Mid-Atlantic Nearshore and Mid-Shelf Baleen Whale Monitoring, Virginia Beach, Virginia: 2021/22 Annual Progress Report

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Cover Photo Credit:

A humpback whale (*Megaptera novaeangliae*), surfaces in front of the research vessel prior to a tagging and biopsy event. Cover photograph collected from the sUAS by Mark Cotter, taken under National Marine Fisheries Service Scientific Research Permit No. 21482, issued to Dan Engelhaupt, HDR.

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Acronyms and Abbreviations

BSS	Beaufort sea state
CTD	conductivity, temperature, and depth
DTAG	Digital Acoustic Recording Tag
ESA	Endangered Species Act
GPS	Global Positioning System
km	kilometer(s)
LiDAR	Light Detection and Ranging
LIMPET	Low Impact Minimally Percutaneous External-electronics Transmitter
m	meter(s)
MAHWC	Mid-Atlantic Humpback Whale Catalog
min	minute(s)
MINEX	Mine Neutralization Exercise
NAHWC	North Atlantic Humpback Whale Catalog
NAVFAC	Naval Facilities Engineering Systems Command
nm	nautical mile(s)
OPAREA	Operating Area
photo-ID	photo-identification
SE	standard error
SMA	Seasonal Management Area
SPOT	Smart Position and Temperature
sUAS	small Unmanned Aerial System
UME	Unusual Mortality Event
U.S.	United States
VACAPES	Virginia Capes Operating Area
VHF	very-high frequency

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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 (Aschettino et al. 2016, 2017, 2018, 2019, 2021, 2022a) (**Table 1**). Vessel surveys focused on photo-identification (photo-ID), biopsy sampling, and tagging using medium-resolution satellite tags and high-resolution suction-cup tags as well as a small Unmanned Aerial Systems (sUAS) for length and body condition assessments. These baseline data are critical for assessing the potential for disturbance to humpback whales within this part of the mid-Atlantic. Although humpback whales were 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 species of baleen whales, including endangered fin (*Balaenoptera physalus*) and North Atlantic right whales (*Eubalaena glacialis*), 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 aerial and vessel surveys (NEFSC and SEFSC 2012, 2013) as well as previously funded U.S. Navy aerial and vessel surveys (Mallette et al. 2018,Cotter 2019).

Fin whales, considered a strategic stock given their Endangered Species Act (ESA) status, appear to show a reliable pattern of occurrence near or over the continental shelf break throughout the Virginia Capes Operating Area (VACAPES OPAREA) (Hayes et al. 2022, Mallette et al. 2018). Led by researchers from HDR Inc., satellite-monitored tags deployed between 2016 and 2021 on fin whales within VACAPES show both localized and extensive movements over all areas of the continental shelf (Engelhaupt et al. 2017, 2018, 2019; Aschettino et al. 2018, 2021, 2022a). Confirmed sightings of critically endangered North Atlantic right whales off Virginia have also increased as coverage during the Mid-Atlantic Humpback Whale Project surveys extended farther from the coastline in recent years (Aschettino et al. 2022a). Movements of satellite-tagged North Atlantic right whales show extensive use of the mid-shelf region to both the north and south of the primary study area (Aschettino et al. 2022a, D.T. Engelhaupt et al. 2022). Although sightings of blue whales (*Balaenoptera musculus)* off Virginia are infrequent, they have now been documented during HDR Inc. surveys in 2018 (Engelhaupt et al. 2019), 2019 (Cotter 2019), 2021 (A. Engelhaupt 2022), and 2022 (Engelhaupt et al. 2023); Argos location data from satellite-tagged blue whales showed at least some movements through the shallow continental shelf waters (Lesage et al. 2017, A. Engelhaupt et al. 2022, Aschettino et al. 2022b).

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 expands the previous study area to encompass mid-shelf waters out to approximately 75 km from shore, where the diversity of baleen whale species increases. The goals of this study are to assist the U.S. Navy and regulatory agencies by addressing the following questions:

- What is the baseline ecology and behavior of baleen whales (including 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, years?
- What is the seasonal extent of baleen whale movements within and around U.S. Navy OPAREAs?
- Do baleen whales spend significant time within or primarily move through areas of U.S. Navy live-fire or anti-submarine warfare training events?
- Are baleen whale movement patterns affected by U.S. Navy training exercises?
- Are baleen whales likely to be exposed to significant sound levels produced by vessel traffic and/or military training exercises using active sonar?

The humpback whale field season off Virginia Beach runs from approximately the end of October through March, typically concentrated between December and February, with a smaller number of sightings occurring outside this timeframe. Since the inception of the Mid-Atlantic humpback whale monitoring project, eight 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 has evolved to include deployment of satellite-linked telemetry and Digital Acoustic Recording Tags (DTAGs); collaboration with researchers from Duke University to examine behavioral response of humpbacks to large vessels (Shearer et al. 2020); photogrammetry using sUAS; and, most recently, an expansion into the mid-shelf region with the addition 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 2021/22 season.

Twenty-eight surveys were completed during the 2021/22 field season. Eleven of these surveys were considered nearshore surveys, and 17 surveys were defined as mid-shelf. In total, there were 78 baleen whale sightings, including 64 sightings of humpback whales composed of 98 individuals, 7 sightings of fin whales composed of 10 individuals, 4 sightings of minke whales composed of 5 individuals, and 3 sightings of North Atlantic right whales composed of 5 individuals. Ten satellite tags were deployed: nine on humpback whales and one tag on a North Atlantic right whale. Two DTAGs were deployed on humpback whales and seven biopsy samples were collected from tagged humpback whales (**Table 1**).

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

Season	Begin	End	Objectives	Biopsy samples	Satellite Tags deployed	Suction Cup Tags Deployed	Report
1 (2014/15[a])	31-Dec-2014	15-May-2015	Collect baseline information	12	-	-	Aschettino et al. 2015; Engelhaupt et al. 2015
2 (2015/16)	01-Dec-2015	09-May-2016	Collect baseline information and deploy telemetry tags	11	9	-	Aschettino et al. 2016
3 (2016/17)	01-Nov-2016	21-Mar-2017	Collect baseline information and deploy telemetry tags	29	26	-	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	9[b]	-	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; Shearer et al. 2020)	9	10	-	Aschettino et al. 2019; Aschettino et al. 2020a
6 (2019/20)	21-Dec-2019	27-Mar-2020	Collect baseline information, deploy telemetry tags, photogrammetry using sUAS, collaborate on behavioral response of humpbacks to large vessels (Shearer et al. 2021)	7	10[c]	-	Aschettino et al. 2021
7 (2020/21)	19-Nov-2020	27-Mar-2021	Collect baseline information, deploy telemetry and acoustic tags, photogrammetry using sUAS, 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. 2022)	6	11[d]	4	Aschettino et al. 2022a
8 (2021/22)	14-Nov-2021	15-Mar-2022	Collect baseline information, deploy telemetry and acoustic tags, photogrammetry using sUAS, continued 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	10[e]	2	Current report

[a] Additional humpback whale sighting information from coastal line-transect surveys for bottlenose dolphins (*Tursiops truncatus*) conducted from 2012 through 2015 (see Engelhaupt et al. 2016) was also incorporated into these analyses
[b] Six tags on humpback whales, 3 tags on fin whales
[c] Nine tags on humpback whales, 1 tag on a fin whale
[d] Seven tags on humpback whales, 2 tags on fin whales, 2 tags on North Atlantic right whales
[e] Nine tags on humpback whales (1 never transmitted), 1 tag on a North Atlantic right whale

2. Methods

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). 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 two wind turbines are currently 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 or 5, or visibility was reduced to less than 1 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 nearshore effort was the 8.8-meter (m), fiberglass, hybrid-foam-collar boat *Whale Research* (**Figure 2**), owned and operated by HDR Inc. 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-m fishing vessel *Top Notch* (**Figure 3**) or 16.5-m fishing vessel *Game On*. Surveys using these vessels departed from the Virginia Beach Fishing Center, located on Rudee Inlet.

The crew typically consisted of three or four qualified marine mammal scientists, with one also serving as the vessel operator when working from the *Whale Research*. 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**). Sightings of non-target species within the survey area (i.e., bottlenose dolphins) were not always recorded and are not presented in this report.

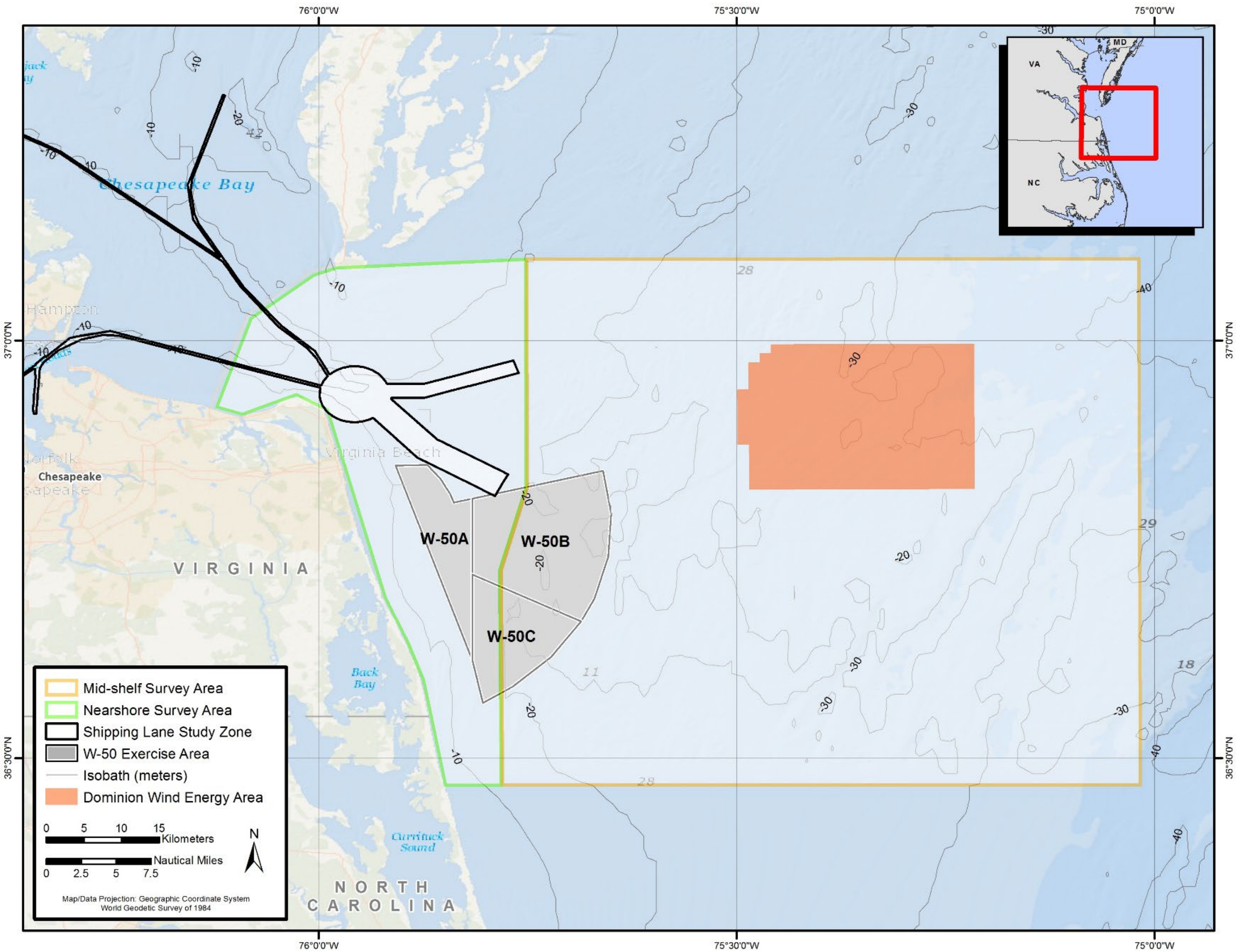

Figure 1. Map of the nearshore and mid-shelf study area, which includes waters within and around the mouth of Chesapeake Bay shipping lanes, the W-50 MINEX region off Virginia Beach, the Dominion Wind Energy Area.

Figure 2. Nearshore survey vessel *Whale Research* (photograph © Alexis Rabon, Rudee Tours).

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

2.1 Photo-ID and Photogrammetry

Photographs of humpback, fin, right, and minke whales were collected using a digital single-lens reflex camera (Canon 7D, 7D Mark II, or 1DX Mark II) with a zoom lens (Canon 100- to 400-millimeter). Photographs were post-processed using ACDSee (Versions 7–9) by cropping the best image of each individual whale's dorsal fin (left and right) and tail flukes (when obtained).

Photographs were assembled into a project catalog managed by HDR Inc. in which each new whale was assigned a unique identifier using the naming convention "HDRVA," followed by the two-letter abbreviation for the scientific name of the species, followed by a numerical sequence of three numbers (e.g., HDRVAMn001, HDRVABa001). Each whale was then compared with the others. At the end of the 2014/15 field season, images of humpback whale flukes were submitted to Allied Whale for comparison to the North Atlantic Humpback Whale Catalog (NAHWC) and images of humpback whale dorsal fins and flukes were submitted to the Virginia Aquarium and Marine Science Center for comparison and integration with the Mid-Atlantic Humpback Whale Catalog (MAHWC). Images of fin whales were initially shared with Duke University and researchers from the Center for Coastal Studies in Provincetown, Massachusetts, then subsequently Whale Watch Azores, Blue Ocean Society, and Marine and Environmental Sciences Centre of Madeira, Portugal (although matching is still in-progress). Images of humpback whales from subsequent seasons were submitted to the MAHWC (see Mallette and Barco 2019) and compared with images from local whale watch operation Rudee Tours as well as Gotham Whale (Brown et al. 2022). Photographs of North Atlantic right whales were submitted to the New England Aquarium for incorporation into the North Atlantic Right Whale Catalog. Given the small population size of North Atlantic right whales (fewer than 350) and the publicly accessible online catalog, the official catalog identifications were used rather than the conventional HDR Inc. naming mechanism for other species.

The use of a sUAS was incorporated into the field effort beginning in the 2018/19 field season. A DJI Phantom 4 Pro V2.0 was used to collect morphometric data and assess overall body condition. In the field, live video was also used to assist the research team during tagging attempts to maximize successful deployments. 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 sUAS collected 4K ultra-high-definition video at 30 frames per second. Initial measurements were made from data using altitude values from the drone's stock barometer, although some error is expected with this method. HDR Inc. used open-source software developed by researchers at Duke University (Torres and Bierlich 2020) to calculate lengths. Following the methodology described in Dawson et al. (2017), the DJI Phantom 4 Pro V2.0 was retrofitted with a custom Light Detection and Ranging (LiDAR) altimeter in 2020. This upgrade increases precision (to within 5 centimeters) and consistency of the sUAS altimetry measurements to minimize possible error in estimated animal lengths.

Age class of humpback whales were assigned based on subjective size assessments from the research vessel. The length of the HDR Inc. research vessel was often used for reference in making these subjective assessments. For example, individuals that were estimated to be approximately the length of the vessel (8.8 m) or smaller were typically classified as juveniles, whereas individuals that appeared longer than the research vessel were typically classified as sub-adults or adults. Although not precise, these estimates roughly fall in line with the estimated length at weaning of 8.0 m (Rice 1963) and length at sexual maturity starting at 11.0 m for humpback whales (Nishiwaki 1959).

2.1 Biopsy Sampling

Biopsy samples were collected from whales of interest 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 stable isotope analysis by Duke University, 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 Southeast Fisheries Science Center. Blubber from the samples was wrapped in foil and frozen for archiving for Southeast Fisheries Science Center. Stable isotope analysis and gender determination was performed on a portion of samples at the end of the 2016/17 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 HDR Inc.'s 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). Samples from the 2019/20 through 2021/22 field seasons are currently being analyzed.

2.2 Satellite Tagging

Satellite tagging has been a primary component of the project since the 2015/16 field season. Initially, Wildlife Computers (Redmond, Washington) Smart Position and Temperature (SPOT6) Argos satellite-linked 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 depth data in addition to location data, were incorporated into the project in subsequent seasons. The SPLASH10-F tags use Fastloc® Global Positioning System (GPS) technology and were intended to be deployed during windows of opportunity during which researchers from Duke University 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**).

Given existing information about attachment durations of LIMPET tags on humpback 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 during attachment rather than to extend battery life. Based on satellite availability within the area, tags were programmed to transmit for between 18 and 22 hours per day with an unlimited number of transmissions for SPOT6 tags, and 800 to 1,200 transmissions per day for SPLASH10-292B and SPLASH10-F tags. 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 above.

In order to constitute a "dive" for the Wildlife Computers-generated behavior and time-series data outputs of the SPLASH10-292B and SPLASH10-F tags, a definition was established for humpback whales 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 most tagged whales using the same protocol described previously; conductivity, temperature, and depth (CTD) casts were typically taken following a tag deployment.

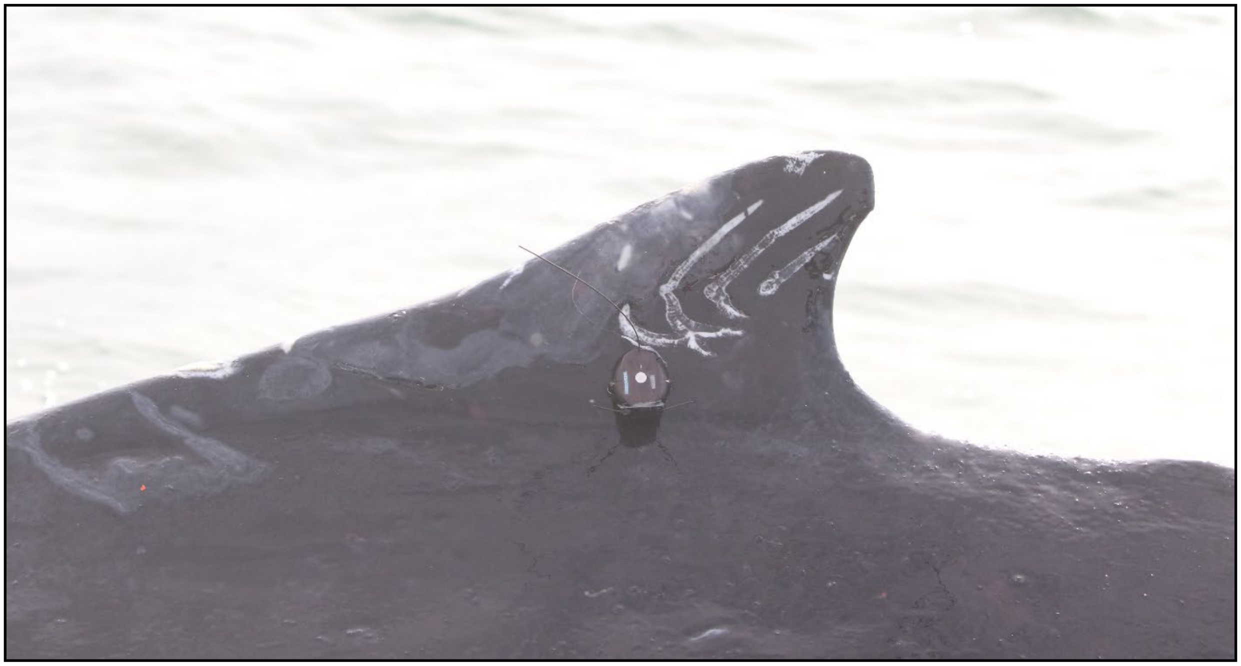

Figure 4. LIMPET SPLASH10-F tag on a humpback whale immediately after deployment.

2.3 DTAG Tagging

During the 2020/21 field season, HDR Inc. added a suction-cup-tagging component to the project with the goal of deploying DTAGs (Johnson and Tyack 2003) on baleen whales within the mid-shelf and/or MINEX region of the study area. Version 3 DTAGs were deployed using a hand-held carbon fiber pole. DTAGs are 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. Programmed release time was set according to conditions and logistics to facilitate best opportunity for tag retrieval. Each tag also contained a very-high frequency (VHF) transmitter that, following release, 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.

Tag calibration and data visualization following recovery of the tag was completed using a suite of tools found on animaltags.org using MATLAB R2021b.

3. Results

3.1 Nearshore and Mid-shelf Surveys

Survey efforts typically begin when the local whale watch-operations and other mariners first start reporting humpback sightings. For the 2021/22 season, the first survey took place on 14 November 2021, and the last survey occurred on 15 March 2022. In total, the study team conducted 28 surveys, covering 3,432 kilometers (km) of trackline with more than 213 hours of effort (**Table 2, Figure 5**). Eleven of these surveys were considered nearshore (**Figure 6**), and 17 surveys were defined as mid-shelf (**Figure 7**). In total, there were 78 baleen whale sightings, including 64 humpback whale sightings composed of 98 individuals, 7 fin whale sightings composed of 10 individuals, 4 minke whale sightings composed of 5 individuals, and 3 North Atlantic right whale sightings composed of 5 individuals (**Figure 5**; **Table 2**; and **Appendix A**, **Table A-1**).

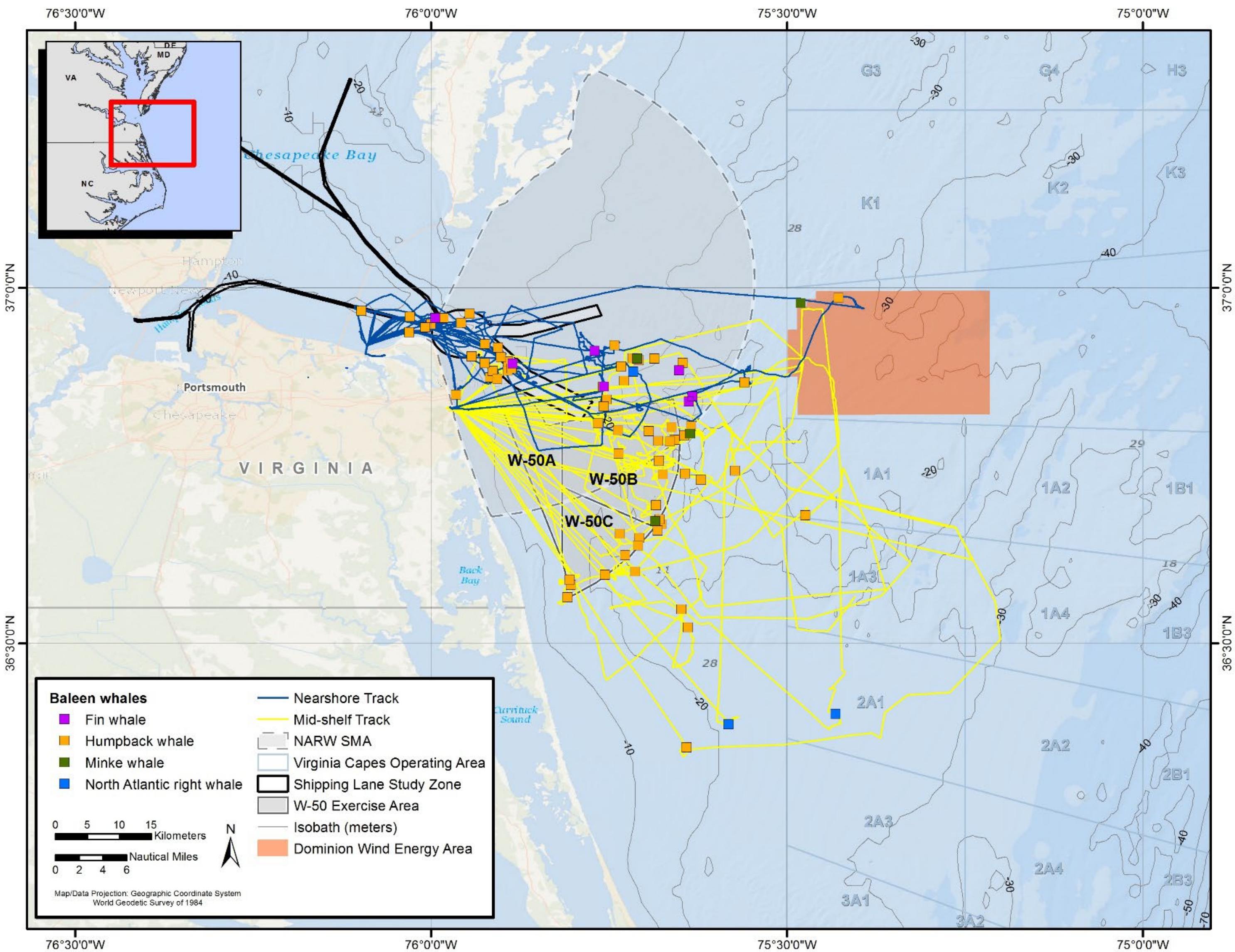

Figure 5. Nearshore (gray) and mid-shelf (yellow) survey tracks, with locations of all humpback (*n*=64), fin (*n*=7), minke (*n*=4), and North Atlantic right (*n*=3) whale sightings for the 2021/22 field season.

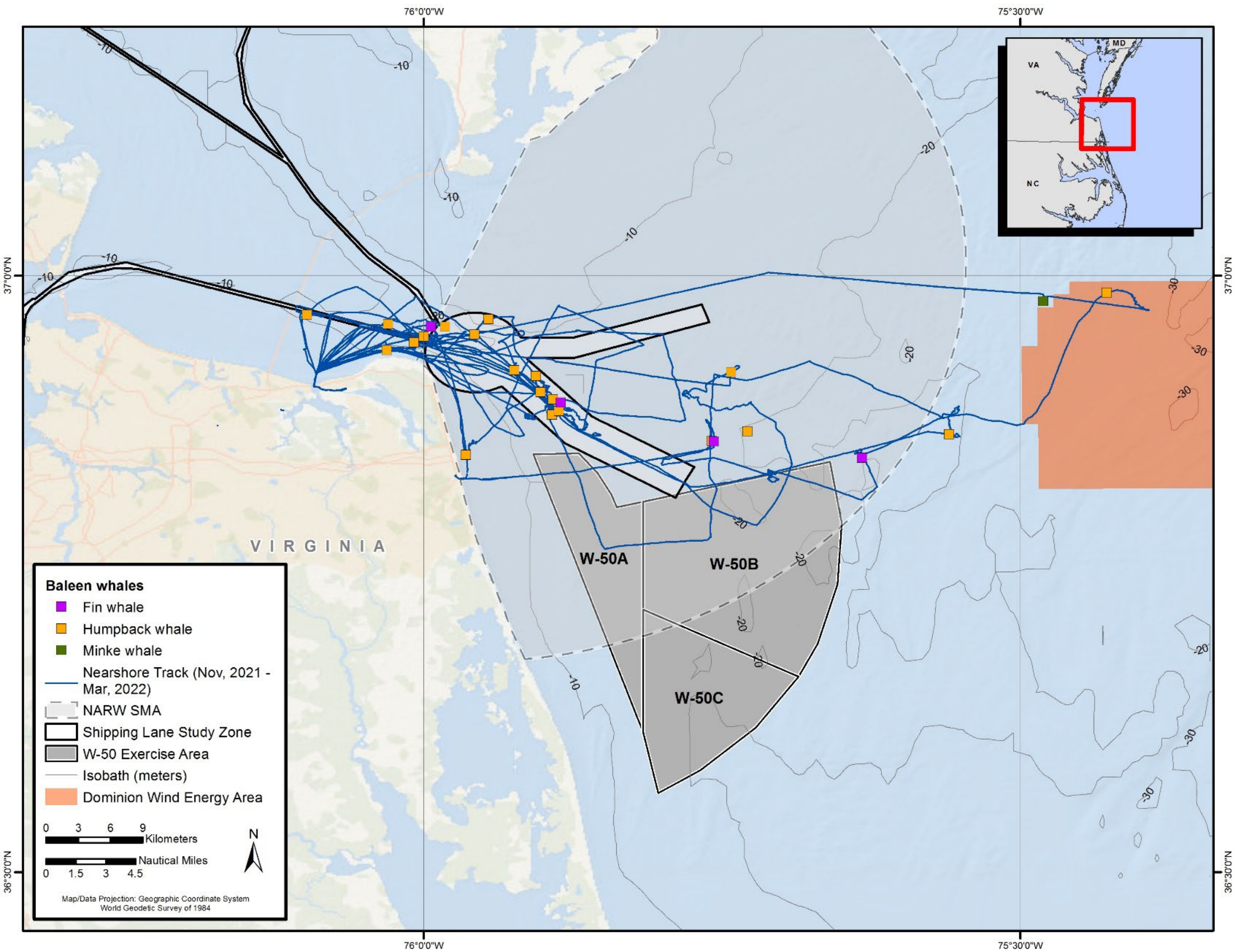

Figure 6. Nearshore survey tracks (gray), with locations of all humpback (*n*=20), fin (*n*=4), and minke (*n*=1) whale sightings for the 2021/22 field season.

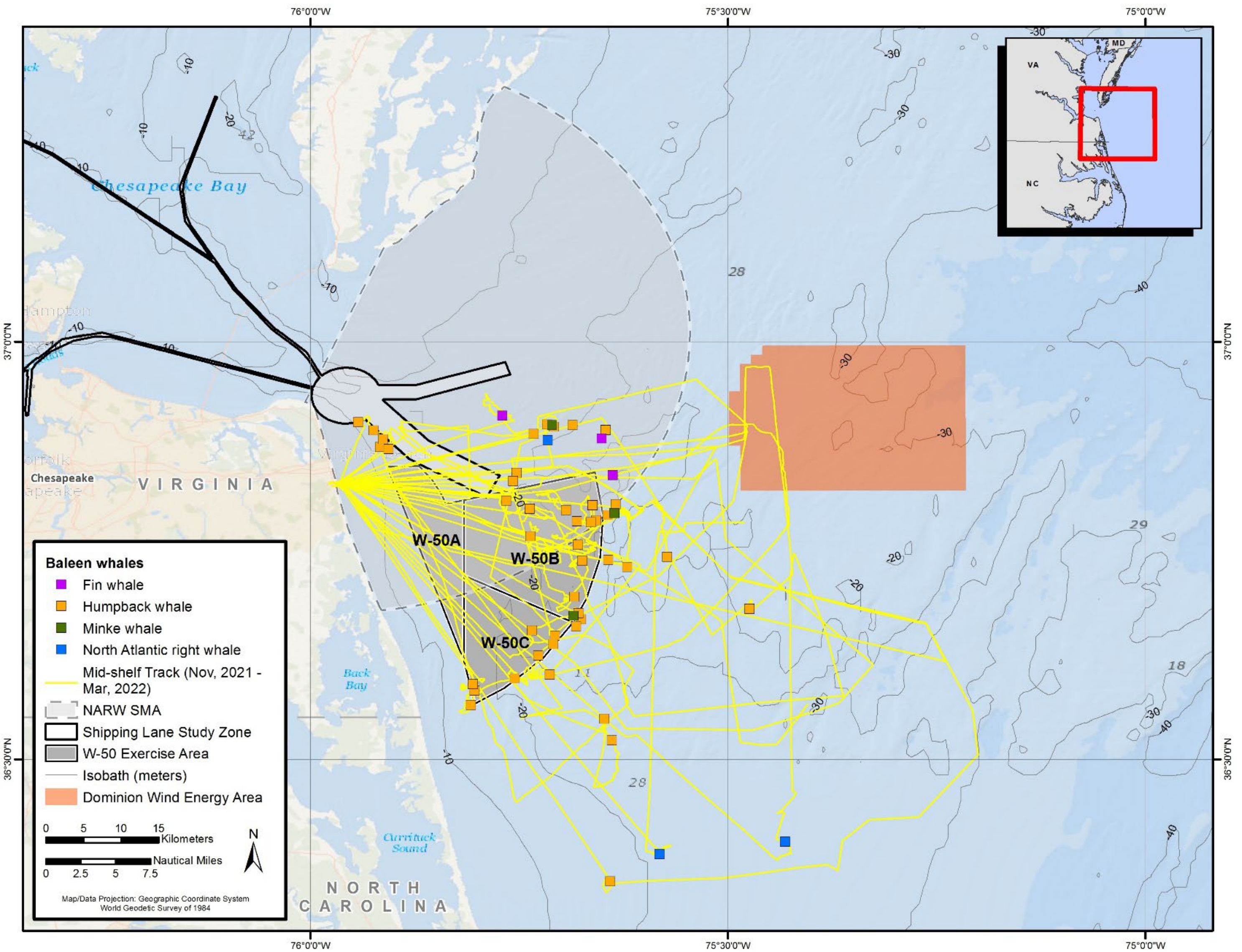

Figure 7. Mid-shelf survey tracks (yellow), with locations of all humpback (*n*=44), fin (*n*=3), minke (*n*=3), and North Atlantic right (*n*=3) whale sightings for the 2021/22 field season.

Table 2. Summary of nearshore and mid-shelf survey efforts off Virginia Beach, Virginia, for the 2021/22 field season.

Date	Survey Type	Survey Time (min)	Distance surveyed (km)	# Sightings Mn	# Individual Mn	# Sightings Ba	# Individual Ba	# Sightings Bp	# Individual Bp	# Sighting Eg	# Individual Eg
14-Nov-21	Mid-shelf	506	161	2	2	0	0	0	0	0	0
14-Nov-21	Mid-shelf	506	161	2	2	0	0	0	0	0	0
16-Nov-21	Mid-shelf	529	156	3	3	0	0	0	0	0	0
21-Nov-21	Mid-shelf	673	130	4	8	0	0	0	0	0	0
01-Dec-21	Mid-shelf	624	163	5	7	1	1	0	0	0	0
04-Dec-21	Mid-shelf	546	131	3	5	0	0	0	0	0	0
10-Dec-21	Mid-shelf	458	99	4	5	0	0	0	4	0	0
13-Dec-21	Mid-shelf	567	137	4	12	1	1	0	0	0	0
17-Dec-21	Mid-shelf	590	134	6	10	0	0	0	0	0	0
18-Dec-21	Mid-shelf	197	57	0	0	0	0	0	0	0	0
28-Dec-21	Mid-shelf	484	133	5	9	1	2	0	0	0	0
30-Dec-21	Mid-shelf	297	90	0	0	0	0	0	0	0	0
06-Jan-22	Nearshore	498	154	3	4	0	0	0	0	0	0
12-Jan-22	Nearshore	244	48	1	2	0	0	1	1	0	0
19-Jan-22	Nearshore	331	59	2	2	0	0	0	0	0	0
24-Jan-22	Nearshore	423	116	1	2	0	0	0	0	0	0
28-Jan-22	Mid-shelf	555	149	5	5	0	0	0	0	0	0
30-Jan-22	Nearshore	238	86	0	0	0	0	0	0	0	0
31-Jan-22	Nearshore	228	58	1	1	0	0	0	0	0	0
08-Feb-22	Nearshore	408	65	2	2	0	0	0	0	0	0
09-Feb-22	Nearshore	593	164	5	7	1	1	2	2	0	0
10-Feb-22	Nearshore	304	62	2	2	0	0	0	0	0	0
11-Feb-22	Nearshore	425	116	1	2	0	0	1	1	0	0
15-Feb-22	Mid-shelf	640	204	0	0	0	0	0	0	1	2
21-Feb-22	Mid-shelf	627	136	2	3	0	0	3	6	1	1
27-Feb-22	Nearshore	313	94	2	2	0	0	0	0	0	0
02-Mar-22	Mid-shelf	527	216	0	0	0	0	0	0	1	2
11-Mar-22	Mid-shelf	455	166	0	0	0	0	0	0	0	0
15-Mar-22	Mid-shelf	540	148	1	3	0	0	0	0	0	0
Total	**—**	**12,820**	**3,432**	**64**	**98**	**4**	**5**	**7**	**10**	**3**	**5**

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

3.2 Photo-ID and Photogrammetry Results

The 64 sightings of humpback whales during the 2021/22 season included 98 total individuals and resulted in 54 unique humpback whales identified using dorsal fin and fluke images. An additional four humpback whales were also seen during the Outer Continental Shelf Cetacean Study surveys in January 2022 (including one re-sighting from the nearshore and mid-shelf effort) and are included in catalog results (Engelhaupt et al. 2023) (**Figure 8**; **Appendix A**, **Table A-1**). Of the 57 total unique humpback whales seen during the 2021/22 season, 26 (45.6 percent) were classified as sub-adults/adults based on their estimated size in the field, 15 (26.3 percent) were categorized as juveniles, 12 (21.1 percent) were classified as adults, 3 (5.3 percent) were classified as subadults, and 1 (1.8 percent) was classified as a large calf. Twenty (35.1 percent) of the 57 individuals were re-sights to HDR Inc.'s catalog; 1 individual had not been seen since the 2014/2015 season (HDRVAMn008), and the remaining re-sights included individuals from each of the previous seven field seasons. The additional 37 whales were new individuals added to HDR Inc.'s growing catalog, which, to date, has 245 unique humpback whales (inclusive of identifications added from the Outer Continental Shelf Break Cetacean Study [Engelhaupt et al. 2023]) (**Figure 8**; **Appendix A**, **Table A-1**). Twenty-two of the 57 humpback whales (38.6 percent) were seen on more than 1 occasion this season, and 5 of those were seen on 3 or more occasions. This is up from the 2020/21 season in which only 4 of the 31 (12.9 percent) humpback whales were seen on more than 1 occasion and more comparable to prior seasons (42.9 percent during 2019/2020; 44.7 percent during 2018/2019; 21.9 during 2017/2018; and 69.5 percent during 2016/2017).

Evidence of human interaction, either presumed line-entanglement scars or propeller scars, was apparent on at least 25 of the 245 (10.2 percent) cataloged humpback whales (**Appendix A**, **Table A-1**).

Drone video was collected on numerous humpback whales, and the lengths of 30 individuals were calculated (data from December 2018 through June 2020; **Table 3** (from Aschettino et al. 2022a)**, Figure 9**). Each of these whales has a unique identifier in the catalog and had previously been assigned an age-class based on subjective size assessments from the research vessel. From the calculations based on the sUAS video, the measured humpback whales ranged in size from 6.8 to 14.0 m in total length, with a mean length of 9.5 m and a median length of 9.6 m. All whales that measured 10.5 m or larger (*n*=9) had been classified as sub-adults or adults in the field. All but two of the whales that measured 8.8 m or smaller (*n*=13) had been classified as juveniles in the field. Whales that ranged from 9.0 to 10.1 m (*n*=15) were classified as either juvenile (*n*=8), juvenile/sub-adult (*n*=1), or sub-adult (*n*=6) in the field, highlighting the difficulty of assigning an age-class for whales that may be of intermediate length and/or transitioning from one age-class to another.

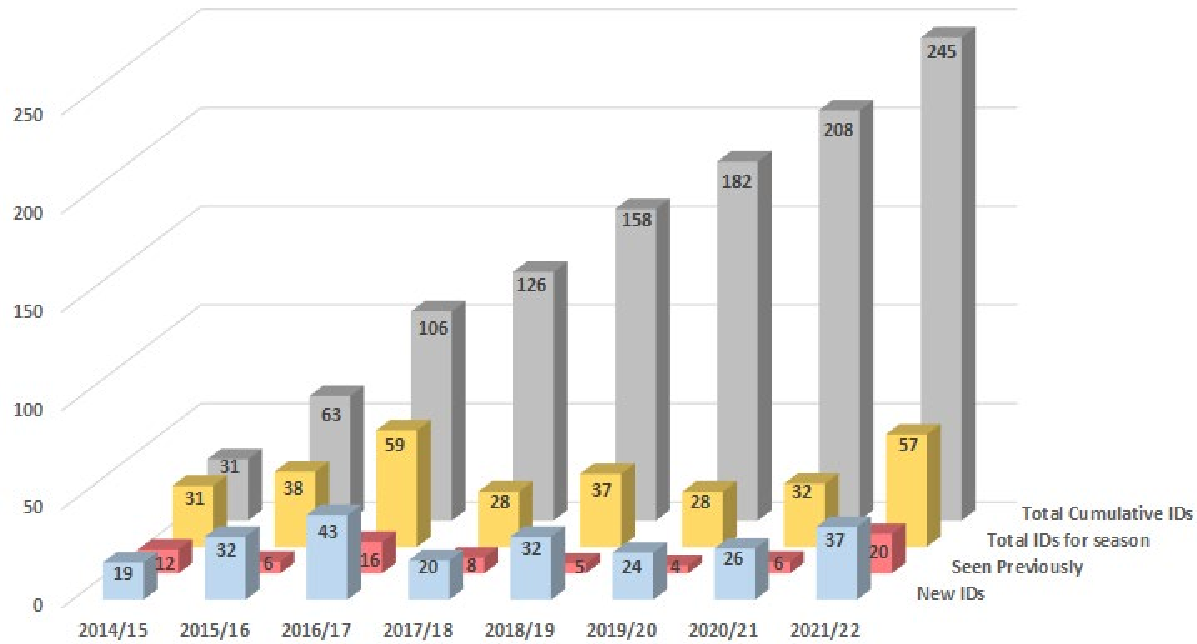

Figure 8. Humpback whale identifications (ID) over eight seasons within the Virginia study area (yellow bars = total number of IDs each season; red bars = number of those IDs seen in previous seasons; blue bars = number of new IDs added to catalog; gray bars = total number of cumulative unique IDs).

Figure 9. Total length measurement being taken in MorphoMetriX using a still video grab from sUAS-collected data for humpback whale HDRVAMn208.

Table 3. Overall lengths of all humpback whales measured to-date using drone photogrammetry, sorted from smallest to largest.

Humpback Whale ID	Overall Length Based on Photogrammetry (m)	Total Unique Measurement Days	Age-class Assigned Based on Initial Visual Assessment
HDRVAMn166	6.8	2	Juvenile
HDRVAMn163	7.0	1	Juvenile
HDRVAMn165	7.3	1	Juvenile
HDRVAMn152	7.4	2	Juvenile
HDRVAMn189	7.5	1	Juvenile
HDRVAMn177	7.6	3	Juvenile
HDRVAMn175	7.9	1	Juvenile
HDRVAMn183	8.2	1	Sub-adult
HDRVAMn093	8.2	2	Juvenile
HDRVAMn164	8.2	1	Juvenile
HDRVAMn187	8.5	2	Sub-adult
HDRVAMn173	8.7	3	Juvenile
HDRVAMn147	8.8	1	Juvenile
HDRVAMn170	9.0	1	Sub-adult
HDRVAMn186	9.1	4	Sub-adult
HDRVAMn208	9.5	1	Juvenile
HDRVAMn184	9.6	1	Juvenile
HDRVAMn196	9.6	1	Sub-adult
HDRVAMn153	9.6	1	Juvenile
HDRVAMn174	9.7	3	Juvenile/Sub-adult[a]
HDRVAMn193	9.7	2	Juvenile
HDRVAMn191	9.8	1	Juvenile
HDRVAMn021	10.0	2	Sub-adult
HDRVAMn012	10.0	2	Sub-adult
HDRVAMn199	10.0	1	Juvenile
HDRVAMn149	10.1	1	Juvenile
HDRVAMn190	10.1	1	Juvenile
HDRVAMn215	10.1	1	Sub-adult[b]
HDRVAMn200	10.5	1	Sub-adult[b]
HDRVAMn181	10.8	1	Sub-adult or adult
HDRVAMn097	10.8	1	Sub-adult or adult
HDRVAMn172	11.1	5	Sub-adult or adult
HDRVAMn132	11.3	3	Sub-adult or adult
HDRVAMn223	11.4	1	Sub-adult or adult
HDRVAMn202	13.0	1	Sub-adult or adult
HDRVAMn003	13.9	2	Adult
HDRVAMn197	14.0	1	Sub-adult or adult

Key: ID = Identification Number
[a] Assessed as two different age classes within same season
[b] Most recent assessment; assigned a different age class in previous years

3.3 Biopsy Results

Seven biopsy samples were collected from humpback whales during the 2021/22 season (**Appendix A**, **Table A-1)** and are awaiting analyses along with samples collected during the 2019/20 field season. Thirty-one samples (29 humpback and 2 fin whales) from 2014 to 2016 were processed for stable-isotope analyses ($\delta^{13}C$ and $\delta^{15}N$). The stable-isotope signatures for all samples were comparable to those reported for other regions of the North Atlantic (Waples 2017). Significant differences exist in both $\delta^{13}C$ and $\delta^{15}N$ values between the humpback and fin whales within the study area. The humpback whales were slightly more depleted in carbon and had significantly higher $\delta^{15}N$ signatures than the fin whales. The humpback whales had a mean $\delta^{15}N$ value of 14.6 (standard error [SE]=0.9) compared to the fin whales' value of 10.5 (SE=0.0).

Given a difference in $\delta^{15}N$ values between the two species, it is likely that the humpback whales within this area are feeding at a higher trophic level than the fin whales (Waples 2017). Genetic analyses identified 14 female and 15 male humpback whales from these samples. No significant differences in $\delta^{13}C$ values occurred between male and female humpback whales, but females did have significantly lower $\delta^{15}N$ values than males, indicating that the diets of the two sexes may differ in this area: Waples 2017).

These biopsy samples were provided to the University of Groningen for genetic analysis and integration into a larger North Atlantic humpback whale population study. In addition to the 29 humpback and 2 fin whale samples collected between 2014 and 2016, an additional 34 humpback and 6 fin whale samples collected between 2016 and 2019 (total humpback whales [*n*=63] and fin whales [*n*=8]) were also sent to the University of Groningen. Gender results with the larger sample size also 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 NAHWC, which contains more than 9,200 individuals, showed that 18 samples matched to samples collected elsewhere along the eastern U.S. No duplicate humpback whale samples occurred in the HDR 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).

3.4 Satellite-Tagging Results

In total, 10 Argos-linked satellite tags were deployed on baleen whales during the 2021/2022 season. Nine tags were deployed on humpback whales: 1 SPOT-6, 2 SPLASH10-292, and 6 SPLASH10-F (**Figures 10** through **21**, **Table 4**). One SPLASH10-F tag was also deployed on a North Atlantic right whale (**Figure 22**, **Table 5**). One SPLASH10-292 tag deployed on a humpback whale never transmitted. The remaining humpback tags transmitted between 2.7 and 13.3 days (mean=6.2 days) and the North Atlantic right whale tag transmitted 18.7 days.

Whales tagged during the 2021/2022 field season showed varied movement patterns, with some exclusively spending time within the primary study area and others moving outside the study area, farther offshore, or to the north or south (**Figures 12** through **18**). Two individuals

(HDRVAMn163 and HDRVAMn246) primarily spent time at the mouth of Chesapeake Bay and heavily used the shipping channels (24.7 and 45.8 percent of locations within shipping channels, respectively) (**Figures 16** and **18**). Individuals who spent little to no time within shipping channels (HDRVAMn012, HDRVAMn223, HDRVAMn225, HDRVAMn243, HDRVAMn251, and HDRVAMn233) more heavily used the offshore region of the VACAPES OPAREA (**Figures 13** through **15,** and **17**).

Humpback whale HDRVAMn012 was satellited tagged for the third time during the 2020/21 season. A comparison of tracklines from the previous tag deployments in December 2016 and December 2017 is shown in **Figure 19**. Tag deployments were less than 1.5 km apart between deployments 1 and 3, and less than 7 km apart from the second deployment location. During the first tag deployment in 2016, HDRVAMn012 stayed within the primary nearshore study zone, spending the majority of time within and around the mouth of Chesapeake Bay and shipping channels. During the second tag deployment in 2017, HDRVAMn012 spent some time within the W-50 MINEX region before moving away from the primary study area, down along the coast and into waters off North Carolina. And during the January 2022 deployment, HDRVAMn012 moved farther offshore within the VACAPES OPAREA.

Humpback whale HDRVAMn163 was satellited tagged for the second time (**Figure 20**). The initial deployment in 2019 was an out-of-season deployment, occurring in May 2019 when this individual spent some time within the primary study area before moving down the coastline into waters off North Carolina and turning back north before the tag stopped transmitting. During the 2022 deployment, HDRVAMn163 spent the entire deployment within the primary study zone, within and around the mouth of Chesapeake Bay and shipping channels. Interestingly, tag deployment locations were less than 1 km apart for HDRVMn163.

Figure 21 shows a zoomed-in view of all humpback whale tag locations during the 2021/22 field season, focused on the nearshore study zone. As in previous years, a high number of locations occurred within and around the shipping channels and at the mouth of Chesapeake Bay. Unlike in some previous seasons (e.g., Aschettino et al. 2018, 2020b, 2021), no Argos locations occurred west of the Chesapeake Bay Bridge Tunnel, although locations to the west of the North Atlantic right whale Seasonal Management Area (SMA), where vessel speed restrictions are in place seasonally, were common.

The tagged yearling North Atlantic right whale initially showed movement along the coastline to the south, before abruptly changing direction and heading back to the north, first along the coast but then moving out to deeper, continental shelf waters before the tag stopped transmitting approximately 40 km off Delaware Bay. This individual covered over 2,200 km during the 18-day deployment (roughly 124 km/day) (**Figure 22**).

Table 4. Satellite-tag deployments on humpback whales during the 2021/22 field season.

Animal ID	Estimated Age Class	Tag Type	Argos ID	Deployment Latitude (°N)	Deployment Longitude (°W)	Deployment Date	Last Transmission Date	Tag Duration (Days)
HDRVAMn219	Adult	SPLASH10-292	177355	36.82660	75.7581	21-Nov-21	N/A[a]	—
HDRVAMn223	Adult	SPLASH10-292	183916	36.67540	75.6871	01-Dec-21	04-Dec-21	2.7
HDRVAMn225	Adult	SPOT-6	177042	36.53930	75.6462	04-Dec-21	11-Dec-21	6.2
HDRVAMn233	Adult/Sub-adult	SPLASH10-F	208691	36.76136	75.6739	17-Dec-21	21-Dec-21	3.8
HDRVAMn012	Adult	SPLASH10-F	208692	36.94675	75.9954	19-Jan-22	24-Jan-22	4.2
HDRVAMn243	Adult/Sub-adult	SPLASH10-F	221008	36.94467	75.9938	19-Jan-22	26-Jan-22	6.7
HDRVAMn163	Juvenile	SPLASH10-F	201569	36.85879	75.9619	31-Jan-22	13-Feb-22	13.3
HDRVAMn251	Juvenile	SPLASH10-F	201570	36.97749	75.4030	09-Feb-22	14-Feb-22	4.2
HDRVAMn246	Juvenile	SPLASH10-F	201571	36.87306	75.8651	10-Feb-22	19-Feb-22	8.7

Key: ID = Identification Number; °N = degrees North; °W = degrees West; N/A = not applicable
[a] Tag never transmitted

Table 5. Satellite-tag deployment on a North Atlantic right whale during the 2021/22 field season.

Animal ID	Age Class	Tag Type	Argos ID	Deployment Latitude (°N)	Deployment Longitude (°W)	Deployment Date	Last Transmission Date	Tag Duration (Days)
2021CalfofEg3232	Yearling	SPLASH10-F	208687	36.88088	75.6984	21-Feb-22	11-Mar-22	18.71

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

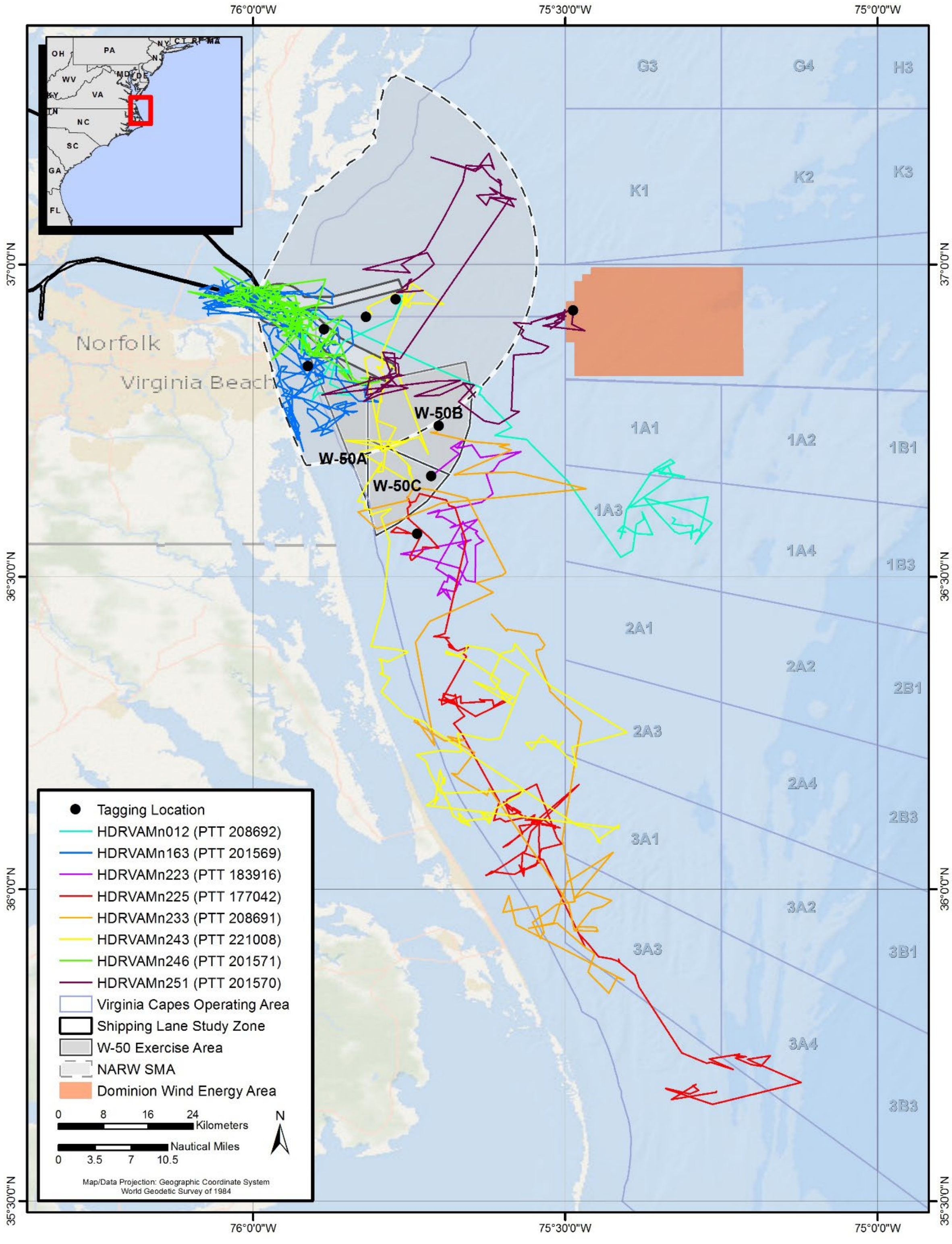

Figure 10. Argos tracks for all humpback whales tagged (*n*=8) during the 2021/22 field season.

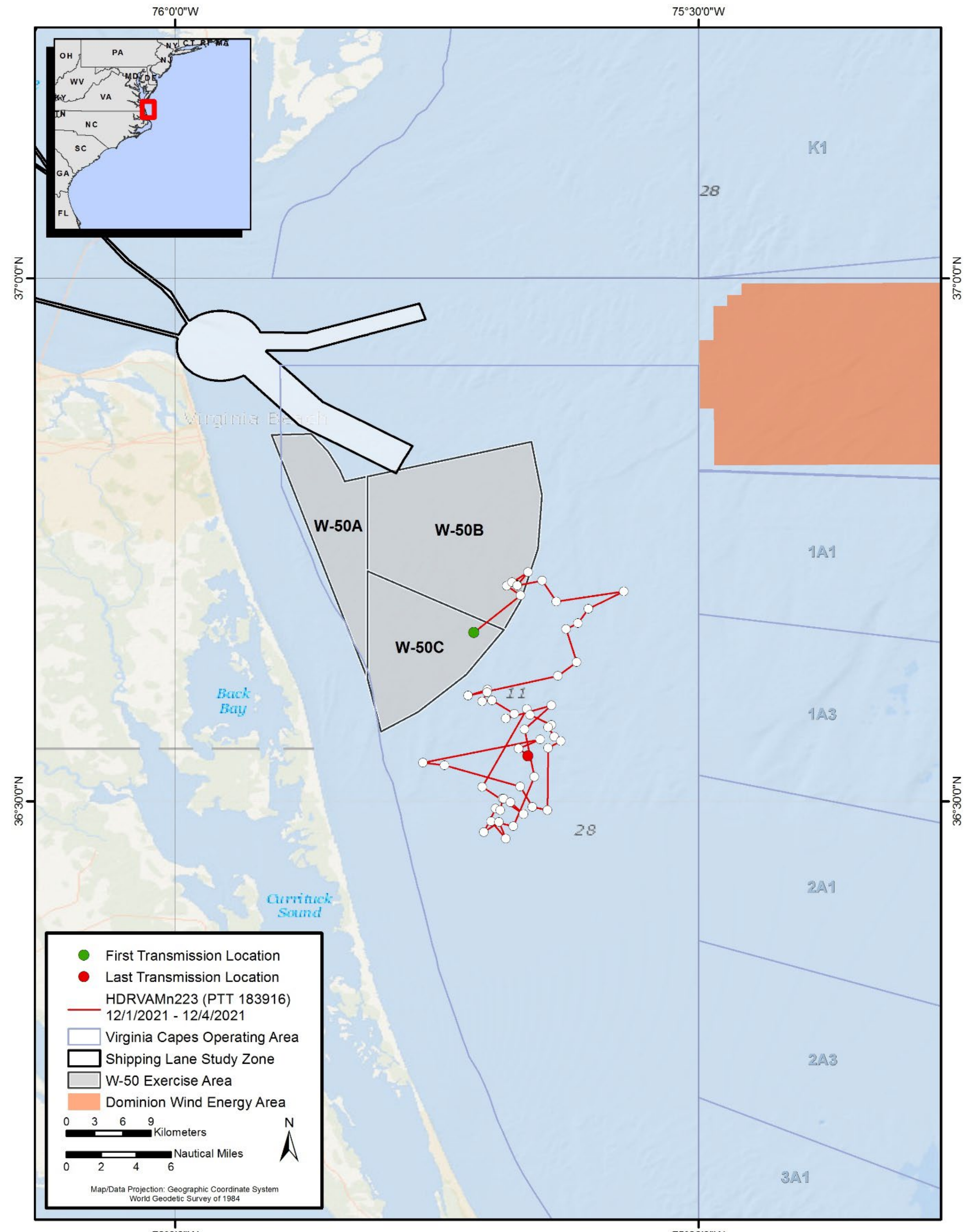

Figure 11. Filtered locations (white dots) and trackline of humpback whale HDRVAMn223, tagged on 01 December 2021, over 2.7 days of tag-attachment duration.

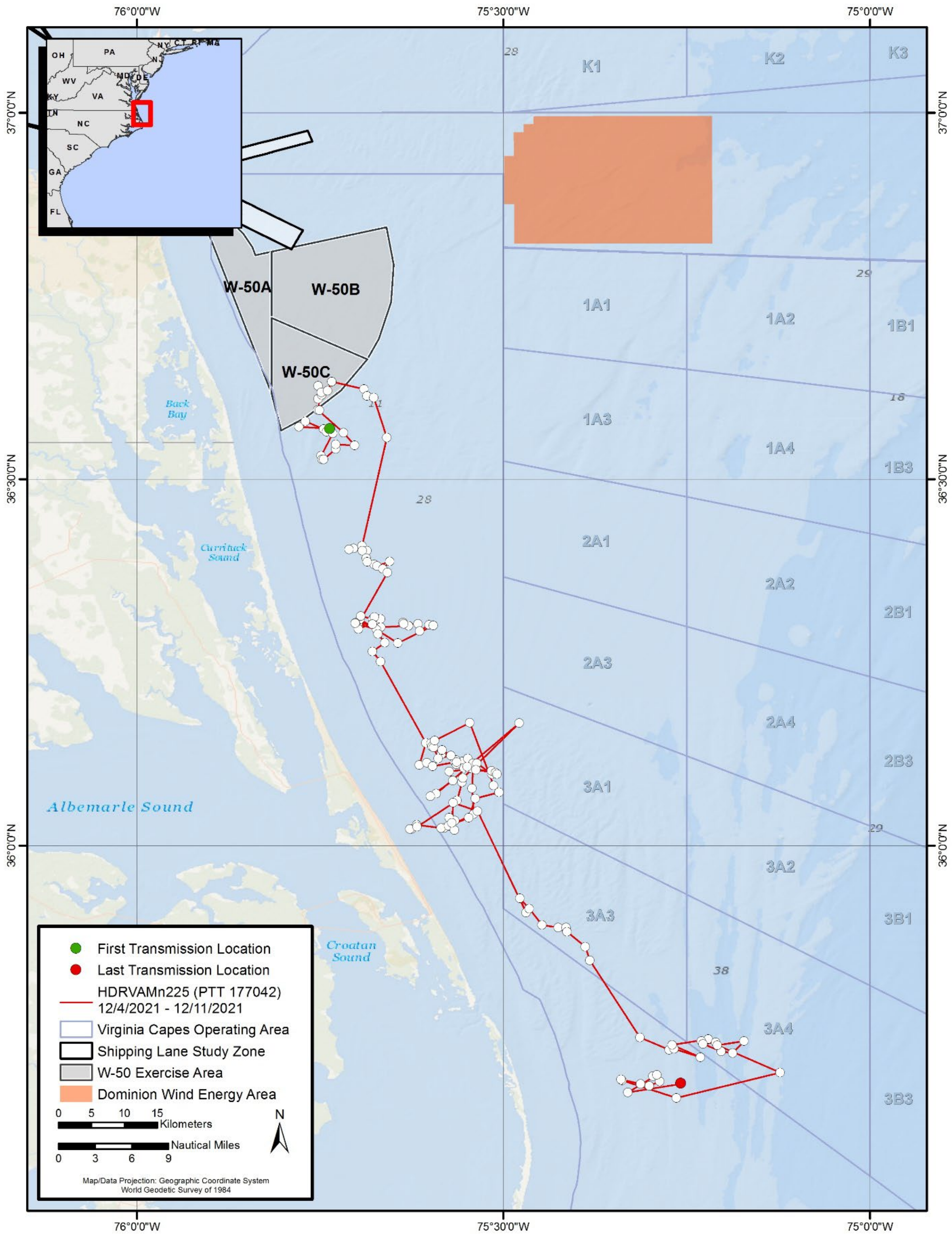

Figure 12. Filtered locations (white dots) and trackline of humpback whale HDRVAMn225, tagged on 04 December 2021, over 6.2 days of tag-attachment duration.

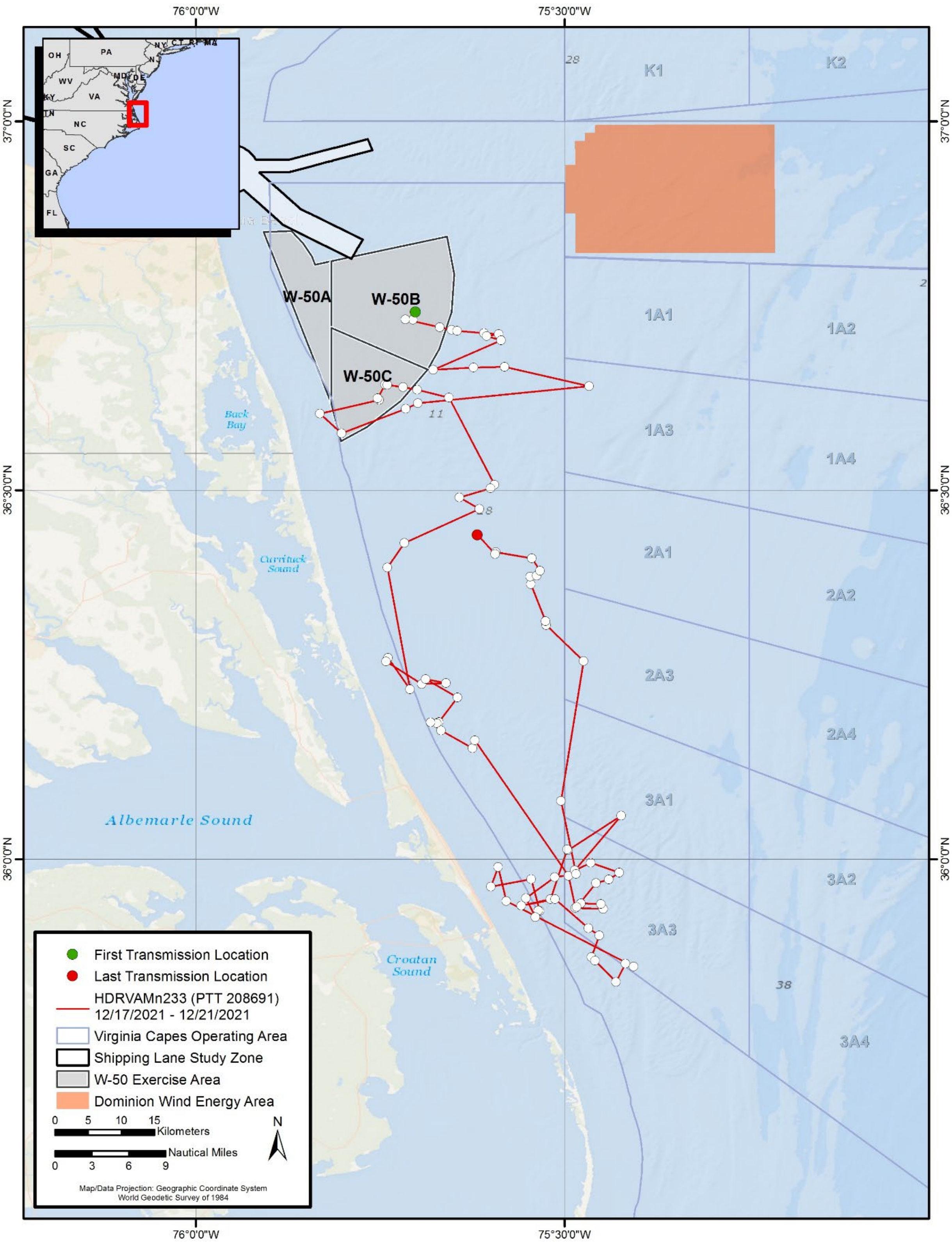

Figure 13. Filtered locations (white dots) and trackline of humpback whale HDRVAMn233, tagged on 17 December 2021, over 3.8 days of tag-attachment duration.

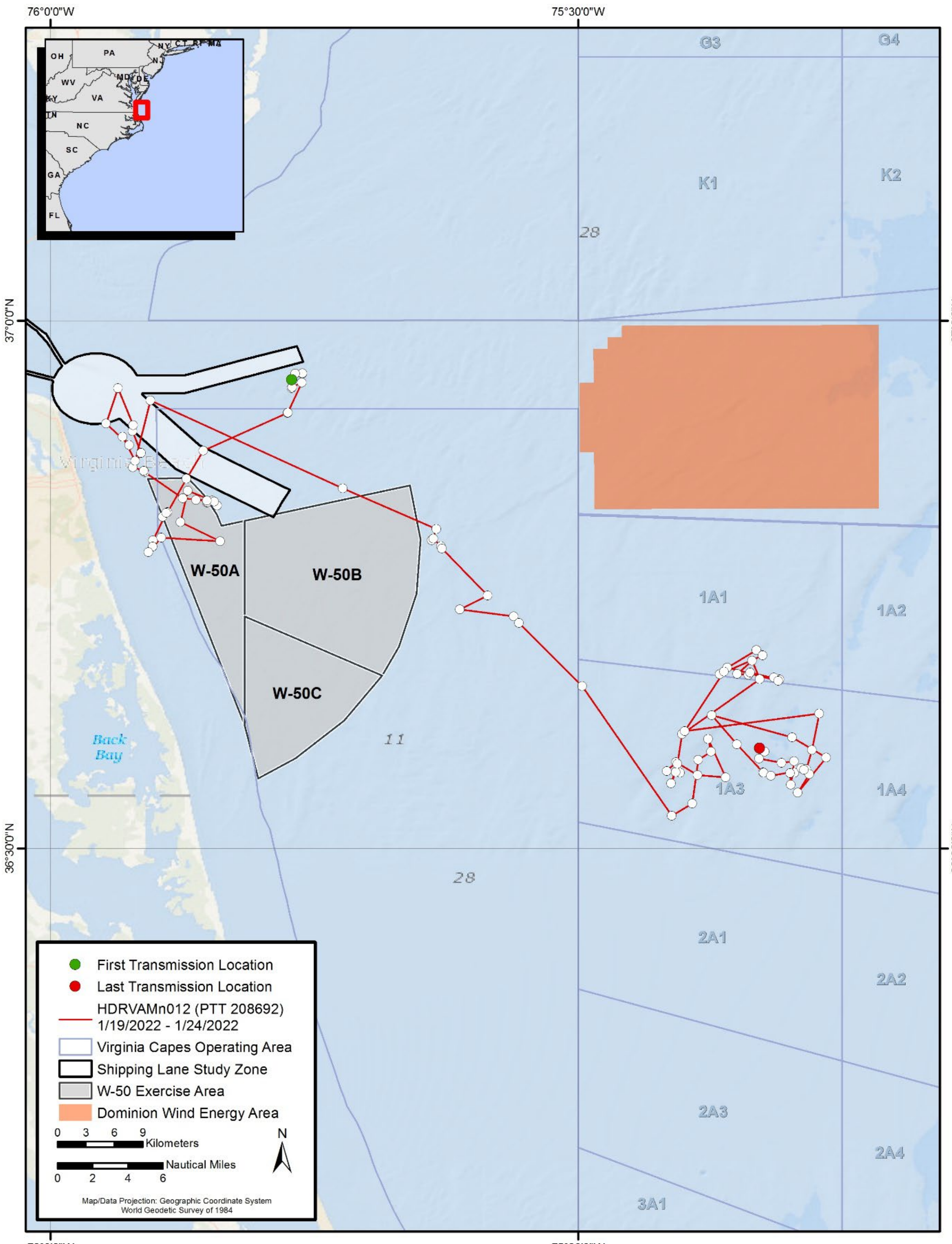

Figure 14. Filtered locations (white dots) and trackline of humpback whale HDRVAMn012, tagged on 19 January 2022, over 4.2 days of tag-attachment duration.

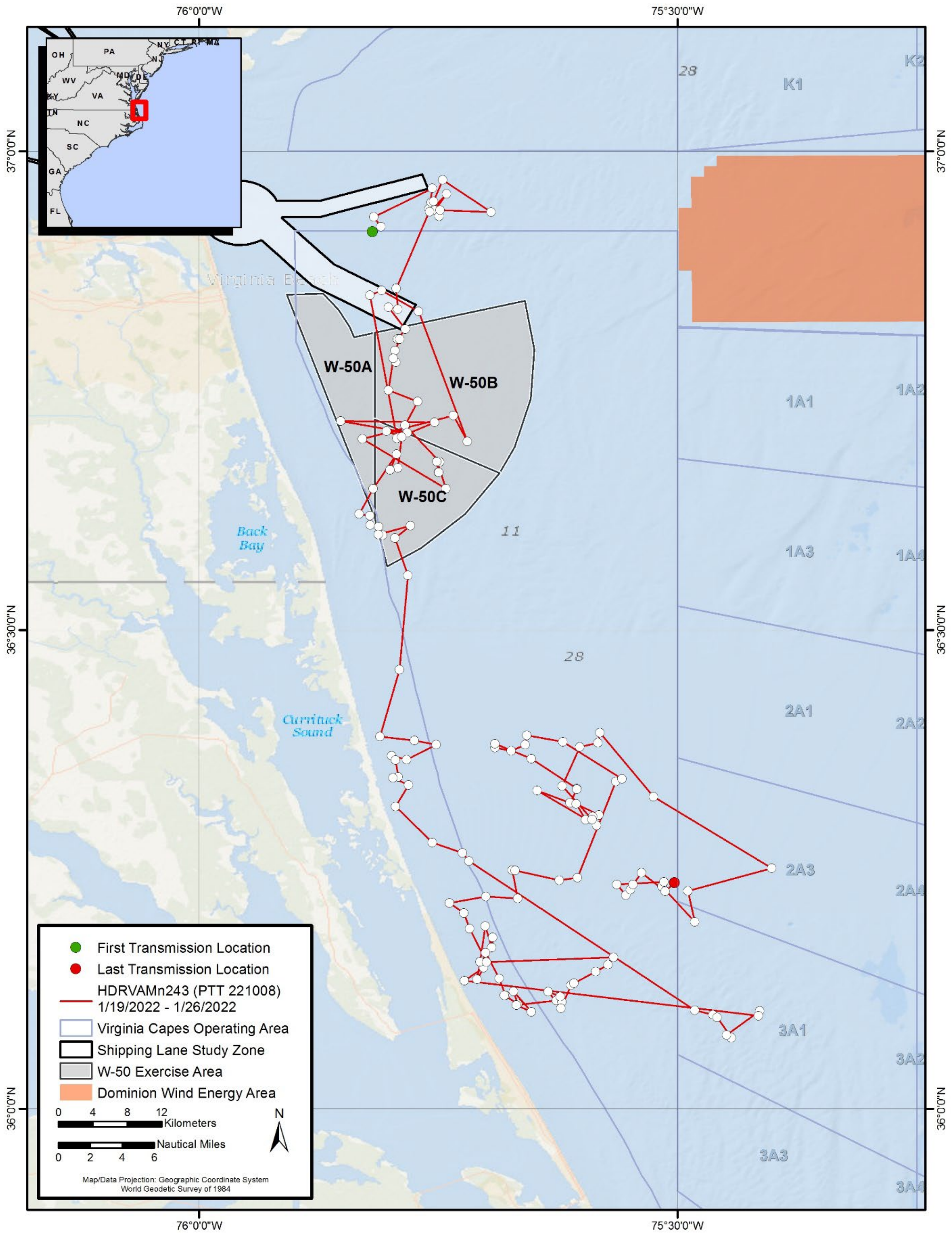

Figure 15. Filtered locations (white dots) and trackline of humpback whale HDRVAMn243, tagged on 19 January 2022, over 6.7 days of tag-attachment duration.

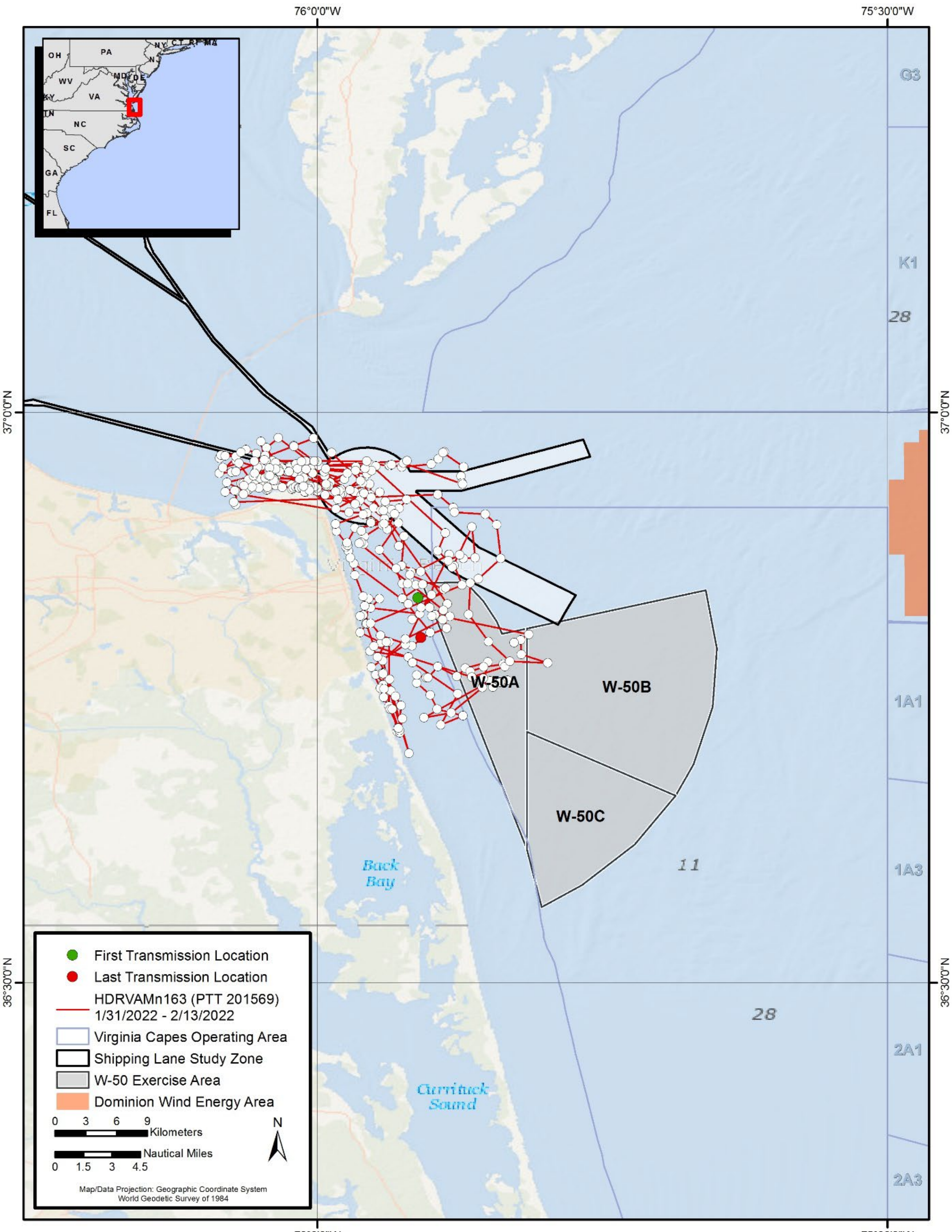

Figure 16. Filtered locations (white dots) and trackline of humpback whale HDRVAMn163, tagged on 31 January 2022, over 13.2 days of tag-attachment duration.

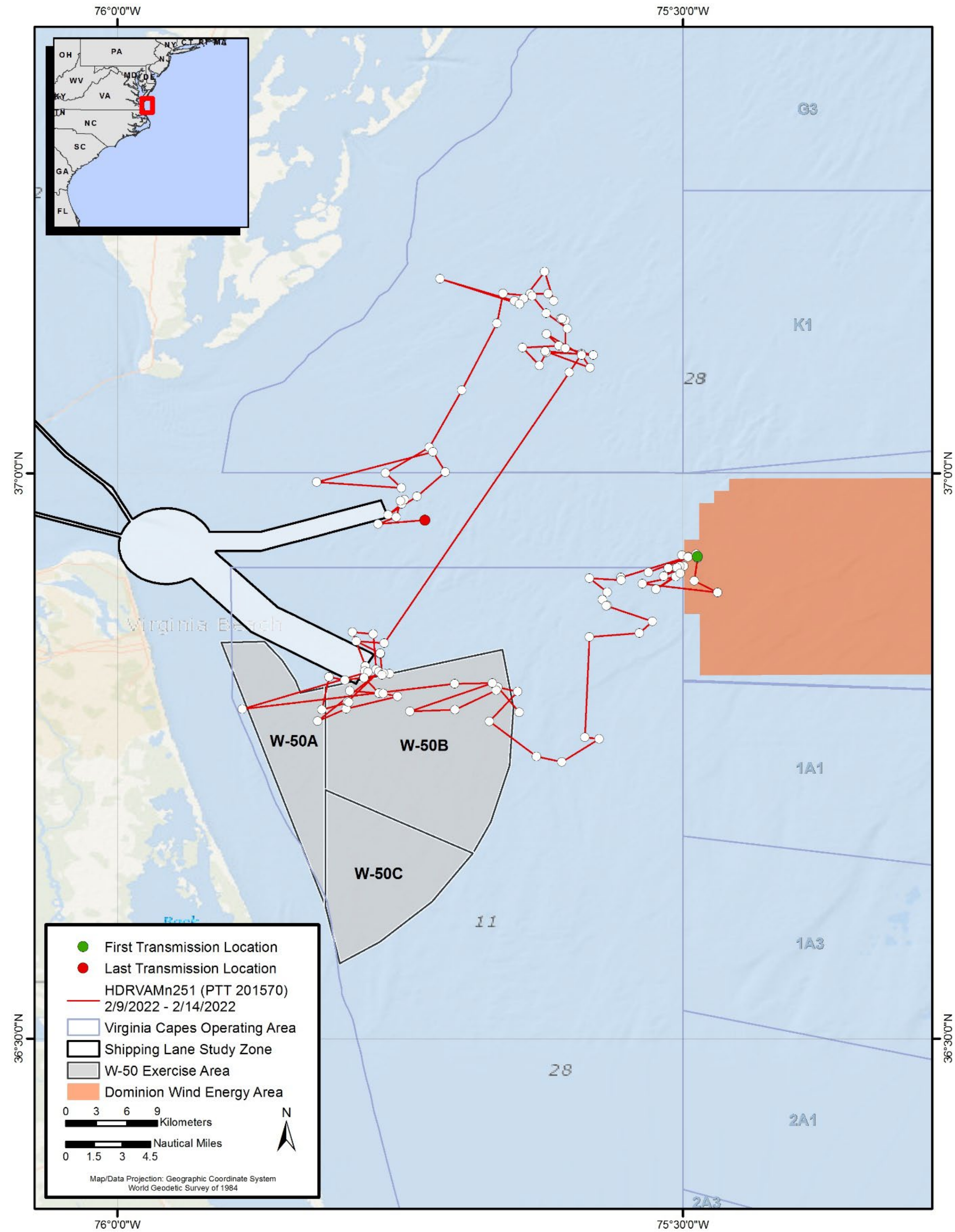

Figure 17. Filtered locations (white dots) and trackline of humpback whale HDRVAMn251, tagged on 09 February 2022, over 4.2 days of tag-attachment duration.

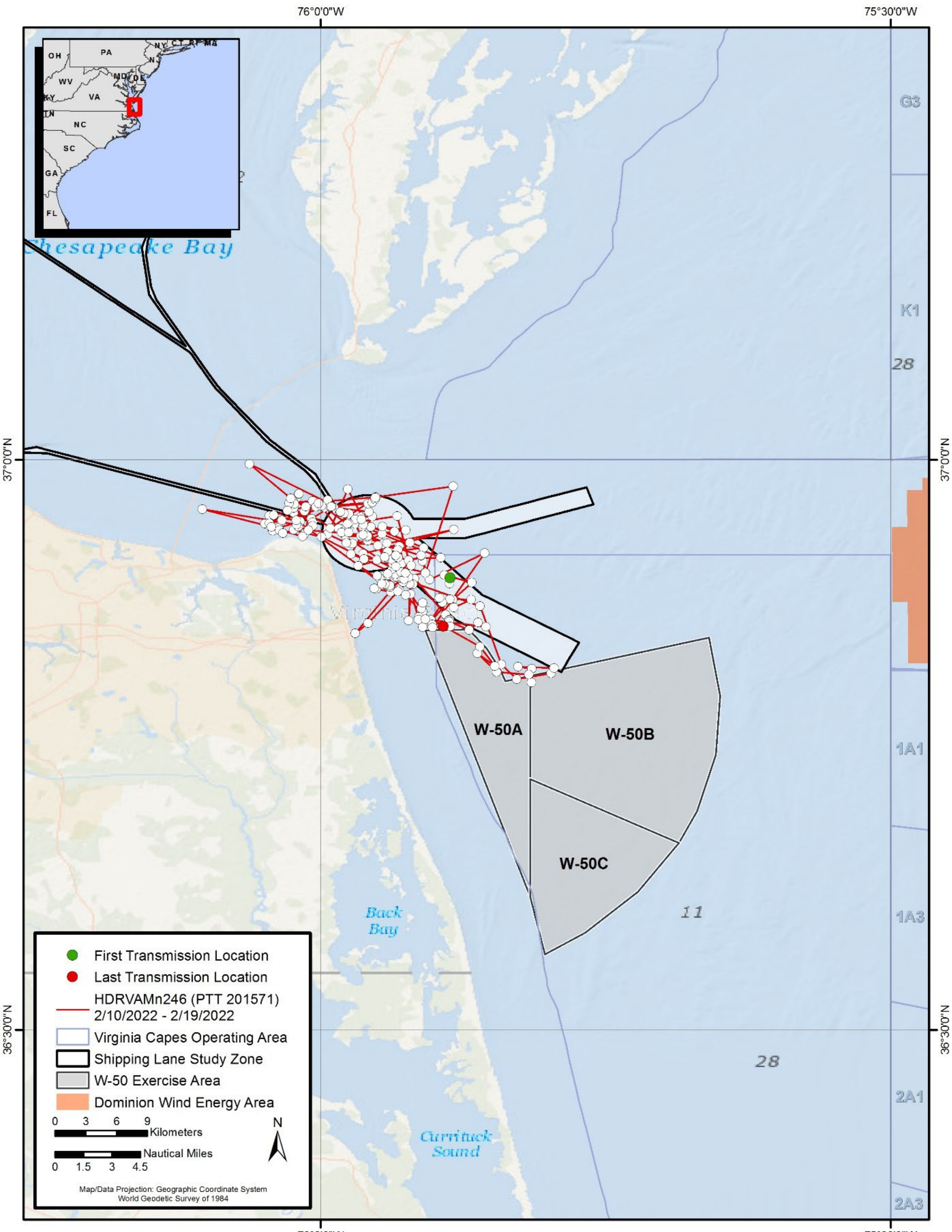

Figure 18. Filtered locations (white dots) and trackline of humpback whale HDRVAMn246, tagged on 10 February 2022. Over 8.7 days of tag-attachment duration.

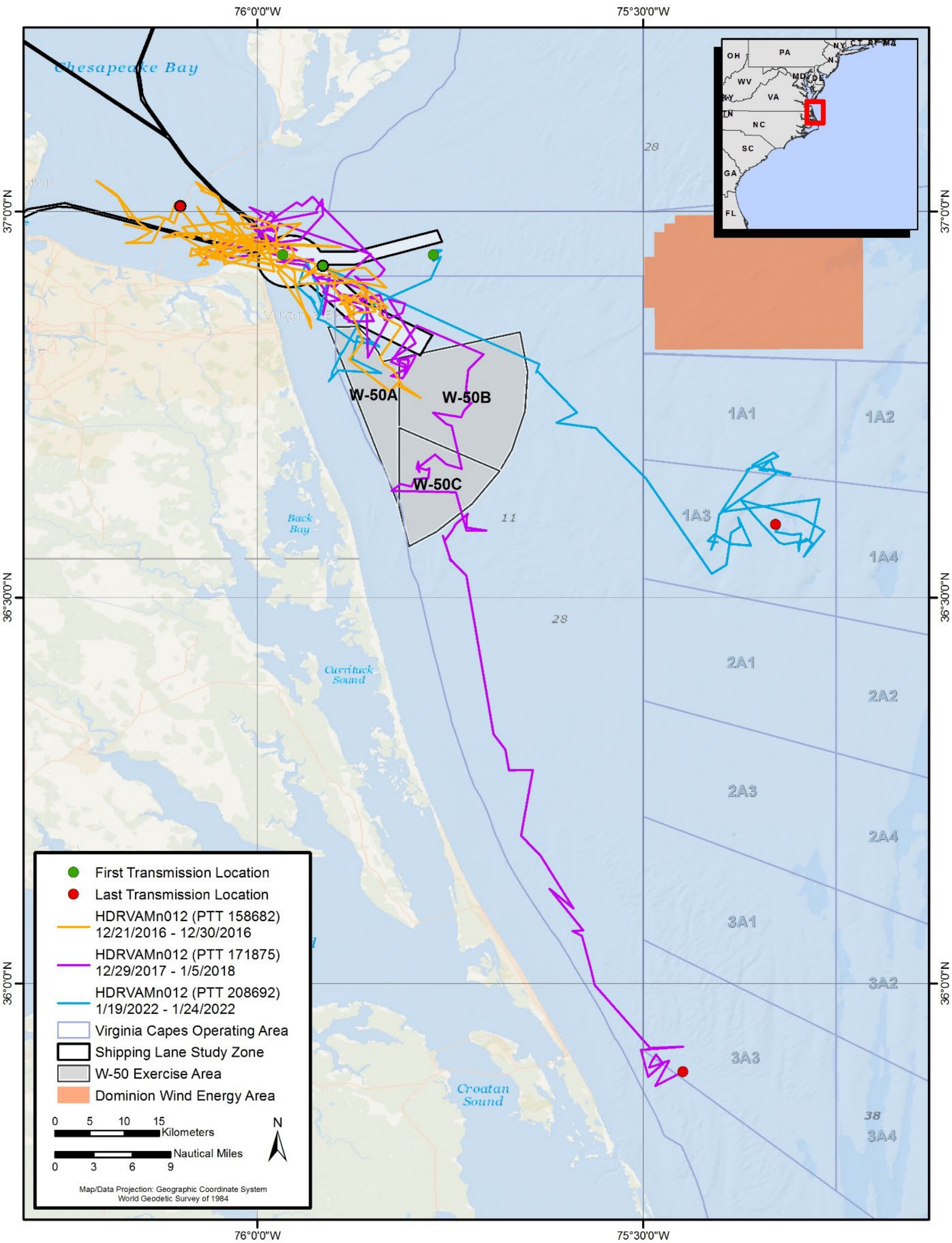

Figure 19. Comparison of tracks for HDRVAMn012 tagged in December 2016 (orange trackline, 8.4 days), December 2017 (purple trackline, 6.3 days), and January 2022 (blue trackline, 4.2 days).

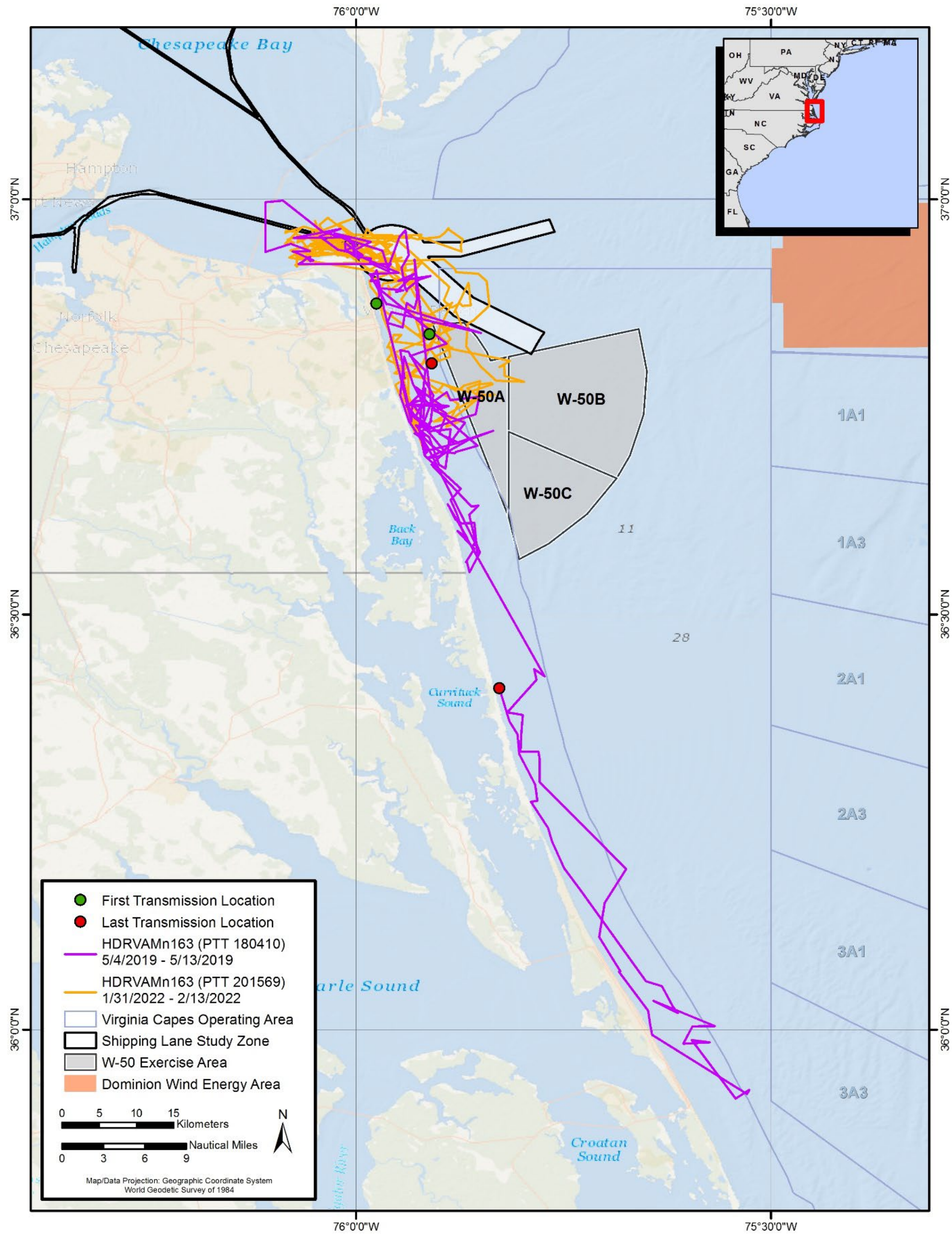

Figure 20. Comparison of tracks for HDRVAMn163 tagged in May 2019 (purple trackline, 9.3 days) and January 2022 (orange trackline, 13.3 days).

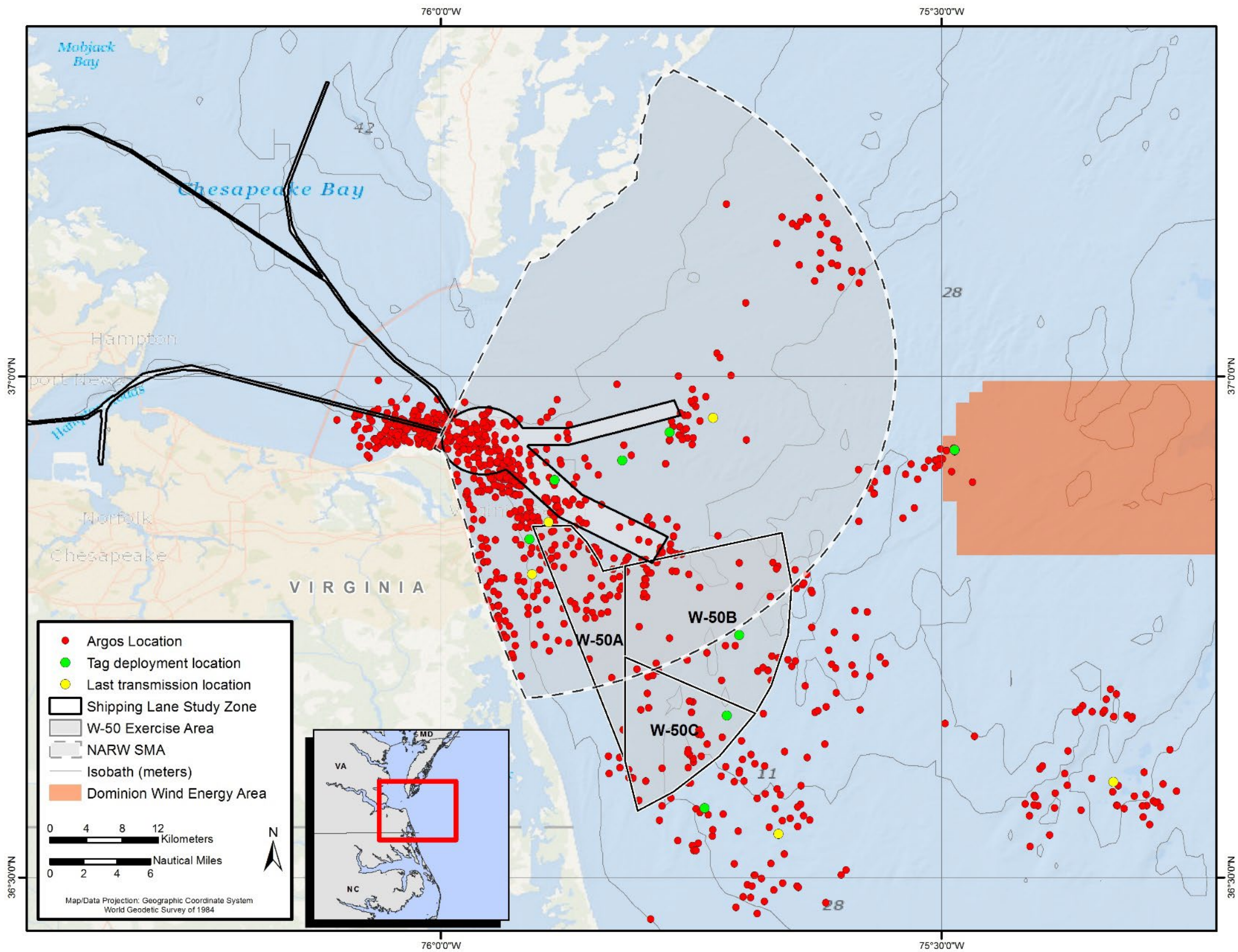

Figure 21. Filtered locations of all humpback whale Argos locations within the immediate vicinity of shipping channels at the mouth of Chesapeake Bay from tag deployments (*n*=7) during the 2021/22 field season.

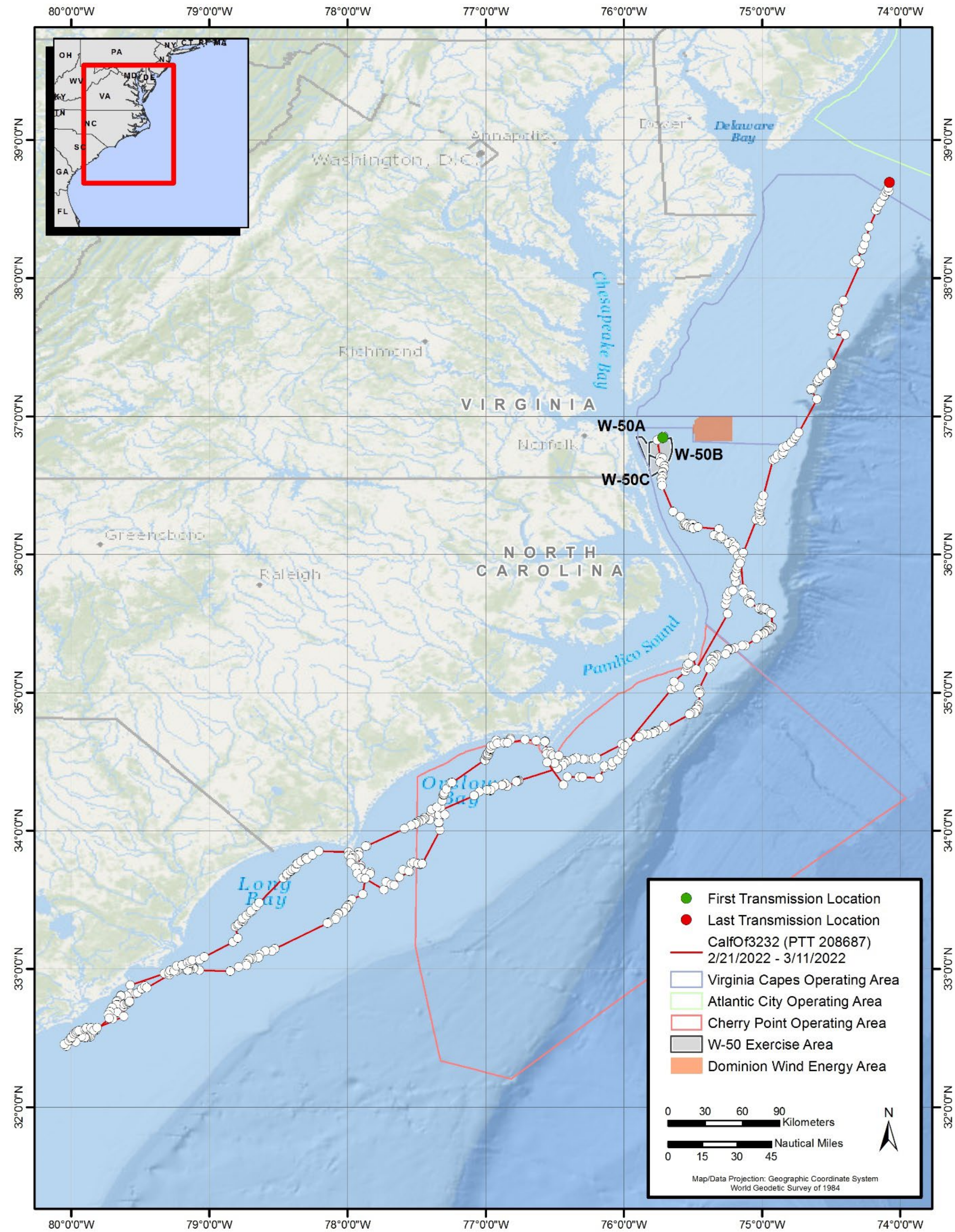

Figure 22. Filtered locations (white dots) and trackline of North Atlantic right whale '2021 Calf of 3232', tagged on 21 February 2022, over 18.7 days of tag-attachment duration.

Maximum straight-line distance from the initial tagging location ranged from 20.7 to 629.3 km (mean = 123.0 km) for all species (**Table 6**). The percentage of locations occurring within the shipping channel study area ranged from 0 to 45.8 percent (mean = 8.5 percent), with three humpback whales and the North Atlantic right whale spending no time within the Virginia shipping channels (**Table 6**). The percentage of locations within VACAPES ranged from 14.2 to 100 percent (mean = 63.8 percent) (**Table 6**).

Table 6. Summary of results from satellite-tag data for all baleen whales tagged during the 2021/22 season.

Animal ID	Species	# Locations Post Filtering	Percent Within Shipping Channels	Percent Within VACAPES	Max Distance from Initial Location (km)	Mean Distance from Initial Location (km)
HDRVAMn219	Humpback whale	0	—	—	—	—
HDRVAMn223	Humpback whale	52	0	100	22.1	12.6
HDRVAMn225	Humpback whale	156	0	96.8	112.1	50.5
HDRVAMn233	Humpback whale	90	0	88.9	103.7	54.6
HDRVAMn012	Humpback whale	102	2.9	78.4	61	34.7
HDRVAMn243	Humpback whale	150	2.57	67.3	99.3	55.2
HDRVAMn163	Humpback whale	352	24.7	14.2	20.7	11.2
HDRVAMn251	Humpback whale	114	0.9	81.6	38.9	20.4
HDRVAMn246	Humpback whale	203	45.8	16.3	20.5	11.2
2021CalfofEg3232	North Atlantic right whale	507	0	30.6	629.3	303.0

Key: Max = Maximum

Eight satellite tags recorded data on dive depth and duration in addition to the Argos capabilities (**Table 7**). Seven humpback whale tags recorded a total of 4,519 dives. Mean dive depth ranged from 13.9 to 17.6 m, with a maximum dive depth of 281 m by one individual. Mean dive durations ranged from 2.7 to 3.1 minutes. The North Atlantic right whale tag recorded a total of 1,770 dives. Mean dive depth was 20.2 m, and mean dive duration was 4.5 minutes.

Dive durations of humpback whales tagged during the 2021/22 season were similar to humpbacks tagged during the 2019/20 field season (*n*=11,708 dives) in which the mean dive durations ranged from 2.4 to 3.9 minutes, and the 2020/21 field season (*n*=4,119 dives) where mean dive duration was 2.5 to 3.8 minutes. Mean dive depths were more similar to whales tagged during the 2020/21 season (mean depth of 15.7 to 30.5 m) than to those tagged during the 2019/20 season (mean depth of 12.6 to 16.3 m). Dives for humpback whales tagged during the 2018/19 field season were shorter, ranging from 1.8 to 3.0 minutes (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.

Table 7. Summary of dive depth and duration data collected from tagged baleen whales during the 2021/22 season.

Animal ID	Species	No. Dives Logged	Mean Dive Depth (m)	Max Dive Depth (m)	Mean Dive Duration (mm:ss)	Max Dive Duration (mm:ss)
HDRVAMn223	Humpback whale	255	16.9	22	2:58	6:05
HDRVAMn233	Humpback whale	370	17.6	26	3:07	8:47
HDRVAMn012	Humpback whale	405	14.4	29	3:04	8:29
HDRVAMn243	Humpback whale	500	16.5	281	2:42	5:37
HDRVAMn163	Humpback whale	1,434	13.9	32	2:46	6:31
HDRVAMn251	Humpback whale	495	16.1	33	3:04	5:41
HDRVAMn246	Humpback whale	1,060	15.3	33	2:51	5:27
2021 Calf of 3232	North Atlantic right whale	1,170	20.2	94	4:29	12:45

Key: ID = Identification Number; Max = Maximum; mm:ss = minutes:seconds

3.5 DTAG Results

In January 2019, Duke University researchers initiated a concurrent tagging project on humpback whales around the shipping lanes within the Chesapeake Bay study area. This study continued into the 2020/21 field season. High-resolution DTAGs were deployed on overwintering humpback whales to better understand the factors that influence their responses to approaching vessels. More information about this project can be found in Shearer et al. (2022).

In November 2020, HDR Inc. also incorporated the use of DTAGs into their existing project. The goal was to deploy tags on individuals within the mid-shelf region to learn more about their foraging and fine-scale dive behavior within these areas. Two DTAGs were deployed on humpback whales during the 2021/22 season (**Table 8**). One tag broke on impact and was not recovered. The recovered tag, which was deployed in association with a SPLASH10-F tag, recorded 805 minutes of data. These data are still being analyzed; however, the dive-depth profile for the DTAG that was successfully recovered is shown in **Figure 23**.

Table 8. DTAG deployments on humpback whales during the 2021/22 field season.

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

Key: ID = Identification Number; GMT = Greenwich Mean Time; min = minute(s)
[a] Tag broke on impact and was not recovered

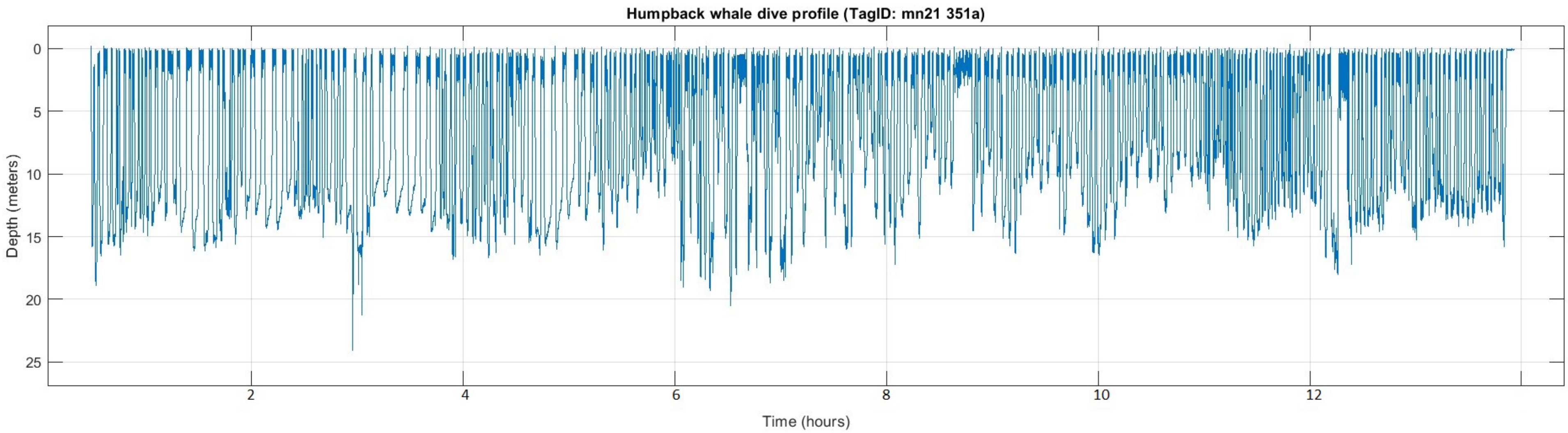

Figure 23. Dive depth profile (in meters) for humpback HDRVAMn012 (DTAG *mn21_351a*).

4. Discussion

Analyses of data from this multi-year project are 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, W-50 MINEX, and U.S. Navy OPAREAS all occur within the habitat that these whales use seasonally. Results continue to show site fidelity within the study area for many individuals and a high level of occurrence within areas that are heavily used by the U.S. Navy, commercial shipping, and recreational and commercial fishing vessels. These findings are supported by information collected during the past 8 years of this study, including photo-IDs, focal follows, and satellite-tagging results.

Interactions with vessels, both large and small, are a significant cause for concern for both humpback and endangered fin 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 North Carolina, based on elevated mortalities of this species since January 2016. At the time of this report, 200 humpback whales are included in this UME, and 58 (29.0 percent) of those have occurred along the shore or in waters off the coast of Virginia or North Carolina (NOAA 2023). Given this designation, a group of subject matter experts, the UME working group, will further investigate what is causing or contributing to the increased number of deaths of humpback whales within this area. Some of the whales examined thus far have exhibited evidence of pre-mortem vessel strike, but the UME investigation process remains ongoing. While the UME working group will look at humpback whales of all age classes, approximately two-thirds of the humpback whales identified during the 8 years of survey effort on this project appear to be juveniles 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.

Additionally, an UME for North Atlantic right whales was also declared in 2017, with 114 instances of mortality, serious injury, and morbidity, primarily from rope entanglements and vessel strikes (NOAA 2023). The first vessel-related death of a North Atlantic right whale in 2023 was reported in Virginia Beach and highlights the potential for injuries and fatalities within this area.

The number of humpback whale identifications per season grew steadily over the course of the first 3 years of this project, decreased during the 2017/18 field season, increased slightly for the 2018/19 season before dropping slightly in 2019/20 season, and increased slightly in the 2020/21 and 2021/22 seasons (**Figure 8**). Because these surveys are not primarily intended to support density or abundance estimates, trends in sightings across study years cannot be evaluated statistically; however, some subjective inferences may be made.

Part of the increase in the number of identifications over the first three seasons is likely due to effort—the 2016/17 and 2017/18 field seasons began 2 months earlier than the 2014/15 season and 1 month earlier than the 2015/16 field season. Also, during the 2014/15 season, effort was focused on collecting focal follows of individual whales, so priority was given to staying with one whale over a longer period of time rather than collecting as many photo-IDs of animals within the surrounding areas. Overall effort on the water, both in terms of survey days and hours, also increased during the first three field seasons, partially accounting for the increase in sighting information during the 2016/17 field season.

The 2017/18 field season was also somewhat anomalous in terms of temperature, with multiple cold-weather systems significantly affecting water temperature within and around Chesapeake Bay and the surrounding areas. Based on HDR Inc.'s experience, when water temperatures drop, the whales seem to be less numerous or altogether absent despite continued survey effort. It is presumed that the colder water temperatures likely affected prey distribution within the area and may have forced animals to look elsewhere for food—either farther south, toward the Outer Banks of North Carolina; or farther offshore, as was observed in some of the tag data and evidenced by the need to survey farther offshore to locate whales. The decrease in the number of overall sightings and overall individuals identified during the 2017/18 field season may be related to the low water temperatures that began in early January 2018.

Less time was spent on the water (both in terms of number of days and overall effort) during the 2019/20 field season compared to the 2018/19 field season, which may also account for the smaller number of identifications. Additional sightings during the 2020/21 and 2021/22 field seasons correspond with increased survey effort. It is also plausible that feeding opportunities in other locations, such as the Gulf of Maine or maritime Canada, play a role in how many animals move further south into the mid-Atlantic.

Integration of the drone component to the study, beginning in 2018, has allowed for additional opportunities to examine body condition and estimate length. The drone also proved valuable in assisting with tag deployments, observing unique behavior (such as bubble-net feeding), and collecting follow-up images from tagged whales. The study team recently retrofitted the drone and installed a custom LiDAR altimeter, which increases the precision and consistency of the sUAS altimetry measurements to minimize possible error in measured animal lengths. HDR Inc. is in the process of acquiring a new American-made sUAS with improved capabilities such as a LiDAR sensors, longer flight times, and a higher-resolution camera.

With seven seasons of satellite-tag deployments completed, trends are emerging, as is the variability both between individuals and between years. The mouth of Chesapeake Bay, and shipping lanes in particular, continues to be an area heavily used by humpback whales seasonally. 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. These speed restrictions require all vessels 65 feet (19.8 m) or longer to travel at 10 knots (18.5 km/hour) or less, and a proposed rule to extend these restrictions to smaller vessels within a wider area is under review.

The SMA within this study area begins at the mouth of Chesapeake Bay and extends outwards 37 km from shore; however, as Argos locations from tagged humpback whales have shown, these boundaries do not necessarily protect all large whales using the area (**Figure 21**). Portions of Chesapeake Bay, west of the Chesapeake Bay Bridge Tunnel, were not used by any tagged humpback whales during the 2015/16, 2017/18, 2020/21, or 2021/22 field seasons; only sparsely used during the 2018/19 field season; and heavily used during the 2016/17 and 2019/20 field seasons.

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 Chesapeake Bay Bridge Tunnel raises additional concerns given the high traffic flow within that area, increased vessel speeds allowed, and extent of marine-based training occurring out of Joint Expeditionary Base Little Creek.

While the percentage of tag locations occurring within the shipping lanes decreased during the 2021/22 season, an increase in the percentage of locations within the VACAPES OPAREA occurred. While this shift may cause certain individuals to be less at risk for ship strikes, different risk factors may occur within the offshore areas. Increased survey and tagging effort within the offshore waters during the 2020/21 and 2021/22 field seasons have shown this to also be an important habitat for humpback, fin, and North Atlantic right whales. Further analysis of water-temperature data collected from CTD measurements, buoy data, and tag data may provide a better understanding of thresholds that result in humpback whales (and presumably their prey) remaining in or moving outside the nearshore area. Efforts for the 2022/23 field season will continue to focus on pushing farther into the mid-shelf waters as well as continuation of photo-ID efforts within nearshore waters. During the 2022/23 field season, the study team will continue to deploy DTAGs 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 measurements to add to the existing medium-duration dataset.

State-Space Modeling and home range analyses were previously performed on a subset of data (see Aschettino et al. 2018), and results provided inference on animal behavior for all but the shortest duration (or sparsely reporting) tags. Animals showed varied movement strategies, the most common of which was area-restricted search centered around the mouth of Chesapeake Bay, where most tags were deployed. It may be that tags were lost before significant movement was undertaken, but it still highlights the lower Chesapeake Bay as an important foraging area. Other strategies included looping down the Outer Banks to feed and then returning north, foraging deeper into Chesapeake Bay, and directing movements northward along the coast and the shelf break before recruiting to additional locations where area-restricted search behavior was performed. Updating these analyses following the 2021/22 field season, with the inclusion of additional tags, will provide a more robust picture of humpback whale habitat use within Chesapeake Bay. This population has been shown to engage in diverse feeding and movement strategies, which need to be considered when mitigating impacts and making management decisions.

In addition to integrating additional tag data into the switching state-space model, further tag analyses will continue. As additional SPLASH10-F tags are deployed, dive depths and durations will be looked at more closely and in association with the concurrent DTAG efforts being conducted by Duke University (see Shearer et al. 2023).

The numbers of sightings of humpback, fin, 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 effort 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 DTAG collaboration effort with Duke University, which will examine the three-dimensional movements of humpback 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.

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Appendix A
Sighting History Table

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Table A-1. Sighting history (number of days seen per season) and additional information for all photo-identified baleen whales off Virginia Beach, Virginia: December 2014–March 2022

HDR Catalog ID	Season 1 Dec 2014–Apr 2015	Season 2 Oct 2015–May 2016	Season 3 Nov 2016–Mar 2017	Season 4 Oct 2017–Mar 2018	Season 5 July 2018–May 2019	Season 6 Dec 2019–Mar 2020	Season 7 Nov 2020–Apr 2021	Season 8 Nov 2021–Mar 2022	Total No. Days Seen	Total No. Seasons Seen	Biopsied? (Y/N) Gender (M/F/U)	Satellite Tagged? (Y/N)	D-Tagged? (Y/N)	Estimated Age Class (A/SA/J/Ye)	Propeller Scars or Injuries? (Y/N/P)	Total No. Focal Follows	Total No. Focal Follow Minutes
Humpback Whales:																	
HDRVAMn003	1						1	2	4	3	N/U	N	N	A	N	0	-
HDRVAMn004	1								1	1	N/U	N	N	A	N	0	-
HDRVAMn005	2		5						7	2	Y/F	Y	N	A	N	1	64
HDRVAMn006	2								2	1	N/U	N	N	J	N	1	69
HDRVAMn007	4	1	7		8	1			21	5	Y/F	Y	N	J	N	1	60
HDRVAMn008	5							2	7	2	N/U	N	N	J; SA/A	N	3	215
HDRVAMn009	4								4	1	Y/F	N	N	J	N	2	112
HDRVAMn010	1	2		1					4	3	Y/M	Y (2)	N	J	N	1	76
HDRVAMn011	4		1						5	2	Y/F	N	N	J	N	1	60
HDRVAMn012	3	2	6	2	3		2		18	6	Y/F	Y (3)	Y	J; SA/A	N	3	47
HDRVAMn013	10								10	1	Y/F	N	N	J	N	4	357
HDRVAMn014	5	1	1	1					8	4	Y/F	N	N	J	N	1	60
HDRVAMn015	2		1						3	2	Y/F	N	N	J	N	1	58
HDRVAMn016	1								1	1	N/U	N	N	U	N	0	-
HDRVAMn017	1								1	1	N/U	N	N	U	N	0	-
HDRVAMn018	1								1	1	N/U	N	N	U	Y	0	-
HDRVAMn019	1								1	1	N/U	N	N	U	N	0	-
HDRVAMn020	1								1	1	N/U	N	N	U	N	0	-
HDRVAMn021	2		3	2	6	1			14	5	N/U	N	N	SA	N	1	78

Key: Y = yes; N = no; P = possible; A = adult; SA = sub-adult; J = juvenile; C = calf; Ye = yearling; U = unknown; ID = Identification Number; No. = Number
[a] Deceased
[b] Sighting occurred on offshore survey

HDR Catalog ID	Season 1 Dec 2014–Apr 2015	Season 2 Oct 2015–May 2016	Season 3 Nov 2016–Mar 2017	Season 4 Oct 2017–Mar 2018	Season 5 July 2018–May 2019	Season 6 Dec 2019–Mar 2020	Season 7 Nov 2020–Apr 2021	Season 8 Nov 2021–Mar 2022	Total No. Days Seen	Total No. Seasons Seen	Biopsied? (Y/N) Gender (M/F/U)	Satellite Tagged? (Y/N)	D-Tagged? (Y/N)	Estimated Age Class (A/SA/J/Ye)	Propeller Scars or Injuries? (Y/N/P)	Total No. Focal Follows	Total No. Focal Follow Minutes
Humpback Whales (continued):																	
HDRVAMn022	2								2	1	N/U	N	N	J	N	1	85
HDRVAMn023	1		3[a]	-	-	-			4	2	Y/M	Y	N	J	N	1	80
HDRVAMn024	2								2	1	Y/M	N	N	A	P	1	60
HDRVAMn025	1						1		2	2	Y/M	N	N	SA/A	N	1	62
HDRVAMn027	2	3	1	1[b]					7	4	Y/F	N	N	J	N	1	61
HDRVAMn028	1								1	1	N/U	N	N	J	N	0	-
HDRVAMn029	1								1	1	Y/M	N	N	J	P	1	63
HDRVAMn030	1	1							2	2	N/U	N	N	A	N	1	62
HDRVAMn031	1		1	1					3	3	Y/M	Y	N	J	N	0	-
HDRVAMn032	1								1	1	N/U	N	N	SA	N	1	-
HDRVAMn033	1								1	1	N/U	N	N	J	N	0	63
HDRVAMn034	1								1	1	N/U	N	N	J	N	0	-
HDRVAMn035		2							2	1	N/U	N	N	J	N	0	-
HDRVAMn036		2							2	1	N/U	N	N	J	N	0	-
HDRVAMn037		3							3	1	N/U	N	N	J	N	0	-
HDRVAMn039		1							1	1	Y/M	Y	N	J	N	0	-
HDRVAMn041		1							1	1	Y/M	Y	N	J	N	0	-
HDRVAMn042		6							6	1	N/U	N	N	J	N	0	-
HDRVAMn043		1							1	1	N/U	N	N	J	N	0	-
HDRVAMn044		1							1	1	Y/F	Y	N	J	Y	0	-
HDRVAMn045		6							6	1	Y/M	Y	N	J	Y	0	-
HDRVAMn046		4							4	1	N/U	N	N	J	N	0	-

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Humpback Whales (continued):																	
HDRVAMn047		1							1	1	N/U	N	N	J	N	0	-
HDRVAMn048		2	1						3	2	Y/M	Y	N	SA/A	N	0	-
HDRVAMn049		2	6	1, 1[b]				1	11	4	Y/F	Y (2)	N	SA/A	N	0	-
HDRVAMn050		4							4	1	Y/M	N	N	J	N	0	-
HDRVAMn051		9							9	1	Y/M	N	N	J	Y	0	-
HDRVAMn052		3							3	1	Y/F	N	N	J	N	0	-
HDRVAMn053		2							2	1	N/U	N	N	J	Y	0	-
HDRVAMn054		7							7	1	Y/M	Y	N	J	N	0	-
HDRVAMn055		2							2	1	N/U	N	N	J	N	0	-
HDRVAMn056		2							2	1	N/U	N	N	J	N	0	-
HDRVAMn057		1							1	1	N/U	N	N	J	N	0	-
HDRVAMn058		1						3	2	4	N/U	N	N	J/SA; SA/A	Y	0	-
HDRVAMn059		1	2						3	2	Y/M	Y	N	SA	N	0	-
HDRVAMn060		1							1	1	N/U	N	N	J	N	0	-
HDRVAMn061		3							3	1	Y/M	Y	N	J	N	0	-
HDRVAMn062		3							3	1	N/U	N	N	J	N	0	-
HDRVAMn063		4							4	1	Y/M	Y	N	J	N	1	120
HDRVAMn064		2	12	2	3	2			21	5	Y/F	Y (2)	N	J	N	0	-
HDRVAMn065		1	3						4	2	N/U	N	N	J	N	0	-
HDRVAMn066		2	2						4	2	Y/M	Y	N	J	N	0	-
HDRVAMn067		1[b]							1	1	N/U	N	N	J	N	0	-
HDRVAMn068		1							1	1	N/U	N	N	J	N	0	-

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Humpback Whales (continued):																	
HDRVAMn069			1						1	1	Y/F	Y	N	SA	N	0	-
HDRVAMn071			2						2	1	Y/M	Y	N	SA	N	0	-
HDRVAMn072			1						1	1	N/U	N	N	J	N	0	-
HDRVAMn073			1					1,1[b]	3	2	N/U	N	N	SA; A	N	0	-
HDRVAMn074			1						1	1	N/U	N	N	J	N	0	-
HDRVAMn075			1						1	1	N/U	N	N	SA	N	0	-
HDRVAMn076			1						1	1	N/U	N	N	SA	N	0	-
HDRVAMn077			1						1	1	N/U	N	N	SA	N	0	-
HDRVAMn078			1[a]	-	-	-			1	1	N/U	N	N	J	N	0	-
HDRVAMn079			3						3	1	N/U	N	N	J	N	0	-
HDRVAMn080			1						1	1	N/U	N	N	J	N	0	-
HDRVAMn081			9						9	1	Y/F	Y	N	J	N	0	-
HDRVAMn082			4		-	-			3	1	Y/F	Y	N	J	N	0	-
HDRVAMn083			2						2	1	N/U	Y	N	J	N	0	-
HDRVAMn084			11						11	1	Y/F	Y	N	J	N	0	-
HDRVAMn085			8						8	1	N/U	N	N	J	Y	0	-
HDRVAMn086			1					1	2	2	N/U	N	N	J; SA	N	0	-
HDRVAMn087			3						3	1	N/U	N	N	J	N	0	-
HDRVAMn088			6						6	1	Y/M	Y	N	J	N	0	-
HDRVAMn089			1						1	1	N/U	N	N	J	N	0	-
HDRVAMn090			4[a]	-	-	-			4	1	Y/M	Y	N	J	Y	0	-
HDRVAMn091			5[a]	-	-	-			5	1	Y/M	N	N	SA	Y	0	-
HDRVAMn092			6						6	1	Y/F	Y	N	J	N	0	-

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Humpback Whales (continued):																	
HDRVAMn093			6		4	1			11	3	Y/F	Y (3)	N	J	N	0	-
HDRVAMn094			1						1	1	N/U	N	N	J	N	0	-
HDRVAMn095			2						2	1	Y/M	Y	N	J	N	0	-
HDRVAMn096			5						5	1	Y/M	N	N	J	N	0	-
HDRVAMn097			1					2	3	2	N/U	Y	N	J; SA	N	0	-
HDRVAMn098			8						8	1	Y/F	N	N	J	N	0	-
HDRVAMn099			6						6	1	Y/F	Y	N	J	N	0	-
HDRVAMn100			1[a]	-					1	1	N/U	N	N	J	N	0	-
HDRVAMn101			1						1	1	Y/M	Y	N	J	N	0	-
HDRVAMn102			7						7	1	Y/M	Y	N	J	N	0	-
HDRVAMn103			4						4	1	N/U	N	N	J	N	0	-
HDRVAMn104			4						4	1	Y/F	Y	N	J	N	0	-
HDRVAMn105			3						3	1	Y/F	Y	N	J	N	0	-
HDRVAMn106			3						3	1	N/U	N	N	J	P	0	-
HDRVAMn107			2						2	1	N/U	N	N	J	N	0	-
HDRVAMn108			2						2	1	N/U	N	N	J	N	0	-
HDRVAMn109			3						3	1	Y/M	N	N	J	N	0	-
HDRVAMn110			2						2	1	N/U	N	N	J	N	0	-
HDRVAMn111			1						1	1	Y/F	N	N	SA/A	N	0	-
HDRVAMn112			1						1	1	Y/M	N	N	J	P	0	-
HDRVAMn113				1					1	1	N/U	N	N	J	N	0	-
HDRVAMn114				2					2	1	N/U	N	N	J	N	0	-
HDRVAMn115				2					2	1	N/U	N	N	J	N	0	-
HDRVAMn116				1					1	1	N/U	N	N	J	N	0	-
HDRVAMn117				1					1	1	N/U	N	N	J	N	0	-

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Humpback Whales (continued):																	
HDRVAMn118				1					1	1	N/U	N	N	J	N	0	-
HDRVAMn119				2					2	1	N/U	N	N	J	N	0	-
HDRVAMn120				1					1	1	Y/M	Y	N	J	N	0	-
HDRVAMn121				1					1	1	N/U	N	N	J	N	0	-
HDRVAMn122				3					3	1	Y/M	N	N	J	N	0	-
HDRVAMn123				1					1	1	N/U	N	N	J	N	0	-
HDRVAMn124				1					1	1	N/U	N	N	J	N	0	-
HDRVAMn125				2					2	1	N/U	N	N	J	Y	0	-
HDRVAMn126				1[b]					1	1	Y/M	Y	N	SA/A	N	0	-
HDRVAMn127				1[b]					1	1	N/U	N	N	J	N	0	-
HDRVAMn128				1[b]					1	1	N/U	N	N	A	N	0	-
HDRVAMn129				1[b]					1	1	N/U	N	N	A	N	0	-
HDRVAMn130				1[b]					1	1	N/U	N	N	J/SA	N	0	-
HDRVAMn131				1[b]					1	1	N/U	N	N	U	N	0	-
HDRVAMn132					1		1	2	4	3	Y/F	Y	N	J; SA/A	N	0	-
HDRVAMn133					1[b]				1	1	N/U	N	N	J	N	0	-
HDRVAMn134					1[b]			2	3	2	N/U	N	N	J; SA/A	N	0	-
HDRVAMn135					2				2	1	N/U	N	N	J	N	0	-
HDRVAMn136					1				1	1	N/U	Y	N	J	N	0	-
HDRVAMn137					2				2	1	N/U	N	N	J	N	0	-
HDRVAMn138					1				1	1	N/U	N	N	J	N	0	-
HDRVAMn139					1				1	1	N/U	N	N	J	N	0	-
HDRVAMn140					1				1	1	N/U	N	N	U	N	0	-
HDRVAMn142					4				4	1	N/U	N	N	J	N	0	-
HDRVAMn143					2				2	1	N/U	N	N	J/SA	N	0	-

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Humpback Whales (continued):																	
HDRVAMn144					1				1	1	N/U	N	N	J	N	0	-
HDRVAMn145					2				2	1	N/U	N	N	J	N	0	-
HDRVAMn146					1[b]				1	1	Y/M	Y	N	J	N	0	-
HDRVAMn147					1				1	1	N/U	N	N	J	Y	0	-
HDRVAMn148					3				3	1	N/U	N	N	J	N	0	-
HDRVAMn149					4				4	1	N/U	N	N	SA/A	N	0	-
HDRVAMn150					1				1	1	N/U	N	N	SA/A	N	0	-
HDRVAMn151					2[a]	-			2	1	Y/F	Y	N	J	N	0	-
HDRVAMn152					3				3	1	Y/M	Y	N	J	N	0	-
HDRVAMn153					2				2	1	Y/F	Y	N	J	N	0	-
HDRVAMn154					1				1	1	Y/F	Y	N	J	N	0	-
HDRVAMn155				1[b]					1	1	N/U	N	N	J	N	0	-
HDRVAMn156					2				2	1	Y/F	N	N	SA/A	N	0	-
HDRVAMn157					1				1	1	N/U	N	N	SA/A	N	0	-
HDRVAMn158					1				1	1	N/U	N	N	J	N	0	-
HDRVAMn159					1				1	1	N/U	N	N	J	N	0	-
HDRVAMn160					1				1	1	N/U	N	N	A	N	0	-
HDRVAMn161					1				1	1	N/U	N	N	J	N	0	-
HDRVAMn162					1				1	1	N/U	Y	N	J	N	0	-
HDRVAMn163					2			2	4	2	Y/F	Y (2)	N	J	N	0	-
HDRVAMn164					1				1	1	N/U	N	N	J	N	0	-
HDRVAMn165					1				1	1	N/U	N	N	J	N	0	-
HDRVAMn166						3			3	1	Y/U	Y	N	J	N	0	-
HDRVAMn167						1			1	1	N/U	N	N	J	Y	0	-
HDRVAMn168						1			1	1	N/U	N	N	SA/A	N	0	-

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Humpback Whales (continued):																	
HDRVAMn169						1			1	1	N/U	N	N	J	N	0	-
HDRVAMn170						2			2	1	N/U	N	N	SA/A	N	0	-
HDRVAMn171						1		1	2	2	N/U	N	N	J	N	0	-
HDRVAMn172						3	1	1	5	3	Y/U	Y (2)	N	SA/A; A	N	0	-
HDRVAMn173						4			4	1	Y/U	Y	N	J	N	0	-
HDRVAMn174						3	3		6	2	N/U	Y	N	J	Y	0	-
HDRVAMn175						1		1	2	2	Y/U	Y	N	J	N	0	-
HDRVAMn176						1			1	1	N/U	N	N	J	N	0	-
HDRVAMn177						4			4	1	N/U	Y	N	J	N	0	-
HDRVAMn178						1			1	1	N/U	N	N	J	N	0	-
HDRVAMn179						1	1		2	2	N/U	N	N	J	Y	0	-
HDRVAMn180						1			1	1	N/U	N	N	J	N	0	-
HDRVAMn181						1		1	2	2	N/U	N	N	J; SA/A	N	0	-
HDRVAMn182						2			2	1	Y/U	N	N	SA	N	0	-
HDRVAMn183						1			1	1	N/U	N	N	SA	N	0	-
HDRVAMn184						4			4	1	Y/U	Y	N	J	N	0	-
HDRVAMn185						1			1	1	N/U	N	N	SA	N	0	-
HDRVAMn186						2		1	3	2	Y/U	Y	N	SA	N	0	-
HDRVAMn187						2			2	1	N/U	Y	N	SA	N	0	-
HDRVAMn188						1			1	1	N/U	N	N	SA	N	0	-
HDRVAMn189						1			1	1	N/U	N	N	J	N	0	-
HDRVAMn190							1		1	1	Y/U	N	Y	J	N	1	313
HDRVAMn191							1		1	1	N/U	N	N	J	N	0	-
HDRVAMn192							1		1	1	N/U	N	N	SA/A	N	0	-

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Humpback Whales (continued):																	
HDRVAMn193							2		2	1	Y/U	Y	N	J	N	0	-
HDRVAMn194							1		1	1	N/U	N	N	J	N	0	-
HDRVAMn195							1		1	1	N/U	N	N	J	N	0	-
HDRVAMn196							1		1	1	Y/U	Y	N	SA/A	N	0	-
HDRVAMn197							2		2	1	N/U	N	N	SA/A	N	0	-
HDRVAMn198							1	3	4	4	N/U	N	N	A	N	0	-
HDRVAMn199							1		1	1	N/U	N	N	J	N	0	-
HDRVAMn200							2		2	1	N/U	N	N	SA/A	N	0	-
HDRVAMn201							1		1	1	N/U	N	N	SA/A	N	0	-
HDRVAMn202							1		1	1	Y/U	Y	N	SA/A	N	0	-
HDRVAMn203							1	1	2	2	N/U	N	N	SA/A	N	0	-
HDRVAMn204							2		2	1	Y/U	Y	N	J	N	0	-
HDRVAMn205							2		2	1	N/U	N	N	J	N	0	-
HDRVAMn206							1	1	2	2	N/U	N	N	J	N	0	-
HDRVAMn207							1		1	1	N/U	N	N	J	N	0	-
HDRVAMn208							1		1	1	N/U	N	Y	J	N	1	
HDRVAMn209							1		1	1	N/U	N	N	A	N	0	-
HDRVAMn210							1[b]		1	1	N/U	N	N	A	N	0	-
HDRVAMn211							1[b]	1	2	2	N/U	N	N	J; A	N	0	-
HDRVAMn212							1[b]		1	1	N/U	N	N	J	N	0	-
HDRVAMn213							1[b]		1	1	N/F	N	N	A	N	0	-
HDRVAMn214							1[b]		1	1	N/U	N	N	C	N	0	-
HDRVAMn215								1	1	1	N/U	N	N	SA/A	N	0	-

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Humpback Whales (continued):																	
HDRVAMn216								1	1	1	N/U	N	N	J	N	0	-
HDRVAMn217								1 [b]	1	1	N/U	N	N	SA/A	N	0	-
HDRVAMn218								2	2	1	N/U	N	N	SA/A	N	0	-
HDRVAMn219								1	1	1	Y/U	Y	Y	SA/A	N	1	307
HDRVAMn220								1	1	1	N/U	N	N	SA/A	Y	0	-
HDRVAMn221								1	1	1	N/U	N	N	SA/A	Y	0	-
HDRVAMn222								1	1	1	N/U	N	N	SA/A	Y	0	-
HDRVAMn223								2	2	1	Y/U	Y	N	SA/A	N	0	-
HDRVAMn224								1	1	1	N/U	N	N	J	N	0	-
HDRVAMn225								1	1	1	Y/U	Y	N	SA/A	N	0	-
HDRVAMn226								1	1	1	N/F	N	N	A	N	0	-
HDRVAMn227								1	1	1	N/U	N	N	C	N	0	-
HDRVAMn228								1	1	1	N/U	N	N	A	N	0	-
HDRVAMn229								1	1	1	N/U	N	N	SA/A	N	0	-
HDRVAMn230								2	2	1	N/U	N	N	SA/A	N	0	-
HDRVAMn231								2	2	1	N/U	N	N	SA/A	N	0	-
HDRVAMn232								2	2	1	N/U	N	N	SA/A	N	0	-
HDRVAMn233								1	1	1	Y/U	Y	N	SA/A	N	0	-
HDRVAMn234								2	2	1	N/U	N	N	J	Y	0	-
HDRVAMn235								1	1	1	N/U	N	N	A	N	0	-
HDRVAMn236								1	1	1	N/U	N	N	J	N	0	-
HDRVAMn237								1	1	1	N/U	N	N	SA/A	N	0	-
HDRVAMn238								1	1	1	N/U	N	N	SA/A	N	0	-

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Humpback Whales (continued):																	
HDRVAMn240								1[b]	1	1	N/U	N	N	A	N	0	-
HDRVAMn241								1[b]	1	1	N/U	N	N	J	N	0	-
HDRVAMn242								1[b]	1	1	N/U	N	N	J	Y	0	-
HDRVAMn243								1	1	1	N/U	Y	N	SA	N	0	-
HDRVAMn244								2	2	1	N/U	N	N	SA/A	N	0	-
HDRVAMn245								2	2	1	N/U	N	N	J	N	0	-
HDRVAMn246								4	4	1	Y/U	Y	N	J	N	0	-
HDRVAMn247								3	3	1	N/U	N	N	J	N	0	-
HDRVAMn248								4	4	1	N/U	N	N	J	N	0	-
HDRVAMn249								1	1	1	N/U	N	N	J	N	0	-
HDRVAMn250								1	1	1	N/U	N	N	SA/A	N	0	-
HDRVAMn251								1	1	1	Y/U	Y	N	J	N	0	-
HDRVAMn252								1	1	1	N/U	N	N	J	N	0	-
HDRVAMn253								1	1	1	N/U	N	N	A	N	0	-
Total	**66**	**91**	**168**	**38**	**69**	**48**	**38**				**69**	**60 / 7**	**2**		**20**	**32**	**2571**
Fin Whales:																	
HDRVABp001	1								1	1	N/U	N	N	A	N	1	61
HDRVABp002	1								1	1	N/U	N	N	C	N	0	-
HDRVABp003	1								1	1	N/U	N	N	A	N	0	-
HDRVABp009		2							2	1	N/U	N	N	SA/A	N	0	-
HDRVABp010		2					1	2	5	3	N/U	N	N	SA/A	N	0	-
HDRVABp011		1							1	1	N/U	N	N	A	N	0	-
HDRVABp016			1[b]	1					2	2	N/U	Y	N	SA	N	0	-

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Fin Whales (continued):																	
HDRVABp020			1[b]	1				1	3	3	N/U	Y	N	SA	N	0	-
HDRVABp027							1	1	3	2	Y/M	Y	N	SA/A	N	0	-
HDRVABp030			1[b]	1[b]			1		3	3	N/U	Y	N	SA/A	P	0	-
HDRVABp035				1[a]	-	-			1	1	N/U	N	N	SA	N	0	-
HDRVABp037				1					1	1	N/U	N	N	SA	N	0	-
HDRVABp038				1					1	1	N/U	N	N	SA	N	0	-
HDRVABp040				1					1	1	N/U	N	N	SA	N	0	-
HDRVABp041				1					1	1	N/U	Y	N	SA	N	0	-
HDRVABp042				1					1	1	N/U	N	N	SA	N	0	-
HDRVABp060						1			1	1	Y/U	Y	N	SA/A	N	0	-
HDRVABp092							1	2	3	2	N/U	N	N	SA/A	N	0	-
HDRVABp093							1		1	1	N/U	N	N	SA/A	N	0	-
HDRVABp094							1		1	1	N/U	N	N	SA/A	N	0	-
HDRVABp095							1		1	1	N/U	N	N	SA/A	N	0	-
HDRVABp096							1		1	1	N/U	N	N	SA/A	N	0	-
HDRVABp097							1	1	2	2	N/U	Y	N	J	N	0	-
HDRVABp098							1		1	1	N/U	N	N	J	N	0	-
HDRVABp099							1		1	1	N/U	N	N	J	N	0	-
HDRVABp104							1	1	1	1	N/U	N	N	SA/A	N	0	-
HDRVABp106							1	1	1	1	N/U	N	N	J	N	0	-
Total	**3**	**5**	**3[b]**	**7**	**0**	**1**	**11**				**0**	**7**	**0**		**1**	**1**	**61**

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Minke Whales:																	
HDRVABa003			1						1	1	N/U	N	N	A	N	0	-
HDRVABa004			1						1	1	N/U	N	N	A	N	0	-
HDRVABa009					1				1	1	N/U	N	N	A	N	0	-
HDRVABa010					1				1	1	N/U	N	N	A	N	0	-
HDRVABa011					1				1	1	N/U	N	N	A	N	0	-
HDRVABa012					1				1	1	N/U	N	N	A	N	0	-
HDRVABa013						1			1	1	N/U	N	N	A	N	0	-
Total		**0**	**2**	**0**	**4**	**2**	**0**				**0**	**0**	**0**		**0**	**0**	**0**
North Atlantic Whales:																	
3360/'Horton'				1[b]			1		2	1	N/F	N	N	A	N	0	-
3821/'ZigZag'							2		2	1	N/M	N	N	A	N	0	-
2142/'Rhino'							1		1	1	N/M	N	N	A	N	0	-
4523/"Beaker"							1		1	1	N/M	N	N	A	N	0	-
2020Calfof2642 (now #5042)							1		1	1	N/U	Y	Y	Ye	Y	1	
2020Calfof1612 (now #5012)							2		2	1	N/U	Y	Y	Ye	Y	1	-
1245/'Slalom'								1	1	1	N/F	N	N	A	N	0	-
2021Calfof1245								1	1	1	N/U	N	N	C	N	0	-
2021CalfOf3232								1	1	1	N/U	Y	N	Ye	N	0	-
4180/"Dyad"								1	1	1	N/F	N	N	A	N	0	-
2022Calfof4180								1	1	1	N/U	N	N	C	N	0	-
Total		**0**	**0**	**1**	**0**	**0**	**6**				**0**	**2**	**2**		**0**	**0**	

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