Mid-Atlantic Nearshore and Mid-Shelf Baleen Whale Monitoring, Virgina Beach, VA

2023/24

ANNUAL PROGRESS REPORT

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A minke whale (*Balaenoptera acutorostrata*) surfaces in front of the Chesapeake Bay Bridge Tunnel with a satellite and Customized Animal Tracking Solution (CATS) tag attached. Cover photograph by Dan Engelhaupt, taken under National Marine Fisheries Service Scientific Research Permit No. 21482.

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Science ⚓ Stewardship ⚓ Protection

Executive Summary

A total of 23 nearshore and mid-shelf vessel surveys were completed during the 2023/24 field season. In total, 43 baleen whale sightings, including 33 sightings of humpback whales (*Megaptera novaeangliae*) composed of 43 individuals, 6 sightings of North Atlantic right whales (*Eubalaena glacialis*) composed of 9 individuals (1 deceased), 3 sightings of minke whales (*Balaenoptera acutorostrata*) composed of 3 individuals, and 1 sighting of a fin whale (*Balaenoptera physalus*) composed of 1 individual occurred during the 2023/24 field season. A total of 13 aerial surveys were completed during the 2023/24 field season in association with this effort and the Offshore Cetacean Study (OCS) (Engelhaupt et al. 2025); see Ozog and Engelhaupt 2025 for additional details regarding those surveys. One satellite-linked telemetry tag and one Customized Animal Tracking Solution (CATS) tag was deployed on a minke whale, and one CATS tag was deployed on a humpback whale but did not collect any data. One biopsy sample was collected from the tagged minke whale, and biopsy samples were collected from a deceased humpback whale on behalf of the Virginia Aquarium and Marine Science Center (see **Table 1** in **Section 1**). During the OCS survey effort, 2 CATS tags and 2 Digital Acoustic Tags (DTAGs) were deployed on North Atlantic right whales and are also reported here.

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Acronyms and Abbreviations

°N	degrees North
°W	degrees West
BSS	Beaufort sea state
CATS	Customized Animal Tracking Solution
CBBT	Chesapeake Bay Bridge Tunnel
CLS	Collection & Location by Satellite
CTD	conductivity, temperature, and depth
DMA	Dynamic Management Area
DTAG	Digital Acoustic Recording Tag
ESA	Endangered Species Act
GMT	Greenwich Mean Time
GPS	Global Positioning System
hr	hour(s)
ID	identifier
km	kilometer(s)
LIMPET	Low Impact Minimally Percutaneous External-electronics Transmitter
m	meter(s)
max	maximum
min	minute(s)
MINEX	Mine Neutralization Exercise
mm:ss	minutes:seconds
NAVFAC	Naval Facilities Engineering Systems Command
nm	nautical mile(s)
NOAA	National Oceanic and Atmospheric Administration
OPAREA	Operating Area
photo-ID	photo-identification
SMA	Seasonal Management Area
SPOT	Smart Position and Temperature
UME	Unusual Mortality Event
U.S.	United States
VACAPES	Virginia Capes
VHF	very-high frequency

1 Introduction and Background

Since January 2015, HDR Inc. has been monitoring humpback whales (*Megaptera novaeangliae*) to assess their occurrence, habitat use, and behavior within and near United States (U.S.) Navy training and testing areas off Virginia via the Mid-Atlantic Humpback Whale Monitoring Project (**Table 1**). Vessel surveys focused on photo-identification (photo-ID), biopsy sampling, tagging using medium-resolution satellite-linked telemetry tags ("sat-tags") and high-resolution suction-cup tags, and using a small drone for length and body condition assessments. These baseline data are critical for assessing the potential for disturbance to humpback whales within this part of the Mid-Atlantic.

Although humpback whales were initially the focal species for this study, data on other high-priority baleen whale species were also collected opportunistically. Relatively little information exists on how other baleen whale species, including endangered North Atlantic right (*Eubalaena glacialis*) and fin (*Balaenoptera physalus*) whales, use the central Mid-Atlantic waters of the Atlantic Fleet Training and Testing area. Passive acoustic monitoring results from autonomous gliders and Marine Autonomous Recording Units confirm that humpback, fin, sei (*Balaenoptera borealis*), minke (*Balaenoptera acutorostrata*), and North Atlantic right whales regularly use the continental shelf waters off the coasts of Virginia and North Carolina (Stanistreet et al. 2016, Salisbury et al. 2018, Baumgartner 2019). Acoustic detections are supported by visual sighting data collected by the Atlantic Marine Assessment Program for Protected Species (NEFSC and SEFSC 2012, 2013) as well as extensive aerial and vessel baseline surveys previously funded under the Navy's Marine Species Monitoring Program (Mallette et al. 2018, Cotter 2019).

Fin whales, considered a strategic stock given their Endangered Species Act (ESA) status, appear to show a reliable pattern of occurrence near the continental shelf break throughout the Virginia Capes Operating Area (VACAPES OPAREA) (Hayes et al. 2023, 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 (A. Engelhaupt et al. 2017, 2018, 2019, 2025; Aschettino et al. 2018, 2021, 2022a). Confirmed sightings of critically endangered North Atlantic right whales off Virginia have also increased as coverage during surveys has extended farther offshore in recent years (Aschettino et al. 2022a, 2023, 2024a). Movements of satellite-tagged North Atlantic right whales show extensive use of the mid-shelf region both north and south of the primary study area (Aschettino et al. 2022a, 2023; D. Engelhaupt et al. 2022). Although sightings of blue whales (*Balaenoptera musculus)* off Virginia are infrequent, they have now been documented during HDR Inc. offshore surveys in 2018 (A. Engelhaupt et al. 2019, D.T. Engelhaupt et al. 2020, Engelhaupt et al. 2024), 2019 (Cotter 2019, D.T. Engelhaupt et al. 2020), 2021 (A. Engelhaupt et al. 2022), and 2022 (A. Engelhaupt et al. 2023a). Argos location data from satellite-tagged blue whales have shown at least some movements through shallower continental shelf waters (Lesage et al. 2017, A. Engelhaupt et al. 2022, Aschettino et al. 2022b).

Table 1. Summary of field seasons and objectives since project initiation in 2014.

Season	Begin	End	Objectives	Biopsy samples	Satellite tags deployed Mn / Bp / Eg / Ba	Suction cup tags deployed	Report
1 (2014/15[a])	31-Dec-2014	15-May-2015	Collect baseline information	12	—	—	Aschettino et al. 2015; A. Engelhaupt et al. 2015
2 (2015/16)	01-Dec-2015	09-May-2016	Collect baseline information and deploy telemetry tags	11	9 / 0 / 0 / 0	—	Aschettino et al. 2016
3 (2016/17)	01-Nov-2016	21-Mar-2017	Collect baseline information and deploy telemetry tags	29	26 / 0 / 0 / 0	—	Aschettino et al. 2017
4 (2017/18)	01-Oct-2017	01-Mar-2018	Collect baseline information and deploy telemetry tags, expand spatial extent of coverage	3	6 / 2 / 0 / 0	—	Aschettino et al. 2018
5 (2018/19)	12-Nov-2018	20-May-2019	Collect baseline information and deploy telemetry tags, collaborate on behavioral response of humpbacks to large vessels (Shearer et al. 2019, 2020)	9	10 / 0 / 0 / 0	—	Aschettino et al. 2019; Aschettino et al. 2020a; Aschettino et al. 2020b
6 (2019/20)	21-Dec-2019	27-Mar-2020	Collect baseline information, deploy telemetry tags, conduct photogrammetry using a drone, collaborate on behavioral response of humpbacks to large vessels (Shearer et al. 2021)	7	9 / 1 / 0 / 0	—	Aschettino et al. 2021
7 (2020/21)	19-Nov-2020	27-Mar-2021	Collect baseline information, deploy telemetry and acoustic tags, conduct photogrammetry using a drone, expand to mid-shelf region with addition of other baleen whale species, collaborate on behavioral response of humpbacks to large vessel project (Shearer et al. 2022)	6	7 / 2 / 2 / 0	4	Aschettino et al. 2022a
8 (2021/22)	14-Nov-2021	15-Mar-2022	Collect baseline information, deploy telemetry and acoustic tags, conduct photogrammetry using a drone, continue expansion to mid-shelf region with addition of other baleen whale species, collaborate on behavioral response of humpbacks to large vessel project (Shearer et al. 2023)	7	9 / 0 / 1 / 0	2	Aschettino et al. 2023
9 (2022/23)	21-Nov-2022	06-Mar-2023	Collect baseline information, deploy telemetry and acoustic tags, conduct photogrammetry using a drone, continue expansion to mid-shelf region with addition of other baleen whale species, collaborate on behavioral response of humpbacks to large vessel project (Shearer et al. 2024)	1	2 / 0 / 0 / 0	4	Aschettino et al. 2024a Aschettino et al. 2024b
10 (2023/24)	8-Nov-2023	30-Mar-2024	Collect baseline information, deploy telemetry and acoustic tags, conduct photogrammetry using a drone, continue expansion to mid-shelf region with addition of other baleen whale species	2	0 / 0 / 0 / 1	2	Current report and Aschettino et al. 2025b

Key: Mn = Humpback whale (*Megaptera novaeangliae*); Bp = Fin whale (*Balaenoptera physalus*); Eg = North Atlantic right whale (*Eubalaena glacialis*); Ba = Minke whale (*Balaenoptera acutorostrata*)

[a] Additional humpback whale sighting information from coastal line-transect surveys for bottlenose dolphins (*Tursiops sp.*) conducted from 2012 through 2015 (see A. Engelhaupt et al. 2016) was also incorporated into these analyses

Building upon the long-term dataset established through the ongoing monitoring of humpback whales, the Mid-Atlantic Nearshore and Mid-Shelf Baleen Whale Monitoring Project expanded the previous study area to encompass mid-shelf waters to approximately 75 kilometers (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 North Atlantic right, fin, humpback, sei, minke, and blue whales) within the study area?
- Do individual whales exhibit site fidelity within specific regions of the U.S. Navy OPAREAs over periods of weeks, months, or years?
- What is the seasonal extent of baleen whale movements within and around U.S. Navy OPAREAs?
- Do baleen whales spend significant time within or primarily move through areas of U.S. Navy live-fire or anti-submarine warfare training events?
- Are baleen whale movement patterns affected by U.S. Navy training exercises?
- Are baleen whales likely to be exposed to significant sound levels produced by vessel traffic and/or military training exercises using active sonar?

The core baleen whale field season off Virginia Beach runs from approximately the end of October through March, when humpbacks and North Atlantic right whales are common visitors—humpbacks most typically December through February, and right whales into April and occasionally beyond. Ten field seasons have been dedicated to addressing the above objectives (**Table 1**), starting with collection of basic baseline information using photo-ID, focal-follow, and biopsy-sampling methods. Subsequently, the project evolved to include deployment of satellite-linked telemetry tags, Digital Acoustic Recording Tags (DTAGs), and Customized Animal Tracking Solutions (CATS) tags; collaboration with researchers from Duke University to examine behavioral response of humpbacks to large vessels (Shearer et al. 2020); photogrammetry using a drone; and, more recently, an expansion into the mid-shelf region with the additional focus of other baleen whale species, including fin and North Atlantic right whales. This report will, therefore, present details for both the nearshore and mid-shelf effort during the 2023/24 season.

2 Methods

2.1 Vessel surveys

The study area for this project includes waters within and around the mouth of Chesapeake Bay; the W-50 Mine Neutralization Exercise (MINEX) region off Virginia Beach; and, beginning with the 2020/21 field season, the mid-shelf region of the VACAPES OPAREA (**Figure 1**). Two primary areas of interest within the nearshore study area are U.S. Navy training areas and commercial shipping lanes. Inbound and outbound shipping lanes are defined by the Traffic Separation Scheme. Initially, the "shipping lane study area" was defined by the Traffic Separation Scheme within the mouth of Chesapeake Bay (**Figure 1**). However, as tag locations showed movements outside the defined area but within shipping channels, the area was extended using multiple nautical charts and datasets. This includes using the following guidelines: the Traffic Separation Scheme; Coastal Maintained Channels in U.S. Waters (U.S. Army Corps of Engineers); and Shipping Fairways, Lanes, and Zones for U.S. Waters (National Oceanic and Atmospheric Administration [NOAA]). The U.S. Navy training areas include portions of the W-50 MINEX range. Within the mid-shelf study area, the Dominion Wind Energy Area, where 2 wind turbines are currently installed, 72 are partially installed, and 104 more will be installed, is also an area of interest (**Figure 1**).

Local availability of researchers allowed survey effort to be flexible and take advantage of limited winter weather windows to maximize the ability to achieve project objectives. Optimal weather conditions include good visibility and a Beaufort sea state (BSS) of 3 or lower. Once a survey was underway, if BSS reached 4 to 5, or visibility was reduced to less than 1 nautical mile (nm) because of rain, fog, or snow, the survey was typically aborted, and the vessel returned to port. Efforts were coordinated with the W-50 MINEX range, so the research vessel had clearance to operate when training was not being conducted. Because of frequent range closures and limited weather windows, it was not always possible to conduct surveys within the W-50 MINEX range.

The primary survey vessel for the nearshore effort during the 2023/24 season was the 8.8-meter (m), fiberglass, hybrid-foam collar boat, *Whale Research* (**Figure 2**). Surveys using this vessel departed from Marina Shores, located in Lynnhaven Inlet, Virginia Beach. While working within the mid-shelf area, surveys used the 16.2-m fishing vessel *Top Notch* (**Figure 3**). Surveys using this vessel departed from the Virginia Beach Fishing Center, located within Rudee Inlet. Given the focus on the mid-shelf with the intent to locate North Atlantic right whales, more mid-shelf surveys were conducted than nearshore surveys. When working within the mid-shelf region, the vessel would often coordinate with concurrent aerial surveys being conducted in Virginia and North Carolina by HDR Inc., Clearwater Marine Aquarium Research Institute, and Azura Consulting LLC, primarily to respond to any sightings of North Atlantic right whales.

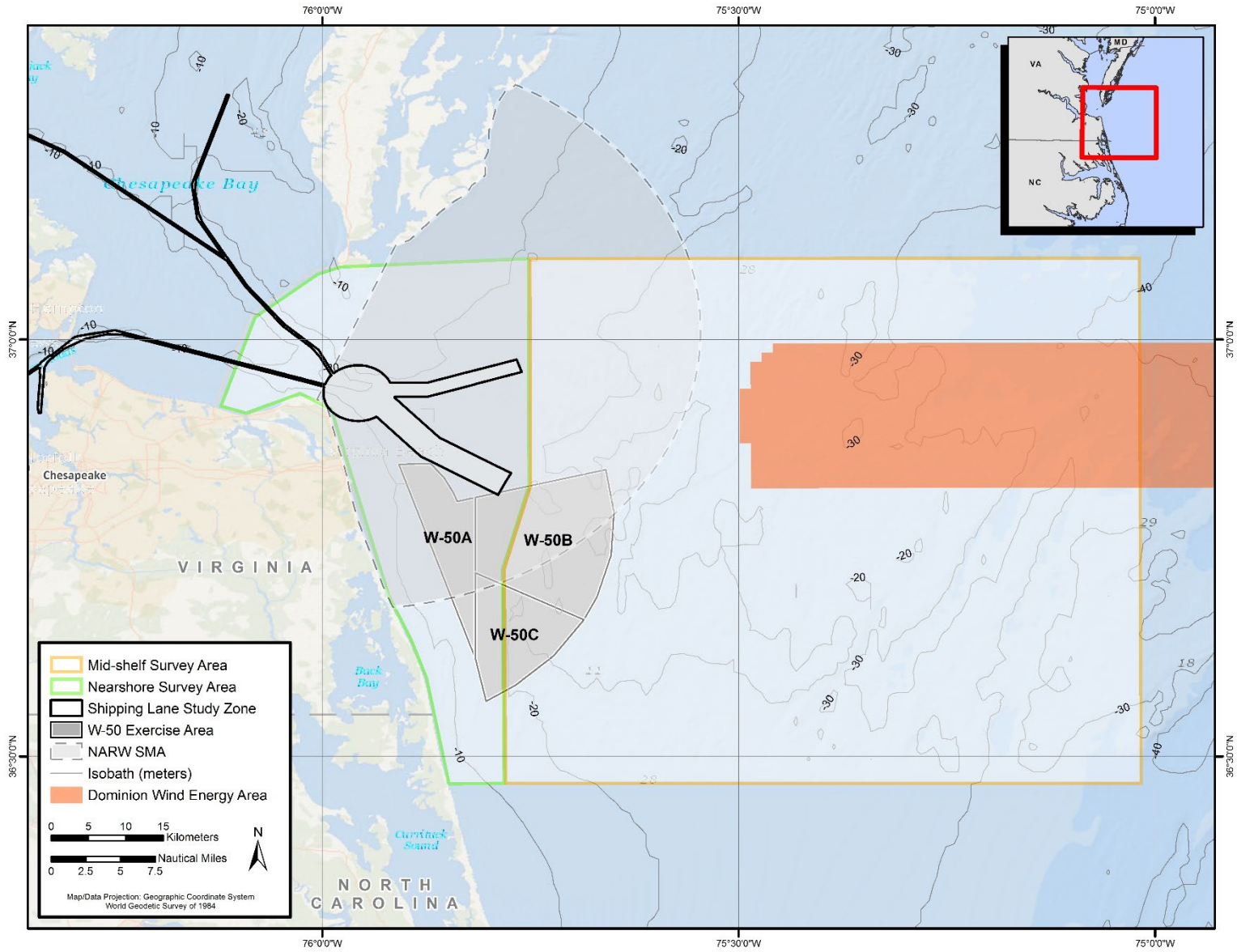

Figure 1. Map of the nearshore and mid-shelf study area, which includes waters within and around the mouth of Chesapeake Bay shipping lanes, the W-50 MINEX region off Virginia Beach, and the Dominion Wind Energy Area.

Figure 2. Nearshore survey vessel, 8-m *Whale Research*.

Figure 3. Mid-shelf survey vessel, 16.2-m *Top Notch* approaches a humpback whale to deploy a satellite tag and suction cup tag simultaneously (photograph © Kristin Rayfield, Rudee Tours).

The crew typically consisted of three or four qualified marine mammal scientists, with one also serving as the vessel operator when working from the nearshore vessel. Survey efforts typically began when the local whale-watch operations and other mariners first started reporting humpback sightings or baleen whales had been detected acoustically on the network of buoys within the survey area (https://robots4whales.whoi.edu/recent-detections/). Once departed from the inlet, the vessel would transit to areas where baleen whales were previously seen or reported. If no whales were located within these areas, the vessel would expand the search into waters farther offshore, north, or south of the primary study area (see **Figure 1**). Survey data were collected on an Apple® iPad using COMPASS (see Richlen et al. 2019), a U.S. Navy-funded, marine mammal survey software platform. Sightings of non-target species within the survey area (i.e., bottlenose dolphins [*Tursiops sp.*] and common dolphins [*Delphinus delphis*]) were not always recorded and are, therefore, not presented in this report.

2.2 Biopsy Sampling

Biopsy samples were collected using either a crossbow or biopsy rifle. Finn Larsen-designed crossbow bolts outfitted with 25-millimeter, ethanol-sterilized, stainless-steel tips were projected by a 68-kilogram pull Barnett recurve crossbow (Barnett Outdoors, LLC, Tarpon Springs, Florida). Alternatively, a Paxarms biopsy rifle (Paxarms New Zealand Ltd., Cheviot, New Zealand) fired 6- by 20-millimeter sterilized dart tips propelled by .22 caliber blank cartridges.

Samples were post-processed by sectioning the skin into three equal-sized pieces. One-third of the skin was placed in a cryovial and frozen (-40 degrees Celsius) for future stable isotope analysis, one-third was placed in a cryovial with a dimethylsulfate and sodium chloride solution in preparation for analysis by University of Groningen, and one-third was frozen (-40 degrees Celsius) for archival storage for the Southeast Fisheries Science Center. Blubber from the samples was wrapped in foil and frozen (-40 degrees Celsius) for archiving for the Southeast Fisheries Science Center. Stable isotope analysis and gender determination was performed on a portion of samples at the end of the 2016/17 field season (see Waples 2017). At the end of the 2018/19 field season, all humpback whale samples were sent to the University of Groningen for processing, where they analyzed 63 humpback whale and 8 fin whale samples collected since the project's inception, and matched them to the larger archive of more than 9,200 North Atlantic humpback whale and more than 1,700 fin whale samples (Bérubé and Palsbøll 2022). At the end of the 2023/24 field season, samples from the 2019/20 through 2023/24 field seasons were sent to the University of Groningen with a shipment from the Center for Coastal Studies to be processed.

2.3 Satellite Tagging

Satellite-linked telemetry tags have been a primary component of the project since the 2015/16 field season. Initially, Wildlife Computers (Redmond, Washington) Smart Position and Temperature (SPOT-6) Argos tags in the Type-A (Andrews et al. 2019) Low Impact Minimally Percutaneous External-electronics Transmitter (LIMPET) configuration (Andrews et al. 2008) were used. SPLASH10-F-333 and SPLASH10-292B tags, which collect dive depth data in addition to location, were incorporated into the project in subsequent seasons. The SPLASH10-F tags use Fastloc® Global Positioning System (GPS) technology; they were initially intended to be deployed during windows of opportunity during which Duke University researchers might also

be within the area and could potentially "double-tag" whales using DTAGs (see Shearer and Read 2020; Shearer et al. 2021). Tags were remotely deployed using a DAN-INJECT JM25 pneumatic projector. The LIMPET tags use two 6.8-centimeter, surgical-grade, titanium darts with six backwards-facing petals to attach tags to or just below the dorsal fin (**Figure 4**).

Figure 4. LIMPET SPLASH10-F tag on a humpback whale immediately after deployment.

Given existing information about attachment durations of LIMPET tags on baleen whales, maximum tag attachment duration was expected to be on the order of days to weeks. Therefore, tags were programmed to maximize the number of transmissions and locations received rather than to extend battery life. Based on satellite availability within the area, tags were programmed to transmit for 18 hours per day and up to 1,100 transmissions per day for the SPLASH10-F tag. A Collection & Location by Satellite (CLS) goniometer was also used as a mobile receiving station to maximize the amount of data (i.e., tag messages) collected that may otherwise be missed by the satellites.

In order to constitute a "dive" for the Wildlife Computers-generated behavior and time-series data outputs of the SPLASH10-F tags, a definition was established in which a submergence needed to be both deeper than 2 m and longer than 120 seconds to be classified as a dive. Locations of tagged individuals were approximated by the Argos system using the Kalman filtering location algorithm (Argos User's Manual © 2007–2015 CLS), and unrealistic locations (i.e., on land) were manually removed using tools provided within Movebank.

Biopsy samples were collected from tagged whales using the protocols described in Section **2.2**; conductivity, temperature, and depth (CTD) casts were typically taken following a tag deployment.

2.4 Digital Archival Tagging

Digital archival tagging was added to the project for the 2020/21 season using DTAGs (Johnson and Tyack 2003) within the mid-shelf and/or MINEX region of the study area. CATS tags were incorporated for the 2022/23 season. Both types of digital tags use suction-cup attachments, are deployed using a hand-held carbon fiber pole, and must be retrieved for data recovery. Version 3 DTAGs were equipped with hydrophones and pressure sensors as well as a three-axis accelerometer and magnetometer. The audio-sampling rate was set to 120 kilohertz for baleen whales, and programmed release time was set according to conditions and logistics to facilitate the best opportunity for tag retrieval. The customized CATS tag contains a 4K high-resolution video camera in addition to the diary that records accelerometer, magnetometer, gyroscope, and pressure data as well as a single hydrophone. Both types of tags contain a very-high frequency (VHF) transmitter that allows recovery using Communications Specialists, Inc. R-1000 VHF receivers with hand-held Yagi antennas to direct the vessel to the tag location after release from the animal. The CATS tag also includes a SPOT-6 satellite tag to support recovery.

Tag calibration and data visualization following recovery of all tags was completed using a suite of tools found on animaltags.org and using MATLAB. CATS tag calibration steps are outlined in Cade et al. (2021).

3 Results

3.1 Vessel Surveys

The first survey for the 2023/24 field season occurred on 08 November 2023, and the last survey occurred on 30 March 2024. In total, 23 vessel surveys were conducted, covering 3,474 km of trackline with more than 172 hours of effort (**Table 2**; **Figure 5**). In total, 43 baleen whale sightings, including 33 humpback whale sightings composed of 43 individuals, 6 North Atlantic right whale sightings composed of 9 individuals (1 deceased), 3 minke whale sightings composed of 3 individuals, and 1 fin whale sighting composed of 1 individual occurred during the 2023/24 field season (**Figure 5**; **Table 2**). An unusual sighting of a pair of Risso's dolphins (*Grampus griseus*) also occurred during these surveys and is included in **Figure 5**. During the late spring OCS survey effort, a persistent aggregation of baleen whales was observed at the shelf break. Results from those surveys are primarily presented in the Engelhaupt et al. (2025) report; however, an overview of the North Atlantic right whales observed also included in this report.

During late spring surveys under the OCS project, a persistent aggregation of baleen whales was observed near the shelf break. Results from those surveys are primarily presented in the Engelhaupt et al. (2025) report; however, an overview of the North Atlantic right whale sightings and tag results are also included in this report. Because North Atlantic right whales are a priority species due to their critically endangered status, a summary of all North Atlantic right whale sightings across both projects is presented in **Table 3** and **Figure 6**.

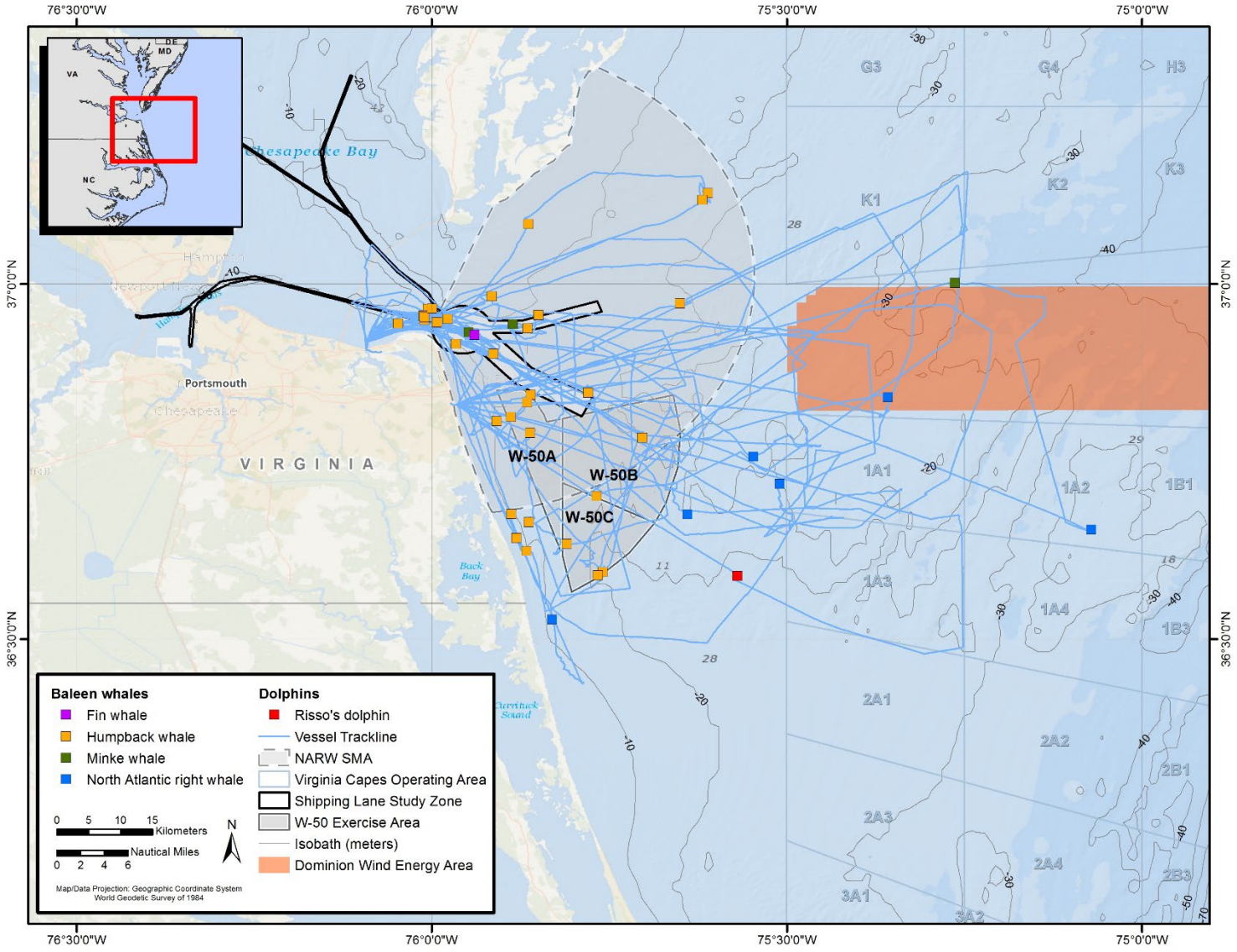

Figure 5. Vessel survey tracks (blue), with locations of all humpback (*n*=33), North Atlantic right (*n*=6), minke (*n*=2), and fin (*n*=1) whale sightings for the 2023/24 field season along with a sighting of Risso's dolphins (*n*=1).

Table 2. Summary of nearshore and mid-shelf vessel survey efforts off Virginia Beach, Virginia, for the 2023/24 field season.

Date	Survey type	Survey time (min)	Distance surveyed (km)	# Sightings Mn	# Individual Mn	# Sightings Eg	# Individual Eg	# Sightings Ba	# Individual Ba	# Sightings Bp	# Individual Bp
8-Nov-23	Nearshore	216	78	0	0	0	0	0	0	0	0
15-Nov-23	Mid-shelf	492	227	1	2	1	1	0	0	0	0
16-Nov-23	Nearshore	465	130	3	7	0	0	0	0	0	0
30-Nov-23	Nearshore	450	138	2	3	0	0	0	0	0	0
4-Dec-23	Mid-shelf	463	107	3	4	0	0	0	0	0	0
8-Dec-23	Nearshore	412	201	1	1	0	0	0	0	0	0
15-Dec-23	Mid-shelf	468	163	4	4	0	0	0	0	0	0
16-Dec-23	Mid-shelf	537	179	0	0	1	1	0	0	0	0
29-Dec-23	Nearshore	432	125	1	1	0	0	0	0	0	0
31-Dec-23	Nearshore	436	123	2	3	0	0	0	0	0	0
3-Jan-24	Mid-shelf	464	191	2	3	0	0	0	0	0	0
22-Jan-24	Nearshore	475	191	0	0	0	0	0	0	0	0
22-Jan-24	Nearshore	481	143	0	0	0	0	0	0	0	0
23-Jan-24	Nearshore	474	203	0	0	1	2	0	0	0	0
2-Feb-24	Mid-shelf	557	170	0	0	1	2	0	0	0	0
8-Feb-24	Nearshore	445	140	0	0	1	1	0	0	0	0
12-Feb-24	Nearshore	465	121	3	3	0	0	1	1	0	0
15-Feb-24	Mid-shelf	542	193	4	4	0	0	0	0	0	0
18-Feb-24	Nearshore	582	75	3	4	0	0	1	1	1	1
19-Feb-24	Nearshore	286	76	1	1	0	0	0	0	0	0
25-Feb-24	Mid-shelf	304	138	2	2	0	0	0	0	0	0
3-Mar-24	Nearshore	444	158	1	1	0	0	0	0	0	0
30-Mar-24	Mid-shelf	480	204	0	0	1	1	1	1	0	0
—	—	**10,370**	**3,474**	**33**	**43**	**6**	**8**	**3**	**3**	**1**	**1**

Key: min = minute(s); Mn = *Megaptera novaeangliae* (humpback whale); Eg = *Eubalaena glacialis* (right whale); Ba = *Balaenoptera acutorostrata* (minke whale); Bp = *Balaenoptera physalus* (fin whale)

Table 3. Summary of all North Atlantic right whale sightings for the 2023/24 field season.

Sighting Date	Survey Type	Report	Group Size	Sighting Latitude (°N)	Sighting Longitude (°W)	Original / Re-sight
15-Nov-23	Vessel	Current report, Aschettino et al. 2025b	1	36.5278	75.8304	Original
16-Dec-23	Aerial	Ozog and Engelhaupt 2025, Aschettino et al. 2025b	1	36.6740	75.6493	Original
16-Dec-23	Vessel	Current report, Aschettino et al. 2025b	1	36.6755	75.6400	Re-sight
23-Jan-24	Aerial	Ozog and Engelhaupt 2025, Aschettino et al. 2025b	2	36.8475	75.3491	Original
23-Jan-24	Vessel	Current report, Aschettino et al. 2025b	2	36.8406	75.3584	Re-sight
2-Feb-24	Aerial	Ozog and Engelhaupt 2025, Aschettino et al. 2025b	2	36.7188	75.5186	Original
2-Feb-24	Vessel	Current report, Aschettino et al. 2025b	2	36.7188	75.5103	Re-sight
10-Feb-24	Vessel	Current report, Aschettino et al. 2025b	1	36.7569	75.5474	Original
30-Mar-24	Aerial	Ozog and Engelhaupt 2025, Aschettino et al. 2025b	1	36.6534	75.0701	Original
30-Mar-24	Vessel	Current report, Aschettino et al. 2025b	1	36.6543	75.0718	Re-sight
22-May-24	Vessel	Engelhaupt et al. 2025, Aschettino et al. 2025b	7	36.9224	74.6971	Original
25-May-24	Vessel	Engelhaupt et al. 2025, Aschettino et al. 2025b	8	36.8065	74.6859	Original
25-May-24	Aerial	Ozog and Engelhaupt 2025, Aschettino et al. 2025b	1	36.8081	74.7306	Re-sight
25-May-24	Aerial	Ozog and Engelhaupt 2025, Aschettino et al. 2025b	1	36.8570	74.7662	Re-sight
25-May-24	Aerial	Ozog and Engelhaupt 2025, Aschettino et al. 2025b	4	36.7898	74.6766	Re-sight
25-May-24	Aerial	Ozog and Engelhaupt 2025, Aschettino et al. 2025b	1	36.8465	74.7059	Re-sight
29-May-24	Vessel	Engelhaupt et al. 2025, Aschettino et al. 2025b	14	36.7462	74.6927	Original
30-May-24	Vessel	Engelhaupt et al. 2025, Aschettino et al. 2025b	1	36.7507	74.7925	Original
30-May-24	Vessel	Engelhaupt et al. 2025, Aschettino et al. 2025b	1	36.7340	74.7395	Original
30-May-24	Vessel	Engelhaupt et al. 2025, Aschettino et al. 2025b	1	36.6833	74.7192	Original
30-May-24	Vessel	Engelhaupt et al. 2025, Aschettino et al. 2025b	5	36.6311	74.7166	Original
30-May-24	Vessel	Engelhaupt et al. 2025, Aschettino et al. 2025b	1	36.6331	74.7517	Original
01-Jun-24	Vessel	Engelhaupt et al. 2025, Aschettino et al. 2025b	2	36.5697	74.7352	Original

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

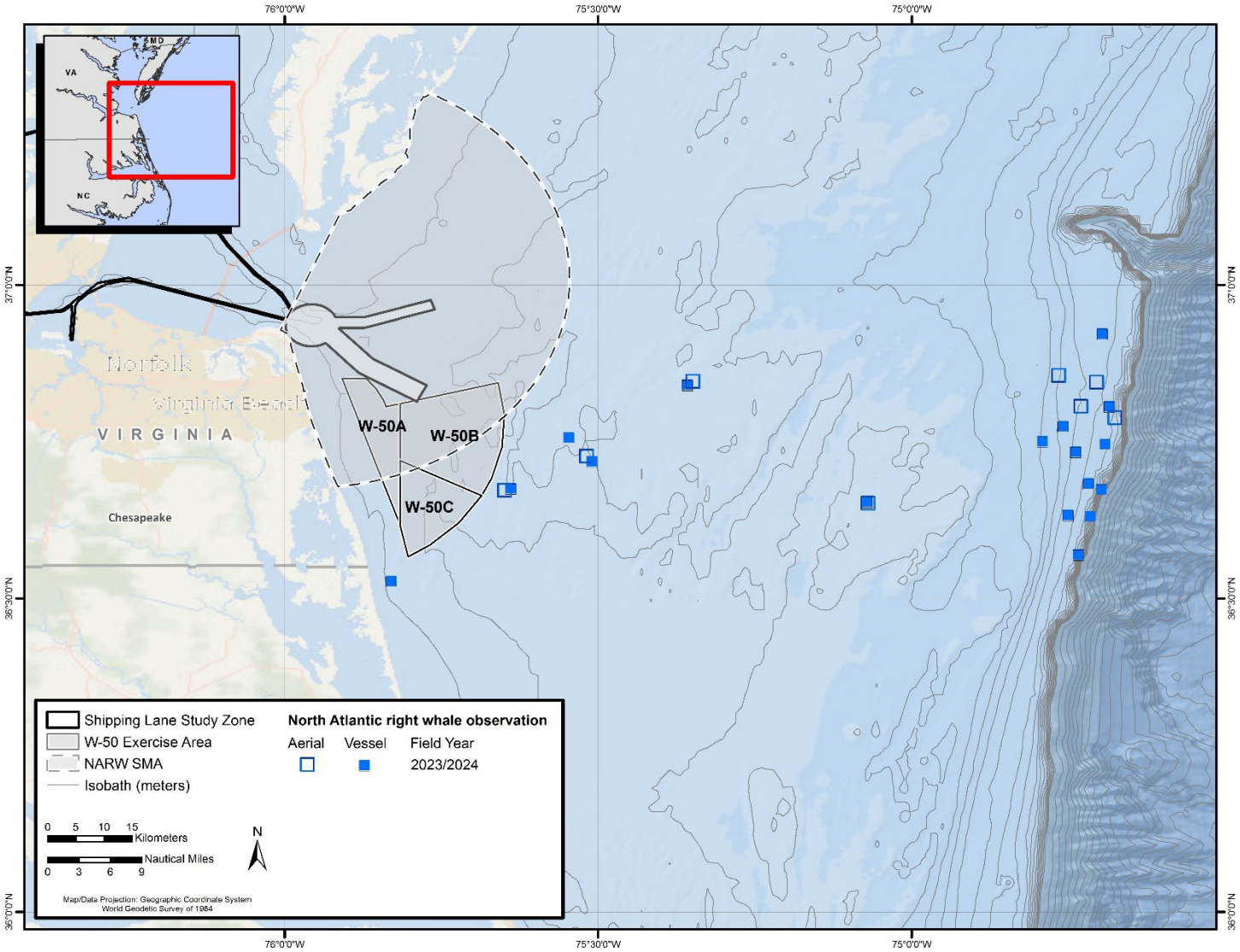

Figure 6. Sighting locations of all North Atlantic right whales observed during aerial and vessel surveys during the 2023/2024 season.

3.2 Biopsy Results

One biopsy sample was collected from tagged minke whale HDRVABa015 during the 2023/24 field season and is awaiting analyses, along with samples collected between the 2019/20 and 2022/22 field seasons. Additional humpback and fin whale biopsy samples were collected in 2024 during the Offshore Cetacean Study (see Engelhaupt et al. 2025).

Thirty-one samples (29 humpback and 2 fin whales) from 2014 to 2016 were previously processed for stable-isotope analyses ($\delta^{13}C$ and $\delta^{15}N$) (Waples 2017). Sixty-three humpback samples and eight fin whale samples (inclusive of the samples analyzed for stable isotopes) were previously provided to the University of Groningen for genetic analysis, with humpback samples being integrated into a larger North Atlantic humpback whale population study. Gender results from the full set of samples show roughly equal sex ratios of humpback whales (32 males and 31 females) and a skewed gender ratio of fin whales (6 males and 1 female) (Bérubé and Palsbøll 2022). Genetic matching to the larger North Atlantic Humpback Whale Catalog, which contains 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 occurred 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).

3.3 Satellite Tagging Results

One Argos-linked SPLASH10-F satellite tag was deployed on a minke whale during the 2023/24 field season (**Table 4**; **Figure 7** and **Figure 8**). The tag transmitted for 11.8 days and is the first satellite tag deployed on a minke whale within the study area. See Engelhaupt et al. (2025) for details of satellite tags deployed on humpback and fin whales during the OCS survey effort.

Table 4. Satellite-tag deployments on a minke whale during the 2023/24 field season.

Animal ID	Estimated age class	Tag type	Argos ID	Deployment latitude (°N)	Deployment longitude (°W)	Deployment date	Last trans-mission date	Tag duration (days)
HDRVABa015	Adult	SPLASH10-333F	221011	36.9380	75.8863	12-Feb-24	24-Feb-24	11.8

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

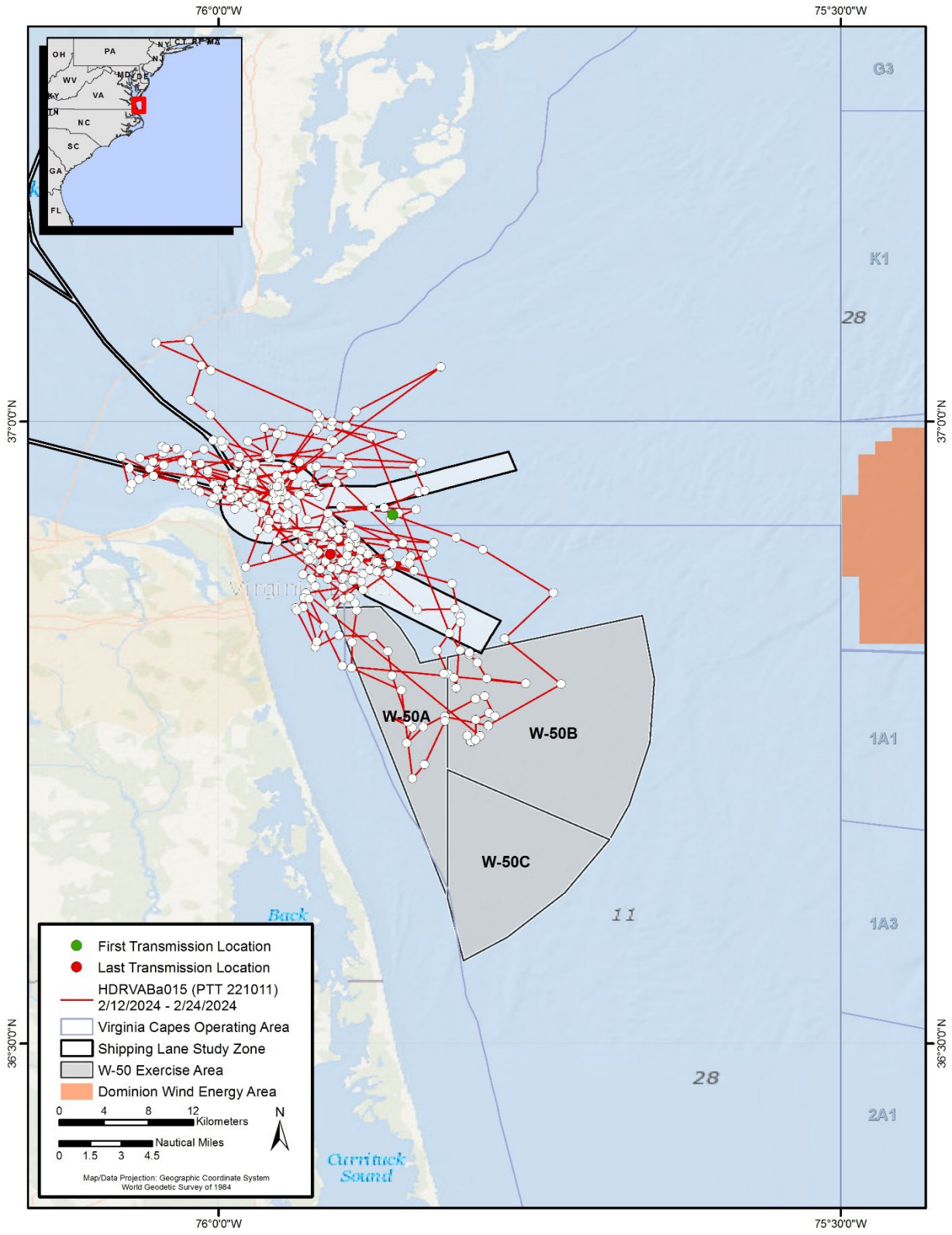

Figure 7. Filtered locations (white dots) and trackline of minke whale HDRVAMBa015, tagged on 12 February 2024, over 11.8 days of tag-attachment duration.

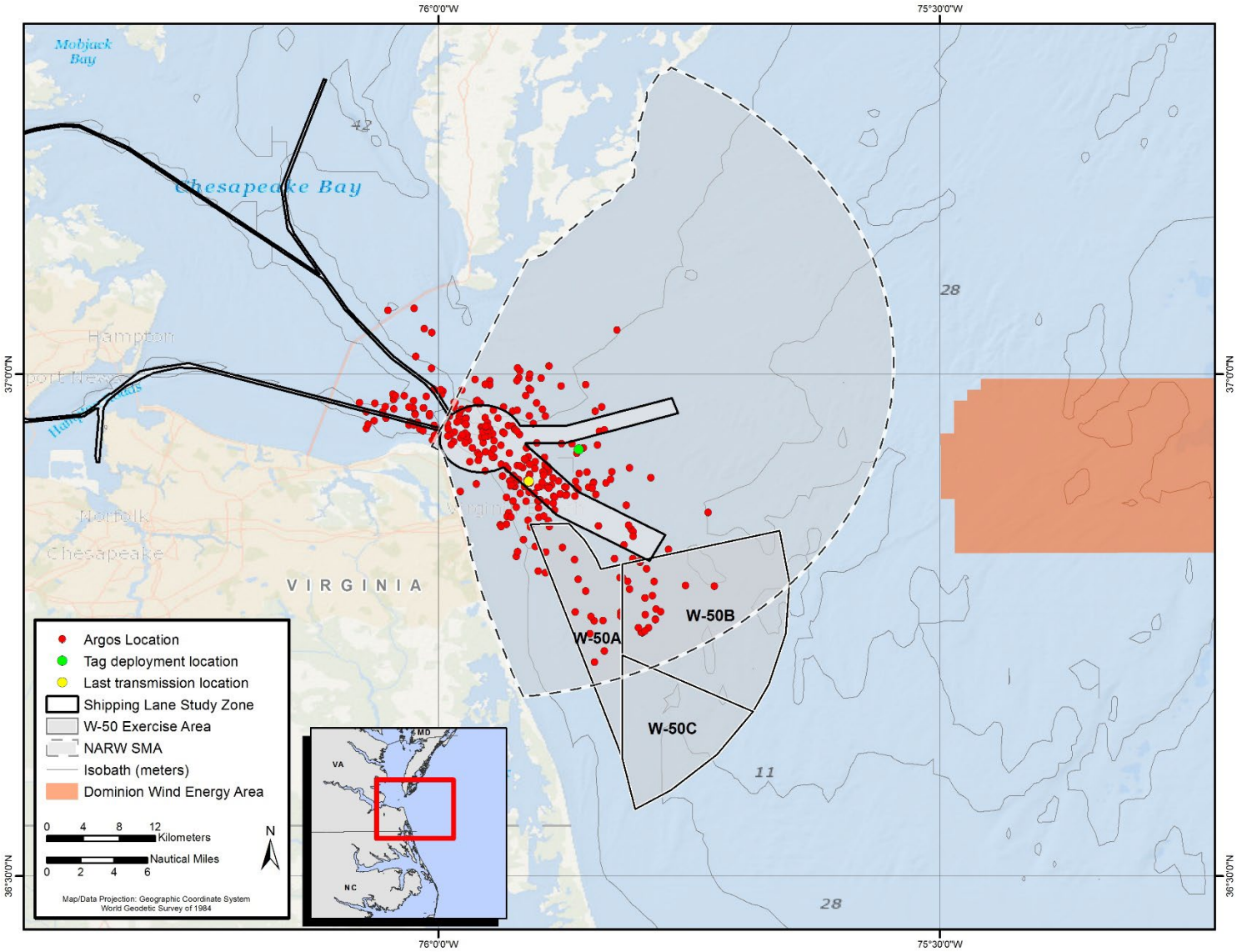

Figure 8. Filtered locations of minke whale HDRVAMBa015 within the immediate vicinity of shipping channels at the mouth of Chesapeake Bay from tag deployments (*n*=1) during the 2023/24 field season.

HDRVABa015 was tagged approximately 6.5 nm east of Cape Henry, and just outside the shipping channels (**Figure 7**). This individual remained within the primary study area for the duration (11.8 days) 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 (see **Section 3.4**). 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 region of VACAPES (**Figure 8**; **Table 5**). Many locations also occurred outside the North Atlantic right whale Seasonal Management Area (SMA), where vessel speed restrictions are in place seasonally (**Figure 8**). Maximum straight-line distance from the initial tagging location was 23.5 km, and mean distance was only 10.1 km (**Table 5**).

Table 5. Summary of results from satellite-tag data for the minke whale tagged during the 2023/24 field season.

Animal ID	# locations post filtering	Percent within shipping channels	Percent within VACAPES	Maximum distance from initial location (km)	Mean distance from initial location (km)
HDRVABa015	316	43.0	31.0	23.5	10.1

Key: ID = identifier

The satellite tag also recorded data on dive depth and duration in addition to the Argos capabilities (**Table 6**). 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 durations range was 2.7 minutes (min) with a maximum dive duration of 6.2 min (**Table 6**).

Table 6. Summary of dive depth and duration data collected from tagged minke whale during the 2022/23 field season.

Animal ID	# dives logged	Mean dive depth (m)	Maximum dive depth (m)	Mean dive duration (mm:ss)	Maximum dive duration (mm:ss)
HDRVABa015	670	8.9	24.0	2:43	6:13

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

The dive duration of the minke whale was similar to that of humpbacks tagged during the previous three seasons; during the 2019/20 field season (*n*=11,708 dives), mean dive durations ranged from 2.4 to 3.9 min; during the 2020/21 field season (*n*=4,119 dives), mean dive duration ranged from 2.5 to 3.8 min; and during the 2021/22 field season (*n*=4,519 dives), mean dive duration ranged from 2.7 to 3.1 min. Mean dive depths were shallower compared with humpback whales tagged during previous seasons: mean dive depth of 12.6 to 16.3 m in 2019/20, 15.7 to 30.5 m in 2020/21, and 13.9 to 17.6 m in 2021/22. Dives for humpback whales tagged during the 2018/19 field season were shorter, ranging from 1.8 to 3.0 min (Aschettino et al. 2020a), and shallower, ranging from 8.6 to 14.6 m, which may be a result of a smaller dataset (*n*=230 dives) or different foraging strategies.

3.4 Digital Archival Tagging Results – Minke and Humpback Whales

Two CATS suction-cup tags were deployed during the 2023/24 field season, one each on a humpback and minke whale (**Table 7**). The tag deployed on humpback whale HDRVAMn294 was successfully recovered 2 days after deployment. Unfortunately, no data was 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 7**). **Table 8** summarizes the dive statistics calculated using the find-dive MATLAB script from the toolbox posted to the animaltags.org site, with a dive-depth definition of 2 m and 2 min. A total of 145 dives and 144 surfacing bouts were recorded during the tags' deployment. Dive duration ranged from 2.0 to 6.47 min (mean = 2.61 min). Maximum dive depth was 24.6 m (mean = 7.85 m) (**Table 8**). **Figure 9** shows the dive profile of HDRVABa015. Further analysis of all tag data is underway.

Table 7. CATS deployments on humpback and minke whales during the 2023/24 field season.

Animal ID	Species	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 16:04	20.0	2024-Feb-19 13:15	1,269

Key: ID = identifier; GMT = Greenwich Mean Time

Table 8. Summary of dive depth and duration data collected from CATS tag ba240218-01.

Deployment ID	Animal ID	# dives logged	Mean dive depth (m)	Maximum dive depth (m)	Mean dive duration (mm:ss)	Maximum dive duration (mm:ss)
ba240218-01	HDRVABa015	145	7.8	24.6	2:37	6:28

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

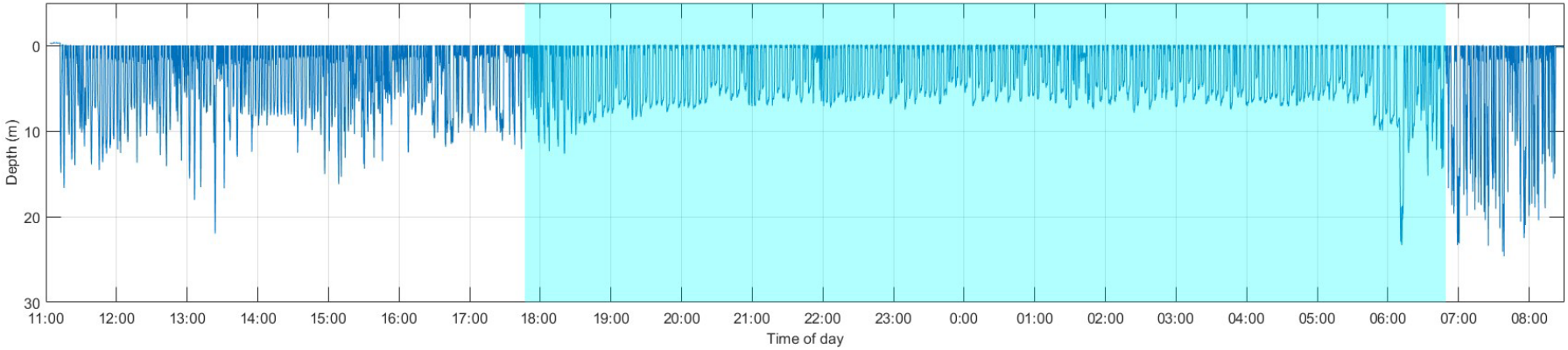

Figure 9. Dive-depth profile (in meters) for HDRVABa015 (CATS ba240218-01) with sunset through sunrise shaded blue in local time.

3.5 Digital Archival Tagging Results – North Atlantic Right Whales

Two successful DTAG deployments and two successful CATS tag deployments occurred during 2024 on North Atlantic right whales (**Table 9** and **Table 10**).

Figure 10 through **Figure 13** show dive profiles for the four suction-cup-tagged NARWs. **Table 11** shows all dives defined using a modified MATLAB script from the animaltags.org toolbox with a dive-depth definition of 2 m and duration of 2 min. A total of 122 dives were logged, and the maximum dive depth recorded was 145 m. 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. Bottom depths recorded from the vessel echosounder during sightings and tag GPS locations ranged between 79 and 119 m, though data was not available for all tag deployment durations. 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).

Table 9. Successful North Atlantic right whale DTAG deployment details.

Animal ID	DTAG No./ Deployment ID	Deployment (GMT)	Depth at Tagging (m)	Tag Off Animal (GMT)	Tag Duration (min)	Gender
NARW #3908	345/ eg24_146a	2024-May-25 17:26	97	2024-May-25, 19:55[a]	149[a]	Female
NARW #3101	340/ eg24_150a	2024-May-29 18:12	103	2024-May-30, 09:30[a]	918[a]	Female

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

[a] Research team was not present during tag release; the tag-off time and tag duration are estimated

Table 10. Successful North Atlantic right whale CATS tag deployment details.

Animal ID	CATS Tag No./ Deployment ID	Deployment (GMT)	Depth at Tagging (m)	Tag Off Animal (GMT)	Tag Duration (min)	Gender
NARW #3241	CATS 01/ eg052524-01	2024-May-25 14:52	97	2024-May-26, 01:51[a]	659[a]	Male
NARW #3391	CATS 01/ eg052924-01	2024-May-29 16:47	103	2024-May-29, 17:36	49	Male

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

[a] Research team was not present during tag release; the tag-off time and tag duration are estimated

Table 11. Summary of archival tag dive data for all NARWs deployed in 2024.

NARW ID/Name	NARW #3241	NARW #3908/Zero	NARW #3391	NARW #3101/Harmonia	All Tags Combined
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 (hr)	10.98	2.48	0.82	14.3	—
Number of dives	51	11	4	56	122
Mean dive duration (min)	6.34	8.75	8.13	4.2	5.63
Median dive duration (min)	6.42	8.61	8.8	3.5	5.27
Mean surface duration (min)	7.34	3.84	3.3	11.67	8.88
Median surface duration (min)	2.6	3.9	3.3	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	43.2	67.32

Notes: hr = hour(s); ID = Identification Number; max = maximum

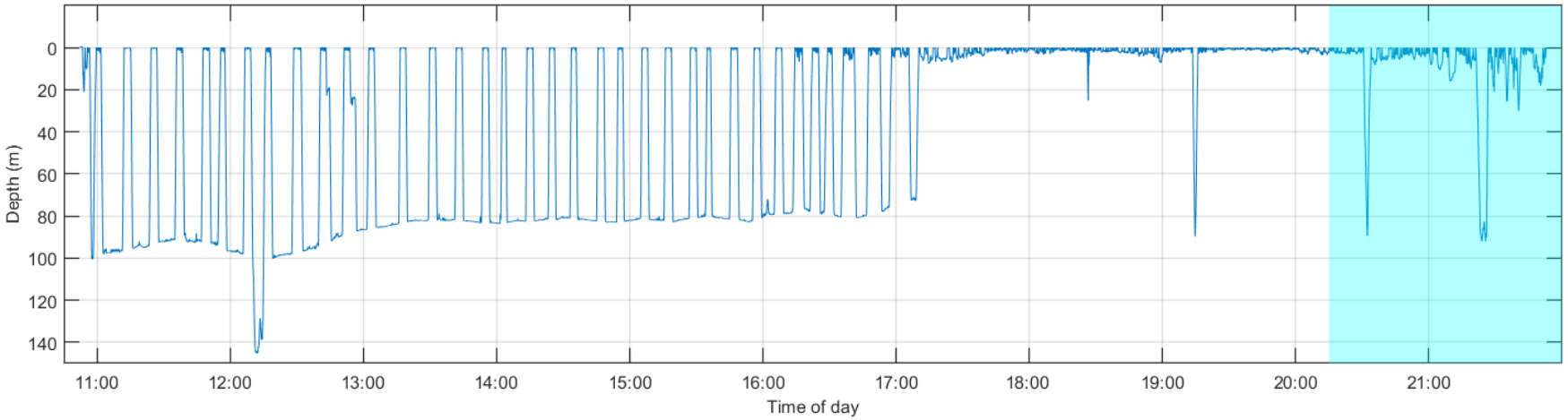

Figure 10. Dive-depth profile (in meters) for NARW 3241 (CATS eg052524-01), with hours between sunset and sunrise shaded blue in local time.

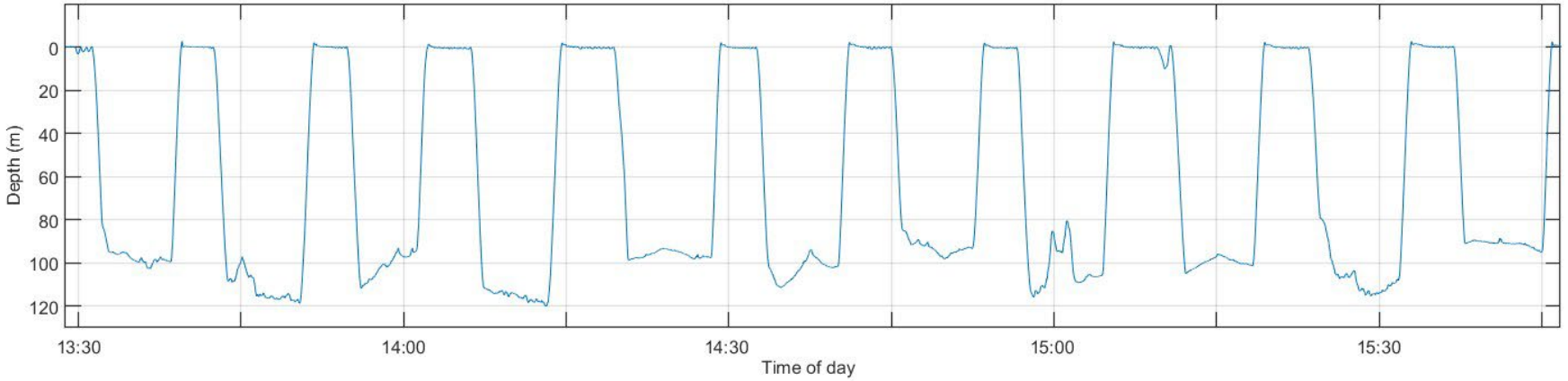

Figure 11. Dive-depth profile (in meters) for NARW 3908 (DTAG eg24_146a) in local time.

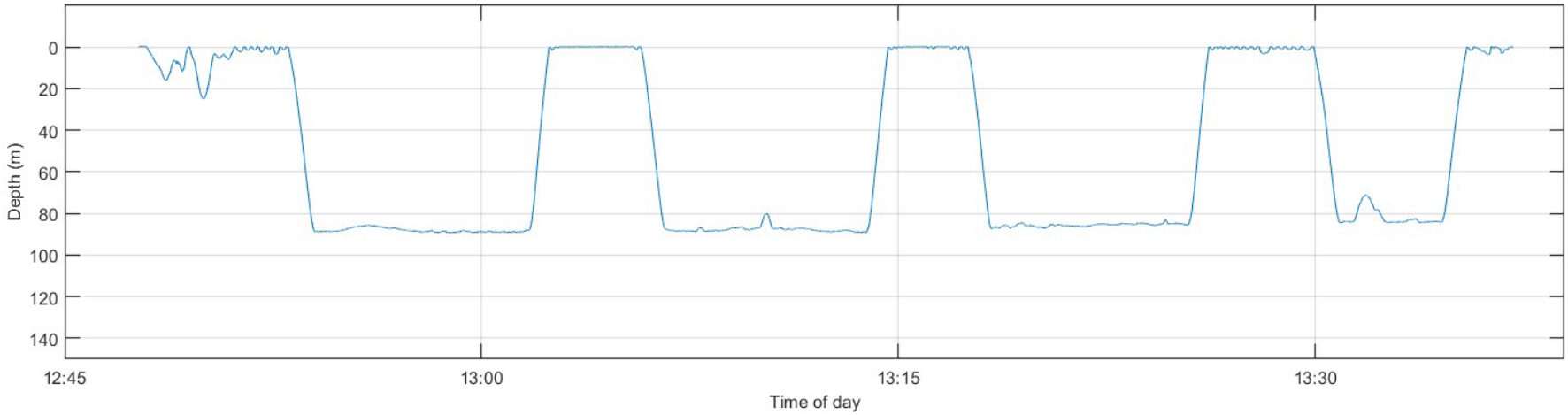

Figure 12. Dive-depth profile (in meters) for NARW 3391 (CATS eg052924-01) in local time.

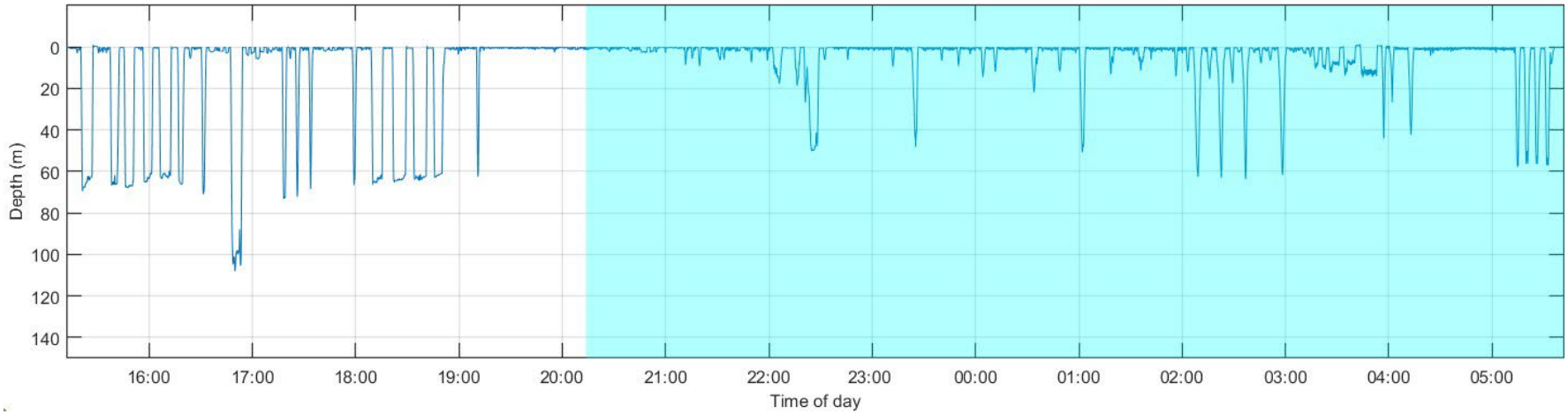

Figure 13. Dive-depth profile (in meters) for NARW 3101 (DTAG eg24_150a), with hours between sunset and sunrise shaded blue in local time.

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 OPAREAs, and wind energy development areas all overlap with the 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.

Interactions with vessels, both large and small, are a significant cause for concern for humpbacks as well as endangered fin and North Atlantic right whales within the study area. In April 2017, the National Marine Fisheries Service declared an Unusual Mortality Event (UME) for humpback whales within the Atlantic Ocean, from Maine to Florida, based on elevated mortalities of this species since January 2016. As of April 2025, 252 humpback whales are included in this UME, and 70 (27.7 percent) of those have occurred along the shore or in waters off the coast of Virginia or North Carolina (NOAA 2025a). Given this designation, a group of subject matter experts, the UME working group, aim to further investigate what is causing or contributing to the increased number of deaths of humpback whales within this area. Although the UME investigation process is ongoing, of the approximately 90 whales that were examined, an estimated 40 percent showed evidence of human interaction via vessel strike or entanglement. While the UME working group will look at humpback whales of all age classes, approximately two-thirds of the humpback whales identified during the 9 years of survey effort on this project appear to be juveniles (Aschettino et al. 2024a) that are spending more time within the study area than larger animals, presumed to be adults, and may be at greater risk for injury. Sightings of sub-adult-sized humpback whales are highest early in the field season or farther from shore within the mid-shelf region, and those individuals are often re-sighted less frequently, suggesting that sightings early in the season may be whales passing through the area rather than whales remaining within the nearshore study area for longer durations. The large percentage of juveniles observed in this study matches both historic stranding (e.g., Wiley et al. 1995) and observational (e.g., Swingle et al. 1993) data for the area.

A UME for North Atlantic right whales was also declared in 2017, with 1,157 instances of mortality, serious injury, and morbidity, primarily from rope entanglements and vessel strikes as of April 2025 (NOAA 2025b). The first vessel-related death of a North Atlantic right whale in 2023 was reported in February 2023 in Virginia Beach, and highlights the potential for serious injuries and fatalities within this area. In a statement released by NOAA regarding the results of the necropsy, it states that “the whale suffered a catastrophic blunt force traumatic injury, impacting a large portion of the vertebral column. The injuries, consistent with vessel strike, included multiple vertebral fractures and separations that would have resulted in death shortly after the injury” (NOAA 2023). 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 North Atlantic right whales 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 like those observed during the 2022/23 season (Aschettino et al. 2023) had not previously been observed within the area. The persistence of individuals to remain within the same general area over the course of 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. 2024c; A. Engelhaupt et al. 2023b).

During the OCS survey effort, a relatively unusual density and diversity of cetaceans, including aggregations of multiple species of baleen whales, was first noted during early May 2024, when sei whales, which are rarely seen within the study area, and a large number of fin whales were documented (Engelhaupt et al. 2025). 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 OCS survey also documented sei and fin whales, and on 22 May 2024, a large feeding aggregation of sei, fin, and North Atlantic right whales was encountered near the outer edge of the continental shelf. Effort was focused within this area for the remainder of May and into early June 2024, with repeated encounters of multiple species of baleen whales and, most notably, aggregations of North Atlantic right whales. When the sea surface temperature increased, the number of baleen whales detected returned to levels consistent with previous years. During the event, 11 OCS vessel surveys were completed, covering more than 3,000 km within the study area (Engelhaupt et al. 2025). A total of 97 sightings of baleen whales consisting of 291 individuals was recorded, including 55 sightings of fin whales, 26 sightings of humpback whales, 11 sightings of North Atlantic right whales, and 5 sightings of sei whales (Engelhaupt et al. 2025). Four biopsies were collected (two humpback and two fin whales), six satellite tags were successfully deployed (two humpback and four fin whales), and five archival tags were successfully deployed and recovered with full datasets (four North Atlantic right whales and one fin whale). These data were partially analyzed and presented at the North Atlantic Right Whale Consortium Meeting in October 2024 (Aschettino et al. 2024c). Further analysis, still in progress, includes the tag data shown in **Figure 10** through **Figure 13** and **Table 9** through **Table 11**.

For North Atlantic right whales, high-resolution archival tag data showed dives at or near the sea floor during daylight hours, and shallower dives and shorter surface intervals more often at nighttime or the hours approaching sunset (**Figure 10** through **Figure 13**). High-resolution dive data from these archival tags indicated the median surface duration for all tagged individuals was greater than 2.5 min and the mean was greater than 3 min and up to 11.7 min for adult female NARW 3101, further demonstrating the vulnerability of vessel interaction (**Table 11**).

Future work on these data include acoustic audits of archival tag data, track plot visualization of pitch-roll-heading archival tag data, modeling sighting data and satellite tag 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 the available environmental condition models to alert if and when a possible event occurs during future seasons, allowing for a similar increase in survey and tagging efforts.

With nine seasons of satellite-tag deployments completed, trends are emerging, as is the variability among individuals and between years. The mouth of Chesapeake Bay, and shipping lanes in particular, continue to be an area heavily used by multiple species of baleen whales on a seasonal basis. From November through April, a ship-speed reduction rule is in effect at the mouth of

Chesapeake Bay as part of the SMA set up to protect ESA-listed North Atlantic right whales, with added benefits to other species of whales that also use this area. These speed restrictions require all vessels 65 feet (19.8 m) or longer to travel at 10 knots (18.5 km/hour) or less. A proposed rule to extend these restrictions to smaller vessels within a wider area was proposed, but ultimately not approved.

The SMA within this study area begins at the mouth of Chesapeake Bay and extends outward 37 km from shore; however, 8 of 9 sightings of North Atlantic right whale groups occurred outside the SMA during the 2022/23 (Aschettino et al. 2024a) field season, and all sightings of North Atlantic right whales occurred outside the SMA during the 2023/24 field season (**Figure 6**), highlighting that these boundaries do not offer sufficient protection to NARW or any species of baleen whale in this region. The socializing and milling behavior observed by many of these aggregations may put these individuals at increased risk for vessel strikes while they spend more time at the surface and may be distracted while engaging with other whales. Dynamic Management Areas (DMAs) are created when three or more North Atlantic right whales are observed together. For a period of 15 days after a grouping is detected, NOAA uses these DMAs to notify vessel operators of the presence of North Atlantic right whales within a given area and urge mariners to reduce speed to 10 knots or less when traveling through these areas (NOAA 2024). These are voluntary requirements, however, and therefore do not guarantee additional protection to whales using those areas. Argos locations from the tagged minke whale also show that the SMA boundaries do not necessarily protect all large whales using the area (**Figure 8**).

Portions of Chesapeake Bay, west of the Chesapeake Bay Bridge Tunnel (CBBT), were not used by any tagged humpback whales during the 2015/16, 2017/18, 2020/21, or 2021/22 field seasons; used sparsely during the 2018/19 and 2022/23 field seasons; but used heavily during the 2016/17 and 2019/20 field seasons. No humpback whales were satellite tagged during the 2023/24 season, and only one location from the tagged minke whale occurred west of the CBBT. Short-term distributional shifts related to oceanographic conditions may have caused prey to become concentrated farther into Chesapeake Bay during the 2016/17 and 2019/20 field seasons, resulting in an increased presence of humpback whales within that area. The presence of humpback whales west of the CBBT raises additional concerns given the high traffic within that area, increased vessel speeds allowed outside the SMA boundaries, and extent of marine-based training occurring out of Joint Expeditionary Base Little Creek. Future analyses should explore year-to-year differences in oceanographic conditions to help better understand the factors that may contribute to these findings.

Efforts for the 2024/25 field season will 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 2024/25 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 numbers of sightings of humpback, fin, minke, and North Atlantic right whales, as well as the level of interaction between whales and vessel traffic detailed to date, support previous recommendations to continue this study using the same techniques to better understand movement patterns and habitat use. Continued photo-ID efforts will build a more complete picture of inter-annual site fidelity to this region. The inclusion of SPLASH10-F tags with Fastloc® GPS technology, capable of providing high-resolution data logging, will provide superior quality with respect to accuracy of locations. Coupled with the use of DTAGs and CATS tags, which can examine the three-dimensional movements of baleen whales within and around high-traffic shipping channels, 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 behavioral response studies.

5 References

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