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MARINE SPECIES MONITORING PROGRAM

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

  

Photo credits from left to right:

A satellite tag is deployed on a Kemp's ridley (L*epidochelys kempii*) sea turtle as part of the Kemp's ridley and green turtle availability bias study supported by the U.S. Navy. Photographed by Andie Fisher (project partner Inwater Research Group), taken under Florida State Marine Turtle Permit 24-125.

North Atlantic right whale (*Eubalaena glacialis*) 2024 calf of #3270/Pico surfacing near the shelf break off Virginia Beach, Virginia. Photographed by Jessica Aschettino (HDR Inc.), taken under National Marine Fisheries Service Scientific Research Permit No. 21482.

Toothless adult male goose-beaked whale (*Ziphius cavirostris*) surfacing off Cape Hatteras, North Carolina. Photographed by Will Cioffi (Duke University), taken under General Authorization Letter of Confirmation 25471 held by Duke University.

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

°C	degrees Celsius
°N	degrees North
°W	degrees West
ABBYPT	Abby Point
ACNWR	Archie Carr National Wildlife Refuge
AFTT	Atlantic Fleet Training and Testing
AMAPPS	Atlantic Marine Assessment Program for Protected Species
AMR	Adaptive Management Review
AUTEC	Atlantic Undersea Test and Evaluation Center
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
cm	centimeter(s)
Cm	*Chelonia mydas*
CMARI	Clearwater Marine Aquarium Research Institute
CRTHPT	Courthouse Point
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
FL	fork length
FM	frequency-modulated
GA	Georgia
GAM	Generalized Additive Model
GMT	Greenwich Mean Time
GOM	Gulf of Mexico
GPS	Global Positioning System
GS	Gulf Stream
HARP	High-frequency Acoustic Recording Package
HAT	Hatteras
HDR	HDR Inc.
Hz	hertz
HZ	Heezen Canyon
ID	identifier or identification number
IRG	Inwater Research Group
IRL	Indian River Lagoon
JAX	Jacksonville
JSWTR	Jacksonville Shallow Water Training Range
kHz	kilohertz
km	kilometer(s)
lat	latitude
LF	low frequency
LFDCS	Low-frequency Detection and Classification System
Lk	*Lepidochelys kempii*
LMR	Living Marine Resources
lon	longitude
M3R	Marine Mammal Monitoring on Navy Ranges
m	meter(s)
MAHWC	Mid-Atlantic Humpback Whale Photo-ID Catalog
MATOS	Mid-Atlantic Acoustic Telemetry Observation System
Max	Maximum
Mb	*Mesoplodon bidens*
MD	Maryland
Md	*Mesoplodon densirostris*
Me	*Mesoplodon europaeus*
ME DMR	Maine Department of Marine Resources

MFAS	mid-frequency active sonar
MILL	Mill Cove
min	minute(s)
MINEX	Mine-neutralization Exercise
Mm	*Mesoplodon mirus*
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
NBATH	Northern Bath Iron Works
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 miles
NMFS	National Marine Fisheries Services
No.	Number
NOAA	National Oceanic and Atmospheric Administration
NSWC	U.S. Naval Surface Warfare Center
NUWC	Naval Undersea Warfare Center
NUWCDIVNPT	Naval Undersea Warfare Center Division Newport
NY	New York
OBIS-SEAMAP	Ocean Biogeographic Information System-Spatial Ecological Analysis of Megavertebrate Populations
OC	Oceanographer Canyon
OCS	Outer Continental Shelf
ONR	Office of Naval Research
OPAREA	operating area
PAM	passive acoustic monitoring
PAS	pulsed active sonar
PHIPPW	Phippsburg West
photo-ID	photo-identification
PMRF	Pacific Missile Range Facility
PTT	Platform Transmitter Terminal
RL	received level
RMS	root mean square
R/V	research vessel
s	second(s)
SAS	Sasanoa
SBU	Stony Brook University
SCL	straight carapace length
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
UCF	University of Central Florida
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
VV	visually verified
WC	Wilmington Canyon
Zc	*Ziphius cavirostris*

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1 Introduction

This report contains a summary of Marine Species Monitoring (MSM) investments funded by the United States (U.S.) Navy in 2024 within the Atlantic Fleet Training and Testing (AFTT) study area as described in the AFTT Final Environmental Impact Statement/Overseas Environmental Impact Statement Phase III (DoN 2018). The U.S. Navy supports monitoring for a variety of protected marine species in compliance with the Final Rule and Letters of Authorization (NMFS 2019) and Biological Opinion (NMFS 2018) issued under the Marine Mammal Protection Act of 1972 (MMPA) and the Endangered Species Act of 1973 (ESA) for training and testing activities within the AFTT study area.

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

- Detailed technical reports for individual projects are provided as supporting technical documents to this report (Aschettino et al. 2025a, 2025b; DiMatteo and Mansfield 2025; Engelhaupt et al. 2025; Guins and Rees 2025; Jones 2024; Kristan et al. 2025; Ozog and Engelhaupt 2025; Southall et al. 2025; Van Parijs et al. 2025; Waples and Read 2025) 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 2024–2025 is provided in **Appendix A**.
- Publications and conference presentations for 2024 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 pierside 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

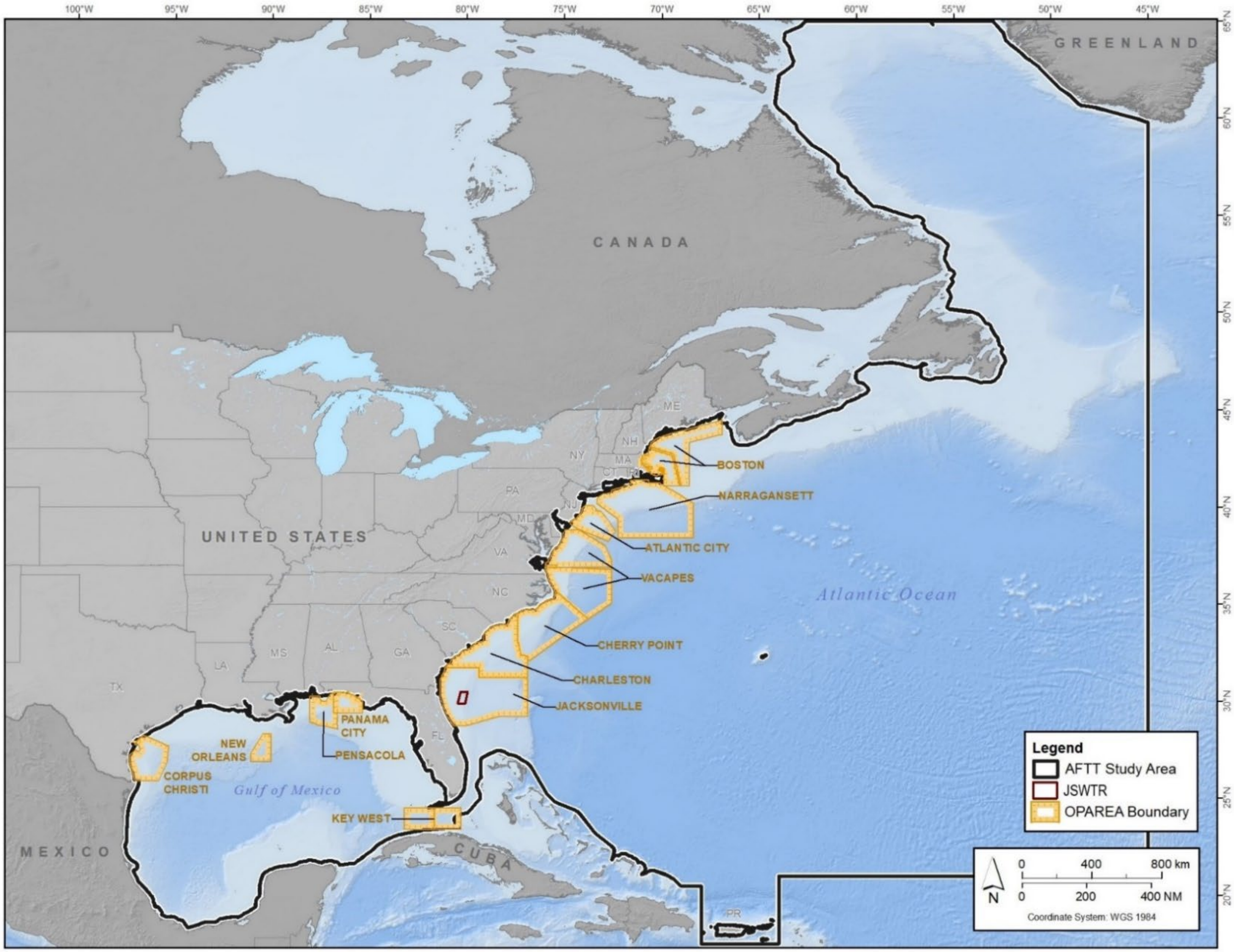


Figure 1. Atlantic Fleet Training and Testing study area.

In order to authorize the incidental taking of marine mammals under the MMPA, the National Marine Fisheries Services (NMFS) must set forth "requirements pertaining to the monitoring and reporting of such taking" (50 Code of Federal Regulations § 216.101(a)(5)(a)). A request for a Letter of Authorization must include a plan to meet the necessary monitoring and reporting requirements, while increasing the understanding, and minimizing the disturbance, of marine mammal and sea turtle populations expected to be present. While the ESA does not have a specific monitoring requirement, the Biological Opinion issued by NMFS for the AFTT study area includes terms and conditions for continued monitoring within this region.

The U.S. Navy has invested nearly $60 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 2009–2024.

Fiscal Year (01 October–30 September)	Funding
2009–2013	$15,330,000
2014–2018	$17,715,000
2019	$4,187,000
2020	$4,022,000
2021	$4,240,000
2022	$4,175,000
2023	$4,690,000
2024	$4,180,000
Total	**$58,359,000**

In addition to the compliance monitoring program for training and testing activities, the Office of Naval Research (ONR) Marine Mammals and Biology Program supports basic and applied research and technology development related to understanding the effects of sound on marine mammals, including physiological, behavioral, ecological, and population-level effects, and the Office of the Chief of Naval Operations Environmental Readiness Program's Living Marine Resources (LMR) Program invests in projects supporting risk threshold criteria and impact assessment, analysis tools, and monitoring technology demonstrations. These programs each currently fund significant portfolios of ongoing projects relative to potential operational impacts on marine species with the primary goal of supporting U.S. Navy environmental planning and compliance 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 Navy's Marine Species Monitoring Program is to assess the effects of 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.
- The penitential 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 towards 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 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 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, and to solicit valuable input from meeting participants including NMFS, 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 5-10 years across a range from basic research through applied monitoring. The summit meeting also facilitated increased coordination and synergy across the Navy's protected marine species investment programs (LMR and ONR Marine Mammals & Biology). 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 2024 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 2024, 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 2025 and beyond, improve understanding of the occurrence and distribution of protected marine species within the AFTT study area, improve understanding of their exposure and response to sonar and explosives training and testing activities, and ultimately inform us on the consequences of that exposure.

Appendix A summarizes U.S. Navy MSM investments within the Atlantic for 2024 and projects continuing in 2025. 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**, and **2.3**), 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 (**Section 2.10**).

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 Baseline Occurrence – 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 in 2012, and Norfolk Canyon (NFC) in 2014. Deployments ended at the Onslow Bay site in 2013, JAX in 2019, Cape Hatteras in 2020, and NFC in 2022. The primary objective of deployments at all locations was to determine species distributions and document spatiotemporal patterns of cetaceans throughout areas of interest. Links to available 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 collaborative analysis of North Atlantic shelf break species (see **Section 2.2**) and has resulted in multiple peer-reviewed publications. A synthesis of the entire HARP data collection program is currently underway and individual reports for each location will be available in 2025. For more information on the HARP program, refer to the primary literature publications using data from previous HARP deployments (Stanistreet et al. 2016; Davis et al. 2017, 2020; Hodge et al. 2018; DeAngelis et al. 2025).

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 2019. Together these combined efforts bring the total to 11 recording sites spanning the U.S. eastern seaboard, from New England to Florida.

Data from earlier HARP recorders have been analyzed in multiple previous studies (e.g., Davis et al. 2017; Stanistreet et al. 2017, 2018). This project focuses on analyses of the datasets collected from 2015-2019. The focus of our efforts in 2024 have been to finalize projects for submission to peer-reviewed journals and continue analyses of beaked whale and baleen whale species.

Work conducted in 2024 was aimed at finalizing components for these key objectives:

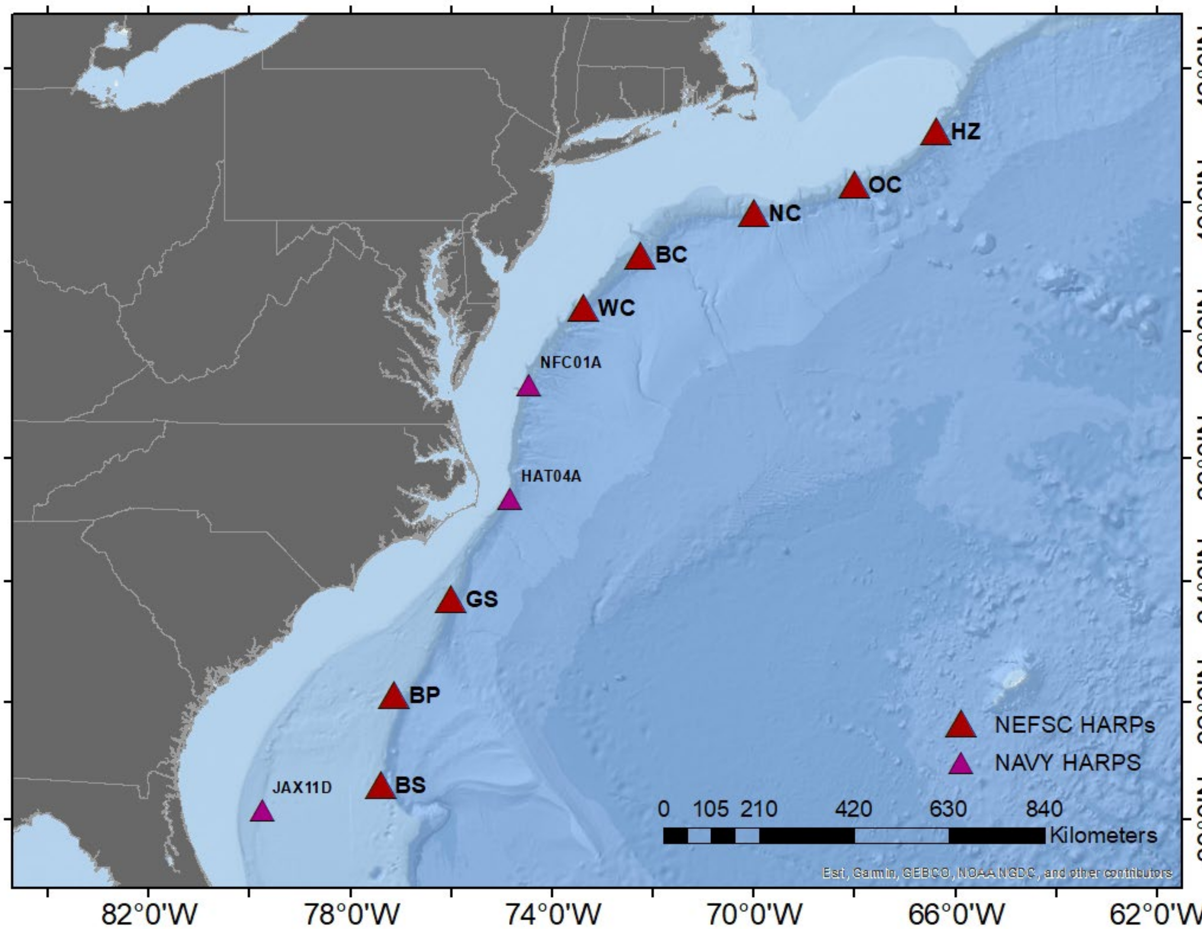
- Analyze beaked whale presence across HARP sites, with a focus on northern bottlenose whale (*Hyperoodon ampullatus*) and BWG presence.
- Assessing effects of anthropogenic noise on beaked whale vocal activity
- Analyze minke whale (*Balaenoptera acutorostrata*) presence on the Navy HARP sites
- Revising a manuscript comparing and contrasting two PAM methodologies—towed array and shelf break HARPs—concerning beaked whale temporal, spatial presence and diving behavior.
- Submit a manuscript that utilizes passive acoustic data from ten shelf-break environments to evaluate composition and dissimilarity of marine mammal community groups at different latitudes.
- Submit a manuscript describing the methodology of the beaked whale neural net classifier to be cited in future publications utilizing this approach
- Submit a manuscript comparing and contrasting two PAM methodologies—towed array and shelf break HARPs—concerning beaked whale temporal, spatial presence, and diving behavior
- Utilize passive acoustic data from 10 shelf-break environments to evaluate composition and dissimilarity of marine mammal community groups at different latitudes

Continuous passive acoustic recordings have been collected at 11 sites by the NEFSC and U.S. Navy along the Atlantic continental shelf break of the U.S. beginning as early as 2015. The sites deployed starting in 2015 include Heezen Canyon, Oceanographer Canyon, Nantucket Canyon (three northernmost sites), NFC, Cape Hatteras, and JAX (U.S. Navy deployments). These were expanded in 2016 to include Wilmington and Babylon Canyons north of Cape Hatteras as well as Gulf Stream, Blake Plateau, and Blake Spur south of Cape Hatteras (**Table 2, Figure 2**). Each HARP was programmed to record continuously at a sampling rate of 200 kilohertz (kHz) with 16-bit quantization, providing an effective recording bandwidth from 0.01 to 100 kHz. Further details of HARP design are described in Wiggins and Hildebrand (2007).

Table 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	May 2019	950–1,050
Hatteras (HAT)	April 2015	May 2019	980–1,350
Gulf Stream (GS)	April 2016	June 2019	930–953
Blake Plateau (BP)	April 2016	May 2019	940–945
Blake Spur (BS)	April 2016	June 2019	1,000–1,005
Jacksonville (JAX)	April 2015	June 2019	736–750

Key: m = meter(s)



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

Figure 2. HARP deployment sites for data analyzed from 2015 through 2019.

2.2.1 Analyses

I. Analyze beaked whale presence across HARP sites, with a focus on northern bottlenose whale and BWG presence.

Using the beaked whale neural net output developed in the earlier phase of this project (Solsona-Berga et al. 2024), data from the HARP deployed at Blake Spur were analyzed from April 2016 - June 2019 for clicks matching the spectral properties of BWG. This click type has not been attributed to a species yet, but contains a frequency modulated upsweep that is diagnostic of echolocation clicks emitted by beaked whales (Baumann-Pickering et al. 2013). All click detection output from the neural net was reviewed in Matlab 2016b (MathWorks Inc., Natick, MA) using the detEdit software (Solsona-Berga et al. 2020). detEdit groups nearby detections into "sessions," in which the duration of the session is dependent upon the number of clicks present and their temporal spread.

Out of 6, 255 sessions reviewed across 1143 days, four sessions contained clicks, which were spread across three days, that matched the characteristics of BWG. These three days were all in 2017: January 7, May 22, and November 18.

The data collected at the Heezen Canyon site from April 2016 to May 2019 was analyzed using the beaked whale detector (BWD). The resulting output was reviewed by a trained analyst for northern bottlenose clicks. Out of the three-year period, no northern bottlenose whales were definitively detected, and two encounters were labeled as "possible." These were also shared with Department of Fisheries and Oceans Canada, who also agreed with the "possible" category based on the paucity of clicks received. As such, the data collected at sites further south were not analyzed as it is believed that their southern extent is north of Heezen Canyon, or in deeper water.

II. Assessing effects of anthropogenic noise on beaked whale vocal activity.

This objective investigated the impact of mid-frequency active (MFA) sonar on the acoustic behavior of beaked whales in the Western North Atlantic, focusing on three U.S. Navy sites with varying levels of sonar activity. Acoustic data was analyzed from several beaked whale species, accounting for natural variations in their vocalizations due to factors like seasonality, habitat, and individual behavior. Acoustic detections were integrated by combining the data into 1-minute (min) segments as detection units instead of individual detections of beaked whales and MFA sonar (**Table 3**). A deep neural network was employed to detect and classify beaked whale calls, and a modified sonar detection system was used to identify MFA sonar pings. Data were aggregated into 1-min segments to analyze the presence or absence of both whale vocalizations and sonar. The analysis primarily focused on data from the NFC and Hatteras (HAT) sites due to low beaked whale presence at the JAX site.

Table 3. Summary of beaked whales and MFAS detections at three U.S. Navy sites.

		NFC	HAT	JAX
		2014–2020	**2015–2020**	**2016–2020**
Beaked whales				
Effort 1-min bins (total in days)		1,702	1,812	1,130
Bins with presence	Zc	0.22%	12.77%	0.003%
	Me	0.13%	0.44%	0.004%
	Mb	0.12%	0.003%	0.0004%
	Md	0.0007%	0.005%	0.001%
	Mm	0.075%	0.02%	0.0%
MFAS				
Effort 1-min bins (total in days)		1,333	1,793	1,128
Bins with presence		0.65%	0.21%	1.68%

Notes: Me = *Mesoplodon europaeus*; Mb = *Mesoplodon bidens*; Md = *Mesoplodon densirostris*; Mm = *Mesoplodon mirus*; Zc = *Ziphius cavirostris* (*Ziphius*)

Generalized Estimating Equations were used to model the acoustic presence of beaked whales at each site for Sowerby's (*Mesoplodon bidens*), Gervais' (*M. europaeus*), and goose-beaked whales (*Ziphius cavirostris*), accounting for the correlated nature of the acoustic detections. Several predictor variables were considered, including short-term sonar exposure metrics (presence/absence, maximum received level (RL), cumulative sound exposure level, and proportion of sonar per min), a long-term sonar lag variable representing the time since last sonar use, and temporal variables (year, Julian day, and time of day). Model selection was performed using a backward stepwise procedure to identify the most significant predictors. Due to data limitations, modeling efforts were concentrated on Sowerby's, Gervais', and goose-beaked whales at NFC and Gervais' and goose-beaked whales at HAT.

The models revealed distinct temporal patterns in beaked whale presence, with significant variations across years and seasons for all species at both sites. At NFC, all three species showed increased presence during prolonged periods without MFA sonar activity. At HAT, similar patterns were observed, with both Gervais' and goose-beaked whales showing increased presence with longer sonar lags. Goose-beaked whales at HAT, which had the highest overlap with sonar activity, exhibited a decrease in presence with increasing maximum sonar levels. The findings suggest that MFA sonar activity may influence beaked whale acoustic behavior.

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

Analysis of daily presence of minke whales at the Cape Hatteras HARP site continued 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.

Data were reviewed from 1 June 2018 – 29 October 2020, spanning a total of 853 days. Of that time, 2.3 percent (20 days) of days contained a positive minke whale pulse train detection. Minke whales were more commonly detected during the winter months of January to March across the two years, with more days of detection in 2019 (*n* = 15 days) than in 2020 (*n* = 5 days; **Figure 3**). These results will be incorporated into the HAT site comprehensive report currently in preparation.

For more information regarding this study, refer to the annual progress report for this project (Van Parijs et al. 2025).

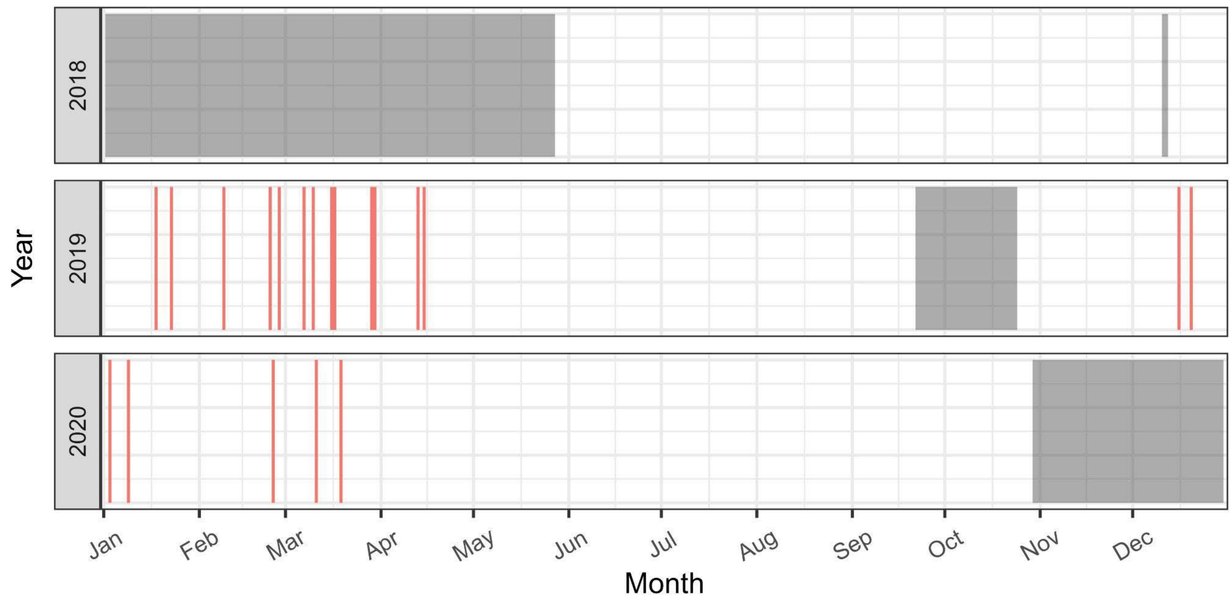


Figure 3. Daily acoustic presence of minke whales from 1 June 2018 – 29 October 2020 at the HAT HARP site. Red lines show days that minke whale calls were present. Gray shading indicates dates with no data.

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

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

To improve management of human-based activities in the core habitat of these endangered whales, the Southeast Fisheries Science Center (SEFSC) began deploying a sparse array of 17 PAM units concurrent with one long-term 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 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, they have been continuously recording ambient noise and other acoustic events in the 10-hertz to 100-kHz frequency range since 2010 to monitor the impacts of the Deepwater Horizon oil spill and subsequent restoration activities on cetaceans. Together with the sparse array of SoundTraps, these PAM deployments provide the necessary data to understand seasonal distribution and density of Rice's whales.

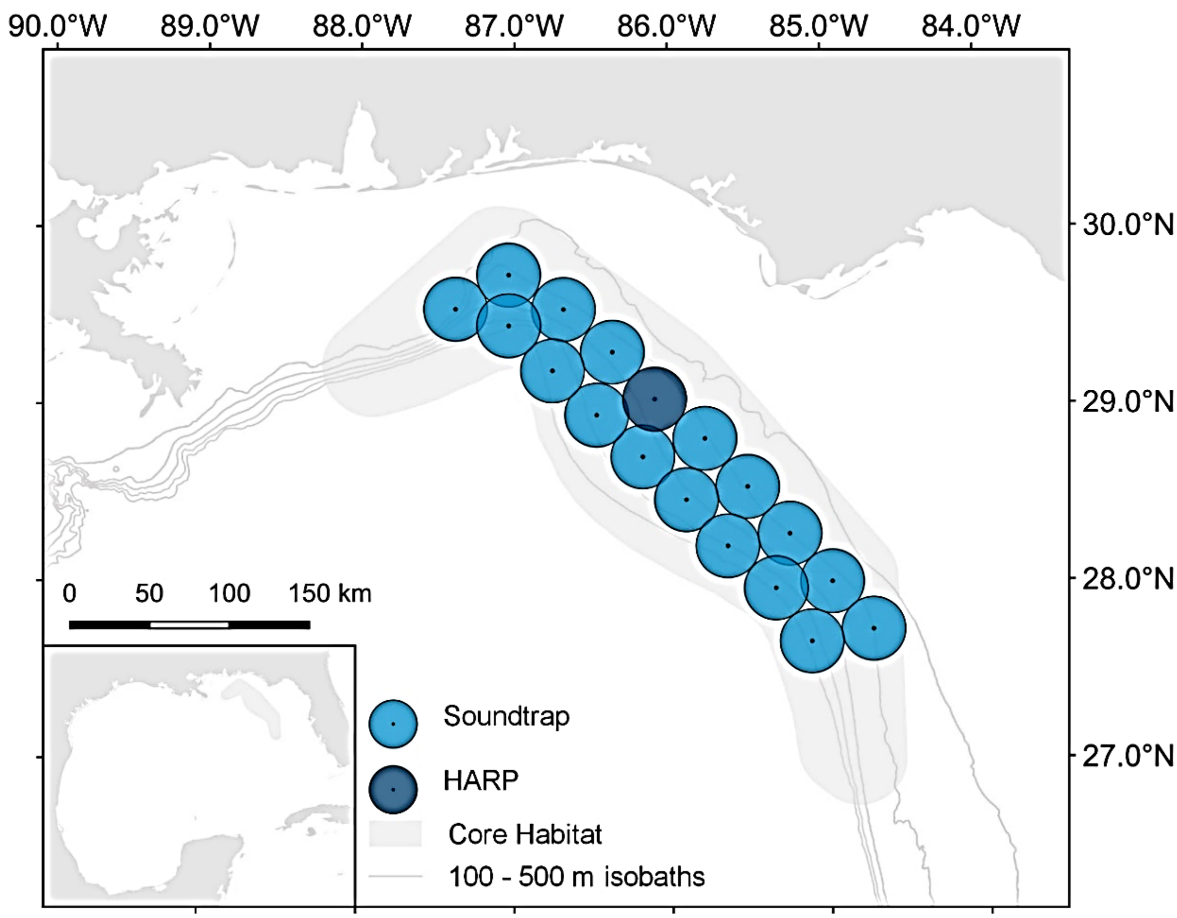


Figure 4. Historic long-term PAM station in the Rice's whale core habitat since 2010 (HARP) and 2021 to 2023 PAM stations (SoundTraps). The NMFS core habitat of Rice's whales is indicated.

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 2022-23. An additional year of data collection is planned to begin in April 2025 under funding from the U.S. Navy MSM Program and will be incorporated into analyses when available. 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.

2.4 Mid-Atlantic Cetaceans

2.4.1 Passive Acoustics

2.4.1.1 Autonomous Real-Time Detection Buoy

An autonomous real-time reporting passive acoustic detection buoy (**Figure 5**) was deployed by Woods Hole Oceanographic Institute off the coast of Cape Charles, Virginia, July 2024, replacing the buoy deployed in October 2023 at the same location. The buoy has the ability to detect and classify whale vocalizations using a digital acoustic monitoring instrument (DMON) and sophisticated analysis software to listen for whales as well as send notifications and data to researchers in near-real time.

Figure 5. DMON buoy 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 humpback (*Megaptera novaeangliae*), fin (*Balaenoptera physalus*), sei (*B. borealis*), and North Atlantic right whales (NARWs; *Eubalaena glacialis*). Detection data are transmitted in near real time to shore where they are reviewed daily by trained analysts, and the results posted on the project website, distributed to interested parties by automated email messages, made available on WhaleMap, and integrated into NOAA's Passive Acoustic Cetacean Mapper.

This buoy was strategically placed to complement sound trap deployments (**Section 2.4.1.2**) as well as another real-time detection buoy deployed off southern Virginia by another organization, and to facilitate the HDR Inc. field team efforts in the area. This location also falls within the jurisdiction of the New England/Mid-Atlantic branch of NOAA Fisheries; therefore, 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 less 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 less while transiting through these areas. Active Slow Zones can be found on NOAA's website as well as WhaleMap.

Of the four baleen whale species monitored, humpback and fin whales were the most commonly detected (**Figure 6**). NARWs were also relatively commonly detected from December through February. From December 2024 to March 2025, the Cape Charles buoy had 22 confirmed detections of NARWs, which led to a slow zone in the area surrounding the buoy for a 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." Up to date daily detections are available at the project's page on Robots4Whales.

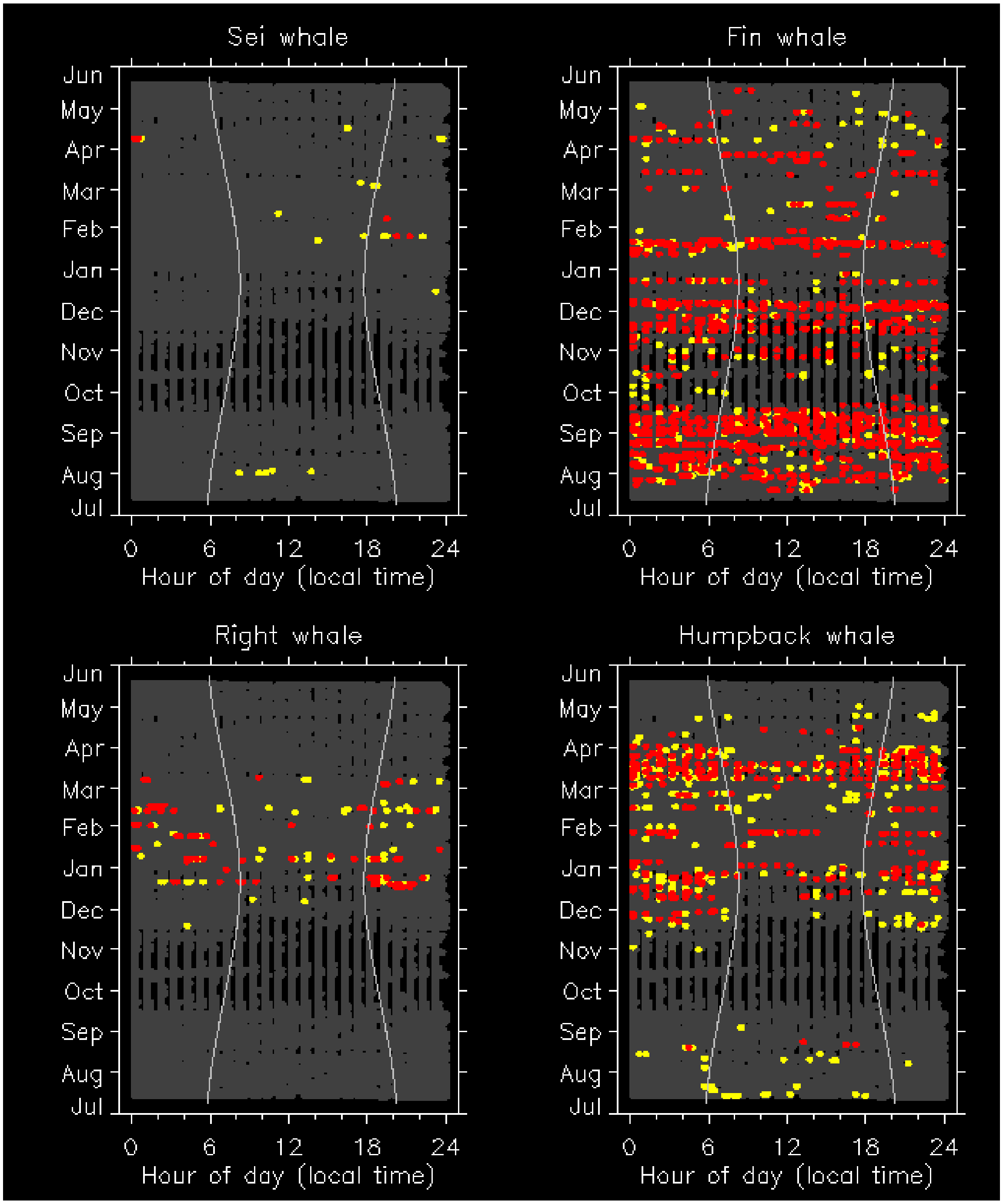


Figure 6. **Diel plot showing detections (yellow = possible, red = confirmed) of baleen whales from the DMON buoy deployed off the coast of Cape Charles, Virginia, from July 2024 through June 2025.**

2.4.1.2 Archival SoundTrap Deployments

Three arrays of SoundTraps previously deployed to monitor for the presence of NARWs within the western Mid-Atlantic in collaboration with NOAA NEFSC were serviced in 2024, maintaining continuous coverage since July 2022 (**Figure 7**). The units off the coast of Delaware and southeastern Virginia were serviced in May and November, and the eastern shore units in April and September. 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 (PACM). Analysis is nearing completion, and most SoundTraps deployed from June 2022 to April 2024 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 amount of detections for the call types specified, that species was logged as "detected". Only the first deployment off Virginia (three sites: CB01, CB02, and CB03) have been analyzed for humpback whales so far. **Figure 8** 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.

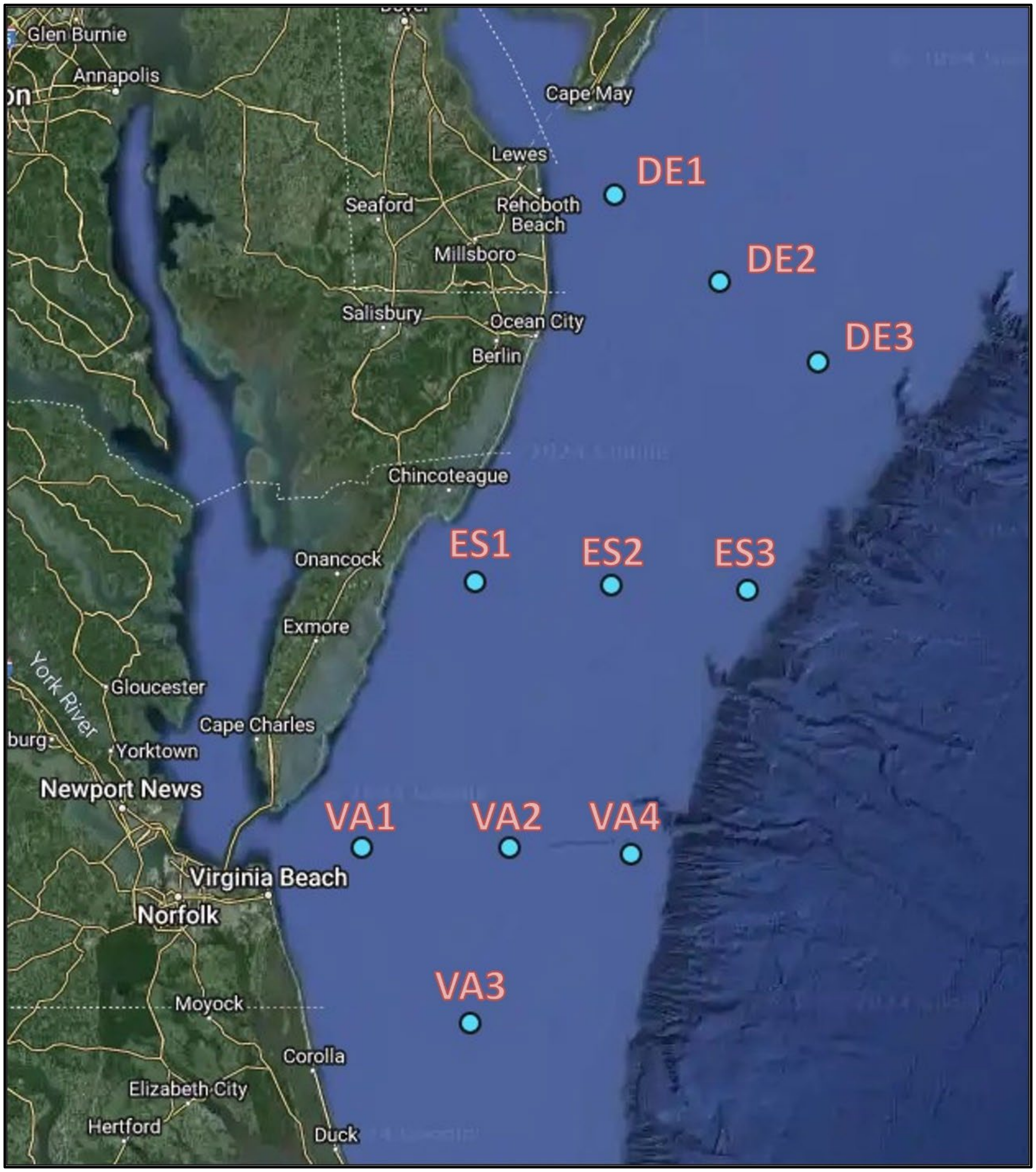


Figure 7. Locations of SoundTrap deployment locations serviced during 2024.

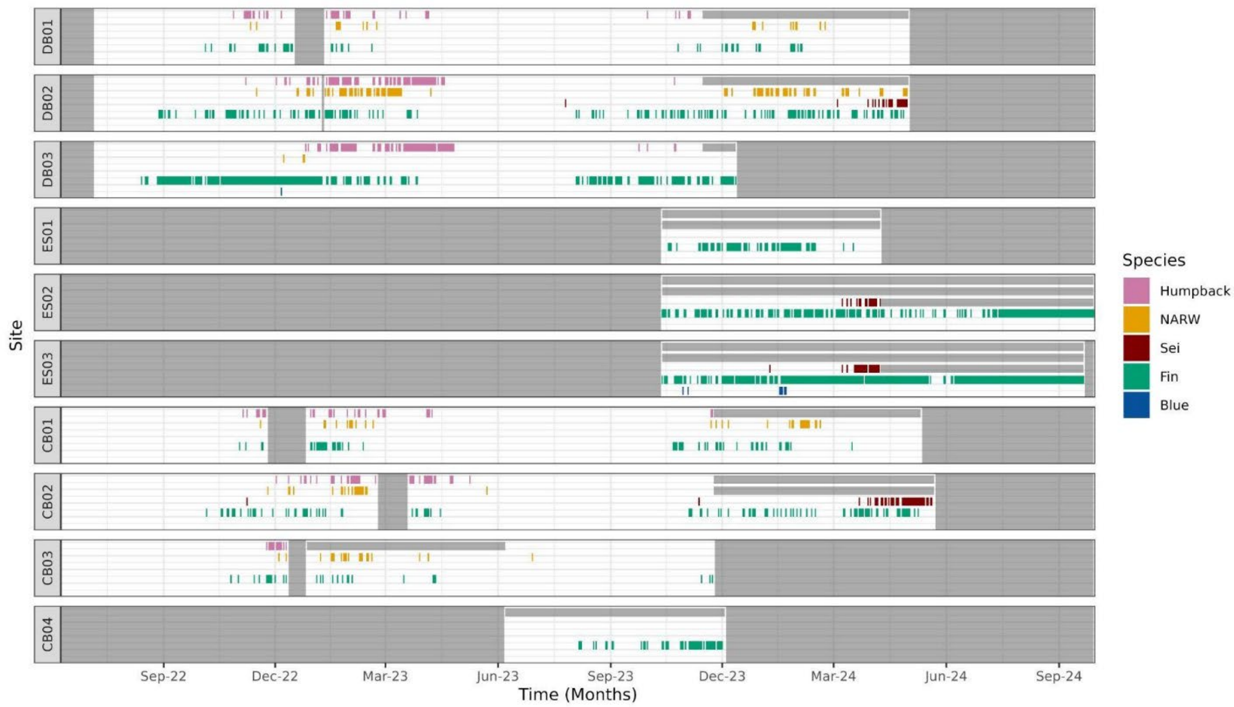


Figure 8. Daily confirmed detections of baleen whales from SoundTraps deployed from June 2022 to September 2024.

2.4.2 Mid-Atlantic Marine Mammal Aerial Survey Effort

Dedicated, systematic marine mammal aerial surveys have previously been conducted throughout VACAPES. The Virginia Aquarium & Marine Science Center Foundation, Inc. and the University of North Carolina Wilmington (UNCW) conducted aerial line-transect surveys within the VACAPES 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 in VACAPES since these surveys ended in August 2019.

Both the Mid-Shelf Baleen Whale Monitoring Project (**Section 2.4.3**) and Offshore Cetacean Study (**Section 2.4.4**) aim to provide baseline 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]). To better assist the vessel with these efforts and in locating target species, non-systematic aerial surveys were implemented beginning in March 2021 (Aschettino et al. 2023a). Aerial survey effort increased beginning in the 2022/2023 season, with eight surveys flown (Aschettino et al. 2024a). While surveys were primarily associated with locating NARWs, some aerial surveys were also flown in tandem with Offshore Cetacean Study surveys. This section details the coverage and sightings from aerial surveys flown during the 2023/2024 field season in coordination with vessel surveys for both projects (Aschettino et al. 2025a, Engelhaupt et al. 2025).

2.4.2.1 Survey Effort/Summary

Thirteen aerial surveys were flown during the 2023/2024 field season, covering 10,875 kilometers (km) of trackline with more than 55 hours of survey effort (**Figure 9**). The first aerial survey occurred on 15 December 2023, and the last survey occurred on 26 May 2024.

2.4.2.2 Sightings

In total, 40 sightings of baleen whales occurred, including 8 NARW sightings composed of 13 individuals, 12 fin whale sightings composed of 17 individuals, 15 humpback whale sightings composed of 22 individuals, and 5 minke whale sightings composed of 5 individuals (**Figure 9**) (see **Section 2.4.5** and Aschettino et al. 2025b for additional details on baleen whale sightings and photo-ID and **Section 2.4.6** for additional details on NARWs). Of these sightings, two were recorded as multi-species and were both comprised of fin and humpback whales. On 30 March 2024, the carcass of adult female NARW #1950 was first documented (NOAA 2025a). Additionally, one individual sperm whale (*Physeter macrocephalus)* sighting and one *Kogia* spp. sighting composed of three individuals occurred during aerial surveys that extended out to deeper waters past the shelf break in association with offshore vessel surveys (**Figure 9**; Engelhaupt et al. 2025). Sightings of dolphins, including bottlenose (*Tursiops truncatus*), common (*Delphinus delphis*), striped (*Stenella coeruleoalba*), and Risso's (*Grampus griseus*), as well as pilot whales (*Globicephala* sp.), basking sharks (*Cetorhinus maximus*), and ocean sunfish (*Mola mola*), occurred during aerial surveys but were not always recorded, and therefore, are not reported on further.

2.4.2.3 Discussion

The addition of aerial surveys to complement vessel surveys for the Mid-Atlantic Baleen Whale Monitoring Project and Offshore Cetacean Study has proven extremely beneficial by (1) providing greater coverage of the study area; (2) locating and identifying individuals and aggregations of critically endangered NARWs using VACAPES; 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 and highlight the importance of the Mid-Atlantic as more than just a migratory corridor.

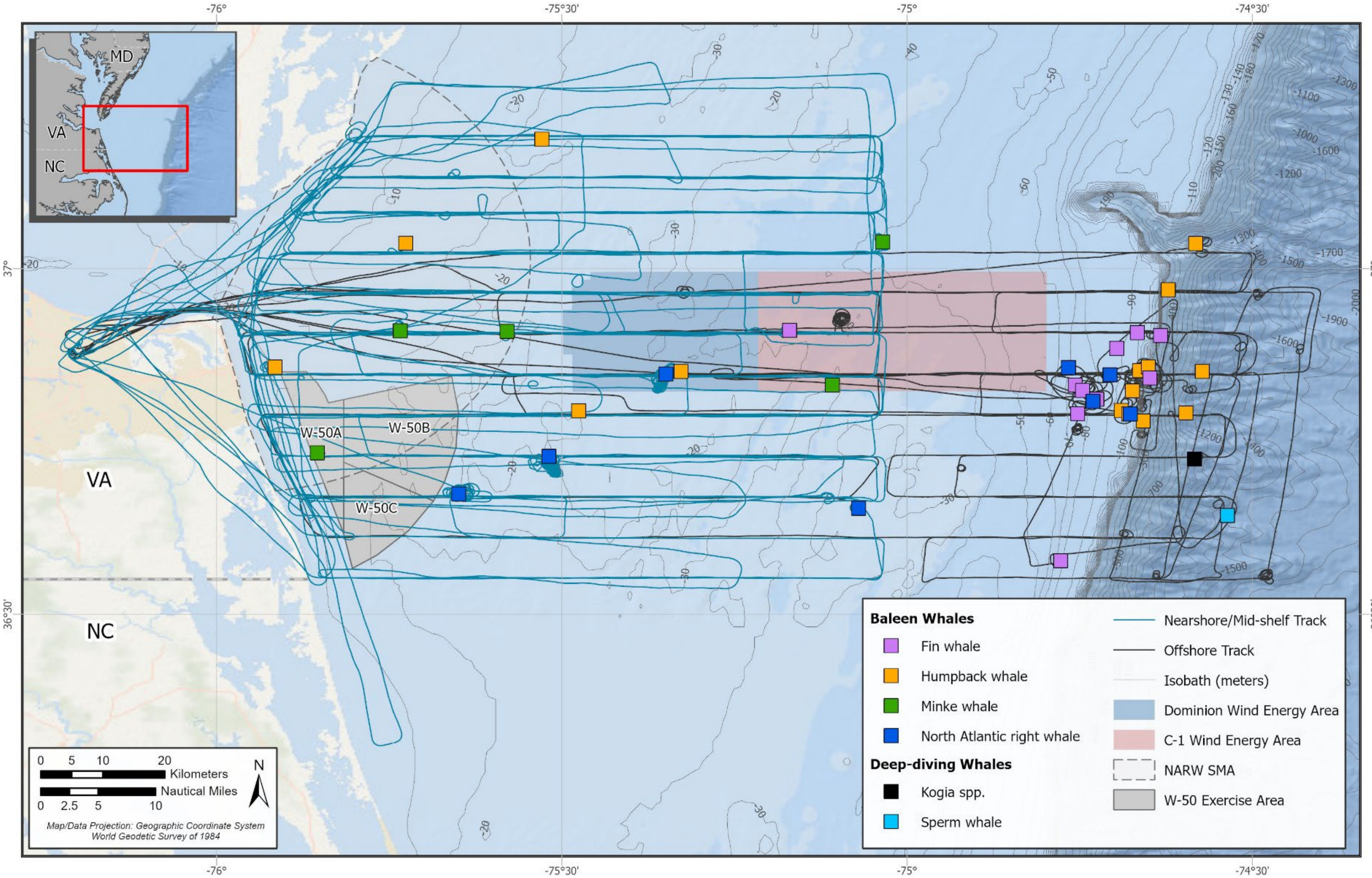


Figure 9. Aerial survey tracks (teal and gray), with locations of all North Atlantic right (n = 8), fin (n = 12), humpback (n = 15), minke (n = 5), *Kogia* spp. (n = 1), and sperm (n = 1) whale sightings for the 2023/2024 field season.

The waters off Virginia and the mouth of the Chesapeake Bay are used extensively for commercial shipping, both 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 the Chesapeake Bay to 37 km from shore. Within the SMA, a 10-knot vessel speed restriction is in place for vessels 65 feet (19.8 m) or longer; however, the majority of NARW sightings during the 2022/2023 season (Aschettino et al. 2024a) and all during the 2023/2024 season occurred outside the SMA, indicating that current conservation measures do not offer sufficient protection within the area (**Figure 9**).

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 2025b). The initial sighting of the carcass of adult female NARW #1950 by the HDR Inc. aerial team on 30 March 2024 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 in the vicinity of the carcass and has not been seen since February 2024 on the calving grounds (NOAA 2025a). 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 2025a). This finding, coupled with the fact that all NARW sightings over the past two field seasons occurred outside the SMA, further emphasize the vulnerability of NARWs to vessel strikes in the Mid-Atlantic.

Aerial surveys during the 2024/2025 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 2025).

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 using drones for length and body-condition assessments. These baseline data are critical for assessing the potential for disturbance to humpback whales within this part of the mid-Atlantic. Data on other baleen whale species have also been collected opportunistically, although relatively little information exists on how other species of baleen whales, including endangered fin whales and NARWs, use this region.

PAM results from autonomous gliders and Marine Autonomous Recording Units confirm that humpback, fin, sei, minke, and NARWs regularly use the continental shelf waters off the coasts of Virginia and North Carolina (Baumgartner 2019; Salisbury et al. 2018; Stanistreet et al. 2016). Acoustic detections are supported by visual sighting data collected by 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 coverage during the Mid-Atlantic Humpback Whale Project surveys has extended farther from the coastline in recent years (Aschettino et al. 2022b, 2023b, 2024a). 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 established through ongoing monitoring of humpback whales, the Mid-Atlantic Nearshore and Mid-Shelf Baleen Whale Monitoring Project expands the previous study area to encompass mid-shelf waters to approximately 75 km from shore, where the diversity of baleen whale species increases. The goals of this study are to assist the U.S. Navy and regulatory agencies by addressing the following questions:

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

The humpback whale field season off Virginia Beach runs from approximately the end of October/early November through March, typically concentrated between December and February, with smaller numbers of sightings occurring outside this time frame. Since this project's inception in 2015, 10 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 the addition of other baleen whale species, including fin whales and NARWs.

Since the field season spans calendar years from fall through spring, this report focuses on survey effort and observations made across late 2023 into early 2024.

2.4.3.1 Survey Effort/Summary

Twenty-three vessel surveys were conducted between 08 November 2023 and 30 March 2024. Fourteen of these surveys were considered nearshore, and nine were defined as mid-shelf. More than 172 hours of survey effort were completed, and 3,474 km of trackline were covered (**Figure 10**).

2.4.3.2 Sightings

In total, 43 baleen whale sightings occurred during vessel surveys during the 2023/2024 season, including 33 humpback whale sightings totaling 43 individuals, 6 NARW sightings totaling 9 individuals (1 deceased), 3 minke whale sightings totaling 3 individuals, and 1 fin whale sighting of a single individual (**Figure 10**). An unusual sighting of a pair of Risso's dolphins also occurred during these surveys (**Figure 10**).

2.4.3.3 Tagging and Biopsy Samples

One biopsy sample was collected from tagged minke whale HDRVABa015 during the 2023/2024 season and is awaiting analysis, along with samples collected during previous field seasons. Additional humpback and fin whale biopsy samples were collected in 2024 during the Offshore Cetacean Study (**Section 2.4.4**; Engelhaupt et al. 2025).

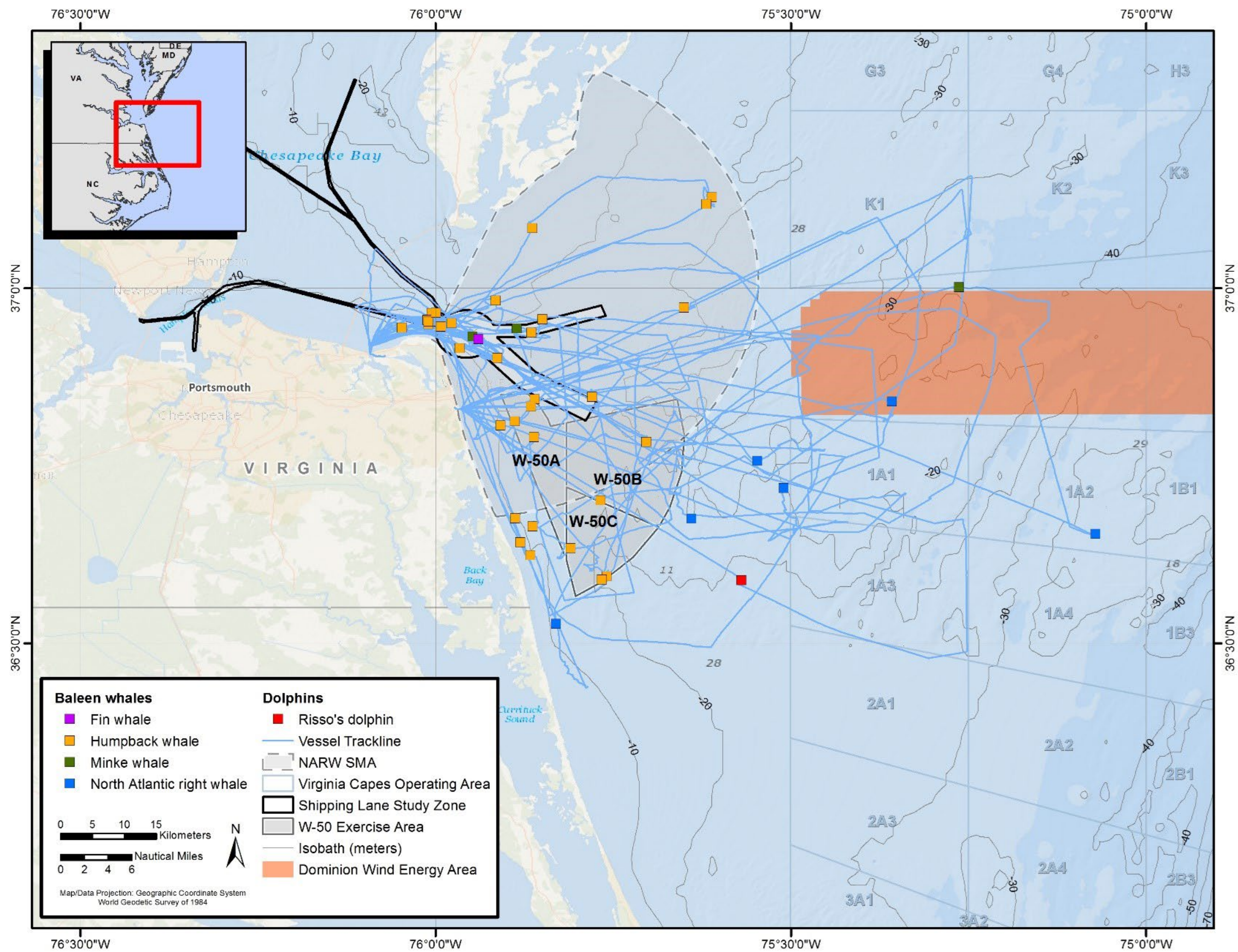


Figure 10. Vessel survey tracks (blue), with locations of all humpback (*n* = 33), fin (*n* = 1), North Atlantic right (*n* = 5), and minke (*n* = 2) whale sightings for the 2023/2024 field season, along with a sighting of Risso's dolphins (*n* = 1).

Thirty-one samples (29 humpback and 2 fin whales) from 2014 to 2016 were previously processed for stable-isotope analysis. A total of 63 humpback whale samples (including duplicates of the samples provided for stable isotope analysis [Waples 2017]) was provided to the University of Groningen in the Netherlands for genetic analysis and integration into a larger North Atlantic humpback whale population study. Eight fin whale samples were also provided. Gender results show roughly equal sex ratios of humpback whales (32 males and 31 females) and a skewed gender ratio of 6:1 (male to female) for fin whales (Bérubé and Palsbøll 2022). Genetic matching to the larger North Atlantic humpback whale catalog of more than 9,200 individuals showed that 18 samples matched to samples collected elsewhere along the eastern U.S., and no duplicate humpback whale samples exist in the HDR Inc. dataset. All samples matched 100 percent on all loci genotyped in both samples in each pair (i.e., no mismatching genotypes were detected). A single pair of duplicate samples was detected between two HDR Inc. fin whale samples; however, none of the HDR Inc. fin whale samples matched to the 1,789 samples contained in the North Atlantic fin whale genetic archive (Bérubé and Palsbøll 2022).

One Argos-linked SPLASH10-F satellite tag was deployed on a minke whale during the 2023/2024 season (**Table 4**). The tag transmitted for 11.8 days and is the first satellite tag deployed on a minke whale within the study area. HDRVABa015 was tagged approximately 6.5 nm east of Cape Henry, and just outside the shipping channels (**Figure 11**). This individual remained within the primary study area for the duration of the tag deployment. Six days after the initial tagging, HDRVABa015 was re-sighted by the field team on 18 February 2024, and a CATS tag was deployed. The individual continued to stay within the primary study area, with 43.0 percent of all Argos locations located within the shipping lanes and 31.0 percent located within the W-50 Mine-neutralization Exercise (MINEX) region of VACAPES (**Figure 11**). Many locations also occurred outside the NARW SMA, where vessel speed restrictions are in place seasonally (**Figure 12**).

The satellite tag also recorded information on dive depth and duration in addition to the Argos capabilities (**Table 5**). This tag recorded a total of 670 dives. Mean dive depth was 8.9 m, with a maximum dive depth of 24.0 m. The mean dive duration range was 2.7 min with a maximum dive duration of 6.2 min.

Table 4. Satellite-tag deployment on a minke whale during the 2023/2024 field season.

Animal ID	Estimated Age Class	Tag Type	Argos ID	Deployment Date	Last Transmission Date	Tag Duration (Days)
HDRVABa015	Adult	SPLASH10-333F	221011	12-Feb-2024	24-Feb-2024	11.8

Table 5. Summary of dive depth and duration collected from the tagged minke whale during the 2023/2024 field season.

Animal ID	No. Dives Logged	Mean Dive Depth (m)	Max Dive Depth (m)	Mean Dive Duration (mm:ss)	Max Dive Duration (mm:ss)
HDRVABa015	670	8.9	24.0	02:43	06:13

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

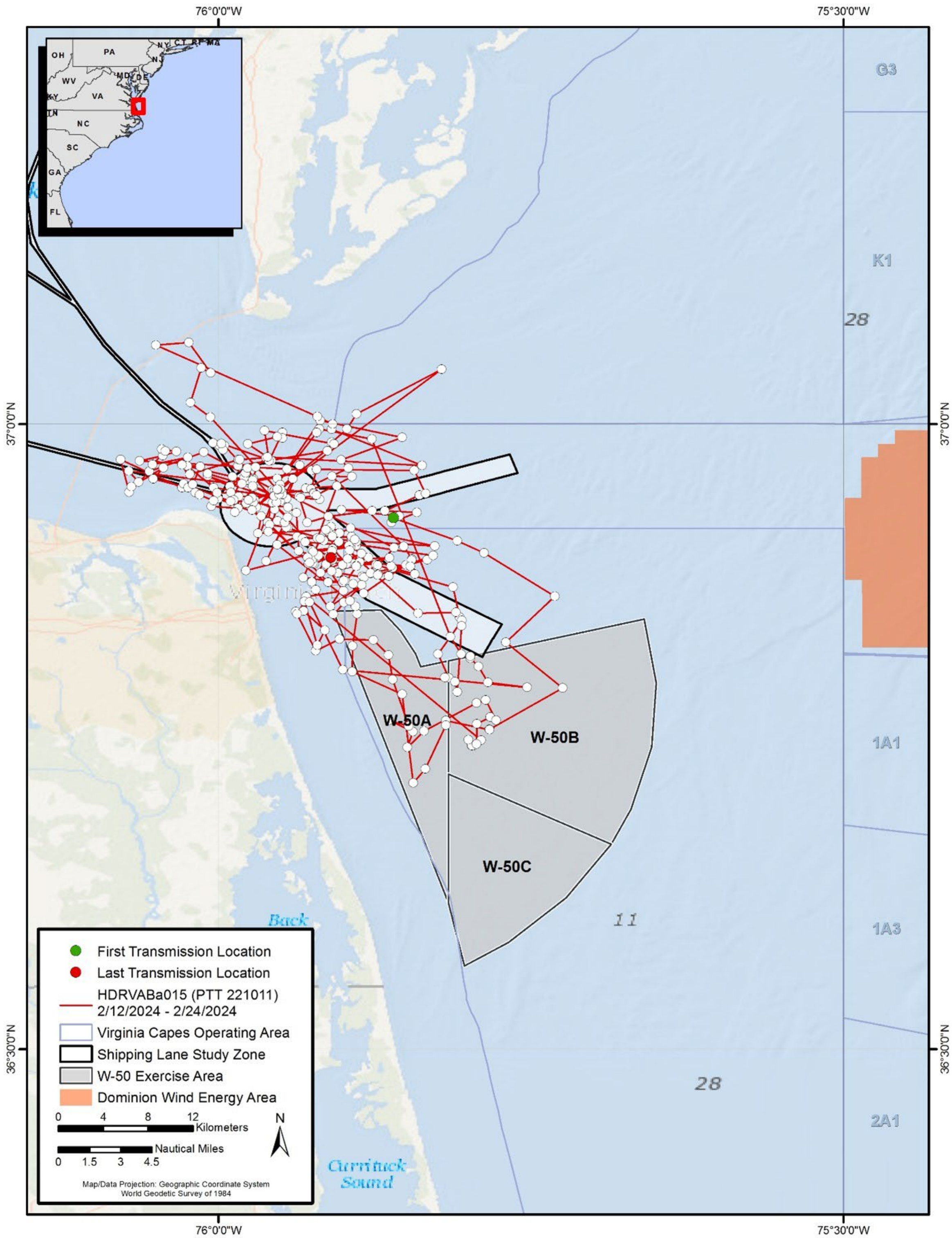


Figure 11. Filtered locations (white dots) and trackline of minke whale HDRVABa015, tagged on 12 February 2024, over 11.8 days of tag-attachment duration.

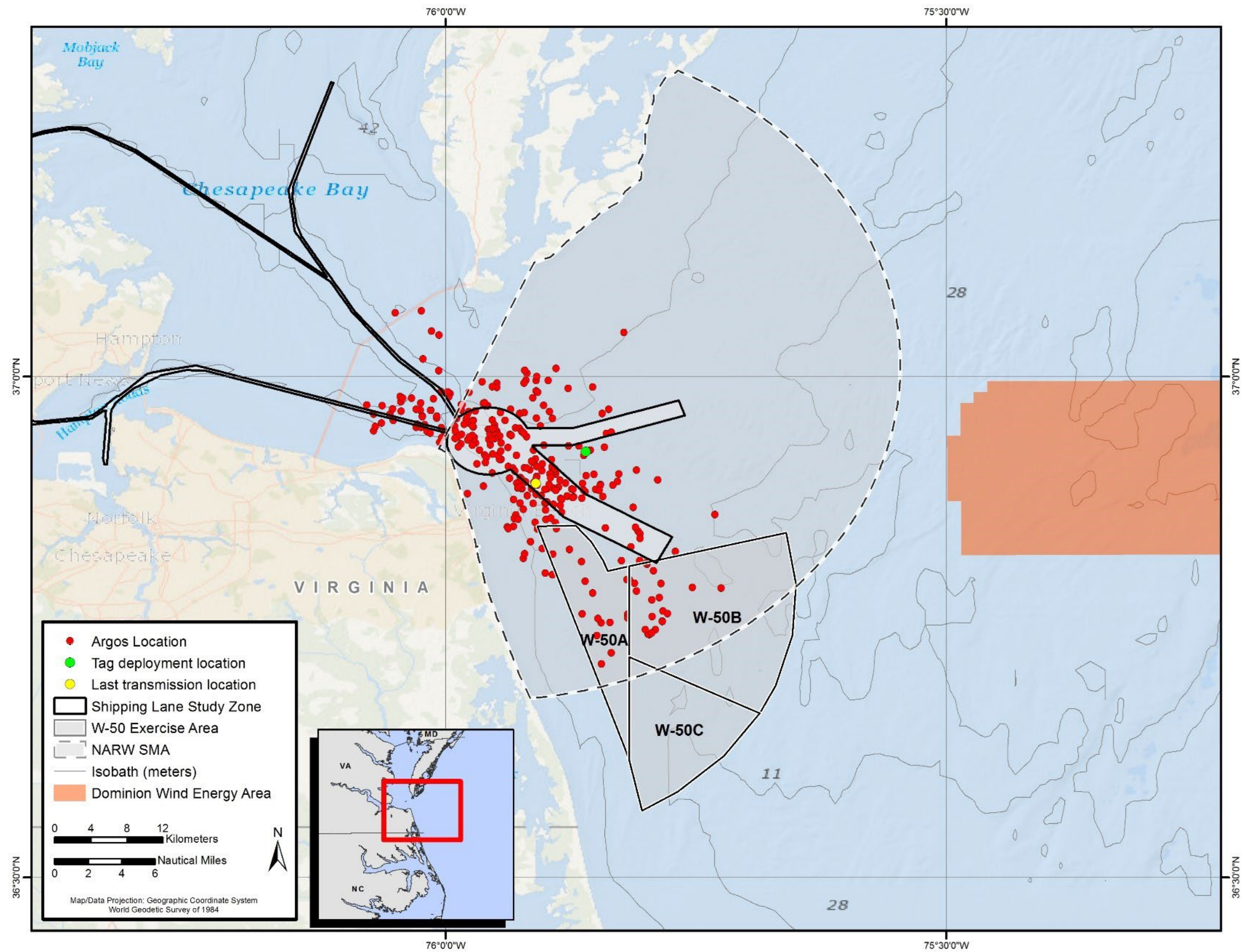


Figure 12. Filtered Argos locations of minke whale HDRVABa015 within the immediate vicinity of shipping channels at the mouth of Chesapeake Bay from tag deployments (*n* = 1) during the 2023/2024 field season.

Two CATS suction-cup tags were deployed during the 2023/2024 field season, one each on a humpback and minke whale (**Table 6**). The tag deployed on humpback whale HDRVAMn294 was successfully recovered 2 days after deployment. Unfortunately, no data were recorded. The tag deployed on the minke whale was recovered the following day and recorded approximately 21 hours of three-dimensional movement, acoustic, and video data (**Table 6**). A total of 145 dives and 144 surfacing bouts were recorded during the tag's deployment (**Table 7**). Maximum dive depth was 24.6 m (mean = 7.85 m), and dive duration ranged from 2.0 to 6.47 min (mean = 2.61 min) (**Table 7**). **Figure 13** shows the dive profile of ba210218-01. Further analysis of all tag data is underway.

Table 6. CATS deployments on baleen whales during the 2023/2024 field season.

Animal ID	Species	Number/ Deployment ID	Tag Type	Deployment (GMT)	Depth at Tagging (m)	Tag off Animal (GMT)	Tag Duration (min)
HDRVAMn294	Humpback whale	mn231229-01	CATS	2023-Dec-29 14:20	9.0	Unknown	Unknown
HDRVABa015	Minke whale	ba240218-01	CATS	2024-Feb-18 12:04	20.0	2024-Feb-19 13:15	1,269

Key: ID = identifier; GMT = Greenwich Mean Time

Table 7. Summary of dive depth and duration data collected from CATS Tag ba240218-01.

Deployment ID	No. Dives Logged	Mean Dive Depth (m)	Max Dive Depth (m)	Mean Dive Duration (mm:ss)	Max Dive Duration (mm:ss)
ba240218-01	145	7.8	24.6	2:37	6:28

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

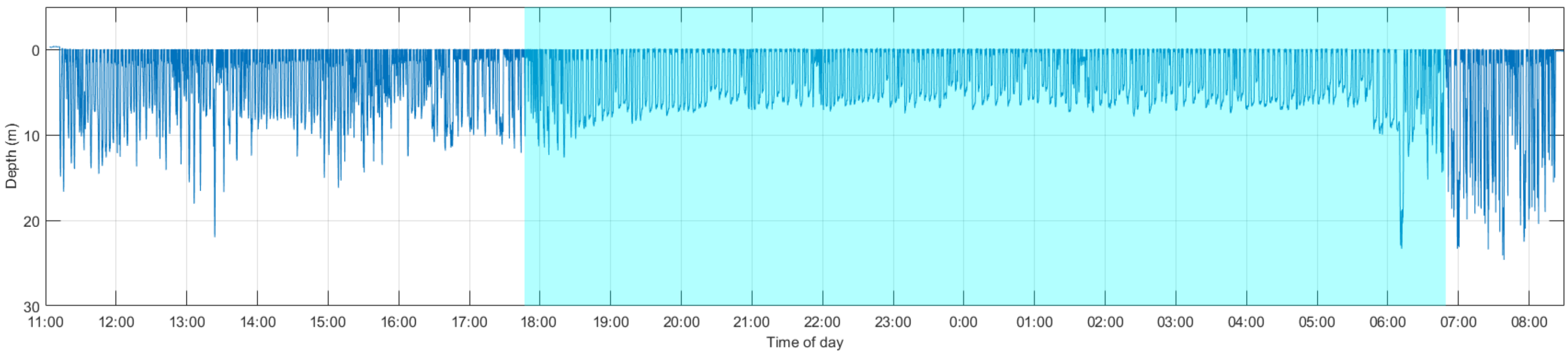


Figure 13. Dive-depth profile (in meters) for HDRVABa015 (CATS ba240218-01) with night shaded blue.

2.4.3.4 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 future 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. Additionally, a UME for NARWs was also declared in 2017, with 1,157 instances of mortalities, serious injuries, and morbidity, primarily from rope entanglements and vessel strikes as of April 2025. The first vessel-related death of a NARW in 2023 occurred near Virginia Beach 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 large number of sightings of individual NARWs over the last two field seasons may partially be a result of the increased survey effort within the area and in association with aerial survey support, although the presence of relatively large groups such as those observed during the 2022/2023 season (Aschettino et al. 2024a) had not previously been observed within the area. 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).

Efforts for the 2024/2025 field season continue to focus on pushing farther into mid-shelf waters as well as continuing humpback photo-ID and body-condition assessment efforts within nearshore waters. During the upcoming 2024/2025 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. 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 reports for this project (Aschettino et al. 2025a, 2025b).

2.4.4 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, and within the W-50 MINEX zone since 2012 (Engelhaupt et al. 2016). However, survey effort had not previously occurred farther offshore within the VACAPES OPAREA near the continental shelf break. Therefore, limited information existed regarding how offshore species, including beaked whales, endangered fin and sperm whales, and other baleen whales use the deeper waters of this region. Vessel surveys for the VACAPES Offshore Cetacean Study were initially conducted from April 2015 through June 2016 in association with the Mid-Atlantic Humpback Whale Monitoring Project and subsequently became a dedicated project in July 2016. The goal of this study is to assess the seasonal occurrence, movement patterns, site fidelity, behavior, and ecology of cetaceans within VACAPES OPAREA offshore waters. During the vessel surveys, researchers use a combination of techniques, including focal follows, photo-ID, biopsy sampling, drone photogrammetry, satellite-linked telemetry tags, and DTAGs or CATS tags. Activities conducted during the 2024 field season are summarized below and detailed in Engelhaupt et al. (2025).

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?

2.4.4.1 Vessel Survey Effort/Summary

The study area is located approximately 90 to 160 km off the Virginia coast, encompassing regions of the outer continental shelf, shelf break, slope waters, and both Norfolk and Washington Canyons. Depth throughout the study area ranges from approximately 50 to 2,500 m. HDR Inc. conducted 15 offshore vessel surveys, covering 4,510 km of trackline and more than 190 hours of effort between March and July 2024 (**Figure 14**). Following detection of an unusually high number of baleen whale sightings during May, an increase in survey effort was directed to the area 100 to 120 km from shore during the following month.

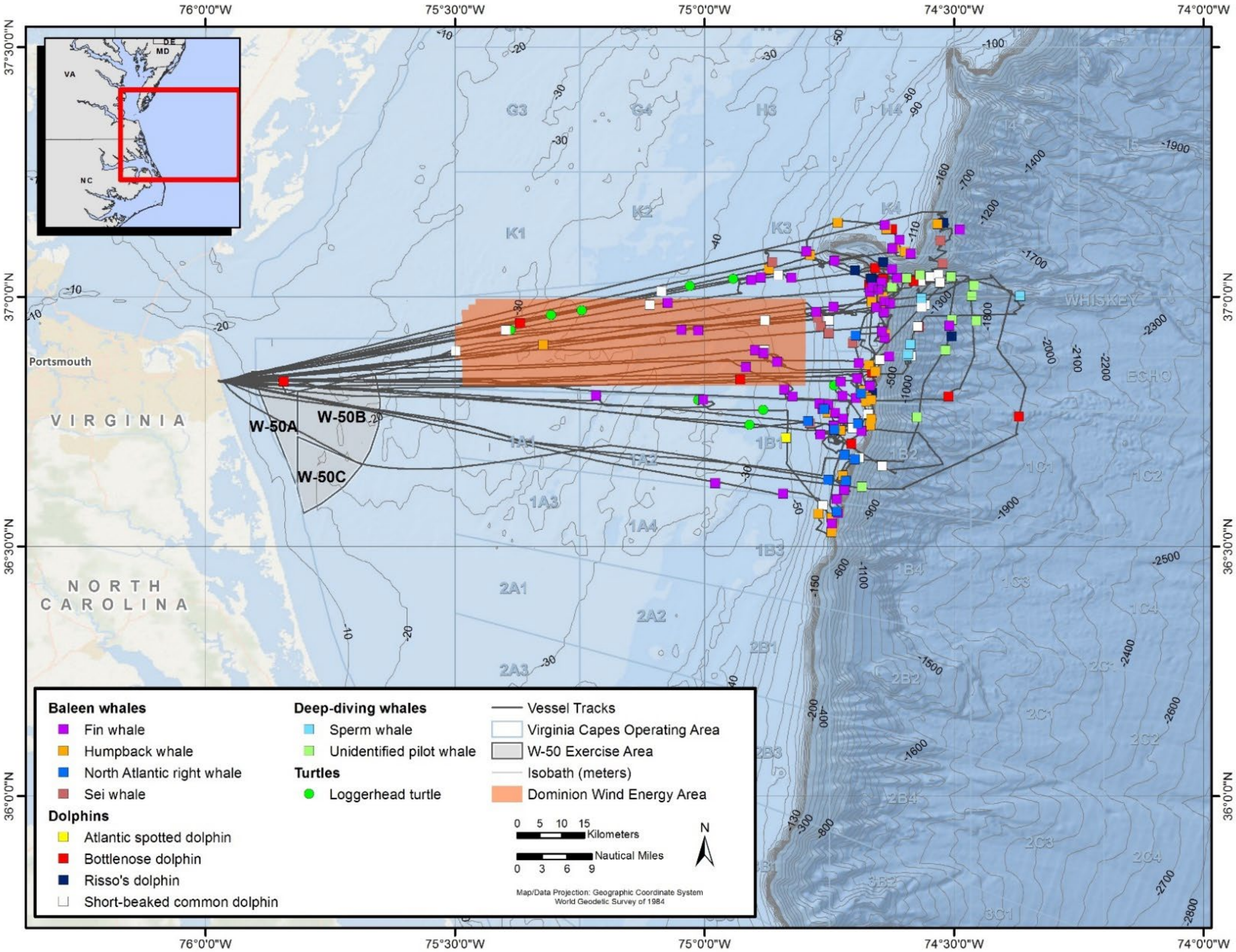


Figure 14. Offshore survey tracks with locations of all baleen whale (*n* = 107), deep-diving odontocete (*n* = 17), dolphin (*n* = 45), and sea turtle (*n* = 9) sightings during surveys conducted from March through July 2024.

A total of 169 marine mammal sightings and 9 sea turtle sightings were recorded during vessel surveys in 2024 (**Figure 14**). Eleven cetacean taxa were identified (in order of decreasing frequency): fin whale (*n* = 57), humpback whale (*n* = 31), common dolphin (*n* = 23), common bottlenose dolphin (*n* = 14), pilot whale (*n* = 12), NARW (*n* = 11), sei whale (*n* = 8), Risso's dolphin (*n* = 7), sperm whale (*n* = 5), and Atlantic spotted dolphin (*Stenella frontalis)* (*n* = 1). One sea turtle species was identified: loggerhead turtle (*Caretta caretta*; *n* = 9). Given the study's focus on priority species that do not include pilot whales, the overlapping range of both short-finned (*Globicephala macrorhynchus*) and long-finned (*G. melas*) pilot whales within the study area, and the challenge of identifying the genus *Globicephala* down to species from a distance, most pilot whale groups were classed as unidentified pilot whales, unless the animals were closely approached and species could be identified.

Sightings of deep-diving species, including sperm and pilot whales, were again concentrated beyond the shelf break and into deeper offshore waters during 2024 surveys, similar to previous years. Baleen whales were encountered both over the shelf and beyond the shelf break, also similar to previous years, although in unusually higher concentrations. Dolphin species were sighted throughout the core study and transit areas, and all sea turtle sightings were over the shelf.

2.4.4.2 Tagging and Biopsy Samples

During 2024, seven biopsies were collected: two from sperm whales, two from humpback whales, and three from fin whales. Processing and analysis of these samples will occur in the future. The sperm whale samples will be held at HDR Inc. and sent to Oregon State University for processing, along with any additional samples collected during spring and summer 2025. The humpback and fin whale samples were sent to the University of Groningen to add to the data for the Mid-Atlantic Nearshore and Mid-shelf Baleen Whale Monitoring Project (Aschettino et al. 2025a).

Ten satellite tags were successfully deployed in 2024: four on sperm whales, two on humpback whales, and four on fin whales. One Smart Position and Temperature (SPOT) location-only tag was deployed on a sperm whale, and the remainder of tags were either SPLASH10 or SPLASH10-F tags, which collected location and dive depth/duration information (**Table 8**). Tag durations for sperm whales were between 10.1 and 32.5 days. Maximum dive depths were 1,023 and 1,119 m, and maximum dive durations were 47.5, 57.4, and 39.1 min. Tag durations for humpback whales were 5.5 and 10.1 days. Maximum dive depths were 225 and 209 m, and maximum dive durations were 8.8 and 9.9 min. Fin whale satellite tag durations ranged from 10.9 to 23.5 days. Maximum dive depths ranged from 62 to 419 m, and maximum dive durations were from 10.4 to 11.6 min.

Table 8. Satellite tag deployments for all species during Offshore Cetacean Study fieldwork during 2024.

Animal ID	Species	Tag Type	Deployment Date	Last Transmission Date	Tag Duration (Days)
HDRVAPm149	Sperm whale	SPLASH10	13-Mar-2024	04-Apr-2024	21.9
HDRVAPm146	Sperm whale	SPLASH10	13-Mar-2024	15-Apr-2024	32.5
HDRVAPm147	Sperm whale	SPLASH10	14-Mar-2024	25-Mar-2024	10.1
HDRVAPm148	Sperm whale	SPOT6	14-Mar-2024	27-Mar-2024	13.0
HDRVAMn311	Humpback whale	SPLASH10-F	13-May-2024	19-May-2024	5.5
HDRVAMn312	Humpback whale	SPLASH10-F	13-May-2024	23-May-2024	10.1
HDRVABp142	Fin whale	SPLASH10-F	29-May-2024	09-Jun-2024	10.9
HDRVABp143	Fin whale	SPLASH10-F	29-May-2024	14-Jun-2024	15.2
HDRVABp163	Fin whale	SPLASH10-F	12-Jun-2024	06-Jul-2024	23.5
HDRVABp164	Fin whale	SPLASH10-F	12-Jun-2024	01-Jul-2024	18.6

Key: ID = identifier

Locations from satellite-tagged sperm whales showed movements throughout the VACAPES OPAREA, except HDRVAPm146, whose track showed movement directly east of VACAPES with a break to the north and back to a similar track, outside the OPAREAs north of the study area (**Figure 15**). Tagged sperm whales traveled up to 1,663 km from initial tag deployment locations, and 21.3 to 100.0 percent of their locations were within the VACAPES OPAREA. Locations from satellite-tagged humpback whales were all near the continental shelf break and south of the tag deployment locations (**Figure 16**). Tagged humpback whales traveled up to 75 km from initial tag deployment locations, and 88.7 and 100.0 percent of their locations were within the VACAPES OPAREA. Locations from satellite-tagged fin whales showed extensive movements limited to the VACAPES OPAREA and several into the Atlantic City OPAREA (**Figure 17**). Tagged fin whales traveled 87 to 258 km from initial tag deployment locations, and 41.7 to 87.0 percent of their locations were within the VACAPES OPAREA.

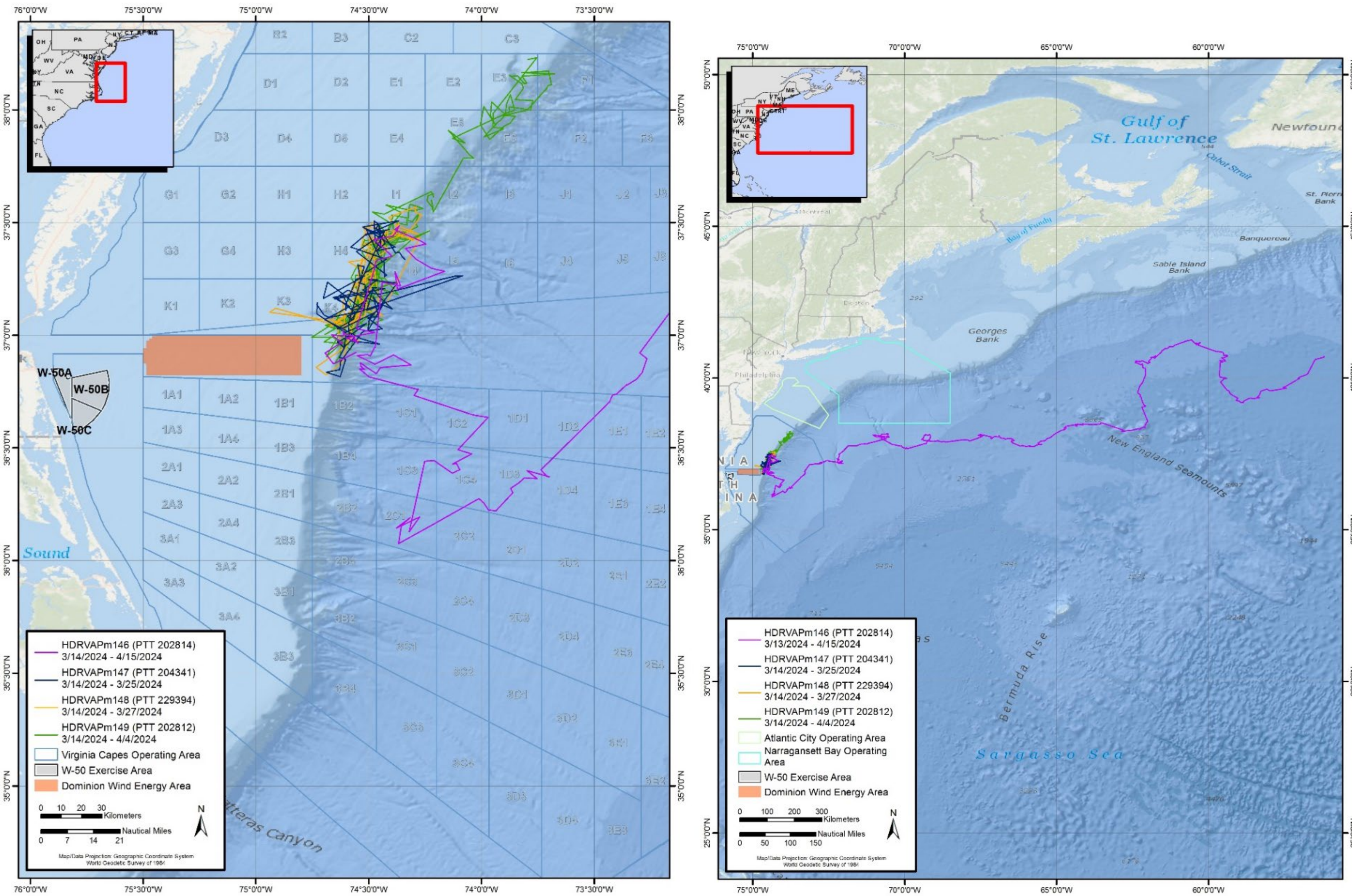


Figure 15. Tracks of all sperm whales tagged (*n* = 4) during offshore surveys in 2024 (left). The full extent of the trackline of HDRVAPm146 extended outside the VACAPES study area (right).

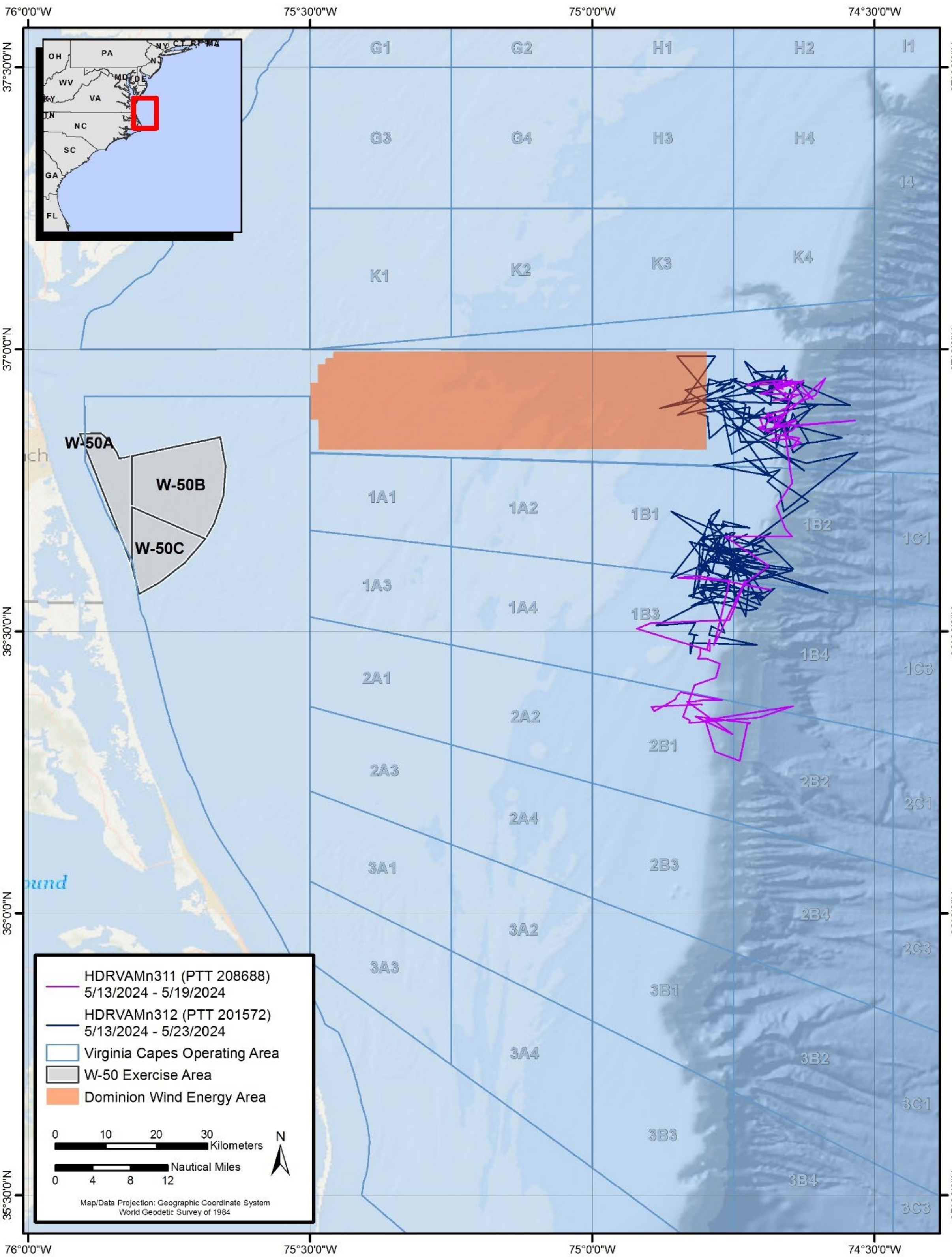


Figure 16. Tracks of all humpback whales tagged (*n* = 2) during offshore surveys in 2024.

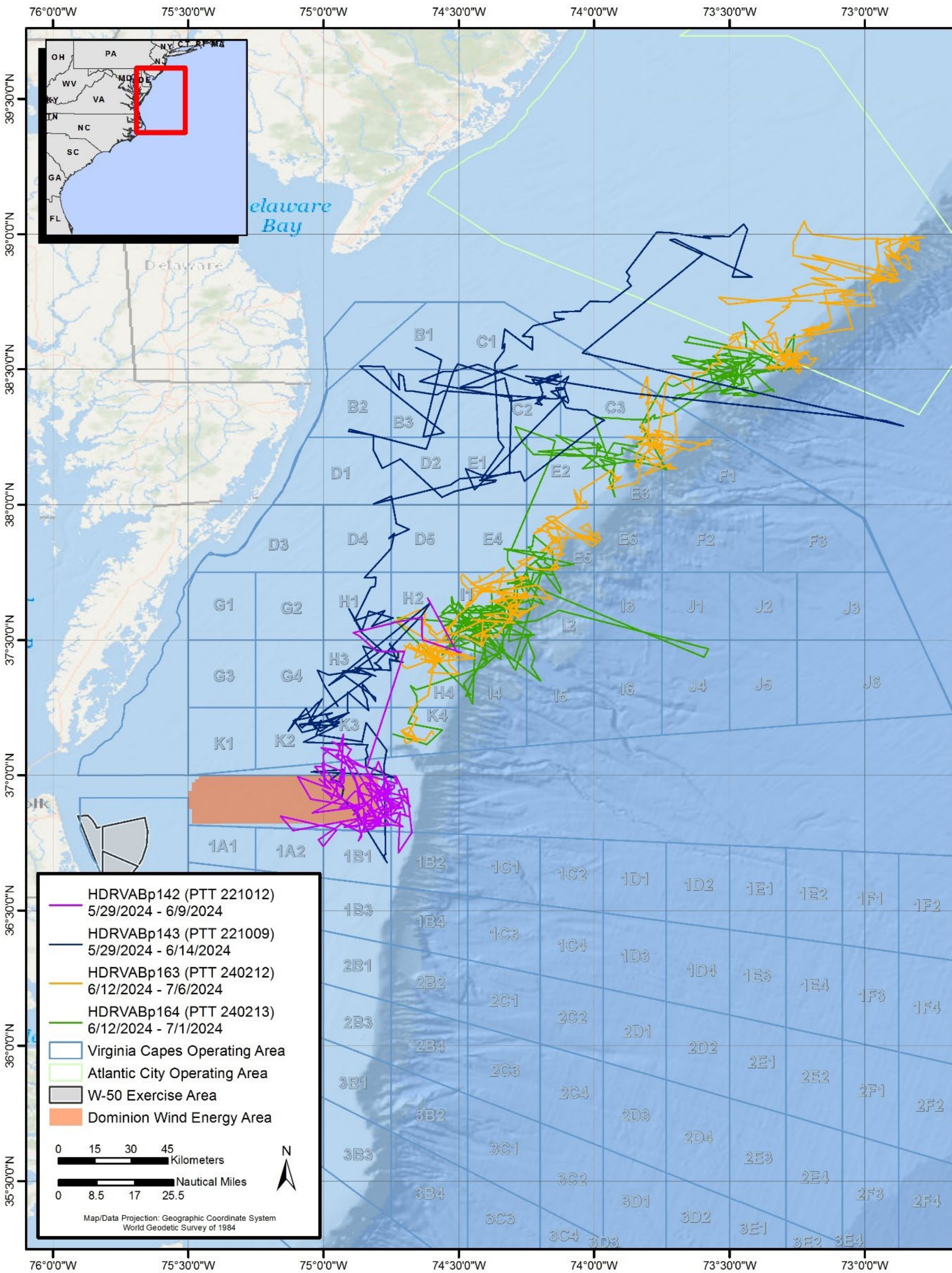


Figure 17. Tracks of all fin whales tagged (*n* = 4) during offshore surveys in 2024.

Two successful DTAG deployments occurred during 2024 on both a fin and sperm whale (**Table 9**). One of the individuals, sperm whale HDRVAPm149, was also satellite tagged and biopsied. An acoustic audit was completed for this individual and is shown with dive profile in **Figure 18**, displaying consistent foraging dives throughout the 20-hour deployment. Maximum dive depth ranged from 347 to 547 m, except one dive to a depth greater than 800 m. This individual was seen for 2 days as part of a loose aggregation of five to seven sperm whales.

Fin whale HDRVABp133 was tagged during an unusual sighting event during May and June 2024, when a large number of baleen whales were repeatedly sighted inside the continental shelf break. A total of 113 dives were logged, ranging in depth from 3 to 81 m. Mean dive depth was 54.2 m, and median dive depth was 64.8 m. The dive profile, shown in **Figure 19**, indicates a change in dive behavior around sunset. The dive depth during daylight hours in the 40- to 80-m range drops to shallower dives and time spent at the surface after sunset.

Additionally, two successful DTAG deployments and two successful CATS tag deployments occurred during 2024 on NARWs. See **Section 2.4.6** for additional information on NARWs and suction-cup tag results.

Table 9. DTAG deployments on all species during 2024.

Animal ID	Species	DTAG Number/ Deployment ID	Deployment (GMT)	Depth at Tagging (m)	Tag off Animal (GMT)	Tag Duration (min)
HDRVAPm149	Sperm whale	345/ pm24_073a	2024-Mar-13 18:03	783	2024-Mar-14 14:54	1,251
HDRVABp133	Fin whale	340/ bp24_146a	2024-May-25 12:45	93	2024-May-26 10:44[a]	1,319[a]

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

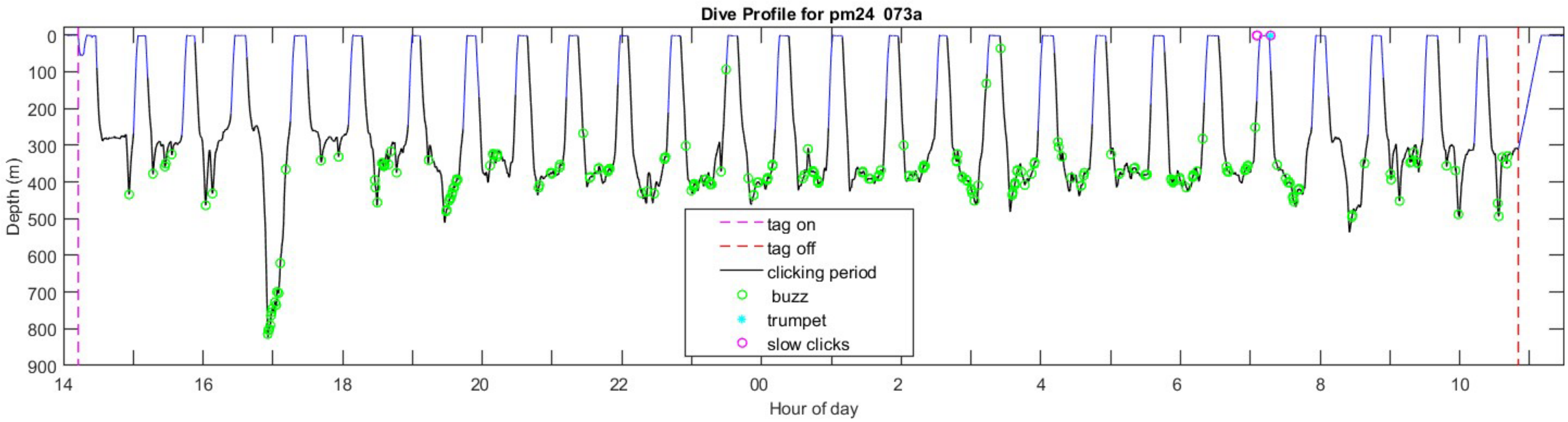


Figure 18. Acoustic audit results for sperm whale DTAG dataset pm24_073a plotted with the dive profile. The black lines indicate clicking, and green circles indicate buzzing from the tagged animal. Slow clicks are indicated by pink circles, and trumpeting is indicated by blue stars. The pink dashed line marks the tag on animal time, and the red dashed line marks the tag off animal time.

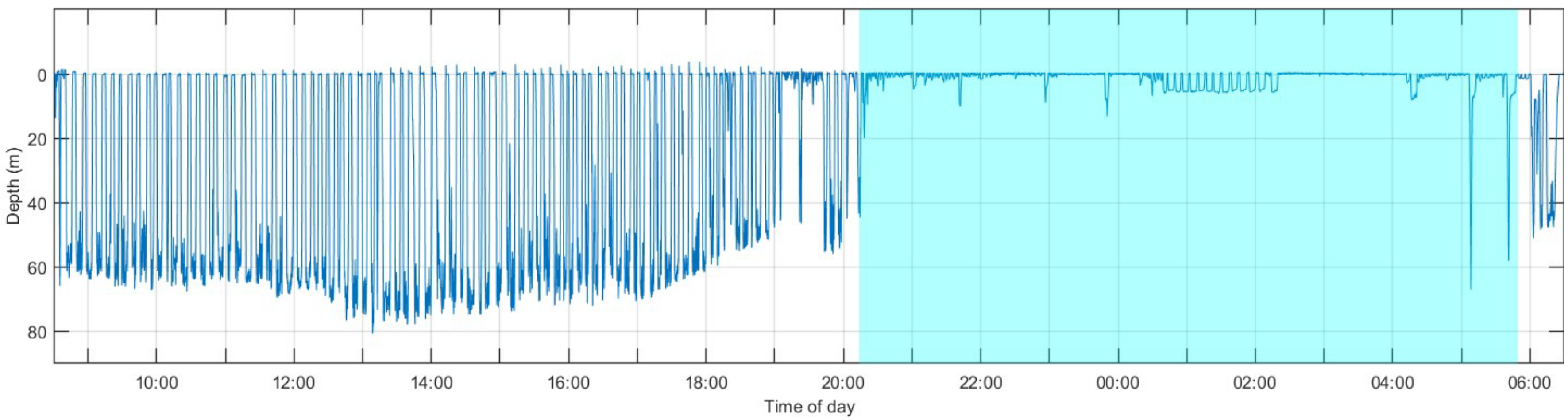


Figure 19. Dive-depth profile (in meters) for fin whale HDRVABp133 (DTAG bp_24_146a), with hours between sunset and sunrise shaded blue.

2.4.4.3 Photo-identification

Photo-ID images were collected from 86 of the 169 marine mammal sightings. All photographs of baleen whales were added to HDR Inc.'s existing catalogs, and results are reported in Aschettino et al. 2025b, except sei whale images, which have been shared with the NEFSC to add to their catalog. Five unique sperm whales were identified during 2024 and added to the sperm whale catalog, which now contains 147 individuals. All sperm whale individuals photographed on 13 May 2024 were new individuals to the catalog, and four of the five were re-sighted the following day. Of the total catalog of 147 individuals, 26 (17.7 percent) were sighted on more than 1 day, ranging from 1 to 2,185 days between first and last sightings (mean = 426, median = 343).

Pilot whale photographs have been provided to Duke University, and comparisons of individuals through 2024 with their Cape Hatteras catalog have been completed (**Section 2.5.5**, Waples and Read 2025). An additional four individuals were added to the pilot whale catalog for this project, none of which were re-sightings. The Norfolk catalog now contains 324 individual pilot whales, and the updated total of matches between Virginia and North Carolina is 14.5 percent (47 of 324).

2.4.4.4 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 important ESA-listed species—sperm, fin, blue, and sei whales, and NARWs—within this high-use, U.S. Navy training and testing activity area.

The aggregation of baleen whales within the study area was first noted during early May, when sei whales, which are rarely seen within the study area, and a large number of fin whales were documented. The sea surface temperature was carefully monitored with available images from satellite data collected by Rutgers University, and further effort was directed toward areas of relatively cold temperatures for the season. A mid-May survey also documented sei and fin whales, and on 22 May 2024, a large feeding aggregation of sei, fin, and NARWs was encountered. Effort was focused within this area for the remainder of May and into early June, when the sea surface temperature increased, and the number of baleen whales detected returned to levels consistent with previous years. During the event, 11 vessel surveys were completed, covering more than 3,000 km within the study area. A total of 97 sightings of baleen whales consisting of 291 individuals was recorded, 4 biopsies were collected (2 humpback and 2 fin whales), 6 satellite tags were successfully deployed (2 humpback and 4 fin whales), and 5 archival tags were successfully deployed and recovered with full datasets (4 NARWs and 1 fin whale). These data were partially analyzed and presented at the North Atlantic Right Whale Consortium Meeting in October 2024 (Aschettino et al. 2024b).

Future work on these data includes acoustic audits of archival tag data, trackplot visualization of pitch-roll-heading archival tag data, modeling sighting data and location data with environmental data, and completion of photo-ID updates (Aschettino et al. 2025b). Further collaboration with Rutgers University has been initiated to monitor environmental models to alert if a possible event occurs during future seasons, allowing for a similar increase in survey and tagging efforts.

The importance of NFC to sperm whales has become evident through re-sightings and tagged whale movements. The combination of methods over time, including length estimates from drone images (Engelhaupt et al. 2024), genetic sexing from biopsies (A. Engelhaupt et al. 2023a), re-sightings discovered though photo-ID, and acoustic and movement behavior recorded by satellite and archival tags, has begun to show the study area as an important habitat for juvenile male sperm whales. The need for communication and social interaction of these individuals that return to the area in subsequent years or seasons is an important consideration when addressing potential of exposure and consequence within an area of crucial U.S. Navy use.

Capability to respond to reports and changing environmental conditions has allowed for increased success in data collection for multiple vulnerable species. The addition of digital archival tag deployments on deep-diving species and ESA-listed baleen whale species will allow researchers to better detail fine-scale movement, dive patterns, foraging behavior, and acoustic activity to add to the existing medium-duration telemetry dataset. Understanding fine-scale baseline data and recording subtle changes in behavior (including acoustic activity) will provide valuable insights on animal behavior and potential impacts from anthropogenic stressors. The results of this multi-year effort are expected to provide the level of detailed information required to make informed decisions regarding future training and testing planning and mitigation measures within the survey area to minimize potential impacts on protected marine species.

For more information on this study, refer to the annual progress report for this project (Engelhaupt et al. 2025).

2.4.5 Baleen Whale Photo-identification and Mid-Atlantic Humpback Whale Catalog

2.4.5.1 Photo-identification – NARWs

The 23 sightings of NARWs resulted in 35 unique individuals identified during the 2023/2024 field season and included all age classes and both sexes. Fourteen individuals were observed on 2 or more days and two of those individuals were observed on 3 different days. Two males, #3701/"Eros" and #3350 and one female, #4610, were seen previously within the study area in 2023 (#3701 and #4610) and 2018 (#3350). Also noteworthy is that none of the 23 sightings occurred within the NARW SMA (**Figure 9, Figure 10**, and **Figure 14**), where vessels larger than 65 feet (19.8 m) are required to slow down to speeds of 10 knots or less from November through April. For additional information on NARWs in the Mid-Atlantic, see **Section 2.4.6** of this report and **Table 12** (in **Section 2.4.6**) for specifics on all aerial and vessel NARW sightings during the 2023/2024 field season.

2.4.5.2 Photo-identification – Humpback Whales

The 33 sightings of humpback whales observed during the 2023/2024 nearshore and mid-shelf baleen whale season included 43 total individuals and resulted in 29 unique humpback whales identified using dorsal fin and fluke images (Aschettino et al. 2025a). During offshore surveys, 31 sightings of humpback whales totaled 126 individuals and resulted in 45 unique humpback whales (Engelhaupt et al. 2025). In total, 74 unique humpback whales were identified during the 2023/2024 season (**Figure 20**).

Of the 74 unique humpback whales seen during the 2023/2024 season, 34 (46.0 percent) were classified as adults based on their estimated size in the field, 17 (23.0 percent) were categorized as juveniles, 8 (10.8 percent) were classified as sub-adults/adults, 2 (2.7 percent) were classified as calves, and the remaining 13 (17.6 percent) were not assigned an age class. Ten (13.5 percent) of the 74 individuals were re-sights to HDR Inc.'s catalog; 1 individual had not been seen since the initial 2014/2015 season (HDRVAMn017), and the remaining re-sights included individuals from six of the nine previous field seasons. The additional 64 whales were new individuals added to the growing project catalog, which, to date, has 340 unique humpback whales. Two individuals, HDRVAMn001 and HDRVAMn002, seen only once each in 2013 are not included in **Figure 20**. To date, evidence of human interaction, either presumed line-entanglement scars or propeller scars, was apparent on at least 28 of the 340 (8.2 percent) cataloged humpback whales and 6 individuals are known to be deceased.

Of the 74 unique humpback whales seen during the 2023/2024 season, 27 (36.5 percent) were seen on more than 1 occasion, and 9 (12.2 percent) were seen on 3 or more occasions. Within-season re-sightings spanned 1.0 to 48.0 days apart (mean = 14.5 days; median = 11.9 days). This occurrence of re-sightings is similar to several previous seasons—38.6 percent during 2021/2022, 42.9 percent during 2019/2020, 44.7 percent during 2018/2019, and 21.9 percent during 2017/2018—but is less than the 2016/2017 season (69.5 percent), and more than the 2020/2021 (12.9 percent) and 2022/2023 (13.5 percent) seasons.

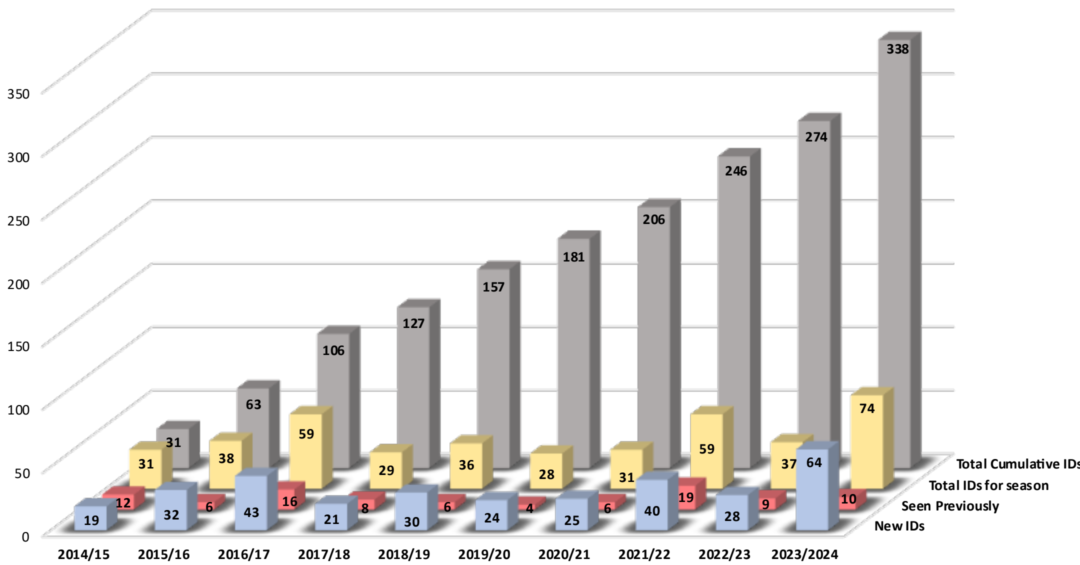


Figure 20. Humpback whale identifications (IDs) over ten field seasons within the Virginia study area: yellow bars = total number of IDs for each season; red bars = number of those IDs that were seen in previous seasons; blue bars = number of new IDs added to the catalog; gray bars = total number of cumulative unique IDs.

Beginning in December 2018, drone video was collected from numerous humpback whales. In the field, live video was used to assist the research team in assessing overall body condition, as well as during tagging attempts to maximize successful deployments. A DJI Phantom 4 Pro V2.0 drone was used to collect morphometric data. Data were typically collected at flight heights between 15 and 30 m, depending on the behavior of the focal animal during the time of the encounter. The drone collected 4K ultra-high-definition video at 30 frames per second. Measurements used altitude data from the drone's stock barometer, although some error is expected with this method. Open-source software developed by researchers at Duke University (Torres and Bierlich 2020) was used to calculate lengths of 7 individual humpback whales (data from November and December 2023). Each of these whales has a unique identification in the HDR Inc. humpback whale catalog and had previously been assigned an age-class based on subjective size assessments from the research vessel. Following the methodology described in Dawson et al. (2017), the drone was recently retrofitted with a custom LiDAR altimeter (Lightware SF11). This upgrade increases the precision (to within 5 centimeters [cm]) and consistency of the drone altimetry measurements to minimize possible error in measured animal lengths. The photogrammetry techniques remain the same, however, with greater accuracy than the stock DJI barometer.

Body length measurements were calculated for 7 individuals from drone footage collected between November and December 2023, and the lengths of 82 unique individuals have been calculated to date (Aschettino et al. 2023b, 2024c). The best photograph was selected for each individual and image grading criteria from Christiansen et al. (2018) were applied. Five of these images met the grading criteria, and these individuals ranged from 10.3 to 13.23 m in total length (mean = 12.16 m; median = 12.58 m). One whale measured less than 11 m and was classified as a juvenile in the field. The remaining 4 whales measured over 11 m and were classified as adults in the field.

2.4.5.3 Photo-identification – Fin Whales

A substantial increase in fin whale sightings and collection of identification photos during Outer Continental Shelf (OCS) surveys (see **Section 2.4.4** and Engelhaupt et al. 2025 for additional details) occurred during May and June of 2024, boosting the total fin whale sightings during the reporting period to 57 sightings of 116 individuals during OCS surveys and resulted in 53 uniquely identified fin whales. There was one sighting of one individual fin whale during nearshore surveys. In total, 54 unique fin whales were identified during the 2023/2024 season.

Of the 54 unique fin whales seen during the 2023/2024 season, 47 (87.0 percent) were classified as adults or sub-adults based on their estimated size in the field, and 7 (13.0 percent) were categorized as juveniles or sub-adult/juveniles. Six (11.1 percent) of the 54 individuals were re-sights to HDR Inc.'s catalog, 2 individuals had not been seen since 2017 (HDRVABp021, HDRVABp028), 3 individuals had not been seen since 2018 (HDRVABp042, HDRVABp051, HDRVABp054), and HDRVABp093 was seen previously in 2021 and 2023. The additional 48 whales were new individuals added to the growing project catalog, which, to date, has 164 unique fin whales.

Of the 54 unique fin whales seen during the 2023/2024 season, 4 (7.4 percent) were seen on more than 1 occasion, and 1 (1.9 percent) was seen on 3 occasions. Within-season re-sightings spanned 6.3 to 15.0 days apart (mean = 9.5 days; median = 12.2 days).

2.4.5.4 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 individual humpback whales overwinter in the mid-Atlantic, and that this region may serve as a supplemental winter-feeding ground. The Mid-Atlantic Humpback Whale Photo-ID Catalog (MAHWC) is a collaborative, integrative platform that provides a broad-scale and high-quality tool that can be used to inform the U.S. Navy and other stakeholders of the identity, residency, site fidelity, and seasonal habitat use of humpback whales in the mid-Atlantic. This project contributes to the overall community effort to help monitor the West Indies Distinct Population Segment and complements existing U.S. Navy MSM efforts (Mid-Atlantic Humpback Whale Monitoring and Mid-Atlantic Continental Shelf Break Cetacean Study). The MAHWC is hosted on the Ocean Biogeographic Information System-Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP; Halpin et al. 2009), a web-based biogeographic database for marine megafauna. It provides tools for mapping and visualizing species sighting data on a global scale.

In the initial development stages of the MAHWC, a stakeholder workshop was held in June 2017, which focused on submission and data access protocols, establishing workflows, collaboration between Mid-Atlantic organizations, and discussions with already established catalog curators (Gulf of Maine Humpback Whale Catalog and North Atlantic Humpback Whale Catalog [NAHWC]) (Mallette et al. 2017). Building upon this previous meeting, HDR Inc. and NAVFAC LANT coordinated and hosted an in-person MAHWC stakeholder meeting in Virginia Beach, Virginia, on 26 June 2024. Research groups and organizations that had participated in the initial stakeholder meeting and contributed to the MAHWC during earlier years, as well as those that expressed new interest in contributing, participated in the meeting. In total, representatives of nine organizations from North Carolina to New York attended. The main objective of the workshop was to present and demonstrate the updates made to the MAHWC since 2023, primarily the incorporation of the Happywhale algorithm into OBIS-SEAMAP. Additionally, the meeting was intended to gauge continued stakeholder interest in contributing to the MAHWC and inform further catalog developments.

Overall, this stakeholder workshop was productive by allowing all groups to re-engage and discuss continued collaboration and the importance of a catalog specific to the Mid-Atlantic. All stakeholders were supportive of the continuation of the MAHWC despite the existence of publicly accessible sites such as Happywhale and Flukebook. Post-meeting, MAHWC curators revised all contributor documents, which are primarily based on the Mid-Atlantic Bottlenose Dolphin Catalog and the North Atlantic Right Whale Consortium.

The MAHWC was updated with all HDR Inc.'s sighting records and humpback whale images through the end of the 2023/2024 winter season, which currently contains 340 individuals. Images included the best dorsal fin and fluke image, comprehensive of every sighting of a given whale. Additionally, the Duke University Marine Lab catalog was updated with images provided by Kim Urian and contains 42 individuals. A new contributor catalog was created with a submission by Melissa Laurino from Cape May Whale Watch and Research Center and now contains 232 individuals. Matching between catalogs is ongoing.

Additionally, the HDR Inc. Happywhale catalog was updated with individuals and images from the 2023/2024 winter field season. In total, HDR Inc.'s Happywhale humpback whale catalog contains 240 individuals, and 142 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 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 Marine Humpback Whale Catalog has a long-standing naming process and

54 humpback whales in HDR Inc.'s Happywhale catalog have been named to date. **Table 10** 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 10. HDR Inc. humpback whale matches to other organizations within Happywhale.

Organization	Number of matches
Rudee Flipper Dolphin and Whale Watching Tours	96
Gulf of Maine Humpback Whale Catalog	59
Gotham Whale New York City	56
NAHWC	44
Witless Bay Reserve Humpback Whale Catalog	9
Coastal Research & Education Society of Long Island	8
Turks and Caicos Islands Whale Project	8
Saint Pierre and Miquelon	8
Trinity Bay Newfoundland – Kris Prince	3
Marine and Coastal Ecology Research Center	2
Husavik Research Centre	1
Mingan Island Cetacean Study	1

For more information on baleen whale photo-ID, refer to the annual progress report (Aschettino et al. 2025b).

2.4.6 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 2.4.2**, **Section 2.4.3** and **Section 2.4.4** for additional details). Beginning in the winter 2022/2023 field season, there was increased effort to locate NARWs given their critically endangered status and the gap in knowledge for Mid-Atlantic waters. Between November 2023 and June 2024, 23 sightings of NARWs occurred off southern Virginia and northern North Carolina between aerial and vessel platforms, during which 35 unique individuals were documented (**Table 11, Figure 21**).

Table 11. NARW sightings by field season for all aerial and vessel surveys off southern Virginia and northern North Carolina from 2017 to 2024.

Season	Number of Sightings	Number of Individuals	Unique IDs for Season
2017/2018	2	8	7
2018/2019	0	0	0
2019/2020	0	0	0
2020/2021	4	7	6
2021/2022	4	8	8
2022/2023	10	36	27
2023/2024	23	51	35

Key: ID = Identification Number

Table 12 provides a summary of NARWs documented by all platforms during the 2023/2024 field season. All sightings during the primary NARW season (November – March) were comprised of either a single whale or a pair of whales (**Table 12**). Unlike in previous years (Aschettino et al. 2023a; A. Engelhaupt et al. 2023b), no larger surface-active groups were observed during the 2023/2024 field season. However, there was an unusually large aggregation of baleen whales sighted offshore near the shelf break and NFC during May and June 2024, including NARW, sei, fin, and humpback whales (Engelhaupt et al. 2025). These findings were presented at the 2024 North Atlantic Right Whale Consortium Meeting (Aschettino et al. 2024b).

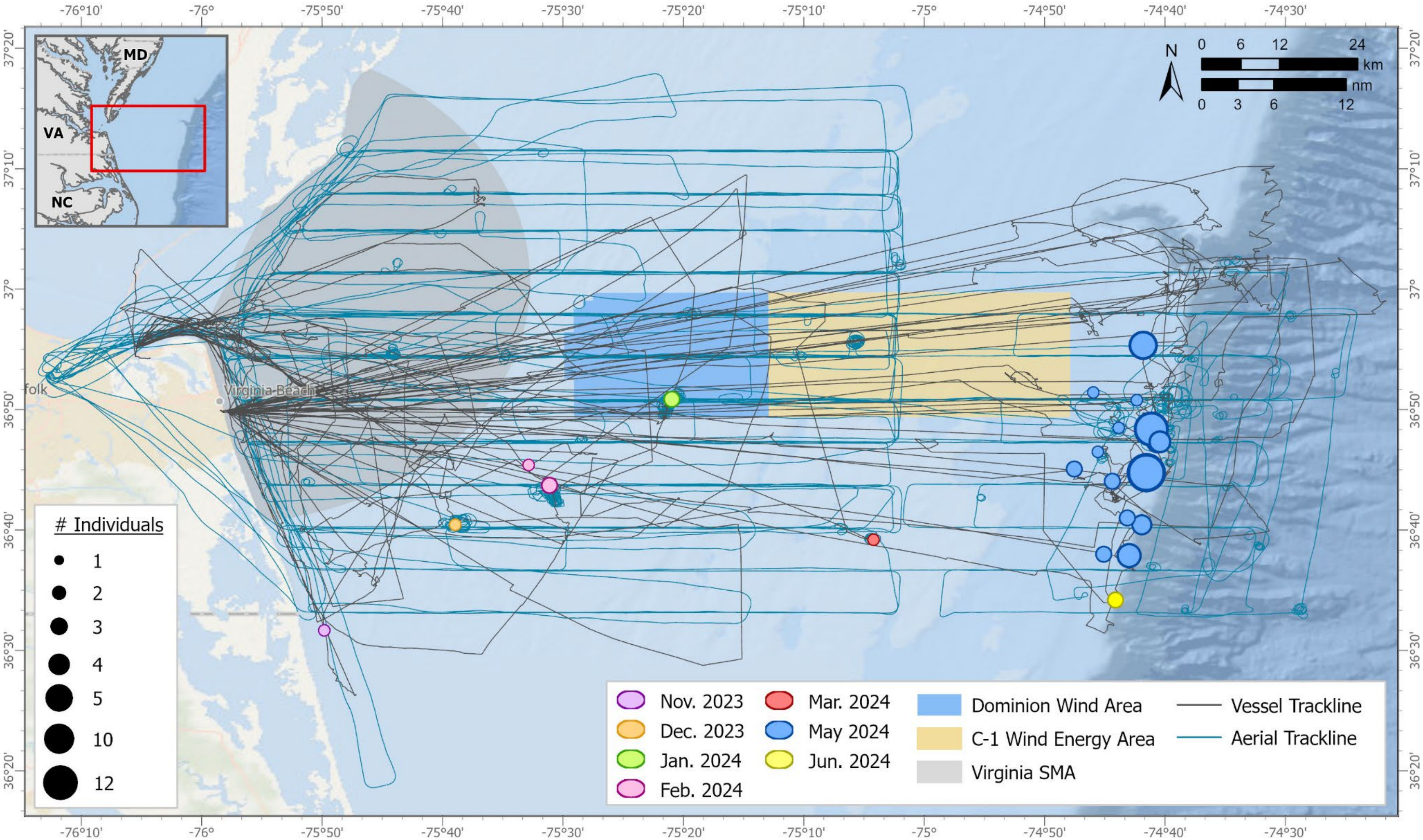


Figure 21. NARW sightings from aerial and vessel platforms collected off southern Virginia and northern North Carolina during the 2023/2024 field season.

Table 12. Summary of photo-identified NARWs from all platforms during the 2023/2024 field season, sorted by sighting date and animal identifier.

Animal ID / Name	Age Class	Sex	Group Size	Behavior	Sighting Date	Survey Type_ Sighting #	Sighting Latitude (°N)	Sighting Longitude (°W)	Unique Sighting Days
#1703 / Wolf	Adult	Female	1	Travel	15-Nov-2023	Midshelf_s1	36.5278	75.8304	1
Unknown	Unknown	Unknown	1	Travel	16-Dec-2023	Aerial_s1	36.6740	75.6493	1
Unknown	Unknown	Unknown	1	Travel	16-Dec-2023	Midshelf_s1	36.6755	75.6400	1
#2440 / Shackleton	Adult	Male	2	Travel	23-Jan-2024	Aerial_s3	36.8475	75.3491	1
#2440 / Shackleton	Adult	Male	2	Mill	23-Jan-2024	Midshelf_s1	36.8406	75.3584	1
#3623 / Bongo	Adult	Male	2	Travel	23-Jan-2024	Aerial_s3	36.8475	75.3491	1
#3623 / Bongo	Adult	Male	2	Mill	23-Jan-2024	Midshelf_s1	36.8406	75.3584	1
#1419 / Killick	Adult	Male	2	Travel	2-Feb-2024	Aerial_s1	36.7188	75.5186	1
#1419 / Killick	Adult	Male	2	Travel	2-Feb-2024	Midshelf_s1	36.7188	75.5103	1
#2470	Adult	Male	2	Travel	2-Feb-2024	Aerial_s1	36.7188	75.5186	1
#2470	Adult	Male	2	Travel	2-Feb-2024	Midshelf_s1	36.7188	75.5103	1
#3701 / Eros	Adult	Male	1	Travel	8-Feb-2024	Midshelf_s1	36.7569	75.5474	4
#1950	Adult	Female	1	Deceased	30-Mar-2024	Aerial_s1	36.6534	75.0701	1
#1950	Adult	Female	1	Deceased	30-Mar-2024	OCS_s1	36.6543	75.0718	1
#1047	Adult	Unknown	7	Feed	22-May-2024	OCS_s8	36.9224	74.6971	1
#1317 / Ergo	Adult	Male	7	Feed	22-May-2024	OCS_s8	36.9224	74.6971	1
#1611 / Clover	Adult	Female	7	Feed	22-May-2024	OCS_s8	36.9224	74.6971	2
#2510 / Mitosis	Adult	Male	7	Feed	22-May-2024	OCS_s8	36.9224	74.6971	1
#3297	Adult	Unknown	7	Feed	22-May-2024	OCS_s8	36.9224	74.6971	2
#3340 / Plover	Adult	Male	7	Feed	22-May-2024	OCS_s8	36.9224	74.6971	1
#4145	Adult	Male	7	Feed	22-May-2024	OCS_s8	36.9224	74.6971	2
#1050	Adult	Male	10	Feed	25-May-2024	OCS_s2	36.8065	74.6859	1
#1050	Adult	Male	4	Travel	25-May-2024	Aerial_s7	36.7898	74.6766	1
#2920	Adult	Male	1	Mill	25-May-2024	Aerial_s4	36.8570	74.7662	2
#3101 / Harmonia	Adult	Female	10	Feed	25-May-2024	OCS_s2	36.8065	74.6859	2

Animal ID / Name	Age Class	Sex	Group Size	Behavior	Sighting Date	Survey Type_ Sighting #	Sighting Latitude (°N)	Sighting Longitude (°W)	Unique Sighting Days
#3101 / Harmonia	Adult	Female	10	Feed	25-May-2024	Aerial_s7	36.7898	74.6766	2
#3241	Adult	Male	10	Feed	25-May-2024	OCS_s2	36.8065	74.6859	2
#3241	Adult	Male	1	Travel	25-May-2024	Aerial_s1	36.8081	74.7306	2
#3391	Adult	Male	1	Travel	25-May-2024	Aerial_s9	36.8465	74.7059	2
#3442 / Armada	Adult	Male	10	Feed	25-May-2024	OCS_s2	36.8065	74.6859	2
#3860 / Bocce	Adult	Female	10	Feed	25-May-2024	OCS_s2	36.8065	74.6859	2
#3908 / Zero	Adult	Female	10	Feed	25-May-2024	OCS_s2	36.8065	74.6859	1
#3908 / Zero	Adult	Female	4	Feed	25-May-2024	Aerial_s7	36.7898	74.6766	1
#4129 / Goldfish	Adult	Male	10	Feed	25-May-2024	OCS_s2	36.8065	74.6859	2
#4610	Adult	Female	4	Travel	25-May-2024	Aerial_s7	36.7898	74.6766	2
2023calfof#2029	Yearling	Unknown	10	Feed	25-May-2024	OCS_s2	36.8065	74.6859	3
#1047	Adult	Unknown	14	Feed	29-May-2024	OCS_s7	36.7462	74.6927	1
#1611 / Clover	Adult	Female	14	Feed	29-May-2024	OCS_s7	36.7462	74.6927	2
#2040 / Naevus	Adult	Female	14	Feed	29-May-2024	OCS_s7	36.7462	74.6927	2
#2920 / Peter Rabbit	Adult	Male	14	Feed	29-May-2024	OCS_s7	36.7462	74.6927	3
#3101 / Harmonia	Adult	Female	14	Feed	29-May-2024	OCS_s7	36.7462	74.6927	2
#3241	Adult	Male	14	Feed	29-May-2024	OCS_s7	36.7462	74.6927	2
#3297	Adult	Unknown	14	Feed	29-May-2024	OCS_s7	36.7462	74.6927	2
#3350 / Polaris	Adult	Male	14	Feed	29-May-2024	OCS_s7	36.7462	74.6927	2
#3442 / Armada	Adult	Male	14	Feed	29-May-2024	OCS_s7	36.7462	74.6927	2
#3545	Adult	Male	14	Feed	29-May-2024	OCS_s7	36.7462	74.6927	1
#3860 / Bocce	Adult	Female	14	Feed	29-May-2024	OCS_s7	36.7462	74.6927	2
#4129 / Goldfish	Adult	Male	14	Feed	29-May-2024	OCS_s7	36.7462	74.6927	2
2022CalfOf2040 (#5240)	Juvenile	Female	14	Feed	29-May-2024	OCS_s7	36.7462	74.6927	1
2023calfof#2029	Yearling	Unknown	14	Feed	29-May-2024	OCS_s7	36.7462	74.6927	3
#1317 / Ergo	Adult	Male	2	Travel	30-May-2024	OCS_s12	36.6833	74.7192	1

Animal ID / Name	Age Class	Sex	Group Size	Behavior	Sighting Date	Survey Type_ Sighting #	Sighting Latitude (°N)	Sighting Longitude (°W)	Unique Sighting Days
#2040 / Naevus	Adult	Female	5	Mill	30-May-2024	OCS_s15	36.6311	74.7166	2
#2520	Adult	Female	5	Mill	30-May-2024	OCS_s15	36.6311	74.7166	1
#2920	Adult	Male	2	Travel	30-May-2024	OCS_s11	36.7340	74.7395	2
#3391	Adult	Male	2	Unknown	30-May-2024	OCS_s16	36.6331	74.7517	2
#3680 / Seadragon	Adult	Male	5	Mill	30-May-2024	OCS_s15	36.6311	74.7166	1
#4145	Adult	Male	5	Mill	30-May-2024	OCS_s15	36.6311	74.7166	2
#4310 / Prickly Pear	Adult	Female	5	Mill	30-May-2024	OCS_s15	36.6311	74.7166	1
2023calfof#2029	Yearling	Unknown	1	Mill	30-May-2024	OCS_s1	36.7507	74.7925	3
#3270 / Pico	Adult	Female	2	Mill	1-Jun-2024	OCS_s8	36.5697	74.7352	1
2024Calfof#3270	Calf	Unknown	2	Mill	1-Jun-2024	OCS_s8	36.5697	74.7352	1

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

During this late-spring aggregation, a total of 11 sightings of NARWs were observed from the vessel and 4 sightings were spotted from the plane. At least 27 unique NARWS were identified across all sightings, including individuals of all age classes and sexes. Fourteen individuals were seen on two or more survey days, ranging from 1–8 days between sightings. Two of the most noteworthy sightings include Eg#1050, who had not been seen since 2011, and Eg#3270/"Pico" and her undocumented calf (**Table 12**). Sightings occurred at depths ranging from 63 to 129 m (mean = 93 m) and were within 0.3 to 11.3 km (mean = 4.3 km) of the shelf break. Sightings were centered along a sea surface temperature gradient from 15.1 to 17.7 degrees Celsius (°C; mean = 16.5°C).

Additionally in May 2024, four suction-cup tags (2 CATS and 2 DTAGs) were deployed on NARWs, which collected 28 hours of behavioral data (**Table 13**, **Table 14**, Aschettino et al. 2025a). Dive profiles for each NARW are shown in **Figure 22** through **Figure 25**. A total of 122 dives were logged, and the maximum dive depth recorded was 145 m (**Table 14**). Average dive depth for all dives combined was 59 m, and the median was 67 m. Dive durations ranged from 2 to 11.8 min, with a mean of 4.2 to 8.8 min for each individual; surface durations had a mean of 3.3 to 11.7 min for each individual (**Table 14**). Bottom depths recorded from the vessel echosounder during sightings and tag Global Positioning System (GPS) locations ranged between 79 and 119 m, though data were not available for all tag deployment durations (**Table 14**). One non-focal individual captured on the CATS video of NARW 3391, deployed 29 May 2024, can be seen feeding at the sea floor and dragging its pectoral fin in the substrate (Aschettino et al. 2024b).

Video collected from the CATS tags, combined with dive profile data, further supports intense foraging activity by NARWs through dense concentrations of prey in late-spring 2024. These results continue to highlight the importance of long-term monitoring for NARWs and other endangered baleen whales throughout the western Mid-Atlantic, and particularly the high vessel traffic area offshore of the mouth of the Chesapeake Bay.

NARW were detected on 26 days between November 2023 and April 2024. NARW were "possibly" detected on an additional 12 days between October 2023 and June 2024. Acoustic detections of NARWs on the DMON buoy deployed off the Atlantic coast of Cape Charles, VA resulted in eleven 15-day long slow zones, resulting in 165 days of slow zone coverage between November and May. An additional slow zone was also triggered by a visual sighting of right whales in the area.

For more information regarding NARWs in the Mid-Atlantic, refer to **Section 2.4.1** for information on passive acoustics; **Section 2.4.2** and Ozog and Engelhaupt 2025 for information on aerial surveys; **Section 2.4.3** and Aschettino et al. 2025a for information on the Mid-Atlantic Baleen Whale Monitoring Program; **Section 2.4.4** and Engelhaupt et al. 2025 for information on the Offshore Cetacean Study; and **Section 2.4.5** and Aschettino et al. 2025b for information on baleen whale photo-ID.

Table 13. Suction-cup tag deployments on NARWs during 2024.

Animal ID	Tag Type	Tag Number/ Deployment ID	Deployment (GMT)	Depth at Tagging (m)	Tag off Animal (GMT)	Tag Duration (min)
NARW 3908	DTAG	345/ eg24_146a	2024-May-25 17:26	97	2024-May-25, 19:55a	149a
NARW 3101	DTAG	340/ eg24_150a	2024-May-29 18:12	103	2024-May-30, 09:30a	918a
NARW 3241	CATS	CATS 01/ eg052524-01	2024-May-25 14:52	97	2024-May-26, 01:51a	659a
NARW 3391	CATS	CATS 01/ eg052924-01	2024-May-29 16:47	103	2024-May-29, 17:36	49

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

Table 14. Summary of suction-cup tag data for all NARWs during 2024.

Data Category	NARW ID/Name				All Tags Combined
	NARW #3241	NARW #3908/Zero	NARW #3391	NARW #3101/Harmonia	
Age-class	Adult	Adult	Adult	Adult	—
Sex	Male	Female	Male	Female	—
Deployment ID	CATS eg052524-01	DTAG eg24_146a	CATS eg052924_01	DTAG eg24_150a	—
Tag duration (hour)	10.98	2.48	0.82	14.30	28.58
Number of dives	51	11	4	56	122
Mean dive duration (min)	6.34	8.75	8.13	4.20	5.63
Median dive duration (min)	6.42	8.61	8.80	3.50	5.27
Mean surface duration (min)	7.34	3.84	3.30	11.67	8.88
Median surface duration (min)	2.60	3.90	3.30	4.43	3.04
Mean max dive depth (m)	69.38	108.45	87.56	37.68	58.95
Median max dive depth (m)	82.46	111.29	88.28	43.20	67.32

Key: ID = identifier; max = maximum

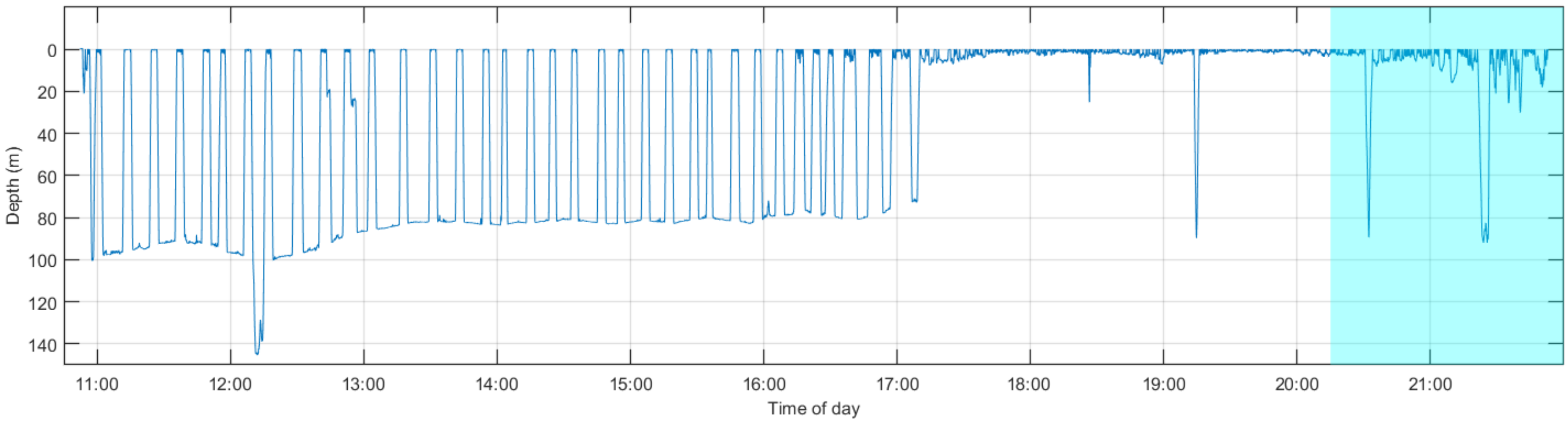


Figure 22. Dive-depth profile (in meters) for NARW 3241 (CATS eg052524-01) with hours between sunset and sunrise shaded blue.

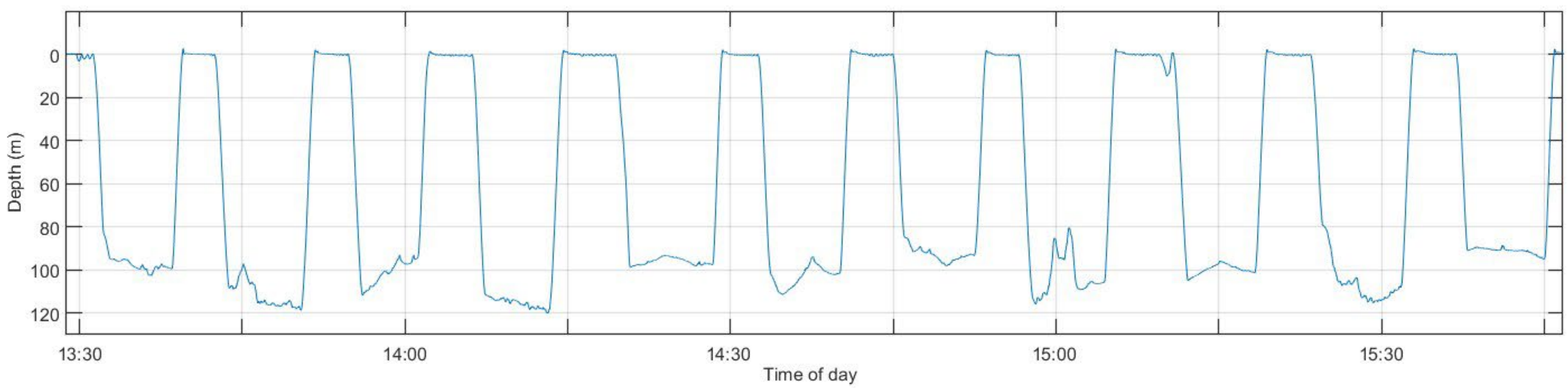


Figure 23. Dive-depth profile (in meters) for NARW 3908 (DTAG eg24_146a).

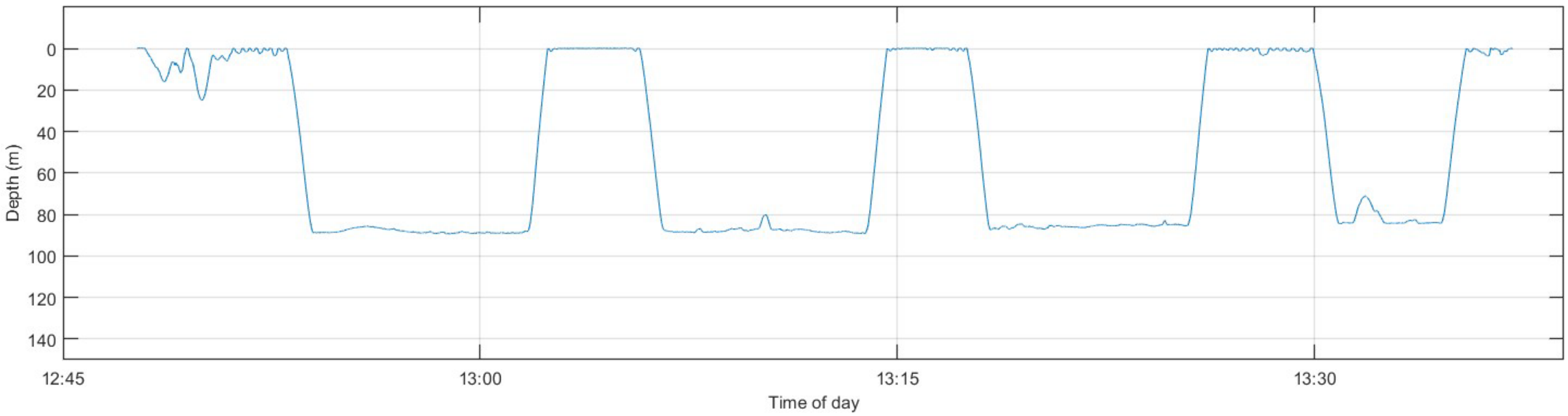


Figure 24. Dive-depth profile (in meters) for NARW 3391 (CATS eg052924-01).

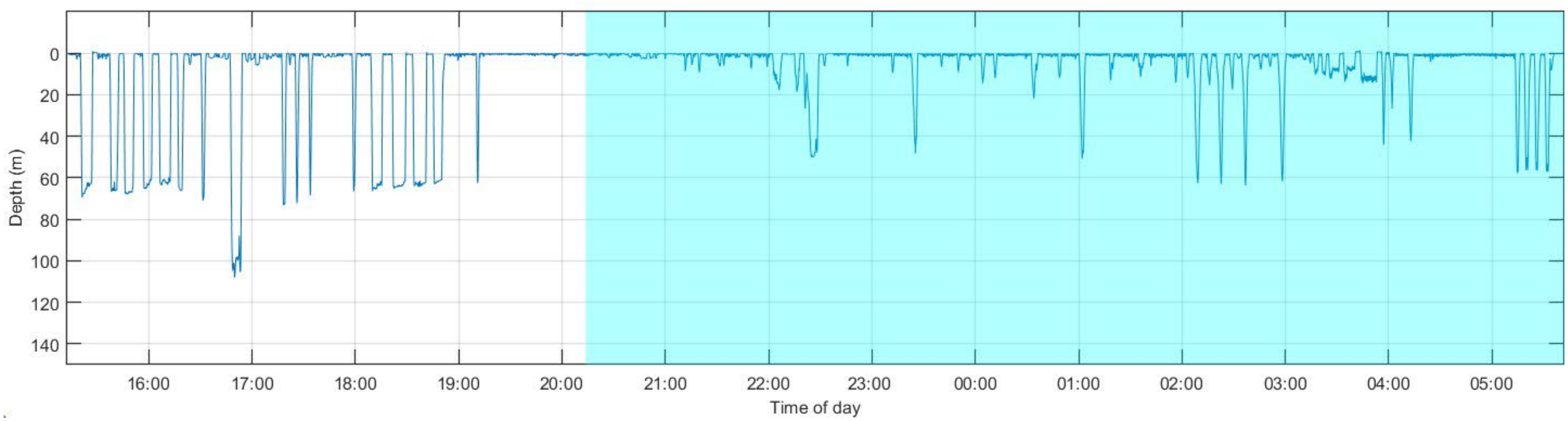


Figure 25. Dive-depth profile (in meters) for NARW 3101 (DTAG eg24_150a) with hours between sunset and sunrise shaded blue.

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 of Cape Hatteras, North Carolina. The project advances approaches developed from previous BRS field and analytical work supported by the U.S. Navy's LMR program and ONR Marine Mammal 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 for these types of responses in relation to key exposure variables (e.g., received sound level, proximity, animal behavioral state). These measurements have and will continue to directly contribute to more informed assessments of the probability and magnitude of potential behavioral responses of these species. These data support the U.S. Navy in meeting their mandated requirements to assess the impacts of training and testing activities on protected species, specifically regarding baseline behavior and exposure-response, and by providing sufficiently large sample sizes to begin addressing exposure consequences, thus directly addressing focal areas for the U.S. Navy's MSM Program.

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

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

Building on earlier field seasons of this project (see the Project Profile), the 2024 field season included the first successful CEE using U.S. Navy CAS MFAS signals for any marine mammal species and the first with any CAS signal and high-priority *Ziphius* individuals. A single, extended field period spanned from summer into autumn. Despite challenging weather and focal species availability conditions, four satellite tags were deployed during suitable weather windows ahead of anticipated U.S. Navy vessel availability. Multiple CAS-capable vessels were scheduled for possible coordination, thanks to sustained coordination and planning between the field team and USFFC. A successful CAS CEE was coordinated with the U.S. Ship (USS) *Thomas Hudner* involving three of the tagged *Ziphius*. A second CAS-capable ship was scheduled and available for coordination, but additional tagging efforts in advance of the availability window of the ship were unsuccessful.

A brief synthesis of experimental methods is provided, as well as summaries of field efforts, tagging results, and exposure-response results for the first-ever CAS CEE conducted with the USS *Thomas Hudner* in 2024. A synthesis of the peer-reviewed papers that have been or are in the process of being published is also provided.

Full details of the experimental design, analytic approach, and field logistics can be found in the 2024 annual progress report (Southall et al. 2025).

2.5.1 Field Effort

Atlantic BRS field efforts for 2024 were spread adaptively based primarily on weather and potential U.S. Navy vessel availability across a single window spanning summer through early autumn. Field teams included a team (4 to 5 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 2024 tag deployments and CEEs, as well as re-sighting of focal individuals thereafter.

Overall, four satellite tags were deployed, all on *Ziphius*, one of the two focal species of the Atlantic BRS (along with short-finned pilot whales) (**Table 15**, **Figure 26**).

Table 15. Satellite tag deployments for *Ziphius* during Atlantic BRS field efforts in 2024.

Species[a]/ Tag ID	Deployment Date	Deployment Latitude (°N)	Deployment Longitude (°W)	Dive Data Streams	Tag Duration (days)
ZcTag147_DUML	22 June 2024	35.5948	74.7122	5-min time series	9
ZcTag148_DUML[b]	22 June 2024	35.5921	74.7112	5-min time series	71
ZcTag149_DUML	14 July 2024	35.5980	74.7269	5-min time series	39
ZcTag150_DUML	14 July 2024	35.6043	74.7278	5-min time series	51

Key: ID = Identification Number; °N = degrees North; °W = degrees West
[a] Zc = *Ziphius cavirostris*; DUML = Duke University Marine Laboratory
[b] Fastloc® GPS tag

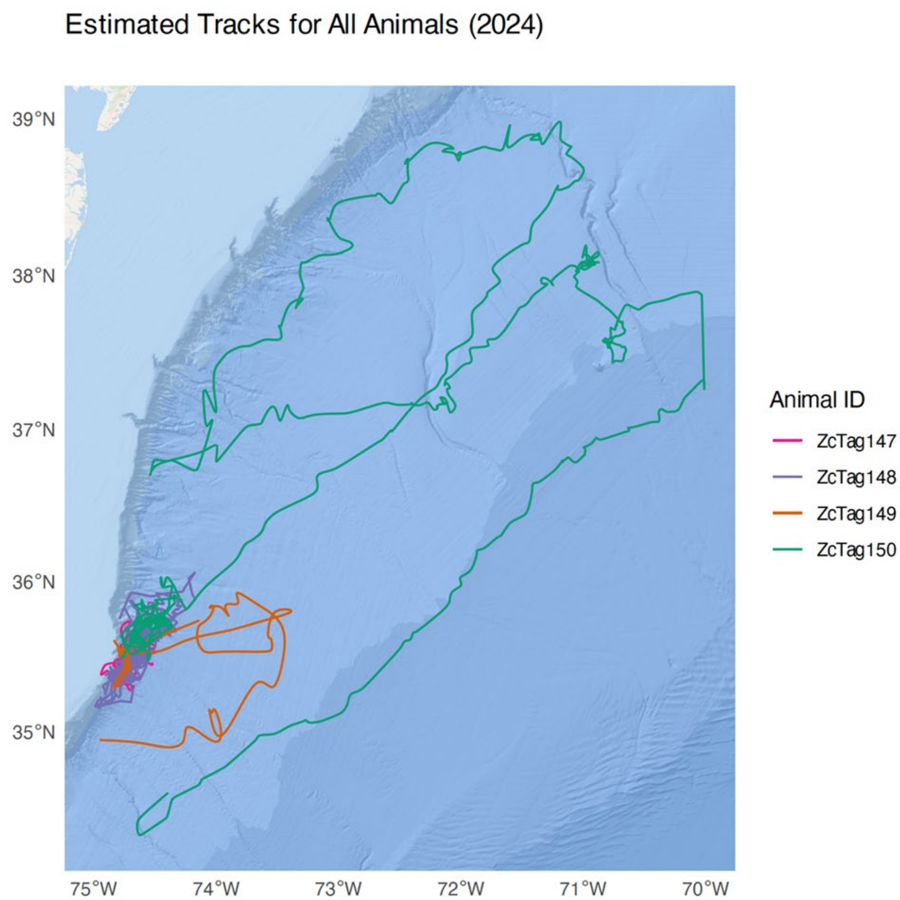


Figure 26. Predicted tracks from multiple imputations for all (*n* = 4) beaked whales tagged during Atlantic BRS field efforts in 2024.

2.5.1.1 Summary of 2024 Field Effort: Accomplishments and Assessment

Accomplishments:

- Successful deployment of four satellite tags on Ziphius, including one Fastloc® GPS tag (identified as a specific objective in the 2022 annual report)
- Conducted first-ever successful CAS CEE with U.S. Navy sources for any species and first-ever for *Ziphius* with any CAS source
- Obtained thousands of photo-ID images
- Continued success with research platform R/V *Shearwater* in locating and tracking animals, including successful overnight tracking ahead of and following CEE
- Sustained efforts to relocate satellite-tagged animals in the field using goniometer detections, increasing chances of subsequent tag deployments; improving animal pseudotracks by providing high confidence surface locations; and resulting in many photo-ID re-sights to evaluate group composition, social interactions, and biopsy samples
- Demonstrated somewhat atypical overall movement patterns using long-term tags, consistent with unusual sighting patterns; conducted multiple scouting trips to evaluate and assess

Assessment of Field Approach:

- The combined team with USFFC successfully identified multiple capable CAS-capable ships and scheduled two for direct participation with the Atlantic BRS project during 2024. This included several new approaches to consider vessels from multiple bases of operation and coordination. Earlier efforts had focused on vessels based from nearby Norfolk Naval Stations for local training operations, whereas this CEE was with a vessel transiting through the study area from a different geographical location. The resulting success of this slightly different approach opens additional options for scheduling and coordinating vessel participation in subsequent field efforts.
- Field teams were adaptive in working through challenging weather conditions throughout the year but especially during June. Based on modifications made during 2024 to shift U.S. Navy ship scheduling later, and this observation of poor conditions occurring again earlier in the season, advance discussions for the 2025 field effort have again included plans to shift field effort and request U.S. Navy ship dates slightly later in the summer.
- Field teams had continued success in locating and tagging beaked whales. However, somewhat atypical sighting conditions and distributions occurred. This both limited tag deployment opportunities and increased the spread of focal and non-focal animals during actual and possible CEE periods.
- Satellite tags collected continuous, high-quality, satellite-transmitting tag dive data due to earlier progress in tag programming strategies to reduce/eliminate gaps in satellite tag data and improve temporal resolution for dive and behavioral data. The team successfully collected continuous dive data for up to 24-day periods, strategically covering CEE periods, as designed. Long-duration (up to 71 days) functioning of tags in reporting Argos positions was again experienced.

2.5.2 Controlled Exposure Experiments

One CEE sequence was conducted during the Atlantic BRS 2024 field effort. As noted above, a dedicated CAS-capable ship (USS *Thomas Hudner*) was scheduled and coordinated with the Atlantic BRS team to support the first MFAS CAS CEE for this project. Three *Ziphius* with SPLASH-10 tags were monitored visually (focal) and remotely (non-focal) during this experiment (CEE #2024_01; see **Table 16**).

Table 16. CEEs conducted during Atlantic BRS field efforts in 2024.

CEE ID	Date	CEE Type	Focal Whales	Non-focal Whales	CEE Duration (min)	Start CEE Source Latitude (°N)	Start CEE Source Longitude (°W)
#2024_01	21-Jul-2024	MFAS CAS	ZcTag150	ZcTag148 ZcTag149	60	35.9728	74.3994

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

Table 17 provides a narrative summary of the control CEE sequence. The full 2024 annual progress report for this project (Southall et al. 2025) includes a complete synthesis of the CEE conducted, with standardized tables and figures. These include: (1) a metadata summary, (2) planning 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 *Thomas Hudner* for Atlantic BRS CEE #2024_01 is shown in **Table 18** and **Figure 27**.

Table 17. Metadata summary for Atlantic BRS CEE #2024_01.

CEE #2024_01	
Date:	21 July 2024
Type:	CAS from USS *Thomas Hudner*
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):	13:24
Start lat/lon (source):	35.9728; –74.3994
End time (UTC):	14:42 (60 min exposure duration matched to operational PAS MFAS)
End lat/lon (source):	35.9182; –74.2480
Beaked whales tagged during CEE:	(*n* = 3): ZcTag150 (focal satellite-tagged animal) Non-focal whales: ZcTag148; ZcTag149
Estimated Range (start CEE):	~26 km at start (focal follow/goniometer locations) for focal
Modeled Max RL:	Variable for final position model runs/depths -> 123–128 dB RMS (across band) = 140–148 dB SEL per ping (based on model runs 11–14; see Table 4 in Southall et al. 2025)
CEE #2024_01 – Narrative Summary	
With sustained coordination and adaptive planning based on animal locations and RL modeling, the USS *Thomas Hudner* conducted the first-ever CAS MFAS CEE using U.S. Navy sonar systems on 21 July 2024. Three *Ziphius* were being monitoring with tag sensors during this CEE. This included a focal individual (ZcTag150) with a satellite tag reporting both dive and location data that was also being tracked in real time before, during, and after this CEE by researchers on the R/V *Shearwater*. Two non-focal whales (ZcTag148 and ZcTag149) also reported location tag data but were not being tracked directly during the CEE. The USS *Thomas Hudner* location and track was positioned accordingly using iterative RL modeling and refinement (see **Table 18**) based on movement patterns of the focal whale. These model estimates yielded estimated start ranges of 14–17 nm (26–31 km) to yield RLs at the whale within specified ranges. Known locations and post-hoc calculations of the focal whale location yielded very similar estimated ranges at the start of the CEE. The focal whale moved away from the USS *Thomas Hudner* location during and following the CEE.	

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

Table 18. Sequential positioning for USS *Thomas Hudner* ahead of Atlantic BRS CEE #2024_01.

Position Request for *USS Thomas Hudner*	Description	Latitude (°N)	Longitude (°W)	Heading
1	Nominal initial position (provided weeks in advance)	35.90	74.50	Not specified
2	18 July 1200 EDT (~72-hour pre-exposure) based on best estimate of ZcTag150 as nominal focal at that point	36.00	74.35	190
3	19 July 1200 EDT (~48-hour pre-exposure) based on best estimate of ZcTag150 as nominal focal at that point; two other whales farther south	35.88	74.40	175
4	20 July 1200 EDT (~24-hour pre-exposure) based on best estimate of ZcTag150 as nominal focal at that point; two other whales farther south	35.90	74.45	179
5	21 July 0700 EDT: Final requested start position for USS *Thomas Hudner* based on committed focal ZcTag150 with two non-focal whales (ZcTag148 and ZcTag149) farther south; adjusted track to east-southeast based on overnight movement patterns of focal	35.98	74.35	135

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

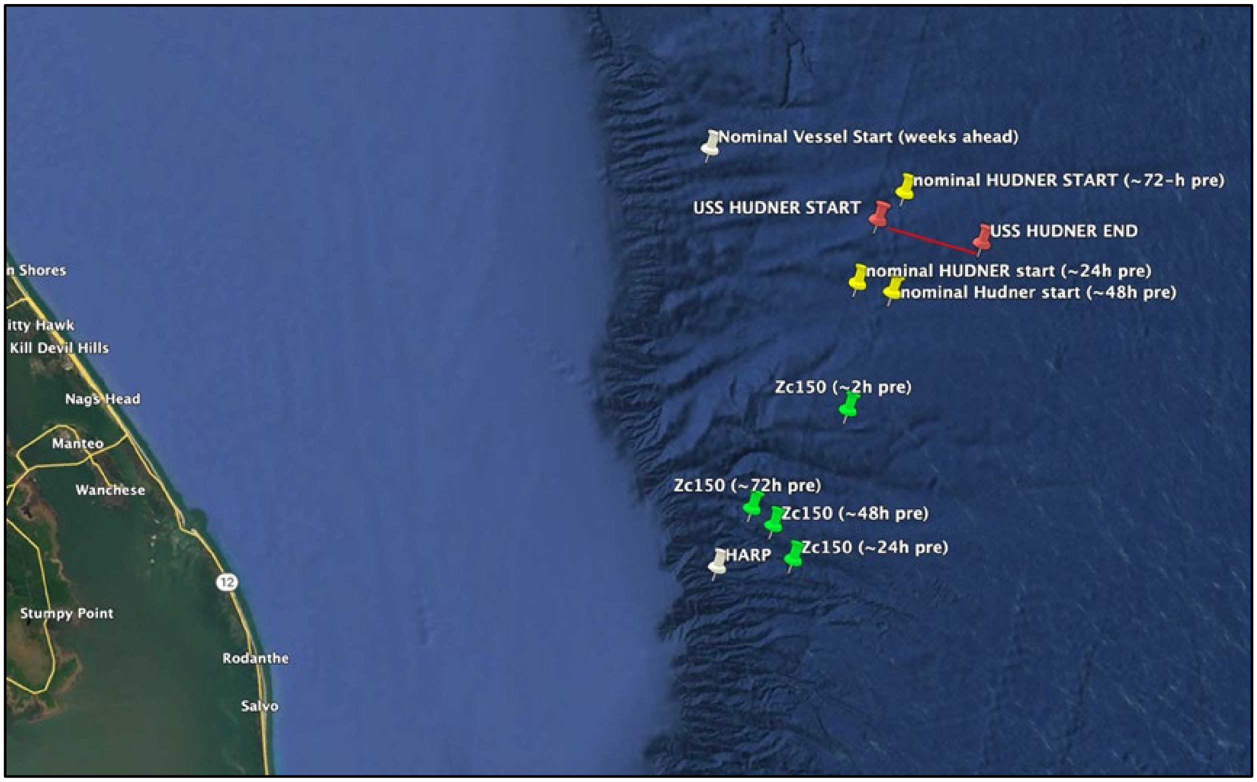


Figure 27. Sequentially requested start positions for the USS *Thomas Hudner* shown weeks (white pin) to specified days in advance (yellow pins) as well as the final start and end positions (red pins; red track ~8 nm) requested on the day of CEE #2024_01. Vessel positions are shown relative to sequential focal animal (ZcTag150) position estimates (green pins) used in RL modeling and to inform the vessel position requests.

2.5.3 Results, Analytical Developments, Publications, and Presentations

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

As the Atlantic BRS project has progressed, it is consistently producing peer-reviewed publications both directly through the project and in collaboration with the ONR-funded Double Mocha effort, which developed analytical tools and methods that are now being applied to Atlantic BRS response analyses. A summary of papers that are published, in review, or in advanced stages of development is included in **Table 19**; direct links to publications are provided where available.

Table 19. Atlantic BRS publications and manuscripts in review or advanced stages of preparation.

Category	Nominal Title/Subject	Lead Author (Institution)	Status
Baseline behavior	Diving behaviour of Cuvier's beaked whales (*Ziphius cavirostris*) off Cape Hatteras, North Carolina	Shearer (Duke 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 cavirostris*	Cioffi (Duke University)	In preparation
CEE exposure-response	Behavioral responses of *Ziphius cavirostris* to simulated mid-frequency active military sonar off Cape Hatteras, NC	Southall (SEA)	In review
Methodology – technology	Estimating RLs and horizontal avoidance with dynamic covariates in exposed animals	Schick (Duke University)	Published
Baseline behavior	Possible orientation behavior in *Ziphius*	Quick (Duke University)	In preparation
CEE exposure-response	Behavioral responses of Cuvier's beaked whales to operational mid-frequency active military sonar off Cape Hatteras, NC	Southall (SEA)	In preparation

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 (Duke University)	In preparation
Baseline behavior	Wound-healing from satellite tag deployments in *Ziphius*	Read (Duke University)	In preparation
Methodology – technology	Improvements to received level estimates with the use of Fastloc® tags in behavioral response studies	Cioffi (SEA)	In preparation

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

2.5.4 Overall Assessment and Recommendations

The following summarizes the accomplishments and general assessments for the 2024 field effort:

- Operational conditions (wind, sea state) proved challenging for much of the 2024 field season, particularly during the first month (June). This again extends a longer-term pattern of fewer overall windows of ideal conditions, which require extended periods of adaptive effort to achieve research objectives and has influenced the team to focus on windows of potential U.S. Navy ship coordination during July and August, or even into September.
- Somewhat atypical patterns of animal density and distribution were observed during 2024. This included periods with fewer sightings of focal species in workable conditions within the core study area than would be expected. Additionally, several tagged whales moved large distances from the core area of typical distributions. These patterns have been observed previously but were possibly more common than would be expected based on extensive baseline data. Combined, these suggested some atypical patterns in distribution that may have made tag deployments more challenging.
- Given the above challenges, the 2024 field season included a relatively low overall number (n = 4) of tags on high-priority Ziphius. However, this is only relative to the very high degree of success for this challenging species repeatedly accomplished within this study area. These tags still resulted in the collection of several thousand hours of movement and diving behavior.
- Deployment strategies and satellite tag programming settings were maintained as developed during earlier years, again with very positive results. Many of the 2024 tags again achieved relatively long duration deployments for returning Argos position data (up to 71 days) as well as to up to 24 days of focused, high-resolution, continuous time-series dive data.
- The 2024 field season had successful coordination and adaptive planning with USFFC colleagues in scheduling and coordinating with multiple CAS-capable vessels for coordination. Importantly, this included new adaptive measures of working with transiting vessels, including those from multiple home ports, to increase chances of success with CAS-capable ships.
- The Atlantic BRS team conducted the first-ever CEE with U.S. Navy ship-based, full-scale CAS MFAS projected from the USS *Thomas Hudner*. This CEE was planned and executed as scheduled and planned with regular coordination; adaptive planning using biological data; and close coordination, including final bridge-bridge coordination based on real-time animal behavior.
- Efforts to deploy additional tags following this successful CEE ahead of a second scheduled ship window were not successful, given the challenging environmental and focal species distribution patterns mentioned above. It was notable that a second CAS-capable ship was scheduled and available, but in this instance the limiting factor precluding another CEE was the lack of additional tagged individuals.

- Preliminary results for the nearest focal whale suggest both horizontal avoidance responses as well as dive changes, specifically longer than typical inter-deep-dive-intervals, and more and longer bounce dives than baseline. These are similar patterns as in other focal Ziphius in both simulated and real PAS CEEs at similar RLs. Interestingly, however, this whale was on a bounce dive during the exposure; despite these changes, it did not initiate an atypical deep dive as has been observed in many focal Ziphius with PAS sources. Non-focal whales at greater ranges (approximately 60 to 80 km) did not appear to exhibit avoidance or diving response changes relative to baseline behavior, based on preliminary assessments.
- The team demonstrated sustained progress in presenting and publishing results during 2024. Multiple invited and submitted technical presentations from the project were given at the international Effects of Sound on Marine Mammals conference. Several publications in baseline behavior and methodological advances occurred, and a large sample size (*n* = 72) exposure-response paper for Ziphius and simulated PAS that was slated for submission in 2024 also occurred.

Future efforts and recommendations include:

- The team was encouraged and excited about the first CAS CEE, and believe the primary need is simply to replicate the overall approach and increase sample size focused on Ziphius. While the total numbers of tagged individuals included in this initial CEE (*n* = 3) were lower than most of the operational vessel PAS CEEs, this—and the inability to match the availability of a second CAS-capable ship—was a function of somewhat challenging and unusual conditions during 2024.
- Coordination with U.S. Navy vessels should be maintained using identical approaches as previous seasons through advance and sustained planning and coordination via USFFC. The team was encouraged as well by the adaptive approach to engage vessels from multiple home ports and in transit scenarios as well as possible coordination around operational training windows. A similar strategy in scheduling up to four ships across the summer with a realistic goal of conducting CEEs with two, ideally each with many tagged Ziphius, is recommended.
- Given the repeated and proven record of successful tag deployments of both satellite tags and DTAGs, the team does not recommend any substantial changes in the overall patterns of field and tagging effort. The combination of advance deployment of satellite tags in weeks to days ahead of CEEs and DTAG deployments in the day to hours ahead of CEEs should be maintained in the context of the multi-scale design. Priority should be given to simultaneously deploying DTAGs within groups with satellite-tagged individuals. Given the extensive optimization of satellite-tag time-series settings for the Atlantic BRS field site (see: Cioffi et al. 2023), no substantive changes to satellite tag programming setting are anticipated. Further deployments of the Fastloc® GPS satellite tags are recommended for 2025 as a supplement to existing tag configurations. The team is considering a possible mix of version-3 and version-4 DTAGs in 2025.

- Field efforts to locate tagged animals with validated locations using goniometer detections, visual observations, and photo-ID should be maintained as much as possible before, and especially after, CEEs given the substantial and demonstrated improvements in spatial movement data, RL model estimates, and other factors.

Please refer to the annual progress report for detailed information on 2024 fieldwork, preliminary results from 2017 to 2023, and ongoing analyses (Southall et al. 2025).

2.5.5 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 2024 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 eight 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 Bryde's whale (*Balaenoptera brydei*), fin whale, short-finned pilot whale, Risso's dolphin, humpback whale, sperm whale, and common bottlenose dolphin (**Table 20**).

Table 20. Cetacean sightings with numbers of photo-ID images collected for species within the Cape Hatteras study area during 2024.

Species	Common Name	Number of Sightings	Number of Photo-ID Images
Balaenoptera physalus	Fin whale	1	146
Delphinus delphis	Common dolphin	2	0
Globicephala macrorhynchus	Short-finned pilot whale	28	2,615
Grampus griseus	Risso's dolphin	1	44
Megaptera novaeangliae	Humpback whale	1	51
Physeter macrocephalus	Sperm whale	2	304
Stenella frontalis	Atlantic spotted dolphin	1	0
Stenella species	Spotted dolphin species	2	0
Tursiops truncatus	Bottlenose dolphin	27	1,332
Unidentified odontocete	Unidentified odontocete	2	0
Unidentified ziphiid	Unidentified ziphiid	2	3
Ziphius cavirostris	Goose-beaked whale	31	3,306
Total		**100**	**7,801**

Note: Unidentified ziphiid may be either *Mesoplodon* sp. or *Ziphius*.

All digital images were individually graded for photographic quality and animal distinctiveness. All images of sufficient quality and distinctiveness were then sorted by individual within a sighting and assigned temporary identifications. The best image for each individual in that sighting was selected, and the images were cropped and placed into a folder for each sighting.

Images of 69 newly identified animals were added to existing photo-ID catalogs of fin whales, short-finned pilot whales, Risso's dolphins, humpback whales, sperm whales, bottlenose dolphins, and *Ziphius* (**Table 21**). Additionally, 16 new photo-ID matches were made within the sperm whale, bottlenose dolphin, and *Ziphius* catalogs. In addition to the existing 12 photo-ID catalogs previously created for cetacean species within the Cape Hatteras area, a new catalog was created during 2024. On 14 July 2024, the field team encountered and photographed what appears to have been a Bryde's whale. It was identified as being a member of the Bryde's whale complex based on the three parallel ridges on the rostrum anterior to the blowholes (**Figure 28**). Images were sent to Dr. Keith Mullins at the NOAA SEFSC, where they were compared to a catalog of Rice's whales (*Balaenoptera ricei*) from the GOM, but no photographic matches were made. In total, these 13 catalogs include more than 2,300 distinct individuals, with 660 individuals re-sighted across all species (**Table 21**).

Table 21. Summary of all images collected by species during fieldwork within the Cape Hatteras study area during 2024 showing number of new identifications, photo-ID catalog sizes, number of new re-sights, and total re-sights to date.

Species	New Images Collected	No. New IDs	Catalog Size	New Re-sights	Re-sights to Date
Balaenoptera physalus	146	1	2	0	0
Delphinus delphis	0	0	46	0	1
Globicephala macrorhynchus	2,615	2	1,390	0	480
Grampus griseus	44	7	54	0	6
Kogia species	0	0	1	0	0
Megaptera novaeangliae	51	2	4	0	0
Mesoplodon species	0	0	10	0	2
Physeter macrocephalus	304	2	32	2	3
Stenella clymene	0	0	3	0	0
Stenella frontalis	0	0	42	0	0
Tursiops truncatus	1,332	7	376	1	20
Ziphius cavirostris	3,306	48	359	13	148
Total	**7,923**	**69**	**2,319**	**16**	**660**

Key: ID = Identification Number; No. = Number

Figure 28. Photograph of Bbr_001 taken in July 2024; note the presence of three rostral ridges.

2.5.5.1 Ziphius

A total of 47 new identifications were added to the *Ziphius* photo-ID catalog during 2024, and 13 new re-sights were made (both within and between years). The current re-sight rate for *Ziphius* within the Cape Hatteras area is 41 percent. To date, 101 of the 148 (68 percent) re-sighted *Ziphius* have been documented in multiple years, and 57 of those have been re-sighted more than 3 years after the initial observation (**Table 22**). Four *Ziphius* were tagged during 2024; however, none of these tagged whales had prior photo-ID histories.

Table 22. 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	47
1 to 2	26
2 to 3	18
3 to 4	21
4 to 5	11
5 to 6	10
6 to 7	10
7 to 8	3
8 to 9	2
Total	**148**

The *Ziphius* sighted most frequently is Zca_049, which has been photographed on 13 occasions from 2018 to 2023 and satellite-tagged in 2021. Two *Ziphius* share the longest interval between re-sightings of 8 to 9 years. Zca_016 was first photographed by the UNCW aerial survey team in August 2014. It was re-sighted by this team in 2015, 2019, 2020, and 2022 and notably in July 2023, when it was accompanied by a calf. Over an almost 9-year period, this female acquired few if any scars (**Figure 29**). Zca_024 was satellite-tagged in May 2016 (ZcTag046); at that time, it already had erupted teeth. It was seen again in 2017 and 2020, when it was equipped with a second satellite tag (ZcTag103) and was photographed again in July 2024. It appears that both adult males and females exhibit site fidelity to the Cape Hatteras area.

Individual *Ziphius* have been observed associating in the same groups over periods of days to weeks, but long-term social associations are still uncommon. Previously, only four instances of a long-term association had been documented; two adult male pairs, and two adult male and adult female pairs. An additional long-term association was found in 2024. Zca_049, an adult male, was seen with Zca_080r in May 2018 and again in June 2023; in 2023, Zca_080r was accompanied by a calf, confirming she is an adult female. This is the third long-term association Duke University researchers have seen between an adult male and an adult female.

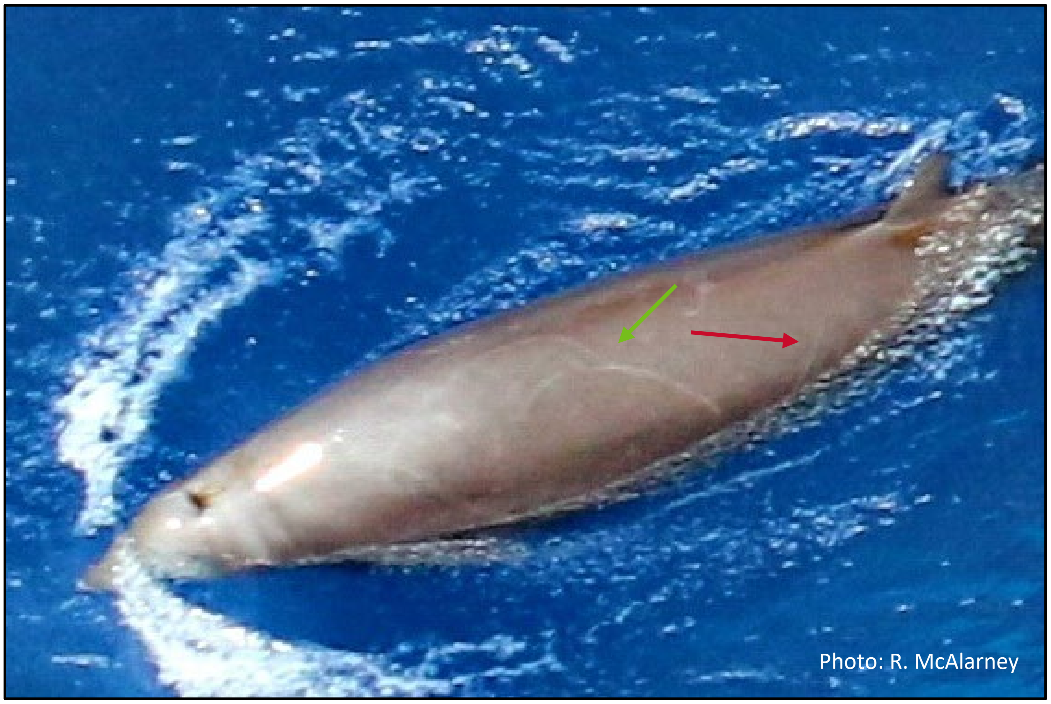


Figure 29. Photographs of Zca_016 first seen by the UNCW aerial survey team in August 2014 (top) and most recently re-sighted by Duke University researchers in July 2023 (bottom). Note that few, if any, scars were acquired during that time.

In total, five 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 is ongoing (**Table 23**). Previously, nine photo-ID matches had been made between four of the catalogs; the three longest-term re-sightings of *Ziphius* are derived from these inter-catalog comparisons. These include: a match between the HAT and UNCW catalogs of an adult female with 8 years between re-sightings; a match between the HAT and Sutherland/Patteson catalogs of an adult male, first photographed by Kate Sutherland in 2010 and satellite-tagged by Duke University researchers 10 years later in August 2020; and an adult male photographed by Kate Sutherland in May 2004 and satellite-tagged by the Duke University team in July 2019, 15 years after its first sighting. An additional inter-catalog match was found during this reporting period. Kate Sutherland photographed Zca_029 off Oregon Inlet in July 2003. Duke University satellite-tagged this adult male in May 2017, and it was re-sighted again in August 2021 with two healed scars on the dorsal fin (**Figure 30**). This is currently the longest photo-ID match of a *Ziphius* in the Northwest Atlantic

Table 23. 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	2007–2024	359
UNCW catalog	Cape Hatteras, North Carolina Aerial Surveys	2012–2017	51
NEAQ catalog	Northeast Canyons and Seamounts Marine National Monument Aerial Surveys	2017–2023	7
HDR catalog	Norfolk, Virginia	2019–2022	3
SBU catalog	New York Shelf Break, New York	2019	4

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

To date, six *Ziphius* catalogs for the Western North Atlantic have been created and will continue to be maintained by Duke University researchers. A seventh *Ziphius* catalog is planned, which will include aerial images collected by research staff at the Clearwater Marine Aquarium Research Institute (CMARI). 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 (40 miles) offshore, from mid-November to mid-April. These would be valuable images as the team works during months when Duke University has little or no offshore effort, and CMARI covers an extensive geographic area. Duke University has received permission from the U.S. Army Corp of Engineers for access to these images and are coordinating with CMARI as how to best share images and data.

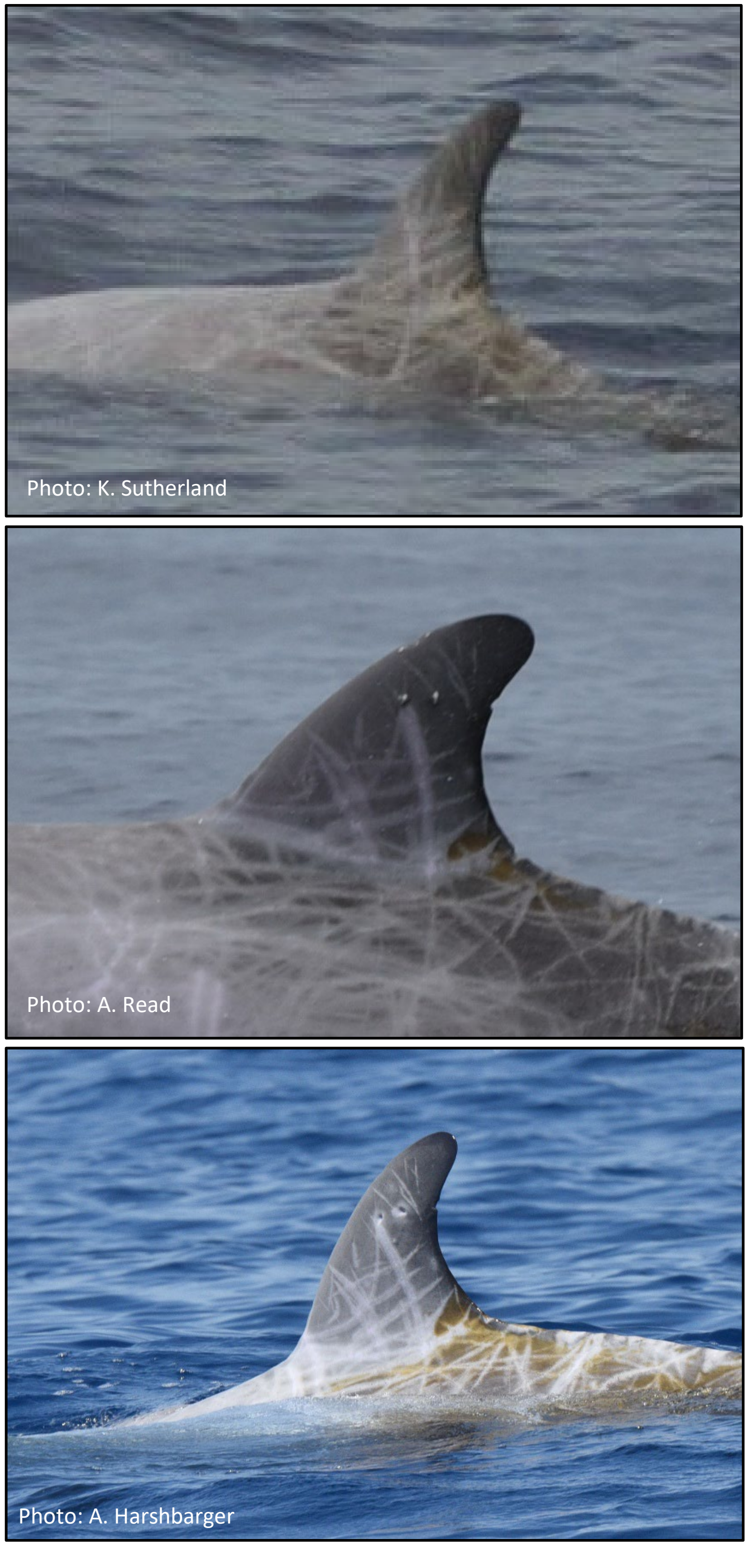


Figure 30. Photographs of Zca_029, initially seen in July 2003 (top), satellite-tagged in May 2017 (ZcTag054; middle), and re-sighted in August 2021 (bottom).

During summer 2024, Maya Reilly, an undergraduate student at Duke University, examined the stability of goose-beaked whale social associations over time. She analyzed all re-sightings of individual goose-beaked whales, using the social analysis program SOCPROG, developed by Hal Whitehead. SOCPROG produces a matrix of association indices for each pair of whales that ranges from 0.0 (animals never photographed together) to 1.0 (animals always photographed together). She used SOCPROG to create a social network, using only whales with four or more re-sightings and an association index greater than 0.5. There was no defined grouping within the social network.

Kira Lichtenfeld, another undergraduate student at Duke University, investigated the rate of wound healing in *Ziphius* off Cape Hatteras. She examined photographs of individuals with new wounds, caused by conspecifics, and followed the process of wound healing. She characterized new wounds as being open with broken skin, appearing textured, often pink or orange and sometimes containing pus (**Figure 31**). She calculated the number of days between the sighting of a new wound and subsequent re-sightings, and scored whether the wound had healed, as characterized by a flat, white scar (**Figure 31**). She found that the shortest healing time of a wound was 35 days. This information is useful in defining scar acquisition rate over time.

Ms. Lichtenfeld also used her analysis to determine if there is seasonality to the acquisition of new wounds and calculated the rate of wound acquisition for each month. The results were not statistically significant but suggested a trend of increased wound acquisition rate during August. More data are needed, but her results suggest that there may be some seasonality to reproduction, because new wounds on adult males likely reflect agonistic social interactions during competition for mates (MacLeod 1998). More data are needed from winter months when Duke University has little field effort.

Danielle Waples presented a poster, titled "Goose-beaked whales (*Ziphius cavirostris*) off Cape Hatteras, North Carolina, USA live in a fission-fusion society," at the 25th Biennial Conference on the Biology of Marine Mammals held in Perth, Western Australia, from 11 to 15 November 2024. The poster provided insights into the social structure of *Ziphius* off Cape Hatteras, which included calculating catalog size and photo-ID re-sight rates, both within and between years, and the range of group sizes. Additionally, fission-fusion events (joins and exits into or out of a group) were calculated by comparing the identities of individuals in sequential sightings of groups. The focus was on groups re-sighted the day after their initial sighting, and an average of 4.3 joins/exits occurred per day (± 3.5), which is much lower than published rates from other odontocetes. These findings suggest that *Ziphius* off Cape Hatteras live in a fission-fusion society, in which long-term associations are rare, but short-term associations of days to weeks are common. These findings provide important, new information on the social structure of this *Ziphius* population that can be used to evaluate their social responses to MFAS.

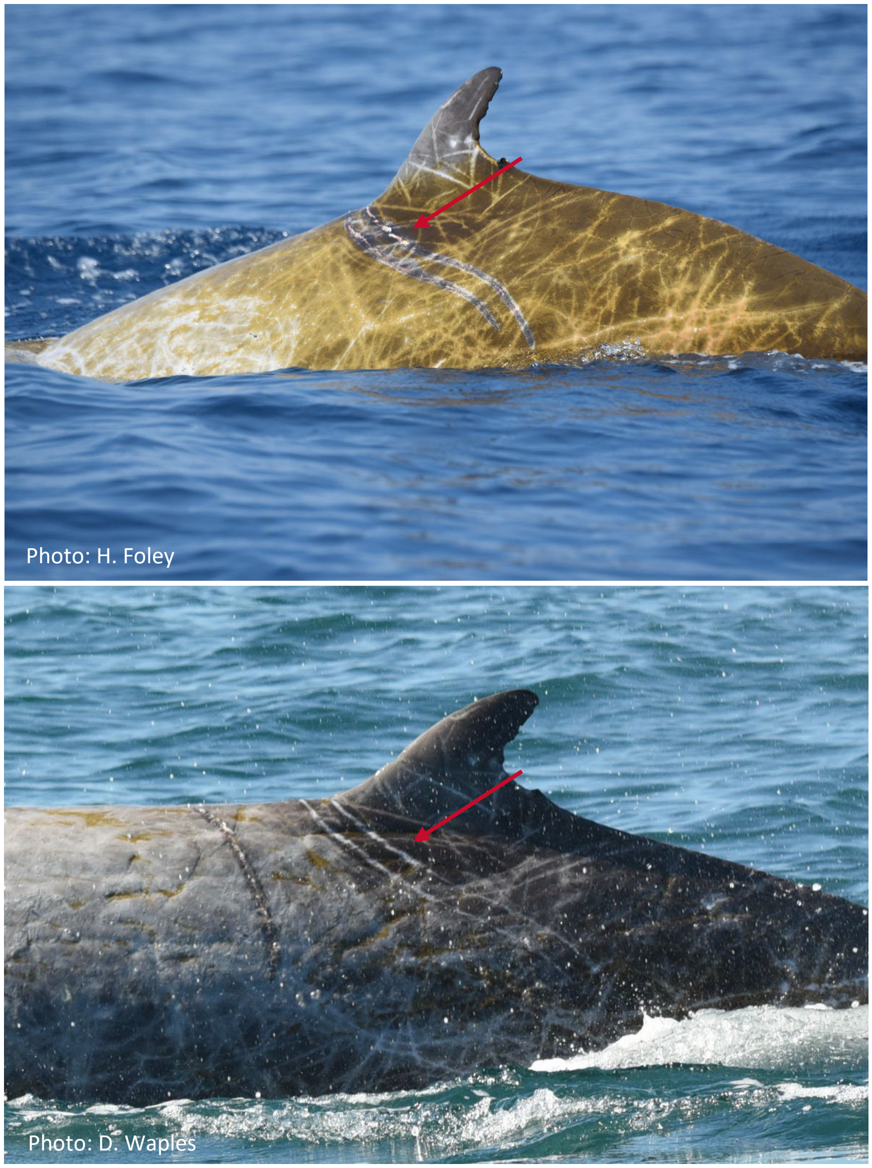


Figure 31. New wound on Zca_031 photographed on 18 August 2020; the wound is characterized by textured, broken, pink skin (top). Healed scar on Zca_031 photographed on 01 October 2020; the scar is closed, flat, and white in appearance. Note that an additional new wound is anterior to the healed scar (bottom).

2.5.5.2 Short-finned Pilot Whales

Two new identifications were added to the short-finned pilot whale catalog during 2024. No new individuals were re-sighted; however, some individuals were photographed during 2024 that had been previously re-sighted. The current re-sight rate of short-finned pilot whales is 34 percent, unchanged from 2023. More than 200 short-finned pilot whales have been seen on three or more occasions, and 24 animals have been re-sighted more than six times. The short-finned pilot whale most frequently re-sighted is Gma_6-078, an animal that has been photographed on 12 occasions over a 17-year period. It was first seen in May 2007 and re-sighted multiple times in 2008 and 2015; it was re-sighted again in 2018, when it was equipped with a satellite tag (GmTag218) and finally seen again in May 2024 (**Figure 32**).

Short-finned pilot whales return to or are resident within the Cape Hatteras study area over extended periods. More than 120 pilot whales have records of 5 or more years between their first and last sightings, and 26 individuals have histories that span 10 or more years (**Table 24**). In addition to the 17-year re-sight mentioned above, another 17-year re-sight was made during this reporting period. Gma_6-097 was first seen in August 2007. It was re-sighted several times in 2010, again in 2015, and finally in May 2024 (**Figure 33**). These two 17-year re-sights are the longest found within the HAT short-finned pilot whale catalog. These long-term photo-ID records demonstrate that short-finned pilot whales exhibit strong, but intermittent, site fidelity to the Cape Hatteras area.

Table 24. Frequency distribution of the number of years between first and last sightings of photo-identified short-finned pilot whales within the Cape Hatteras study area.

Number of Years Between First and Last Sighting	Number of Individuals
Less than 1	141
1 to 2	43
2 to 3	44
3 to 4	64
4 to 5	65
5 to 6	17
6 to 7	20
7 to 8	45
8 to 9	14
9 to 10	1
10 to 11	12
11 to 12	9
More than 12	5
Total	**480**

The 13 newly identified short-finned pilot whales added to the Cape Hatteras photo-ID catalog during 2023 and the 2 whales from 2024 were systematically compared to catalogs for this species from Onslow Bay, North Carolina, and Jacksonville, Florida. Four pilot whales were previously matched between the Cape Hatteras and Onslow Bay study areas. These four photo-ID matches are the only short-finned pilot whale matches documented between the Cape Hatteras and Onslow Bay catalogs. To date, no matches have been made between the Cape Hatteras and JAX catalogs.

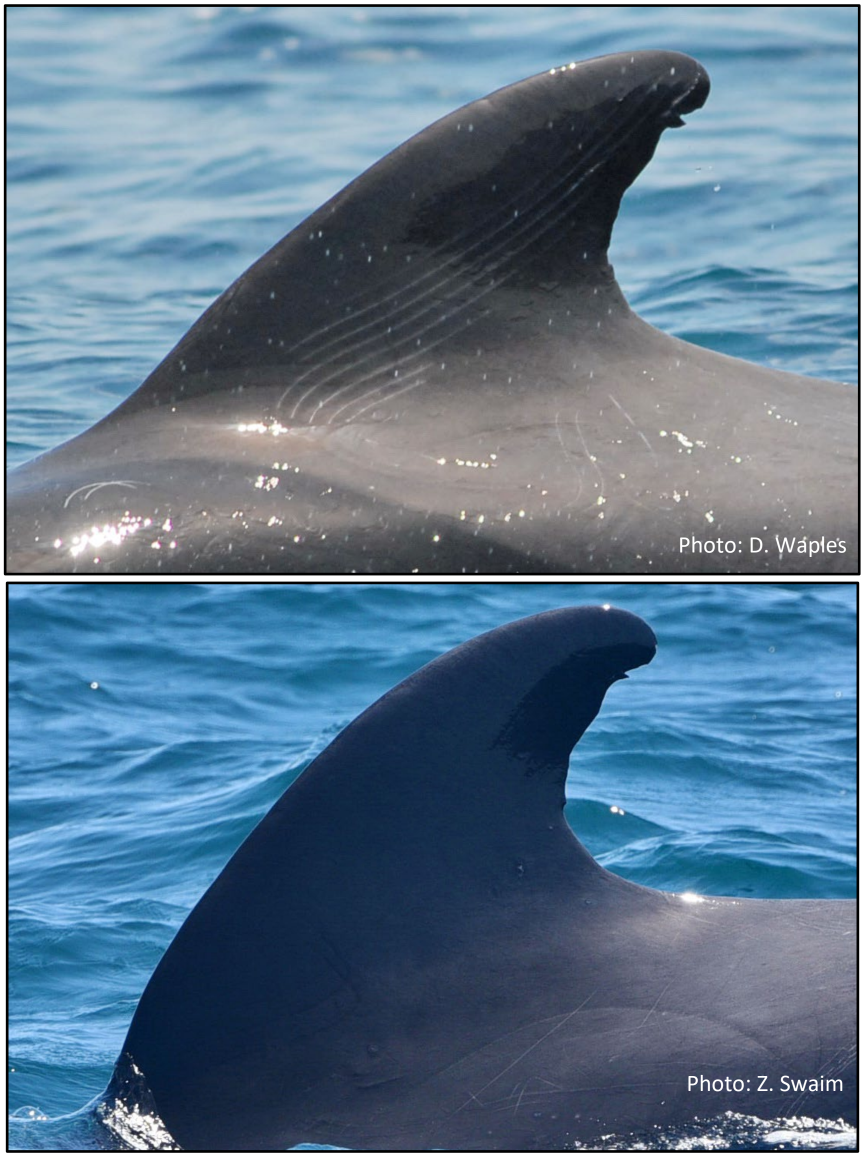


Figure 32. Photographs of Gma_6-078 in May 2007 (top) and May 2024 (bottom).

Figure 33. Photographs of Gma_6-097 in August 2007 (top) and May 2024 (bottom).

Images of short-finned pilot whales collected by HDR Inc. researchers during NFC surveys in 2024 were contributed for analysis (**Section 2.4.4**, Engelhaupt et al. 2025). Approximately 900 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 4 new individuals were added to the Norfolk short-finned pilot whale catalog; this catalog currently contains 324 individuals (**Table 25**). These 4 new individuals were compared to the HAT catalog, which contains 1,390 individuals; however, no new matches were made. To date, 47 matches have been made between the Norfolk and HAT catalogs. The new individuals were also compared to the short-finned pilot whale catalogs from Onslow Bay, North Carolina; Jacksonville, Florida; and Stony Brook University, New York, but no matches were made.

Table 25. Catalog sizes for short-finned pilot whales within the NFC area, including the original 2015–2019 catalog and individuals added during recent photo-ID efforts.

Species	2015–2019 Catalog	2020–2022 Catalog	2022–2023 Catalog	2023–2024 New IDs	Current Catalog Size	New Re-sights	Total Re-sights
Globicephala macrorhynchus	230	295	320	4	324	0	11

Note: ID = Identifier

Currently, Duke has created short-finned pilot whale catalogs for six research locations (**Table 26**). 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 these inter-catalog comparisons. These catalogs will increase the understanding of movements of short-finned pilot whales along the U.S. East Coast, GOM, and Caribbean.

Table 26. 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	2006–2024	1,390
OSB catalog	Onslow Bay, North Carolina	2007–2013	24
JAX catalog	Jacksonville, Florida	2009–2018	52
HDR catalog	Norfolk Canyon, Virginia	2015–2024	324
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 Lab catalog from research trips off Cape Hatteras; OSB catalog = Duke University Marine Lab catalog from research trips off Onslow Bay; JAX catalog = Duke University Marine Lab 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

2.5.5.3 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, 109 satellite tags have been deployed on 103 individual *Ziphius* between 2014 and 2024, and 70 of these animals (64 percent) have been re-sighted. Many re-sightings occurred within the same field season, but 41 whales (58 percent) were photographed at least 1 year after tagging.

ZcTag090 was satellite-tagged in July 2019, re-sighted once during that field season, and not sighted again until July 2024. Both the tag and hardware had been shed, with only two small scars remaining. ZcTag121 was tagged in July 2021; it was re-sighted in June 2022, and still had the satellite tag and associated hardware, although the tag was no longer transmitting. It was photographed again in August 2024, and the tag and hardware had been shed, leaving two scars on the dorsal fin (**Figure 34**). It was accompanied by a small calf, confirming that this whale is an adult female.

During 2024, two *Ziphius* were re-sighted for the first time since they were satellite-tagged. ZcTag083 was tagged in May 2019 and not sighted again until it was photographed in July 2024. The tag and hardware had been shed, with two scars remining. Finally, ZcTag141, an adult male, was satellite-tagged in July 2023 and was photographed in August 2024. The tag and hardware had been shed, and there was a new healed notch on the trailing edge of the dorsal fin.

To date, 80 satellite tags have been deployed on 79 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. One satellite-tagged short-finned pilot whale was re-sighted during this reporting period. GmTag218 had been photographed in 2007, 2008, and 2015; it was satellite tagged in August 2018. It was photographed again in May 2024 (**Figure 35**). The tag and hardware had been shed, and only a very small scar remained.

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 2025.

For more information regarding this study, refer to the annual progress report for this project (Waples and Read 2025).

Figure 34. Photographs of ZcTag121 during satellite-tagging in July 2021 (top), and at re-sight in August 2024; note the healed scars on the dorsal fin (middle) and the young calf accompanying her (bottom).

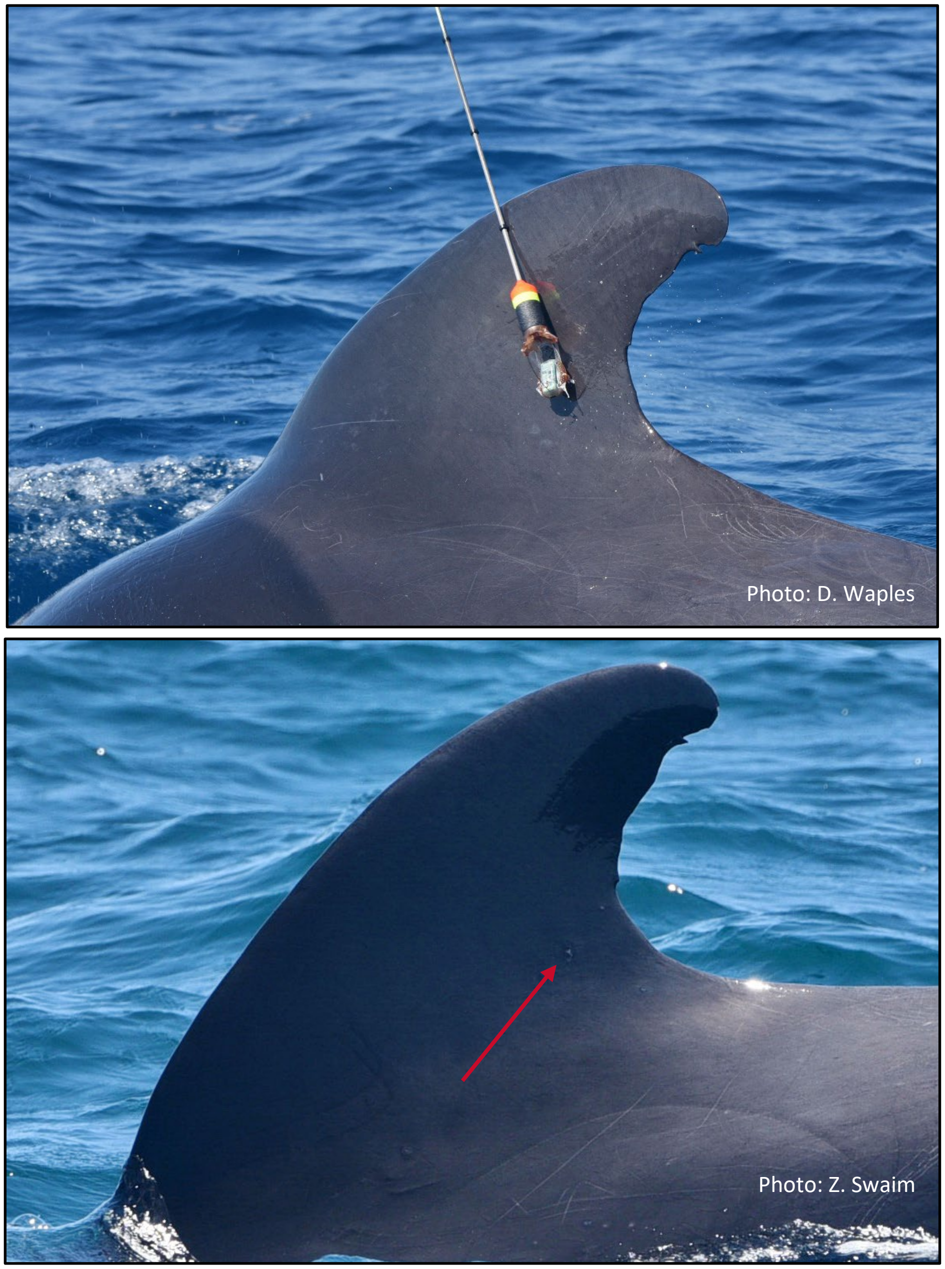


Figure 35. Photographs of GmTag218 during satellite-tagging in August 2018 (top) and re-sight in May 2024 (bottom); note the very small, healed scars at the base of the dorsal fin.

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 to assist with the implementation of the Marine Mammal Monitoring on Navy Ranges (M3R) passive acoustic system in conjunction with the Naval Undersea Warfare Center Division Newport (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 2024.

Surveys were conducted from the R/V *Shearwater* in May 2024 (**Table 27**, **Figure 36**, **Figure 37**) by researchers from Duke University. Vessel surveys in 2024 were conducted for a total of 3 days within the JAX study area, and for 2 additional days during transits from and to Beaufort, North Carolina, totaling 542.5 km and 30.08 hours of survey effort (**Table 27**). These surveys were conducted in Beaufort sea states 1 to 4 and covered the JSWTR site (**Figure 36**, **Figure 37**) as well as shelf and pelagic waters between Florida and North Carolina during transits. Additional surveys were anticipated in October and November, but the power to JSWTR was impacted by Hurricane Milton.

Table 27. Dates, distances, and durations surveyed during vessel surveys within the JAX survey area in 2024.

Date	Beaufort Sea State	Distance Surveyed (km)	Survey Time (hours:minutes)	At-Sea Time (hours:minutes)	Platform
7-May-2024	3–6	—	—	18:40	R/V *Shearwater*
8-May-2024	3	75.9	4:24	23:23	R/V *Shearwater*
9-May-2024	—	—	—	—	—
10-May-2024	—	—	—	—	—
11-May-2024	3–4	130.5	9:51	18:05	R/V *Shearwater*
12-May-2024	2–4	192.6	10:47	24:00	R/V *Shearwater*
13-May-2024	0–4	143.5	5:03	14:55	R/V *Shearwater*

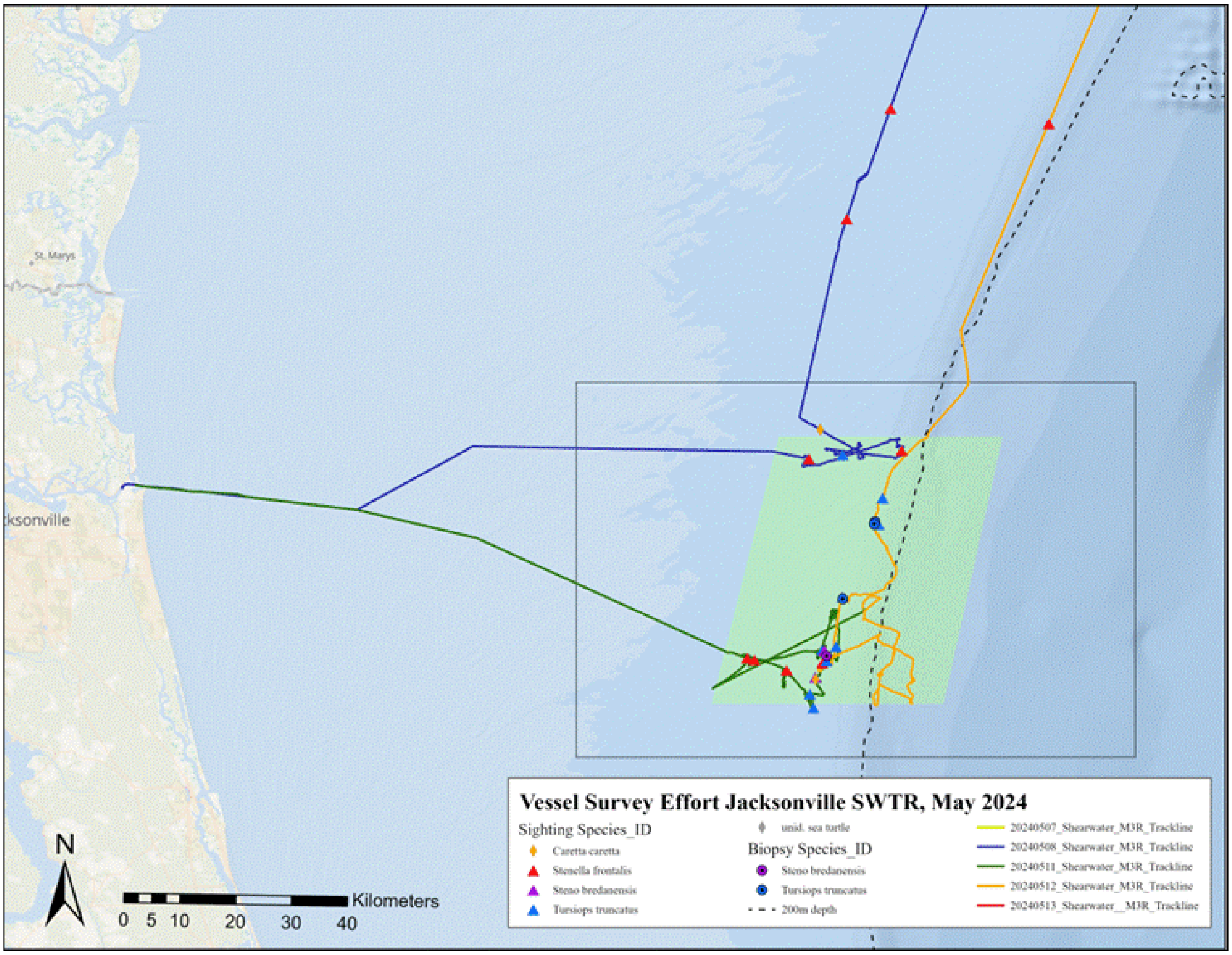


Figure 36. Vessel survey effort conducted by the R/V *Shearwater* in May 2024 within the JAX OPAREA. The gray rectangle is the JAX study area, and the green shaded parallelogram encompasses the JSWTR.

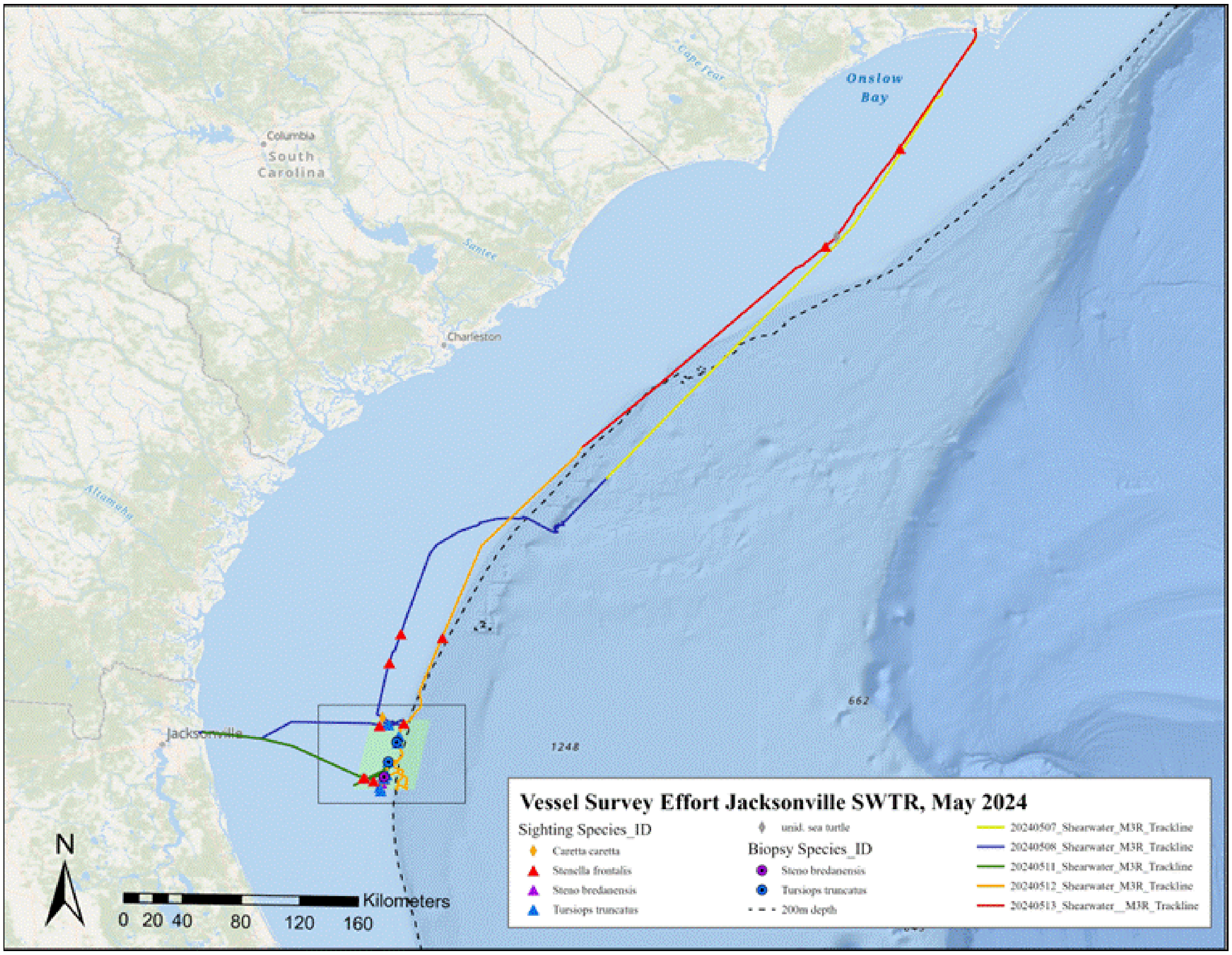


Figure 37. Vessel survey effort conducted by the R/V *Shearwater* in May 2024 during transit and within the JAX OPAREA. The gray rectangle is the JAX study area, and the green shaded parallelogram encompasses the JSWTR.

Twenty-two cetacean sightings were recorded, and most (90 percent) comprised two species: Atlantic spotted dolphins (*n* = 11) and common bottlenose dolphins (*n* = 9) (**Figure 38**). Two groups of rough-toothed dolphins were also observed. Two sightings of loggerhead sea turtles and one unidentified sea turtle were also recorded. Consistent with observations in previous years, Atlantic spotted dolphins were restricted to shallow shelf waters. However, common bottlenose dolphins were only observed in shallow shelf waters inshore of the continental shelf break, whereas they were also observed offshore of the continental shelf break in previous years. However, very limited survey effort in 2024 occurred over the shelf break due to sea state conditions. Rough-toothed dolphins were observed in shallow shelf waters in proximity to bottlenose dolphin sightings.

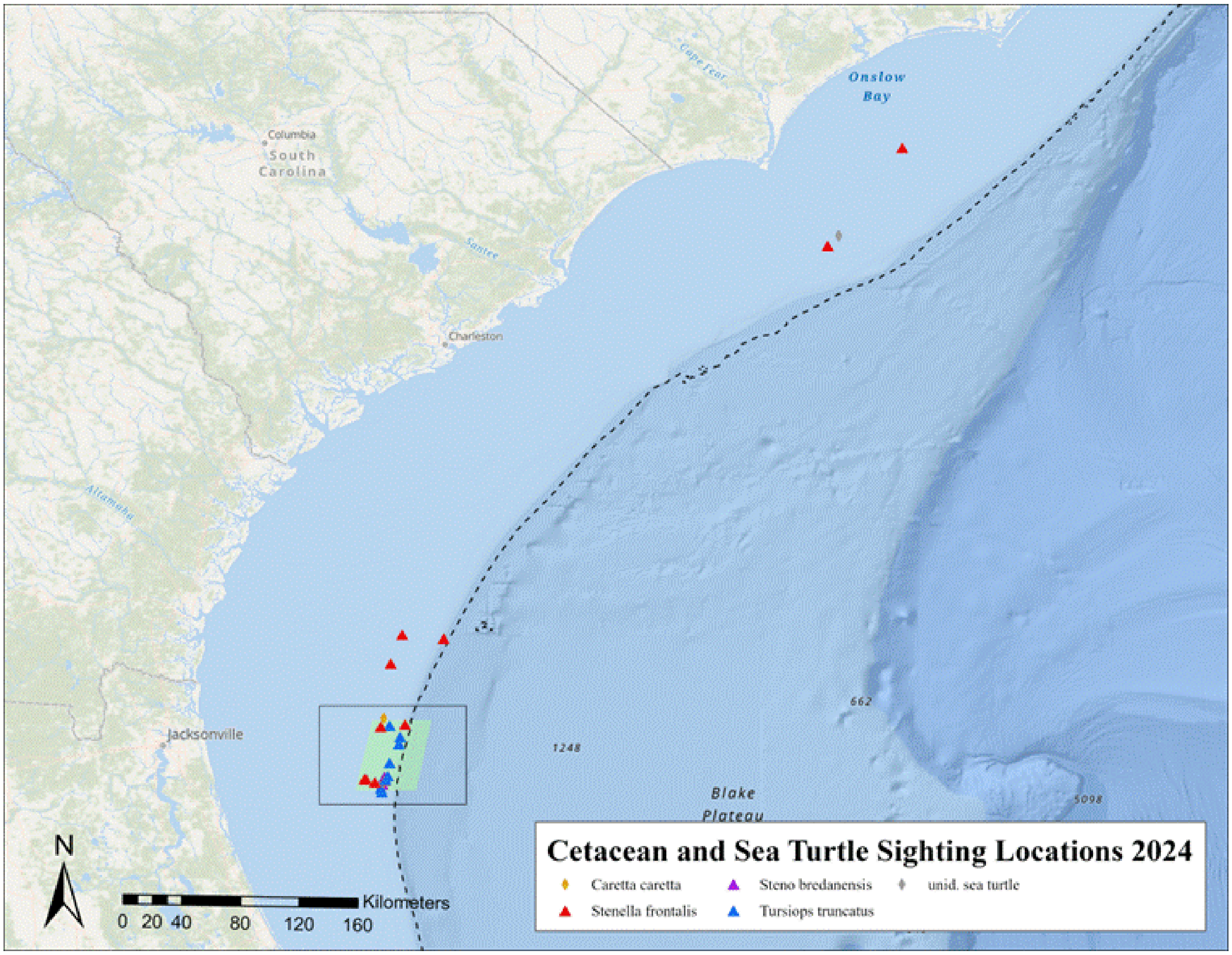


Figure 38. Distribution of cetacean and sea turtle sightings recorded during vessel surveys in 2024. The gray rectangle is the JAX study area, and the green shaded parallelogram encompasses the JSWTR.

Two biopsy samples were collected from bottlenose dolphins, and one was collected from a rough-toothed dolphin within the JAX survey area in 2024 (**Figure 39**). Voucher specimens of these samples are archived at the Duke University Marine Laboratory in Beaufort, North Carolina.

For additional details and information on this study, please refer to the annual progress report for this project (Kristan et al. 2025).

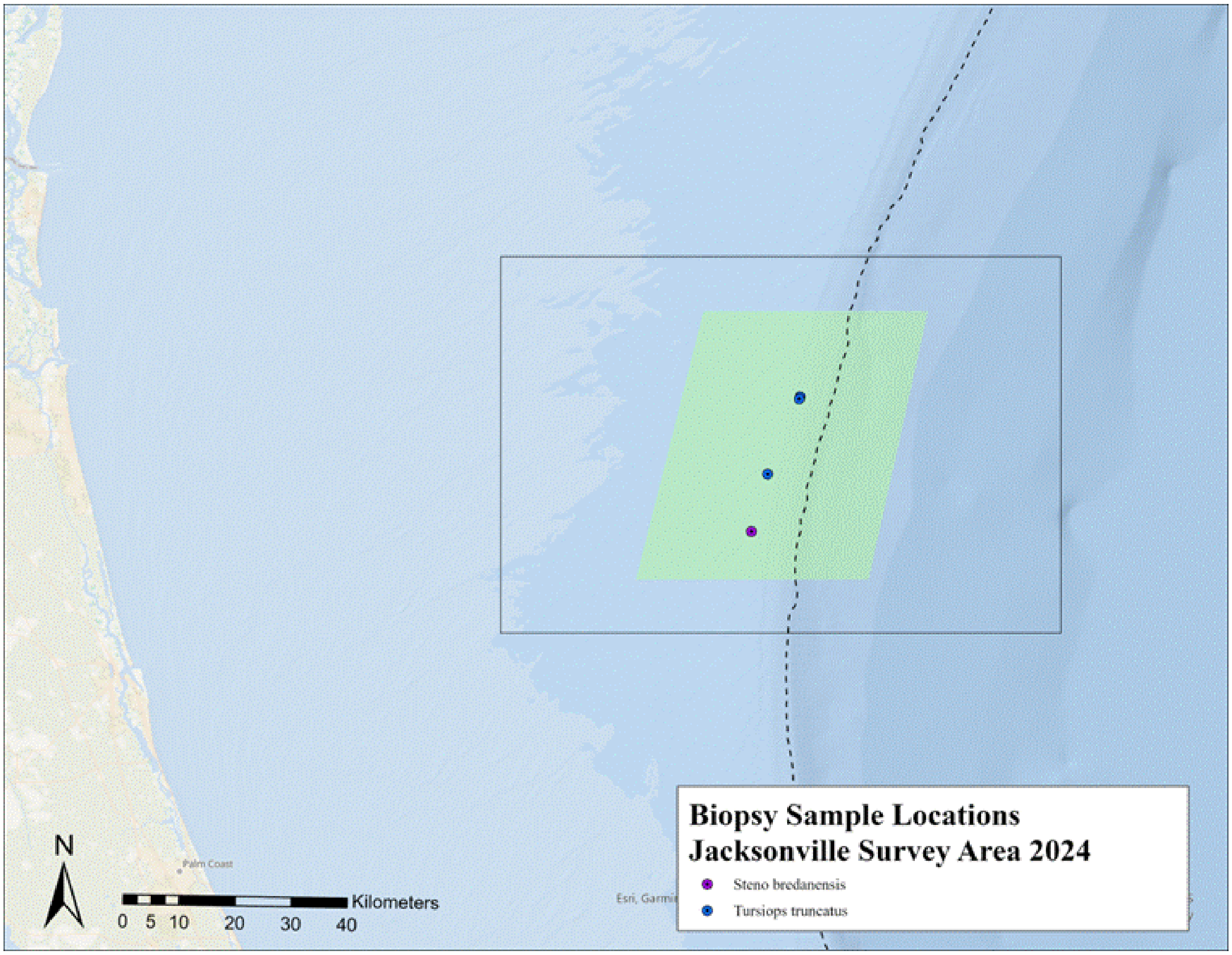


Figure 39. Locations of biopsy samples collected within the JAX study area during 2024.

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 detector/classifiers: a Fast Fourier Transform-based detector, a Class-Specific Support Vector Machine (CS-SVM) detector/classifier, and a Blainville's beaked whale foraging click matched filter (Jarvis et al. 2008). The CS-SVM classifier currently has six classes at JSWTR: Blainville's beaked whale foraging and buzz clicks, *Ziphius* foraging and buzz clicks, sperm whale clicks, and "generalized dolphin" clicks.

The M3R team conducted one species-verification trial from 8 to 12 May 2024 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 their photo-ID catalogs, took biopsy samples, and potentially deployed satellite tags. The focal species for these efforts were:

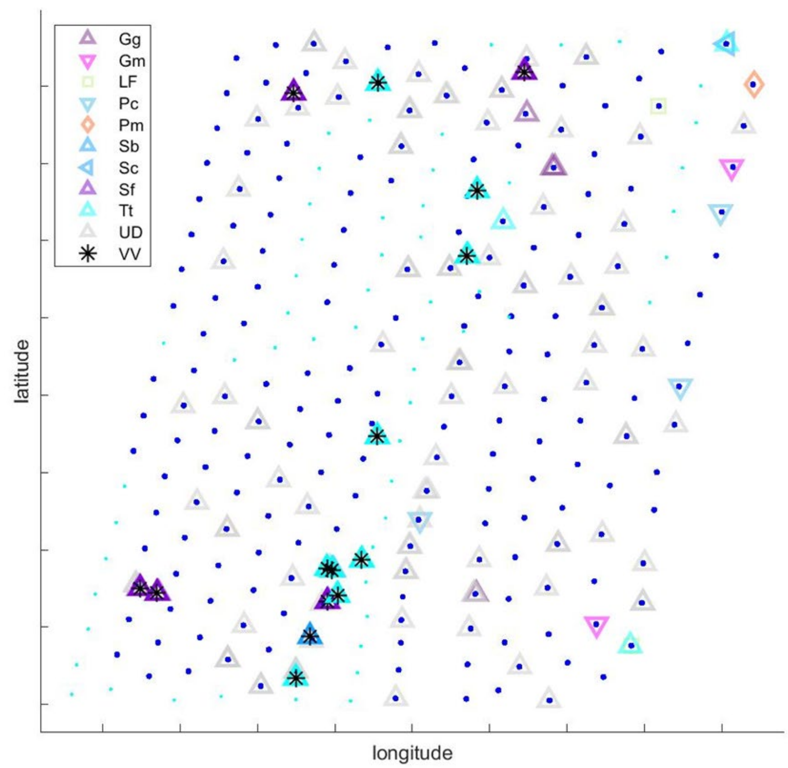
1. Short-finned pilot whales
2. Bottlenose dolphins
3. Atlantic spotted dolphins
4. Risso's dolphins
5. Rough-toothed dolphins

During the 2024 trial, all five focal species were acoustically identified by M3R, and three were visually verified by the on-water team: bottlenose dolphins, Atlantic spotted dolphins, and rough-toothed dolphins (**Table 28**, **Figure 40**).

Table 28. M3R acoustic detections and visual verifications at JSWTR in 2024.

Species		Number of Acoustic Detections Logged	Number of Acoustic Detections Directed	Number of Acoustic Detections Visually Verified
Common Name	Scientific Name			
Bottlenose dolphin	*Tursiops truncatus*	9	6	9
Atlantic spotted dolphin	*Stenella frontalis*	6	6	6
Risso's dolphin	*Grampus griseus*	4	0	0
Rough-toothed dolphin	*Steno bredanensis*	2	2	2
False killer whale	*Pseudorca crassidens*	3	0	0
Striped dolphin	*Stenella coeruleoalba*	1	0	0
Short-finned pilot whale	*Globicephala macrorhynchus*	2	0	0
Sperm whale	*Physeter macrocephalus*	1	0	0
Unidentified dolphin	*Delphinidae* sp.	95	3	0
Unknown low-frequency biological source	N/A	2	0	0

Key: N/A = not applicable



Key: Species included Risso's dolphin (Gg), short-finned pilot whale (Gm), false killer whale (Pc), sperm whale (Pm), rough-toothed dolphin (Sb), striped dolphin (Sc), Atlantic spotted dolphin (Sf), bottlenose dolphin (Tt), unknown *Delphinidae* species (UD), and unknown biological low frequency source (LF; <1 kHz). Detections that were visually verified (VV) by Duke University are overlaid with an asterisk.

Figure 40. Acoustic detections and visual verifications (*) at JSWTR from 8 to 13 May 2024.

2.7 Atlantic Marine Assessment Program for Protected Species

The Atlantic Marine Assessment Program for Protected Species (AMAPPS) was initiated in 2010 (AMAPPS I – 2010–2014, AMAPPS II – 2015–2019, AMAPPS III – 2020–2024) as a comprehensive multi-agency research program in the U.S. Atlantic Ocean, from Maine to the Florida Keys. Its aims are to assess the abundance, distribution, ecology, and behavior of marine mammals, sea turtles, and seabirds throughout the U.S. Atlantic and to place them in an ecosystem context. This information can then provide spatially explicit information in a format that can be used when making marine resource management decisions and provide enhanced data to managers and other users by addressing data gaps that are needed to support conservation initiatives mandated under the MMPA, ESA, National Environmental Policy Act (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. Data products and technical reports are available online: annual and final reports, and Marine Mammal Model Viewer.

Although the program 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 planned for winter of 2025. Similar future investments will be considered on a case-by-case basis to help address identified data gaps and support U.S. navy monitoring and compliance needs.

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

Harbor seals (*Phoca vitulina*) and gray seals (*Halichoerus grypus atlantica*) are year-round coastal inhabitants in eastern Canada and New England and occur seasonally in the mid-Atlantic U.S. between September and May (Hayes et al. 2022). Until 2018, NMFS Stock Assessment Reports indicated that the gray and harbor seal populations range from Labrador to New Jersey, with scattered sightings and strandings reported as far south as North Carolina for gray seals and Florida for harbor seals (Hayes et al. 2018). Other researchers have reported that harbor and gray seal distributions along the U.S. Atlantic coast appear to be expanding or shifting (den Heyer et al. 2021; 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 the winter, but not on a consistent basis (Ampela et al. 2023; Jones and Rees 2022). More recent stock assessments now indicate the southern extent for the harbor seal population range is North Carolina. However, the geographic range for the gray seal population remains the same (Hayes et al. 2022).

In 2014, the U.S. Navy initiated a study to investigate seal presence at select haul-out locations within the lower Chesapeake Bay and coastal waters of Virginia, which are important areas to U.S. Navy training and testing activities. Haul-out counts and photo-ID methods are being used to acquire a better understanding of seasonal occurrence, habitat use, and haul-out patterns within this area.

For the 2023/2024 field season, systematic vessel-based counts of all seal species were conducted at two different survey areas shown in **Figure 41**: 1) within lower Chesapeake Bay along the Chesapeake Bay Bridge-Tunnel (CBBT), on the four "islands" (referred to as CBBT 1, CBBT 2, CBBT 3, and CBBT 4); and on the southern tip of the Eastern Shore, which is composed of five main haul-out locations. Haul-out surveys started in November and ended in April to ensure the documentation of seal arrival and departure for the season. During each survey, the number of seals hauled out and in the water was recorded with associated environmental data (e.g., air and water temperature). An unmanned aircraft system (i.e., drone) was also used at the Eastern Shore survey area to help improve count data collected during vessel-based point counts. Photographs of seals were collected between counts for photo-ID for a mark-recapture study to estimate local population abundance and to develop a local catalog.

2.8.1 Haul-out Count Results

For the 2023/2024 field season at the CBBT survey area, 11 survey days were completed between 3 November 2023 and 8 April 2024. Overall, 92 seals in total (combined in-water and hauled-out) were sighted across the four CBBT haul-out locations, with more seals observed at CBBT 4 (n = 50) and CBBT 3 (n = 40). All of 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 38 seals, with the highest count recorded in January. For the Eastern Shore survey area, 12 survey days were completed between 2 November 2023 and 15 April 2024. Seals were observed on 9 of the 12 (75 percent) survey days, with a total of 185 seal sightings recorded for the season. Of the 185 seal sightings, 183 were harbor seals and two were gray seals. The total daily number of seals counted ranged from 0 to 45 individuals per survey day, with the highest count recorded in March. Seals were observed hauled out at only one of the five main haul-out sites—site E.

The UAS (i.e., drone) was used to conduct seven counts during the 2023/2024 season, specifically from November 2023 to February 2024. The UAS was unable to be used during several surveys throughout the season due to high winds and limited availability of UAS operator. A higher seal count was recorded from the UAS (compared to observers on the vessel) during three of the seven survey days, with the count differential ranging from 7-23 animals. However, during the surveys on 8 February 2024 and 22 February 2024, the hauled-out seals flushed due to the presence and sounds from the vessel and UAS, respectively. This resulted in a lower count recorded by the observers for both of those survey days. The observers recorded more seals from the vessel-based counts compared to the UAS counts during three of the seven survey days, with the count differential ranging from 1-4 animals. There was no significant difference between the mean counts for the UAS compared to the observer (tstat = 0.75, p = 0.47).

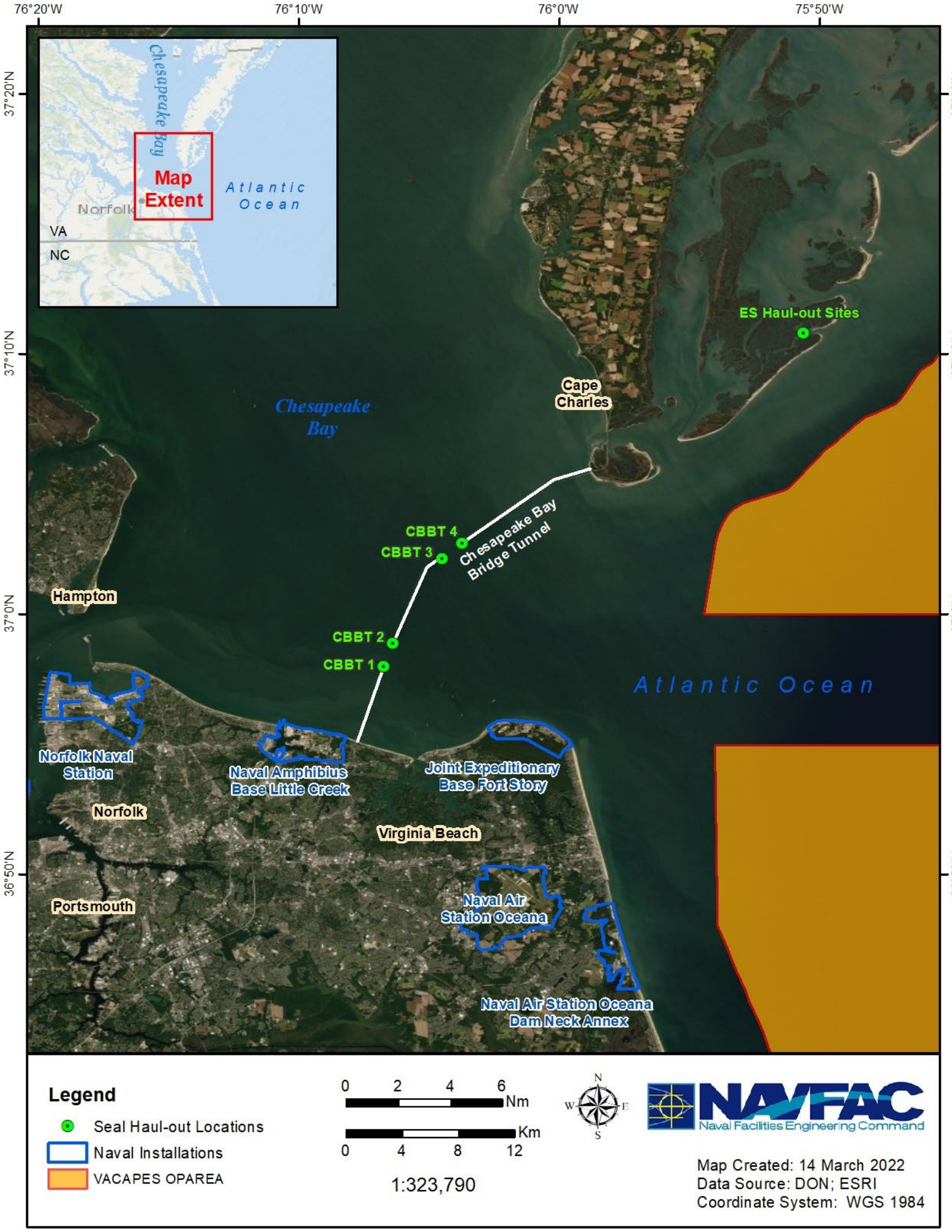


Figure 41. Chesapeake Bay Bridge Tunnel and Eastern Shore haul-out locations and their proximity to U.S. Naval installations.

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 average and maximum count from 2014 to 2018, followed by a decrease from 2018 to 2020 (**Table 29**). For the 2020/2021 season, seal presence appeared to rebound, with an increase in average seal count as well as maximum seal count for a single survey day. A slight decrease was observed for the 2021/2022 and 2022/2023 seasons, followed by a slight increase in the 2023/2024 season. A similar fluctuation in seal presence was observed for the Eastern Shore survey area, over eight field seasons, there has been a fluctuation in seal presence, similar to what was observed for the CBBT survey area. The total count and maximum count for a single survey increased from the 2016-2018 field seasons and again for the 2020-2023 seasons (**Table 30**), followed by a decrease for both summary statistics for the 2023/2024 season. The average number of seals observed per survey day increased from 2016 to 2018 but decreased to 15 seals for the 2018/2019 season. Average seal count started to increase again for the 2019/2020 season with some fluctuation over the 2020/2021 and2021/2022 seasons. Average count remained the same at 21 seals for the 2022/2023 and2023/2024 seasons. The difference between the mean counts across the eight field seasons was not statistically significant (Fstat=0.35, p=0.93), which could indicate that the local population is relatively stable. This between-season comparison, however, does not take into account the sampling bias for the first two seasons (2016-2018), which consisted of inconsistent survey effort across months (e.g., no surveys conducted in January 2017 and March-April 2018).

Table 29. Seasonal survey effort (number of survey days), total seal count (best estimate), maximum seal count for a single survey, and effort-normalized average seal count (number of seals observed per "in season survey" day) for the CBBT survey area.

Field Season	"In Season" Survey Effort (days)	Seal Counts		
		Total	Average	Maximum
2014–2015	11	113	10	33
2015–2016	14	187	13	39
2016–2017	22	308	14	40
2017–2018	15	340	23	45
2018–2019	10	82	8	17
2019–2020	6	29	5	9
2020–2021	11	137	12	32
2021–2022	10	98	10	25
2022–2023	11	110	10	30
2023-2024	7	92	13	38

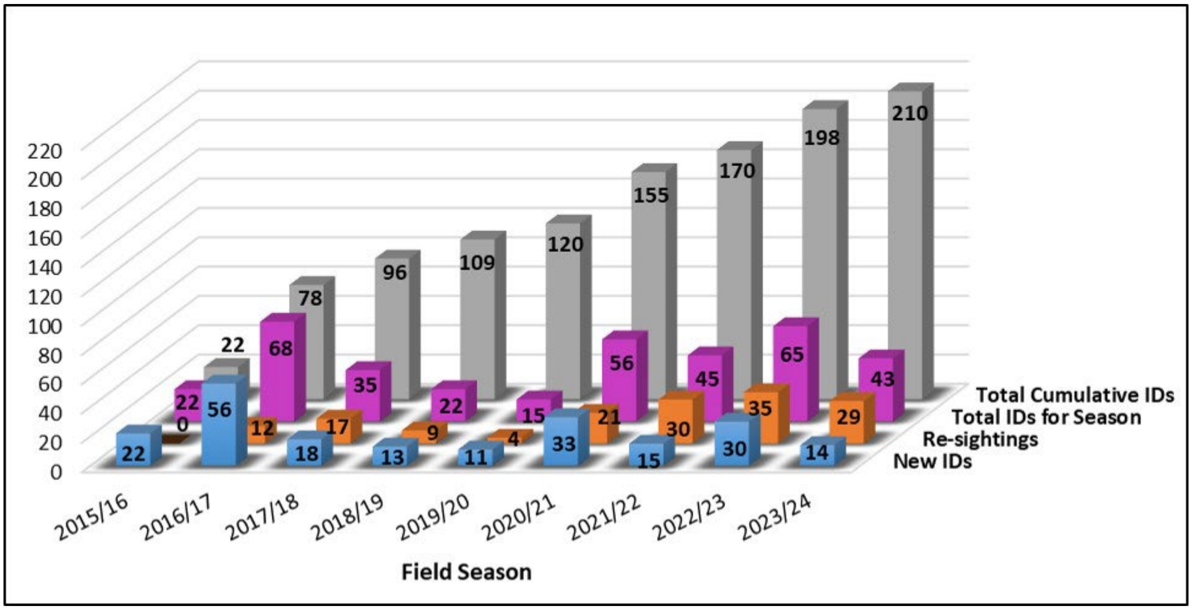
Table 30. Seasonal survey effort (number of survey days), total seal count (best estimate), maximum seal count for a single survey, and effort-normalized average seal count number of seals observed per "in season survey" day) for the Eastern Shore survey area.

Field Season	"In Season" Survey Effort (days)	Seal Counts		
		Total	Average	Maximum
2016–2017	7	105	15	24
2017–2018	8	197	25	69
2018–2019	11	160	15	66
2019–2020	9	157	17	39
2020–2021	12	219	18	44
2021–2022	9	143	16	45
2022–2023	9	187	21	68
2023-2024	9	185	21	45

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

Between 2015 and 2024, image analysis identified 210 harbor seals and 5 gray seals within the study area, averaging 24 new harbor seals identified each year. Data from the 2014/2015 season was unusable due to poor image quality. Initially, seals were identified only from the CBBT in 2015/2016. From 2016 onward, seals were identified from both CBBT and the Eastern Shore (ES) after surveys began at the latter location. Of the cataloged seals, 111 harbor and 2 gray seals have been resighted, with some harbor seals seen across seven or eight seasons. This suggests seasonal site fidelity to the lower Chesapeake Bay and coastal Virginia waters. The longest re-sighting span for harbor seals is about 12 years, thanks to supplemental photos from a local angler, while the longest gray seal re-sighting spanned two years. Over half of the identified harbor seals were observed only at CBBT, while a smaller, but still substantial number were observed solely at ES. A small number of harbor seals have been documented at both locations.

Mark-recapture analysis generated harbor seal abundance estimates fluctuating between 81 and 242 individuals across the 2015-2024 seasons. The lowest estimate occurred in 2015/2016, likely due to the limited survey area (CBBT only). The highest estimate (2018/2019) had a wide confidence interval (CI), potentially attributable to low recapture numbers. General trends show an initial increase in abundance from 2015-2019, followed by a decrease and relative stabilization between 2019-2022. The most recent two seasons show a further decline to below 100 individuals. Regression analysis of these estimates revealed no statistically significant trend ($p=0.54$), suggesting a relatively stable population. A mean abundance estimate across all nine seasons was calculated at 141 individuals. For more information on the Virginia seal haul-out count visual surveys, please see Jones (2024) and visit the project profile page.



Key: ID = identifier

Figure 42. Harbor seal identifications over nine field seasons (2015-2024). 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.

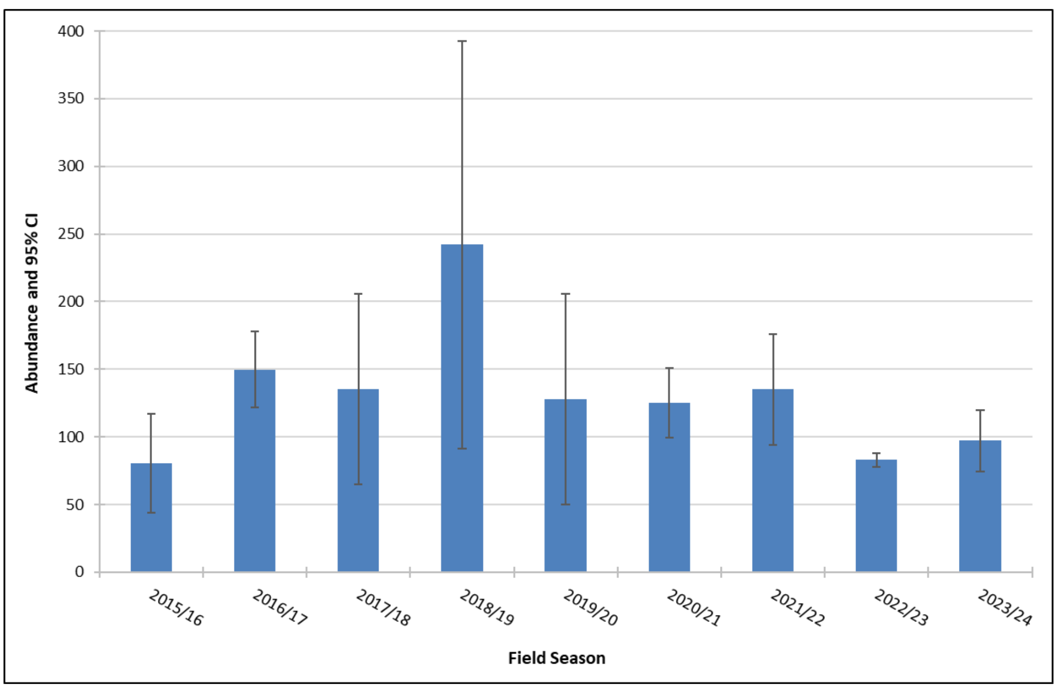


Figure 43. Total abundance estimates (blue bars) and 95% CIs for the CBBT and Eastern Shore survey areas combined during each of the field seasons from 2015-2024.

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 to 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 of time, with relatively low personnel demands.

For this project, cameras were placed at multiple locations covering the known haul-out sites at two survey areas in southeastern Virginia and were operated in time-lapse mode, recording images every 15 min.

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 and time-lapse camera data collection. 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 Commander, USFFC and Commander, Navy Installations Command in the region. These data will also provide important baseline information for the assessment of potential future impacts from climate change or anthropogenic activities.

To date, the study team has completed five seasons (2019/2020, 2020/2021, 2021/2022, 2022/2023, and 2023/2024), with a sixth (2024/2025) in progress. Cameras are deployed from October to May at both the Eastern Shore and CBBT survey areas. Images are recorded in time-lapse mode, at a frequency of 15 min. All cameras record during daylight hours, and at one of the Eastern Shore haul-out sites, night images are collected.

The Timelapse Image Analysis system and the Timelapse2 program (Greenberg 2024) is used to count, mark, and record the number of seals and vessels in each image. **Figure 44** 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 the data from each image, including custom data recording template, automatic extraction of image data (e.g., file name, date, and 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, and image enhancement) (Greenberg 2024).

Figure 44. Screenshot of Timelapse Image Analysis workspace.

Images are reviewed for the presence of seals, and sightings are recorded as either hauled out or in the water, as well as for the presence of vessels. While images from the camera surveys are not of high enough quality to identify seals to species in most cases, the vessel surveys can be relied upon to provide the frequency of harbor versus gray seals visiting the survey areas.

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. Total counts for both the Eastern Shore and CBBT study areas are shown in **Table 31.**

Table 31. Total seal haul-out count from (all images) for each season at both survey areas.

Season	Eastern Shore	CBBT	Total
2019/2020	46,079	4,314	50,393
2020/2021	50,374	8,953	59,327
2021/2022	57,937	12,739	70,676
2022/2023	55,914	11,844	67,758
2023/2024	67,091	14,401	81,492

Seal occupancy and camera survey sighting summaries are shown in **Table 32** for the Eastern Shore survey area and **Table 33** for the CBBT survey area.

Table 32. Camera trap effort summary for the Eastern Shore survey area during the occupancy season.

Season	First Seal Recorded	Last Seal Recorded	Average Seals Hauled Out	% of Days Hauled Out	% of Days Present[a]
2019/2020	4-Nov-19	20-Apr-20	12	79.8	88.2
2020/2021	30-Oct-20	25-May-21	10	78.8	90.9
2021/2022	15-Oct-21	28-Apr-22	14	72.9	86.2
2022/2023	22-Oct-22	17-May-23	10	75.5	89.9
2023/2024	26-Oct-23	9-May-24	14	73.6	86.8

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

Table 33. 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]
2019/2020b	CBBT3	8-Jan-20	28-Apr-20	4	31.3	73.2
	CBBT4	10-Jan-20	17-Apr-20	4	42.9	55.4
2020/2021	CBBT3	30-Oct-20	1-May-21	5	24.4	51.6
	CBBT4	4-Dec-20	22-May-21	5	33.2	58.0
2021/2022	CBBT3	20-Oct-21	16-Apr-22	5	21.7	60.5
	CBBT4	30-Nov-21	1-May-22	7	43.3	57.7
2022/2023	CBBT3	25-Oct-22	23-Apr-23	5	45.6	90.6
	CBBT4	25-Oct-22	31-Mar-23c	6	71.8	97.3
2023/2024	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 CBBT4 after 31 March 2023, due to camera failure

During the 2023/2024 season, at the Eastern Shore study area, the average seal count increased until the peak count in February, decreased slightly in March, then quickly decreased until the seals left the area (**Figure 45**). No seals were observed hauled out in the month of May, but a single seal was recorded in the water on three different days in May. At the CBBT survey area, the average seal count was highest in February, followed by a decrease through the end of the season (**Figure 46**). Results from one-way ANOVA tests showed that the average number of seals hauled out at both the Eastern Shore and CBBT survey areas varied significantly by month ($F = 4.187$, $p < 0.001$; $F = 8.254$, $p < 0.001$, respectively).

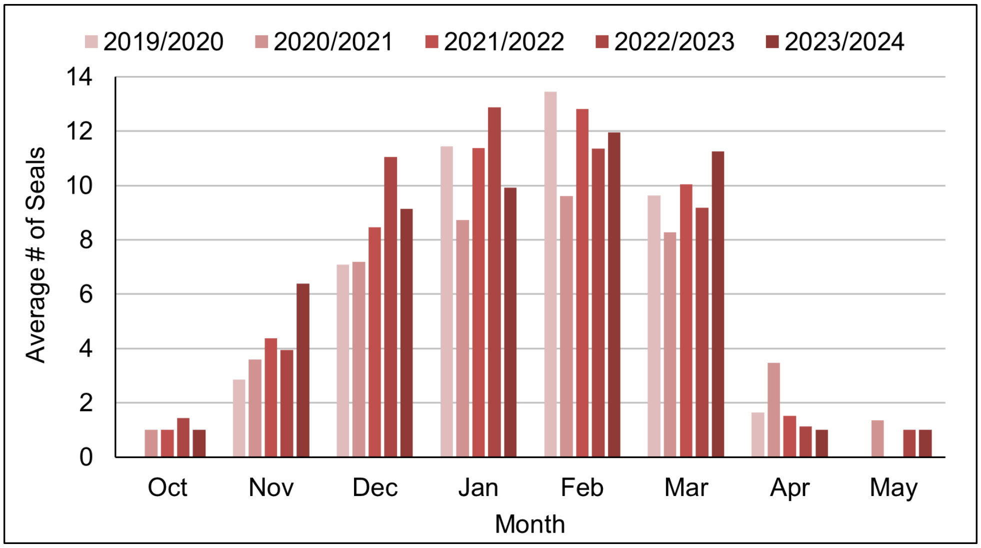


Figure 45. Average seals counted by month at the Eastern Shore survey area.

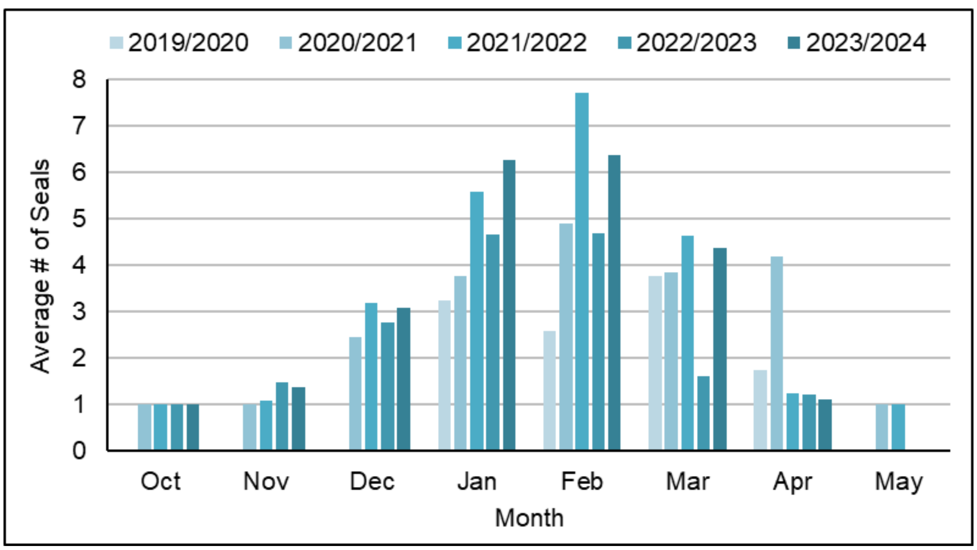


Figure 46. Average seals counted by month at the CBBT survey area.

A comparison of hauled out seals to environmental factors and the number of hours after sunrise was completed for all seasons and is detailed in Guins and Rees (2025).

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

A comparison of counts to vessel presence as a potential factor of disturbance was completed for all seasons. During the 2023/2024 season, vessels were captured on 29.4 percent of the survey days at the Eastern Shore survey area and 49.5 percent of the survey days at the CBBT survey area.

For more information on the Virginia seal camera survey work, including details of analyses conducted, please see Guins and Rees (2025) and visit the project profile page.

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

Availability bias, or the time 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 (Mansfield 2006; Roberts et al. 2022; DiMatteo et al. 2024). As such, if availability bias estimates are not applied to density spatial models, 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 (GAMs) 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 East Coast of the U.S., four species of sea turtle can commonly be found: loggerhead, green (*Chelonia mydas*), Kemp's ridley (*Lepidochelys kempii*), and leatherback (*Dermochelys coriacea*), 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 is ongoing within the region, sponsored by NMFS and other private organizations, with some initial studies of leatherback availability starting to be published (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. The study team proposed deploying up to 50 Wildlife Computers satellite-linked telemetry tags per year for 3 years, split evenly between Kemp's ridley and green sea turtles (or as encounters allow), at several sites along the East Coast ranging from Florida to Massachusetts. In partnership with several rehabilitation and research groups, the study team aims to collect and record sea turtle behavioral data in multiple representative environments and times of year. Year 4 will be the capstone analysis, fitting a GAM, or other appropriate statistical framework, relating environmental covariates to dive behavior. The anticipated availability bias models will describe the proportion of time animals are expected to be within 2 m of the surface, a common threshold for where sea turtles are visible to aerial observers, the most common type of survey data incorporated into U.S. Navy density estimates.

2.9.1 Methodology

Wildlife Computers SPLASH10 telemetry tags will be deployed annually, starting June 2024 (Year 1), and totaling approximately 150 tags, split evenly among two species of turtles, greens and Kemp's ridleys, if feasible. In Year 1, the study team obtained 60 tags for deployment. The goal is to deploy tags on a range of turtle sizes to best represent size-based physiological differences in behavior. Planned Year 1 field sites for animal acquisition include the Archie Carr National Wildlife Refuge (ACNWR) nesting beach (Melbourne Beach and Brevard County, Florida); Trident Submarine Basin, Port Canaveral, Florida; Indian River Lagoon (IRL) south of Sebastian Inlet (Indian River County, Florida); and Jensen Beach, Florida, nesting beach as well as the St. Lucie Power Plant intake canal.

Project principal investigators are also working with project partners to deploy satellite tags on turtles from other active in-water or rehabilitation entities in Florida, Georgia, Maryland, New York, and Massachusetts, pending confirmation of permit and staff availability with each project partner. For Year 1, the study team focused initially on field sites in Florida since they were already permitted and staffed for this project. 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 34**), with mostly Kemp's ridleys to be sourced from New England and mid-Atlantic regions during the winter cold stun season (December to March of any given year, with anticipated turtle releases from January to May). The final distribution of tags will be determined once cold stuns from northern areas are transported to rehabilitation centers.

Up to 60 Wildlife Computers SPLASH10 satellite tags were allocated for Year 1 deployments. These are Argos tags with depth sensors and depth profile capabilities. All tags were programmed with the same configuration to maximize data collection for availability bias models; tag dive-data products will allow the study team to calculate the dive statistics required for availability bias modeling, such as percent time below a depth threshold as well as dive and surface intervals. Tags were all tested to ensure they functioned and set to "stand-by" mode in anticipation of deployment. All tags were painted with Trilux 33 anti-foulant prior to tag attachment.

Availability bias, also referred to as "g0" after the common distance sampling nomenclature (despite g0 technically including both availability and perception bias components), was summarized in several ways for the various depth bins and data types. Availability bias estimates were calculated for individuals; by species; and then by sex, age class (juvenile versus adult), month, and depth, all of which were segregated by species to account for differences in foraging and dive behavior between species. 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.

Table 34. List of project partners along with sampling location, anticipated species tagged, number of tags provided (Year 1), and anticipated 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	Greens	15	14	Wild caught	Seasonally for adult female greens, year-round for juvenile greens
IRG	St. Lucie Power Plant, Jensen Beach, FL	Kemp's ridleys and greens	10	2	Wild caught	December – May
Loggerhead MarineLife Center	Juno Beach, FL	Kemp's ridleys	5	0	Rehabilitation	December – May (cold stun rehabilitation)
Georgia Sea Turtle Center	Jekyll Island, GA	Kemp's ridleys and greens	10	0	Rehabilitation	January – May (cold stun rehabilitation)
National Aquarium	Baltimore, MD	Kemp's ridleys and greens	10	0	Rehabilitation	January – May (cold stun rehabilitation)
New York Marine Animal Rescue	Long Island, NY	Kemp's ridleys and greens	10	0	Rehabilitation	January – May (cold stun rehabilitation)
New England Aquarium	Boston, MA	Kemp's ridleys	0	0	Rehabilitation	January – May (cold stun rehabilitation)

Key: FL = Florida; GA = Georgia; MD = Maryland; NY = New York

2.9.2 Tagging Results

Sixteen turtles have been satellite tagged to date (June to December 2024) (**Table 35**). All turtles were captured from the central and southeast Florida coast. The UCF deployed 14 tags, including 7 on adult female green turtles (96.2 to 109.5 cm straight carapace length [SCL]) found nesting within the ACNWR during June and July 2024, 4 on small juvenile green turtles (32.3 to 45.4 cm SCL) captured at Trident Submarine Basin during late July 2024, and 3 on larger juvenile green turtles from the IRL (45.4 to 53.6 cm SCL) during July through December 2024. Four of the adult females nesting within the ACNWR and one of the Trident Basin juvenile green turtles were recaptured turtles who had been previously flipper tagged and encountered by the UCF. Additionally, one adult male green turtle (85.0 cm SCL), and one subadult Kemp's ridley (55.6 cm SCL) from the St. Lucie Power Plant intake canal were satellite tagged by IRG. Should any of the satellite tagged turtles in this study be recaptured by any project partner, the turtles would not be re-tagged as part of this study; the study team aims for 150 distinct individuals tagged.

At the time of writing this report, approximately 24,000 Argos locations were collected from the 16 tags deployed to date (**Figure 47**), three of which are still actively transmitting. Green turtle locations comprised the vast majority of locations, with only 700 Kemp's ridley locations collected from a single tag. The correlated random walk (CRW) models fitted to each tag converged. Model fit statistics and plots were examined for each tag, and no indications of poor fit or structural issues with predictions occurred. Approximately 7,000 predicted locations were created at 4-hour intervals (**Figure 47**), covering the 16 deployments. No large temporal gaps were noted, indicating that turtles were surfacing regularly, and transmissions from the tags were being received frequently.

Locations ranged from the Florida/Georgia border in the north, to the southern Florida Keys in the south. Most animals stayed close to shore; however, two animals— "Dodman" (Platform Transmitter Terminal [PTT] 264818), a Kemp's ridley; and "Cheung" (PTT 264820), a green—ranged away from the shore, providing samples in waters not frequented by other animals to date. Dodman was released at the St. Lucie Power Plant and remained on the continental shelf but spent several weeks using mid-shelf waters (**Figure 48**). Cheung, an adult nesting female, spent several weeks close to the ACNWR before moving off the continental shelf, looping up and around to northern Florida, then moving south along the Florida coast, eventually reaching the Florida Keys (**Figure 49**).

Table 35. Summaries for each satellite tag deployed (tag status current as of 19 November 2024).

PTT	Deploying Organization	Date Deployed	Deployment Location	Species	Turtle SCL	Age Class	Sex	Recapture	Turtle Name	Status
264822	UCF	19 June 2024	ACNWR, Brevard County, FL	Cm	101.9	Adult	Female	Yes	Kalvin	Active
264819	UCF	19 June 2024	ACNWR, Brevard County, FL	Cm	96.2	Adult	Female	No	Blanco	Inactive
264815	UCF	19 June 2024	Archie Carr NWR, Brevard County, FL	Cm	97.0	Adult	Female	No	Aldunce	Inactive
264820	UCF	20 June 2024	Archie Carr NWR, Brevard County, FL	Cm	97.0	Adult	Female	Yes	Cheung	Active
264825	UCF	20 June 2024	Archie Carr NWR, Brevard County, FL	Cm	98.0	Adult	Female	Yes	Dasgupta	Inactive
264816	IRG	29 June 2024	St. Lucie Power Plant, Jensen Beach, FL	Cm	85.0	Adult	Male	No	Denton	Inactive
264837	UCF	9 July 2024	IRL, Melbourne Beach, FL	Cm	53.6	Juvenile	Unknown	No	Diongue	Inactive
264818	IRG	20 July 2024	St. Lucie Power Plant, Jensen Beach, FL	Lk	55.6	Juvenile	Unknown	No	Dodman	Inactive
264827	UCF	21 July 2024	ACNWR, Brevard County, FL	Cm	109.5	Adult	Female	No	Geden	Active
264834	UCF	21 July 2024	ACNWR, Brevard County, FL	Cm	99.4	Adult	Female	Yes	Garschagen	Inactive
264823	UCF	26 July 2024	Trident Turning Basin, Port Canaveral, FL	Cm	32.3	Juvenile	Unknown	No	Hayward	Inactive
264839	UCF	26 July 2024	Trident Turning Basin, Port Canaveral, FL	Cm	39.6	Juvenile	Unknown	No	Jones	Inactive
264831	UCF	27 July 2024	Trident Turning Basin, Port Canaveral, FL	Cm	40.5	Juvenile	Unknown	No	Krinner	Inactive
264826	UCF	27 July 2024	Trident Turning Basin, Port Canaveral, FL	Cm	40.9	Juvenile	Unknown	Yes	Jotzo	Inactive
264830	UCF	13 August 2024	IRL, Melbourne Beach, FL	Cm	45.4	Juvenile	Unknown	No	Krinner	Inactive
264851	UCF	5 September 2024	IRL, Melbourne Beach, FL	Cm	48.2	Juvenile	Unknown	No	Lee	Inactive

Key: Cm = *Chelonia mydas*; FL = Florida; Lk = *Lepidochelys kempii*;

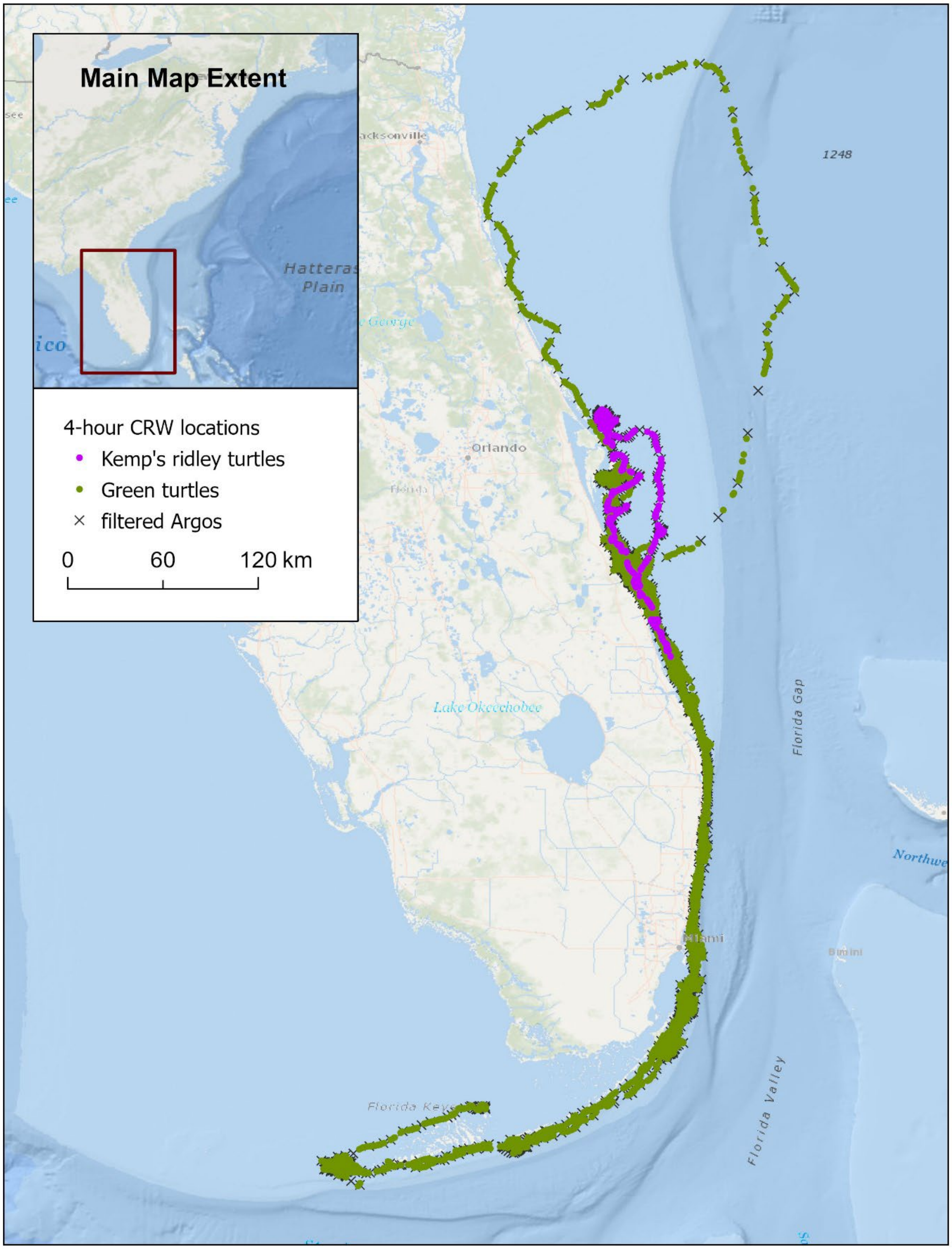


Figure 47. Correlated random walk locations for all 16 tagged turtles.

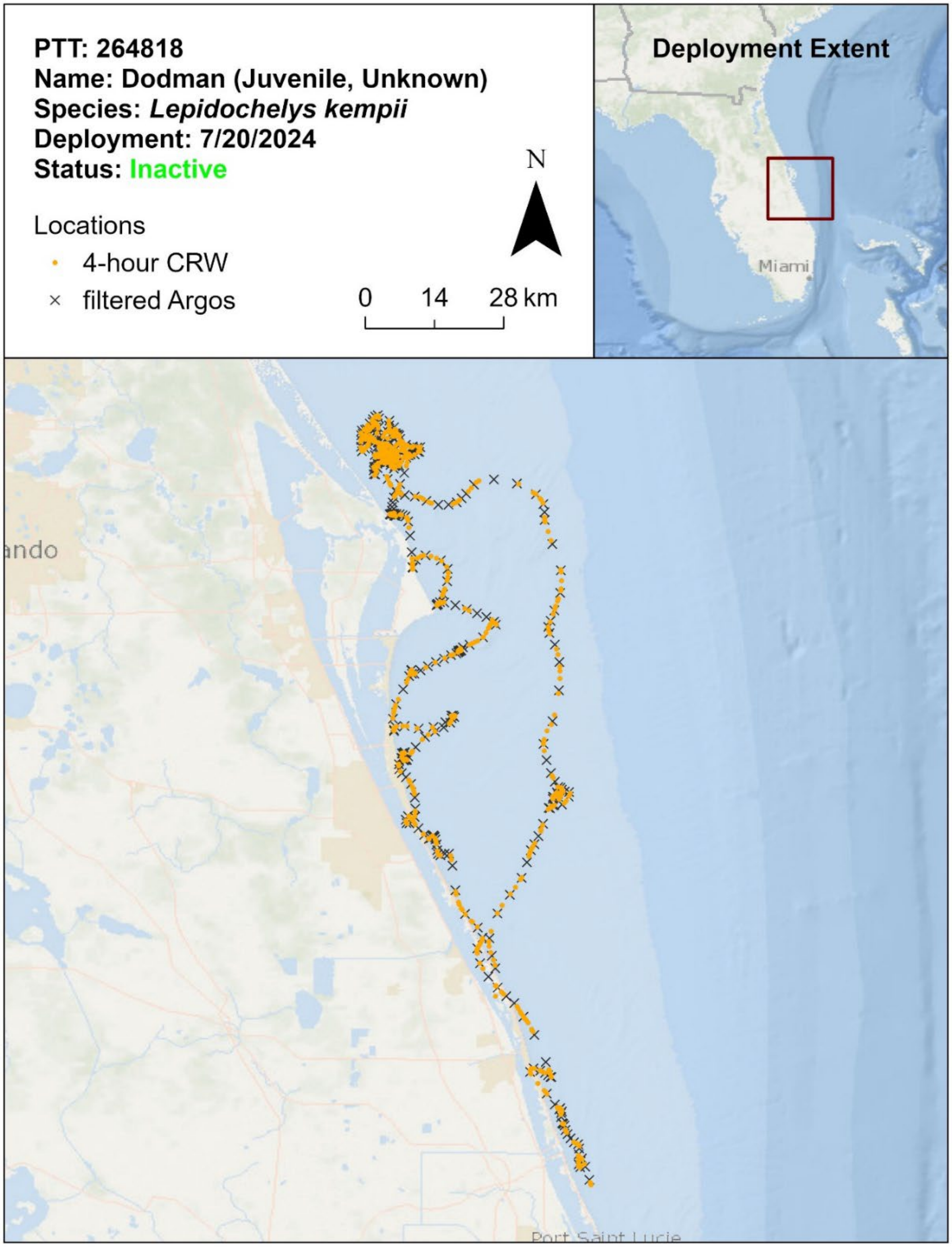


Figure 48. Argos and 4-hour CRW locations for PTT 264818.

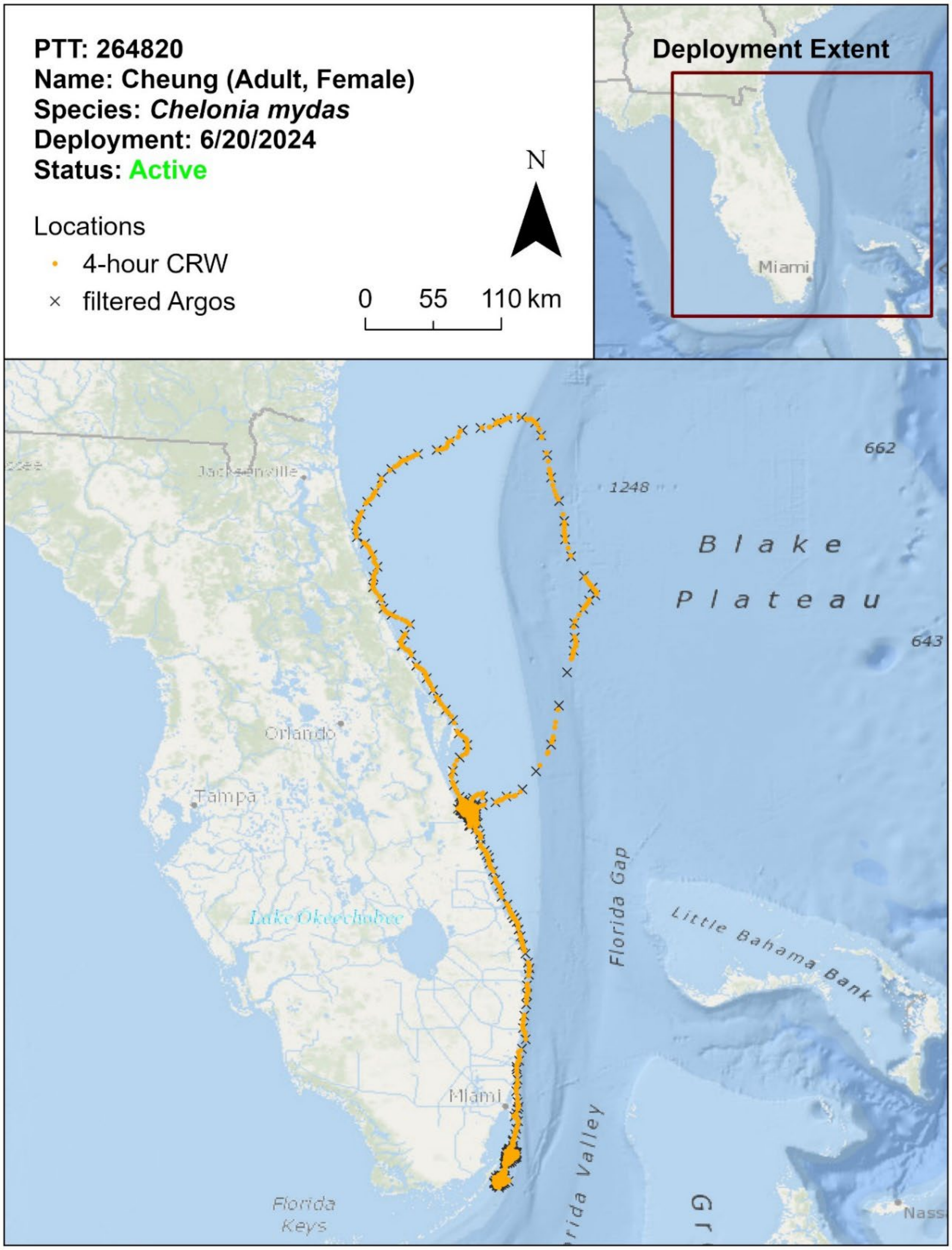


Figure 49. Argos and 4-hour CRW locations for PTT 264820.

Locations were recorded from June to November for green turtles and from July to September for the single Kemp's ridley turtle. Deep shelf and deep waters were poorly sampled, with only 10 and 9 daytime, 4-hour locations falling in these waters, respectively, all from a single green turtle (Cheung, PTT 264820). Shallow waters and shallow shelf depths were better sampled, with approximately 1,700 and 550 daytime, 4-hour locations, falling in these waters, respectively.

2.9.3 Availability Bias

For animals that traveled to the Florida Keys (all adult green turtles), 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 showed animals spending more time in shallower depths. The one Kemp's ridley turtle spent most of its time below 2-m depth, with average availability bias estimates below 0.1, regardless of the data or depth cutoff used.

Mean availability bias by species was 0.42 and 0.06 based on the 2-m histogram data for green and Kemp's ridley turtles, respectively. The study team recommends the reader interpret the results for Kemp's ridley turtles cautiously, as only one animal has been tagged to date and is presented for information purposes only.

Based on initial availability bias averages, juvenile green turtles appear to spend more time at shallow depths than adult green turtles. The availability bias estimates for green turtles were higher during warmer months and lower during cooler months; data are not available for all months. These data currently cover predominantly coastal Florida, so relationships elsewhere may be different. Green turtles were more available in shallow waters than shallow shelf waters, perhaps reflecting the more limited three-dimensional habitat. At this early date, the study team did not test this statistically and results should be considered preliminary. The study team does not offer interpretation of the results from deeper waters, given the low sample size at this point.

2.9.4 Discussion

Though the results presented in this report are extremely preliminary and based on a small sample size, the study team has taken the first steps toward providing robust, defensible availability bias estimates for Kemp's ridley and green sea turtles on the East Coast, with the eventual goal of providing not just point estimates, but surfaces of availability bias, varying in space and time. The current study results should be interpreted with caution, given the small number of deployments to date, which limits the available information both spatially and temporally. Particular caution should be taken with the results for Kemp's ridley and male green turtles, both with only one deployment each to date.

For Year 2, the study team's highest priorities are Kemp's ridley turtles and northern deployments, which were hindered this year by receiving tags after cold stunned animals were released, U.S. Fish and Wildlife Service limitations on what size animals can be tagged (currently limited to animals 50 cm and greater for northern collaborators), and delays in permitting. The study team is actively working with northern collaborators to modify their permits to allow animals as small as 30 cm to be tagged. The study team will also work with Wildlife Computers to see if the next batch of tags can be modified to reduce drag and weight (i.e., remove the four "towers" in each corner of the tags whose main function is to protect the antenna, but also add drag and weight to the tags).

In the south, the study team may switch focus away from smaller green turtles tagged in inland waters and focus more on larger green turtles and individuals captured at sea, to more broadly sample geographic and environmental space. The study team will continue to tag animals entrained in the St. Lucie Power Plant intake and work with IRG to modify their permits as needed to increase sample sizes or to also include adult female green turtles.

For more information on this study, refer to the annual progress report for this project (DiMatteo and Mansfield 2025).

2.10 Sturgeon Monitoring

2.10.1 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 oxyrhynchus*) and shortnose sturgeon (*A. oxyrhynchus*) in the lower Kennebec River (from north of Bath Iron Works [BIW] to Fort Popham), and to collect data during recurrent Naval activities. This study also implemented monitoring stations offshore of Popham Beach to capture coastal movements of sturgeon and other species, including white sharks. Offshore stations form a curtain between Fox-Seguin Islands and the Jackknife Ledge Dredge Disposal area.

Project objectives are: (1) Monitor year-round presence and migration of Atlantic sturgeon in the lower Kennebec River; (2) Monitor year-round presence and migration of shortnose sturgeon in the lower Kennebec River; (3) Monitor sturgeon activity in the proximity of BIW; (4) Add additional acoustic tags to the population of sturgeon occurring in the Kennebec River system; and (5) Document coastal movements of fish offshore from Popham Beach (sturgeon, white sharks, striped bass [*Morone saxitilis]*, 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, U.S. Geological Survey, Portsmouth Navy Yard, and University of Maryland Center for Environmental Science. Data collected from this study will help to clarify/define/determine movement patterns in and out of the Kennebec basin, identify potentially new overwintering and/or foraging areas, and identify coastal movements of protected sturgeon between river systems that also contain compatible acoustic telemetry monitoring stations. Additional tagging efforts could create a large enough sample size to allow real time detection of fish to avoid or minimize take during dredging activities. Forty Atlantic sturgeon ranging from 57 to 168 cm fork length (FL) and 23 shortnose sturgeon ranging from 54 to 87 cm FL were captured in June, July, and October 2022. To increase the population of tagged fish in the Kennebec, 61 of these fish were acoustically tagged with surgically implanted transmitters (VEMCO Innovasea, models V16 or V13). These are the total number of tags for the project since its inception in 2020. As of December 2024, 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 51**). 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 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*).

For the time period representing the last two download cycles (November 2023 – October 2024), 478,938 matched detections were recorded across all stations (**Table 36**), with the exception of Courthouse Point (label: CRTHPT) that is pending retrieval by divers in spring 2025. Detections of fish tagged by other organizations were recorded from several different tagging projects in the Mid-Atlantic Acoustic Telemetry Observation System (MATOS), a data portal that supports the collaborative sharing of the Atlantic Cooperative Telemetry Network. These projects include Gulf of Maine Sturgeon (University of Maine and U.S. Geological Survey), University of New England Anadromous Striped Bass Project, Ocean Tracking Network Canadian Atlantic Sturgeon, UMaine assessment of salmon migratory success, and ME DMR sea run fish tracking efforts.

The addition of new U.S. Navy-tagged sturgeon to the Kennebec system in 2022 significantly increased the dataset in-river. Of all detections matched in the MATOS database (tagged by Navy and/or other projects), the vast majority were Atlantic sturgeon (river: 430,321), followed by shortnose sturgeon (river: 37,400), striped bass (river: 9,190), and white shark (ocean [FS stations]: 182). However, the frequency of tag observations should not be interpreted as a proxy for population distribution or abundance, as the proportion of tagged individuals for each species is not equivalent. Notably, a higher percentage of Atlantic sturgeon are tagged in the Gulf of Maine region, as compared with shortnose sturgeon.

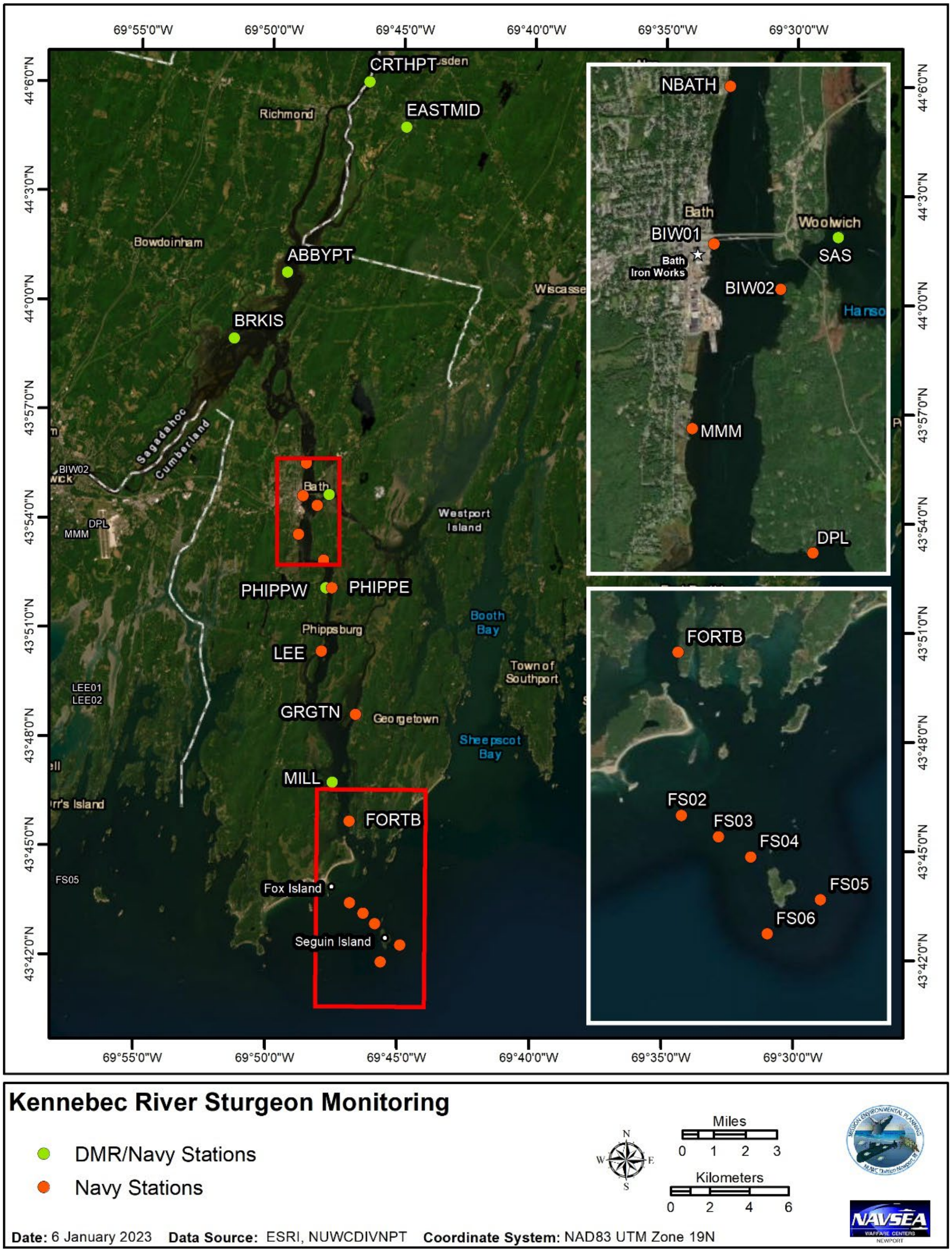


Figure 50. Array map showing the location of Navy and ME DMR monitoring stations in the lower Kennebec River basin extending to offshore Seguin Island.

Table 36. Number of detections at river and ocean stations for each species across the study period (November 2023 – October 2024).

Species	Date Range	Count	Mid-River	Lower River	Ocean
Atlantic sturgeon	Nov 2023–April 2024	Total Detects	26,382	133,750	173
		Unique IDs	15	16	8
	May 2024–October 2024	Total Detects	19,112	251,077	796
		Unique IDs	26	27	17
Shortnose sturgeon	Nov 2023–April 2024	Total Detects	5,994	11,103	0
		Unique IDs	13	14	0
	May 2024–October 2024	Total Detects	11,349	8,954	0
		Unique IDs	14	15	0
White Shark	Nov 2023–April 2024	Total Detects	N/A	N/A	7
		Unique IDs	N/A	N/A	1
	May 2024–October 2024	Total Detects	N/A	N/A	175
		Unique IDs	N/A	N/A	16
Striped bass	Nov 2023–April 2024	Total Detects	N/A	470	N/A
		Unique IDs	N/A	1	N/A
	May 2024–October 2024	Total Detects	730	7,990	876
		Unique IDs	6	6	8

Note: ID = Identifiers; N/A = not applicable

Mid-River stations are those located north of Bath, lower river stations are from Bath to Fort Popham, and ocean stations from Fox to Seguin Island. These data provide a unique comparison for the winter/early spring months compared to the warmer months leading up to fall. For Atlantic sturgeon, there were noticeably higher detections on mid-river stations during cooler months, consistent with data from prior years and where a portion of this species is known to overwinter. The opposite trend was found to be true for warmer months with greater detections in the lower river, when fish move further downstream (and offshore) with warmer temperatures. For tagged shortnose sturgeon, the abundance of detections was, again, higher mid-river during the warmer months, typical of this species known to overwinter in the vicinity of Merrymeeting Bay and not as resident to the Eastern River. As with prior years, there was a fairly event split between mid- and lower-river detects for shortnose sturgeon during the two time periods, highlighting the widespread movement of this species in the Kennebec.

Notably, there were 17 unique white sharks detected that were tagged by Massachusetts Division of Marine Fisheries, an increasingly important dataset showing movements for this highly migratory species. These white shark detection data were recently included in a manuscript titled "Insights into the Habitat-Use Patterns of White Sharks (*Carcharodon carcharias*) Along the Maine Coastline" for consideration of publication in *Frontiers in Marine Science*, section Marine Megafauna. The objective of that paper is to characterize white shark patterns of spatial distribution in the Northern Gulf of Maine, utilizing data from multiple acoustic telemetry projects. Of note, the stations adjacent to Seguin Island between Seguin and Popham Beach had some of the highest intra-annual revisitation rates among all receivers at >50 percent.

Finally, 2024 represents the first year of Atlantic salmon detects of captive-reared fish tagged in the Penobscot River (75 to 80 km distance from mouth of Kennebec River to Penobscot Bay). One of these fish was detected at station FS06 offshore Seguin in February 2024, while another was detected on five stations between Abby Point (ABBYPT) and Mill Cove (MILL) during April 2024 (moving south over a period of 2 days).

For Atlantic sturgeon, the highest frequency of observations and unique number of individuals detected was at riverine stations beginning at Maine Maritime Museum, including North Bath (NBATH), BIW1, and BIW2 during May and June (**Figure 52** in **Section 2.10.2**). These stations had up to nineteen (19) unique Atlantic sturgeon documented in a single month. As with previous data, Atlantic sturgeon were recorded nearly each day at some of these stations during the month of May, indicating residential/feeding behavior rather than strictly transitory. Overall, the abundance of Atlantic sturgeon detections in this portion of the lower Kennebec was higher in early spring/summer (April-June) and lower in the summer (July/August). Towards the early fall (September), the overall number of fish observed declined on all stations in the lower Kennebec (south of Brick Island [BRKIS]). In the winter months (December-March), the prevalence of detects was noticeably higher upriver on stations NBATH and north, with detects recorded for only 1-2 fish in Feb/Mar on stations from Sasanoa (SAS) to Phippsburg West (PHIPPW). These months represent that absolute lowest presence in the area around BIW and directly to the south. This reflects general life history trends of Atlantic sturgeon in the Kennebec, with sub-adults that remain in the system over-wintering further upriver, and returning adults moving upriver around the month of June prior to spawning. Data gaps remain for characterization of seasonal coastal movements for this species.

Total detections for shortnose sturgeon were much lower than Atlantic sturgeon, although differences are reflective of current number of active tags in the region. The highest number of detections/individuals were recorded in similar months as those observed for Atlantic (April – June), although there was a fairly even spread ranging from Doubling Point (DPL) in the lower river to ABBYPT in the mid-river. Shortnose sturgeon spawn earlier in the season than Atlantic sturgeon (approximately May), though many remain in the system and overwinter. Only one shortnose sturgeon was detected on any station in the lower Kennebec shown in **Figure 52** outside March to June (SAS and MILL). Also, one shortnose sturgeon was detected on the BRKIS station in Merrymeeting Bay for the month of December, showing the need for additional overwintering data for this species. Still, these data highlight shortnose sturgeon distribution during the warmer months and comparable prevalence at mid-river stations to Atlantic sturgeon. As with Atlantic sturgeon, more data is needed to further characterize coastal movements for shortnose sturgeon.

Overall counts and frequency of Atlantic sturgeon at offshore stations are unsurprisingly lower, with highest counts at these stations occurring May through August 2024, with notable detections also recorded in April. Offshore detections likely represent data for fish moving in and out of the system during those months (**Figure 51**). No sturgeon were detected on any station offshore in October through February.

The data for those sturgeon tagged by NUWCDIVNPT in 2022 overall reflected the trends of the larger dataset . There were only two unique Atlantic sturgeon detected in the vicinity of BIW in February/March, and there was a fairly even spread of detections for shortnose sturgeon from April-July for stations from DPL north to ABBYPT.

Courthouse Point (CRTHPT) station was not recovered in two successive attempts, but a new station was re-deployed in October 2024, with plans for diver recovery of the original station in May 2025. Also, PHIPPW was not recovered in October 2024, and MILL station was malfunctioning upon recovery in November 2024.

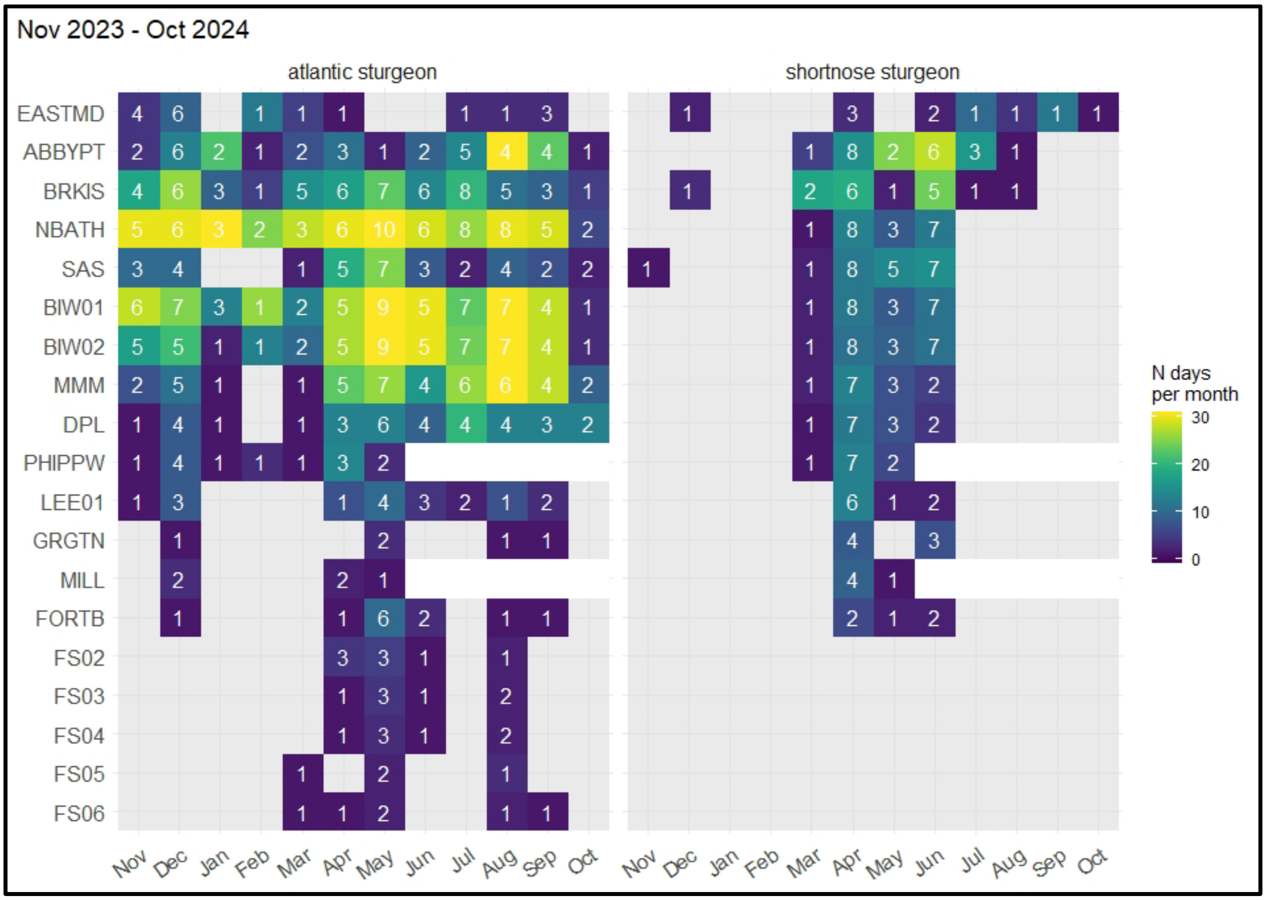


Figure 51. **Species detected at each station during the monitoring period November 2023 – October 2024, showing the number of days per month with detections and median number of unique individuals (white numbers). Current numbers of actively tagged fish are not uniform across species, so results can be used to infer presence and seasonality, but not relative abundance of species. (Note: unshaded cells represent months with no coverage for that station).**

2.10.2 Distribution of Gulf Sturgeon within the Panama City Testing Range

Gulf sturgeon (*Acipenser oxyrinchus desotoi*) were ESA-listed as threatened in 1991. From spring to fall, adults undergo a prolonged period of fasting in rivers before transiting to marine foraging areas, which are linked to reproductive success and key to the recovery of this species. Improving the limited understanding of marine habitat requirements is emphasized in the Gulf Sturgeon Recovery Plan (USFWS and GSMFC 1995), which highlights the need for multi-year tracking studies and will also assist in the Biological Assessment required under Section 7 of the ESA. The U.S. Naval Surface Warfare Center (NSWC) Panama City Division Testing Range overlaps extensively with Gulf Sturgeon Critical Habitat, as well as adjacent areas where Gulf sturgeon are believed to occur, and information on the spatial and temporal patterns of habitat use is needed.

Thirty Gulf sturgeon had previously been implanted with acoustic transmitters (VEMCO Ltd. V-16-6H) during 2021 (see Fox et al. 2000 for surgical procedures). An acoustic receiver array was also deployed within the NSWC Panama City Testing Range to monitor for these transmitters as well as transmitters deployed for other projects (in Gulf sturgeon and other species). This array consisted of 30 VEMCO Acoustic Release and 46 VEMCO Transmitting Receivers and was maintained until mid-May 2022. In October 2022, a modified acoustic receiver array was deployed based on the findings from the first sampling season and included 37 VEMCO Acoustic Release and 43 VEMCO Transmitting Receivers. These modifications included moving the furthest offshore receivers to the nearshore environment where most Gulf sturgeon were detected. Additional receivers were also added to increase resolution in the northeast portion of the study area (**Figure 52**). In the third field season of this project, our array was reconfigured into a finer scale array to facilitate identifying important habitats, key use areas and seasonal patterns for Gulf Sturgeon during their winter foraging season in the NSWC Panama City Test Range (**Figure 53**). This array was redeployed in early October 2023 and was active throughout this reporting period.

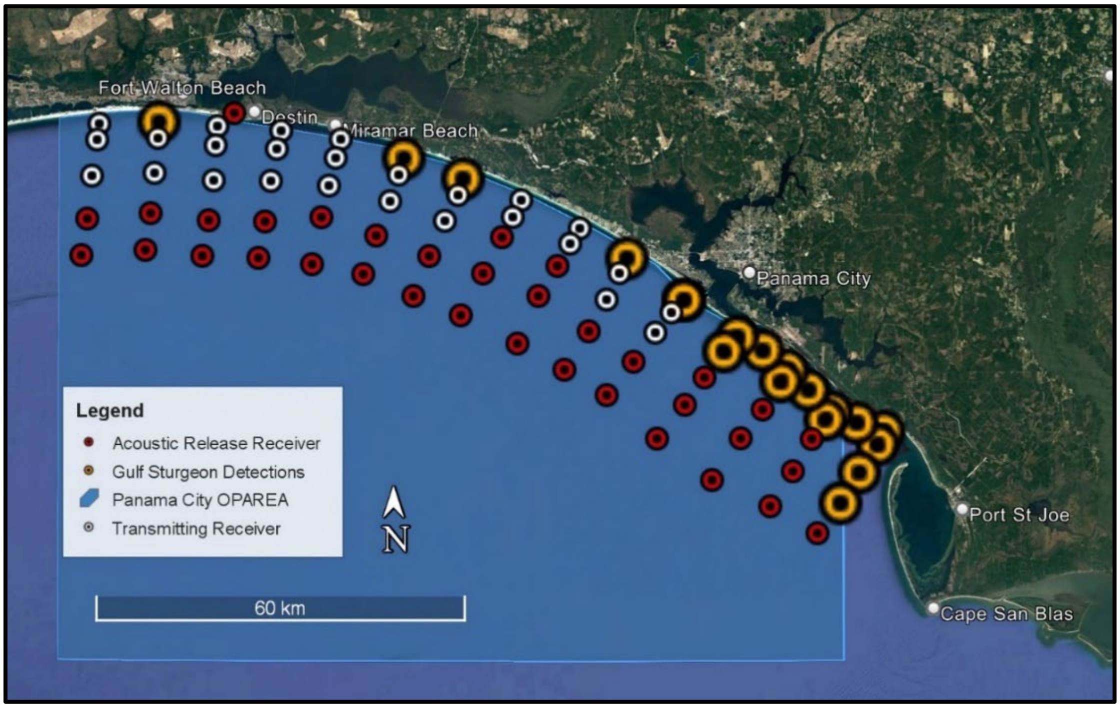


Figure 52. Acoustic receiver locations with detections of Gulf sturgeon in the NSWC Panama City Division Testing Range in the second field season (white = transmitting receivers, red = Acoustic Release receivers, orange = detections of Gulf sturgeon).

Figure 53. Deployment locations of passive acoustic receivers to monitor Gulf sturgeon in the NSWC Panama City Division Testing Range in the final field season (white = transmitting receivers, red = Acoustic Release receivers).

A total of 73 Gulf sturgeon were detected in the GOM during the 2022/2023 field season representing telemetered individuals from several river systems including the Choctawhatchee, Apalachicola, Suwanee, Yellow and Pascagoula Rivers. The majority of Gulf sturgeon detections remained close to shore with no confirmed detections beyond 7 km offshore (**Figure 54**).

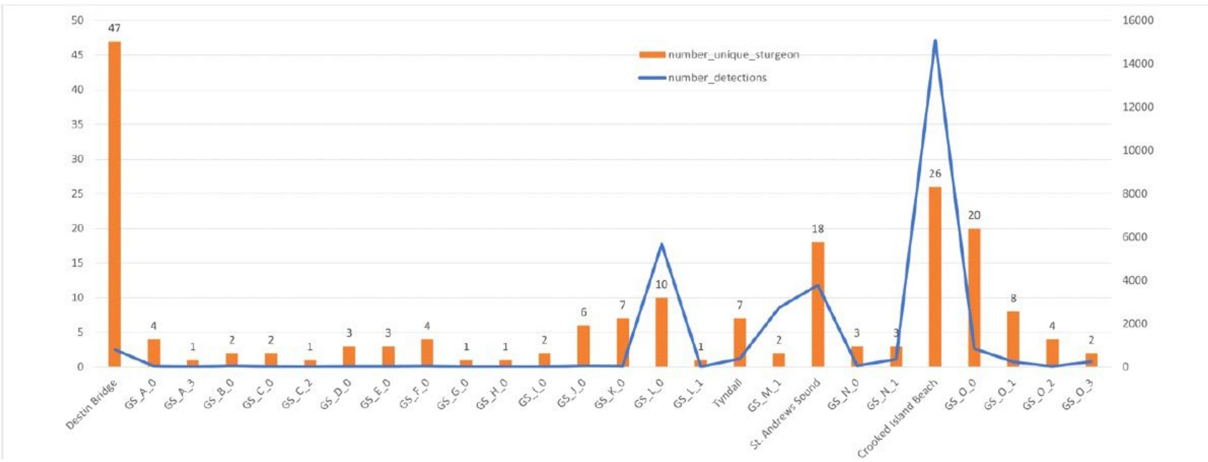


Figure 54. Total detections and number of unique telemetered Gulf sturgeon detected in the NSWC Panama City Division Testing Range. Station names ending with 0 are the closest to shore followed by 1, 2, and 3. The x axis is labeled from west to east beginning with Destin Pass inside the mouth of the Choctawhatchee Bay.

In the first 3 years of the acoustic array, transmitters in many other fish species including Black Drum, Bull Shark, Cobia, Crevalle Jack, Great Hammerhead, Lesser Devil Ray, Mutton Snapper, Spotted Eagle Ray, Southern Flounder, Tarpon, Triple Tail, Tiger Shark, and White Sharks were detected in our array. In addition to these fishes, we also detected increasing numbers of ESA listed Green, Kemp's Ridley, and Loggerhead Turtles. These data have been shared with the tag owners and we have received permission to include them in the final analyses. Note, there are still dozens of transmitters with unidentified species so this list will likely expand after final consultation with iTag when tag owners upload their information. We have been in touch with Dr. Sue Lowerre-Barbieri who runs iTag at the University of Florida and she informed us that they have secured funding to get the system fully operational and are planning a meeting for the spring of 2025 at which time we hope to be put in contact with the tag owners for unknown transmitters.

The year three acoustic receiver array was serviced in February, May, and October 2024 (beginning of the 4th season). This over summer deployment of the acoustic array was the first for these efforts and done so to determine additional species utilizing the northern end of the NSWC Panama City Test Range outside the times of year traditionally associated with Gulf Sturgeon's winter range. Of the 80 receivers deployed during year two of the project, one went missing between March and May until being returned by a private citizen who found it washed ashore in Mexico Beach. Initial results from that deployment again showed that Gulf Sturgeon were almost exclusively detected in the nearshore environment. Twenty-five of the 80 receivers detected sturgeon and 21 of those 25 were within 5 km of shore which corresponds very closely to designated Gulf Sturgeon critical habitat.

One final REMUS 100 mission was conducted in February 2024 to image and locate Gulf Sturgeon. Unfortunately, due to heavy seas and high swells in shallow waters, this mission was moved to deeper water and could not safely be conducted in the very nearshore environment where the highest concentrations of Gulf Sturgeon were observed during previous efforts.

Upon retrieval and full download of the array in late spring or early summer 2025, all telemetry data will be coordinated with I-Tag and the Gulf Sturgeon telemetry databases to confirm species and metadata associated with acoustic detections. We will analyze these detection data with habitat parameters such as temperature, time of year, location, and depth to determine the primary use areas and habitat characteristics for Gulf Sturgeon during winter foraging in the GOM. Additionally, data collected from the REMUS 100 missions will be evaluated in hopes of identifying fine scale Gulf Sturgeon congregations particularly in the northeastern portions of the Test Range.

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Appendix A.
Summary of Monitoring Investments in the Atlantic for 2024–2025

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Appendix A: Summary of Monitoring Investments in the Atlantic for 2024–2025[1]

Project Description	Intermediate Scientific Objectives	Status
Title: Atlantic Behavioral Response Study [2] **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 **Funding**: FY16 - $35K, FY17 - $1.25M, FY18 - $1.4M, FY19 - $1.4M, FY20 - $1.3M, FY21 - $1.25M, FY22 - $1.3M, FY23 - $1.17M, FY24 - $1.5M	• Evaluate behavioral responses by marine mammals exposed to Navy training and testing activities	**Field work ongoing** • Mid-frequency active sonar-controlled exposure experiment (CEEs) completed 2022 • Continuously active sonar CEEs began 2023 • Supplemental High-frequency Acoustic Recording Package (HARP) deployment in 2024 • Technical progress reports available – 2017–2024 • Tagging data available - Animal Telemetry Network • Multiple peer-reviewed publications and manuscripts in prep or review
Title: Behavioral Response Analysis of Two Populations of Short-finned Pilot Whales to Mid-Frequency Active Sonar [3] **Location**: Cape Hatteras and Hawaii **Objectives**: Utilize newly developed statistical methods from the Atlantic behavioral response study (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 **Funding**: FY24 - $20K	• Evaluate behavioral responses of marine mammals exposed to Navy training and testing activities	**FY24 New Start**

[1] All projects funded by U.S. Fleet Forces Command unless otherwise noted

[2] FY24 supplemental funding provided by Naval Air Systems Command

[3] Co-funded by U.S. Fleet Forces Command, Commander Pacific Fleet, and Naval Air Systems Command

<table>
<tr><th>Project Description</th><th>Intermediate Scientific Objectives</th><th>Status</th></tr>
<tr><td>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</td><td>• Determine what populations of marine mammals are exposed to Navy training and testing activities
• Establish the baseline behavior (foraging, dive patterns, etc.) of marine mammals where Navy training and testing activities occur
• Evaluate behavioral responses by marine mammals exposed to Navy training and testing activities</td><td>Field work ongoing
• Tagging field work continues under Atlantic BRS
• Technical progress reports available – 2013–2018
• Tagging data - Animal Telemetry Network
• Ongoing photo-identification analysis
• Photo-identification technical reports available 2019-2024
• Multiple peer-reviewed publications</td></tr>
<tr><td>Title: Mid-Atlantic Offshore Cetacean Study
Location: Virginia Capes (VACAPES) Operating Area (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
Funding: FY15 – $75K, FY16 – $645K, FY18 – $321K, FY19 – $357K, FY20 – $371K, FY21 – $430K, FY22 - $530K, FY23 - $435K</td><td>• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes
• Establish the baseline habitat uses and movement patterns of marine mammals where Navy training and testing activities occur
• Establish the baseline behavior (foraging, dive patterns, etc.) of marine mammals where Navy training and testing activities occur</td><td>Field work ongoing
• Sperm whale diving and feeding ecology focus beginning 2021
• Technical progress reports available – 2016–2024
• Associated photo-identification (photo-ID) analysis ongoing
• Peer-reviewed publications
• Sighting data – OBIS-SEAMAP
• Tagging data - Animal Telemetry Network</td></tr>
<tr><td>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
Methods: Visual surveys, UAS and focal follow observations, photo-ID, biopsy sampling, satellite-linked telemetry tags
Performing Organizations: HDR Inc., Kimora Solutions
Timeline: 2021-ongoing
Funding: FY21 - $320K, FY22 - $420K, FY23 - $775K, FY24 - $740K</td><td>• Establish the baseline habitat uses and movement patterns of marine mammals where Navy training and testing activities occur
• Establish the baseline behavior (foraging, dive patterns, etc.) of marine mammals where Navy training and testing activities occur</td><td>Fieldwork ongoing
• Expansion of nearshore humpback monitoring project in 2021
• Technical progress report available – 2022-2024
• Associated photo-ID analysis ongoing
• Tagging primarily focused on mid-shelf
• Humpback component focused on photo-ID and morphometric assessments
• Sighting data – OBIS-SEAMAP
• Tagging data - Animal Telemetry Network</td></tr>
</table>

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 **Funding**: FY13 – $535K, FY14 – $640K, FY15 – $755K, FY16 – $540K, FY17 – $528K, FY18 – $518K, FY19 – $464K, FY20 – $615K, FY21 – $450K, FY22 - $450K, FY23 - $790K, FY24 - $800K	• Establish the baseline habitat uses and movement patterns of marine mammals where Navy training and testing activities occur • Establish the baseline vocalization behavior of marine mammals and sea turtles where Navy training and testing activities occur • Establish the baseline behavior (foraging, dive patterns, etc.) of marine mammals where Navy training and testing activities occur	**Fieldwork ongoing** • DTAG deployments on SE calving grounds 2014–2017 • Aerial/vessel visual monitoring, satellite-telemetry tagging, suction-cup tag deployments, and photo-identification work in Mid-Atlantic beginning 2021 • Autonomous passive acoustic monitoring (PAM) glider deployments (2018-20), fixed auto-reporting PAM buoy off Cape Hatteras (2021-23) and Cape Charles (2023-25), Mid-Atlantic SoundTrap deployments (2022-25) • Multiple peer-reviewed publications available • Sighting data - WhaleMap **-Annual financial support to SE Early Warning System surveys** **-Participation on NE and SE recovery plan implementation teams**
Title: 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 **Funding**: FY24 – $345K	• Establish the baseline habitat use, seasonality, and movement patterns of marine mammals and Endangered Species Act (ESA)-listed species where Navy training and testing activities occur • Establish the baseline behavioral patterns (foraging, diving, etc.) of marine mammals and ESA-listed species where Navy training and testing activities occur • Estimate the distribution, abundance, and density of marine mammals and ESA-listed species in Navy range complexes, testing ranges, and in specific training and testing areas • Evaluate potential exposure of marine mammals and ESA-listed species to Navy training and testing activities	**FY24 New Start** • Field work in progress • Technical progress report available – 2024 • Tagging data - Animal Telemetry Network

Project Description	Intermediate Scientific Objectives	Status
Title: Haul Out Counts and Photo-Identification of Pinnipeds in Chesapeake Bay, Virginia **Location**: Chesapeake Bay **Objectives**: Document seasonal occurrence, habitat use, and haul-out patterns of seals **Methods**: Visual surveys, photo-ID **Performing Organizations**: NAVFAC Atlantic, The Nature Conservancy, HDR Inc. **Timeline**: 2015-2025 **Funding**: FY15 - $52K, FY16 - $36K, FY17 - $7K, FY18 - $29K, FY19 - $62K, FY20 – $40K, FY21 – $39K, FY22 - $93K, FY23 - $115K, FY24 - $30K	• Estimate the density of marine mammals and sea turtles in Navy range complexes and in specific training areas • Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to sonar and underwater explosives	**Fieldwork ongoing** • Anticipate completion of field work in 2025 • Technical progress reports available – 2016–2024 • Time-lapse camera traps incorporated in 2019
Title: Time-lapse Camera Surveys of Pinnipeds in Southeastern Virginia **Location:** Lower Chesapeake Bay and Virginia Eastern Shore **Objectives:** Document seasonal occurrence, habitat use, and haul-out patterns of seals **Methods:** Remote time-lapse camera traps, photo-ID **Performing Organizations**: NAVFAC Atlantic, The Nature Conservancy **Timeline:** 2019-ongoing **Funding:** FY19 - $15k, FY20 – $18K, FY21 – $11K, FY22 - $34K, FY23 - $58K, FY24 - $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** • Technical progress reports available – 2019–2024 • Peer-reviewed publication in press
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**: PAM **Performing Organizations**: National Oceanic and Atmospheric Administration-National Marine Fisheries Services (NOAA-NMFS) Southeast Fisheries Science Center (SEFSC) **Timeline**: 2019-2026 **Funding**: FY18 – $78K, FY19 – $395K, FY20 – $250K, FY22 - $59K	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Establish the baseline vocalization behavior of marine mammals where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to Navy training and testing activities	**Data collection and analysis ongoing** • Technical progress reports available – 2019–2023 • Analysis ongoing • Additional data collection 2025-2026 • Multiple peer-reviewed publications in prep

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

Project Description	Intermediate Scientific Objectives	Status
Title: Baseline Monitoring for Marine Mammals in the East Coast Range Complexes – Passive Acoustics **Location**: Virginia Capes, Cherry Point, and Jacksonville Range Complexes **Objectives**: Assess occurrence, habitat associations, density, and vocal activity of marine mammals in key areas of Navy range complexes **Methods**: Passive acoustic monitoring **Performing Organizations**: Duke University, Scripps Institute of Oceanography, NOAA-NMFS Northeast Fisheries Science Center (NEFSC) **Timeline**: 2007–2022 **Funding**: FY13 – $780K, FY14 – $800K, FY15 – $680K, FY16 – $596K, FY17 – $426K, FY18 – $299K, FY19 – $303K, FY20 – $231K, FY24 - $250K	• 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 in development (2024-25)
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 NEFSC **Timeline**: 2019-ongoing **Funding**: FY18 – $143k, FY19 – $145K, FY20 – $145K, FY21 – $150K, FY22 - $150K, FY23 - $0, FY24 - $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** • 2024 focus on multi-species beaked whale analyses • Technical progress reports available – 2019–2024 • 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, passive acoustic monitoring, tagging **Performing Organizations:** NOAA Fisheries NEFSC and SEFSC **Timeline:** 2010-2025 **Funding:** 2010-2023 - $250K annually. FY24-25 - $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]

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

Project Description	Intermediate Scientific Objectives	Status
Title: Jacksonville Shallow Water Training Range **Location**: Jacksonville Shallow Water Training Range (JSWTR) **Objectives**: Monitor species composition and distribution on JSWTR, conduct Marine Mammal Monitoring on Navy Ranges (M3R) species detection visual verifications **Methods**: Passive acoustics (M3R), visual surveys, satellite-linked tags, biopsy sampling, photo-ID **Performing Organizations**: Duke University, HDR Inc., Naval Undersea Warfare Center (NUWC) Newport **Timeline**: 2020–2025 **Funding**: FY18 – $261K, FY19 – $62K, FY20 – $97K, FY21 – $304K, FY22- $116K, FY23 - $279K, FY24 - $315K	• 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	**Development and Field work ongoing** • Transitioned from small vessel baseline surveys (2009-2018) • Field work resumed in 2020 with passive acoustics component leveraging M3R system • Current focus on M3R systems development, visual species verifications, supplemental photo-ID and tagging • North Atlantic right whale classifier in development
Title: Distribution of Gulf Sturgeon in the Panama City Testing Range [6] **Location**: U.S. Naval Surface Warfare Center (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**: 2021–2025 **Funding:** FY21 - $177K, FY22 - $149K, FY23 - $152K	• 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

[6] Funded by Naval Sea Systems Command

Project Description	Intermediate Scientific Objectives	Status
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**: 2021–2025 **Funding:** FY22 - $149K, FY23 - $102K, FY24 - $68K	• 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 and analysis ongoing** • Data collection anticipated to be complete in 2025

Appendix B.
2024 Publications and Presentations Resulting from AFTT-related Monitoring Investments

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Appendix B: 2024 Publications and Presentations Resulting from AFTT-related Monitoring Investments

Publications

Adcock, D.L., J.M. Shearer, H.J. Foley, Z.T. Swaim, and A.J. Read. 2024. Song fragments recorded on a tagged juvenile humpback whale (Megaptera novaeangliae) on a winter feeding ground at the mouth of the Chesapeake Bay, Virginia, USA. *Marine Mammal Science* 40:e13110.

DiMatteo, A., J.J. Roberts, D. Jones, L. Garrison, K.M. Hart, R.D. Kenney, W.A. McLellan, K. Lomac-MacNair, D. Palka, M.E. Rickard, K.E. Roberts, A.M. Zoidis, L. Sparks. 2024. Sea turtle density surface models along the United States Atlantic coast. *Endangered Species Research* 53:227–245.

Roberts, J.J., T.M. Yack, E. Fujioka, P.N. Halpin, M.F. Baumgartner, O. Boisseau, S. Chavez-Rosales, T.V. N. Cole, M.P. Cotter, G.E. Davis, R.A. DiGiovanni Jr., L.C. Ganley, L.P. Garrison, C.P. Good, T.A. Gowan, K.A. Jackson, R.D. Kenney, C.B. Khan, A.R. Knowlton, S.D. Kraus, G.G. Lockhart1, K.S. Lomac-MacNair, C.A. Mayo, B.E. McKenna, W.A. McLellan, D.P. Nowacek, O. O'Brien, D.A. Pabst, D.L. Palka, E.M. Patterson, D.E. Pendleton, E. Quintana-Rizzo, N.R. Record, J.V. Redfern, M.E. Rickard, M. White, A.D. Whitt, A.M. Zoidis. 2024. North Atlantic right whale density surface model for the US Atlantic evaluated with passive acoustic monitoring. *Marine Ecology Progress Series* 732:167–194.

Schick, R.S., W.R. Cioffi, H.J. Foley, J. Joseph, N.A. Kaney, T. Margolina, Z.T. Swaim, L. Zheng, B.L. Southall. 2024. Estimating received level in behavioral response studies through the use of ancillary data. *JASA* 156:4169–4180.

Shearer, J.M., H.J. Foley, Z.T. Swaim, V.M. Janik, and A.J. Read. 2024. Overwintering humpback whales adapt foraging strategies to shallow water environments at the mouth of the Chesapeake Bay, Virginia, USA. *Marine Mammal Science* e13184.

Presentations

Aschettino, J.M., D. Engelhaupt, A. Engelhaupt, J. Ozog, J. Bort Thornton, J. Bell, and K. Jackson. 2024. A closer look at an unusual late-spring aggregation of North Atlantic right whales off Virginia using tag and environmental data. Presentation, North Atlantic Right Whale Consortium Meeting, Providence, Rhode Island, October 2024.

Waples, D.M., W.R. Cioffi, Z.T. Swaim, and A.J. Read. 2024. Goose-beaked whales (*Ziphius cavirostris*) off Cape Hatteras, North Carolina, USA live in a fission-fusion society. 25th Biennial Conference on the Biology of Marine Mammals, 11–15 November 2024, Perth, Australia.

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

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