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MARINE SPECIES MONITORING PROGRAM

2025

ANNUAL REPORT

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

June 2026

Photo credits from left to right:

A satellite tag is deployed on a green turtle (*Chelonia mydas*) as part of the Kemp's ridley and green turtle availability bias study. Photographed by Annessia Michaels (project partner Inwater Research Group) taken under Florida State Marine Turtle Permit 25-125.

Adult male Ziphius (*Ziphius cavirostris*) surfacing off Cape Hatteras, North Carolina. Photographed by Will Cioffi (Southall Environmental Associates), taken under General Authorization Letter of Confirmation 25471 held by Duke University.

Harbor seals (*Phoca vitulina*) hauled out at Little Inlet on the Eastern Shore of Virginia during an aerial survey, taken under NMFS Scientific Research Permit Number 28184, issued to Dan Engelhaupt.

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
AOI	Area of Interest
AUTEC	Atlantic Undersea Test and Evaluation Center
BC	Babylon Canyon
BIW	Bath Iron Works
BP	Blake Plateau
BRS	behavioral response study
BS	Blake Spur
CAS	continuously active sonar
CATS	Customized Animal Tracking Solution
CBBT	Chesapeake Bay Bridge-Tunnel
CEE	controlled exposure experiment
CI	confidence interval
CMARI	Clearwater Marine Aquarium Research Institute
CRW	correlated random walk
CS-SVM	Class-Specific Support Vector Machine
dB	decibel(s)
DMON	digital acoustic monitoring instrument
DoN	Department of the Navy
DTAG	Digital Acoustic Recording Tag
DUML	Duke University Marine Laboratory
EDT	Eastern Daylight Time
ESA	Endangered Species Act
FL	Florida
FM	frequency-modulated
GA	Georgia
GMT	Greenwich Mean Time
GOM	Gulf of Mexico
GPS	Global Positioning System
GS	Gulf Stream
GUI	graphical user interface
HARP	High-frequency Acoustic Recording Package
HAT	Cape Hatteras
HDR	HDR Inc.
Hz	hertz
HZ	Heezen Canyon
ID	identifier or identification number
IRG	Inwater Research Group
JAX	Jacksonville
JSWTR	Jacksonville Shallow Water Training Range
kHz	kilohertz
km	kilometer(s)
lat	latitude
LFDCS	Low-frequency Detection and Classification System
LMR	Living Marine Resources
lon	longitude
M3R	Marine Mammal Monitoring on Navy Ranges
m	meter(s)
MA	Massachusetts
MAHWC	Mid-Atlantic Humpback Whale Photo-ID Catalog
Max/max	Maximum
MD	Maryland
ME DMR	Maine Department of Marine Resources
MFAS	mid-frequency active sonar
min	minute(s)
MINEX	Mine-neutralization Exercise
MMPA	Marine Mammal Protection Act
mm:ss	minutes:seconds
MSM	Marine Species Monitoring
N/A	not available or not applicable
NAHWC	North Atlantic Humpback Whale Photo-ID Catalog
NARW	North Atlantic right whale

NAVFAC	Naval Facilities Engineering Systems Command
NC	Nantucket Canyon
NC	North Carolina
NEAQ	New England Aquarium
NEFSC	Northeast Fisheries Science Center
NEPA	National Environmental Policy Act
NFC	Norfolk Canyon
nm	nautical mile(s)
NMFS	National Marine Fisheries Service
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
NY	New York
OBIS-SEAMAP	Ocean Biogeographic Information System-Spatial Ecological Analysis of Megavertebrate Populations
OC	Oceanographer Canyon
OCS	Offshore Cetacean Study
ONR	Office of Naval Research
OPAREA	operating area
OSB	Onslow Bay
PAM	passive acoustic monitoring
PAS	pulsed active sonar
photo-ID	photo-identification
PMRF	Pacific Missile Range Facility
RL	received level
RMS	root mean square
R/V	research vessel
s	second(s)
SBU	Stony Brook University
SEA	Southall Environmental Associates Inc.
SEFSC	Southeast Fisheries Science Center
SEL	Sound Exposure Level
SMA	Seasonal Management Area
SOAR	Southern California Anti-Submarine Warfare Range
SP	Sutherland/Patteson
SPOT	Smart Position and Temperature
UAS	unmanned aircraft system
UCF	University of Central Florida
UMaine	University of Maine
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
WAT	Western Atlantic
WC	Wilmington Canyon
Zc	*Ziphius cavirostris*

1 Introduction

This report contains a summary of Marine Species Monitoring (MSM) investments funded by the United States (U.S.) Navy in 2025 within the Atlantic Fleet Training and Testing (AFTT) study area as described in the *Atlantic Fleet Training and Testing Final Environmental Impact Statement/Overseas Environmental Impact Statement,* Phase III (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 (MMPA) of 1972 and Endangered Species Act (ESA) of 1973 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 (Aschettino et al. 2026; Debich et al. 2026; DiMatteo and Mansfield 2026; Engelhaupt et al. 2026; Fox and Breece 2026; Iafrate 2026; Jones 2026; Jones et al. 2026; Kristan et al. 2026; Ozog and Engelhaupt 2026, Ozog et al. 2025; Southall et al. 2026a; Van Parijs et al. 2026; Waples et al. 2026) 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 the 2025/26 season is provided in **Appendix A**.
- Publications and conference presentations for 2025 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 training and testing areas 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 of bays, harbors, inshore waterways, ports, and pier-side locations where military readiness activities occur. The U.S. Navy's range complexes that fall within the AFTT study area include the following (**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

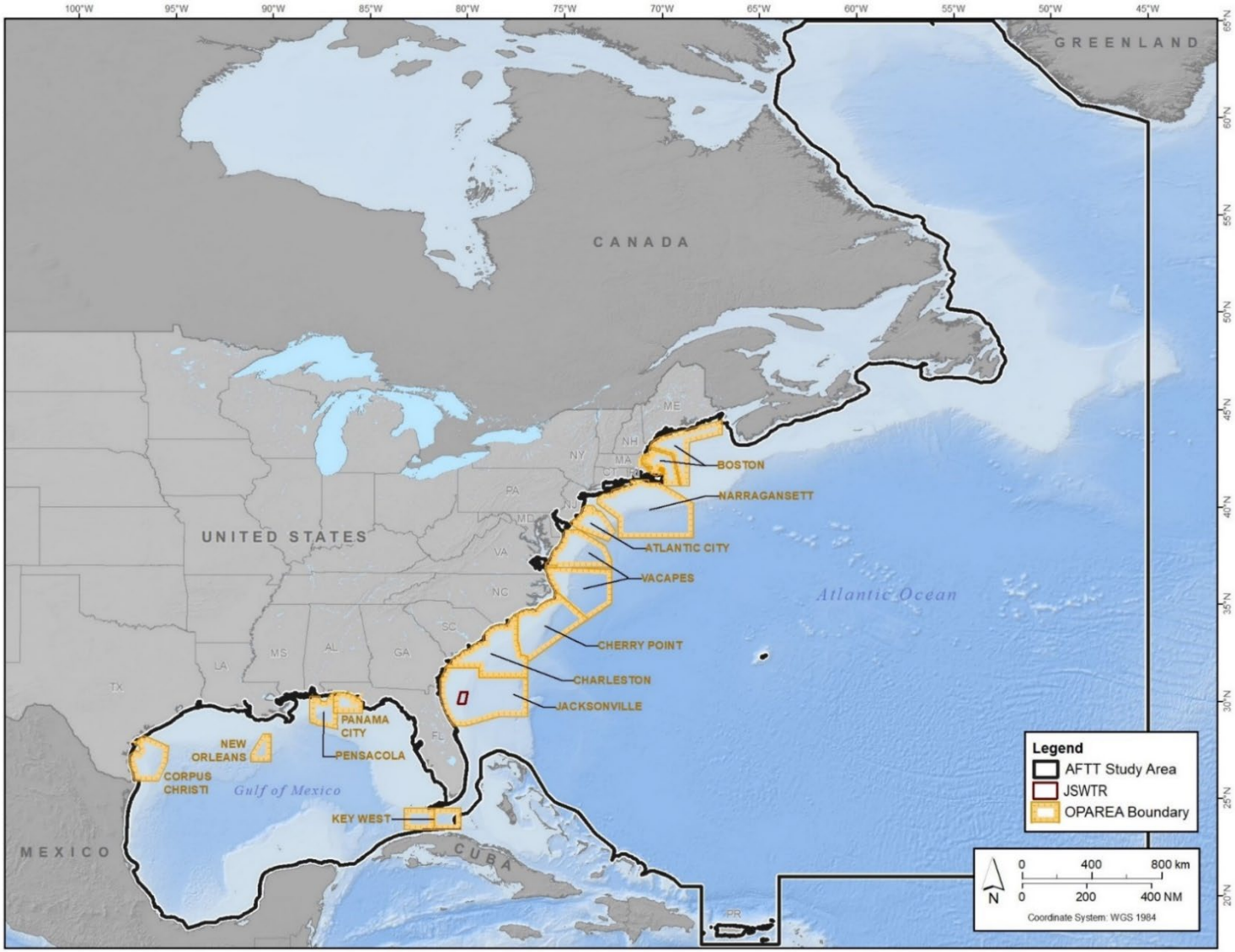


Figure 1. Atlantic Fleet Training and Testing study area.

In order to authorize the incidental taking of marine mammals under the MMPA, the National Marine Fisheries Service (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.

The U.S. Navy has invested more than $63 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 2009–2025.

Fiscal Year (01 October–30 September)	Funding
2009–2013	$15,330,000
2014–2018	$17,715,000
2019–2023	$21,314,000
2024	$4,180,000
2025	$4,724,000
Total	**$63,083,000**

In addition to the compliance monitoring program for training and testing activities, the Office of Naval Research (ONR) Marine Biology Program supports basic and applied research as well as technology development related to understanding the effects of sound on marine mammals, including physiological, behavioral, ecological, and population-level effects. The Office of the Chief of Naval Operations Environmental Readiness Program's Living Marine Resources (LMR) Program invests in Research Development Test and Evaluation projects supporting risk threshold criteria and impact assessments, 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 as components of an overall marine species research and monitoring strategic investment strategy.

1.2 Marine Species Research and Monitoring Strategic Framework

The mission of the U.S. Navy's MSM Program is to assess the effects of U.S. Navy training and testing on protected marine species by improving knowledge and understanding of marine species' occurrence and ecology, their exposure to military readiness activities, and the potential response of marine species when exposed to those activities. Secondarily, the program strives to contribute to the overall scientific knowledge base of marine species to support management, conservation, and protection. Specifically, overarching goals of the program are to increase understanding of:

- The occurrence of marine mammals and ESA-listed marine species within training and testing areas in terms of presence, abundance, distribution, and density;
- The nature, scope, or context of the exposure of marine mammals or ESA-listed marine species to any of the potential stressor(s) associated with the action;
- The behavioral or physiological response of individuals to specific stressors; and
- The detrimental consequences of responses to the long-term fitness and survival of individuals or the stock, population, or species overall.

New investments are developed and prioritized based on a set of Intermediate Scientific Objectives within a conceptual framework of Occurrence, Exposure, Response, and Consequences, progressing toward understanding the impacts that training and testing activities have on stocks and populations. The MSM Program has developed and matured significantly since its inception, and it now supports a portfolio of 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 U.S. Navy-wide needs such as the behavioral response of beaked whales to mid-frequency active sonar (MFAS). 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.

A Research and Monitoring Summit was held in early 2023 to evaluate the current state of the MSM Program in terms of progress, objectives, priorities, and needs as well as to solicit valuable input from meeting participants, including NMFS, the Marine Mammal Commission, and scientific experts. The overarching goal of the summit was to identify data gaps (i.e., "needs") as well as update and refine priorities to be addressed over the next 5 to 10 years across a range of tasks, from basic research through applied monitoring. The summit meeting also facilitated increased coordination and synergy across the U.S. Navy's protected marine species investment programs (LMR and ONR Marine Mammals and Biology Program). This will contribute to 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 2025 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 2025, 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 2026 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 the consequences of that exposure.

Appendix A summarizes U.S. Navy MSM investments within the Atlantic for 2025 and projects continuing in 2026. 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.

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 focused on acoustic monitoring (**Sections 2.1**, **2.2**, **2.3**, and **2.4.3.1**), Mid-Atlantic cetaceans (**Section 2.4**), behavioral response studies (BRSs; **Section 2.5**), species-verification trials (**Section 2.6**), Atlantic Marine Assessment Program for Protected Species (AMAPPS; **Section 2.7**), pinniped monitoring (**Section 2.8**), sea turtle tagging (**Section 2.9**), and sturgeon monitoring (**Sections 2.10** and **2.11**).

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 Historical High-Frequency Acoustic Recording Package Data Synthesis

Duke University and Scripps Institution of Oceanography began deploying High-frequency Acoustic Recording Packages (HARPs) as part of the original multi-disciplinary monitoring effort for Onslow Bay in 2007, which was later expanded to the JAX OPAREA in 2009, Cape Hatteras (HAT) in 2012, and Norfolk Canyon (NFC) in 2014. Deployments ended at the Onslow Bay site in 2013, JAX in 2019, HAT in 2020, and NFC in 2022. The primary objective of deployments at all locations was to determine patterns of species occurrence, compare distributional patterns across regions, and document species-specific vocalizations. In 2024/25, 57 deployments across all study areas underwent comprehensive re-analysis using standardized, state-of-the-art methods to ensure robust comparability of the data across sites. Details of the processing and synthesis of results are now available in a series of comprehensive technical reports. These long-term PAM projects have provided valuable insights into the dynamic marine mammal communities of the U.S. Mid-Atlantic and Southeastern shelf.

Data analyses reveal significant depth-stratification and seasonal variations in the presence of odontocetes (i.e., toothed whales and dolphins). Deep-diving species, such as sperm (*Physeter macrocephalus*) and Gervais' beaked (*Mesoplodon europaeus*) whales, were the most consistent deep-water residents in the southern, Gulf Stream-influenced waters of Onslow Bay and HAT. In contrast, True's (*Mesoplodon mirus*) and Sowerby's (*Mesoplodon bidens*) beaked whales were more prevalent in cooler, northern slope habitats, highlighting HAT as a key biogeographic boundary. Smaller delphinids, including various *Stenella* species and offshore

bottlenose dolphins (*Tursiops truncatus*), were common across all areas, but showed preferences for shallower shelf waters and exhibited seasonal peaks during summer and fall months.

Mysticetes (i.e., baleen whales) generally used the monitored areas for seasonal migrations and transitional habitat rather than primary feeding grounds. Fin (*Balaenoptera physalus*) and minke (*B. acutorostrata*) whales were the most regularly detected baleen whales, with primary presence from fall through spring. Other species such as humpback (*Megaptera novaeangliae*), blue (*B. musculus*), and sei (*B. borealis*) whales were detected during their seasonal movements, although North Atlantic right whales (NARWs; *Eubalaena glacialis*) were only sporadically or occasionally detected, consistent with animals in transit through the region.

The local acoustic environment within all four regions was characterized by a combination of natural and anthropogenic sound sources. The persistent, basin-wide presence of commercial shipping traffic was a dominant source of low-frequency ambient noise. Naval activity was also detected, with mid-frequency tactical sonar (1 to 10 kilohertz [kHz]) and explosions recorded intermittently across the Onslow Bay and NFC OPAREAs. Sonar signals were detected during specific periods within the monitored areas.

These extensive datasets provide a crucial baseline for understanding the diverse marine mammal communities that inhabit these variable oceanographic settings, and how they interact with both natural soundscapes and human activities. The comprehensive re-analysis ensures consistent data quality, enabling robust future assessments of environmental change and anthropogenic impacts on marine life distribution and acoustic habitat use across the western North Atlantic.

Links to available individual technical analyses from all previous HARP deployments can be found through the PAM data explorer on the U.S. Navy's MSM Program web portal.

All data from deployments has been contributed to a broad analysis of North Atlantic shelf break species (see **Section 2.2**) and multiple other collaborative studies, resulting in dozens of peer-reviewed publications and presentations at scientific conferences. For more information on the HARP program, refer to the primary literature publications using data from previous HARP deployments (Davis et al. 2017, 2020; DeAngelis et al. 2025; Haver et al. 2025; Hodge et al. 2018; Stanistreet et al. 2016).

Refer to Posdaljian et al. (2026a) for more information on HAT; Posdaljian et al. (2026b) for more information on Onslow Bay; Posdaljian et al. (2026c) for more information on NFC; Posdaljian et al. (2026d) for more information on JAX; and Posdaljian et al. (2026e) on anthropogenic noise.

2.2 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, National Oceanic and Atmospheric Administration's (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 to 2021. 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; DeAngelis et al. 2025; Stanistreet et al. 2017, 2018). This project focuses on analyses of the datasets collected from 2015 to 2021, with the inclusion of older (pre-2015) datasets where relevant. The focus of 2025 study efforts have been to make substantial progress in the review of various detector classifications (e.g., beaked whale, minke whale, sonar) to support this project's fine scale scientific questions.

Work conducted during 2025 was aimed at these key objectives:

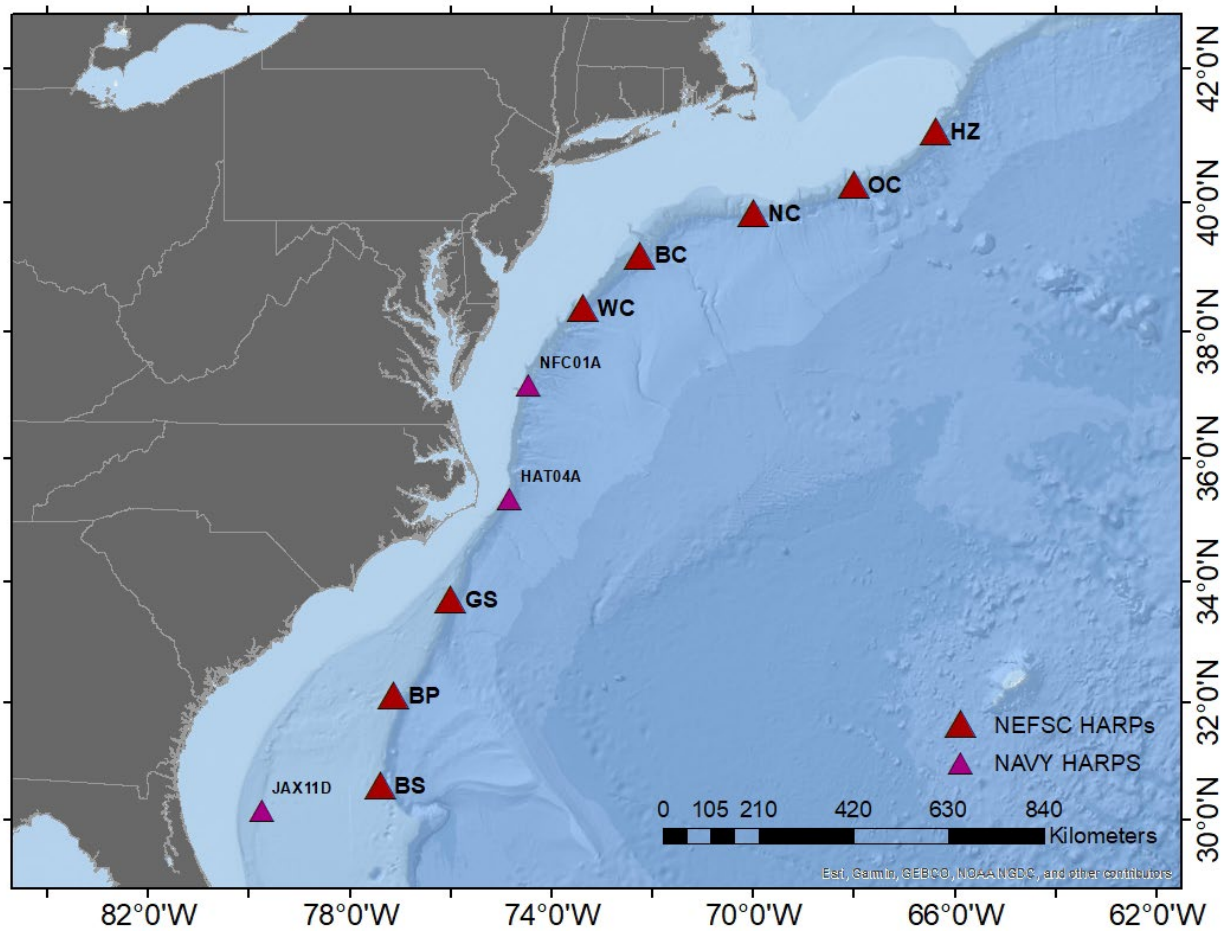
- Validate neural net classifications of beaked whales across HARP sites, with the goal to use the results for fine scale ecological questions;
- Assess the effects of anthropogenic noise on beaked whale vocal activity; and
- Analyze minke whale presence at the U.S. Navy HARP sites.

The NEFSC and U.S. Navy have been collecting continuous passive acoustic recordings at 11 sites 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), NFC, HAT, and JAX (U.S. Navy deployments). These were expanded in 2016 to include Wilmington and Babylon Canyons north of HAT as well as Gulf Stream, Blake Plateau, and Blake Spur south of HAT (**Table 2, Figure 2**). 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 2. 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	September 2021	950–1,050
Cape Hatteras (HAT)	April 2015	October 2020	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 2020	736–750

Key: m = meter(s)



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

Figure 2. HARP deployment sites for data analyzed from 2015 through 2021.

2.2.1 Analyses

I. Validate neural net classifications of beaked whales across HARP sites.

Beaked whale echolocation is considered to be cryptic with respect to other odontocete species. Echolocation periods range from 19 to 35 minutes (min) (DeAngelis et al. 2025), and due to their high directionality (e.g., Shaffer et al. 2013), small group sizes (Claridge 2006), and synchronized foraging dives (Alcázar-Treviño et al. 2021), a subset of the group's total echolocation is captured on a single sensor (Hildebrand et al. 2015). This is in contrast to less directional echolocating species such as sperm whales, and members of Delphinidae family that occur in relatively larger groups. As such, beaked whales echolocation clicks are considered "ephemeral" and require a tailored click detection process that is able to filter out much of the "noise" caused by Delphinidae and sperm whales for an analyst to review. Solsona-Berga et al. (2024) designed a two-stage, machine-learning, neural network that first removes clicks that

match the characteristics of non-beaked whale echolocation clicks (i.e., impulsive clicks) and then bins the remaining data based on classifications learned from a subset of the Western Atlantic (WAT) dataset. These classifications then need to be reviewed by a trained analyst to confirm the species classification.

All of the datasets were processed with the neural network. Review of the U.S. Navy range HARPs at NFC, HAT, and JAX were completed and are being used for anthropogenic noise impact analysis. Review of 3 years from the remaining eight sites is currently in progress. Each site is subdivided into hard-drive disks, which do not represent a set interval of time (**Figure 3**).

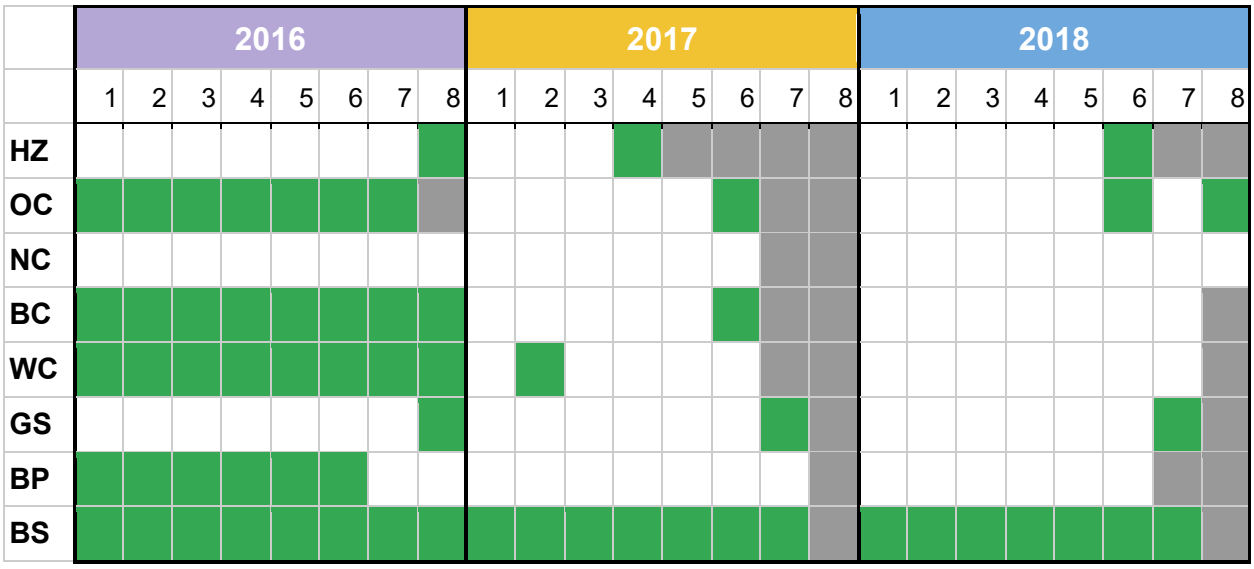


Figure 3. Progress of validating the neural network classifications across the WAT HARP sites. Green cells represent disks that have been completely validated, gray cells represent disks with no data collected, and white cells represent those that have yet to be validated.

II. Assess the effects of anthropogenic noise on beaked whale vocal activity.

The goal for this component of the project is to assess the potential impacts of MFAS on beaked whale acoustic activity in the Western North Atlantic. The analyses incorporate data for several beaked whale species to detect acoustic behavioral responses to sonar operations within areas with varying naval activity. Understanding the relationship between MFAS and the acoustic behavior of beaked whales is complex and requires the inclusion of natural temporal and spatial variability in click densities, such as those caused by species or population-level seasonality, habitat preference, the behavioral context of echolocating, and individual variability. For this part of the project, analyses focused on the U.S. Navy HARP sites where MFAS is present.

For this reporting period, the focus was on expanding the number of deployments included in this analysis, since previous efforts showed there were not enough data with beaked whale presence and MFAS overlap to understand potential impacts (Van Parijs et al. 2025). The

previous statistical analysis of sonar impact was conducted using beaked whale and MFAS acoustic data for NFC between 2014 and 2020, HAT between 2015 and 2020, and JAX between 2016 and 2020 (Van Parijs et al. 2025). For each of these three sites, an additional year's worth of data has been added (**Table 3**). Additionally, the Cherry Point OPEREA (Onslow) site has been added. Deployments included in this analysis now span across four U.S. Navy sites (NFC, HAT, Onslow, and JAX) between 2011 and 2021. The current effort processed these additional deployments for detection of MFAS and prepared data for modeling. Beaked whale signals were detected and classified in 1-min bins using a deep neural network (Solsona-Berga et al. 2024), developed and trained with funding from this project. The resulting labels from the neural network were validated using DetEdit (Solsona-Berga et al. 2020). Automatic detection of MFAS was implemented using a modified version of the Silbido detection system (Roch et al. 2011) designed for characterizing toothed whale whistles. Method details for the detection of MFAS were reported in Van Parijs et al. (2021).

Table 3. Summary of analysis of U.S. Navy HARP sites using automated methods for beaked whale and MFAS detections.

Location[a]	Season	Site	Beaked Whales	MFAS
Norfolk Canyon (NFC)	—	—	—	—
—	2014–2015	NFC01A	Previously completed	Previously completed
Added	2016–2017	NFC_A_02	Previously completed	Completed in 2025
—	2017–2018	NFC_A_03	Previously completed	Previously completed
—	2018–2019	NFC_A_04	Previously completed	Previously completed
—	2019–2020	NFC_A_05	Previously completed	Previously completed
—	2021–2021	NFC_A_06	Previously completed	Previously completed
Cape Hatteras (HAT)	—	—	—	—
Added	2012–2012	HAT01A	Previously completed	Completed in 2025
Added	2012–2013	HAT02A	Previously completed	Completed in 2025
Added	2013–2014	HAT03A	Previously completed	Completed in 2025
Added	2014–2014	HAT04A	Previously completed	Completed in 2025
—	2015–2016	HAT_A_05	Previously completed	Previously completed
—	2016–2017	HAT_A_06	Previously completed	Previously completed
—	2017–2017	HAT_B_01_01	Previously completed	Previously completed
—	2017–2018	HAT_B_03_01	Previously completed	Previously completed
—	2018–2018	HAT_B_04_01	Previously completed	Previously completed
—	2018–2019	HAT_B_05	Previously completed	Previously completed
—	2019–2019	HAT_B_06_01	Previously completed	Previously completed
—	2019–2020	HAT_B_07	Previously completed	Previously completed

Location[a]	Season	Site	Beaked Whales	MFAS
Cherry Point (Onslow)	—	—	—	—
Added	2011–2011	USWTR06E	Previously completed	Completed in 2025
Added	2012–2012	USWTR07E	Previously completed	Completed in 2025
Added	2012–2013	USWTR08E	Previously completed	Completed in 2025
Jacksonville (JAX)	—	—	—	—
Added	2014–2015	JAX11D	Previously completed	Completed in 2025
—	2016–2017	JAX_D_13	Previously completed	Previously completed
Added	2017–2017	JAX_D_14	Previously completed	Completed in 2025
—	2018–2019	JAX_D_15	Previously completed	Previously completed
—	2019–2020	JAX_D_16	Previously completed	Previously completed

[a] Newly included deployments are denoted as 'Added'

Five species of beaked whales—Sowerby's, Blainville's (*Mesoplodon densirostris*), Gervais', True's, and goose-beaked (*Ziphius cavirostris*)—were studied across the four U.S. Navy sites. Overall presence was highest at HAT, which also had the lowest MFAS activity. In contrast, JAX had the highest MFAS use and the lowest beaked whale presence, though the shallower depth of JAX may also influence the occurrence of these deep-diving species. Goose-beaked whales showed particularly high presence at HAT and were the most frequently detected species there, where they also had the greatest overlap with sonar activity. They occurred at low to moderate levels at NFC and at generally low levels with occasional peaks at Onslow. Gervais' beaked whales had especially high presence at Onslow and were the most frequently detected species at that site, which was also where their overlap with sonar was greatest. The co-occurrence of higher presence and sonar at Onslow allows evaluation of potential effects on this species. Gervais' beaked whales also occurred at low to moderate levels at HAT. Sowerby's and True's beaked whales showed the most consistent and highest presence at the northernmost site, NFC, where they also exhibited the greatest overlap with sonar, enabling assessment of potential effects. This additional data will be incorporated into a comprehensive statistical analysis of MFAS effects on beaked whale acoustic behavior in the coming study year.

III. Analyze minke whale presence on the U.S. Navy HARP sites.

Daily presence analysis of minke whales at all HARP sites within U.S. Navy ranges (NFC, HAT, Onslow, JAX) was completed using an improved minke whale detection algorithm written in python. This algorithm uses a binary ResNet18 deep neural network to detect and automatically classify minke whale pulse trains based on spectrogram images. An analyst then manually reviewed the detections based on the algorithm's confidence using the spectrograms and audio files written in the detector output. Detections were organized by confidence score per day with the highest confidence detections reviewed first, until a true positive was identified. In general, minke whales were present at all U.S. Navy HARP sites during non-summer months (October through May).

For more information regarding this study, refer to the annual progress report for this project (Van Parijs et al. 2026).

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

The Rice's whale (*Balaenoptera ricei*; formerly Gulf of Mexico Bryde's whale) is estimated to have a population size of 51 individuals in U.S. waters (Garrison et al. 2020) and was listed as endangered under the ESA in 2019 (84 *Federal Register* 15446, 87 *Federal Register* 8981). The majority of modern sightings occur within waters between the 100- and 400-meter (m) isobaths within an area near the De Soto Canyon off northwestern Florida (Rosel et al. 2021; Soldevilla et al. 2017). 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 to 2024 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 beyond, 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 as well as Eglin Air Force Base activities, overlap with the whales' core distribution area. Understanding seasonal distribution and density of Rice's whales throughout the core habitat will improve understanding of potential impact of human activities within 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 within the core habitat of these endangered whales, the Southeast Fisheries Science Center (SEFSC) began deploying a sparse array of 17 PAM units concurrent with 1 long-term HARP in May 2021. The PAM moorings were deployed in two lines of nine units each to nearly completely cover the core habitat (**Figure 4**) over a 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 (Hz) to 48-kHz frequency range, including Rice's whale calls and ambient noise, for up to 6 months. Additionally, the study leverages a long-term HARP 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, the units have been continuously recording ambient noise and other acoustic events in the 10-Hz to 100-kHz frequency range since 2010 to monitor the impacts of the Deepwater Horizon oil spill and subsequent restoration activities on cetaceans. Together with the sparse array of SoundTraps, these PAM deployments provide the necessary data to understand seasonal distribution and density of Rice's whales.

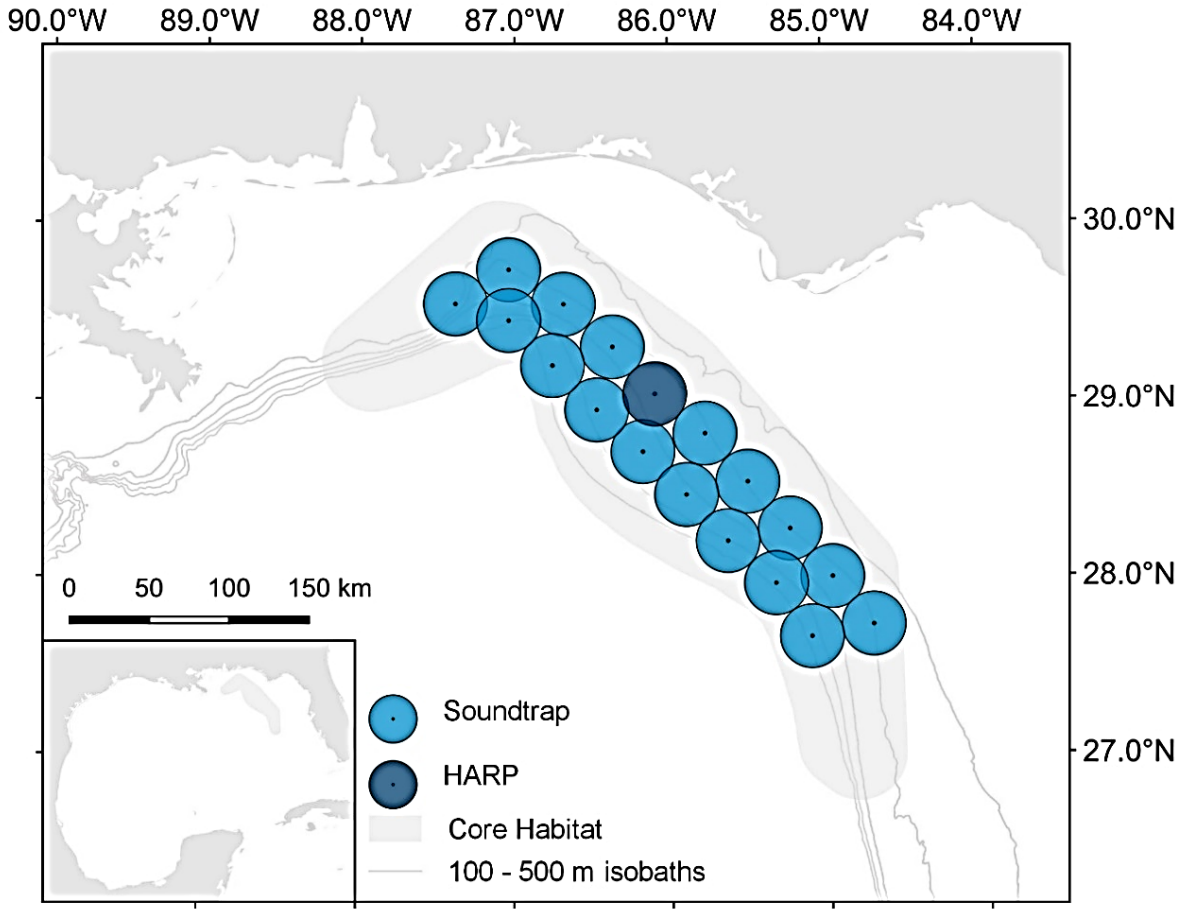


Figure 4. Historic long-term HARP in the Rice's whale core habitat since 2010, and 2021 through 2026 SoundTrap stations.

Statistical analyses and manuscript preparation are currently underway. These analyses also include data from a fourth deployment funded by NOAA Office of Protected Resources in 2022–2023. An additional year of data collection (two approximately 6-month deployments) began in June 2025 under funding from the U.S. Navy. Data collection will be completed in 2026, when the SoundTraps and HARP will be retrieved. Statistical analyses to evaluate diel, seasonal, and spatial variation, as well as call density estimation will begin during fall 2026 and will be incorporated into analysis products and manuscripts for publication. 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.

For more information regarding this study as well as details of ongoing analyses and results, refer to the annual progress report for this project (Debich et al. 2026).

2.4 Mid-Atlantic Cetaceans

2.4.1 Mid-Atlantic Marine Mammal Aerial Survey Effort

Dedicated, systematic marine mammal aerial surveys using distance sampling protocols have previously been conducted throughout the VACAPES OPAREA. The Virginia Aquarium & Marine Science Center Foundation, Inc. and the University of North Carolina Wilmington (UNCW) conducted aerial line-transect surveys within the VACAPES OPAREA continental shelf region from 2016 to 2017 (Mallette et al. 2017). Offshore aerial line-transect surveys were flown near NFC by UNCW from 2015 to 2017 (McAlarney et al. 2016, 2017, 2018) and by HDR Inc. from 2018 to 2019 (Cotter 2019). HDR Inc. researchers recorded their first NARW sightings during these surveys in April 2018 (Cotter 2019). Dedicated systematic aerial survey coverage has not been conducted within the VACAPES OPAREA since these surveys ended in August 2019; however, targeted aerial survey effort has recently been implemented to support ongoing vessel-based fieldwork within the region.

Both the Offshore Cetacean Study (OCS; **Section 2.4.2**) and Mid-Shelf Baleen Whale Monitoring Project (**Section 2.4.3**) aim to provide baseline habitat use and ecological information to the U.S. Navy regarding how marine mammals use the VACAPES OPAREA. These projects aim to answer questions regarding the baseline ecology, behavior, occurrence, movement patterns, and site fidelity of marine mammals that may be exposed to U.S. Navy training and testing exercises. HDR Inc. researchers use a variety of methodologies, including photo-identification (photo-ID), biopsy sampling, drones, satellite-linked telemetry tags, and digital archival tags (Digital Acoustic Recording Tags [DTAGs] and Customized Animal Tracking Solution [CATS] tags). To assist the vessel team with these efforts in locating target species, non-systematic aerial surveys were implemented beginning in March 2021 (Aschettino et al. 2023a). Aerial survey efforts increased during the 2022/23 and 2023/24 seasons, with 8 (Aschettino et al. 2024a) and 13 (Ozog and Engelhaupt 2025) surveys flown, respectively. While surveys were primarily associated with locating NARWs, some aerial surveys were also flown in tandem with OCS fieldwork. This section details the coverage and sightings from aerial surveys flown during the 2024/25 field season in coordination with vessel surveys for both projects (Aschettino et al. 2026; Engelhaupt et al. 2026).

2.4.1.1 Survey Effort/Summary

Twenty-four aerial surveys were flown during the 2024/25 field season, covering 21,292 kilometers (km) of trackline with more than 100 hours of survey effort (**Figure 5**). The first aerial survey occurred on 19 November 2024, and the last survey occurred on 23 September 2025.

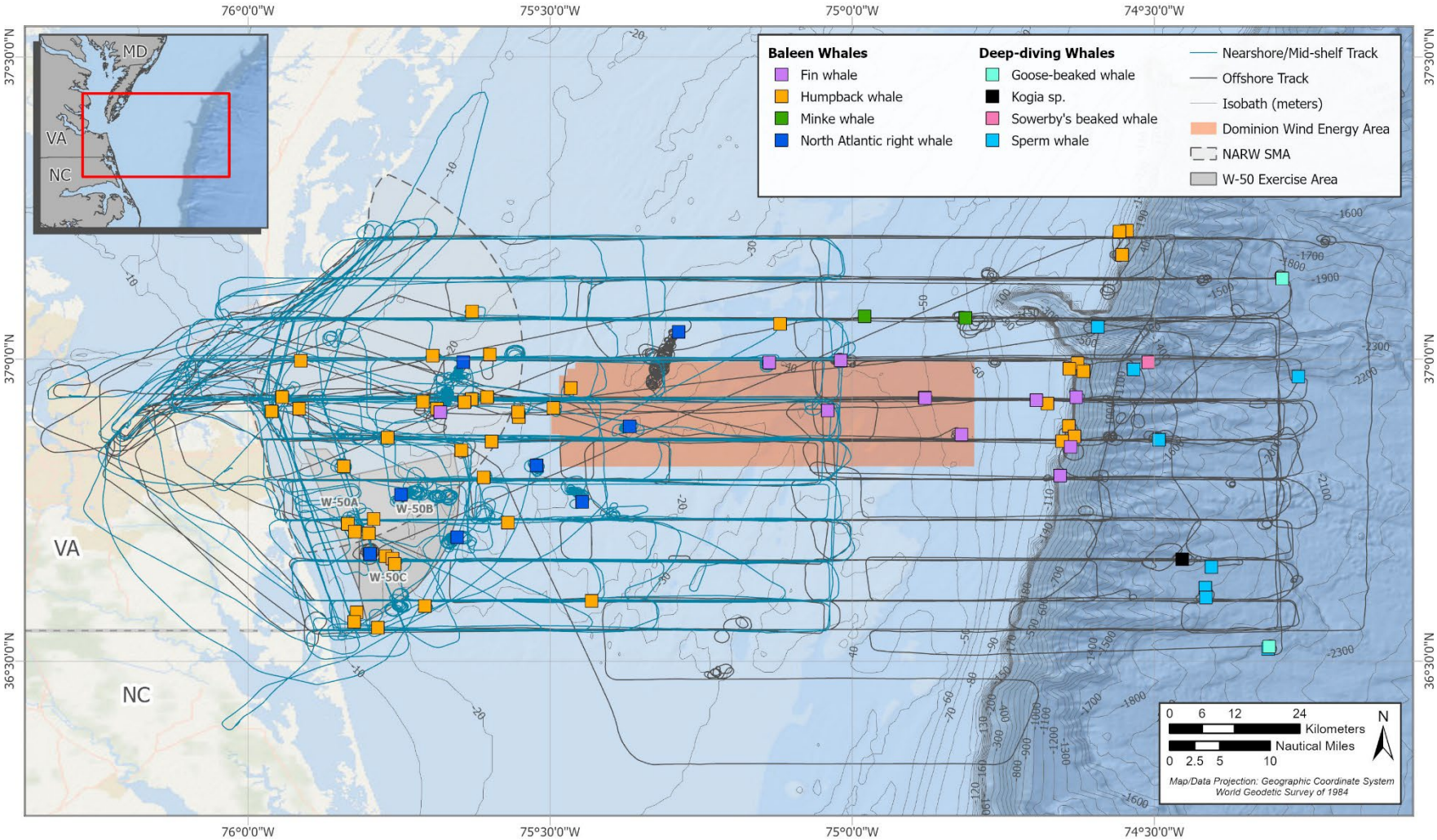


Figure 5. **Aerial survey tracks (teal and gray), with locations of all fin (*n*=11), humpback (*n*=45), minke (*n*=3), North Atlantic right (*n*=8), *Ziphius* (*n*=2), *Kogia* sp. (*n*=1), Sowerby's beaked (*n*=1), and sperm (*n*=8) whale sightings for the 2024/25 field season.**

2.4.1.2 Sightings

In total, 67 sightings of baleen whales occurred, including 8 NARW sightings totaling 23 individuals, 11 fin whale sightings totaling 17 individuals, 45 humpback whale sightings totaling 67 individuals, and 3 minke whale sightings totaling 3 individuals (**Figure 5**; see **Section 2.4.3.2** and Aschettino et al. 2026 for additional details on baleen whale sightings and photo-ID, and **Section 2.4.4** for additional details on NARWs). Of these sightings, one was recorded as multi-species and was composed of fin and humpback whales.

Additionally, 12 sightings of deep-diving whales were recorded, including 8 sperm whale sightings totaling 14 individuals, 2 *Ziphius* sightings totaling 4 individuals, 1 Sowerby's beaked whale sighting of 2 individuals, and 1 *Kogia* sp. sighting of 2 individuals, during aerial surveys that extended out to deeper waters beyond the shelf break (**Figure 5**; see **Section 2.4.2.2** and Engelhaupt et al. 2026 for additional details on sperm whale sightings and photo-ID). Additionally, one deceased short-finned pilot whale (*Globicephala macrorhynchus*) was observed with an entanglement on 8 May 2025. Sighting information and photographs of the individual were shared with the Virginia Aquarium Stranding Response Program post-survey.

Sightings of dolphins, including bottlenose, common (*Delphinus delphis*), striped (*Stenella coeruleoalba*), Atlantic spotted (*Stenella frontalis*), and Risso's (*Grampus griseus)*, as well as pilot whales (*Globicephala* sp.), harbor porpoise (*Phocoena phocoena*), great white sharks (*Carcharodon carcharias*), basking sharks (*Cetorhinus maximus*), and ocean sunfish (*Mola mola*) occurred during aerial surveys but were not always recorded.

2.4.1.3 Discussion

The waters off Virginia and the mouth of Chesapeake Bay are used extensively for commercial shipping, recreational and commercial fishing, wind energy development, and U.S. Navy training exercises. From 1 November to 30 April, a NARW Seasonal Management Area (SMA) is in place from the mouth of Chesapeake Bay out to 37 km from shore. Within the SMA, a 10-knot vessel speed restriction is in place for vessels of 19.8 m or longer. However, the majority of NARW sightings during the 2022/23 season (Aschettino et al. 2024a), all during the 2023/24 season (Aschettino et al. 2025a; Ozog and Engelhaupt 2025), and the majority during the 2024/25 season occurred outside the SMA, indicating that current conservation measures do not offer sufficient protection within the region (**Figure 5**).

The addition of aerial surveys to complement vessel surveys for the Mid-Atlantic Baleen Whale Monitoring Project and OCS has proven extremely beneficial by (1) providing greater coverage of the study area; (2) locating and identifying individuals and aggregations of critically endangered NARWs; and (3) working with the vessel team to maximize sighting opportunities and photo-ID, photogrammetry, and tagging efforts. Additionally, the aerial team's perspective allows for NARW behavioral observations that may not be obvious from the vessel, such as subsurface and social behaviors. Overall, these efforts have begun to fill critical data gaps in NARW habitat use and distribution as well as highlight the importance of the Mid-Atlantic as more than just a migratory corridor.

Since 2017, an Unusual Mortality Event (UME) has been ongoing for NARWs due to increased cases of mortality, serious injury, and morbidity, of which most are attributed to fishing gear entanglements or vessel strikes (NOAA 2026a). In February 2023, the carcass of adult male NARW #3343 washed up on a beach near the Chesapeake Bay Bridge Tunnel (CBBT) in Virginia Beach, and necropsy results indicated he "suffered a catastrophic blunt force traumatic injury, which impacted a large portion of the spinal column. The injuries are consistent with a vessel strike" (NOAA 2026b). In March 2024, the HDR Inc. aerial team first documented the carcass of adult female NARW #1950, which was a significant finding for the UME. NARW #1950 was a mother from the 2024 calving season and had a dependent calf, which was not relocated near the carcass. The calf was last seen in February 2024 on the calving grounds (NOAA 2026c). NOAA released a statement on the necropsy indicating that "preliminary findings included catastrophic injuries with a dislocation of the whale's spine and fractures to all vertebrae in the lower back. These findings are consistent with blunt force trauma from a vessel strike prior to death" (NOAA 2026c). These necropsy results, coupled with most NARW sightings from HDR Inc. aerial and vessel surveys over the past three field seasons occurring outside the SMA (Aschettino et al. 2024a, 2025a, 2026; Engelhaupt et al. 2025; Ozog and Engelhaupt 2025), further emphasize the vulnerability of NARWs to vessel strikes in the Mid-Atlantic.

Aerial surveys during the 2025/26 field season will continue to coordinate efforts with the vessel team to maximize additional opportunities to deploy satellite and digital archival tags on baleen and deep-diving whales within the VACAPES OPAREA.

For more information on these survey efforts, refer to the annual aerial progress report (Ozog and Engelhaupt 2026).

2.4.2 VACAPES Offshore Cetacean Study

HDR Inc. 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 as well as within the W-50 Mine-neutralization Exercise (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 OCS 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 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 2025 field season are summarized below and detailed in Engelhaupt et al. (2026).

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?

2.4.2.1 Vessel Survey Effort/Summary

The study area spans 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 17 offshore vessel surveys, covering 5,283 km of trackline as well as more than 205 hours of effort between September 2024 and August 2025 (**Figure 6**).

A total of 176 marine mammal sightings and 18 sea turtle sightings were recorded during vessel surveys during the 2024/25 reporting period (**Figure 6**). Twelve cetacean taxa were identified: five baleen whale species, including fin whale (*n*=12), humpback whale (*n*=7), blue whale (*n*=1), minke whale (*n*=1), and NARW (*n*=1); and seven odontocete taxa, including unidentified pilot whale (*n*=39), sperm whale (*n*=17), *Ziphius* (*n*=1), short-finned pilot whale (*n*=1), common bottlenose dolphin (*n*=32), common dolphin (n=31), Risso's dolphin (*n*=26), and Atlantic spotted dolphin (*n*=7). Because both short- and long-finned pilot whales may occur within this region, most sightings of the genus *Globicephala* spp. were not assigned a species unless they were closely approached and could be definitively identified, which was not typically the case. Two sea turtle species were also identified: loggerhead turtle (*Caretta caretta*; *n*=14) and leatherback turtle (*Dermochelys coriacea*; *n*=4).

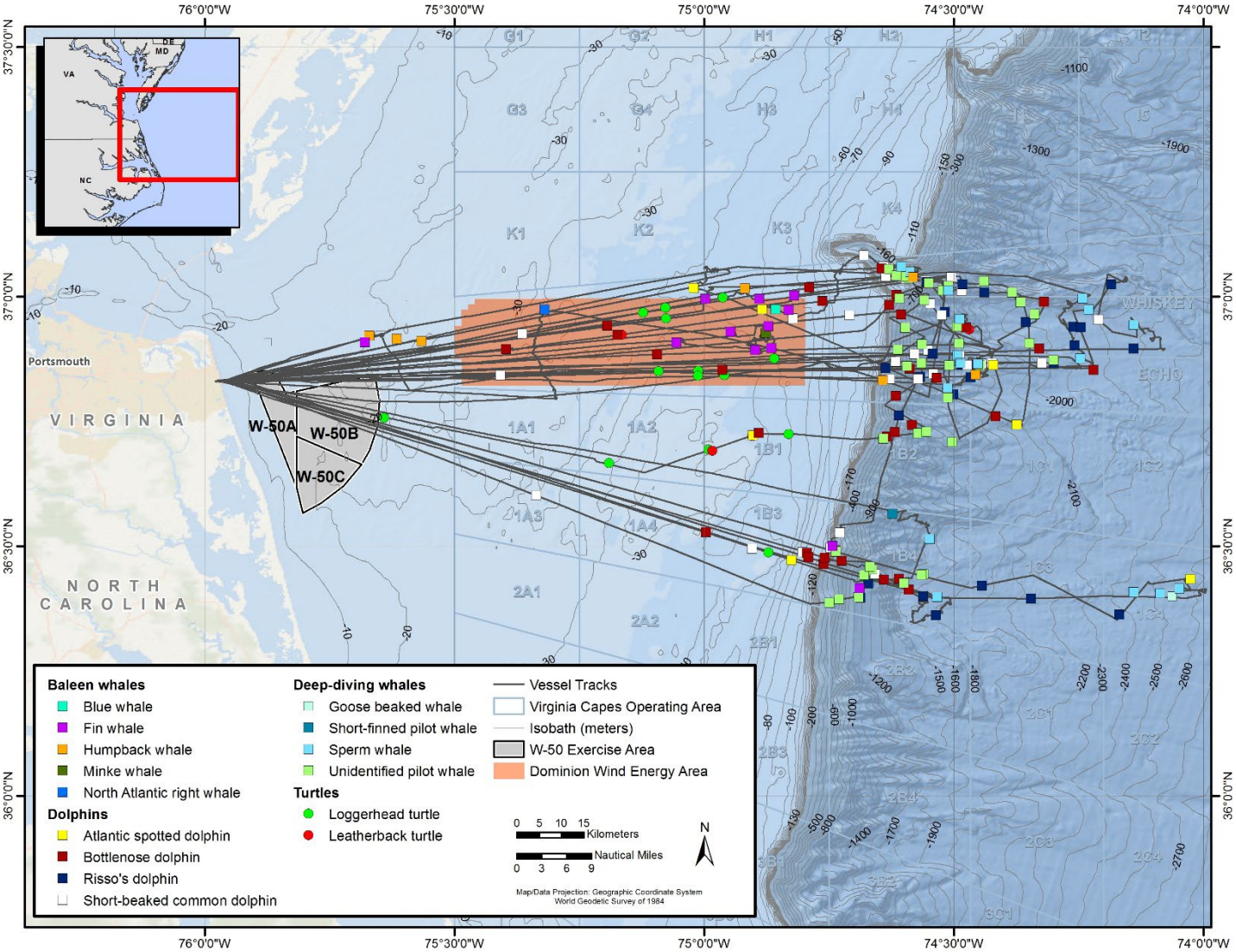


Figure 6. **Offshore survey tracks with locations of all baleen whale (*n*=22), deep-diving odontocete (*n*=58), dolphin (*n*=96), and sea turtle (*n*=18) sightings during surveys conducted during the 2024/25 reporting period.**

2.4.2.2 Photo-identification

Photo-ID images were collected from 55 of the 176 marine mammal sightings. All photographs of baleen whales were added to HDR Inc.'s existing catalogs, and results are reported in Aschettino et al. (2026). Photographs were collected of 49 individual sperm whales during the 2024/25 season, consisting of 44 uniquely identified individuals. All photo-IDs were added to the sperm whale catalog, which now contains 185 individuals. The majority of sperm whale individuals photographed during the reporting period were new to the catalog (40 of 44, 90.1 percent). A group sighted on 11 May 2025 included one individual initially sighted by HDR Inc. in August 2017 (HDRVAPm023) and again in July 2022. Many individuals from that same group were re-sighted together on 28 August 2025. Five were new individuals to the catalog, and four of the five were re-sighted the following day. Of the total catalog of 185 individuals, 31 (16.7 percent) were sighted on more than 1 day, ranging from 1 to 2,947 days between first and last sightings (mean = 769, median = 428) and 23 (12.4 percent) have been seen in 2 or more years (range = 2 to 5 years).

Pilot whale photographs were provided to Duke University, and comparisons of individuals through 2025 with their HAT catalog have been completed (**Section 2.5.6**, Waples et al. 2026). Twenty individuals were added to the pilot whale catalog for this project, none of which were re-sightings. The Norfolk catalog now contains 344 individual pilot whales, and the updated total of matches between Virginia and North Carolina is 13.6 percent (47 of 344).

2.4.2.3 Tagging and Biopsy Samples

Four biopsies were collected, all from sperm whales. Processing and analysis of these samples, as well as the five sperm whale samples collected previously during 2023 and 2024, was completed by Oregon State University. One 2025 sample was a genetic match to a female sampled in 2017 but was not matched using photo-ID because the earlier sighting did not include fluke photographs. One sample was not large enough to produce conclusive gender results but did generate a haplotype. The sampled individuals consisted of three females, five males, and one undetermined; one was haplotype C and the remaining eight were haplotype A.

Seven satellite tags were successfully deployed: five on sperm whales, one on a humpback whale, and one on a fin whale. Data from the humpback and fin whale tags have been added to the baleen whale tag dataset and are reported in Aschettino et al. (2026).

The five sperm whale tags were SPLASH10 tags, which collected both location and dive depth/duration information (**Table 4**). Tag durations for sperm whales ranged from 5.3 to 15.6 days. Maximum dive depths ranged from 1,439 to 1,791 m, and maximum dive durations ranged from 46.1 to 64.5 min.

Table 4. Summary of satellite tag deployment details for all sperm whale tags deployed in 2024/25.

Animal ID	Tag Type	Argos ID	Deployment Date	Last Transmission Date	Tag Duration (Days)
HDRVAPm153	SPLASH10	229396	07-May-2025	19-May-2025	11.2
HDRVAPm116	SPLASH10	229397	11-May-2025	27-May-2025	15.2
HDRVAPm023	SPLASH10	233707	11-May-2025	17-May-2025	5.3
HDRVAPm166	SPLASH10	229398	25-May-2025	10-Jun-2025	15.3
HDRVAPm184	SPLASH10-F	229399	24-Jun-2025	10-Jul-2025	15.6

Key: ID = identifier

Locations from satellite-tagged sperm whales showed movements throughout the VACAPES OPAREA (**Figure 7**), with two individuals (HDRVAPm166 and HDRVAPm184) whose tracks continued northeast of VACAPES along the shelf break, through the Atlantic City and Narragansett OPAREAs north of the study area (**Figure 7**). The travel pattern was very similar between the two individuals despite being tagged approximately 1 month apart. HDRVAPm166 traveled over the continental shelf for a short period within the Narragansett OPAREA; however, HDRVAPm184 never ventured over the shelf, even though the end locations were farther northeast with similar tag durations. Tagged sperm whales traveled up to 856 km from the initial deployment locations, and 34.1 to 100.0 percent of locations were within the VACAPES OPAREA.

Two successful DTAG and four successful CATS tag deployments occurred during the 2024/25 reporting period on sperm whales (**Table 5**). However, one DTAG could not be recovered because it did not release as programmed before the battery died. One CATS tag was also deployed on a humpback whale during this period, and additional details can be found in Aschettino et al. (2026).

Table 5. DTAG and CATS tag deployments on sperm whales during 2024/25 reporting period.

Animal ID	Tag Number/ Deployment ID	Deployment (GMT)	Depth at Tagging (m)	Tag off Animal (GMT)	Tag Duration (min)	Gender
HDRVAPm156	DTAG 338/ pm25_127a	2025-May-07 19:15	1,880	2025-May-08, 08:54[a]	945[a]	Unknown
HDRVAPm168	DTAG 338/ pm25_154a	2025-Jun-03 15:08	1,860	—	—	Unknown
HDRVAPm155	CATS 002/ pm250507	2025-May-07 16:58	1,880	2025-May-09 07:43[a]	2,325[a]	Unknown
HDRVAPm123	CATS 003/ pm250511	2025-May-11 12:56	1,428	2025-May-11 16:37	220	Female[b]
HDRVAPm169	CATS 002/ pm250603	2025-Jun-03 17:10	1,860	2025-Jun-04, 09:21[a]	971[a]	Unknown
HDRVAPm181	CATS 002/ pm250624	2024-Jun-24 15:18	1,550	2025-Jun-25, 00:49[a]	571[a]	Unknown

Key: ID = identifier; GMT = Greenwich Mean Time
[a] Research team was not present during tag release; the tag-off time and tag duration are estimated
[b] Gender assumed based on presence of calf

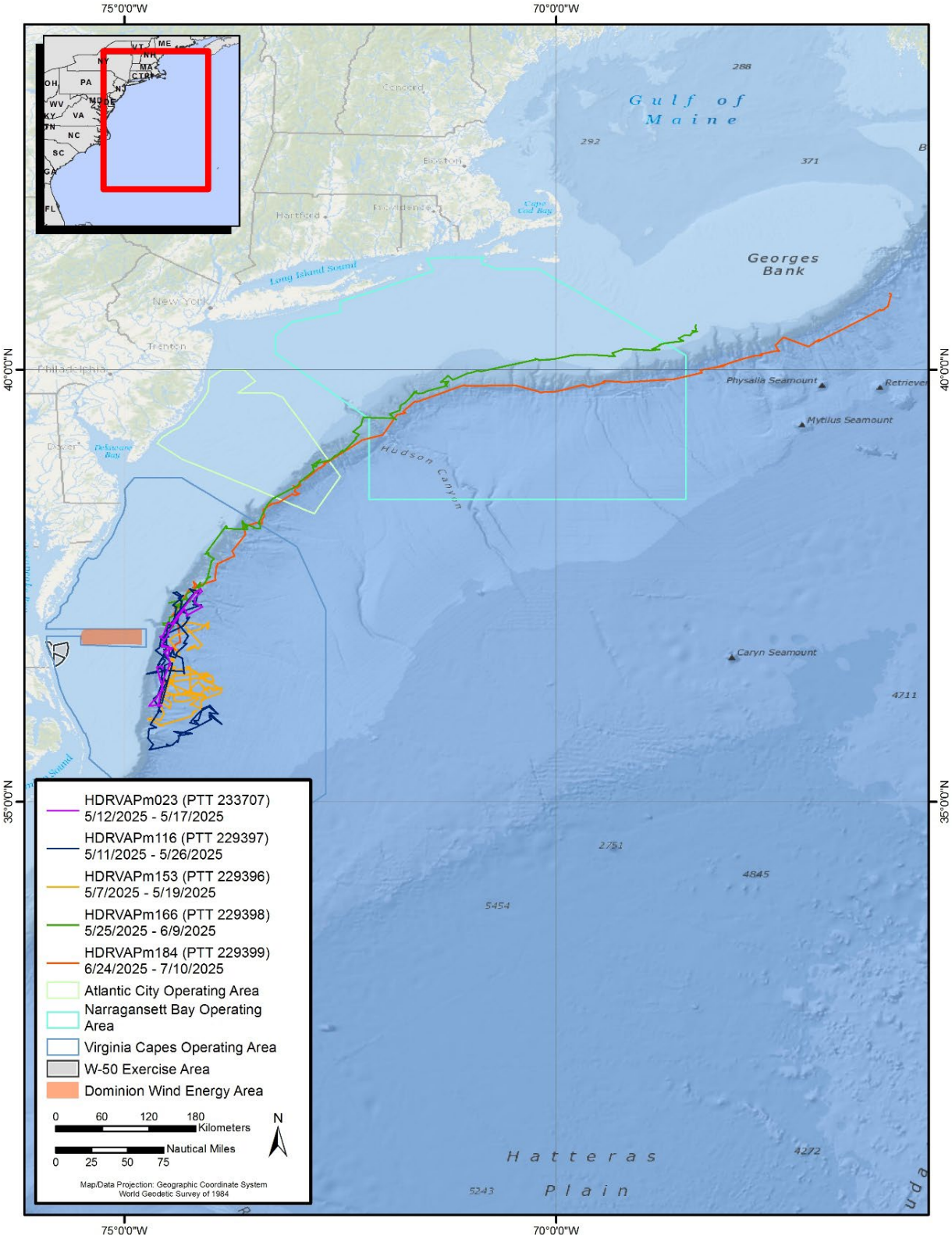


Figure 7. Tracks of all sperm whales tagged (*n*=5) during offshore surveys in the 2024/25 reporting period.

Acoustic audits were completed for the five sperm whale archival tag deployments. All individuals displayed consistent foraging dives to depths in the 600- to 1,000-m range throughout the deployments, with some shallower foraging dives and periods at the surface with increased social vocalizations. Maximum dive depths ranged from 334 to 1,233 m (mean = 818, median = 833). Foraging dives consistently terminated above the sea floor.

2.4.2.4 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 multiple ESA-listed species, within this high-use, U.S. Navy training and testing activity area.

Spatial patterns observed during the 2024/25 field season remain consistent with established OCS findings. Deep-diving species, including sperm and pilot whales, were encountered beyond the shelf break as well as within slope and canyon habitats. Baleen whales were observed both over the shelf and near the shelf break. Dolphin species were distributed broadly throughout the study and transit areas, while sea turtle sightings were largely restricted to shelf waters, except one leatherback turtle sighted off the shelf. Continued concentration of sightings in bathymetrically complex regions such as NFC reinforces the ecological importance of canyon and slope habitats within the VACAPES OPAREA.

Satellite-tagged sperm whales demonstrated a range of movement behaviors, including localized use of shelf break and slope waters as well as broader movements extending beyond the VACAPES OPAREA into adjacent U.S. Navy OPAREAs. These patterns highlight the importance of considering cetacean exposure across multiple OPAREAs and emphasize that individual animals may experience repeated or cumulative exposure to training activities across spatially connected offshore regions.

These areas likely provide foraging opportunities and may serve as focal regions for repeated use by certain species, particularly sperm whales, as evidenced by sightings, re-sightings, and tag-derived movement data. Integration of movement data with behavioral and acoustic information provides further support for these waters as foraging habitat.

Ongoing and planned analyses include continued photo-ID matching, expanded evaluation of telemetry tracks, and integration of sighting and movement data with environmental variables to better resolve drivers of habitat use. Continued collaboration with external partners and long-term monitoring will further strengthen the ability to detect interannual variability and refine estimates of seasonal occurrence, site fidelity, and movement patterns. Collectively, the results of this multi-year effort provide the U.S. Navy with scientifically robust information necessary to support environmental planning, regulatory compliance, and adaptive management within the VACAPES OPAREA. As the OCS dataset grows, it will increasingly support informed decision making aimed at minimizing potential impacts on protected species while maintaining mission readiness.

For more information on this study, refer to the annual progress report for this project (Engelhaupt et al. 2026).

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

Since January 2015, HDR Inc. has been monitoring humpback whales to assess their occurrence, habitat use, and behavior in and near U.S. Navy training and testing areas off Virginia via the Mid-Atlantic Humpback Whale Monitoring Project. 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 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.

Although humpback whales were initially the focal species for this study, data on other high-priority baleen whale species were also collected opportunistically. Relatively little information exists on how other baleen whale species, including endangered NARWs and fin whales, use the central Mid-Atlantic waters of the AFTT study area. PAM results from autonomous gliders and Marine Autonomous Recording Units confirm that NARWs and humpback, fin, sei, and minke whales 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 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 within 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, 2025). Confirmed sightings of critically endangered NARWs off Virginia have increased as survey coverage has extended farther from the coastline in recent years (Aschettino et al. 2022b, 2023b, 2024a, 2025a). 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, 2023b; D. Engelhaupt et al. 2022). Although sightings of blue whales off Virginia are infrequent, they have now been documented during HDR Inc. surveys in 2018 (Engelhaupt et al. 2019, 2024; D. Engelhaupt et al. 2020), 2019 (Cotter 2019, D. Engelhaupt et al. 2020), 2021 (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; A. Engelhaupt et al. 2022; Lesage et al. 2017).

Building upon the long-term dataset initially established through monitoring of humpback whales, the Mid-Atlantic Nearshore and Mid-Shelf Baleen Whale Monitoring Project expanded the study area to encompass mid-shelf waters 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 and 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 core baleen whale field season off Virginia Beach runs from approximately the end of October through March, when humpback whales and NARWs are common visitors—humpback whales most typically during December through February, and NARWs into April and occasionally beyond. Since this project's inception in 2015, 11 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, DTAGs, and CATS tags; collaboration with researchers from Duke University to examine behavioral response of humpbacks to large vessels (Shearer et al. 2020); photogrammetry using drones; and, most recently, an expansion into the mid-shelf region with 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 2024 into early 2025.

2.4.3.1 Passive Acoustics

2.4.3.1.1 Autonomous Real-Time Detection Buoy

An autonomous real-time reporting passive acoustic detection buoy (**Figure 8**) developed by the Woods Hole Oceanographic Institute has been maintained off the coast of Cape Charles since October 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. A refurbished buoy was deployed on 20 May 2025 to replace a previous buoy that was in the water from 14 July 2024 to 20 May 2025.

Figure 8. DMON buoy managed by NAVFAC Atlantic deployed off the coast of Cape Charles, Virginia.

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 NARWs and humpback, fin, and sei whales. Detection data are transmitted in near real time to shore where they are reviewed daily by trained analysts, and the results are 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.

This buoy was strategically placed to complement sound trap deployments (**Section 2.4.3.1.2**) as well as another real-time detection buoy deployed off southern Virginia by another organization, and to facilitate the HDR Inc. field team efforts within the area. Confirmed detections of NARWs 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 NARWs—maintaining speeds of 10 knots or fewer can help protect NARWs from vessel collisions. Under these programs, NOAA Fisheries provides maps and coordinates to vessel operators indicating areas where NARWs 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 fewer while transiting through these areas. Active Slow Zones can be found on NOAA's website as well as WhaleMap.

During the period of September 2024 to August 2025, fin whales were the most commonly detected species, followed by humpback whales (**Figure 9**). From December 2024 to March 2025, the Cape Charles buoy had 22 confirmed detections of NARWs, which led to a slow zone within the area surrounding the buoy for a cumulative total of 87 days—nearly continuously from mid-December through the end of February. There were also 10 additional "possible" NARW detections that did not meet the criteria to be confirmed as detected. The last NARW detection for the season occurred on 10 March 2025, while fin and humpback whale detections continued through the beginning of May 2025. From 20 May to 19 July 2025, there were only sporadic "possible" detections of both fin and humpback whales. On 19 July 2025, there were humpback whale calls confirmed as detected on this single day. Fin whale calls began being regularly detected again during early August. There were no data from 15 through 31 August 2025 due to a hydrophone failure from seawater intrusion.

Up to date daily detections are available at the project's page on Robots4Whales: July 2024 to May 2025 and May 2025 ongoing.

Figure 9. Plot showing daily detections (yellow = possible, red = confirmed) of four species of baleen whales from the DMON buoy deployed off the coast of Cape Charles, Virginia, from September 2024 through August 2025.

2.4.3.1.2 Archival SoundTrap Deployments

Three arrays of SoundTraps initially deployed beginning in July 2022 (Eastern Shore began in October 2023) to monitor for the presence of NARWs within the western Mid-Atlantic in collaboration with NOAA NEFSC were serviced in 2025 (**Figure 10**). The units off the coast of Delaware were serviced in April and November, and the southeastern Virginia and Eastern Shore units were serviced in April and 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 continue to be serviced and re-deployed approximately twice annually. 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 Map. All SoundTraps deployed from June 2022 to November 2024 (September 2024 for Eastern Shore) have been processed with the LFDCS and analyzed for daily presence for NARW upcalls, fin whale pulses, blue whale song, humpback 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 number of detections for the call types specified, that species was logged as "detected." **Figure 11** 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 analysis still in progress) available.

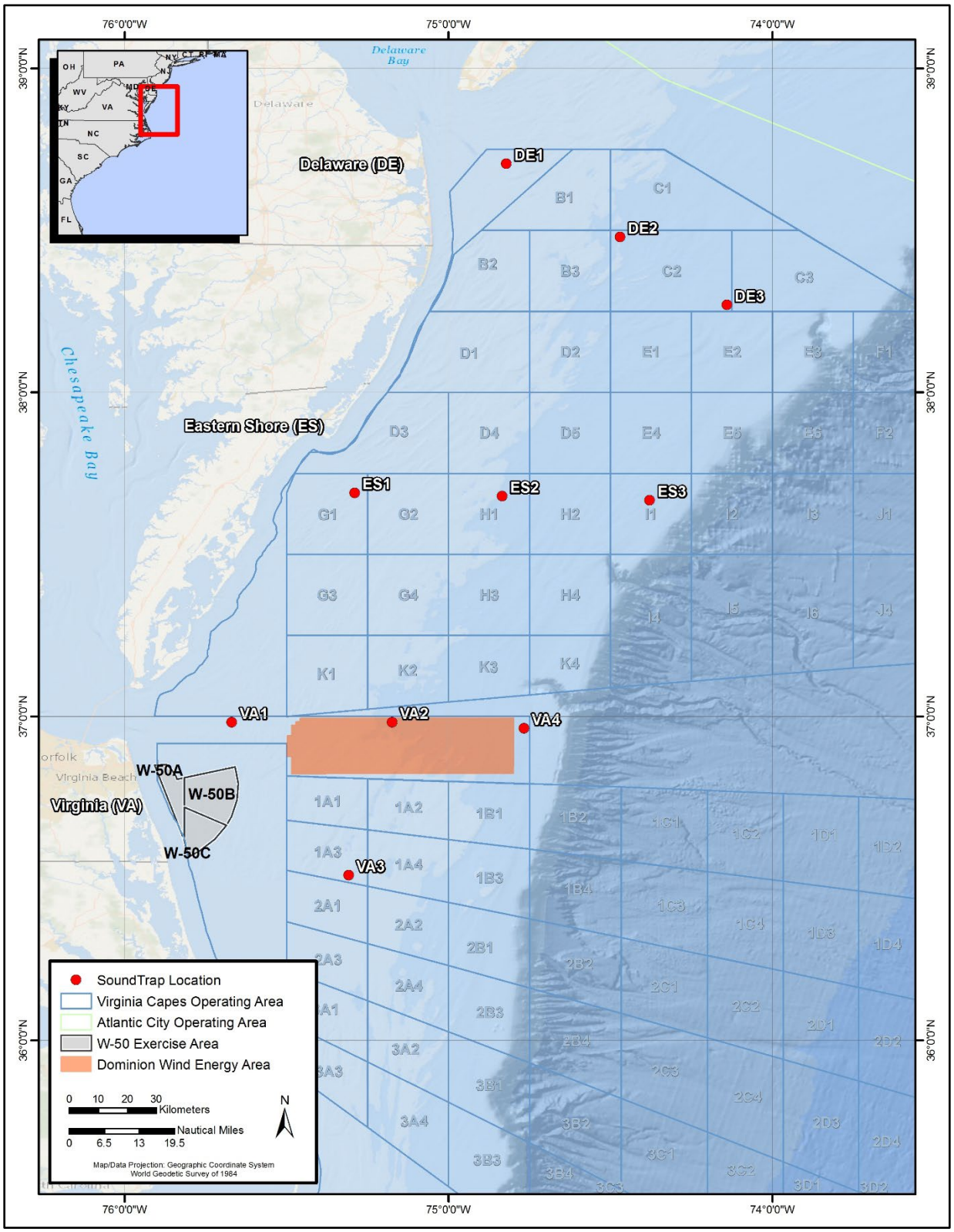


Figure 10. Locations of SoundTrap deployment locations serviced during 2025.

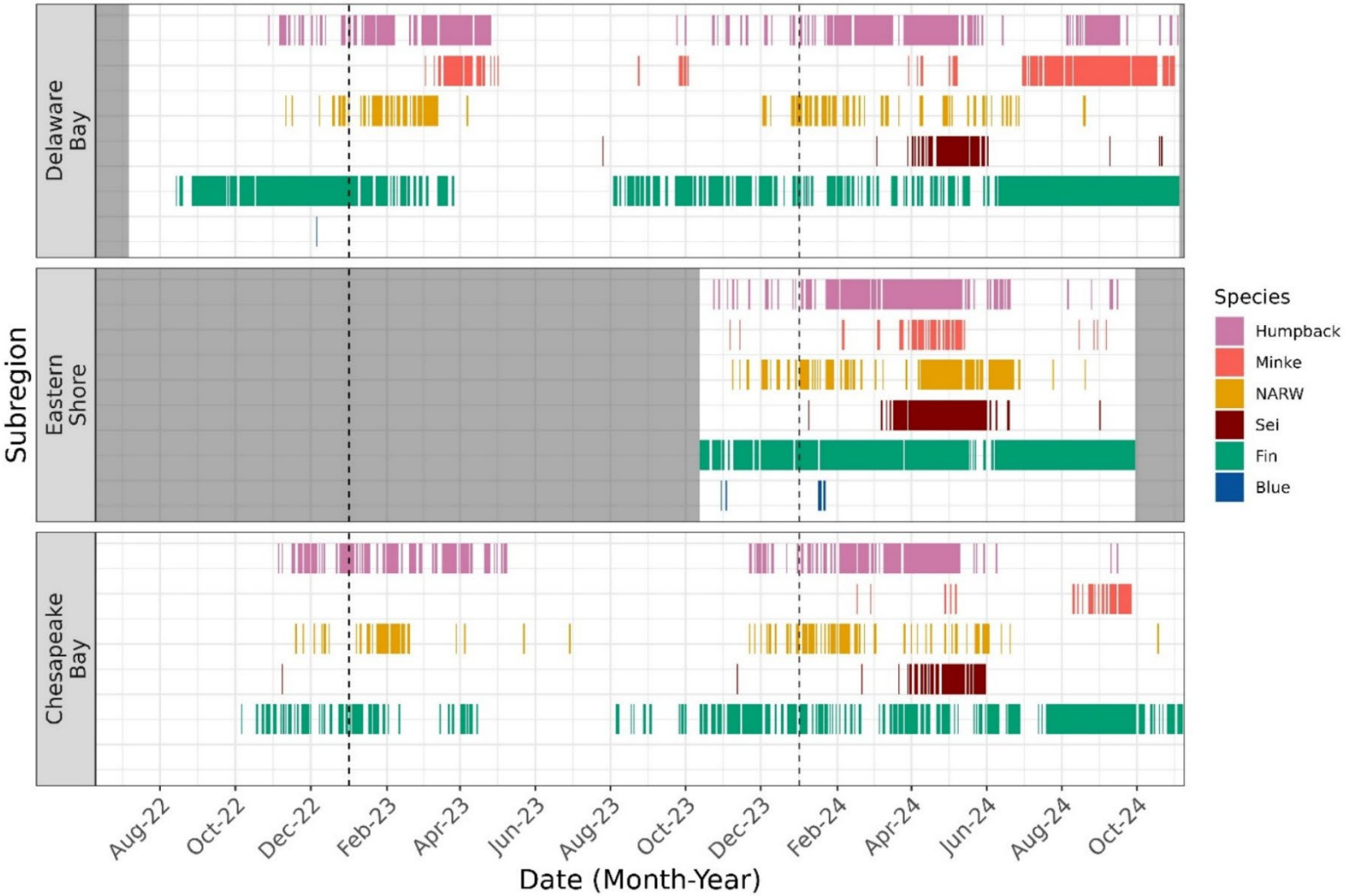


Figure 11. Daily acoustic presence of humpback, minke, North Atlantic right, sei, fin, and blue whales from June 2022 to November 2024 compiled by recorder location into the three subregions of the Mid-Atlantic Bight, from north (top) to south (bottom): Delaware Bay, Eastern Shore, and Chesapeake Bay. Gray blocks signify no available data and vertical dashed lines separate years.

2.4.3.2 Vessel Surveys and Tagging

Twenty-two vessel surveys were conducted between 18 November 2024 and 19 March 2025. More than 151 hours of survey effort were completed, and 2,719 km of trackline were covered (**Figure 12**).

2.4.3.2.1 Sightings Summary

In total, 60 baleen whale sightings occurred during vessel surveys during the 2024/25 season, including 40 humpback whale sightings totaling 59 individuals, 10 NARW sightings totaling 22 individuals, 7 fin whale sightings totaling 14 individuals, and 3 minke whale sightings totaling 3 individuals (**Figure 12**). For further information on NARWs in the Mid-Atlantic, see **Section 2.4.4** of this report and **Table 15** (in **Section 2.4.4**) for specifics on all aerial and vessel NARW sightings during the 2024/25 field season.

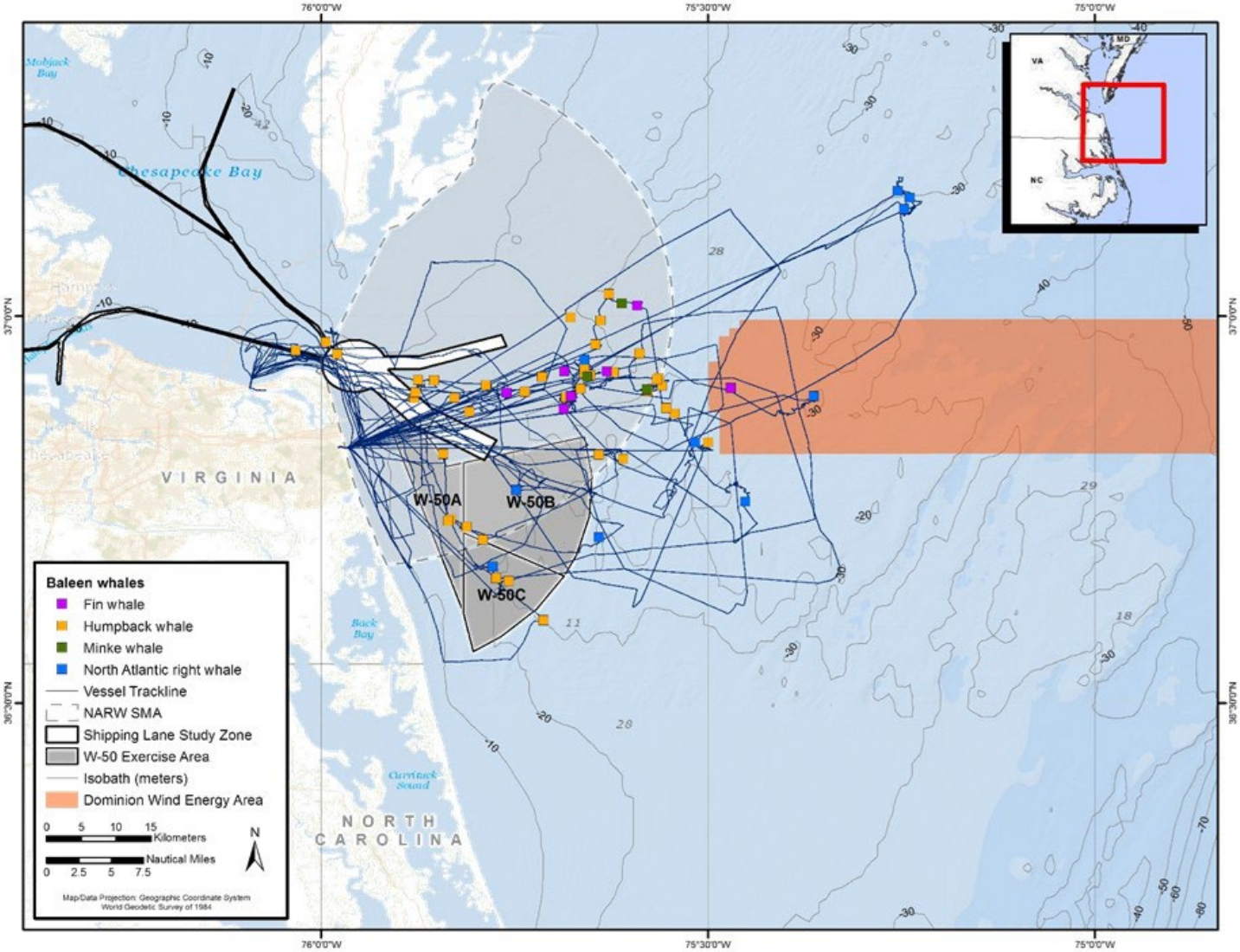


Figure 12. Vessel survey tracks (blue), with locations of all humpback (*n*=40), fin (*n*=7), North Atlantic right (*n*=10), and minke (*n*=3) whale sightings for the 2024/25 field season.

2.4.3.2.2 Humpback Whales

The 40 sightings of humpback whales observed during the 2024/25 nearshore and mid-shelf baleen whale season included 59 total individuals and resulted in 37 unique humpback whales identified using dorsal fin and fluke images (Aschettino et al. 2026). During offshore surveys, 7 sightings of humpback whales totaled 18 individuals and resulted in 7 unique humpback whales (Engelhaupt et al. 2026). Humpback whales photographed from the aerial surveys (Ozog and Engelhaupt 2026) were not included in the cataloging effort. In total, 43 unique humpback whales were identified during the 2024/25 season (**Figure 13**).

Of the 43 unique humpback whales seen during the 2024/25 season, 18 (41.9 percent) were categorized as juveniles based on their estimated size in the field, 9 (20.1 percent) were classified as sub-adults/adults, 6 (14.0 percent) were classified as adults, 4 (9.3 percent) were classified as sub-adults, 3 (7.0 percent) were classified as juveniles/sub-adults, and 1 (2.3 percent) was seen on 5 occasions and classified as either juvenile, juvenile/sub-adult, or sub-adult, reinforcing the difficultly and subjectivity of assessing age class in the field. Fifteen (34.9 percent) of the 43 individuals were re-sights to HDR Inc.'s catalog; the additional 28 whales were new individuals added to the growing project catalog, which, to date, has 367 unique humpback whales. Two individuals, HDRVAMn001 and HDRVAMn002, seen only once each in 2013, are not included in **Figure 13**. To date, evidence of human interaction, either presumed line-entanglement scars or propeller scars, was apparent on at least 29 of the 367 (7.9 percent) cataloged humpback whales. Eight cataloged individuals are known to be deceased.

Of the 43 unique humpback whales seen during the 2024/25 season. Excluding same day resights, 10 (23.3 percent) were seen on more than 1 occasion, and 5 (11.6 percent) were seen on 3 or more occasions. Within-season re-sightings spanned 1.8 to 34.7 days apart (mean=31.0 days; median=19.0 days).

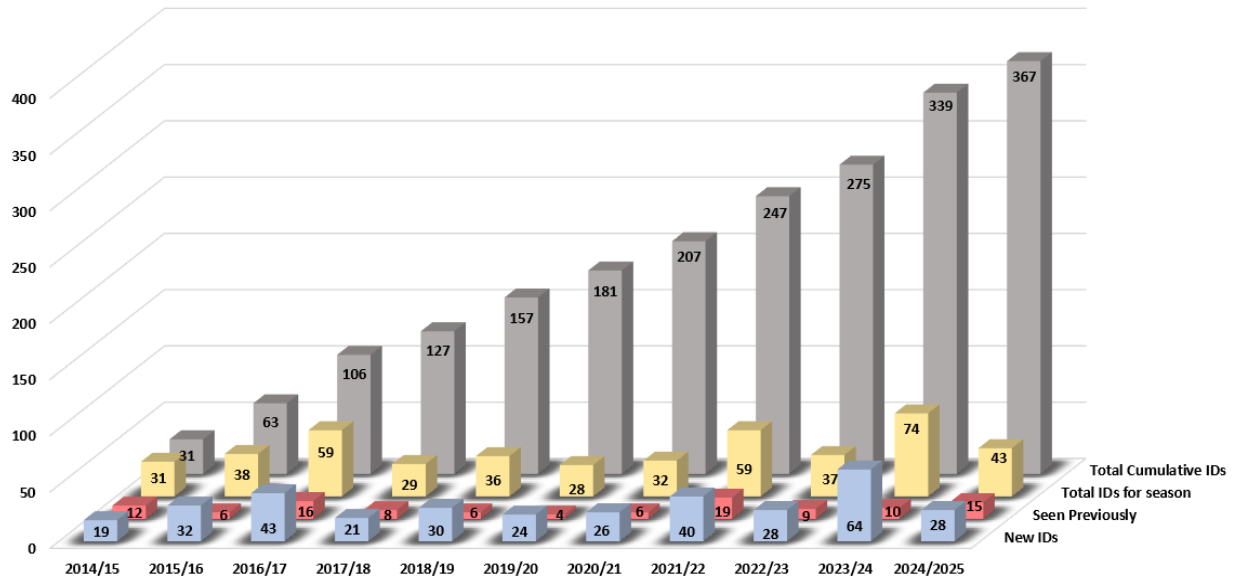


Figure 13. Humpback whale identifications (IDs) over 11 field seasons within the Virginia study area: yellow bars = total number of IDs for each season; red bars = number of those IDs that were seen in previous seasons; blue bars = number of new IDs added to the catalog; gray bars = total number of cumulative unique IDs.

One Argos-linked SPLASH10-F satellite tag was deployed on a humpback whale during an OCS survey (Engelhaupt et al. 2026) (**Table 6**, **Table 7**, **Figure 14**). The tag transmitted for 4.3 days.

Table 6. Satellite-tag deployment on a humpback whale during the 2024/25 field season.

Animal ID	Estimated Age Class	Tag Type	Argos ID	Deployment Latitude (°N)	Deployment Longitude (°W)	Deployment Date	Last Trans-mission Date	Tag Duration (days)
HDRVA Mn375	Juvenile	SPLASH10-333F	240216	36.0077	74.9270	25-May-25	30-May-25	4.3

Key: ID = identifier; °N = degrees North; °W = degrees West

HDRVAMn375 was tagged approximately 95 km east northeast of Rudee Inlet, within the VACAPES OPAREA (**Figure 14**). This individual remained close to the location where it was tagged (mean distance from initial tagging location was 5.6 km; **Table 7**) for the 4.3 days that the tag transmitted.

Table 7. Summary of results from satellite-tag data for the humpback whale tagged during the 2024/25 field season.

Animal ID	# Locations Post Filtering	Percent Within Shipping Channels	Percent Within VACAPES	Maximum Distance from Initial Location (km)	Mean Distance from Initial Location (km)
HDRVAMn375	102	0.0	30.4	13.3	5.6

Key: ID = identifier

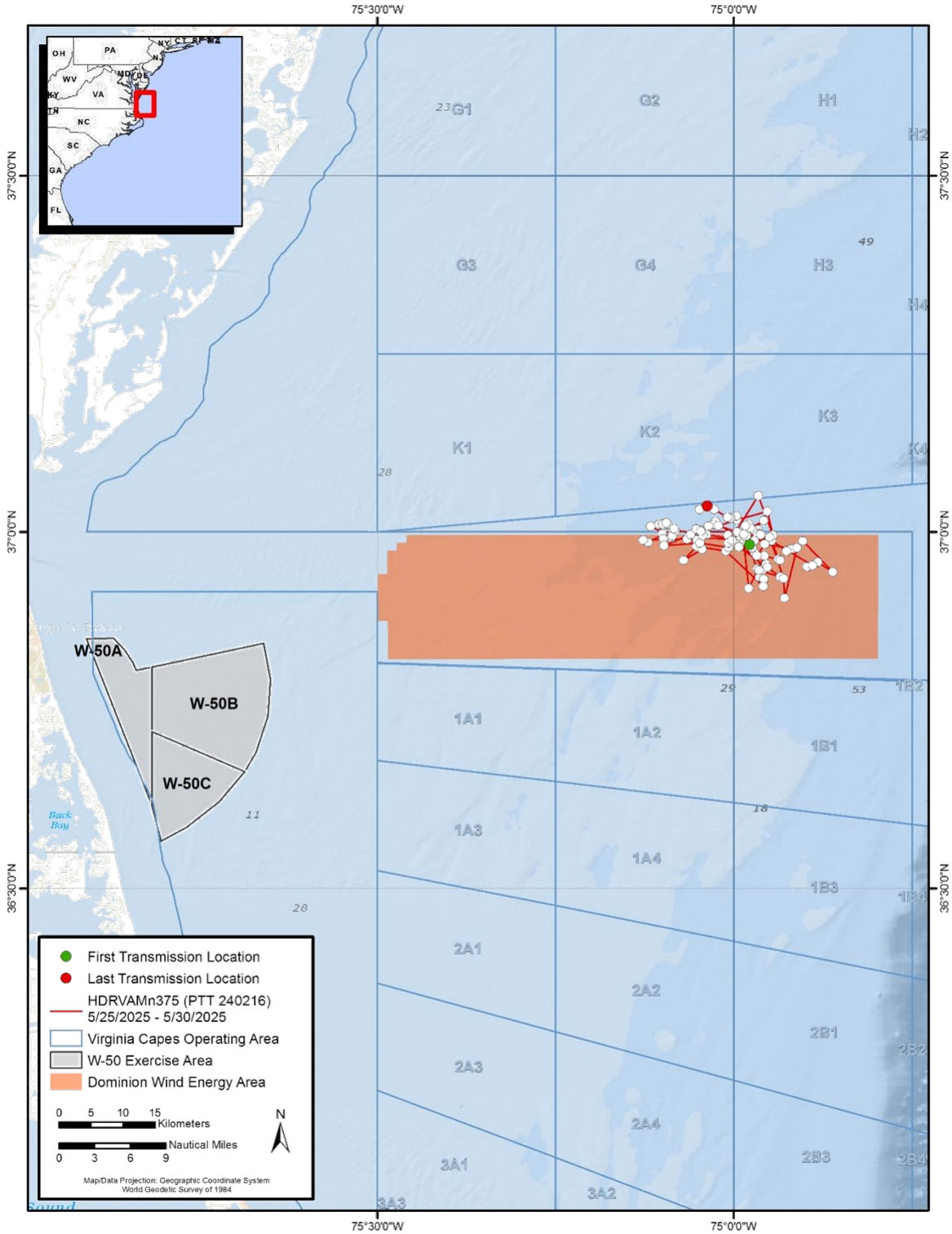


Figure 14. Filtered locations (white dots) and trackline of HDRVAMn375, tagged on 25 May 2025, over 4.3 day of tag-attachment duration showing Argos positions.

Two CATS suction-cup tags were deployed on humpback whales during the 2024/25 field season (**Table 8**). The tags were recovered the following day and recorded a total of approximately 8.5 hours of three-dimensional movement, acoustic, and video data (**Table 8**). **Table 9** summarizes the dive statistics calculated using the find-dive MATLAB script from the toolbox posted to the animaltags.org site, with a dive-depth definition of 2 m and 2 min. A total of 271 dives and 269 surfacing bouts were recorded during the tags' deployments. Dive duration ranged from 8.1 seconds to 6.44 min (mean = 1.34 min). Maximum dive depth was 20.8 m (mean = 8.51 m) (**Table 9**). **Figure 15** and **Figure 16** shows the dive profile of each individual.

Table 8. CATS tag deployments on humpback whales during the 2024/25 field season.

Animal ID	CATS Tag No./ Deployment ID	Deployment (GMT)	Depth at Tagging (m)	Tag Off Animal (GMT)	Tag Duration (min)
HDRVAMn300	CATS 001/ mn250204	2025-Feb-04 16:11	11.0	2025-Feb-04 21:25	313
HDRVAMn291	CATS 001/ mn250223	2025-Feb-23 22:15	21.0	2025-Feb-24 01:34	198

Key: ID = identifier; GMT = Greenwich Mean Time; No. = Number

Table 9. Summary of dive depth and duration data collected from CATS tagged humpback whales during the 2024/25 field season.

Animal ID	Deployment ID	# Dives Logged	Mean Dive Depth (m)	Maximum Dive Depth (m)	Mean Dive Duration (mm:ss)	Maximum Dive Duration (mm:ss)
HDRVAMn300	mn250204	124	5.6	13.6	1:50	6:26
HDRVAMn291	mn250223	147	11.0	20.8	0:54	3:22

Key: ID = identifier; mm:ss = minutes:seconds

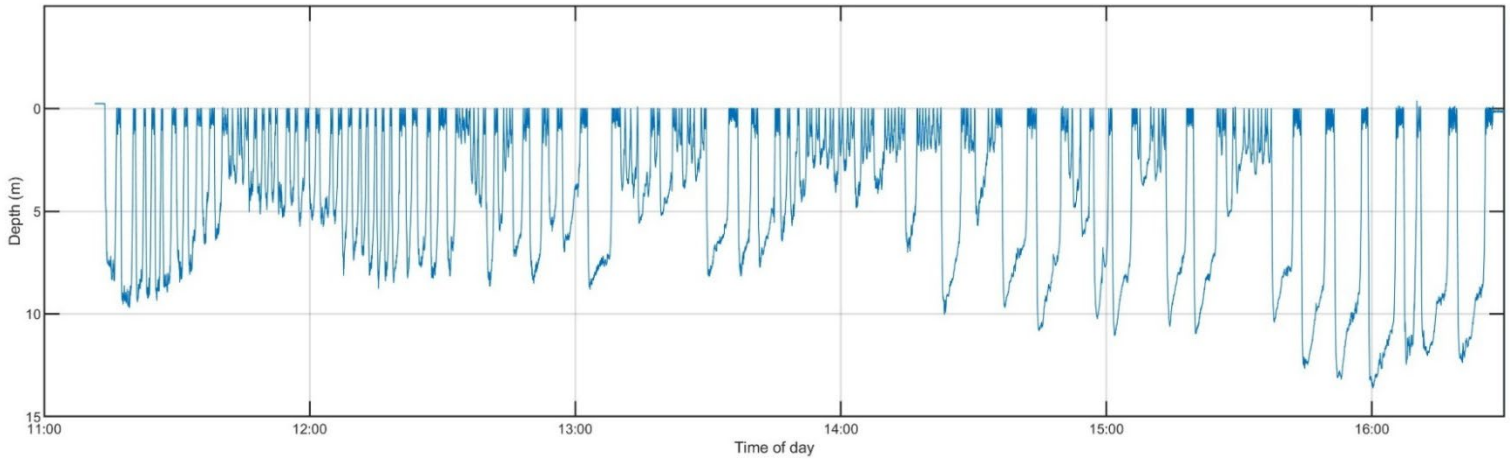


Figure 15. Dive-depth profile (in meters) for HDRVAMn300 (CATS mn250204).

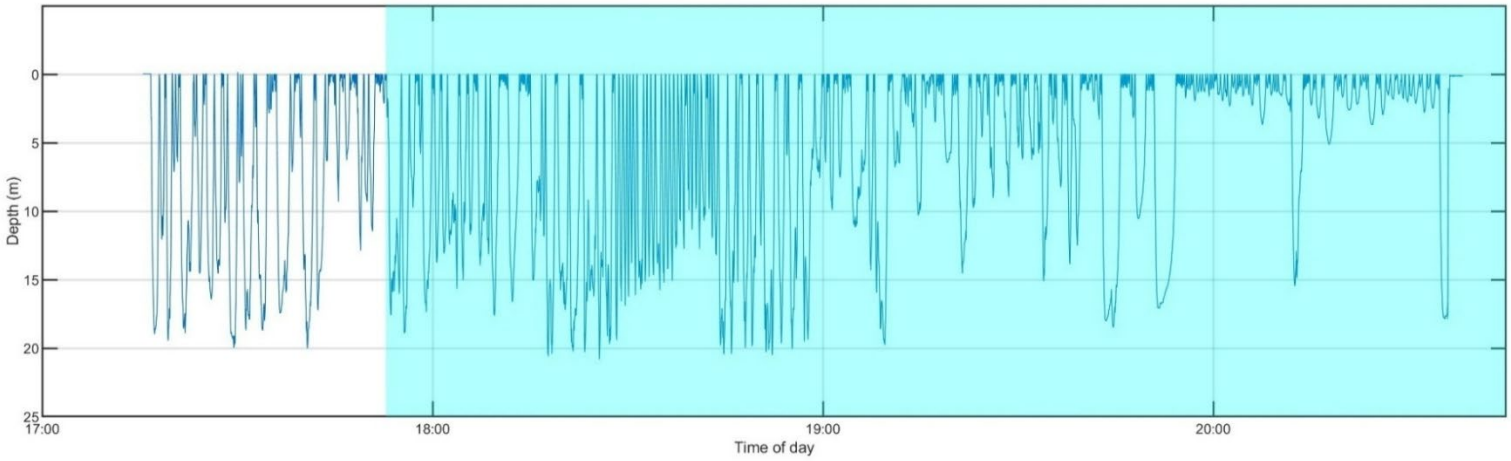


Figure 16. Dive-depth profile (in meters) for HDRVAMn291 (CATS mn250223), with sunset through sunrise (in local time) shaded blue.

2.4.3.2.2.1 Mid-Atlantic Humpback Whale Catalog and Happywhale

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 individuals 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). 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 sighting data on a global scale. Beginning in 2023, HDR Inc. and Naval Facilities Engineering Systems Command (NAVFAC) Atlantic took on the curator role for the MAHWC.

Happywhale.com is a citizen-science platform that allows any user to upload images of whales to gain information on where that whale had been previously seen. An artificial-intelligence-based, automated, image-recognition algorithm was developed for humpback whale flukes, which constitutes the majority of image types available on Happywhale. More recently, an additional algorithm was also developed for humpback whale dorsal fins. Currently, more than 118,000 individuals are in the humpback whale database, of which more than 12,000 are from the North Atlantic and Atlantic Arctic.

In 2025, the MAHWC was updated with all HDR Inc.'s sighting records and humpback whale images through May 2025, which currently contains 369 individuals (**Table 10**). Images included the best dorsal fin and fluke image, comprehensive of every sighting of a given whale. Additionally, the Duke University Marine Laboratory (DUML) catalog was updated with images and sighting information from 2023 provided by Kim Urian, and now contains 44 individuals. A new contributor catalog was created with a submission by Kristin Rayfield from Rudee Tours and now contains 299 individuals. Matching between catalogs is ongoing.

Table 10. All catalogs created and/or updated within the MAHWC since 2024, including the years of data collection and number of unique individuals.

Organization/Research Team	Location	Years	Number of Individuals
HDR Inc.	Virginia	2013–2025	369
DUML	Virginia, North Carolina	2017; 2019–2024	44
Cape May Whale Watch and Research Center	Delaware, New Jersey	2011–2023	232
Rudee Tours	Virginia	2009–2025	299

HDR Inc.'s Happywhale catalog was updated with individuals and images from the 2024/25 winter field season. Additionally, the catalog underwent quality assurance/quality control, and full sighting histories and images of individuals were uploaded from 2013 onward. In total, HDR Inc.'s Happywhale humpback whale catalog contains 367 individuals, and 191 of these individuals yielded match records. Whales were matched to feeding grounds in waters off the northeastern U.S., Canada, Iceland, and Svalbard, and were also matched to breeding grounds off the Dominican Republic as well as the Turks and Caicos Islands. Matches within the Mid-Atlantic, including Virginia, Delaware, New Jersey, and New York, were also made; in fact, some whales were only matched within Virginia and not to outside areas.

Both the Gulf of Maine Humpback Whale Catalog and North Atlantic Humpback Whale Photo-ID Catalog (NAHWC) recently began a partnership with Happywhale, and comparisons of individuals between Happywhale and both catalogs are ongoing. If an individual has a sighting history in one or both catalogs and is also currently in Happywhale, identification information was added to the individual's page for the respective catalog. The Gulf of Maine Humpback Whale Catalog has a long-standing naming process, and 69 humpback whales in HDR Inc.'s Happywhale catalog have been named to date. **Table 11** includes matches to other maintained catalogs; however, this table does not include sightings added by individuals (rather than organizations), such as photographs collected on a whale-watch tour by a customer.

Table 11. HDR Inc. humpback whale matches to other organizations within Happywhale.

Organization	Number of Matches
Rudee Flipper Dolphin and Whale Watching Tours	118
Gotham Whale New York City	70
GOM Catalog	69
NAHWC	60
Turks and Caicos Islands Whale Project	15
Coastal Research & Education Society of Long Island	10
Saint Pierre and Miquelon	10
Witless Bay Reserve Humpback Whale Catalog	9
Trinity Bay Newfoundland – Kris Prince	5
Marine and Coastal Ecology Research Center	2
Mingan Island Cetacean Study	2
Husavik Research Centre	1

2.4.3.2.3 Fin Whales

Seven sightings of 14 individual fin whales were made during the 2024/25 season for nearshore and mid-shelf baleen whales, with photographs of 6 unique individuals collected. During the offshore surveys, 12 sightings of fin whales totaled 22 individuals (Engelhaupt et al. 2026) and resulted in 20 uniquely identified fin whales. Four individuals were sighted on 2 or 3 survey days during the season, resulting in a total of 20 unique fin whales identified during the 2024/25 season.

Of the 20 unique fin whales seen during the 2024/25 season, 17 (85.0 percent) were classified as adults or sub-adults based on their estimated size in the field, 2 (10.0 percent) were categorized as juveniles, and 1 (5.0 percent) was categorized as a calf. Eight (40.0 percent) of the 20 individuals were re-sights to HDR Inc.'s catalog, 3 individuals (HDRVABp028, HDRVABp029, and HDRVABp033) were initially sighted in August 2017, 1 individual (HDRVABp093) has been seen multiple times since its initial sighting in 2021, and the remaining re-sighted individuals (HDRVABp119, HDRVABp128, HDRVABp158, and HDRVABp166) were first added to HDR's catalog during the 2023/24 season. The additional 12 whales were new individuals added to the growing project catalog, which, to date, has 176 unique fin whales.

Of the 20 unique fin whales seen during the 2024/25 season, 4 (20.0 percent) were seen on more than 1 occasion and 1 (5.0 percent) was seen on 3 occasions. Within-season re-sightings spanned 4.5 to 27.1 days apart (mean = 15.4 days; median = 14.9 days).

One Argos-linked SPLASH10-F satellite tag was deployed on a fin whale during an OCS survey (Engelhaupt et al. 2026) (**Table 12**, **Table 13**, **Figure 17**). The tag transmitted for 7.7 days.

Table 12. Satellite-tag deployment on a fin whale during the 2024/25 field season.

Animal ID	Estimated Age Class	Tag Type	Argos ID	Deployment Latitude (°N)	Deployment Longitude (°W)	Deployment Date	Last Trans-mission Date	Tag Duration (days)
HDRVABp 172	Sub-adult	SPLASH 10-333F	282238	36.9043	74.9126	14-Jul-25	22-Jul-25	7.7

Key: ID = identifier; °N = degrees North; °W = degrees West

HDRVABp172 was tagged approximately 101 km offshore of Virginia Beach (**Figure 17**). This individual remained within the primary study area and relatively close to the deployment location for the first 5 days of the tag deployment before beginning to move a bit farther south, just past the Virginia/North Carolina border. No Argos locations occurred within shipping channels, however, 34.5 percent were located within VACAPES (**Figure 17**; **Table 13**). Maximum straight-line distance from the initial tagging location was 58.9 km, and mean distance was only 18.3 km (**Table 13**).

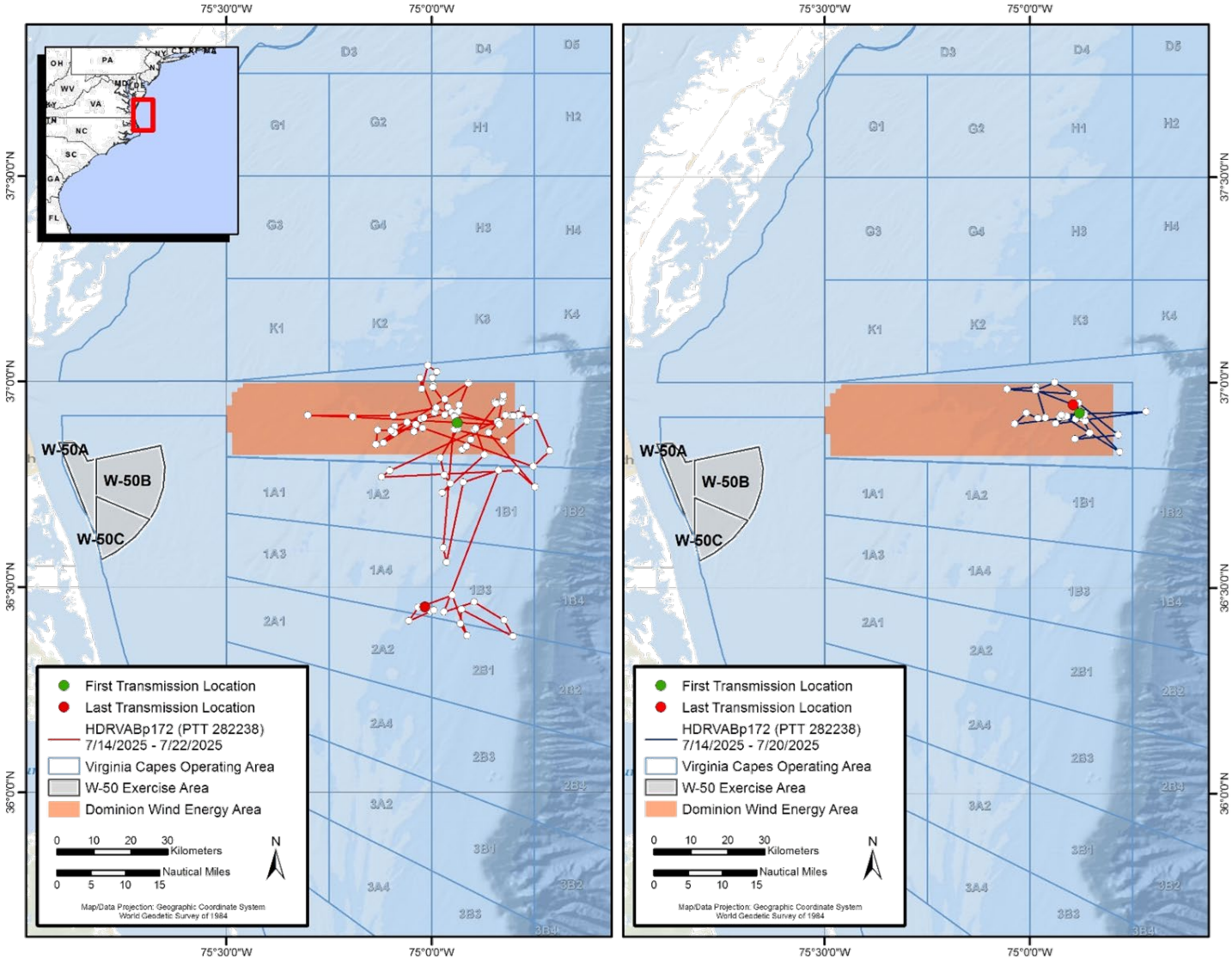


Figure 17. Filtered locations (white dots) and trackline of HDRVABp172, tagged on 14 July 2025, over 7.7 day of tag-attachment duration showing Argos (left) and Fastloc (right) positions.

Table 13. Summary of results from satellite-tag data for the fin whale tagged during the 2024/25 field season.

Animal ID	# Locations Post Filtering	Percent Within Shipping Channels	Percent Within VACAPES	Maximum Distance from Initial Location (km)	Mean Distance from Initial Location (km)
HDRVABp172	87	0.0	34.5	58.9	18.3

Key: ID = identifier

2.4.3.2.4 Minke Whales

Minke whales are occasionally encountered within the study area; however, minimal effort is spent trying to work with or photograph them given they are not currently a priority species. Minke whales were observed on three occasions during the mid-shelf vessel surveys. An additional sighting occurred during the OCS effort (see Engelhaupt et al. 2026) and three sightings during the aerial survey effort (see Ozog and Engelhaupt 2026). Across all years and projects, the minke whale catalog currently contains 18 individuals. No re-sights between years have been made.

2.4.3.2.5 Blue Whales

During the 2024/25 season, one blue whale was sighted and photographed during an OCS survey (Engelhaupt et al. 2026) and added to HDR's blue whale catalog, bringing the total unique individuals documented to nine.

2.4.3.2.6 Discussion

Continued analysis of data from this multi-year project is ongoing; however, each season of data helps build a more comprehensive picture of how baleen whales use the waters within and around the mouth of Chesapeake Bay and the surrounding area. Shipping channels, U.S. Navy training and OPAREAs, and wind energy development areas all overlap with habitat that these whales use seasonally. Results continue to show a high level of occurrence within areas that are heavily used by the U.S. Navy; commercial shipping, recreational and commercial fishing vessels; and wind energy areas. These findings are supported by information collected during the past 10 years of this study, including photo-IDs, focal follows, and tagging results.

Vessel interactions within the overall study area remain a concern for humpback and other baleen whales. In 2017, NMFS declared a UME for humpback whales in the Atlantic Ocean 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.

Efforts for the 2025/26 field season will continue to focus on mid-shelf waters as well as continuing humpback photo-ID and body-condition assessment efforts within nearshore waters. During the upcoming 2025/26 field season, the study team will also continue to deploy DTAGs and CATS tags on baleen whales, with a focus on the W-50 MINEX and mid-shelf areas. An U.S. National Defense Authorization Act-compliant drone, equipped with a customized tag drop system, will also be used to deploy DTAGs and CATS tags. This will allow the team to continue

to better detail fine-scale movement, dive patterns, and foraging behavior as well as record acoustic activity to add to the existing medium-duration dataset. The entirety of these data will provide a better understanding of the occurrence and behavior of large whales within this area and further support future Mid-Atlantic BRSs.

For more information regarding this study, refer to the annual progress report for this project (Aschettino et al. 2026).

2.4.4 North Atlantic Right Whales

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 2.4.1**, **Section 2.4.2**, and **Section 2.4.3** for additional details). Beginning in the winter 2022/23 field season, there was increased effort to locate NARWs given their critically endangered status and the gap in knowledge for Mid-Atlantic waters.

2.4.4.1 Sightings and Photo-Identification

Between November 2024 and March 2025, 11 total sightings of NARWs occurred off southern Virginia between aerial and vessel platforms. The 10 sightings of NARWs observed during the 2024/25 nearshore and mid-shelf baleen whale season included 22 individuals and resulted in 19 unique NARWs identified using callosity patterns and body scarring. During the offshore surveys, one sighting of six individual NARWs was made (Engelhaupt et al. 2026) and photographs were collected of those six unique NARWs. During the aerial surveys, 8 sightings totaling 23 individuals resulted in 22 unique individuals (Ozog and Engelhaupt 2026). In total, 25 unique individuals were documented across all platforms and surveys (**Table 14, Figure 18**).

Table 14. NARW sightings by field season for all aerial and vessel surveys off southern Virginia and northern North Carolina from 2017 to 2025.

Season	Number of Sightings	Number of Individuals	Unique IDs for Season
2017/18	2	8	7
2018/19	0	0	0
2019/20	0	0	0
2020/21	4	7	6
2021/22	4	8	8
2022/23	10	36	27
2023/24	23	51	35
2024/25	11	28	25

Key: ID = Identification Number

Table 15 provides a summary of NARWs documented by all platforms during the 2024/25 field season. Of the 25 unique NARWs seen during the 2024/25 season, 18 (72.0 percent) were known adults, 5 (20.0 percent) were juveniles, and 2 (32.0 percent) were yearlings. Approximately 60 percent (*n*=15) were males, 8 (32.0 percent) were females, and sex was

unknown for the remaining 2 (8.0 percent) individuals. One individual was sighted twice within the season (yearling #2024Calfof#3320, 21 days apart).

NARW sightings during the 2024/25 season included single animals, pairs, and groups that were traveling, milling, and socializing. Unlike during previous years (Aschettino et al. 2023a; A. Engelhaupt et al. 2023b), no larger surface-active groups in the area for multiple days were documented.

HDR Inc. has now encountered 98 known individual NARWs off southern Virginia and northern North Carolina since 2018. Individuals have represented both sexes and all age classes. Nine individuals have been sighted during more than one season, spanning from 285 to 2,242 days following the initial sighting.

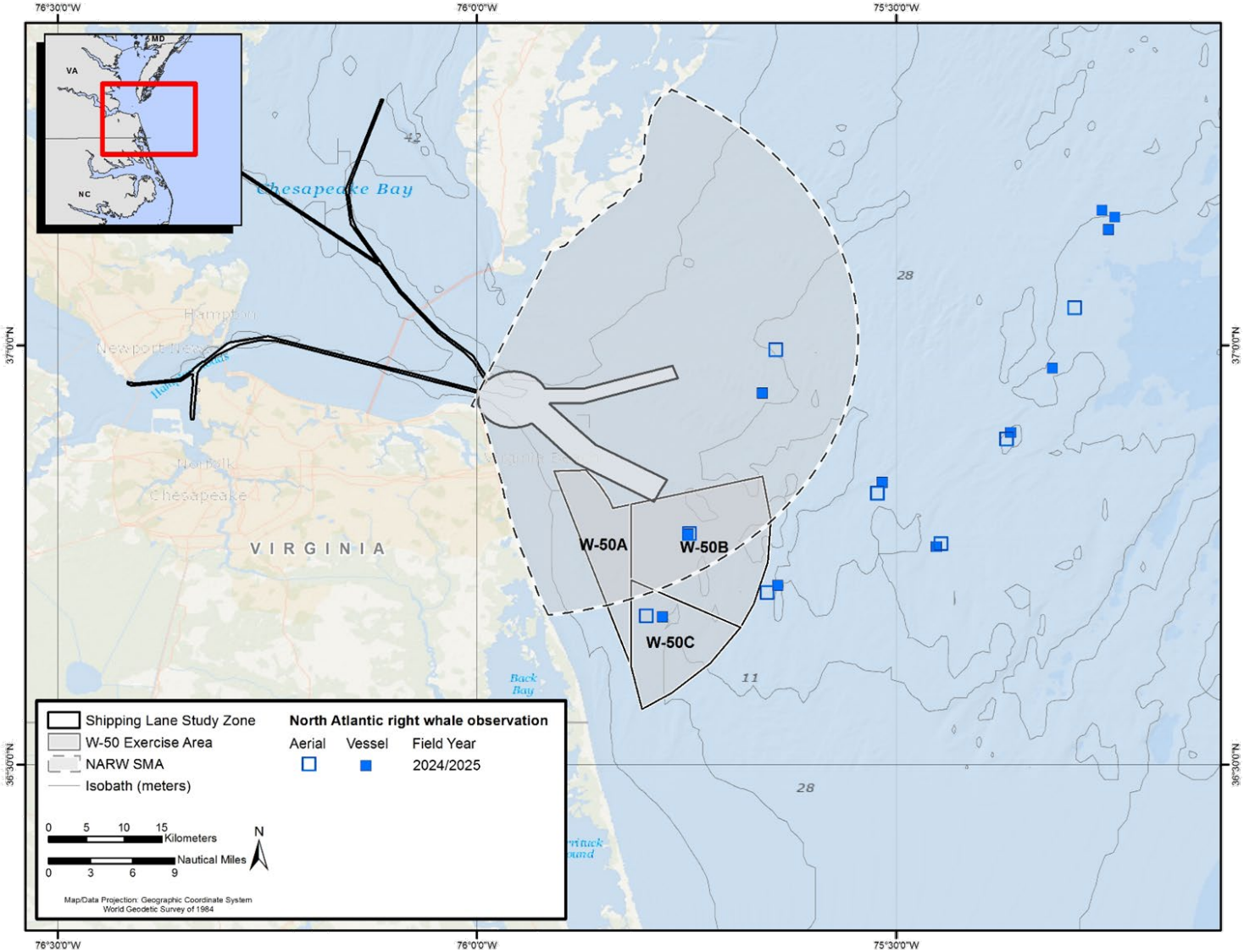


Figure 18. NARW sightings from aerial and vessel platforms collected off southern Virginia during the 2024/25 field season.

Table 15. Summary of photo-identified NARWs by platform during the 2025/25 field season, sorted by sighting data and animal identifier and shaded by individuals sighted together. Vessel sightings are denoted in black font and aerial sightings are denoted in blue font.

Animal ID / Name	Age Class	Sex	Group Size	Behavior	Sighting Date	Survey Type	Sighting Latitude (°N)	Sighting Longitude (°W)	Unique Sighting Days[a]
#3950	Adult	Male	1	Travel	7-Dec-2024	Mid-shelf	36.7140	75.6409	1
#3950	Adult	Male	1	Travel	7-Dec-2024	Aerial	36.7052	75.6540	1
#4540 / Cavatappi	Adult	Female	2	Mill	18-Dec-2024	Mid-shelf	36.6762	75.7786	2
2024Calfof#4540	Yearling	Unknown	2	Mill	18-Dec-2024	Mid-shelf	36.6762	75.7786	2
#4540 / Cavatappi	Adult	Female	2	Mill	18-Dec-2024	Aerial	36.6775	75.7981	2
2024Calfof#4540	Yearling	Unknown	2	Mill	18-Dec-2024	Aerial	36.6775	75.7981	2
#2024Calfof#3320	Yearling	Unknown	1	Travel	27-Dec-2024	Mid-shelf	36.8367	75.5167	2
#2024Calfof#3320	Yearling	Unknown	1	Travel	27-Dec-2024	Aerial	36.8241	75.5225	2
#2024Calfof#3320	Yearling	Unknown	1	Travel	17-Jan-2025	Mid-shelf	36.7750	75.7480	2
#2024Calfof#3320	Yearling	Unknown	1	Travel	17-Jan-2025	Aerial	36.7758	75.7469	2
#1706 / Pencil	Adult	Female	3	Mill	25-Jan-2025	Mid-shelf	36.8964	75.3633	1
#3934	Adult	Female	3	Mill	25-Jan-2025	Mid-shelf	36.8964	75.3633	1
#4146	Adult	Female	3	Mill	25-Jan-2025	Mid-shelf	36.8964	75.3633	1
#1706 / Pencil	Adult	Female	3	Travel	25-Jan-2025	Aerial	36.8887	75.3684	1
#3934	Adult	Female	3	Travel	25-Jan-2025	Aerial	36.8887	75.3684	1
#4146	Adult	Female	3	Travel	25-Jan-2025	Aerial	36.8887	75.3684	1
#3301 / Neptune	Adult	Male	7	Travel	25-Jan-2025	Aerial	36.9951	75.6438	2
#3821 / ZigZag	Adult	Male	7	Travel	25-Jan-2025	Aerial	36.9951	75.6438	3
#4360 / Musketeer	Adult	Male	7	Travel	25-Jan-2025	Aerial	36.9951	75.6438	1
#4523 / Beaker	Adult	Male	7	Travel	25-Jan-2025	Aerial	36.9951	75.6438	5
#5104 / Wall-E	Juvenile	Male	7	Travel	25-Jan-2025	Aerial	36.9951	75.6438	1
#5190	Juvenile	Female	7	Travel	25-Jan-2025	Aerial	36.9951	75.6438	1
#5311 / 2023Calf0f1711	Juvenile	Male	7	Travel	25-Jan-2025	Aerial	36.9951	75.6438	1
#3301 / Neptune	Adult	Male	7	Mill	25-Jan-2025	Mid-shelf	36.9435	75.6595	2
#3821 / ZigZag	Adult	Male	7	Mill	25-Jan-2025	Mid-shelf	36.9435	75.6595	3
#4360 / Musketeer	Adult	Male	7	Mill	25-Jan-2025	Mid-shelf	36.9435	75.6595	1

Animal ID / Name	Age Class	Sex	Group Size	Behavior	Sighting Date	Survey Type	Sighting Latitude (°N)	Sighting Longitude (°W)	Unique Sighting Days[a]
#4523 / Beaker	Adult	Male	7	Mill	25-Jan-2025	Mid-shelf	36.9435	75.6595	5
#5104 / Wall-E	Juvenile	Male	7	Mill	25-Jan-2025	Mid-shelf	36.9435	75.6595	1
#5190	Juvenile	Female	7	Mill	25-Jan-2025	Mid-shelf	36.9435	75.6595	1
#5311 / 2023Calf0f1711	Juvenile	Male	7	Mill	25-Jan-2025	Mid-shelf	36.9435	75.6595	1
#3903 / Taffy	Adult	Female	2	Travel	27-Jan-2025	Mid-shelf	36.7601	75.4512	1
#4980 / Coral	Juvenile	Female	2	Travel	27-Jan-2025	Mid-shelf	36.7601	75.4512	1
#3903 / Taffy	Adult	Female	2	Travel	27-Jan-2025	Aerial	36.7637	75.4470	1
#4980 / Coral	Juvenile	Female	2	Travel	27-Jan-2025	Aerial	36.7637	75.4470	1
#3401 / Tux	Adult	Male	5	Social	15-Feb-2025	Mid-shelf	37.1383	75.2466	1
#4501	Adult	Male	5	Social	15-Feb-2025	Mid-shelf	37.1383	75.2466	1
#5012	Juvenile	Male	5	Social	15-Feb-2025	Mid-shelf	37.1383	75.2466	1
#2406 / Hammer	Adult	Male	6	Travel	10-Mar-2025	Aerial	37.0452	75.2873	1
#2795	Adult	Male	6	Travel	10-Mar-2025	Aerial	37.0452	75.2873	1
#3232 / Lobster	Adult	Female	6	Travel	10-Mar-2025	Aerial	37.0452	75.2873	1
#3423 / Epic	Adult	Male	6	Travel	10-Mar-2025	Aerial	37.0452	75.2873	1
#3545	Adult	Male	6	Travel	10-Mar-2025	Aerial	37.0452	75.2873	2
#4220 / Kermit	Adult	Male	6	Travel	10-Mar-2025	Aerial	37.0452	75.2873	1
#2406 / Hammer	Adult	Male	6	Travel	10-Mar-2025	OCS	36.9731	75.3136	1
#2795	Adult	Male	6	Travel	10-Mar-2025	OCS	36.9731	75.3136	1
#3232 / Lobster	Adult	Female	6	Travel	10-Mar-2025	OCS	36.9731	75.3136	1
#3423 / Epic	Adult	Male	6	Travel	10-Mar-2025	OCS	36.9731	75.3136	1
#3545	Adult	Male	6	Travel	10-Mar-2025	OCS	36.9731	75.3136	2
#4220 / Kermit	Adult	Male	6	Travel	10-Mar-2025	OCS	36.9731	75.3136	1

Key: ID = Identification Number; °N = degrees North; °W = degrees West
[a] Number of days individual has been sighted across all survey years, 2018–2025

2.4.4.2 Satellite Tagging Results

One Argos-linked SPLASH10-F satellite tag was deployed on a NARW during the 2024/25 field season (**Table 16** through **Table 18, Figure 19**). The tag transmitted for only 0.7 day before an unexpected rapid battery failure.

Whale 2024Calfof#3220 was tagged approximately 18.5 km east of Dam Neck on 17 January 2025, within both the MINEX area and inside the NARW SMA (**Figure 19**). The yearling initially traveled westerly, then back toward the east before transmissions ended. A re-sighting of 2024Calfof#3220 was made on 15 February 2025 off North Carolina by Clearwater Marine Aquarium Research Institute (CMARI) and photographs collected showed that the tag was no longer present. Maximum straight-line distance from the initial tagging location was 18.5 km, and mean distance was only 9.9 km (**Table 17**).

Table 16. NARW satellite-tag deployment details during the 2024/25 field season.

Animal ID	Estimated Age Class	Tag Type	Argos ID	Deployment Latitude (°N)	Deployment Longitude (°W)	Deployment Date	Last Trans-mission Date	Tag Duration (days)
2024Calfof #3320	Yearling	SPLASH10-333F	208690	36.7801	75.7406	17-Jan-25	18-Jan-25	0.7

Key: ID = identifier; °N = degrees North; °W = degrees West

Table 17. Summary of results from satellite-tag data for the NARW tagged during the 2024/25 field season.

Animal ID	# Locations Post Filtering	Percent within Shipping Channels	Percent within VACAPES	Maximum Distance from Initial Location (km)	Mean Distance from Initial Location (km)
2024Calfof#3320	15	0.0	100.0	18.5	9.9

Key: ID = identifier

The satellite tag also recorded data on dive depth and duration in addition to the Argos and Fastloc® Global Positioning System (GPS) location capabilities (**Table 18**). Despite the short duration, the tag recorded a total of 38 dives. Mean dive depth was 18.4 m, with a maximum dive depth of 35.0 m. The mean dive duration was 9.4 min with a maximum dive duration of 17.75 min (**Table 18**).

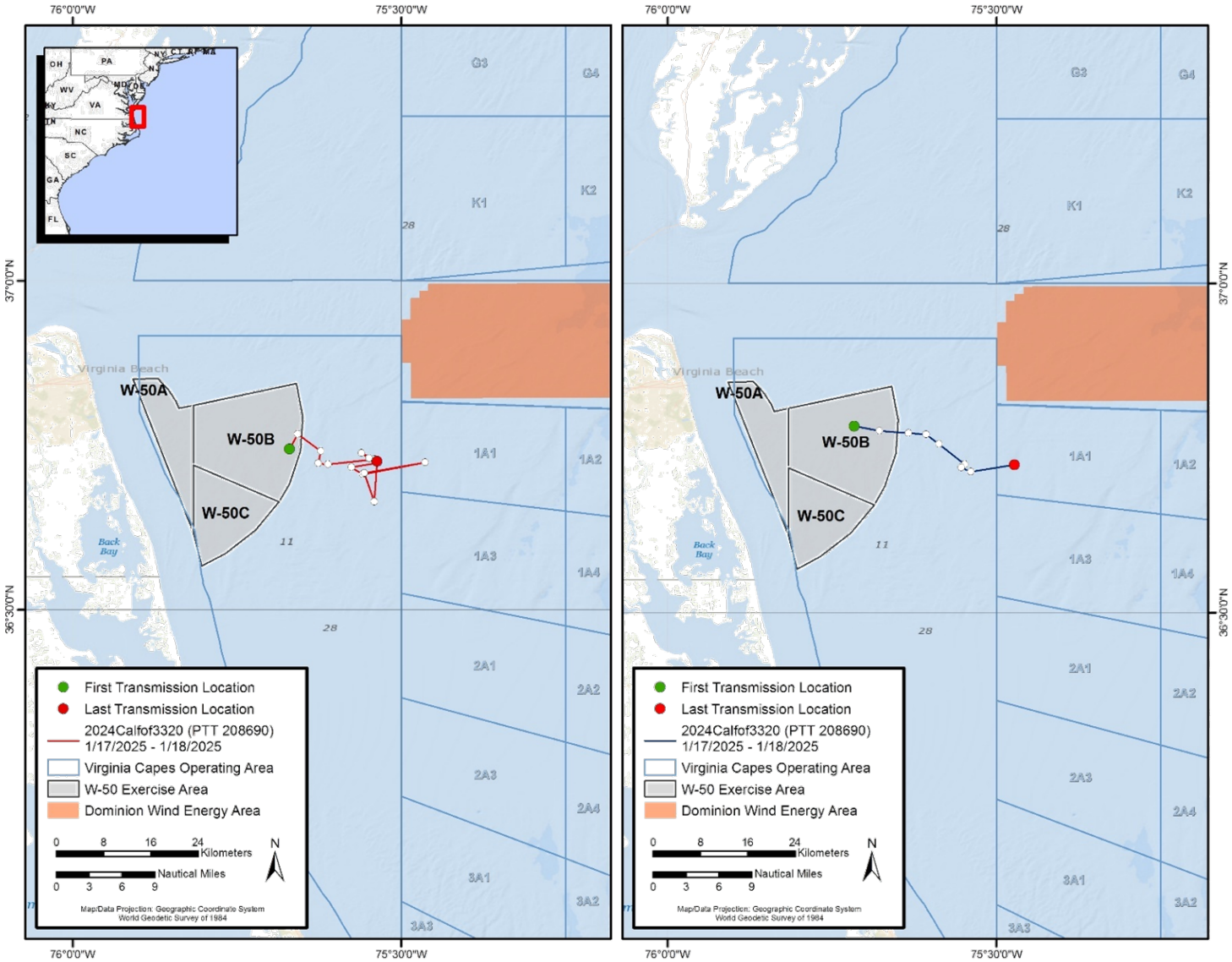


Figure 19. Filtered locations (white dots) and trackline of NARW 2024Calfof#3220, tagged on 17 January 2025, over 0.7 day of tag-attachment duration showing Argos (left) and Fastloc GPS (right) positions.

Table 18. Summary of dive depth and duration data collected from tagged NARW during the 2024/25 field season.

Animal ID	# Dives Logged	Mean Dive Depth (m)	Maximum Dive Depth (m)	Mean Dive Duration (mm:ss)	Maximum Dive Duration (mm:ss)
2024Calfof#3320	38	18.4	35.0	9:23	17:45

Key: ID = identifier; mm:ss = minutes:seconds

2.4.4.3 Digital Archival Tagging Results

Two successful CATS tag deployments occurred during the 2024/25 season on NARWs (**Table 19**).

Table 19. Successful NARW CATS tag deployment details.

Animal ID	CATS Tag No./ Deployment ID	Deployment (GMT)	Depth at Tagging (m)	Tag Off Animal (GMT)	Tag Duration (min)	Gender
NARW #4360	CATS 002/ eg250125	2025-Jan-25 20:53	20.1	2025-Jan-25 21:21	27	Male
NARW #4980	CATS 002/ eg250127	2025-Jan-27 16:09	24.4	2025-Jan-27 16:48	39	Female

Key: GMT = Greenwich Mean Time; No. = number

Figure 20 and **Figure 21** show dive profiles for the suction-cup-tagged NARWs. **Table 20** shows all dives defined using a modified MATLAB script from the animaltags.org toolbox with a dive-depth definition of 2 m and duration of 2 min. Tag durations were brief due to social interactions between individuals, which caused the tags to release prior to the programmed time. A total of 27 dives were logged, and the maximum dive depth recorded was 18 m. Average dive depth for all dives combined was 9.6 m, and the median was 8.2 m. Dive durations ranged from 18 seconds to 8 min, with a mean of 2 min for both individuals; surface durations ranged from 4.2 to 84.2 seconds. Bottom depths recorded from the vessel echosounder during sightings ranged between 27 and 39 m.

2.4.4.4 Discussion

The large number of unique NARW individuals sighted during the 2024/2025 season has remained similar to the last two field seasons, which may partially be a result of the increased survey effort within the area and in association with aerial survey support. The presence of relatively large groups, such as those observed during the 2022/23 season (Aschettino et al. 2024a), had not been documented prior to that season. The persistence of individuals to remain within the same general area up to 14 days suggests these individuals are not simply passing through and are at an increased risk of vessel strike and other anthropogenic activities within the area (Aschettino et al. 2024b; A. Engelhaupt et al. 2023b; D. Engelhaupt et al. 2023).

A UME specific to NARWs was also declared in 2017, with 150 instances of mortalities, serious injuries, and morbidity, primarily from rope entanglements and vessel strikes as of February 2026 (NOAA 2026a). The first vessel-related death of a NARW near Virginia Beach occurred in 2023 and highlights the potential for injuries and fatalities within this area. In March 2024,

another fatality was recorded off Virginia Beach, with this sighting first observed by the HDR Inc. aerial team; adult female #1950 (Ozog and Engelhaupt 2025) who had last been seen with her calf off of Florida. Because her calf was a dependent, both are included in the UME.

The current SMA is problematic because the areas where NARWs and humpback whales frequently occur are not within these boundaries. For instance, eight of nine sightings of NARW groups occurred outside the SMA during the 2022/23 (Aschettino et al. 2024a) field season, and all sightings of NARWs occurred outside the SMA during the 2023/24 field season (Aschettino et al. 2025a). For the 2024/25 season, only 4 out of the 19 NARW sightings were within the SMA (**Figure 18**).

Dynamic Management Areas (DMAs), which last 15 days after a grouping is detected, are used by NOAA to notify vessel operators of the presence of NARWs within a given area and urge mariners to reduce speed to 10 knots or fewer when traveling through (NOAA 2026d). Similarly, Right Whale Slow Zones, can be triggered by either visual or acoustic triggers, such as by the DMON buoys. During the 2024/25 season, five sightings would have yielded a DMA (if no active DMAs were already in place). These are voluntary requirements, however, and therefore do not guarantee additional protection to whales using those areas.

Dive data collected from satellite and digital archival tag deployments during the 2024/25 season have increased knowledge of behavior previously undocumented in the region. Mean dive depths under 20 m and maximum dive depths ranging 18-35 m (**Table 18** and **Table 20**) emphasize the large amount of time spent within the top 15 m of the water column, where they are at risk of vessel interaction. These data, combined with visual survey detections, continue to support the need for improved management strategies within the study area. Providing data that triggers DMAs under the existing management structure to reduce risk in real-time continues to be a valuable tool and continued collection of baseline behavioral data to is crucial to support possible future improved management area delineations.

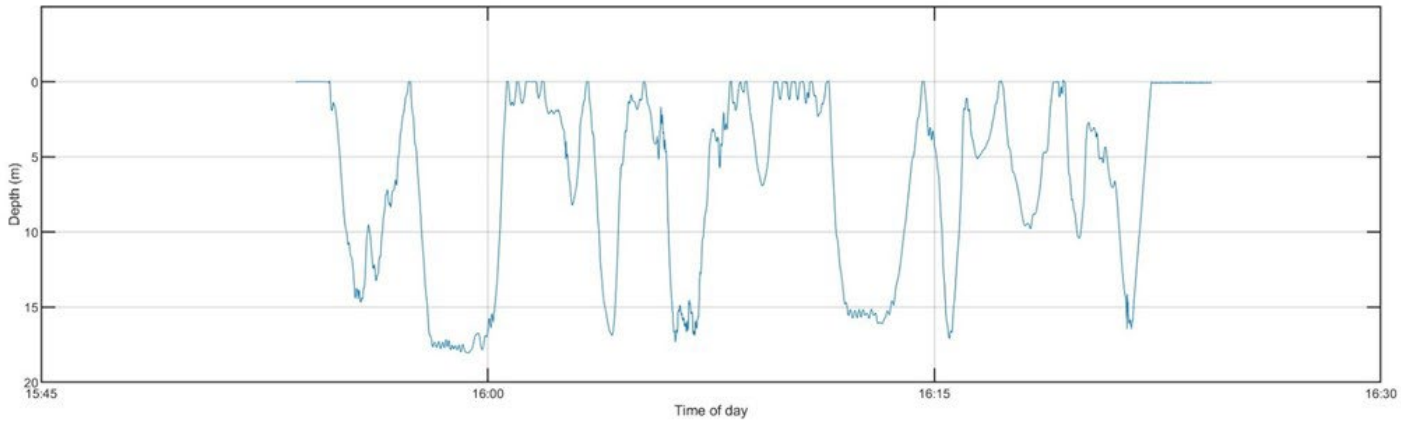


Figure 20. Dive-depth profile (in meters) for NARW 4360 'Musketeer' (CATS eg250125) in local time.

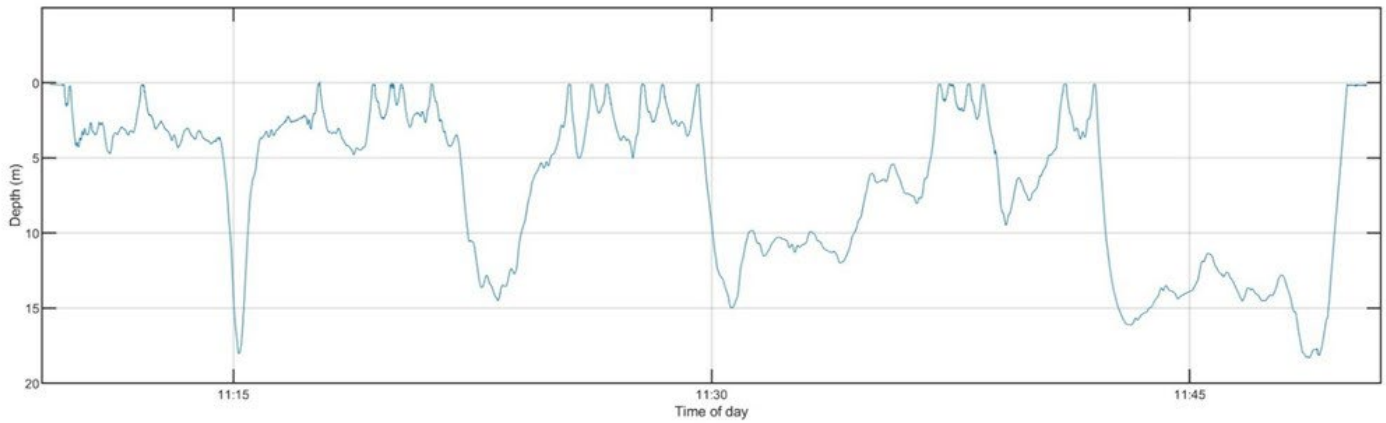


Figure 21. Dive-depth profile (in meters) for NARW 4980 'Coral' (CATS eg250125) in local time.

Table 20. Summary of archival tag dive data for all NARW tags deployed in 2025.

Data Category	NARW #4360/Musketeer	NARW #4980/Coral
Age-class	Adult	Adult
Sex	Male	Female
Deployment date	25 January 2025	27 January 2025
Deployment ID	CATS eg250125	CATS eg250127
Tag duration (hour)	0.45	0.65
Number of dives	11	16
Mean dive duration (min)	2.07	2.31
Median dive duration (min)	2.52	0.96
Mean surface duration (min)	0.48	0.20
Median surface duration (min)	0.28	0.12
Mean max dive depth (m)	13.1	7.18
Median max dive depth (m)	16.12	4.77
Maximum max dive depth (m)	18.1	18.3

Key: ID = Identification Number; max = maximum

For more information regarding NARWs in the Mid-Atlantic, refer to **Section 2.4.1** and Ozog and Engelhaupt (2026) for information on aerial surveys; **Section 2.4.2** and Engelhaupt et al. (2026) for information on the OCS; **Section 2.4.3** and Aschettino et al. (2026) for information on the Mid-Atlantic Baleen Whale Monitoring Program; and **Section 2.4.3.1** for information on passive acoustics.

2.5 Atlantic Behavioral Response Study

The Atlantic BRS was conceived, designed, adapted, and applied through a collaboration building on historical and ongoing U.S. Navy-funded studies under the MSM Program. It uses a combination of novel multi-scale tagging approaches for baseline monitoring and BRSs at multiple temporal and spatial scales for key marine mammal species—primarily *Ziphius* and, secondarily, short-finned pilot whales—off the coast Cape Hatteras, NC. The project advances approaches developed from previous BRS field and analytical work supported by the U.S. Navy's LMR program and ONR 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 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 U.S. Navy's highest-priority marine mammal species, *Ziphius*.

The overall objective of the study 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, 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. The focus of this work in recent years has been solely on the highest-priority species for the U.S. Navy in meeting their mandated requirements to assess the impacts of training and testing activities on protected species, specifically *Ziphius*. This has included baseline behavior and exposure-response, and provided sufficiently large sample sizes to begin addressing exposure consequences for this high-priority species. In 2025, however, the analytical effort also pivoted back to earlier CEEs with pilot whales, in coordination with several U.S. Navy research laboratories, thus directly addressing focal areas for the U.S. Navy's MSM Program for multiple species.

Many U.S. Navy-funded studies of marine mammal responses to MFAS, including the Southern California BRS, focused on the use of short-term, high-resolution acoustic tag sensors (or alternative short-duration monitoring means) to measure fine-scale behavior in response to experimentally controlled noise exposure. Other studies have used coarser-scale, longer-term measurements of movement and diving behavior associated with incidental exposures during sonar training operations. The Atlantic BRS project applies both approaches, expanding the temporal and spatial scales of previous BRSs by combining (1) short-term, high-resolution acoustic archival tags (or DTAGs) providing short-term (hours) but very high-resolution movement and calibrated acoustic data with (2) satellite-linked, time-depth recording tags (satellite tags) providing 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 custom and adapted proven and published statistical methods. These are tuned to address specific, biologically meaningful types of responses, namely (1) potential avoidance of sound sources that influence habitat usage, (2) changes in foraging behavior, and (3) changes in social behavior.

Earlier field seasons involved pulsed active sonar (PAS) signals (approximately 1.5-second duration; 25-second duty cycle) from both simulated and operational MFAS sources. These results have recently been finalized for simulated sources (Southall et al. 2026b) and are nearing submission for publication for operational MFAS. Beginning in 2023, the Atlantic BRS project began investigating responses to continuous active sonar (CAS). While CAS signals are similar in frequency and overall modulation patterns, they are presented entirely or nearly continuously. And while the total output power of these signals may be similar in terms of total energy, the root-mean-square (RMS) sound pressure levels are consequently lower. Therefore, the overall exposure context is quite different, and there is interest in directly measuring and contrasting exposure and response from CAS stimuli with the large PAS data set obtained thus far. This 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 supplemental funding for the program in coordination with the U.S. Navy's MSM Program.

The 2025 field season, which occurred in a single continuous effort from June through September, included one of the study team's most successful campaigns to date in terms of tagging and field operations; U.S. Navy operational coordination; and the fielding of a new, key piece of equipment. Multiple CAS-capable vessels were scheduled for possible coordination thanks to sustained coordination and planning between the field team and U.S. Fleet Forces Command (USFFC). These efforts yielded among the largest number (*n*=14) of beaked whale tags deployed in any field season, with excellent performance in terms of the duration of tags (nine tags exceeding 30-day duration, including the team's longest-ever duration at over 250 days and still transmitting as of June 2026) and number of tagged, high-priority beaked whales monitored in CEEs. The study team conducted two CEEs in 2025 with 11 total *Ziphius* CAS-exposure individuals. This included extensive coordination with the U.S. Ship (USS) *Donald Cook* (DDG-75) to conduct the second-ever CEE operational CAS (*n*=7) as well as the first-ever CEE with a newly constructed MFAS high-power experimental source simulating CAS signals (*n*=4).

A brief synthesis of experimental methods is provided in this report, as well as summaries of field efforts, tagging results, and exposure-response results for two CEEs conducted with the USS *Donald Cook* in 2025. A summary of the peer-reviewed papers that have been or are in the process of being published is also provided.

Full details of the experimental design, analytic approach, and field logistics can be found in the 2025 annual progress report for this project (Southall et al. 2026a).

2.5.1 Field Effort

Atlantic BRS field efforts for 2025 were conducted intermittently and adaptively given field conditions and U.S. Navy vessel schedules, across a single field season that ran from June through September. Tagging priority was placed on *Ziphius* during the 2025 field season. Field teams included a team (four to five individuals) aboard the research vessel (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 six individuals worked offshore from the fast catamaran R/V *Shearwater* along with, in reasonable conditions and daylight hours, the R/V *Barber* (which 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 2025 tag deployments and CEEs, as well as re-sighting and biopsy sampling of focal individuals thereafter.

Overall, 14 satellite tags were deployed, all on *Ziphius*; however, only 12 tags provided sufficient duration for inclusion in the analyses (**Table 21**, **Figure 22**).

Table 21. Satellite tag deployments for *Ziphius cavirostris* during the Atlantic BRS in 2025.

Species/ Tag ID	Deployment Date	Deployment Latitude (°N)	Deployment Longitude (°W)	Dive Data Streams	Tag Duration (days)
ZcTag151_DUML[a,b]	21 June 2025	35.6264	74.7974	5-minute time series	194+
ZcTag152_DUML[a]	22 June 2025	35.5512	74.6787	5-minute time series	0
ZcTag153_DUML[c]	12 July 2025	35.7369	74.7175	5-minute time series	33
ZcTag154_DUML[c]	12 July 2025	35.7350	74.7005	5-minute time series	44.9
ZcTag155_DUML[c]	13 July 2025	35.5601	74.6732	5-minute time series	54.2
ZcTag156_DUML[c]	13 July 2025	35.6488	74.7373	5-minute time series	15.1
ZcTag157_DUML[c]	14 July 2025	35.6223	74.7616	5-minute time series	53.8
ZcTag158_DUML[c]	14 July 2025	35.5207	74.7611	5-minute time series	45.9
ZcTag159_DUML[c]	30 July 2025	35.7256	74.7438	5-minute time series	41.7
ZcTag160_DUML[c]	30 July 2025	35.8525	74.6198	5-minute time series	0
ZcTag161_DUML[c]	4 September 2025	35.5650	74.7785	5-minute time series	27.1
ZcTag162_DUML[c]	4 September 2025	35.5749	74.7628	5-minute time series	51.8
ZcTag163_DUML[c]	5 September 2025	35.6386	74.7642	5-minute time series	0.7
ZcTag164_DUML[c]	5 September 2025	35.6034	74.7863	5-minute time series	36

Key: ID = Identification Number; °N = degrees North; °W = degrees West; Zc = *Ziphius cavirostris*
[a] Smart Position and Temperature (SPOT)-365 tags
[b] Tag still transmitting as of 31 January 2026
[c] SPLASH10-333 tags

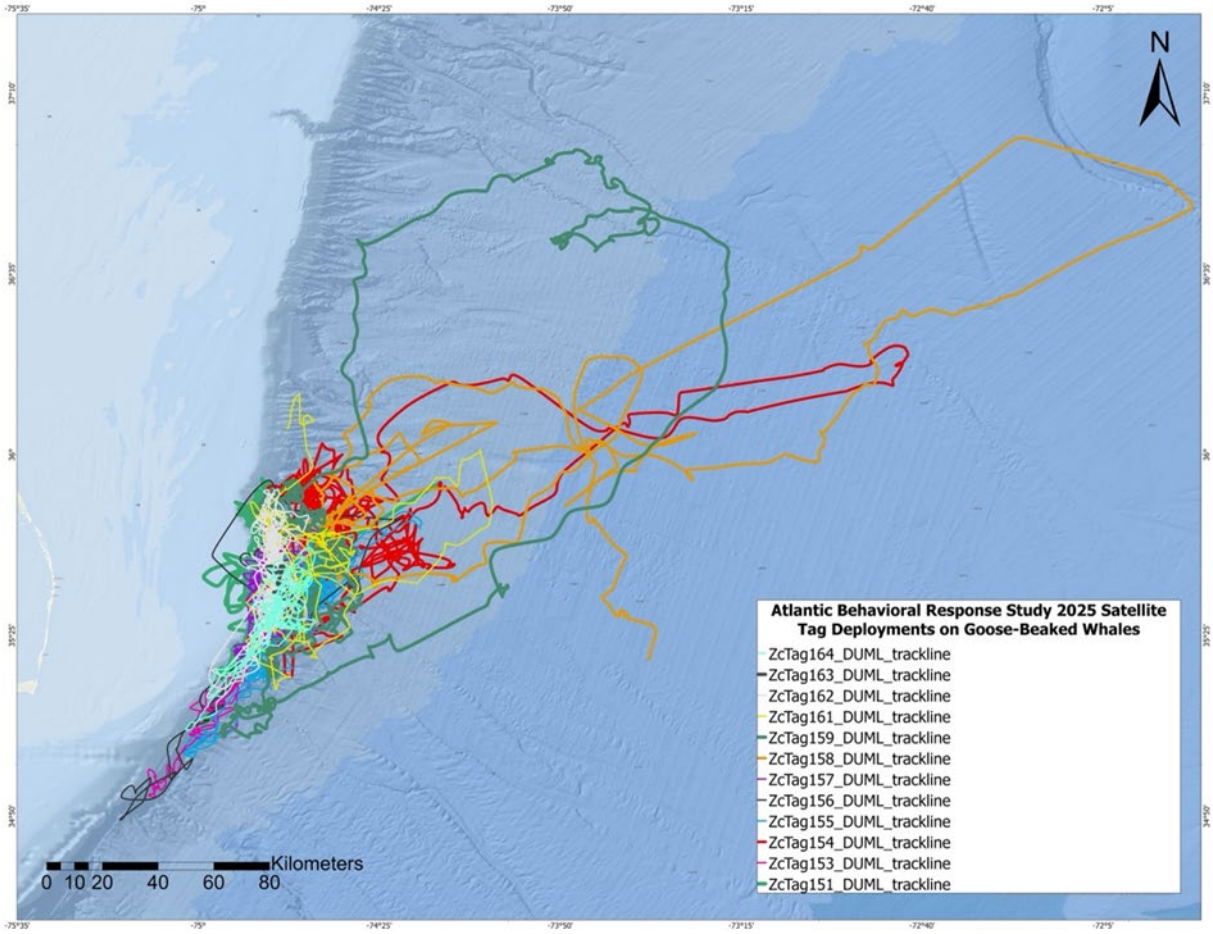


Figure 22. Predicted tracks from multiple imputations for tagged beaked whales (*n*=12) with sufficient spatial data during Atlantic BRS 2025 field effort.

2.5.1.1 Summary of 2024 Field Effort: Accomplishments and Assessment

Accomplishments:

- Successfully deployed 14 satellite tags on beaked whales, resulting in tens of thousands of hours of movement and behavioral data, including several early-season Smart Position and Temperature (SPOT) tags that provided awareness on distribution and re-sight potential through the end of field season.
- Conducted second successful CAS CEE with U.S. Navy operational sources for *Ziphius* (*n*=7).
- Successfully obtained, tested, fielded, and calibrated new operational CAS-capable MFAS simulated sound source.
- Conducted first-ever simulated CAS CEE for any species, including *Ziphius* (*n*=4), with high-power experimental MFAS source.
- Obtained thousands of photo-ID images.

- Continued success with research platform R/V *Shearwater*, which was highly successful in locating and tracking animals, including successful overnight tracking ahead of and following CEE, and serving as a base of operations for a CAS-capable MFAS source.
- Sustained efforts to relocate satellite-tagged animals in the field using goniometer detections, increasing chances of subsequent tag deployments. This improved animal pseudotracks by providing high-confidence surface locations. This resulted in relocating groups to deploy additional tags as well as many photo-ID re-sights to evaluate group composition, social interactions, and biopsy samples.

Assessment of Field Approach:

The combined team with USFFC again successfully identified multiple CAS-capable ships and scheduled two for direct participation with the Atlantic BRS project during 2025. This included efforts to coordinate with vessels operating from nearby Norfolk Naval Station as well as a vessel transiting through the study area from a different geographical location for training and testing within the VACAPES OPAREA. Both scheduled ships were transiting, which provided multiple coordination opportunities in transit. One was successfully conducted and included some operational lessons-learned in terms of field communications. The second ship was poised to coordinate both on the way up, though this was not possible given conditions from Hurricane Erin, and on the way back; however, this was not possible given the ship timing of passage through the area during nighttime operations. These outcomes both highlight the successes and multiple options for transiting vessels, but also the challenges of timing given operational requirements. A hybrid approach that includes specifically scheduled vessels during local training operations, if possible, as well as adaptive approaches for transiting vessels is logical moving forward, in sustained close coordination with USFFC.

The study team again experienced mostly challenging early-season conditions but remained ready to go during the early season and, for the first time in several years, deployed some tags in June 2025. Given the coordinated scheduling with U.S. Navy ships, these were strategically selected as SPOT location-only tags to enable longer-duration monitoring of movement and relocate groups for subsequent tag deployments. This strategy was effective and included the longest-duration locational data for any *Ziphius* in the study's data set. Subsequent adaptive efforts to deploy additional batches of tags during the weeks prior to scheduled ships were again very effective and resulted in many target whales for both CEE periods.

Satellite tags collected and transmitted continuous, high-quality, dive data due to earlier progress in tag programming strategies to minimize gaps in tag data as well as improve temporal resolution of diving and behavioral data. The team successfully collected continuous dive data for up to 24-day periods, strategically covering CEE periods, as designed. Long-duration (more than 200-day) functioning of location-reporting tags in reporting Argos positions occurred. Importantly, the study team observed a major increase in the quality and quantity of the data received from satellite-transmitting tags due to the integration of new low-Earth orbiting satellites (Kinéis) within the Argos network.

2.5.2 Controlled Exposure Experiments

Two CEE sequences were conducted during the Atlantic BRS 2025 field effort (**Table 22**). A dedicated CAS-capable ship (USS *Donald Cook*) was scheduled and coordinated with the Atlantic BRS team in July to support the second operational MFAS CAS CEE for this project. Seven *Ziphius* (with one SPOT and six SPLASH10 tags) were monitored visually (focal) and remotely (non-focal) during this experiment (CEE #25_01). The team tested, fielded, and deployed a new simulated CAS-capable sound source in the first-ever CEE with simulated CAS signals conducted in September with four *Ziphius* (with one SPOT and three SPLASH10 tags) in CEE #25_02.

Table 22. CEEs conducted during Atlantic BRS 2025 field efforts.

CEE ID	Date	CEE Type	Focal Whales[a]	Non-focal Whales[a]	CEE Duration (min)	Start CEE Source Latitude (°N)	Start CEE Source Longitude (°W)
#25_01	19 July 2025	Operational MFAS CAS	ZcTag156	ZcTag151 ZcTag153 ZcTag154 ZcTag155 ZcTag157 ZcTag158	54	35.8667	74.303
#25_02	19 September 2025	Simulated MFAS CAS	ZcTag161	ZcTag151 ZcTag162 ZcTag164	30	35.3397	74.6539

Key: ID = Identification Number; °N = degrees north; °W = degrees west
[a] Zc = *Ziphius cavirostris*

Table 23 and **Table 24** summarize the CEE #25_01 and CEE #25_02 sequences, respectively. The full 2025 annual progress report for this project (Southall et al. 2026a) includes a complete synthesis of the CEEs 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 *Donald Cook* for Atlantic BRS CEE #25_01 is shown in **Table 25** and **Figure 23**. Spatial depiction of animal locations before and after Atlantic BRS CEE #25_01 for all focal and non-focal individuals is shown in **Figure 24**.

Table 23. Metadata summary for Atlantic BRS CEE #25_01.

CEE #25_01	
Date:	19 July 2025
Type:	CAS from USS *Donald Cook*
Signal parameters:	• Linear FM upsweeps: 2,508–3,158-Hz bandwidth (650-Hz bandwidth) • 50-s sweep duration; 100% duty cycle; 60-min total transmit duration • Vessel positioned using in-situ modeling • Requested straight line transit 8 knots (effective speed over ground) • Source level: assumed to be 218 dB RMS (across band)
Start time (UTC):	22:50
Start lat/lon (source):	35.8667; –74.303
End time (UTC):	23:44 (54 min exposure duration; slightly less than requested)
End lat/lon (source):	35.7667; –74.2867
Beaked whales tagged during CEE:	(*n*=7): ZcTag156 (focal satellite-tagged animal) Non-focal whales: ZcTag151; ZcTag153; ZcTag154; ZcTag155; ZcTag157; ZcTag158
Estimated range (start CEE):	~22 km at start (focal follow locations) for focal
Modeled max RL:	Variable for final position model runs/depths ≥ 117–134 dB RMS (across band) = 134–151 dB SEL per ping (based on model runs 25–28; see Table 4 in Southall et al. 2026a)
CEE #25_01 – Narrative Summary	
With support from the U.S. Navy's MSM Program, NAVFAC, and USFFC, a successful CEE was conducted in collaboration between the USS *Donald Cook* and the Atlantic BRS team. This CEE was conducted on 19 July 2025 off the continental shelf break east of Cape Hatteras, North Carolina. This experiment marks just the second such set of direct measurements ever made (following a 2024 coordination with the USS *Thomas Hudner*) of operational, full-scale CAS sonar for one of the U.S. Navy's highest priority species for impact assessment (*Ziphius*). It also included a large increase in sample size from the three individuals tested in the first-ever such CEE in 2024 (just one having associated dive data), with a total of seven individual beaked whales tagged and monitored during the USS *Donald Cook* CEE (including six with associated dive data). There appears to be a less obvious broad spatial movement (horizontal avoidance) evident than in some prior MFAS PAS CEEs and individuals in the 2024 CAS CEE. However, diving responses are evident in many focal and incidental whales from dive-sensing tags, including extended or altered dive patterns relative to non-exposed dives before exposure, with some possible interesting differences relative to prior MFAS PAS findings.	

Key: dB = decibel(s); FM = frequency-modulated; lat = latitude; lon = longitude; max = Maximum; s = second(s); SEL = Sound Exposure Level; UTC = Coordinated Universal Time; Zc = *Ziphius cavirostris* (*Ziphius*)

Table 24. Metadata summary for Atlantic BRS CEE #25_02.

CEE #25_02	
Date:	19 September 2025
Type:	CAS from Experimental Source Simulation
Signal parameters:	• Linear FM upsweeps: 3,100–3,850-Hz bandwidth (650-Hz bandwidth) • 50-s sweep duration; 100% duty cycle; 30-min total transmit duration • Vessel positioned using in-situ modeling • Source level: calibrated as 200 dB RMS (across band); -18 dB re: operational CAS source level
Start time (UTC):	16:26
Start lat/lon (source):	35.3397; –74.6539
End time (UTC):	16:56 (30 min exposure duration)
End lat/lon (source):	35.3386; –74.6391
Beaked whales tagged during CEE:	(*n*=4): ZcTag161 (focal satellite-tagged animal) Non-focal whales: ZcTag151; ZcTag162; ZcTag164
Estimated range (start CEE):	~2.7 km at start (focal follow locations) for focal
Modeled max RL:	Variable for final position model runs/depths ≥ 122–131 dB RMS (across band) = 140–149 dB SEL per ping (based on model runs 33–34; see Table 6 in Southall et al. 2026a)
CEE #25_02 – Narrative Summary	
Prior to field operations in September 2025 that were targeted toward coordinating a second CAS CEE with a scheduled operational U.S. Navy ship, the Atlantic BRS team successfully obtained, tested, fielded, and calibrated a new operational CAS-capable MFAS sound source. When operational limitations precluded coordination with the U.S. Navy vessel, the BRS team adapted to conducting the first-ever CEE simulation U.S. Navy CAS signals for any species, including *Ziphius*, with this high-power experimental MFAS source. This CEE was directed toward focal whale ZcTag161 at a range of ~1.5 nm and with non-focal whales (ZcTag151 [also incidental in CEE #25_01], ZcTag162, and ZcTag164). Initial analyses suggest horizontal avoidance evident in the focal and two of the three non-focal individuals. Some diving responses are evident in the focal and non-focal whales with functioning dive-sensing tags This includes extended or altered dive patterns relative to non-exposed dives prior to CAS exposure.	

Key: dB = decibel(s); FM = frequency-modulated; lat = latitude; lon = longitude; max = Maximum; RMS = root mean square; s = second(s); SEL = Sound Exposure Level; UTC = Coordinated Universal Time; Zc = *Ziphius cavirostris* (*Ziphius*)

Table 25. Sequential positioning for USS *Donald Cook* ahead of Atlantic BRS CEE #25_01.

Position Request for USS *Donald Cook*	Description	Latitude (°N)	Longitude (°W)	Heading
1	Nominal initial position (provided weeks in advance)	35.90	74.50	Not specified
2	16 July 1400 EDT – 72-hour pre-CEE revised position based on three possible focal animal, higher-quality Argos locations at multiple depths	35.85	74.45	Not specified
3	17 July 1200 EDT – 48-hour pre-CEE revised position based on four possible focal animal higher quality Argos locations at multiple depths	35.85	74.35	170
4	18 July 1200 EDT – 24-hour pre-CEE revised position based on three possible focal animal, higher-quality Argos locations at multiple depths	35.90	74.30	175
5	Final requested position 19 July 1100 EDT based on higher quality Argos locations and known/actual positions from selected focal whale Zc156	35.95	74.30	175
6	Actual position and course from USS *Donald Cook* navigation (INS 01)	35.8667	74.3030	193–196 heading maintained; made 173 true course

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

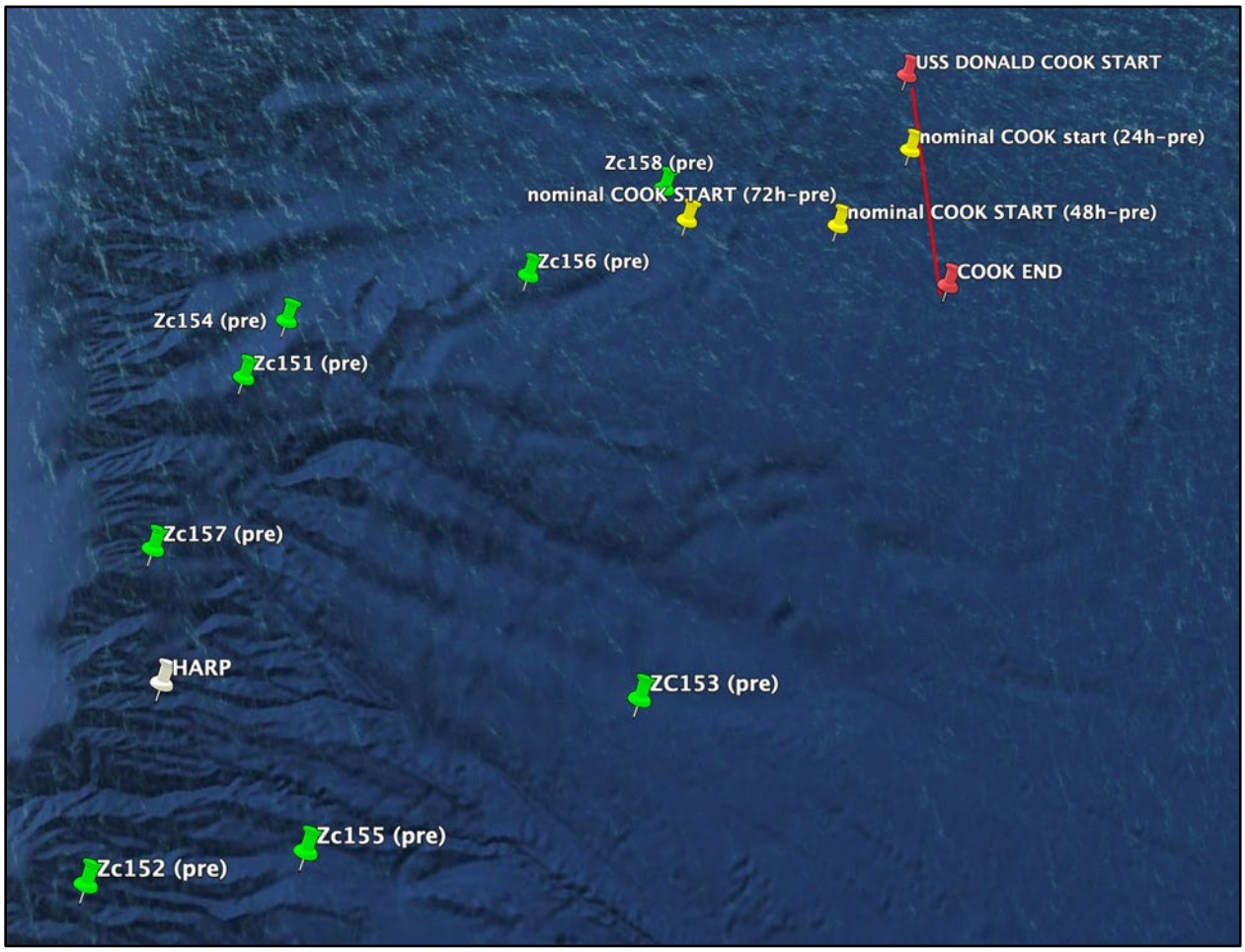


Figure 23. Sequential requested start positions for the USS *Donald Cook* on specified days in advance (yellow pins) as well as the final start and end positions (red pins; red track approximately 8 nm) requested on the day of CEE #25_01. Vessel positions are shown relative to focal animal (ZcTag156) and non-focal whales (ZcTags 151, 153, 154, 155, 157, 158) position estimates (green pins) used in RL modeling and to inform the vessel position requests, and the recording HARP (white pin) is shown.

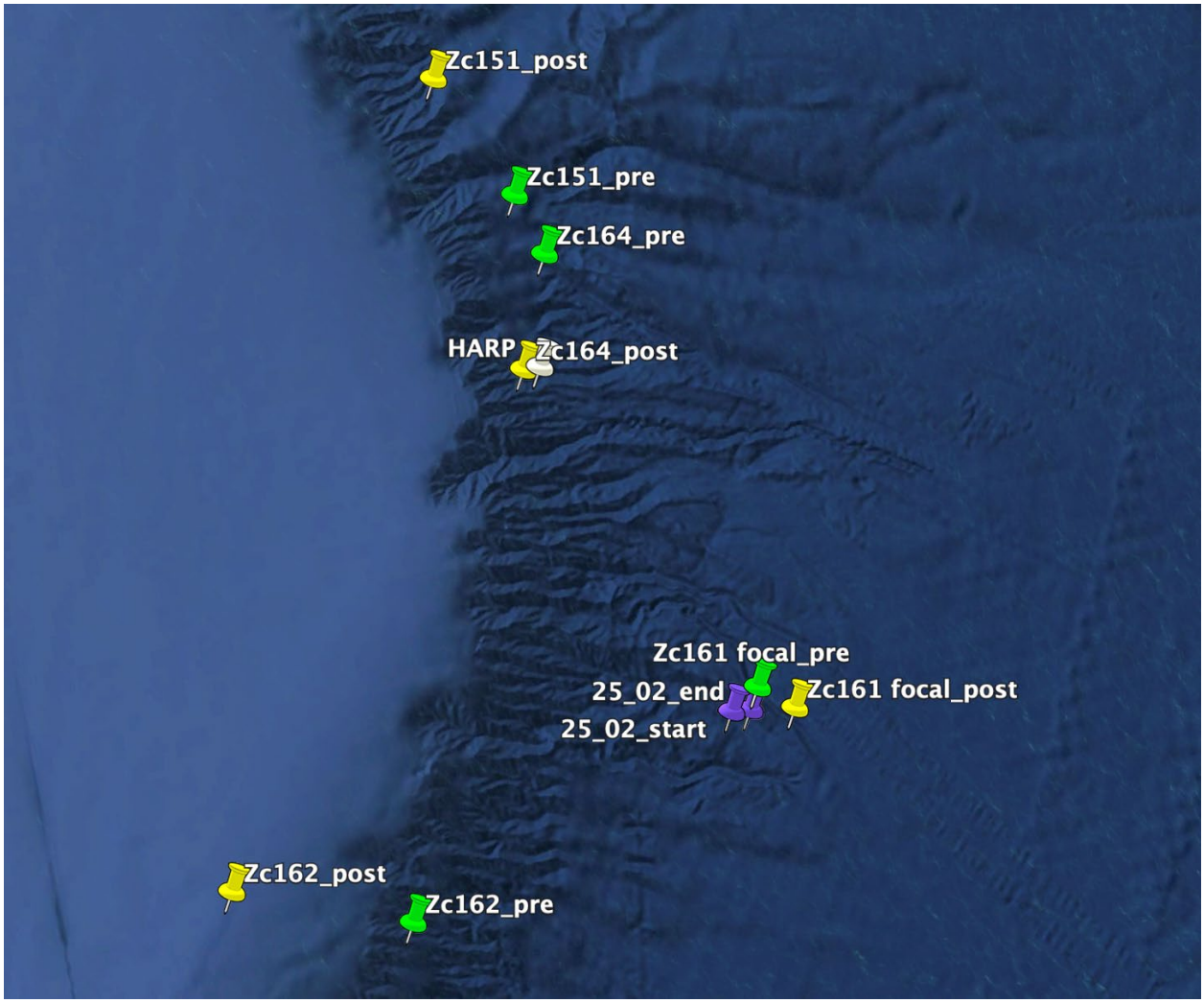


Figure 24. Broad view of focal whale (ZcTag161) and other tagged beaked whales (ZcTag151, ZcTag162, ZcTag164) before (green pins), and after (yellow pins) simulated CAS CEE #25_02. The actual start and end locations (purple pins) and for the M/V *Shearwater* (from which source was deployed) and the recording HARP (white pin) are shown.

2.5.3 Kinéis Satellite System Assessment

In 2025, three NOAA satellites carrying Argos instruments were decommissioned, leaving only five remaining satellites. While future satellite launches are planned with additional Argos instruments, a new constellation of Argos-capable small nanosatellites also came online in the beginning of the field season during late June 2025. Called Kinéis, this system includes 20 satellites with Argos capabilities, and the system boasts greatly improved Argos temporal coverage for most of the Earth's surface (Wildlife Computers 2025). This section includes a brief comparison of actual performance between the legacy Argos satellites and the new Kinéis constellation on the same cohort of deployed Argos-linked tags.

At the time of this analysis, 11 tags had ceased operating after transmitting between 0.7 to approximately 55 days of position data (mean = 37 days, standard deviation = 17 days). A single SPOT tag (ZcTag151) has been transmitting for more than 100 days.

Kinéis delivered 3.1 to 5.7 times the number of positions (mean = 4.2, standard deviation = 0.7) as the legacy system. Day-to-day performance was fairly consistent, with Kinéis outperforming the legacy system on nearly every day, with only a few exceptions. There appeared to be a periodic cycle to the Kinéis positions, perhaps created by the geometry of the constellation (**Figure 25**).

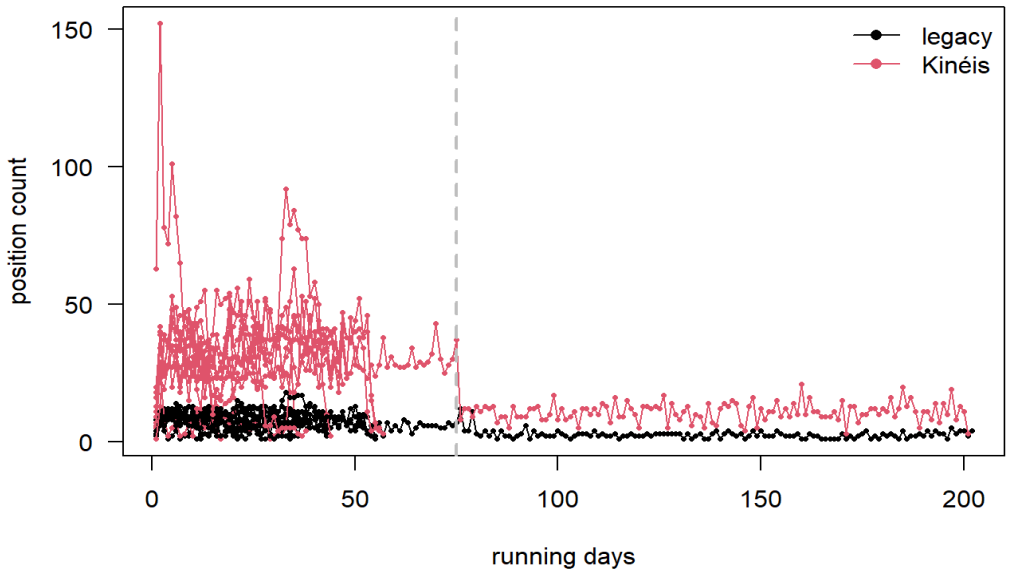


Figure 25. Total daily number of received positions for all tags transmitting during the 2025 field season (*n*=11) on both the legacy Argos and new Kinéis systems. Broken gray line indicates beginning of duty cycling on the SPOT-365 tag (ZcTag151).

Reported error was also markedly lower for the Kinéis data compared to the legacy positions. Note again, however, that the error is reported differently for each system, so direct comparisons should be made with caution. Nevertheless, mean error radius on Kinéis when compared to semi-major axis on the legacy system was more than an order of magnitude smaller (approximately 2.3 km compared to 39 km). Additionally, Kinéis seems much less susceptible to outliers, as the semi-major axis error for the legacy system had a much longer tail (**Figure 26**). The legacy Argos systems use of polar orbiting satellites generates relatively eccentric ellipses typically orientated with their semi-major axis close to the east-west line. North-south (semi-minor axis) error tends to be much less and was smaller on average than the Kinéis error radius (2 km compared to 2.4 km).

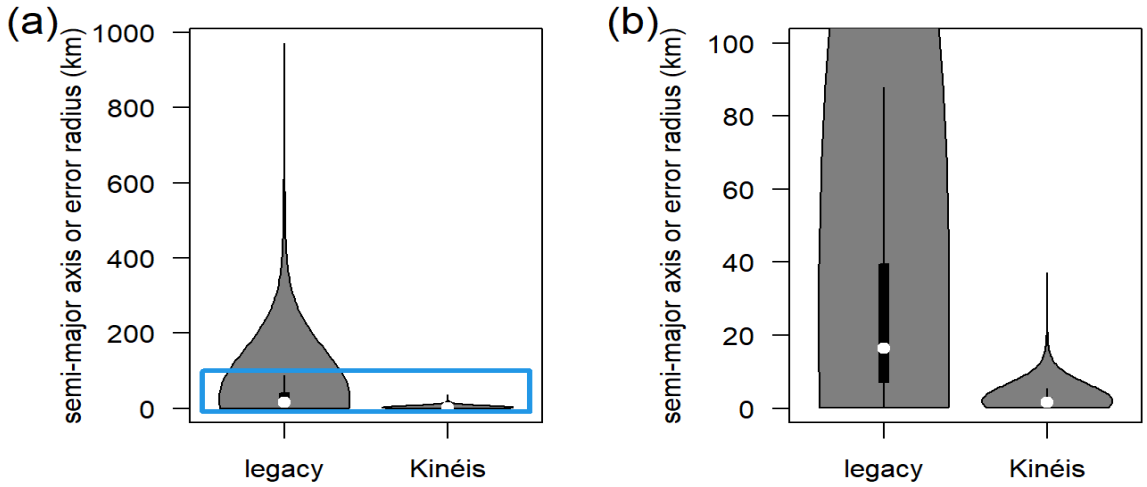


Figure 26. Comparison of distributions of reported error from tags deployed during the 2025 field season (*n*=12) on both the legacy Argos system (error ellipses semi-major axis) and the new Kinéis system (error radius); (b) is a zoom in on (a), indicated by the blue rectangle.

The Kinéis data streams have not yet been fully integrated into the Wildlife Computers data portal, but they can be downloaded manually. Due to malfunctions with the Kinéis portal, only a subset (*n*=9) of the tags was able to be downloaded and decoded at the time of this report. For these tags, between 2.6 and 4.4 times the number of data messages were received on Kinéis compared to the legacy system with a mean data message increase of 3.6 times. The corrupt message rate (i.e., those messages that could not be decoded) was similar for both at 16 and 20 percent, respectively, for the Kinéis and legacy systems.

Kinéis provides clear benefits in the form of a larger number of lower error positions per unit of time. These data should improve position and RL modeling substantially. Additionally, since near real-time position data will be available in subsequent field seasons, the Kinéis data will improve the study team's ability to relocate tagged animals in the field by providing more and lower error positions from which to start the search.

Kinéis effectively increases the study's data bandwidth because of greater satellite availability. This is especially important for infrequent surfacers such as *Ziphius*. The study team should be able to remove the programmed data blackout as well as collect more data and positions overnight. The study team will have to consider battery life trade-offs, however, because as the tags are currently programmed, this would increase battery consumption by 25 percent. Additionally, it may be possible to take advantage of increased data bandwidth to increase the duration or resolution of data collection for time-series depths, for example. Again, battery life trade-offs will have to be considered. While more time-series data was received on all tags on Kinéis when compared to the legacy system, poor performing tags still failed to transmit all their data even on Kinéis, so there is still risk in increasing the study team's data collection.

The study team plans to quantify the benefit to RL modeling in realistic scenarios and compare it to the inclusion of Fastloc data. No Fastloc-equipped tags were deployed during the 2025 field season, so their performance on the Kinéis system is currently unknown; however, the study team can assume the effective increase in data bandwidth could result in the transmission of a greater number of Fastloc positions. Fastloc still represents a significant data burden on Argos-linked tags, so it will be important to measure the benefit of the addition of Fastloc in downstream analyses. There may be diminishing returns of Fastloc when using large numbers of Kinéis-derived locations, since Fastloc positions tend to be infrequent on species such as *Ziphius*.

2.5.4 Results, Analytical Developments, Publications, and Presentations

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 26**; direct links to publications are provided where available.

Table 26. Atlantic BRS publications and manuscripts published or 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 University)	Published
Methodology – technology	Mind the gap – optimising satellite tag settings for time series analysis of foraging dives in Cuvier's beaked whales	Quick (Duke University)	Published
Methodology – technology	Accounting for positional uncertainty when modeling received levels for tagged cetaceans exposed to sonar	Schick (Duke University)	Published
Baseline behavior	Aerobic dive limits in Cuvier's beaked whales	Quick (Duke University)	Published
Methodology – technology	Continuous-time discrete-state modeling for deep whale dives	Hewitt (Duke University) [Double Mocha]	Published
Baseline behavior	Residency and movement patterns of Cuvier's beaked whales (*Ziphius cavirostris*) off Cape Hatteras, North Carolina, USA	Foley (Duke University)	Published
Baseline behavior	Extreme synchrony in diving behaviour of Cuvier's beaked whales (*Ziphius cavirostris*) off Cape Hatteras, North Carolina	Cioffi (Duke University)	Published
Methodology – technology	Kernel density estimation of conditional distributions to detect responses in satellite tag data	Hewitt (Duke University) [Double Mocha]	Published
Methodology – technology	Time-discretization approximation enriches continuous-time discrete-space models for animal movement	Hewitt (Duke University) [Double Mocha]	Published
Methodology – technology	Varying-coefficient stochastic differential equations with applications in ecology	Michelot (University of St. Andrews) [Double Mocha]	Published
Methodology – technology	Continuous-time modelling of behavioural responses in animal movement	Michelot (University of 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*	Cioffi (Duke University)	In preparation
CEE exposure – response	Behavioral responses of *Ziphius cavirostris* to simulated mid-frequency active military sonar	Southall (SEA)	Published
Methodology – technology	Estimating RLs and horizontal avoidance with dynamic covariates in exposed animals	Schick (SEA)	Published
Baseline behavior	Possible orientation behavior in *Ziphius*	Quick (University of Plymouth)	In preparation
CEE exposure-response	Behavioral responses of goose-beaked whales to operational mid-frequency active military sonar systems off Cape Hatteras, NC	Southall (SEA)	Final preparation

Category	Nominal Title/Subject	Lead Author (Institution)	Status
Baseline physiology	Baseline variation of steroid hormones in short-finned pilot whales (*Globicephala macrorhynchus*)	Wisse (Duke University)	In preparation
Disturbance exposure-response	Measuring stress responses in short-finned pilot whale biopsies: are field methods confounding our data?	Wisse (Duke University)	In preparation
Baseline behavior	More than metronomes: variation in diving behaviour of goose-beaked whales (*Ziphius cavirostris*)	Quick (University of Plymouth)	In preparation
Baseline behavior	Wound-healing from satellite tag deployments in *Ziphius*	Read (Duke University)	Final preparation
Methodology – technology	Improvements to received level estimates with the use of Fastloc® tags in behavioral response studies	Cioffi (SEA)	In preparation
Baseline behavior	Benthic foraging tactics in *Ziphius*	Kootstra/Quick (University of Plymouth)	Final preparation
Methodology – technology	Detecting changes in foraging behavior in goose-beaked whales exposed to sonar using coarse resolution data	Cioffi (SEA)	In preparation

Key: NC = North Carolina; SEA = Southall Environmental Associates Inc.

2.5.5 Overall Assessment and Recommendations

The following summarizes the accomplishments and general assessments for the 2025 field effort:

- This field season produced the second-most satellite tag deployments, the most baseline data, the longest reporting satellite tag (more than 250 days and still functioning as of June 2026), and the most exposure events for *Ziphius* over the entire course of the project.
- The Atlantic BRS team conducted the second CEE with U.S. Navy ship-based, full-scale CAS MFAS projected from the USS *Donald Cook*. This CEE included the relatively large (*n*=7) number of simultaneously tagged individual *Ziphius*, as called for in the project experimental design. This significantly increased the total CAS CEE sample size from the first event in 2025.
- Efforts to deploy additional tags following this CEE ahead of a second scheduled ship window were successful in two different waves, yielding multiple additional depth-reporting tags as well as residual location-only sensors from earlier deployments. Unfortunately, sea state or animal configuration conditions precluded the deployment of DTAGs on *Ziphius* in 2025.
- A second CAS-capable ship was scheduled and available, but was ultimately unable to coordinate with the field team due to weather and nighttime availability periods when experimental design and permits would not allow CEE operations.
- The ability to adapt to these changing conditions and conduct meaningful CAS CEEs using experimental simulations of operational signals was enabled thanks to the development, acquisition, testing, and fielding of a new CAS-capable MFAS sound source. The Atlantic BRS team conducted the first-ever simulated CAS CEE with *Ziphius* using this source following the second potential U.S. Navy ship window. This source was assessed to function extremely well in terms of signal quality, repeatability, and output power (exceeding expectations).
- Operational conditions (wind, sea state) were again relatively poor during earlier periods of possible field effort (May to June), although more success occurred in June than in the previous several years. The study team continue to see a longer-term pattern of fewer overall windows of ideal conditions and has consequently extended periods of adaptive effort to achieve research objectives, influencing the team to focus on windows of potential U.S. Navy ship coordination from July through September.
- Deployment strategies and satellite tag programming settings were maintained as developed during earlier study years, again with very positive results in terms of data quality. The study team, however, deployed several location-only tags in earlier portions of the field year with anticipated (and experienced) longer durations to monitor longer-term habitat use patterns and provide options to relocate *Ziphius* groups for additional tag deployments.

- The introduction and availability of the Kinéis satellite system for receiving satellite tag data is providing major improvements in data quantity and quality (see Section 3 in Southall et al. (2026a) for a detailed comparison with legacy Argos systems).
- The publication of a very large sample size (*n*=72) exposure-response paper for *Ziphius* with simulated PAS (Southall et al. 2026b) represents one of the biggest accomplishments of the project and most notable contributions to U.S. Navy environmental compliance analyses to date.

Future efforts and recommendations include:

- The primary goal for 2026 is to replicate the overall approach and increase sample size focused on *Ziphius*, with a priority for conducting CEEs with (multiple) CAS ships.
- The study team again anticipates a single, condition-adaptive field effort beginning as early as June with an emphasis on U.S. Navy ship coordination focused on July and August but extending into September if necessary.
- The overall coordination approach with U.S. Navy vessels should be maintained consistent with previous seasons through advance and sustained planning via USFFC. The adaptive approach to engaging vessels from various home ports and in-transit scenarios was again fruitful in 2025, with both ships slated for coordination coming through this configuration.
- Given the repeated and proven record of successful tag deployments of both satellite tags and DTAGs, the study team does not recommend any substantial changes in the overall patterns of the field and tagging effort. The study team believes that the combination of advanced 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. The team continues to believe that priority should be given to simultaneously deploying DTAGs within groups with satellite-tagged individuals.
- Following the extensive optimization of satellite-tag time-series settings for the Atlantic BRS field site (see Cioffi et al. 2023), no substantive changes programming setting are anticipated. The study team's experience with and assessment of possible changes to tag transmission schedules or other considerations (e.g., battery life) will be informed by the assessment of tag transmission results from the new Kinéis system.
- 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. Particular emphasis should be placed on in-situ goniometer acquisition of satellite-tag data for focal whales to ensure periods around CEEs do not include gaps in data records.

Please refer to the annual progress report for detailed information on 2025 fieldwork and ongoing analyses (Southall et al. 2026a).

2.5.6 Photo-Identification Analysis off Cape Hatteras, North Carolina

To supplement the Atlantic BRS (**Section 2.5**), Duke University continued photo-ID fieldwork within the Cape Hatteras study area during 2025 to confirm species, identify individuals, compile sighting histories, 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 six cetacean species, with the most taken of *Ziphius*, the primary focal species of the Atlantic BRS. Other cetacean species for which photographs were taken include short-finned pilot whale, Risso's dolphin, sperm whale, Atlantic spotted dolphin, and common bottlenose dolphin (**Table 27**).

Table 27. Cetacean sightings with numbers of photo-ID images collected for species within the Cape Hatteras study area during 2025.

Species	Common Name	Number of Sightings	Number of Photo-ID Images
Globicephala macrorhynchus	Short-finned pilot whale	33	2,012
Grampus griseus	Risso's dolphin	2	105
Physeter macrocephalus	Sperm whale	1	146
Stenella frontalis	Atlantic spotted dolphin	3	657
Stenella species	Spotted dolphin species	1	0
Tursiops truncatus	Common bottlenose dolphin	32	1,372
Unidentified delphinid	Unidentified delphinid	1	0
Ziphius cavirostris	Goose-beaked whale	59	8,705
Total	**—**	**132**	**12,997**

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 38 newly identified animals were added to existing photo-ID catalogs of short-finned pilot whales, Risso's dolphins, sperm whales, Atlantic spotted dolphins, and *Ziphius* (**Table 28**). Additionally, 21 new photo-ID re-sights were made within the short-finned pilot whale and *Ziphius* catalogs. To date, 13 photo-ID catalogs have been created for cetacean species within the HAT area. These catalogs include more than 2,330 distinct individuals with 681 individuals re-sighted across all species (**Table 28**). Images from these photo-ID catalogs were also compared to images of stranded cetaceans along the North Carolina coast. Potential matches for two humpback whales and one Atlantic spotted dolphin were searched for; however, no matches were made.

Table 28. Summary of all images collected by species during fieldwork within the HAT study area during 2025 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 brydei	0	0	0	0	0
Balaenoptera physalus	0	0	2	0	0
Delphinus delphis	0	0	46	0	1
Globicephala macrorhynchus	2,012	17	1,393	8	488
Grampus griseus	105	3	57	0	6
Kogia species	0	0	1	0	0
Megaptera novaeangliae	0	0	4	0	0
Mesoplodon species	0	0	10	0	2
Physeter macrocephalus	146	1	33	0	3
Stenella clymene	0	0	3	0	0
Stenella frontalis	657	4	46	0	0
Tursiops truncatus	1,372	0	376	0	20
Ziphius cavirostris	8,705	11	360	13	161
Total	**12,997**	**38**	**2,331**	**21**	**681**

Key: ID = Identification Number; No. = Number

2.5.6.1 Ziphius

A total of 11 new identifications were added to the *Ziphius* photo-ID catalog during 2025, and 13 new re-sights were made. The current re-sight rate for *Ziphius* within the Cape Hatteras area is 44 percent. To date, 117 of the 161 (72 percent) re-sighted *Ziphius* have been documented during multiple years, and 72 of those have been re-sighted more than 3 years after the initial observation (**Table 29**). Internal matches within the *Ziphius* photo-ID catalog were searched for using the Happywhale algorithm, which identified 11 internal matches. Fourteen *Ziphius* were tagged during 2025; three of these whales had prior photo-ID histories.

The *Ziphius* sighted most frequently is Zca_049, which has been photographed on 13 occasions from 2018 to 2023 and satellite-tagged in 2021. The *Ziphius* with the longest interval between re-sightings is Zca_002, with a re-sighting interval of 12 years. Zca_002, an adult male, was first photographed in October 2013 and tagged in August 2018. He was seen multiple times during the 2018 and 2019 field seasons but was not re-sighted until July 2025.

Zca_102 was first seen as a calf with its mother in August and October 2020. It is a very distinctive whale, perhaps from a past predation attempt by a shark (**Figure 27**). It was photographed in a sighting without its mother in June 2025 (**Figure 27**). This is the first time the study team documented a calf successfully weaning from its mother and remaining in the population.

Table 29. 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	44
1 to 2	24
2 to 3	21
3 to 4	18
4 to 5	18
5 to 6	12
6 to 7	11
7 to 8	6
8 to 9	4
More than 10	3
Total	**161**

ZcTag134 was satellite-tagged in August 2022; photographs of the head taken at that time confirm that it had no erupted tusks (**Figure 28**). It was next re-sighted in June 2025. Photographs of the head show a pair of tusks erupting from the lower jaw (**Figure 28**). This is the first time the study team observed a *Ziphius* maturing from a sub-adult into an adult.

In total, six additional catalogs have been created for *Ziphius* from images collected by other researchers and scientists, and efforts to compare the study's images of whales with these catalogs are ongoing (**Table 30**). To date, 10 inter-catalog matches have been made.

Table 30. Contributor and location of *Ziphius* catalogs created, including the number of individuals in each 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	2007–2025	360
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
CMARI catalog	North Carolina Aerial Surveys	2022–2025	6

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

Photo credits: W. Cioffi.

Figure 27. Photographs of Zca_102, seen in October 2020 when it was in association with its mother (top), and next seen in June 2025 (bottom) when it was without its mother.

Photo credits: D. Webster and W. Cioffi.

Figure 28. Photographs of ZcTag134, seen in August 2022 without erupted tusks (top), and next seen in June 2025 (bottom) with tusks beginning to erupt from the lower jaw (red arrow).

During 2025, the sixth external *Ziphius* catalog was developed from aerial images collected by research staff at CMARI, who conduct aerial surveys during the NARW season. The CMARI North Carolina aerial survey team flies from the Virginia-North Carolina border to the North Carolina-South Carolina border, up to 64 km offshore, from mid-November to mid-April. These are valuable images as the CMARI team works during months when Duke University has little or no offshore effort, and CMARI surveys cover an extensive geographic area.

During summer 2025, Madison Eastburn, an undergraduate student at the University of North Carolina at Chapel Hill, examined the potential to use diatom coverage on individual *Ziphius* as a tool for photo-ID. Specifically, she wanted to determine whether patterns of diatom coverage on an individual whale remain constant over seasons and/or years. If this is the case, then diatom coverage could be used to identify re-sightings of otherwise non-distinct whales, such as sub-adults and females, which possess few rake marks.

Ms. Eastburn found that the highest percentage of diatom coverage occurred posterior to the dorsal and along the peduncle, with an average coverage of 62 percent. The dorsal fins had the least amount of diatom coverage, with an average coverage of 3 percent. She also found that there were no seasonal patterns in diatom coverage, and diatom coverage for an individual whale was extremely variable over time. Therefore, patterns of diatom coverage are useful to identify individual whales only over very short periods, such as 1 or 2 weeks. Diatom coverage will still be useful to confirm photo-ID matches that are primarily based on other features such as dorsal fin notches and rake marks. Patterns of diatom coverage are also helpful when matching the right and left sides of a whale within a sighting; this is particularly useful when trying to match animals that are otherwise indistinct.

2.5.6.2 Short-finned Pilot Whales

Seventeen new identifications were added to the short-finned pilot whale catalog during 2025, and eight individuals were re-sighted for the first time since their initial sightings. The current re-sight rate of short-finned pilot whales is 35 percent, unchanged from 2024. More than 200 short-finned pilot whales have been seen on 3 or more occasions, and 24 animals have been re-sighted more than 6 times.

Short-finned pilot whales return to the HAT study area over extended periods. More than 130 pilot whales have records of 5 or more years between their first and last sightings, and 30 individuals have histories that span 10 or more years (**Table 31**). These long-term photo-ID records demonstrate that short-finned pilot whales exhibit strong, but intermittent, site fidelity to the HAT area.

Table 31. Frequency distribution of the number of years between first and last sightings of photo-identified short-finned pilot whales within the HAT study area.

Number of Years Between First and Last Sighting	Number of Individuals
Less than 1	134
1 to 2	48
2 to 3	44
3 to 4	61
4 to 5	68
5 to 6	17
6 to 7	22
7 to 8	46
8 to 9	15
9 to 10	3
10 to 11	14
11 to 12	9
More than 12	7
Total	**488**

A systematic comparison of the 17 newly identified short-finned pilot whales added to the HAT photo-ID catalog in 2025 to the catalogs from Onslow Bay, North Carolina, and Jacksonville, Florida, is ongoing. Four pilot whales were previously matched between the HAT and Onslow Bay study areas. These four photo-ID matches are the only short-finned pilot whale matches documented between the HAT and Onslow Bay catalogs. To date, no matches have been made between the HAT and JAX catalogs.

Images of short-finned pilot whales collected by HDR Inc. researchers during NFC surveys in 2025 were contributed for analysis (**Section 2.4.2**, Engelhaupt et al. 2026). Approximately 3,000 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. A total of 20 new individuals were added to the Norfolk short-finned pilot whale catalog; this catalog currently contains 344 individuals (**Table 32**). No new re-sightings of pilot whales within the Norfolk catalog occurred.

Table 32. Number of new identifications and re-sights within the NFC catalog, and matches to the Cape Hatteras catalog of short-finned pilot whales made during each field season by HDR Inc.

Field Season	New IDs	Catalog Size	Re-sights within NFC Catalog	Matches between NFC and HAT Catalogs
2015	84	84	0	11
2016	47	131	3	13
2017	48	179	3	13
2018	19	198	0	0
2019	32	230	1	3
2020	26	256	2	2
2021	26	282	1	1
2022	13	295	0	1
2023	25	320	1	3
2024	4	324	0	0
2025	20	344	0	0
Total	**344**	**—**	**11**	**47**

Note: HAT = Cape Hatteras; ID = Identifications; NFC = Norfolk Canyon

Happywhale was used to look for internal matches within the DUML short-finned pilot whale catalog. The program identified 12 internal matches. Interestingly, Happywhale identified potential internal matches between several short-finned pilot whales whose dorsal fins had changed over the intervening years between re-sights. Gma_1-115 was first photographed in May 2012 and re-sighted 9 years later in July 2021 missing a top portion of its dorsal fin (**Figure 29**). Additionally, the 20 new individuals in the NFC catalog were compared to the Cape Hatteras catalog using Happywhale. No new matches were made between the catalogs; currently 47 matches exist between the NFC and HAT catalogs.

Currently, DUML has created short-finned pilot whale catalogs for six research locations (**Table 33**). These catalogs will continue to be maintained and updated as images are provided, and inter-catalog comparisons for short-finned pilot whales will be made. To date, 57 photo-ID matches have been made between catalogs. These catalogs will increase the understanding of movements of short-finned pilot whales along the U.S. East Coast, GOM, and Caribbean.

Table 33. Contributor and location of short-finned pilot whale catalogs created for other research groups, including number of individuals in each catalog and years when the images were collected.

Catalog Descriptor[a]	Catalog Location	Years Images Collected	Number of Individuals
GOM catalog	Gulf of Mexico	2003–2007	180
HAT catalog	Cape Hatteras, North Carolina	2006–2025	1,393
OSB catalog	Onslow Bay, North Carolina	2007–2013	24
JAX catalog	Jacksonville, Florida	2009–2018	52
HDR catalog	Norfolk Canyon, Virginia	2015–2025	344
SBU catalog	New York Shelf Break, New York	2018–2019	14

[a] GOM catalog = Catalog from NOAA research cruises in the GOM; HAT catalog = Duke University Marine Laboratory catalog from research trips off Cape Hatteras; OSB catalog = Duke University Marine Laboratory catalog from research trips off Onslow Bay; JAX catalog = Duke University Marine Laboratory catalog from research trips off Jacksonville; HDR catalog = HDR Inc. catalog from research trips offshore of Norfolk; SBU catalog = Stony Brook University catalog from research trips off the New York shelf break

Photo credits: R. Tyson and W. Cioffi.

Figure 29. Photographs of Gma_1-115, seen in May 2012 (top) and July 2021 (bottom).

2.5.6.3 Testing of Computer-Assisted Photo-Identification Matching Programs

As some of DUML's catalogs (short-finned pilot whales, *Ziphius*, bottlenose dolphins, spotted dolphins) have grown over the last two decades, the study team has tested various approaches to make the labor-intensive photo-ID workflow more efficient. However, none of the computer-assisted matching programs the team has tested have eliminated the bottleneck of having a human analyst conducting manual matching.

In 2025, the study team tested the Happywhale matching system, which was trained on 24 different species and has delivered nearly automated results for species such as humpback whales, pilot whales, and bottlenose dolphins (Patton et al. 2023). The algorithm excels with species identifiable by features on their dorsal fins, such as pilot whales, but is less effective for those identified by pigmentation patterns, such as *Ziphius* (Patton et al. 2023). The team collaborated with Dr. Ted Cheeseman, the developer of Happywhale, to use the platform to improve the matching efficiency for DUML's short-finned pilot whale and *Ziphius* photo-ID catalogs.

In June 2025, Dr. Cheeseman demonstrated the Happywhale user interface for matching humpback whales; unfortunately, a graphical user interface (GUI) was not available for use with other species. Additionally, the algorithm was only able to run one-to-one comparisons (i.e., comparing a catalog or collection of images to itself). The study team submitted DUML's short-finned pilot whale and *Ziphius* catalogs to Dr. Cheeseman to identify potential internal matches in these catalogs and see how the results were returned from the matching system. The model performed well for pilot whales, with a high probability of correct matches in the top 5 percent of the catalog, resulting in 13 internal matches out of nearly 1,400 individuals; 3 were pilot whales that had acquired new features to their dorsal fins. For *Ziphius* (n=360), the process was more laborious, requiring manual review of all potential matches. The study team identified 11 internal matches, but it is unclear what features the algorithm used to identify potential matches, including dorsal fin shape, scars, or other features.

In September 2025, the Happywhale development team implemented the ability to compare batches of images (i.e., query images) to a reference set or catalog of images and created a GUI so researchers could run catalog comparisons independently within their own account. The study team still has to submit catalog images to Happywhale for upload; ideally, the team would be able to complete this step as well, something that the developers are working toward in future iterations of the program. The user can select a threshold for the similarity rankings, select "Yes/No/Maybe" for potential matches, and download a CSV export of the results to review offline if necessary.

The Happywhale GUI remains under development, and the study team has provided feedback to Dr. Cheeseman for potential improvements, such as integrated photograph editing tools (e.g., the ability to zoom, flip, rotate images), which will allow improved comparisons of images. Currently, users can upload a limited number of images for comparison but cannot add these to existing catalogs. The ability for a user to upload and manage large reference catalogs would significantly enhance workflow efficiency for managing catalogs. Additionally, enabling catalog

sharing among colleagues and species-specific filtering across research areas would greatly facilitate collaboration. The algorithm's performance for *Ziphius* remains suboptimal; the study team hopes that by contributing its image collection, the team can help improve the training dataset for *Ziphius* and other beaked whales.

2.5.6.4 Satellite Tag Post-Deployment Monitoring

Photo-ID provides a useful means to document and assess the long-term effects of tagging on individual *Ziphius* and short-finned pilot whales. To date, 123 satellite tags have been deployed on 117 individual *Ziphius* between 2014 and 2025, and 84 of these animals (71 percent) have been re-sighted. Many re-sightings occurred within the same field season, but 52 whales (62 percent) were photographed at least 1 year after tagging. Ten whales that were tagged from 2018 through 2023 were re-sighted during 2025. Eight of these whales had not been sighted since the field season in which they were tagged, which gives important information about the long-term effects of satellite tagging on *Ziphius*.

For example, ZcTag074 was satellite-tagged in August 2021; the tag shattered on contact, leaving one pin with a small piece of plastic attached to it in the dorsal fin. The whale was photographed several times during the 2019 season and still had the pin with the piece of plastic in its dorsal fin. It was not re-sighted again until July 2025, at which time the hardware and plastic had been shed, leaving a healed scar in the dorsal fin (**Figure 30**).

To date, 80 satellite tags have been deployed on 79 different short-finned pilot whales off Cape Hatteras, and 31 of these animals (39 percent) have been re-sighted. Most of these re-sightings occurred within the same field season, but 12 (39 percent) occurred across multiple years. There were no re-sights of satellite-tagged short-finned pilot whales during the 2025 field season. This reflects, in part, the focus on *Ziphius* during the 2025 field season.

A manuscript is in preparation on the effects of satellite tags on *Ziphius* and short-finned pilot whales, which is planned to be submitted during 2026.

For more information regarding this study, refer to the annual progress report for this project (Waples et al. 2026).

Photo credits: A. Read and M. Bradley.

Figure 30. Photographs of ZcTag074, seen during satellite-tagging in August 2021 (top) and re-sighted in July 2025 (bottom) with a healed scar (red arrow).

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

2.6.1 Vessel Surveys

The JAX OPAREA was one of the original study sites during the early years of the monitoring program, which 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 assist with the implementation of the Marine Mammal Monitoring on Navy Ranges (M3R) passive acoustic system in conjunction with the Naval Undersea Warfare Center Division Newport (NUWCDIVNPT; see **Section 2.6.2**). 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 2025, which was the final year for these efforts.

Surveys were conducted from the R/V *Shearwater* in February 2025 and R/V *Richard T. Barber* in November 2025 (**Table 34**, **Figure 31** through **Figure 33**) by researchers from Duke University. Vessel surveys in 2025 were conducted for a total of 6 days within the JAX study area, and for 2 additional days during transits from and to Beaufort, North Carolina, totaling 528.4 km and 42 hours of survey effort (**Table 34**). These surveys were conducted in Beaufort sea states 0 to 5 and covered the JSWTR site (**Figure 31** through **Figure 33**) as well as shelf and pelagic waters between Florida and North Carolina during transits.

Table 34. Dates, distances, and durations surveyed during vessel surveys within the JAX survey area in 2025.

Date	Beaufort Sea State	Distance Surveyed (km)	Survey Time (hours:minutes)	At-Sea Time (hours:minutes)	Platform
2-Feb-25	—	—	—	7:36	R/V *Shearwater*
3-Feb-25	—	—	—	24:00	R/V *Shearwater*
4-Feb-25	3–4	120.4	10:10	24:00	R/V Shearwater
5-Feb-25	0–2	105.6	10:16	24:00	R/V Shearwater
6-Feb-25	3–5	87.0	9:35	24:00	R/V *Shearwater*
7-Feb-25	—	—	—	9:37	R/V *Shearwater*
20-Nov-25	3–4	54.5	4:54	10:16	R/V *Richard T. Barber*
21-Nov-25	2–4	160.9	6:44	11:08	R/V *Richard T. Barber*

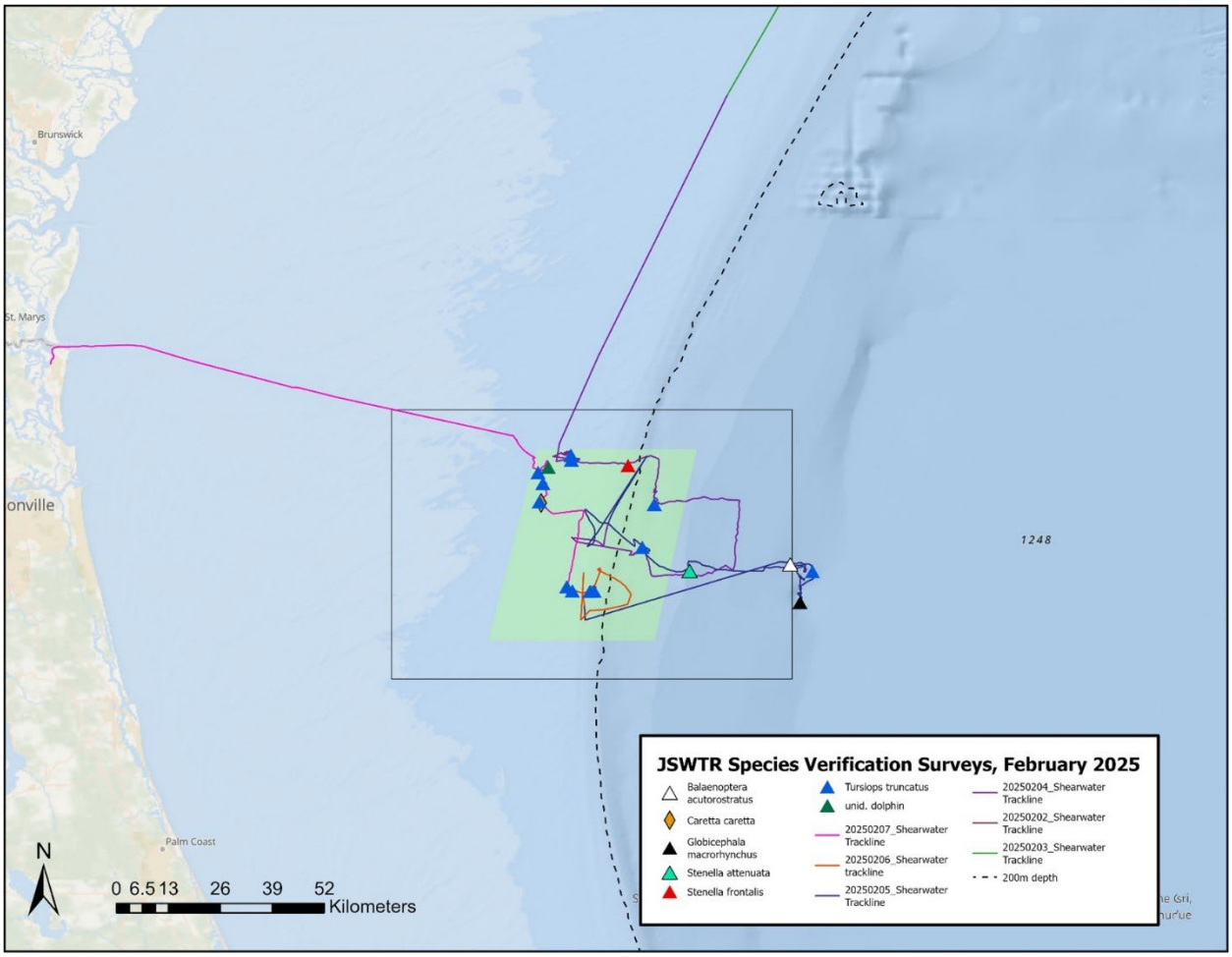


Figure 31. Vessel survey effort conducted by the R/V *Shearwater* for February 2025 within the JAX OPAREA. The gray rectangle is the JAX study area, and the green shaded parallelogram encompasses the JSWTR.

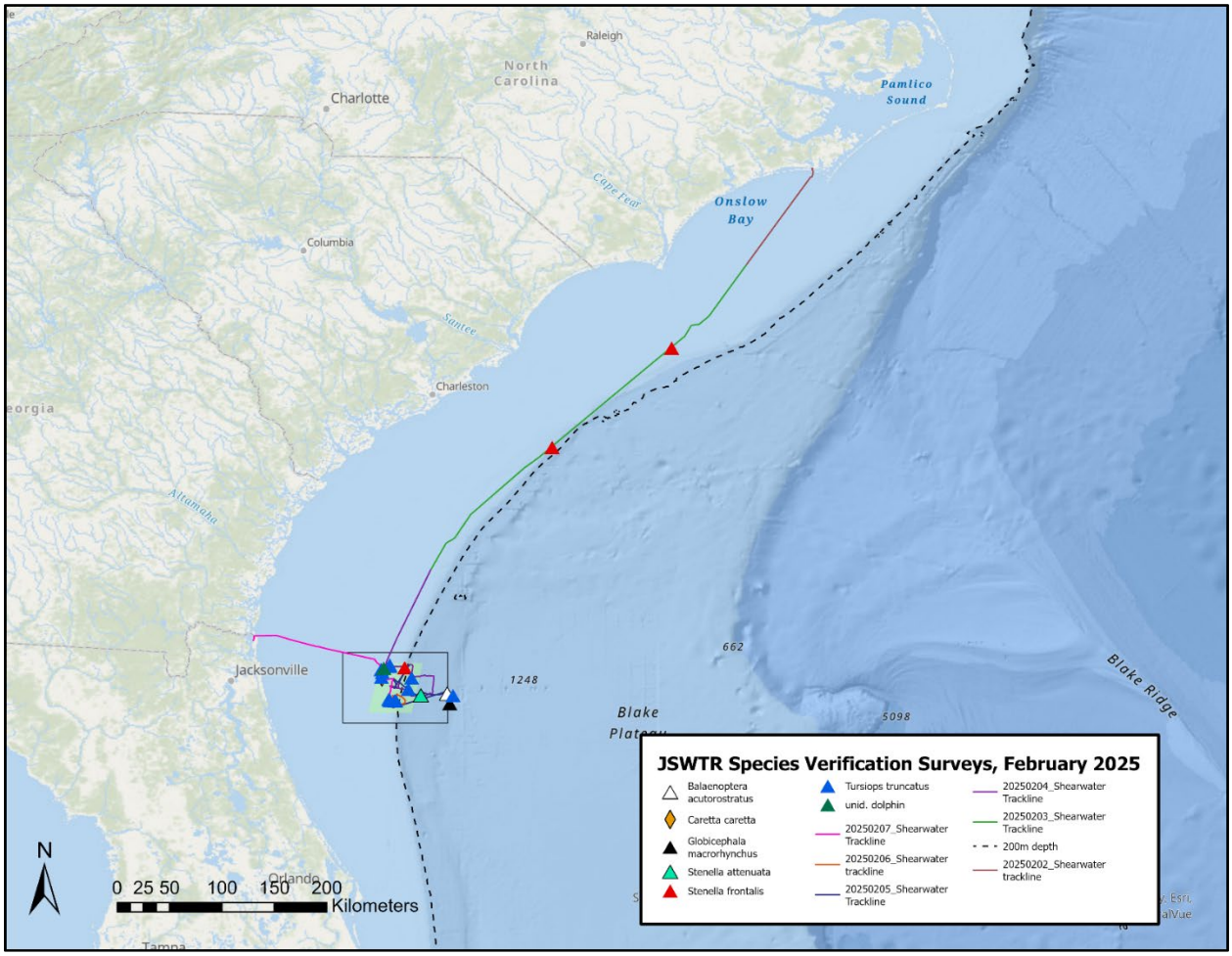


Figure 32. Vessel survey effort conducted by the R/V *Shearwater* for February 2025 during transits and surveys. The gray rectangle is the JAX study area, and the green shaded parallelogram encompasses the JSWTR.

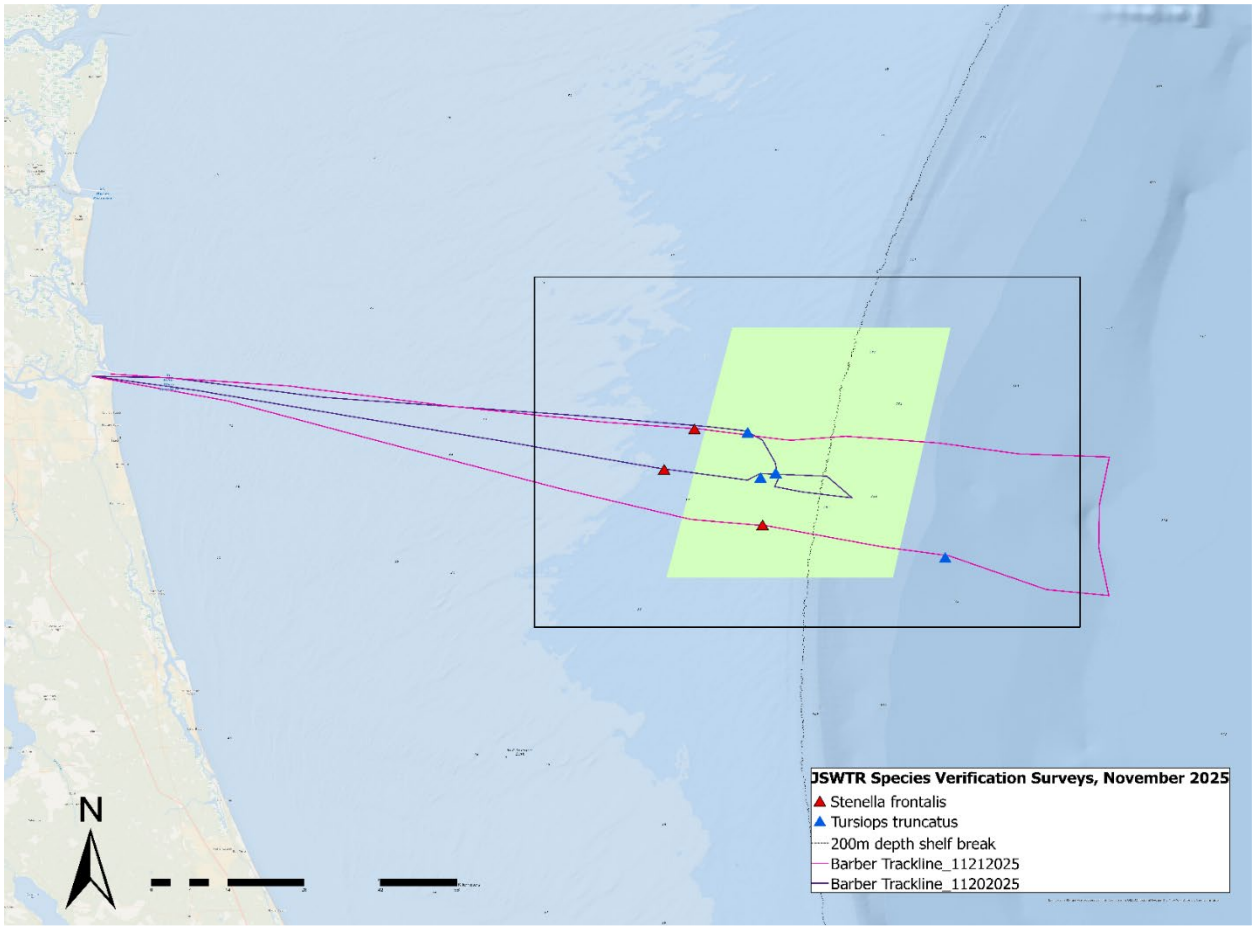


Figure 33. Vessel survey effort conducted by the R/V *Barber* for November 2025. The gray rectangle is the JAX study area, and the green shaded parallelogram encompasses the JSWTR.

Twenty-seven cetacean sightings were recorded, with bottlenose (*n*=16) and Atlantic spotted dolphins (*n*=6) occurring the most (**Figure 34**). Groups of pantropical spotted dolphins (*Stenella attenuata*), short-finned pilot whales, and minke whales were also observed. One sighting of a loggerhead sea turtle was also recorded. As in most previous years, Atlantic spotted dolphins were restricted to shallow shelf waters, while bottlenose dolphins were observed in both the shallow shelf waters and offshore of the continental shelf break. The study team also observed minke and short-finned pilot whales offshore of the shelf break; the minke whales were sighted on the edge of the defined JAX OPAREA, while the short-finned pilot whales were just outside of it (**Figure 34**). This was the second time observing minke whales during JAX vessel surveys, the prior time being in 2023. All other minke whales observed on or near JSWTR were observed during previous AFTT aerial surveys during winter. The group of three included a mother and calf pair as well as a presumed adult male escort.

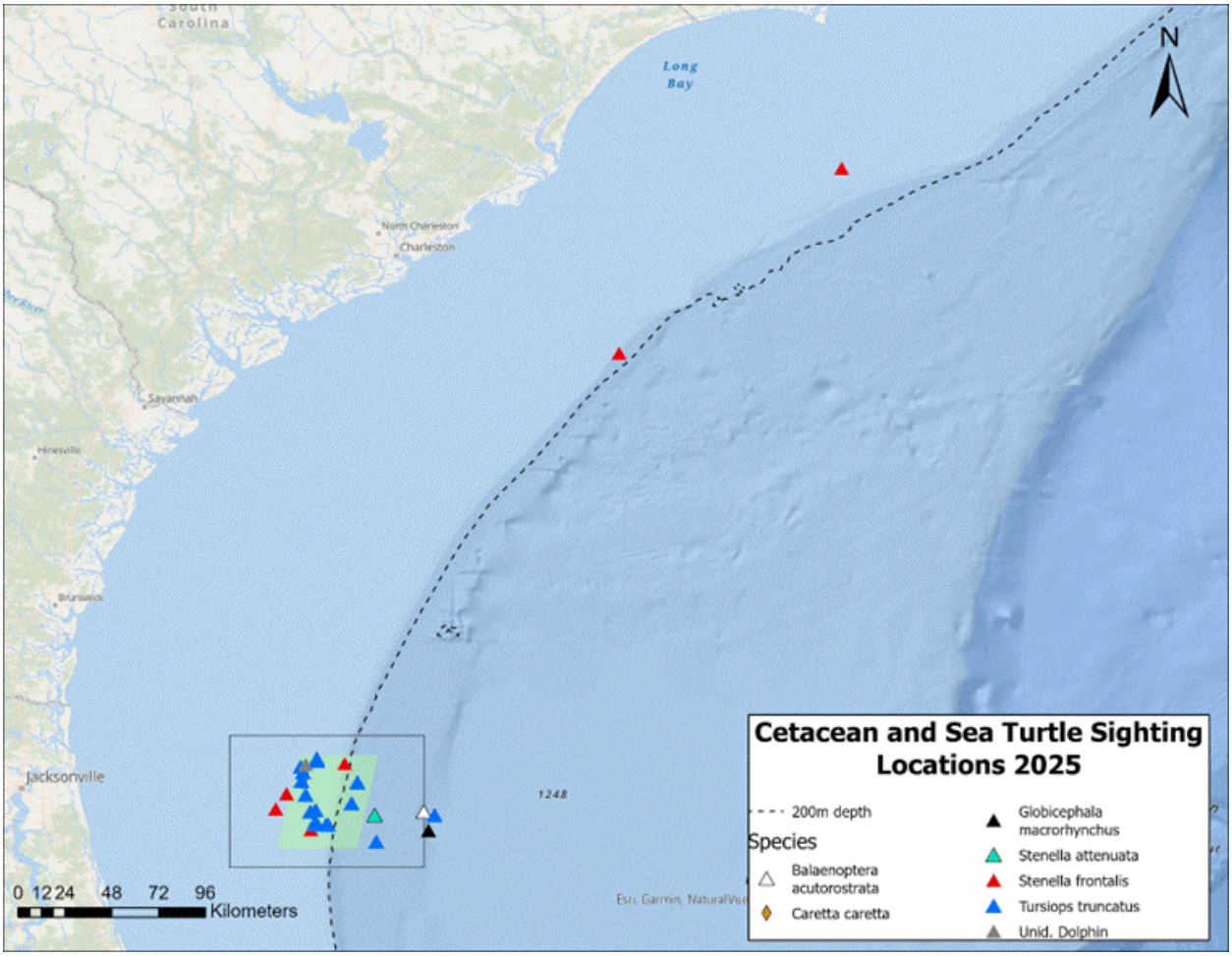


Figure 34. Distribution of cetacean and sea turtle sightings recorded during vessel surveys in 2025. The gray rectangle is the JAX study area, and the green-shaded parallelogram encompasses the JSWTR.

Three biopsy samples were collected in 2025, including one from a bottlenose dolphin, one from an Atlantic spotted dolphin, and one from a minke whale (**Figure 35**). This was the first minke whale biopsy sample collected within the JAX study area, and analysis confirmed the individual as a male. Voucher specimens of these samples are archived at DUML in Beaufort, North Carolina.

During February 2025, three SPLASH10 tags and one SPOT tag were deployed in a group of eight short-finned pilot whales (**Figure 35**). An additional SPOT tag was deployed in a nearby subgroup of approximately 24 animals, consisting of all smaller adults and several mothers with large calves (**Figure 35**). All of these tagged whales moved southward shortly after tagging.

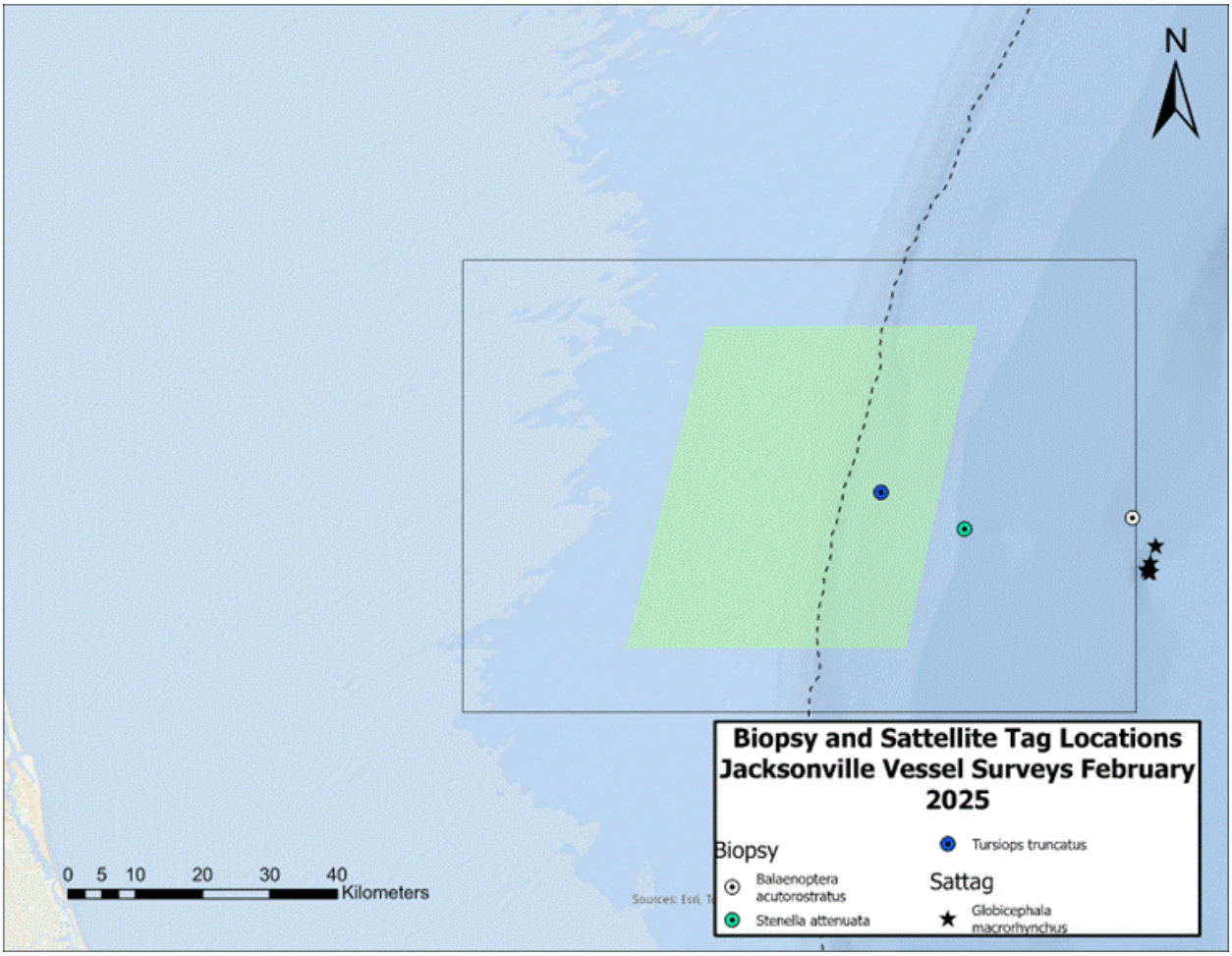


Figure 35. Locations of biopsy samples collected and satellite tags deployed within the JAX survey area in 2025. Dashed line represents the 200-m isobath.

From the beginning of vessel-based visual monitoring within the JAX study area in 2009 to the final survey in November 2025, 17,308 km have been surveyed. The study team has made 510 cetacean sightings and 295 sea turtle sightings, collected 145 biopsy samples, and deployed 16 satellite tags. Additionally, photo-ID catalogs have been created and annually maintained for eight cetacean species. Datasets from all aerial and vessel sightings to date can also be viewed on OBIS-SEAMAP.

For additional details and information on this study, please refer to the final annual progress report for this project (Kristan et al. 2026).

2.6.2 Marine Mammal Monitoring on Navy Ranges

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 km, making it the largest M3R system to date. In contrast to the AUTEC, PMRF, and SOAR deep-water ranges on which the M3R system is deployed, JSWTR is a shallow-water range that is likely to have different species present than those typically found on the deep-water ranges.

The M3R system runs nearly continuously year-round, archiving data from all range hydrophones simultaneously in real time, when no range activities 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 detectors/classifiers: a Fast Fourier Transform-based detector, a Class-Specific Support Vector Machine (CS-SVM) detector/classifier, and a Blainville's beaked whale foraging click-matched filter (Jarvis et al. 2008). The CS-SVM classifier currently has six classes at JSWTR: Blainville's beaked whale foraging and buzz clicks, *Ziphius* foraging and buzz clicks, sperm whale clicks, and "generalized dolphin" clicks.

Between 2021 and 2025 M3R personnel completed 11 species verification trials in collaboration with Duke University and HDR Inc. During these trials, Naval Undersea Warfare Center (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 photo-ID catalogs, took biopsy samples, and potentially deployed satellite tags. The focal species for these efforts were:

1. Short-finned pilot whales
2. False killer whales (*Pseudorca crassidens*)
3. Bottlenose dolphins
4. Atlantic spotted dolphins
5. Risso's dolphins
6. Rough-toothed dolphins (*Steno bredanensis*)

Over the course of these 11 trials, all focal species were acoustically detected on range, and all except 1 (short-finned pilot whale) were visually verified by the on-water team (**Table 35**). The most common animal identified to species was bottlenose dolphins, with 89 groups acoustically detected, 58 of which were directed, with 57 groups visually verified. Acoustic detections are considered "directed" if the M3R team provided a position for the on-water team, and they decided to go to the location. The next most common was Atlantic spotted dolphins, with 37 acoustic detections, 34 directed, and 35 groups visually verified. There were also 651 acoustic detections of unidentified dolphins during the 11 trials.

Table 35. All species acoustically detected, directed, and visually verified by during JSWTR species verification trials from 2021–2025.

Species		Acoustic Detections Logged	Acoustic Detections Directed	Acoustic Detections Visually Verified
Common Name	Scientific Name			
Bottlenose dolphin	*Tursiops truncatus*	89	58	57
Atlantic spotted dolphin	*Stenella frontalis*	37	34	35
Risso's dolphin	*Grampus griseus*	12	4	2
Rough-toothed dolphin	*Steno bredanensis*	5	5	5
False killer whale	*Pseudorca crassidens*	6	1	1
Striped dolphin	*Stenella coeruleoalba*	1	0	0
Short-finned pilot whale	*Globicephala macrorhynchus*	20	2	0
Sperm whale	*Physeter macrocephalus*	1	0	0
Possible *Ziphius* sp.	*Ziphius* sp.	2	0	0
Minke whale	*Balaenoptera acutorostrata*	4	1	1
Snapping shrimp	Alpheidae sp.	X[a]	0	0
Unknown low frequency	Unknown low frequency	11	2	0
Unidentified dolphin	*Delphinidae* sp.	651	49	0

[a] Indicates that snapping shrimp are persistently detected on the range.

2.7 Atlantic Marine Assessment Program for Protected Species

AMAPPS was initiated in 2010 (AMAPPS I – 2010–2014, AMAPPS II – 2015–2019, AMAPPS III – 2020–2025) as a comprehensive multi-agency research program in the U.S. Atlantic Ocean, from Maine to the Florida Keys. Its goals have been 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 as well as 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 (NEPA), and Migratory Bird Treaty Act. The program was 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.

A key focus of AMAPPS III was to enhance methods for processing and analyzing these diverse data sources and integrating information from different data sources. These enhancements led to improved understanding of the distribution, abundance, ecology, and behavior of cetaceans, sea turtles, seabirds, and lower trophic levels, including tuna larvae, plankton, and fish. Specific achievements included developing spatially explicit habitat-density models; estimating abundance; describing the shifting distribution patterns of marine mammals, sea turtles, and seabirds; investigating dive behavior patterns of deep-diving cetaceans and sea turtles; enhancing knowledge of the biology and ecology of sea turtles; connecting protected species to their ecosystem habitat characteristics; and investigating the possibilities of using very high-resolution commercial satellite imagery to monitor cetaceans.

The comprehensive data collected during AMAPPS III resulted in 60 published or in-review scientific papers and 34 presentations at various meetings and conferences. The final report covering 2020 to 2025 will be available later during summer 2026. Data products and technical reports are available online: annual and final reports, and Marine Mammal Model Viewer.

Although the AMAPPS III field work formally concluded in 2024, the U.S. Navy continued to partner with NOAA to co-fund a broad-scale aerial and vessel visual survey of the mid-Atlantic during winter 2025. From 6 January to 21 February 2025, the NEFSC conducted comprehensive shipboard and aerial surveys to estimate the abundance of marine mammals, sea turtles, and seabirds. The survey spanned the area between 33 and 41 degrees North and 70 and 78 degrees West, covering waters off Massachusetts to North Carolina, extending approximately 200 nm offshore.

The survey was executed using two platforms:

- **Shipboard Survey:** Conducted on the NOAA ship *Pisces* in two legs (6 to 29 January 2025 and 3 to 21 February 2025), this effort primarily focused on deeper offshore waters.
- **Aerial Survey:** Flown on the NOAA Twin Otter aircraft from 8 January to 21 February 2025, this portion targeted shallower waters, generally less than the 200-m depth contour.

Methodology and Effort: Both ship and plane used standard visual line transect sampling protocols for marine mammals and sea turtles. The ship platform included several other data collection efforts:

- A dedicated team conducted seabird surveys using strip transect sampling.
- A passive acoustic team deployed a towed hydrophone array to monitor for vocalizing animals.
- An oceanographic team collected physical and biological oceanographic data.

The aerial survey incorporated a nine-camera system for continuous photographic documentation along the track line, complementing the visual observers. A total of 8,044 km of on-effort track lines were surveyed in Beaufort sea states of 8 or fewer, comprising 4,964 km by aircraft and 3,080 km by ship.

Key Findings: Survey efforts resulted in the following notable results:

- **Cetaceans:** More than 504 groups, totaling 4,844 individuals. The most abundant species detected were common and common bottlenose dolphins. Common large whales included humpback and fin whales.
- **Sea Turtles:** 156 groups, totaling 202 individuals, including 57 groups (92 individuals) of loggerhead turtles and 3 leatherback turtles.
- **Seabirds:** 9,691 individual seabirds.
- **Other Species:** 3 basking sharks and 46 ocean sunfish.

2.8 Pinniped Monitoring in Lower Chesapeake Bay and Coastal Waters of Virginia

Harbor (*Phoca vitulina*) and gray (*Halichoerus grypus atlantica*) seals 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; DiGiovanni 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 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 lower Chesapeake Bay and coastal waters of Virginia, which are important areas to U.S. Navy training and testing activities. Haul-out counts and photo-ID methods are being used to acquire a better understanding of seasonal occurrence, habitat use, and haul-out patterns within this area.

For the 2024/25 field season, systematic vessel-based counts of all seal species were conducted at two different survey areas (**Figure 36**): (1) within lower Chesapeake Bay along the CBBT, on the four "islands" (referred to as CBBT 1, CBBT 2, CBBT 3, and CBBT 4); and (2) on the southern tip of the Eastern Shore, which is 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 (UAS) 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 develop a local catalog.

2.8.1 Haul-out Count Results

For the 2024/25 field season at the CBBT survey area, 11 survey days were completed between 4 November 2024 and 22 April 2025. Overall, 76 seals in total (combined in-water and hauled out) were sighted across the 4 CBBT haul-out locations, with more seals observed at CBBT 4 (n=56) and CBBT 3 (n=19). All the seals sighted this season were harbor seals. Seals were observed on 7 of the 11 (63.6 percent) survey days. The total daily number of seals counted per survey day ranged from 0 to 24, with the highest count recorded during January.

For the Eastern Shore survey area, 12 survey days were completed between 5 November 2024 and 24 April 2025. Seals were observed on 10 of the 12 (83.3 percent) survey days, with a total of 132 seal sightings recorded for the season. All the seals sighted this season were harbor seals. The total daily number of seals counted ranged from 0 to 36 individuals per survey day, with the highest count recorded during January. Seals were observed hauled out at only two of the five main haul-out sites that are on the western side of the inlet.

The UAS was used to conduct five counts during the 2024/25 season, specifically from November 2024 to February 2025. The UAS was unable to be used during several surveys throughout the season due to high winds and limited availability of the UAS operator. A higher seal count was recorded from the UAS (compared to observers on the vessel) during 1 of the 5 survey days, with the count differential being only 1 animal. The observers recorded more seals from the vessel-based counts compared to the UAS counts during 4 of the 5 survey days, with the count differential ranging from 1 to 10 animals. There was no significant difference between the mean counts for the UAS compared to the observer (t = -0.31, p = 0.77).

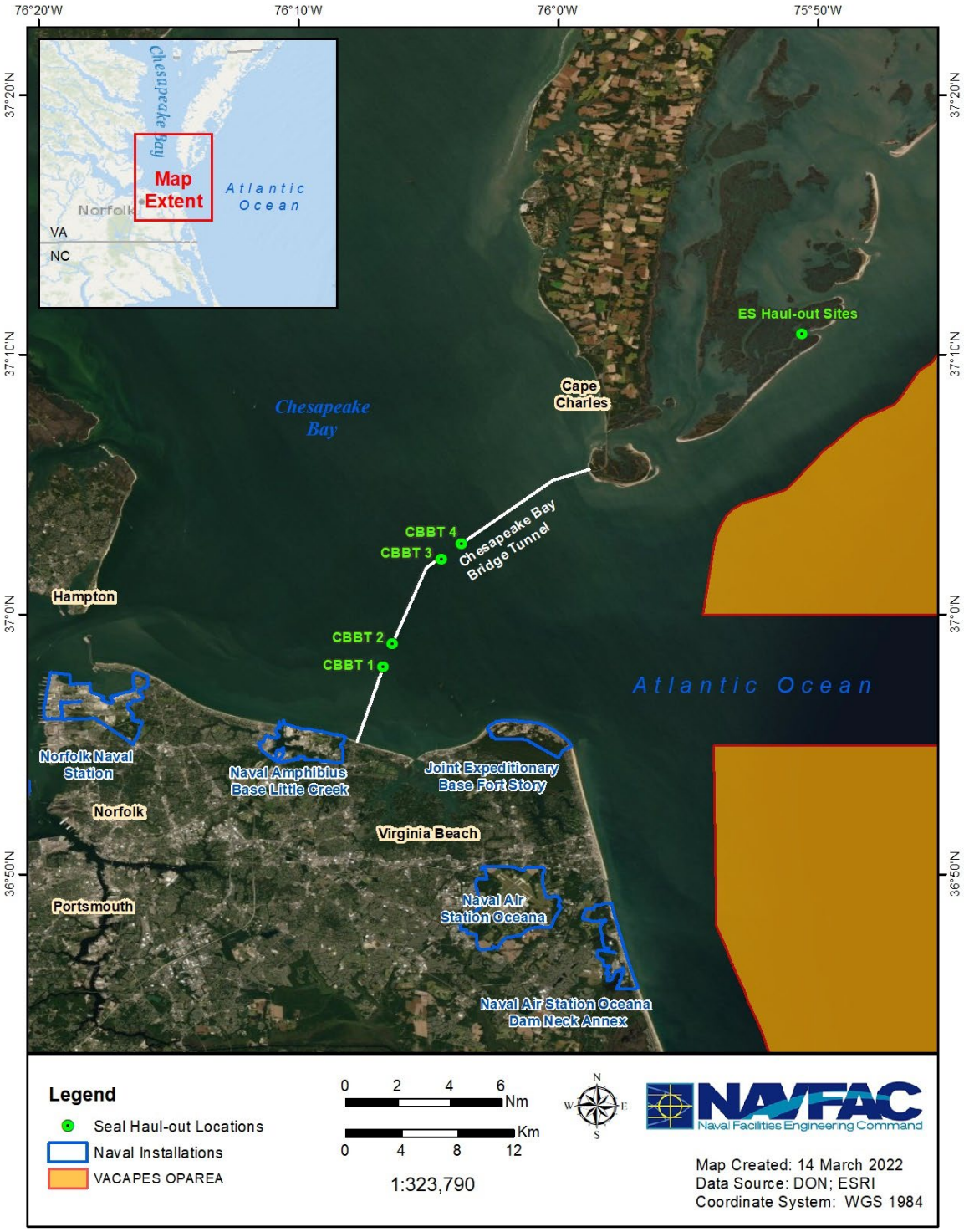


Figure 36. CBBT and Eastern Shore haul-out locations and their proximity to U.S. Naval installations.

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 the average number of seals observed per survey day and maximum count from 2014 to 2018, followed by a decrease from 2018 to 2020 (**Table 36**). For the 2020/21 season, seal presence appeared to rebound, with an increase in average seal count as well as maximum seal count for a single survey day. Seal numbers continued to fluctuate from 2021 to 2025, with the average and maximum count ranging from 10 to 13 seals and 24 to 38 seals, respectively.

Table 36. Seasonal survey effort (number of survey days), total seal count (best estimate), effort-normalized average seal count (number of seals observed per "in season survey" day), and maximum seal count for a single survey 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
2023–2024	7	93	13	38
2024–2025	7	76	11	24

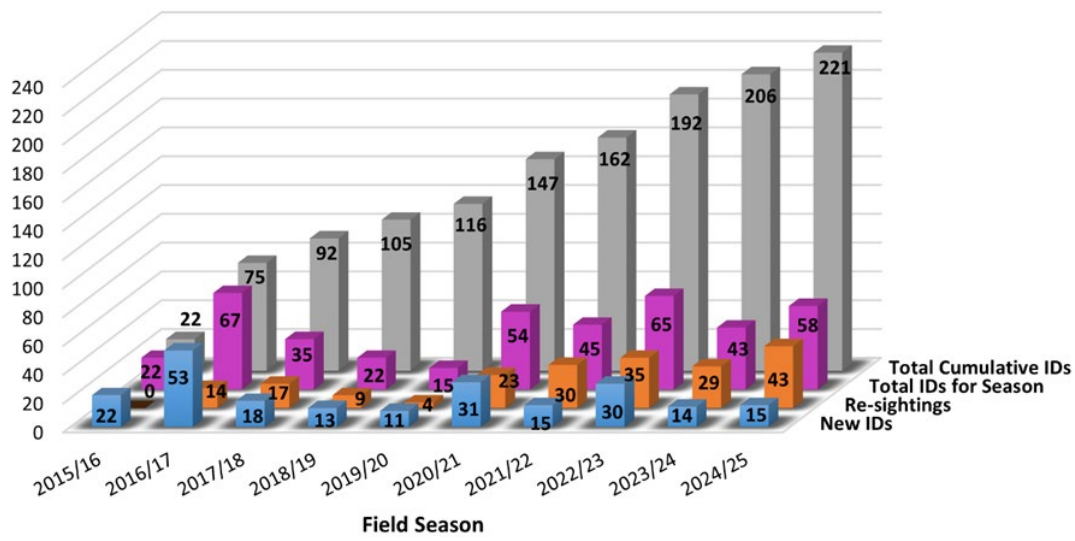
Similar variability in seal presence was observed for the Eastern Shore survey area over nine field seasons (**Table 37**). Average and maximum seal count increased from 2016 to 2018 but decreased to 15 seals for the 2018/19 season. Both average and maximum seal count started to increase again after 2019, with some fluctuation over the 2020 to 2025 seasons. Since the first season for each survey area, some of the lowest total, maximum, and average seal counts for the CBBT and Eastern Shore were reported for the 2018 to 2020 seasons as well as the 2024/25 season. Additionally, a statistically significant difference ($F = 2.04$, $p = 0.035$) was observed between the average seal counts across the 11 field seasons (2014 to 2025) for the CBBT survey area. The interannual variability among the mean counts across the nine field seasons for the Eastern Shore survey area was not statistically different ($F = 0.43$, $p = 0.90$). This between-season comparison, however, does not take into account the sampling bias for some of the field seasons.

Table 37. Seasonal survey effort (number of survey days), total seal count (best estimate), effort-normalized average seal count (number of seals observed per "in season survey" day), and maximum seal count for a single survey 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
2023–2024	9	185	21	45
2024–2025	10	132	13	36

2.8.2 Photo-Identification and Abundance Estimation Results: Chesapeake Bay Bridge-Tunnel and Eastern Shore Combined

For the 2024/25 field season, 58 harbor seals were uniquely identified; 15 (26 percent) were new individuals to the catalog, and 43 (74 percent) were re-sightings of individuals that were identified from previous field seasons (**Figure 37**).



Key: ID = identifier

Figure 37. Harbor seal identifications over nine field seasons (2015–2025). The purple bars indicate the total number of identifiers (IDs) for a season, orange bars indicate the number of re-sightings (i.e., those IDs that were seen in previous seasons), and blue bars indicate the number of new IDs added to the catalog. The gray bars indicate the total number of cumulative unique IDs.

Between 2015 and 2025, image analysis identified 221 harbor seals and 5 gray seals within the study area, averaging 22 new harbor seals identified each year. Of the cataloged seals, 121 harbor seals and 2 gray seals have been re-sighted, with a few harbor seals seen across 8 or 9 seasons. This suggests that harbor seals exhibit seasonal site fidelity to the lower Chesapeake Bay and coastal Virginia waters. About half of the identified harbor seals were observed only at the CBBT, while a smaller, but still substantial, number were observed only at the Eastern Shore. Only 13 percent of the harbor seals were re-sighted at both survey areas within and/or across seasons. These results indicate that harbor seals make localized movements within the region during their seasonal occupancy and 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.

With the data collected under this project as well as the haul-out behavior data from the harbor seal tagging project (see Ampela et al. 2023), the first seasonal abundances for harbor seals in Virginia were estimated using various methods. Mark-recapture data from the photo-ID were used to fit a Chapman modification of the Lincoln-Petersen model. A correction factor was applied to the count data, which was based on telemetry data on harbor seal haul-out activity in Virginia waters. Abundance estimates calculated from the Lincoln-Peterson model and telemetry correction factor approach ranged from 35 (95 percent confidence interval [CI]: 4.56 to 65.44) to 131 (95 percent CI: 78.79 to 182.85), and 62 (95 percent CI: 34.54 to 89.23) to 126 (95 percent CI: 94 to 158.4) individuals, respectively (**Figure 38**). General trends for both approaches show an initial decrease in abundance from 2016 to 2019, followed by an increase and then a fluctuation in estimates between 2021 and 2025. Regression analysis results indicate no statistically significant trend in abundance estimates across seasons; therefore, the local population may be stable. Using the telemetry correction approach, a mean abundance of 82 individuals was estimated for the 2016 to 2025 seasons.

The 2024/25 field season was the final season for the haul-out counts and photo-ID data collection effort for both the CBBT and Eastern Shore survey areas. For more information on the Virginia seal haul-out count visual surveys, please see the final project report (Jones 2026) and visit the project profile page.

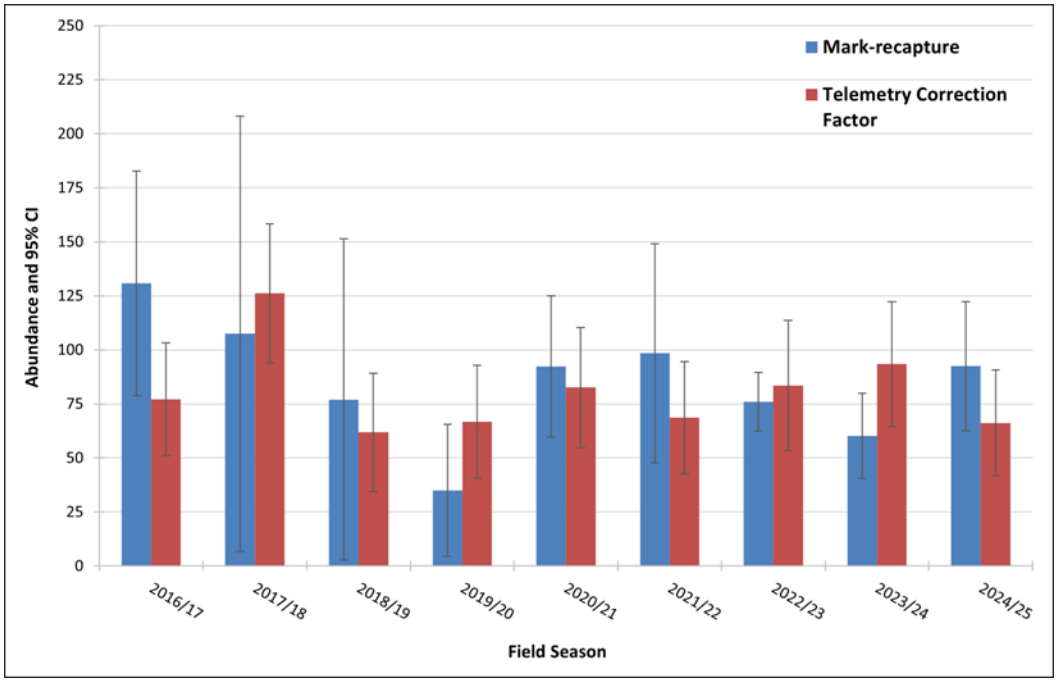


Figure 38. Total abundance estimates and 95 percent CIs for the CBBT and Eastern Shore survey areas combined, calculated from mark-recapture (blue bars) and telemetry correction factor (red bars) approaches during each of the field seasons from 2016 to 2025.

2.8.3 Time-Lapse Camera Monitoring

The vessel and drone 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., near sunrise/sunset) and in adverse weather conditions (e.g., rain, high winds, sea states greater than Beaufort 3). Trail cameras are proven as cost-effective tools for collecting large amounts of data while limiting the impact on the animals as compared to traditional visual surveys (Koivuniemi et al. 2016; Wearn and Glover-Kapfer 2019) 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, with relatively low personnel demands.

For this project, cameras were placed at multiple locations covering the known haul-out sites at the Eastern Shore and CBBT survey areas. To date, the study team has completed six seasons (2019/20, 2020/21, 2021/22, 2022/23, 2023/24, and 2024/25), with a seventh and final season (2025/26) in progress. Cameras were deployed from October to May at both the Eastern Shore and CBBT survey areas. Images were recorded in time-lapse mode, at 15-min intervals. All cameras recorded during daylight hours for both sites. For the 2024/25 season, three infrared time-lapse cameras were also deployed at one Eastern Shore haul-out site, and nighttime images were collected to look at diel haul-out patterns.

Objectives for this study are (1) to improve the understanding of local haul-out patterns, (2) to monitor seasonal patterns and the number of seals hauled out, (3) to investigate any haul-out patterns in relation to environmental factors, and (4) to investigate differences between vessel and drone-based surveys as well as collect time-lapse camera data. The data and results from this effort will further improve the assessment of potential impacts from training and testing activities, installation construction (e.g., pile driving), and vessel transiting as required under the MMPA and NEPA for the U.S. Navy within the region. These data will also provide important baseline information for the assessment of potential future impacts from climate change or anthropogenic activities.

The Timelapse Image Analysis system and Timelapse2 program (Greenberg 2024) were used to count, mark, and record the number of seals and vessels in each image. **Figure 39** shows a screenshot of the program analysis screen; on the right is a customizable data entry field, the yellow dots within the image appear once a seal is manually counted, and the magnifier feature allows the reviewer to zoom in on an area to get a better view. Timelapse2 includes built-in features that simplify the visual examination, encoding, and recording of the data from each image, including a custom data recording template, automatic extraction of image data (e.g., file name, date, time taken), automatic counting of marks as identified by the user-developed template (e.g., harbor seal, gray seal, vessel), persistent marks, automated batch time correction, and image review tools (e.g., magnifier, play forward and reverse, pan/zoom tools, image enhancement) (Greenberg 2024).

Figure 39. Screenshot of Timelapse Image Analysis workspace.

Images were reviewed for the presence of seals, with sightings recorded as either hauled out or in the water, as well as vessel presence. While images from the camera surveys were 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.

A count is defined as the total number of seals or vessels recorded in an image. Total counts indicate the total number of seals counted for the entire season in each image. Images were taken every 15 min; 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. **Table 38** provides total counts for both the Eastern Shore and CBBT study areas**.**

Table 38. Total seal haul-out count from all camera images for each season at the CBBT and Eastern Shore survey areas.

Season	Eastern Shore	CBBT	Total
2019/20	46,079	4,314	50,393
2020/21	50,374	8,953	59,327
2021/22	57,937	12,739	70,676
2022/23	55,914	11,844	67,758
2023/24	67,091	14,401	81,492
2024/25	68,728	TBD[a]	TBD[a]

Note: TBD = to be determined
[a] CBBT camera images are being processed for the 2024/25 season.

Seal occupancy and camera survey sighting summaries are shown in **Table 39** for the Eastern Shore survey area (2019 to 2025 seasons) and **Table 40** for the CBBT survey area (2019 to 2024 seasons). Data from the 2024/25 season for the CBBT are currently being processed. For the 2024/25 season, seals arrived earlier at the Eastern Shore survey area than in past years, with the first observation occurring during early October. However, the seals' departure was also considerably earlier, with the last sighting recorded on 4 April 2025. In preceding seasons, seals were often present until late April or May, making the occupancy longer (**Table 39**).

Table 39. 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]
2019/20	4-Nov-19	20-Apr-20	12	79.8	88.2
2020/21	30-Oct-20	25-May-21	10	78.8	90.9
2021/22	15-Oct-21	28-Apr-22	14	72.9	86.2
2022/23	22-Oct-22	17-May-23	10	75.5	89.9
2023/24	26-Oct-23	9-May-24	14	74.1	86.8
2024/25	9-Oct-24	4-Apr-25	14	71.3	87.6

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

Table 40. 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]
2019/20[b]	CBBT3	8-Jan-20	28-Apr-20	4	31.3	73.2
	CBBT4	10-Jan-20	17-Apr-20	4	42.9	55.4
2020/21	CBBT3	30-Oct-20	1-May-21	5	24.4	51.6
	CBBT4	4-Dec-20	22-May-21	5	33.2	58.0
2021/22	CBBT3	20-Oct-21	16-Apr-22	5	21.7	60.5
	CBBT4	30-Nov-21	1-May-22	7	43.3	57.7
2022/23	CBBT3	25-Oct-22	23-Apr-23	5	45.6	90.6
	CBBT4	25-Oct-22	31-Mar-23[c]	6	71.8	97.3
2023/24	CBBT3	23-Oct-23	24-Apr-24	3	53.5	68.1
	CBBT4	23-Oct-23	24-Apr-24	8	36.6	62.8

[a] Seals present = seals hauled out or in the water
[b] Cameras were not installed until January 2020
[c] No images were taken at CBBT 4 after 31 March 2023 due to camera failure

The following results for the 2024/25 season pertain to only the Eastern Shore survey area. Camera images for the CBBT survey area for the 2024/25 season are still being processed. Similar to previous seasons, the average seal count increased starting from October into February, with a substantial decrease in average count after March, once seals started to migrate out of the area (**Figure 40**). No seals were observed hauled out during May 2025. Looking at maximum counts for hauled out seals (**Figure 41**), numbers peaked between January and February, and declined rapidly after March. The specific timing of peak haul-out counts varied among seasons, occurring sometime between January and March (**Figure 41**). Results from a multi-factor Analysis of Variance confirmed significant differences in mean maximum seal counts across months for each season (F= 48.31, p < 0.05).

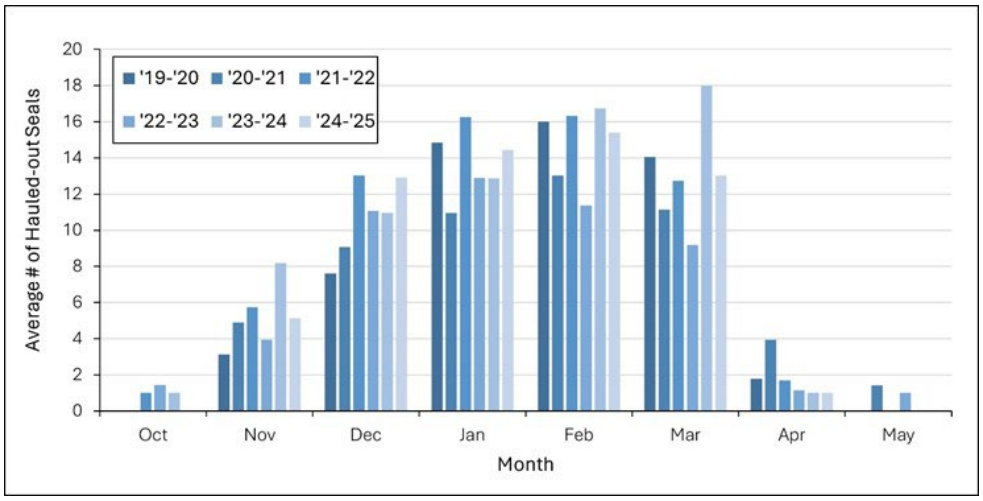


Figure 40. Average seals counted by month for the 2019 to 2025 seasons at the Eastern Shore survey area.

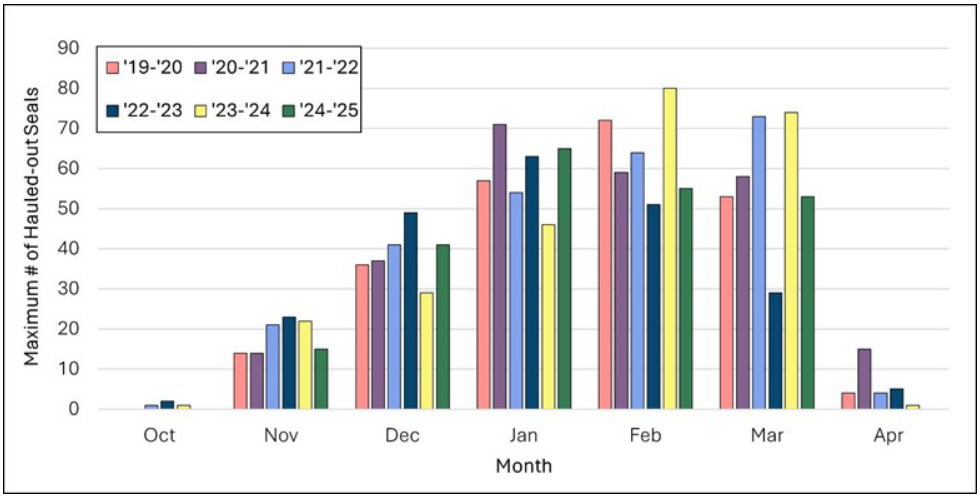


Figure 41. Monthly maximum count for hauled out seals for the 2019 to 2025 seasons at the Eastern Shore survey area.

For the 2024/25 season at the Eastern Shore survey area, daytime and nighttime maximum counts were assessed at one main haul-out site to see if there were any diel haul-out patterns. Results revealed that generally higher monthly maximum counts were recorded at the site during the daytime, with the exception of November and December (**Figure 42**). Overall, an average of 13 seals hauled out during daytime, and 11 seals hauled out during nighttime for the season. Median values for day versus night were similar, with 11 and 10 seals, respectively.

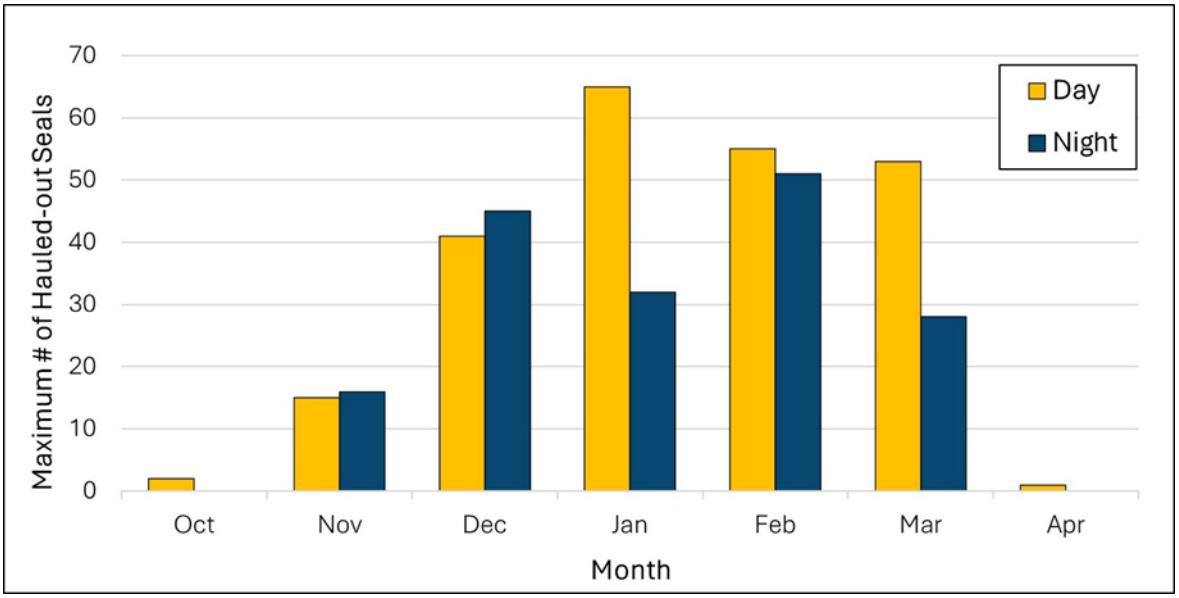


Figure 42. Maximum hauled out seal counts by month and daytime versus nighttime for the 2024/25 season at the Eastern Shore survey area.

A comparison of hauled out seals to environmental factors and the number of hours after sunrise was completed for the 2019 to 2024 seasons for the Eastern Shore and CBBT survey areas, and is detailed in Guins and Rees (2025).

For more information on the Virginia seal camera survey work, including details of analyses conducted, please visit the project profile page. A final project report will be available in 2027.

2.8.4 Aerial Surveys

Recent attempts to develop local abundance estimates from data collected during these efforts have highlighted the need to determine if the CBBT islands and Little Inlet are the only two locations where seals regularly haul out in Virginia. In order to locate any undocumented seal haul-out sites in Virginia, as well as provide additional data collection at the two known haul-out sites, aerial surveys were implemented and flown along the entire Virginia coast during the winter/spring 2025 field season.

2.8.4.1 Survey Effort/Summary

Nine aerial surveys were flown during the winter/spring 2025 field season, covering 2,734 km with more than 14.5 hours of survey effort (**Figure 43**, **Figure 44**). The first aerial survey occurred on 3 January 2025, and the last survey occurred on 28 April 2025. Two survey flight attempts were made on 3 February 2025; however, a full survey of the Virginia coast was ultimately not conducted that day due to poor visibility and fog, and Little Inlet was not surveyed.

2.8.4.2 Sightings

In total, 14 sightings of marine mammals occurred, including 12 harbor seal sightings totaling 223 individuals, 1 humpback whale sighting of a single individual, and 1 deceased bottlenose dolphin sighting (**Figure 43**). Photographs and sighting information of the deceased dolphin were shared with the Virginia Aquarium's Stranding Response Program post-survey. No gray seals were documented during these aerial surveys. No seals were observed during the surveys on 28 March and 28 April 2025 (**Figure 44**). Of the 12 harbor seal sightings, 6 occurred at CBBT Island 4, 5 occurred at Little Inlet, and 1 occurred at CBBT Island 3 (**Figure 44**). During surveys in which both the CBBT islands and Little Inlet were surveyed, more seals were present at Little Inlet than the CBBT islands (**Figure 44**). Harbor seals were observed both hauled out and in the water during eight sightings, only hauled out at one sighting, and only in the water at three sightings. The single harbor seal sighting that occurred at CBBT Island 3 was of seals only in the water (**Figure 44**).

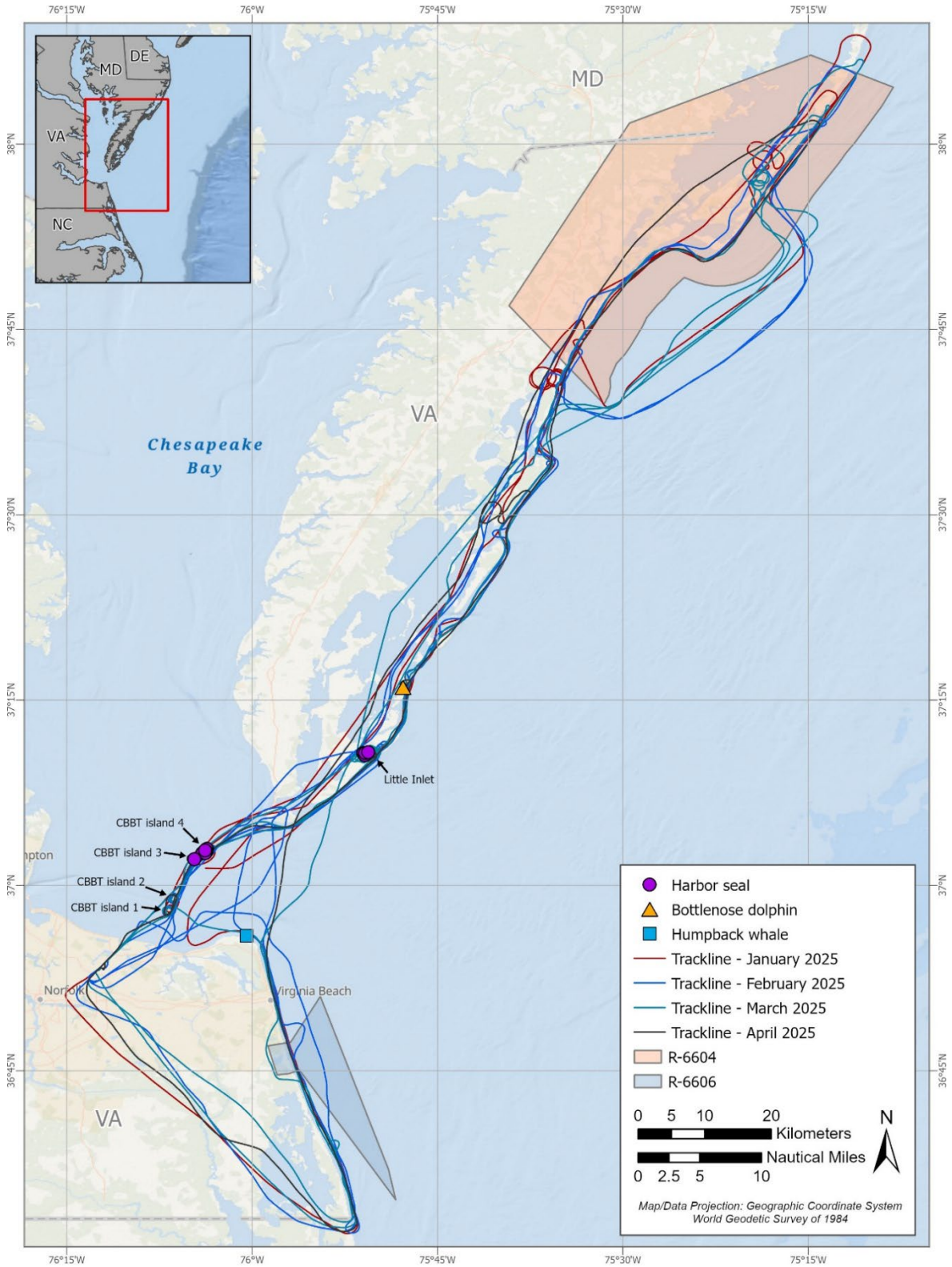


Figure 43. Aerial survey tracks with locations of all harbor seal (*n*=12), humpback whale (*n*=1), and deceased bottlenose dolphin (*n*=1) sightings during the winter/spring 2025 field season.

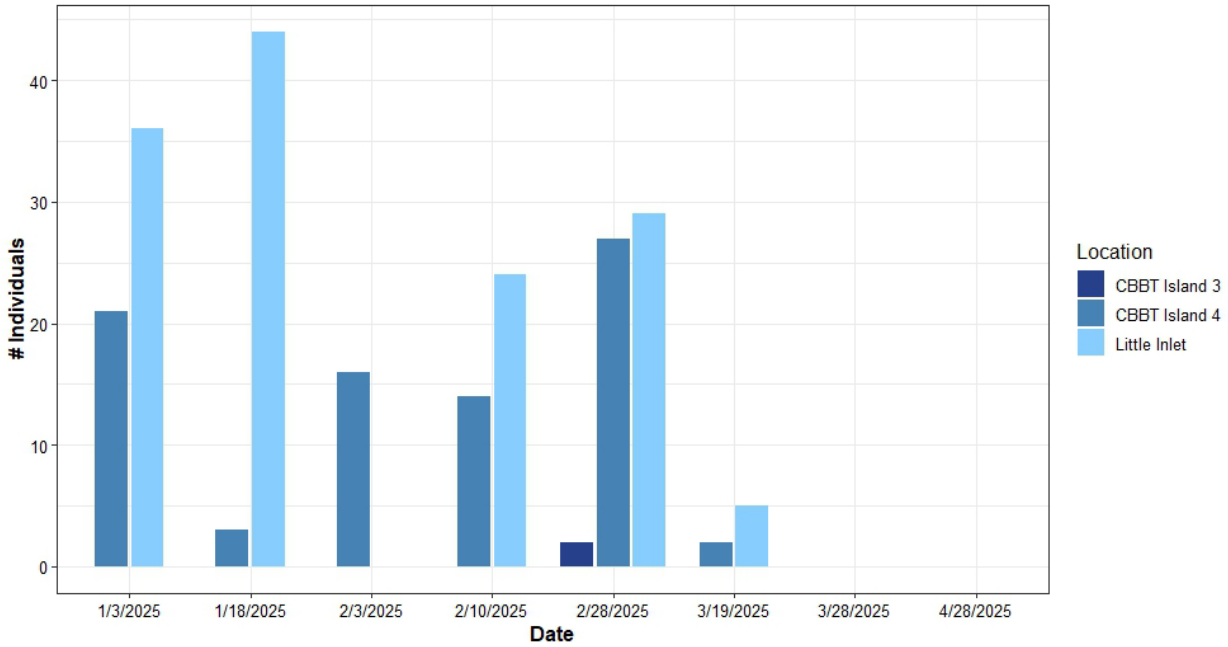


Figure 44. Number of seals hauled out by location by date throughout winter 2025. Little Inlet was not surveyed on 3 February 2025 due to weather. No seals were observed on 28 March or 28 April 2025.

2.8.4.3 Discussion

Results of these surveys further support the presence of only two known haul-out sites in Virginia. No new haul-out sites were identified along the Virginia coast during winter/spring 2025. Previous haul-out surveys and camera trap efforts primarily detected harbor seals, with only occasional gray seal sightings (Guins and Rees 2025, Jones 2024). Similarly, harbor seals were the only pinniped observed and recorded during these aerial surveys. Harbor seals have regularly been documented flushing in response to nearby and/or transiting vessels at both the CBBT islands and Little Inlet (Guins and Rees 2025).

The time for seals to haul out again after disturbance has varied based on haul-out location, as well as varied from season to season; however, on average, it takes multiple hours (Guins and Rees 2025). One sighting at CBBT Island 4 and one sighting at Little Inlet consisted of low numbers of seals only in the water, which may have been due to flushing caused by vessel activity or disturbance earlier in the day. Seals did not react to the presence of the aircraft during these surveys. Additionally, the aerial perspective provided an unobstructed view for accurate seal counts. For all sightings, photographs were subsequently reviewed, and seal counts were higher in photographs compared to initial observations recorded in the field. The number of observed seals from the plane was similar to counts previously documented at the CBBT islands and Little Inlet, with generally more seals present at Little Inlet than the CBBT islands (Guins and Rees 2025; Jones 2024).

Continued monitoring of these two haul-out sites will provide further information on site fidelity, behavior, and habitat use of pinnipeds in southeastern Virginia, and will continue to support U.S. Navy compliance and mitigation efforts within the area. Haul-out surveys have shown a higher number of seals using Little Inlet during recent seasons (Jones 2024), which could potentially be due to ongoing tunnel-expansion construction efforts at CBBT Islands 1 and 2. These local impacts should continue to be monitored, especially as construction efforts expand to CBBT Islands 3 and 4 in the future. Additionally, rebounding gray seal populations in Canada may be causing the displacement of harbor seals in northern areas, potentially leading to an increase of their southward expansion into the Mid-Atlantic (den Heyer et al. 2021; Pace et al. 2019). Future efforts to re-survey the entire Virginia coastline for seal haul-out sites may be warranted based on gray and harbor seal population trends.

For more information on these survey efforts, refer to the annual aerial report (Ozog et al. 2025).

2.9 Kemp's Ridley and Green Sea Turtle Tagging for Availability Bias Analysis

Availability bias, or the proportion of time that animals are unavailable to be detected by visual surveys, is a critical component for accurately estimating abundance in density spatial models (Laake et al. 1997), which are used for conservation and environmental compliance purposes. For air-breathing animals at sea, such as sea turtles and marine mammals, the proportion of time spent below the surface can range from 5 to 90 percent, depending on species, season, and animal behavior (DiMatteo et al. 2024; Mansfield 2006, Roberts et al. 2022). As such, if availability bias estimates are not applied to density spatial models, which rely on visual survey data, abundance may be underestimated by as much as an order of magnitude in some cases, hindering conservation efforts, and significantly underestimating the potential impacts of human activities. Applying robust availability bias estimates to spatial density models should be considered "best available science" and actively pursued for the newer generations of density spatial models being produced.

Animal dive behavior can vary widely by season, habitat, and life stage, and more complex treatments that represent animal availability as spatially varying surfaces can be applied to density spatial models. Several frameworks have been implemented for sea turtles, including spatiotemporal regression models (Hatch et al. 2022) and Generalized Additive Models that relate dive behavior to environmental covariates (Roberts et al. 2022), which allow for cautious extrapolation of availability bias estimates into unsampled areas and times.

On the U.S. East Coast, four species of sea turtle can commonly be found: loggerhead, green (*Chelonia mydas*), Kemp's ridley (*Lepidochelys kempii*), and leatherback turtles, all listed as threatened or endangered under the ESA. Loggerhead availability has been studied on the East Coast (Hatch et al. 2022), and large databases of animal tag data are extant. Leatherback tagging sponsored by NMFS concluded in 2023, with some initial studies of leatherback availability and distribution published (Rider et al. 2026; Rogers et al. 2024).

Within the same region, a critical gap exists for dive data appropriate for availability bias estimates for Kemp's ridley and green turtles, in part because these species are smaller and difficult to tag with depth recorders, given the size of these tags historically. Recent advances in tag technology, namely smaller tags that still have onboard pressure sensors, have made it possible to tag these species with the necessary hardware and in the numbers required to generate robust availability bias estimates. Previous density spatial models for Kemp's ridley and green turtles on the East Coast (DiMatteo et al. 2024) used availability bias estimates from a nearby region (Roberts et al. 2022). However, environmental relationships and dive behaviors may not be transferable between regions, so this type of extrapolation should only be undertaken if local estimates are not available.

Two years into the project, the study now has the first estimates of availability for these species on the East Coast. However, work remains to limit environmental extrapolation throughout the species' ranges by continuing to prioritize tagging underrepresented species within regions where logistically feasible.

2.9.1 Methodology

Wildlife Computers SPLASH10 telemetry tags have been deployed on a rolling basis, starting in June 2024 (Year 1), with the most recent deployment occurring in October 2025. No animals smaller than 30-centimeter straight carapace length have been tagged, as this is the smallest size generally considered to be visible from aerial survey platforms. The goal is to deploy tags on a range of turtle sizes to best represent size-based physiological differences in behavior. Field sites for animal acquisition include the Archie Carr National Wildlife Refuge nesting beach (Melbourne Beach and Brevard County, Florida); Trident Submarine Basin, Port Canaveral, Florida; Indian River Lagoon south of Sebastian Inlet (Indian River County, Florida); Jensen Beach, Florida, nesting beach; and the St. Lucie Power Plant intake canal.

Project Principal Investigators are also working with project partners to deploy satellite tags on turtles from rehabilitation entities in Florida, Georgia, North Carolina, Maryland, New York, and Massachusetts, pending confirmation of permit and staff availability with each project partner. At this time, only the University of Central Florida (UCF) and Inwater Research Group (IRG) are tagging wild-caught turtles; all other project partners anticipate tagging rehabilitated turtles (**Table 41**) ideally sourced from New England and mid-Atlantic regions during the winter cold-stun season.

Table 41. List of past, present, and potential project partners along with sampling location, species tagged, number of tags provided, and deployment period (months).

Project Partner	Location	Target Species	Number of Tags Allocated	Deployed to Date	Turtle Source	Anticipated Deployment Period
UCF	Port Canaveral to Sebastian Inlet, FL	Green	35	35	Wild caught	Seasonally for adult female green, year-round for juvenile green
IRG	St. Lucie Power Plant, Jensen Beach, FL	Kemp's ridley and green	9	7	Wild caught	December – May for Kemp's ridley; year-round opportunistically
Loggerhead Marinelife Center	Juno Beach, FL	Kemp's ridley	10	3 (3 more pending)	Rehabilitation	December – May (cold stun rehabilitation)
Georgia Sea Turtle Center/Jekyll Island Authority	Jekyll Island, GA	Kemp's ridley and green	5	2	Rehabilitation	January – May (cold stun rehabilitation)
National Aquarium	Baltimore, MD	Kemp's ridley and green	0	0	N/A	No longer a partner due to staffing changes
New York Marine Animal Rescue[a]	Long Island, NY	Kemp's ridley and green	0	0	Rehabilitation	January – May (cold stun rehabilitation)
New England Aquarium[a]	Boston, MA	Kemp's ridley	0	0	Rehabilitation	January – May (cold stun rehabilitation)
North Carolina Aquarium on Roanoke Island	Roanoke, NC	Kemp's ridley	0	0	Rehabilitation	January – May (cold stun rehabilitation)

Key: FL = Florida; GA = Georgia; MA = Massachusetts; MD = Maryland; N/A = not applicable; NC = North Carolina; NY = New York
[a] Pending resolution of permitting issues

In Year 2, 40 additional Wildlife Computers SPLASH10 satellite tags were acquired, bringing the total number of tags available for deployments to 100. These are Argos tags with depth sensors and depth profile capabilities. The 40 new tags came in two newly available physical configurations. The previous tags had four "bumpers" or towers in the corners of the tag to protect the antennae, while adding weight and drag to the tags as well as increased height to the tags' profiles. The two new configurations were (1) a single bumper protecting the antennae with two smaller bumpers in the opposite, rear corners; and (2) all bumpers removed, reducing weight and drag. The study team opted for these new models offered by Wildlife Computers as northern tagging partners noted concerns from the U.S. Fish and Wildlife Service over drag associated with the original four-bumper model, particularly when tagging the smaller size classes that usually strand in mid-Atlantic and northern waters. Only two of these new tags have been deployed to date, so assessing deployment lengths compared to the previous tags is premature.

This study uses the R package *animotum* (Jonsen et al. 2020, 2023), which uses Template Model Builder (Auger-Méthé et al. 2017) to rapidly fit correlated random walk (CRW) and movement process models to Argos and GPS data, accounting for location errors and predicting animal locations at regular (or user specified) time intervals. For each tag deployment, locations within the first 48 hours post-release were removed to account for changes in animal behavior associated with tagging and release. A CRW model was fitted in *animotum* for each tag, with prediction time steps at 4- hour intervals, matching the time intervals at which dive histograms were collected. The maximum speed (vmax) parameter was set to 1.25 m per second in accordance with hardshell turtle data presented in the *animotum* vignettes. Gaps in transmission longer than 5 days were not predicted on the premise the animal could not be reasonably localized over that span.

Availability bias was summarized in several ways for surface time, the various depth bins, and behavior data. Availability bias estimates were calculated for individuals; by species; and then by sex, age (juvenile versus adult), season, and depth classes, all of which were segregated by species to account for differences in foraging and dive behavior. Depth classes were defined as shallow (0–10 m), shallow shelf (10–50 m), deep shelf (50–200 m) and deep (>200 m) in order to examine how availability bias may change with available depths.

Given the current permitting issues with rehabilitation centers in the mid-Atlantic and Northeast, sampling in those waters has been limited to animals that have migrated north from Florida and Georgia. Despite these geographic limitations, it may be that the environmental conditions in those waters are being sampled by the existing tagging dataset. The study team examined the extent of environmental sampling for nine covariates that are likely candidates for future availability bias models: depth, surface temperature, bottom temperature, sea-surface height, mixed layer depth, salinity, net primary productivity, and phytoplankton and zooplankton concentration.

2.9.2 Tagging Results

Forty-seven turtles have been satellite tagged to date: 37 green and 10 Kemp's ridley turtles. Green turtle locations ranged as far north as southern South Carolina, as far south as the northern Cuban coast, as far west as the western Florida Keys, and as far east as the Blake Plateau (**Figure 45**). Kemp's ridley turtle locations ranged from Chesapeake Bay in the north, to the Florida Keys in the south. No Kemp's ridley turtles moved east of the continental shelf; however, to the west, one animal passed through the Florida Keys and into Mississippi waters before transmissions ceased (**Figure 46**).

As of the writing of this report, approximately 60,000 Argos locations were collected from the 47 tags deployed to date, 3 of which are still actively transmitting. Green turtle locations comprised the majority of locations (82 percent; **Figure 45**) compared to Kemp's ridley locations (18 percent; **Figure 46**). This is a substantial improvement over last year, during which there were only 700 Kemp's ridley locations from one tag.

The CRW models fitted to each tag converged. The study team examined model fit statistics and plots for each tag and found no indications of poor fit or structural issues with predictions. Approximately 26,000 locations were predicted at 4-hour intervals (**Figure 45**), covering the 47 deployments. Fourteen large transmission gaps across nine tags were not interpolated, several of which spanned 2 to 4 weeks. Reasons for these large gaps in transmission could range from antenna fouling, animal behavior, or software/hardware issues, but exact causes are unclear.

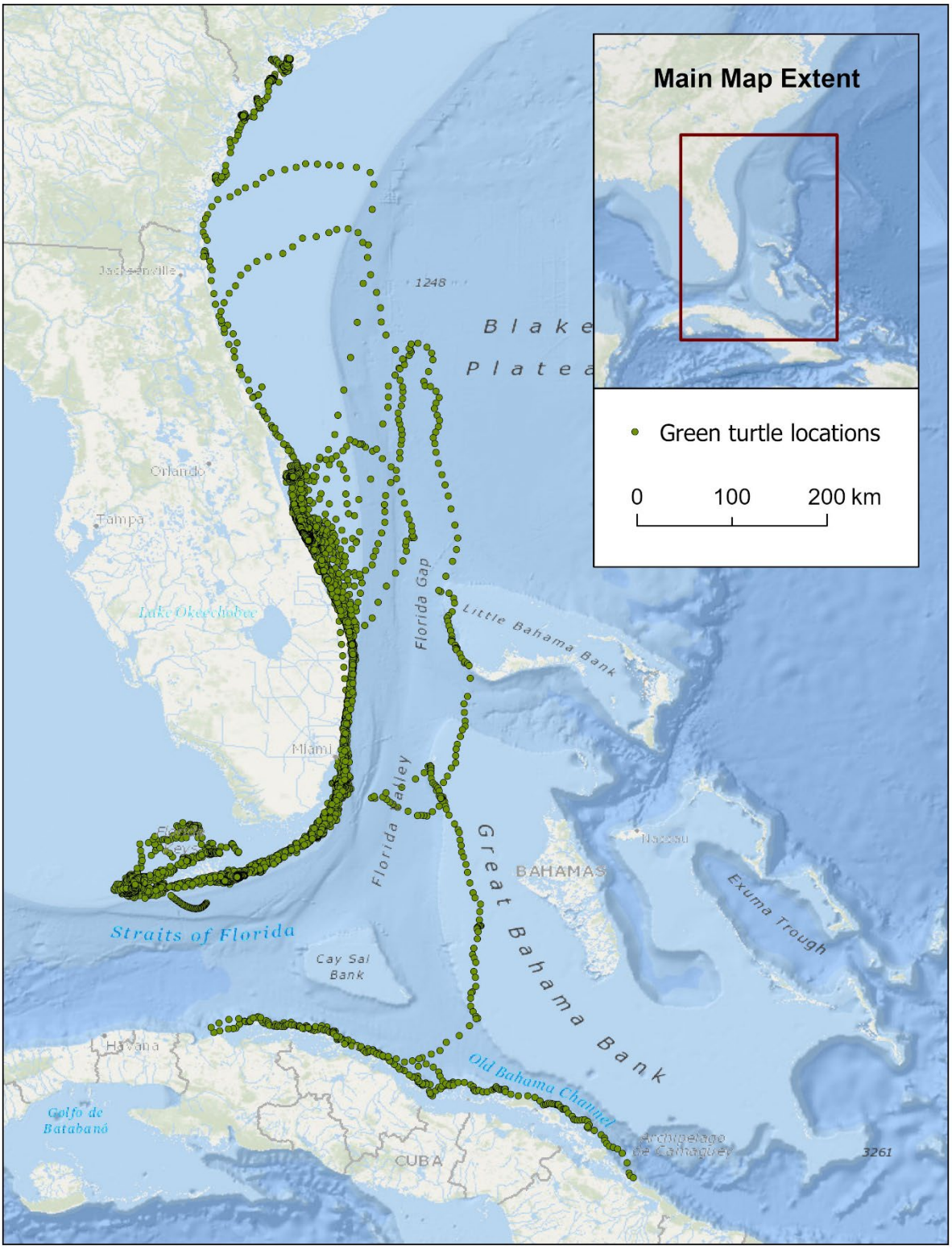


Figure 45. CRW locations for 37 tagged green turtles.

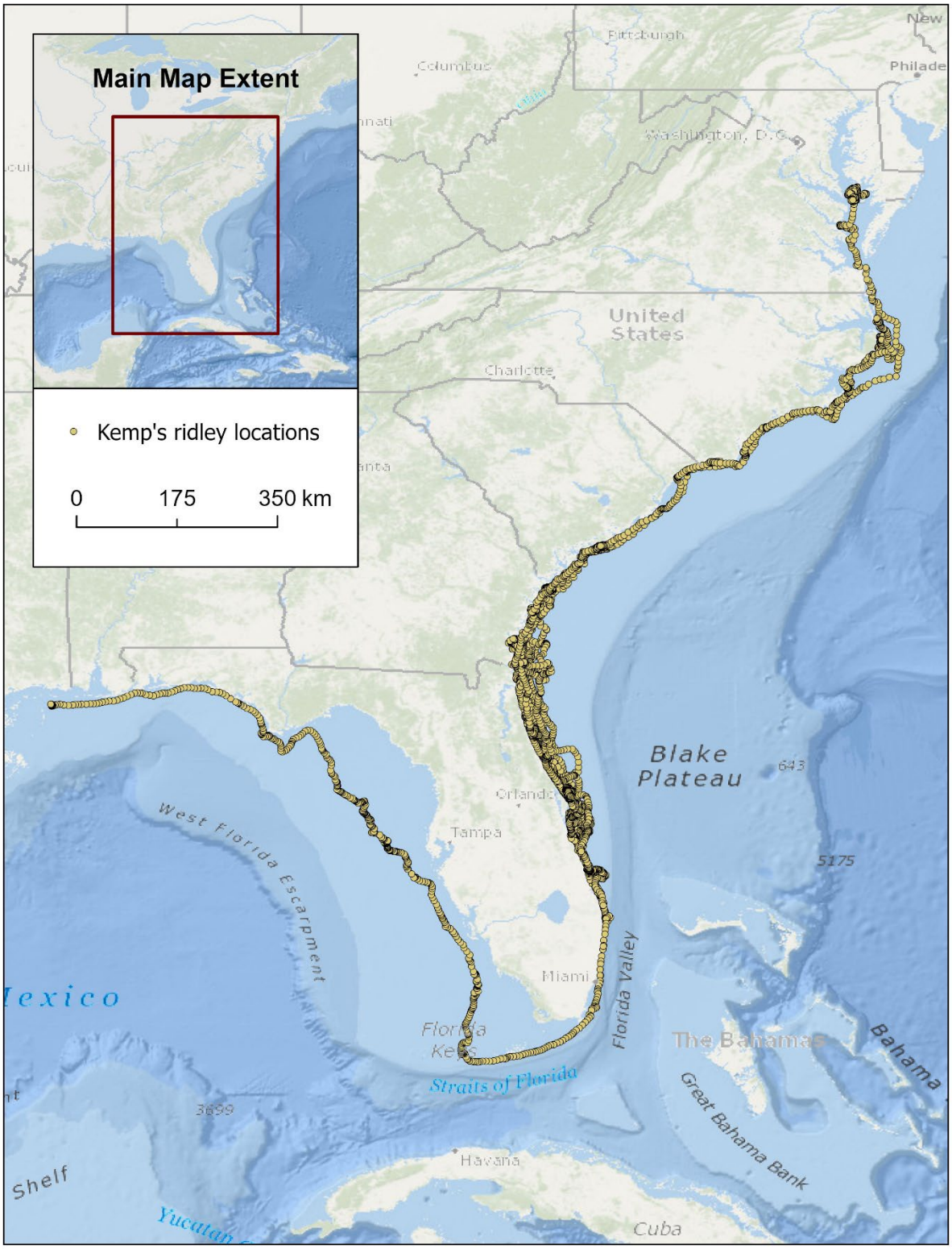


Figure 46. CRW locations for 10 tagged Kemp's ridley turtles.

2.9.3 Availability Bias

For adult green turtles that traveled to the Florida Keys (**Figure 47**), availability bias values derived from the 2-m depth bin histogram were generally lower than 0.4, indicating the animals spent most of the time at depth. This is consistent with the Florida Keys being identified as an area having abundant seagrass beds where green turtles are known to forage (Sloan et al. 2022, Welsh and Mansfield 2022). The availability bias estimates based on the same data for juvenile green turtles in inland waters of the Florida central coast, Georgia, and South Carolina showed animals spending a larger proportion of their time within 2 m of the surface. Offshore locations of traveling green turtles also had lower availability bias values, likely indicating turtles were not pausing to forage as they migrated.

Green turtle availability was lower during winter and fall compared to spring and summer, perhaps reflecting lower thermal gains from basking during those seasons with shorter days and cooler temperatures. Green turtle availability was similar in both shelf depth classes. The deeper depth classes offered conflicting information, but the number of samples was low, which may limit the study's inference in deep depths. In general, availability was lower compared to the Year 1's analyses, possibly reflecting a higher proportion of adults tagged, which were less available than juveniles.

The Kemp's ridley turtles generally spent most of their time below the 2-m depth, even while traveling along the coast. Limited areas of higher availability were found in the few loops to the mid-shelf off the coast of Georgia and Florida, in the sounds of North Carolina, and in Chesapeake Bay (**Figure 48**). No sex or age class comparison was possible for Kemp's ridley turtles because all tagged animals to date are juveniles of indeterminate sex. Seasonal estimates of availability bias were similar during winter, spring, and summer. Fall was lower but had the least number of records, making interpretation of this difference challenging. Availability was lower in the shallow shelf depth class than the shallow depth class, which may reflect animals foraging only at very shallow depth (Mansfield 2006). Fewer than 10 records were collected at greater depths, so results for those depth classes are not reported herein.

Kemp's ridley turtle availability was generally lower than green turtle availability. Exceptions to this comparison occurred when sample numbers were low for a given category, (e.g., male green turtles, winter). The study team opted not to compare estimates to the 2023/24 study year, given the single Kemp's ridley turtle tagged and few samples from that year.

2.9.4 Environmental Sampling Assessment

The environmental sampling assessment only covered the temporal extent of current tag deployments, or roughly 18 months. Assessments were limited to the continental shelf because this is the primary area where both species are found. **Table 42** provides annual assessments for both the Area of Interest (AOI) and the continental shelf.

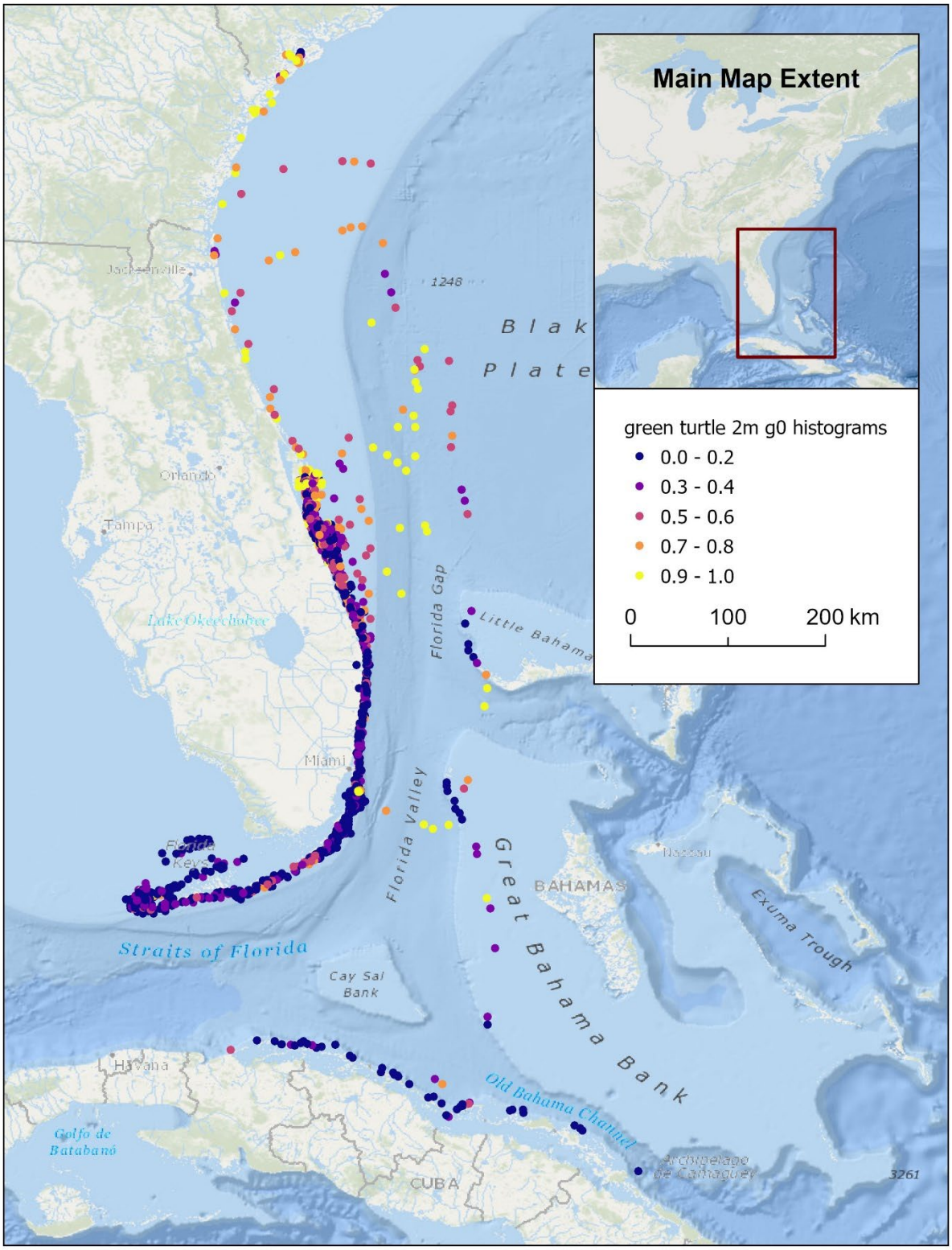


Figure 47. Interpolated daytime green turtle locations with associated availability bias data (2-m histograms).

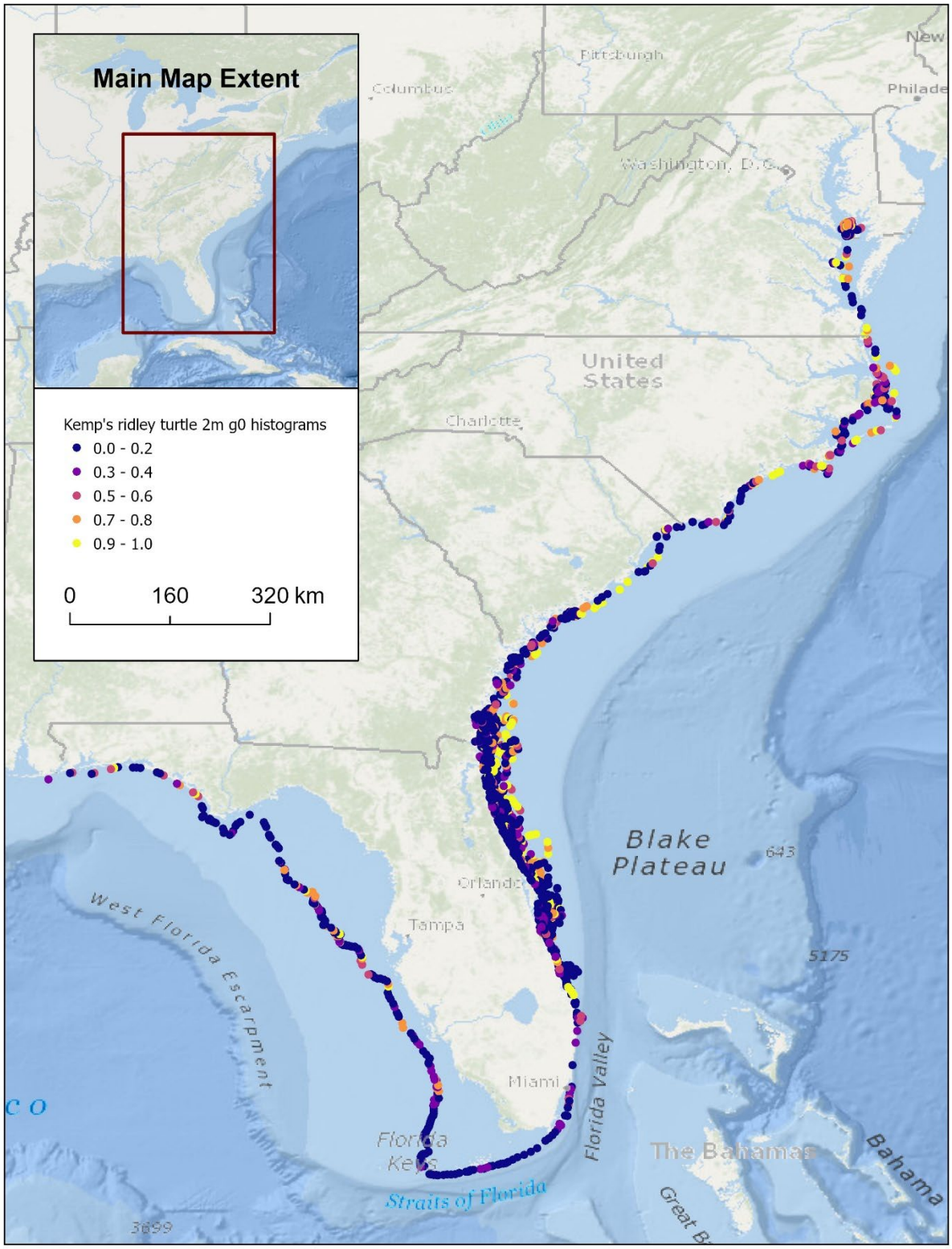


Figure 48. Interpolated daytime Kemp's ridley turtle locations with associated availability bias data (2-m histograms).

Table 42. Proportion of the environment sampled by extant tag data.

Covariate	Green Turtles						Kemp's Ridley Turtles					
	AOI (Annual)	Shelf (Annual)	Winter (Shelf Only)	Spring (Shelf Only)	Summer (Shelf Only)	Fall (Shelf Only)	AOI (Annual)	Shelf (Annual)	Winter (Shelf Only)	Spring (Shelf Only)	Summer (Shelf Only)	Fall (Shelf Only)
Depth	0.50	1	1	1	1	1	0.31	0.91	0.96	0.91	0.91	0.97
Surface temperature	0.75	0.53	0.53	0.62	0.84	0.58	0.87	0.74	0.87	0.85	0.98	0.90
Bottom temperature	0.48	0.91	1	0.99	0.95	0.97	0.23	0.60	0.96	0.82	0.60	0.76
Salinity	0.79	0.48	0.98	0.80	0.43	0.5	0.90	1	1	1	1	1
Mixed layer depth	0.94	1	1	1	1	1	0.83	0.95	0.97	1	1	0.98
Net primary productivity	0.99	0.99	1	0.98	0.98	0.99	0.99	1	1	1	1	1
Phytoplankton concentration	0.91	0.91	0.99	0.84	0.97	0.98	0.93	1	1	1	1	1
Zooplankton concentration	0.91	0.84	0.79	0.77	0.97	0.96	0.95	1	1	1	0.99	1
Sea surface height	0.86	0.96	0.99	0.95	0.99	0.98	0.61	0.99	1	1	1	0.97
Averages	0.79	0.85	0.92	0.88	0.90	0.89	0.74	0.91	0.97	0.95	0.94	0.95

2.9.5 Discussion

Building on Year 1 deployments, Year 2 moved the study toward providing robust, defensible availability bias models for green and Kemp's ridley sea turtles on the East Coast. The current study results should be interpreted with caution, given the relatively small number of deployments to date, particularly for Kemp's ridley turtles (*n*=10 deployments), which limits the available information both spatially and temporally.

Collecting 18 months of data and expanding the analysis, compared to 6 months when the 2024 annual report (DiMatteo and Mansfield 2025) was written, reinforced several findings. Availability generally increased as the depth threshold at which animals were assumed to be able to be seen increased. This is to be expected as more of the water column is considered to be visible. The availability bias estimates from the 2-m depth histograms and dive behavior were similar.

For both species, locations were limited during one or more seasons, making comparisons challenging. Increasing seasonal coverage should remain a priority. However, the environmental sampling assessment provided valuable insights into the current environmental space traversed by the extant tag dataset. Most covariates were well sampled in most seasons and areas with a few limited exceptions, giving the study team confidence that spatial models could be cautiously extrapolated into physically unsampled areas, with the possible exception of areas off the continental shelf, which were generally less well sampled because few turtles ranged off the continental shelf and those that did spent little time in off-shelf waters. Limiting future spatial models to the continental shelf may be advisable, and static averages could be used off the shelf, possibly stratified monthly or seasonally. Spatial models would still cover both species' core distribution within the AOI, which is the continental shelf, limited in northward extent during some seasons.

This study's northern tagging partners continue to not be able to tag animals for this project due to permit restrictions. Because of this, the study's ability to deploy the planned number of tags has been hindered. To date, 47 of 100 available tags have been deployed, 37 on green turtles and 10 on Kemp's ridley turtles, which falls short of not just the study's tagging goal but its goal of species parity. Because Kemp's ridley turtles nest only rarely on the East Coast, the study is reliant on in-water captures or stranding for this species, as opposed to green turtles, which nest extensively in Florida and to a lesser extent northward through the mid-Atlantic.

To combat the disparity between green and Kemp's ridley turtle tagging, the study team has worked with partners that have successfully acquired and released Kemp's ridley turtles to increase their permitted number of tags allowed to be deployed and ensure they have ample tags on hand.

For the remainder of Year 2, the study team will continue to update the existing analyses as transmissions complete and more deployments occur. Future analyses include: (1) moving from a CRW model to a movement persistence or Hidden Markov model approach, which could allow inference on whether and how dive behavior changes with animal behavioral state, though this has proven inconclusive within other regions (DiMatteo et al. unpublished data from the

Mediterranean Sea); (2) expanding the scope of the environmental sampling assessment; and (3) beginning to fit exploratory models to data to guide future modeling decisions and better understand the relationship of availability bias to environmental factors.

For more information on this study, refer to the annual progress report for this project (DiMatteo and Mansfield 2026).

2.10 Atlantic and Shortnose Sturgeon Monitoring in the Lower Kennebec River

This telemetry monitoring study managed by the NUWCDIVNPT was initiated in May 2021 to collect year-round occurrence data for Atlantic sturgeon (*Acipenser oxyrinchus*) and shortnose sturgeon (*A. brevirostrum*) 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 (*Carcharodon carcharias*). Offshore stations form a curtain between Fox-Seguin Islands and the Jackknife Ledge Dredge Disposal area.

Project objectives are to support U.S. Navy environmental compliance and permitting associated with the Kennebec River Federal Navigation Project and activities near BIW, while identifying optimal dredging windows that maintain operational readiness and minimize impacts on ESA-listed species. This is being addressed through (1) monitoring year-round presence and migration of Atlantic sturgeon in the lower Kennebec River; (2) monitoring year-round presence and migration of shortnose sturgeon in the lower Kennebec River; (3) monitoring sturgeon activity in the proximity of BIW; (4) adding additional acoustic tags to the population of sturgeon occurring in the Kennebec River system; and (5) documenting coastal movements of fish offshore from Popham Beach (sturgeon, white sharks, striped bass [*Morone saxatilis]*, and other species designated by NOAA as highly migratory species).

Collaborators on this project include State of Maine Department of Marine Resources (ME DMR), University of Maine (UMaine), U.S. Geological Survey, Portsmouth Naval Shipyard, and University of New Hampshire. Data collected from this study has helped to determine movement patterns in and out of the Kennebec River basin, identify potentially new overwintering and/or foraging areas, and identify coastal movements of protected sturgeon between river systems in the Gulf of Maine.

As of December 2025, 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 49**). Seven of the in-river stations are co-maintained by ME DMR (seasonally April to November) and NUWCDIVNPT. Downloads of telemetry stations occur on a bi-annual basis. In the river, the array has detected both species of sturgeon, as well as tagged American shad (*Alosa sapidissima*), striped bass, and ESA endangered (Gulf of Maine) Atlantic salmon (*Salmo salar;* captive-reared). Offshore data for the project thus far includes detections for both species of sturgeon, striped bass, white sharks, and Atlantic bluefin tuna (*Thunnus thynnus*).

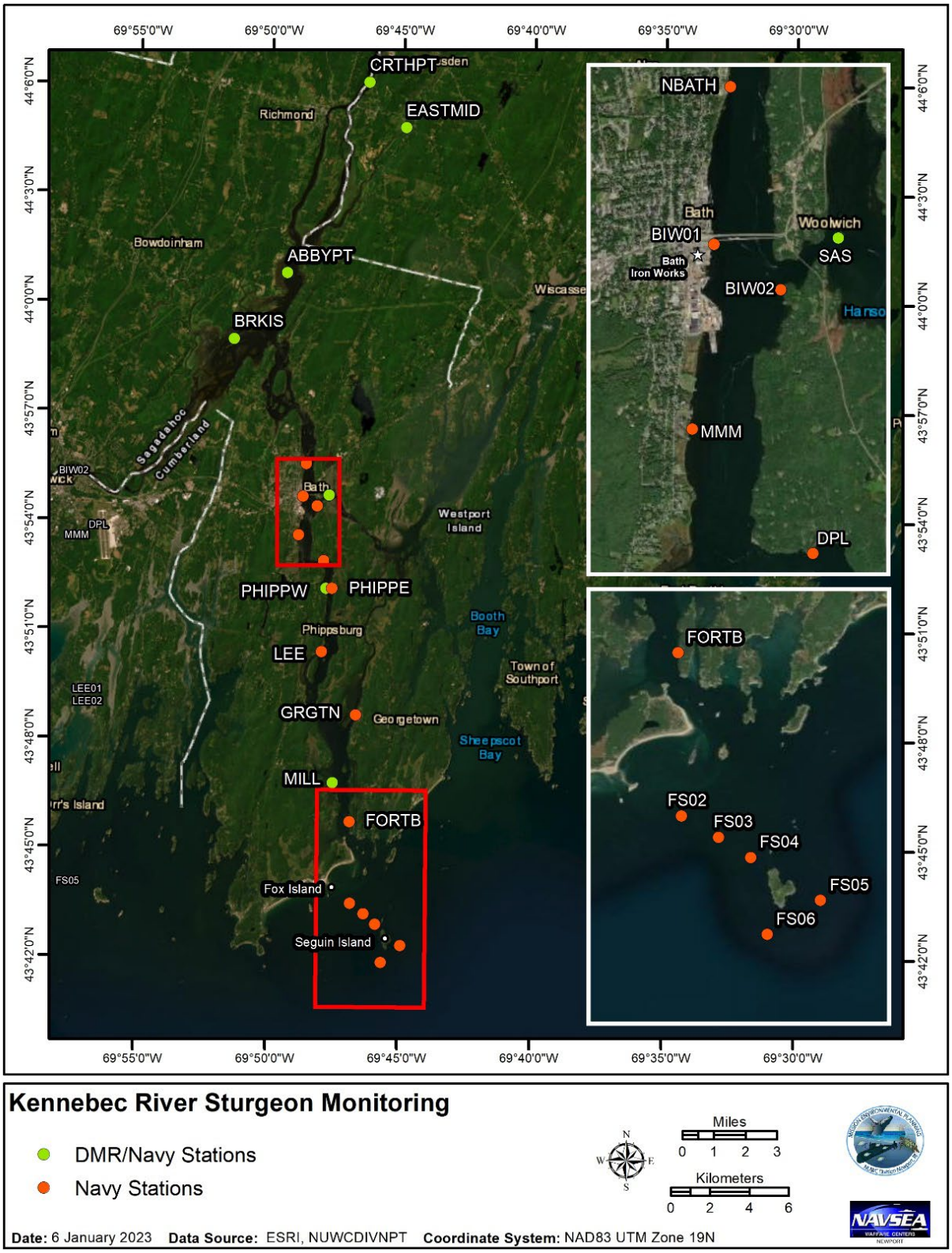


Figure 49. Array map showing the location of U.S. Navy and ME DMR monitoring stations in the lower Kennebec River basin extending to offshore Seguin Island.

During the period covering November 2024 through October 2025, the array recorded 426,926 matched detections across all stations. Atlantic sturgeon accounted for most detections (*n*=396,510 [river]; *n*=953 [ocean]) from 49 unique individuals; while shortnose sturgeon generated only river detections (*n*=23,986 [river]) from 16 individuals (**Table 43**). **Figure 50** provides a monthly heatmap of detections for the four most commonly detected species.

Table 43. Number of detections at river and ocean stations for each species across the study period (November 2024 – October 2025).

Species	Scientific Name	Ocean Detects	River Detects	Unique Ocean IDs	Unique River IDs
Atlantic sturgeon	*Acipenser oxyrhynchus*	953	396,510	14	35
Shortnose sturgeon	*Acipenser brevirostrum*	0	23,986	0	16
Striped bass	*Morone saxitilis*	40	6,428	3	2
Thresher shark	*Alopias vulpinus*	14	0	1	0
White shark	*Carcharodon carcharias*	171	0	10	0
Winter flounder	*Pseudopleuronectes americanus*	0	1	0	1
TOTALS		**1178**	**426,926**	**28**	**55**

Overall, telemetry data collected over the past 2 monitoring years provide valuable information on sturgeon habitat use and seasonal movement patterns in the lower Kennebec River and adjacent coastal waters. Results consistently show that Atlantic sturgeon exhibit strong seasonal use of the mid-river corridor during spring and early summer months, with reduced presence in the lower river during November through March. Shortnose sturgeon detections indicate similar seasonal movements, with broader distribution across mid-river stations during the warmer months. Offshore monitoring stations also continue to document coastal movements of Atlantic sturgeon and other highly migratory species through the Gulf of Maine, demonstrating connectivity between the Kennebec and other river systems.

These findings provide an improved understanding of sturgeon habitat use and seasonal occurrence in the Kennebec River system and contribute to the development of an environmental baseline that supports U.S. Navy compliance and consultation requirements. This monitoring has improved the ability to identify periods of reduced sturgeon presence in specific areas of the Lower Kennebec River, which can inform dredging schedules and other in-water activities to help maintain U.S. Navy operational readiness while minimizing impacts on ESA-listed species.

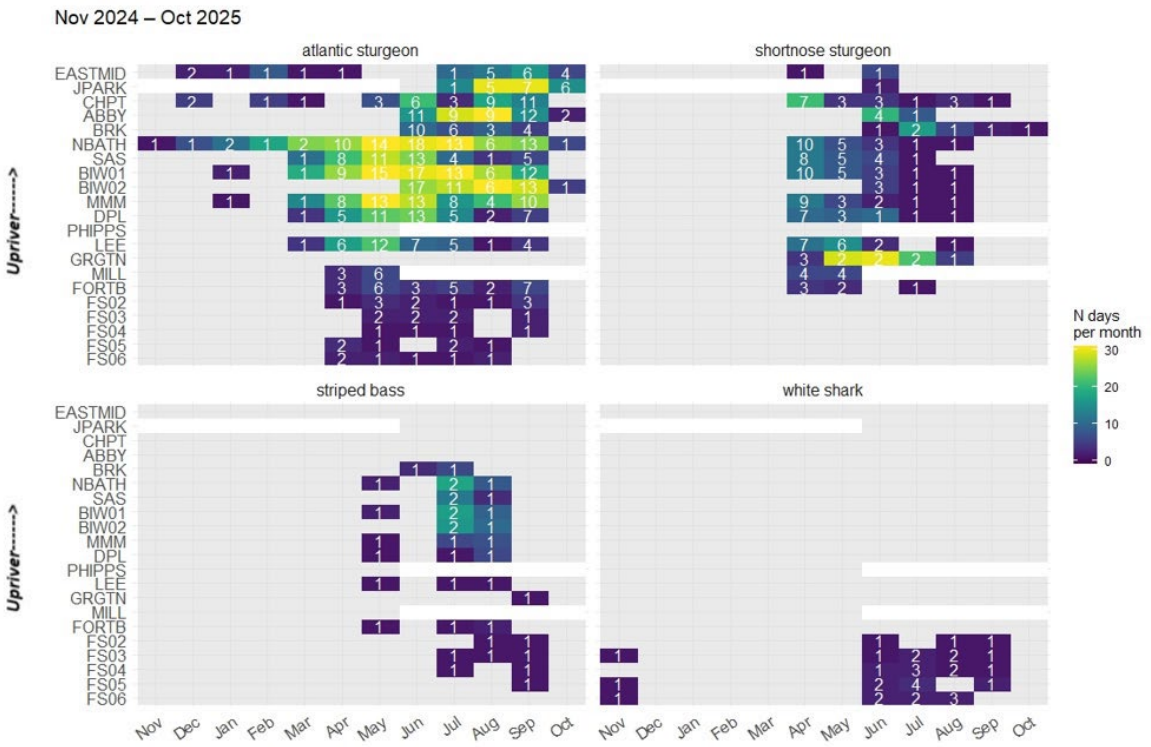


Figure 50. Species detected at each station during the monitoring period November 2024 – October 2025, showing the number of days per month with detections and total number of unique individuals (white numbers). Note: unshaded cells represent months with no coverage for that station.

Going forward, monitoring work in the Kennebec River will focus on the use of side-scan sonar and a telemetry position system to help estimate the spawning run size of both species. This work will help address a NMFS prior recommendation to conduct studies to update population estimates of sturgeon in the Kennebec River system. This focused work in spawning areas will directly complement a greater effort by collaborators such as ME DMR and UMaine to estimate the population of Atlantic and short-nose sturgeon in the Kennebec and Penobscot Rivers.

For more details on the analysis from November 2024 through October 2025, refer to the annual progress report for this project (Iafrate 2026).

2.11 Marine Distribution of Gulf of Mexico Sturgeon

Widely considered the southernmost, extant sturgeon species, the anadromous Gulf sturgeon (*Acipenser desotoi*) occupied large river systems from Texas to peninsular Florida prior to overharvest. Although their general patterns of habitat use and movement in estuarine and riverine systems are fairly well known, data to inform marine habitat use and occupancy modeling are generally lacking. Prior to population declines, Gulf sturgeon were found from the northern portions of South America throughout the northern GOM to the Florida Keys. Present freshwater distribution of Gulf sturgeon appears limited to Gulf Coast river systems from the Mississippi River eastward to the Suwannee River, Florida (Sulak et al. 2016). While current

marine distribution patterns are less documented, they have likely contracted with the concurrent loss of rivers at the edges of their distribution. Ultimately, concerns centered on habitat loss/alternation and overharvest led to the ESA listing of Gulf sturgeon as threatened in 1991 (56 *Federal Register* 49653-49658).

During freshwater residency, which extends from spring to fall, adult Gulf sturgeon undergo a prolonged period of fasting before transiting to marine foraging areas (Mason and Clugston 1993). The lack of freshwater foraging focuses the role of marine habitats in subsequent reproductive success and, ultimately, is 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. This project, which leveraged large numbers of pre-existing transmitters and passive acoustic receivers, provided much needed information to the Naval Sea Systems Command on the spatial temporal patterns of occupancy for the ESA-listed Gulf sturgeon in the Naval Surface Warfare Center (NSWC), Panama City Division Testing Range and the Panama City OPAREA. This information can be used to provide a framework for subsequent efforts to examine the exposure and response to U.S. Navy activities as well as the consequences of these responses on this imperiled species.

In October 2021, 30 adult Gulf sturgeon received long-lived acoustic transmitters (Innovasea Ltd. V-16-6H) that were surgically implanted according to previously developed protocols (Fox et al. 2000). This effort was also supplemented by 25 transmitters deployed in adult Gulf sturgeon in the Choctawhatchee River on 7 and 8 October 2023. Additional tagging efforts led by the Alabama Department of Conservation and Natural Resources have taken place annually through fall 2025, deploying transmitters in adults on the spawning grounds in the Geneva, Alabama, vicinity as part of a companion project focused on examining spring and fall spawning populations.

To monitor for these transmitters as well as tags deployed for other projects, an acoustic receiver array was deployed in the NSWC Panama City Testing Range during fall 2021. The array configuration was modified several times throughout the project duration based on previous findings and desire for increased resolution. See Fox and Breece 2026 for details on the array configuration. A summary of the deployment schedule for the duration of this study is located in **Table 44**.

Table 44. Monthly active assets by type to monitor for Gulf sturgeon occurrence from October 2021 – December 2025.

Monitor Type	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
2021/2022	—	—	—	—	—	—	—	—	—	—	—	—
VR2TXs	—	15	15	46	46	46	46	46	46	—	—	—
VR2ARs	—	—	—	30	30	30	30	30	30	—	—	—
Deployed Transmitters	—	30	—	—	—	—	—	—	—	—	—	—
2022/2023	—	—	—	—	—	—	—	—	—	—	—	—
VR2TXs	—	42	42	42	42	42	42	42	42	—	—	—
VR2ARs	—	37	37	37	37	37	37	37	37	—	—	—
2023/2024	—	—	—	—	—	—	—	—	—	—	—	—
VR2TXs	—	45	45	45	45	45	45	45	45	45	45	45
VR2ARs	—	40	40	40	40	40	40	40	40	40	40	40
Deployed Transmitters	—	25	—	—	—	—	—	—	—	—	—	—
2024/2025	—	—	—	—	—	—	—	—	—	—	—	—
VR2TXs	—	45	45	45	45	45	45	45	43	43	43	43
VR2ARs	—	40	40	40	40	40	40	40	40	40	40	40
2025/2026	—	—	—	—	—	—	—	—	—	—	—	—
VR2TXs	—	43	43	43	—	—	—	—	—	—	—	—
VR2ARs	—	40	40	40	—	—	—	—	—	—	—	—

The passive array detected 414 telemetered Gulf sturgeon over the duration of the project (**Table 45**); however, numbers detected varied across years of this project. Eleven individuals were detected in 2021 and 39 in 2022. There was a large increase in the number of Gulf sturgeon in the years 2023 to 2025 (*n*=74, 112, and 90, respectively) as the array was reconfigured to further refine their core habitat areas closer to shore that were not documented in the first few seasons of this project. Importantly, this Gulf array has been detecting telemetered animals from Gulf sturgeon populations across the entire species range. The vast majority of Gulf sturgeon detections remained close to shore (less than 4 km offshore), with no confirmed detections beyond 7 km from shore for the duration of the study. While most receivers within 2 km of shore detected a few dozen sturgeon, the receivers within the eastern portion of the array from Tyndall Airforce Base to Mexico Beach, Florida, had increased detection windows and greater overall time spent within this area by individual Gulf sturgeon. On average, individual Gulf sturgeon began to migrate into the GOM through Destin Pass on 10 December (minimum = 14 October, maximum = 24 April, median 10 December) and on average were last detected exiting the GOM through Destin Pass on 7 February (minimum = 20 October, maximum = 3 May, median = 20 February) to begin their upstream migration.

Table 45. Monthly active assets by type to monitor for Gulf Sturgeon occurrence from October 2021-December 2025.

Year	Unique Individuals
2021	11
2022	39
2023	74
2024	112
2025	90

This project has collected a wealth of information on Gulf sturgeon and other telemetered species, including ESA-listed turtles in the NSWC Panama City Test Range. The findings underscore the seasonal nature of Gulf sturgeon occupancy in the GOM, and cursory data analysis reveals concentrations in the near shore environment from November to April, with few sturgeon occurring beyond 5 km from shore. Now that there is a better understanding of where and when Gulf sturgeon occur in the NSWC Panama City Test Range, next steps will further refine these insights to get to questions of population and, ultimately, species-level impacts of U.S. Naval activities within this area to improve efficiency and enhance recovery prospects for this imperiled species.

For more details on results from this project, see Fox and Breece 2026.

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Appendix A.
Summary of Monitoring Investments in the Atlantic for 2025–2026

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Appendix A: Summary of Monitoring Investments in the Atlantic for 2025–2026[1]

Project Description	Intermediate Scientific Objectives	Status
Title: Atlantic Behavioral Response Study **Location:** Cape Hatteras **Objectives:** Assess behavioral response of beaked and pilot whales to mid-frequency tactical sonar **Methods:** Controlled exposure experiments, DTAGs, satellite tags **Performing Organizations:** Duke University, Southall Environmental Associates, University of St. Andrews, Bridger Associates, HDR Inc. **Timeline:** 2017–ongoing **Total Funding:** $10.795M **FY25 Funding:** $1.36M	• Evaluate behavioral responses by marine mammals exposed to U.S. Navy training and testing activities	**Field work ongoing** • Mid-frequency active sonar CEEs completed 2022 • Continually active sonar CEEs began 2023 • Supplemental HARP deployments began in 2024 • Technical progress reports available – 2017–2025 • Tagging data available - Animal Telemetry Network • 13 peer-reviewed publications, and 11 manuscripts currently in preparation or review
Title: Behavioral Response Analysis of Two Populations of Short-finned Pilot Whales to Mid-Frequency Active Sonar [2] **Location:** Cape Hatteras and Hawaii **Objectives:** Utilize newly developed statistical methods from the Atlantic BRS project and apply them to all the satellite-tagged pilot whales from both the Atlantic and Pacific studies **Methods:** Controlled exposure experiments, DTAGs, satellite telemetry tags, passive acoustic monitoring **Performing Organizations:** Naval Information Warfare Center, Southall Environmental Associates, National Marine Mammal Foundation, Naval Postgraduate School, Cascadia Research Collective, Duke University. **Timeline:** 2024–2026 **Total Funding:** $159K **FY25 Funding:** $139K	• Evaluate behavioral responses of marine mammals exposed to U.S. Navy training and testing activities	**FY24 New Start** • Analyses to be completed in 2026
Title: Behavioral Response Research Evaluation Workshop II (BRREW II) [3] **Objectives:** **Methods:** Workshop meeting and technical working group Performing Organizations: University of St. Andrews (workshop coordinator) **Timeline:** 2025–2026 **FY25 Funding:** $150K	• Evaluate behavioral responses of marine mammals exposed to U.S. Navy training and testing activities • Strategic planning for future behavioral response investments across U.S. Navy programs	**Workshop to be held May 2026** • Pre-workshop questionnaire and synthesis of stakeholder input completed • Gap analysis and decision support analysis completed • Technical working group and advisory panel established • Workshop proceedings report anticipated late 2026

[1] All projects funded by U.S. Fleet Forces Command unless otherwise noted
[2] Co-funded by U.S. Fleet Forces Command, Commander Pacific Fleet, and Naval Air Systems Command
[3] Co-funded by U.S. Fleet Forces Command, Commander Pacific Fleet, Naval Air Systems Command, Naval Sea Systems Command, and Living Marine Resources Program

Project Description	Intermediate Scientific Objectives	Status
Title: Occurrence, Ecology, and Behavior of Deep Diving Odontocetes Location: Cape Hatteras **Objectives:** Establish behavioral baseline and foraging ecology. Assess behavioral response to acoustic stimuli and Navy training activities **Methods:** Visual surveys, biopsy sampling, DTAGs, satellite-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 (e.g., foraging, dive patterns) of marine mammals where U.S. Navy training and testing activities occur • Evaluate behavioral responses by marine mammals exposed to Navy training and testing activities	**Field work ongoing** • Tagging fieldwork continues under Atlantic BRS • Technical progress reports available – 2013–2018 • Tagging data - Animal Telemetry Network • Ongoing photo-ID analysis • Photo-ID technical reports available 2019–2024 • Multiple peer-reviewed publications
Title: Mid-Atlantic Offshore Cetacean Study **Location:** VACAPES OPAREA **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 **Total Funding:** $3.26M **FY25 Funding:** $95K	• 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 (e.g., foraging, dive patterns) 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 – 2016–2025 • Associated photo-ID analysis ongoing • Peer-reviewed publications, additional manuscripts in preparation • Sighting data – OBIS-SEAMAP • Tagging data – Animal Telemetry Network
Title: Mid-Atlantic Nearshore & Mid-shelf Baleen Whale Monitoring Location: Mid-shelf VACAPES OPAREA **Objectives:** Assess occurrence, habitat use, and baseline behavior of baleen whales in the mid-Atlantic region M**ethods**: Visual surveys, UAS and focal follow observations, photo-ID, biopsy sampling, satellite-linked telemetry tags, high-resolution dive tags **Performing Organizations:** HDR, Inc., Kimora Solutions **Timeline:** 2021-ongoing **Total Funding:** $2.5M, FY25 Funding – $758K **Funding:** FY21 – $320K, FY22 – $420K, FY23 – $775K, FY24 – $740K	• Establish the baseline habitat uses and movement patterns of marine mammals where Navy training and testing activities occur • Establish the baseline behavior (e.g., foraging, dive patterns) of marine mammals where Navy training and testing activities occur	**Fieldwork ongoing** • Evolution of nearshore humpback monitoring project in 2021 • Tagging primarily focused on mid-shelf • Humpback component focused on photo-ID and morphometric assessments • Technical progress report available – 2022–2025 • Associated photo-ID analysis ongoing • Sighting data – OBIS-SEAMAP • Tagging data – Animal Telemetry Network

Project Description	Intermediate Scientific Objectives	Status
Title: North Atlantic Right Whale Monitoring **Location**: Mid-Atlantic **Objectives**: Assess seasonal occurrence, habitat use, behavior and movements in the Mid-Atlantic region **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 – ongoing **Total Funding**: $8.05M **FY25 Funding:** $750K	• 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 (e.g., foraging, dive patterns) of marine mammals where Navy training and testing activities occur	**Fieldwork ongoing** • DTAG deployments on southeastern calving grounds 2014–2017 • Aerial/vessel visual monitoring, satellite-telemetry tagging, suction-cup tag deployments, and photo-ID work in Mid-Atlantic beginning 2021 • Autonomous PAM glider deployments (2018–2020), fixed auto-reporting PAM buoy off Cape Hatteras (2021–2023) and Cape Charles (2023–2026), Mid-Atlantic SoundTrap deployments (2022–2026) • Multiple peer-reviewed publications • Sighting data – WhaleMap **-Annual financial support to SE Early Warning System surveys** **-Participation on NE and SE recovery plan implementation teams**
Title: Green and Kemp's Ridley Turtle Tagging for Availability Bias **Location**: U.S. East Coast **Objectives**: Assess availability bias and habitat associations of endangered Kemp's ridley and threatened green sea turtles to improve spatial density models **Methods**: Telemetry tagging, spatial modelling **Performing Organizations**: University of Central Florida, CheloniData LLC **Timeline**: 2014–2027 **Total Funding**: $623K **FY25 Funding:** $278K	• Establish the baseline habitat use, seasonality, and movement patterns of marine mammals and ESA-listed species where U.S. Navy training and testing activities occur • Establish the baseline behavioral patterns (e.g., foraging, diving) of marine mammals and ESA-listed species where U.S. Navy training and testing activities occur • Estimate the distribution, abundance, and density of marine mammals and ESA-listed species in U.S. Navy range complexes, testing ranges, and specific training and testing areas • Evaluate potential exposure of marine mammals and ESA-listed species to U.S. Navy training and testing activities	**FY24 New Start** • Field work in progress • Technical progress report available – 2024–25 • 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**: 2015–2025 **Total Funding**: $533K **FY25 Funding:** $30K	• Estimate the density of marine mammals and sea turtles in U.S. Navy range complexes and in specific training areas • Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where U.S. Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to sonar and underwater explosives	**Fieldwork complete** • Haul-out count fieldwork completed in 2025 • Technical progress reports available – 2016–2025 • Time-lapse camera traps incorporated in 2019

Project Description	Intermediate Scientific Objectives	Status
Title: Time-lapse Camera Surveys of Pinnipeds in Southeastern Virginia **Location:** Lower Chesapeake Bay and Virginia Eastern Shore **Objectives:** Document seasonal occurrence, habitat use, and haul-out patterns of seals **Methods:** Remote time-lapse camera traps, photo-ID **Performing Organizations**: NAVFAC Atlantic, The Nature Conservancy **Timeline:** 2019–2026 **Total Funding**: $195K **FY25 Funding:** $20K	• 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** • Data collection anticipated to end in 2026 • Technical progress reports available – 2019–2025 • Peer-reviewed publication
Title: Occurrence of Rice's Whales in the Northern Gulf of Mexico [4] **Location**: Northeast Gulf of Mexico **Objectives**: Assess seasonal and occurrence of Rice's whales in the Northeastern Gulf of Mexico **Methods**: Passive acoustic monitoring **Performing Organizations**: NOAA-NMFS Southeast Fisheries Science Center **Timeline**: 2019–2027 **Total Funding**: $1.035M **FY25 Funding:** $253K	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Establish the baseline vocalization behavior of marine mammals where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to Navy training and testing activities	**Data collection and analysis ongoing** • Technical progress reports available – 2019–2023 • Analysis ongoing • Additional data collection 2025–2026 • Multiple peer-reviewed publications in preparation
Title: Baseline Monitoring for Marine Mammals in the East Coast Range Complexes – Passive Acoustics **Location**: VACAPES, Cherry Point, and Jacksonville Range Complexes **Objectives**: Assess occurrence, habitat associations, density, and vocal activity of marine mammals in key areas of Navy range complexes **Methods**: Passive acoustic monitoring **Performing Organizations**: Duke University, Scripps Institute of Oceanography, NOAA-NMFS NEFSC **Timeline**: 2007–2022 **Total Funding**: $5M+ **FY25 Funding:** $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	**HARP baseline 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 data synthesis and technical report series to be completed in 2026

[4] Co-funded by Naval Sea Systems Command and Naval Air Systems Command

Project Description	Intermediate Scientific Objectives	Status
Title: Acoustic Ecology of Northwest Atlantic Shelf Break Cetaceans and Effects of Anthropogenic Noise Impacts **Location**: Northwest Atlantic **Objectives**: Assess seasonal and spatial occurrence, acoustic niches, and anthropogenic drivers of distribution throughout the northwest Atlantic shelf break region **Methods**: Passive acoustic monitoring **Performing Organizations**: NOAA-NMFS Northeast Fisheries Science Center **Timeline**: 2019–ongoing **Total Funding**: $1.25M **FY25 Funding:** $145K	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Establish the baseline vocalization behavior of marine mammals where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to Navy training and testing activities	**Analysis ongoing** • 2025 focus on multi-species beaked whale analyses and assessing minke whale presence • Technical progress reports available – 2019–2025 • Multiple peer-reviewed publications available
Title: Atlantic Marine Assessment Program for Protected Species **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:** 2010–2025 **Funding:** 2010-2023 – $250K annually **FY24–25 Funding:** $575K	• 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 Winter 2025 broad-scale aerial/vessel marine species distribution and abundance survey across mid-Atlantic co-funded with NOAA-NEFSC [5]
Title: Jacksonville Shallow Water Training Range **Location**: Jacksonville Shallow Water Training Range **Objectives**: Monitor species composition and distribution on JSWTR, conduct M3R species detection visual verifications **Methods**: Passive acoustics (M3R), visual surveys, satellite-linked tags, biopsy sampling, photo-ID **Performing Organizations**: Duke University, HDR, Inc., NUWC Newport **Timeline**: 2020–2025 **Total Funding**: $1.6M **FY25 Funding:** $165K	• 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 ended** • Transitioned from small vessel baseline surveys (2009–2018) • Field work resumed in 2020 with passive acoustics component leveraging M3R system • Visual species verifications, supplemental photo-ID, and tagging ended in 2025 • NARW classifier in development

[5] NOAA-NEFSC contributed survey vessel and aerial platform valued at approximately $1.1M

Project Description	Intermediate Scientific Objectives	Status
Title: Distribution of Gulf Sturgeon in the Panama City Testing Range [6] **Location**: NSWC Panama City Testing Range **Objectives**: Assess Gulf sturgeon distribution and habitat use through a multi-phase biotelemetry **Methods**: Acoustic tagging, directed AUV surveys, and environmental monitoring **Performing Organizations**: University of Delaware, Delaware State University **Timeline**: 2021–2026 **Total Funding:** $478K **FY25 Funding:** $0	• 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 complete** • Final analysis in progress
Title: Atlantic and Shortnose Sturgeon Monitoring in the Lower Kennebec River [6] **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**: 2021–2026 **Total Funding:** $411K **FY25 Funding** – $92K	• 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 ongoing** • 2026 focus shift to spawning areas and improvements to population estimates

Notes: AMAPPS = Atlantic Marine Assessment Program for Protected Species; AUV =autonomous underwater vehicle; BRS = behavioral response study; CAS = continuously active sonar; CEE = controlled exposure experiment; DTAG = Digital Acoustic Recording Tag; ESA = Endangered Species Act; FY = Fiscal Year; HARP = High-frequency Acoustic Recording Package; JSTWR = Jacksonville Shallow Water Training Range; K = thousand; M = million; M3R = Marine Mammal Monitoring on Navy Ranges; MFAS = mid-frequency active sonar; NARW = North Atlantic right whale; NAVFAC = Naval Facilities Engineering Systems Command; NCEI = National Centers for Environmental Information; 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; SEFSC = Southeast Fisheries Science Center; UAS = unmanned aircraft system; U.S. = United States; VACAPES = Virginia Capes

[6] Funded by Naval Sea Systems Command

Appendix B.
2025 Publications and Presentations Resulting from Atlantic Fleet Training and Testing-Related Monitoring Investments

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Appendix B: 2025 Publications and Presentations Resulting from Atlantic Fleet Training and Testing-Related Monitoring Investments

Publications

Barlow, J., R.W. Baird, J. Badger, G.S. Schorr, E.A. Falcone, S.N. Coates, P.L. Tyack, A.J. Read, L.S. Hickmott, J.W. Durban, D. Claridge, N. Aguilar de Soto, D. Miranda Gonzalez, F. Visser, M.G. Oudejans, S. DeRuiter, D.A. Sweeney, B.K. Rone, and S.L. Watwood. 2025. A comparison of diving behavior of goose-beaked and dense-beaked whales from tagging studies in multiple ocean basins. *Marine Mammal Science* 42(1):e70070.

Blondin, H., L.P. Garrison, J.D. Adams, J.J, Roberts, C.P. Good, M.P. Gahm, N.E. Lisi, and E.M. Patterson. 2025. Vessel strike encounter risk model informs mortality risk for endangered North Atlantic right whales along the United States east coast. *Scientific Reports* 15:736.

DeAngelis, A.I., A. Westell, S. Baumann-Pickering, J. Bell, D. Cholewiak, P.J. Corkeron, M.S. Soldevilla, A. Solsona-Berga, J.S. Trickey, and S.M. Van Parijs. 2025. Habitat utilization by beaked whales in the western North Atlantic Ocean using passive acoustics. *Marine Ecology Progress Series* 754:137–153.

Guins, M.G., D.R. Rees, and R.E. Sherwin. 2025. First documented harbor seal (*Phoca vitulina*) pupping event in Virginia. *Aquatic Mammals* 51(4):336–342.

Haver, S., P. Corkeron, A. DeAngelis, S. Baumann-Pickering, D. Cholewiak, G. Davis, K. Frasier, N. Posdaljian, M. Kadifa, A. Solsona-Berga, A. Westell, and S.M. Van Parijs. 2025. Exploring the biodiversity of cetacean communities along the western North Atlantic Ocean shelf-break. *Royal Society Open Science* 12(7):241658.

Southall, B.L., R.S. Schick, W.R. Cioffi, S.L. DeRuiter, H.J. Foley, C.M. Harris, A.E. Harshbarger, J.E. Joseph, T. Margolina, D.P. Nowacek, N.J. Quick, Z.T. Swaim, L. Thomas, D.M. Waples, D.L. Webster, J.H. Wisse, and A.J. Read. 2025. Behavioral responses of goose-beaked whales (*Ziphius cavirostris*) to simulated military sonar. ECOSPHERE 17(1):e70501.

Presentations

Briner, R., S.M. Van Parijs, M. Baumgartner, J. Bell, A. Engelhaupt, R. Finley, P. Hanson, H.A. Koilpillai, X. Mouy, M.L. Rekdahl, H.C. Rosenbaum, L.M. Transue, J. Wilder, and G.D. Davis. 2025. North Atlantic right whale acoustic presence in the Mid-Atlantic Bight. Presentation, North Atlantic Right Whale Consortium Meeting, New Bedford, Massachusetts, October 2025.

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

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

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