the Atlantic for 2023–2024

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**: CEEs, DTAGs, satellite tags **Performing Organizations**: Duke University, Southall Environmental Associates, University of St. Andrews, Bridger Associates, Calvin College, HDR, Inc. **Timeline**: 2017–ongoing **Funding**: FY16 – $35K, FY17 – $1.25M, FY18 – $1.4M, FY19 – $1.4M, FY20 – $1.3M, FY21 – $1.25M, FY22 – $1.3M, FY23 – $1.17M	• 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 began 2023 • Technical progress reports available – 2017–2023 • 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** • Tagging field work continues under Atlantic BRS • Technical progress reports available – 2013–2018 • 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–ongoing **Funding**: FY15 – $75K, FY16 – $645K, FY17 – $0, FY18 – $321K, FY19 – $357K, FY20 – $371K, FY21 – $430K, FY22 - $530K, FY23 - $435k	• 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** • Sperm whale diving and feeding ecology focus beginning 2021 • Technical progress reports available – 2016–2023 • 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, FY23 – $790K	• 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** • Opportunistic visual monitoring, satellite-linked tagging, and suction-cup tag deployments in Mid-Atlantic beginning 2021 • DTAG deployments on SE calving grounds 2014–2017 • Autonomous PAM glider deployments (2018–2020), fixed auto-reporting PAM buoy off Cape Hatteras (2021–2023) and Cape Charles (2023–2024), Mid-Atlantic SoundTrap deployments (2022–2024) • 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–ongoing **Funding**: FY21 – $320K, FY22 – $420K, FY23 – $775k	• 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** • Expansion of nearshore humpback monitoring project in 2021 • Technical progress report available – 2022–2023 • Tagging primarily focused on mid-shelf • Humpback component focused on photo-ID and morphometric assessments • Tagging data – Animal Telemetry Network • Sighting data – OBIS-SEAMAP
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 – 2019–2023

Project Description	Intermediate Scientific Objectives	Status
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 completed** • Technical progress report available – 2017–2022 • 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–ongoing **Funding**: FY15 – $52K, FY16 – $57K, FY17 – $7K, FY18 – $29K, FY19 – $62K, FY20 – $40K, FY21 – $50K, FY22 – $93K, FY23 – $115K	• 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 – 2016–2023 • Time-lapse camera traps incorporated in 2019
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–ongoing **Funding:** FY19 – $15k, FY20 – $18K, FY21 – $11K, FY22 – $34K, FY23 – $58K	• 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 – 2019–2023

Project Description	Intermediate Scientific Objectives	Status
Title: Pinniped Monitoring in the Northeast [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:** $365K	• 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 – 2020–2023 • Potential transition to behavioral response study
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**: 2019–2024 **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 complete, final analysis in progress** • Technical progress reports available – 2019–2023 • Publication in prep based on final analysis results
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, PAM, tagging **Performing Organizations:** NOAA Fisheries Northeast and Southeast Fisheries Science Centers **Timeline:** 2010–2024 **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	**Complete** • AMAPPS I – 2010–2014 • AMAPPS II – 2015–2019 • AMAPPS III – 2020–2024 **Future investments for FY24+ TBD**

[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**: PAM **Performing Organizations**: Duke University, Scripps Institute of Oceanography **Timeline**: 2007–2024 **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 completed 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 • Consolidated technical report series in development
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**: PAM **Performing Organizations**: NOAA-NMFS, NEFSC **Timeline**: 2019-ongoing **Funding**: FY18 – $143k, FY19 – $145K, FY20 – $145K, FY21 – $150K, FY22 – $150K, FY23 – $0	• 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 – 2019–2023 • Multiple peer-reviewed publications available
Title: Jacksonville Shallow Water Training 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–ongoing **Funding**: FY18 – $261K, FY19 – $62K, FY20 – $97K, FY21 – $304K, FY22 – $116K, FY23 – $279K	• 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 M3R species verification support, supplemental photo-ID and tagging, and M3R system development

Project Description	Intermediate Scientific Objectives	Status
Title: Distribution of Gulf Sturgeon in the Panama City Testing Range [2] **Location**: NSWC Panama City Testing Range **Objectives**: Assess Gulf sturgeon distribution and habitat use through a multi-phase biotelemetry **Methods**: Passive acoustic telemetry, directed AUV surveys, and environmental monitoring **Performing Organizations**: University of Delaware, Delaware State University **Timeline**: 2021–2024 **Funding:** FY21 – $177K, FY22 – $149K, FY23 – $153K	• 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 Newport, Maine Department of Natural Resources, U.S. Geological Survey, PSNY, University of Maryland **Timeline**: 2021–2024 **Funding:** FY22 – $149K, FY23 – $157K	• 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: AMAPPS = Atlantic Marine Assessment Program for Protected Species; BRS = behavioral response study; CEE = controlled exposure experiment; DTAG = digital acoustic tag; ESA = Endangered Species Act; FY = Fiscal Year; K = thousand; M3R = Marine Mammal Monitoring on Navy Ranges; NAVFAC = Naval Facilities Engineering Systems Command; NE = Northeast; NEFSC = Northeast Fisheries Science Center; NMFS = National Marine Fisheries Service; NOAA = National Oceanic and Atmospheric Administration; NSWC = U.S. Naval Surface Warfare Center; NUWC = Naval Undersea Warfare Center; OBIS-SEAMAP = Ocean Biogeographic Information System-Spatial Ecological Analysis of Megavertebrate Populations; OPAREA = Operating Area; PAM = passive acoustic monitoring; photo-ID = photo identification; PSNY = Portsmouth Navy Yard; SE = Southeast; TBD = to be determined; UAS = Unmanned Aerial Systems; USWTR = Undersea Warfare Training Range; VACAPES = Virginia Capes

[1] Funded by Naval Sea Systems Command

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APPENDIX B

2023 PUBLICATIONS AND PRESENTATIONS RESULTING FROM AFTT-RELATED MONITORING INVESTMENTS

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Appendix B: 2023 Publications and Presentations Resulting from AFTT-related Monitoring Investments

Publications

Bort Thornton, J.E., M.E. Richlen, T.B. McDonald, and J.T. Bell. 2023. Opportunistic Sighting of a Tricolored Bat (*Perimyotis subflavus*). *Southeastern Naturalist* 22(1):N9–N12.

Cioffi, W.R., N.J. Quick, Z.T. Swaim, H.J. Foley, D.M. Waples, D.L. Webster, R.W. Baird, B.L. Southall, D.P. Nowacek, and A.J. Read. 2023. Trade-offs in telemetry tag programming for deep-diving cetaceans: data longevity, resolution, and continuity. *Animal Biotelemetry* 11:23.

Cohen, R.E., K.E. Fraiser, S. Baumann-Pickering, and J.A. Hildebrand. 2023. Spatial and temporal separation of toothed whales in the western North Atlantic. *Marine Ecology Progress Series* 720:1–24.

Hewitt, J., A.E. Gelfand, and R.S. Schick. 2023. Time-discretization approximation enriches continuous-time discrete-space models for animal movement. *Annals of Applied Statistics* 17(1):740–760.

Hin, V., A.M. de Roos, K.J. Benoit-Bird, D.E. Claridge, N. DiMarzio, J.W. Durban, E.A. Falcone, E.K. Jacobson, C.M. Jones-Todd, E. Pirotta, G.S. Schorr, L. Thomas, S. Watwood, and J. Hardwood. 2023. Using individual-based bioenergetic models to predict the aggregate effects of disturbance on populations: A case study with beaked whales and Navy sonar. *PLoS ONE* 18(8):e0290819.

Michelot, T., R. Glennie, L. Thomas, N. Quick, and C.M. Harris. 2023. Continuous-time modelling of behavioural responses in animal movement. *Annals of Applied Statistics* 17(4):3579–3588.

Presentations

Aschettino, J., D. Engelhaupt, A. Engelhaupt, T. Pusser, M. Cotter, M. Richlen, J. Bort Thornton, K. Jackson, and J. Bell. 2023. North Atlantic Right Whale Sightings and Group Composition in the VA/NC Mid-Atlantic: 2018-2023. Poster, 2023 North Atlantic Right Whale Consortium Annual Meeting, Halifax, Nova Scotia, Canada, 24–25 October 2023.

Engelhaupt, A., J. Aschettino, D. Engelhaupt, T. Pusser, J. Bell, and J. Bort Thornton. 2023. More than just a migration corridor: Important North Atlantic right whale surface-active behaviors observed in the western Mid-Atlantic. Presentation, 2023 North Atlantic Right Whale Consortium Annual Meeting, Halifax, Nova Scotia, Canada, 24–25 October 2023.

Engelhaupt, D., A. Engelhaupt, J. Aschettino, J. Bell, and J. Bort Thornton. 2023. In the strike zone? Tag data provides a better understanding of dive and surface behavior of North Atlantic right whales in the western Mid-Atlantic. Poster, 2023 North Atlantic Right Whale Consortium Annual Meeting, Halifax, Nova Scotia, Canada, 24–25 October 2023.

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

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

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