Mid-Atlantic Humpback Whale Monitoring, Virginia Beach, Virginia: 2019/20 Annual Progress Report

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Cover Photo Credit:

A pair of humpback whales (*Megaptera novaeangliae*) surface off the coast of Virginia Beach, Virginia. Cover photograph 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
cm	centimeter(s)
CTD	conductivity, temperature, and depth
DTAG	Digital Acoustic Recording Tag
GPS	Global Positioning System
km	kilometer(s)
LIMPET	Low Impact Minimally Percutaneous External-electronics Transmitter
m	meter(s)
MAHWC	Mid-Atlantic Humpback Whale Catalog
MINEX	Mine Neutralization Exercise
NAHWC	North Atlantic Humpback Whale Catalog
NAVFAC	Naval Facilities Engineering Command
OPAREA	Operating Area
photo-ID	photo-identification
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

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1. Introduction and Background

During winter months, humpback whales (*Megaptera novaeangliae*) of the West Indies distinct population segment (Bettridge et al. 2015) migrate from six northern feeding grounds in the Gulf of Maine, the Gulf of St. Lawrence, Newfoundland/Labrador, western Greenland, Iceland, and Norway to Caribbean Sea waters (Katona and Beard 1990, Christensen et al. 1992, Palsbøll et al. 1997). An unknown portion of the population does not migrate to Caribbean waters but rather uses the Mid-Atlantic region to over-winter (Swingle et al. 1993, Barco et al. 2002). Norfolk, Virginia, is home to the world's largest U.S. Navy installation, Naval Station Norfolk, and it is also ranked the sixth busiest container port in the United States. These factors, combined with the presence of recreational and fishing vessels, result in a constant and often heavy flow of vessel traffic through the mouth of the Chesapeake Bay and adjacent areas. Understanding the occurrence and behavior of humpback whales in this region is important in mitigating potentially harmful impacts on the species.

Until recent years, humpback whale sighting information off the Virginia Beach area had been collected via sporadic and varied field efforts. Shore-based counts in 1991, vessel-based photo-identification (photo-ID) efforts in 1992 (Swingle et al. 1993), and further cataloging efforts using photographs taken on whale-watching excursions and from stranded whales (Wiley et al. 1995, Barco et al. 2002) have been the primary data sources. These studies have shown that some individuals return in subsequent years, and the area may act as a supplemental winter feeding ground for the returning whales (Barco et al. 2002). Photographs of whales sighted off the coast of Virginia have been matched to cataloged whales from the Gulf of Maine, Newfoundland, and the Gulf of St. Lawrence regions (Barco et al. 2002, Aschettino et al. 2018, Mallette and Barco 2019). Until recently, information on the movements of individuals within this region has been limited. Results from the first three years of this study were recently published (Aschettino et al. 2020a) and have highlighted that humpback whales in this region spend a significant portion of their time in high-traffic areas, including the shipping lanes at the mouth of the Chesapeake Bay. This growing body of data is important to assess the potential for disturbance to humpback whales found in U.S. Navy training ranges and high-traffic areas in the Chesapeake Bay and mid-Atlantic coastal waters.

The objective of this multi-year project under the U.S. Navy's Marine Species Monitoring Program has been to establish baseline information on occurrence and behavior of humpback whales near Naval Station Norfolk and within the Virginia Capes (VACAPES) Operating Area (OPAREA) by addressing the following questions.

- *What age classes (juveniles, sub-adults, adults) are utilizing the waters within and adjacent to the mouth of the Chesapeake Bay?*
- *Do humpback whales exhibit site fidelity over periods of days to years?*
- *Do humpback whales congregate in specific high-traffic and/or high-use U.S. Navy training areas?*
- *Do humpback whales spend significant time within or move through areas of U.S. Navy live-fire and mine neutralization exercise (MINEX) training?*

Primary objectives of this project have included the following.

- *Collect baseline occurrence data (location, sex, group size, and behavior) of humpback whales (and other species of baleen whales opportunistically).*
- *Obtain identification photographs of humpback whales for inclusion in regional and local catalogs.*
- *Collect biopsy samples of humpback whales for sex determination, mitochondrial control region sequencing and microsatellite genotyping of tissue samples, and stable isotope analysis to assess foraging related to prey consumption.*
- *Conduct satellite tagging to document seasonal humpback whale movement patterns in the nearshore waters off Virginia Beach, specifically whether the whales spend significant time in areas of high shipping traffic and/or areas of U.S. Navy training exercises.*

Since this project's inception, there have been six dedicated field seasons to address the above objectives. 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. The first season of dedicated surveys began in January 2015 and was completed in May 2015 (see Aschettino et al. 2015). Additional humpback whale sighting information from coastal line-transect surveys for bottlenose dolphins conducted from 2012-2015 (see Engelhaupt et al. 2016) was also incorporated into these analyses, and the first humpback whale sightings from those surveys occurred in December 2014. Therefore, the first field season, encompassing sightings from both the dedicated humpback whale surveys and the bottlenose dolphin surveys, is herein referred to as the 2014/15 field season. During the 2014/15 field season, the primary objectives were to collect baseline information from individual humpback whales (or other species of baleen whales) using photo-ID, focal follow, and biopsy sampling methods.

The second season of dedicated humpback whale surveys began in December 2015 (bottlenose dolphin density surveys were no longer being conducted because of the project's completion in August 2015) and surveys were completed in May 2016 (2015/16 field season; see Aschettino et al. 2016). The objectives for the 2015/16 also were to collect baseline information using photo-ID and biopsy sampling methods; however, less effort was spent on focal follows due to implementing a satellite-tagging component. Nine satellite tags were deployed, and 11 biopsy samples were collected during the 2015/16 season.

The third season of dedicated humpback whale surveys began in November 2016 and continued through March 2017 (2016/17 field season; see Aschettino et al. 2017). Objectives for the 2016/17 field season matched those of the 2015/16 field season—collect baseline information through photo-ID, biopsy sampling, and satellite tagging techniques. Twenty-six satellite tags were deployed, and 29 biopsy samples were collected during the 2016/17 season.

The fourth season of dedicated humpback whale surveys began in October 2017 and continued through March 2018 (2017/18 field season; see Aschettino et al. 2018). Objectives for the 2017/18 field season matched those of the previous two field seasons; however, an additional focus was placed on increased survey effort in the W-50 MINEX region and farther offshore.

Nine satellite tags (six on humpback whales and three on fin whales [*Balaenoptera physalus*]) were deployed and three biopsy samples were collected during the 2017/18 season.

The fifth field season began on 12 November 2018 and the last dedicated survey was conducted on 20 May 2019 (see Aschettino et al. 2019, 2020b) aside from one out-of-season survey conducted on 31 July 2018. This atypical survey was conducted based on reports of multiple humpback whales in the area over several days. The objectives for the 2018/19 field season were similar to previous years, with a continued focus to increase survey effort in the W-50 MINEX region and farther offshore; however, a new component was initiated in collaboration with researchers from Duke University to begin assessing behavioral response of individuals to large vessels in the area of the shipping channels (see Shearer et al. 2020).

The sixth field season began on 21 December 2019 and concluded on 27 March 2020. The objectives for the 2019/20 field season included goals from the previous years, with a focus on supporting the multi-tagging collaboration with Duke researchers via the deployment of Global Positioning System (GPS)-linked Argos satellite tags. Additionally, the use of a small Unmanned Aerial System (sUAS), or drone, was incorporated to assist with better determining estimated lengths of humpback whales.

Fifteen surveys were completed during the 2019/20 field season. There were 47 baleen whale sightings including 44 of humpback whales comprised of 60 individuals, 2 sightings of minke whales (*Balaenoptera acutorostrata*) comprised of 2 individuals, and 1 fin whale sighting of a single individual. Ten satellite tags were deployed - nine SPLASH10-F tags were deployed on humpback whales and one SPLASH10 tag was deployed on a fin whale. Seven biopsy samples were collected from humpback whales and one biopsy sample was collected from a fin whale.

2. Methods

The study area for this project includes waters in and around the mouth of the Chesapeake Bay as well as the W-50 MINEX region off Virginia Beach (**Figure 1**). Two primary areas of interest in this study 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 in the mouth of the Chesapeake Bay (**Figure 1**); however, as tag locations showed movements out of the defined area but within shipping channels, the area was extended using multiple nautical charts and datasets, including 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) as guidelines. The U.S. Navy training areas includes portions of the W-50 MINEX range.

Local availability of researchers allowed survey effort to be flexible and take advantage of limited winter weather windows in order to maximize the ability to achieve project objectives. Optimal weather conditions included 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 nautical mile 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 that 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 was an 8.8-meter (m) fiberglass hybrid-foam-collar boat *Whale Research* (**Figure 2**), owned and operated by HDR. Surveys using this vessel departed from Long Bay Pointe Marina, located in Lynnhaven Inlet, Virginia Beach. Due to required boat repairs during the 2019/20 season, a 16-m fishing vessel, *Top Notch*, was also utilized. Surveys using this vessel departed from the Virginia Beach Fishing Center, located on Rudee Inlet.

The crew typically consisted of four qualified marine mammal scientists with one also serving as the vessel operator. Once departed from the inlet, the vessel would transit to areas where humpback whales were previously seen or reported. If no whales were located in 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 in the survey area (i.e., bottlenose dolphins [*Tursiops truncatus*]) were not always recorded and are not presented in this report.

2.1 Photo-ID and Photogrammetry

Photographs of humpback, fin and minke whales were collected using a digital SLR camera (Canon 7D, 7D Mark II, or 1DX Mark II) with a zoom lens (Canon 100- to 400-millimeter). Photos 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 where each new whale was assigned an ID number using the naming mechanism "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 or HDRVABa001) and compared with one another. 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 shared with Duke University as well as researchers from the Center for Coastal Studies in Provincetown, Massachusetts. Images of humpback whales from all subsequent seasons were submitted to the MAHWC (see Mallette and Barco 2019) and also compared with images from a local whale watch operation, Rudee Tours.

During the 2018/19 season, the use of a sUAS was incorporated into the field effort. A DJI Phantom 4 Pro V2.0 was used to collect morphometric data and to 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 UHD video at 30 frames per second. Initial measurements were made from data using altitude values from the drone's stock barometer, and some error is expected with this method. HDR used open-source software developed by researchers at Duke University (Torres and Bierlich 2020) to calculate lengths.

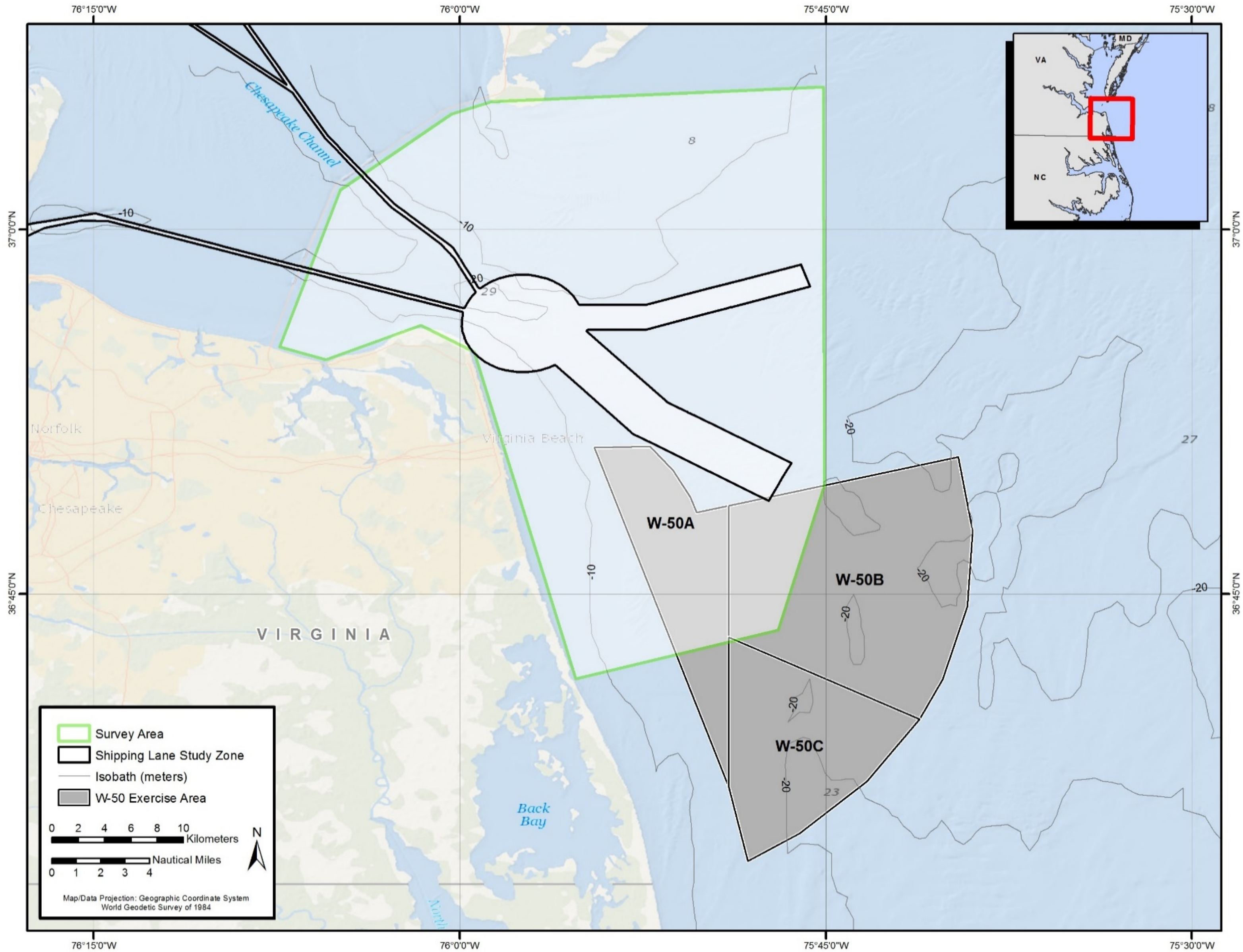

Figure 1. Map of the primary study area, as outlined by the green boundary, which includes waters in and around the mouth of the Chesapeake Bay as well as the W-50 MINEX region off Virginia Beach.

Figure 2. Nearshore survey vessel, *Whale Research.* Photo © Brian Lockwood.

2.2 Biopsy Sampling

Biopsy samples were collected, when possible, from whales of interest using either a crossbow or biopsy rifle. In the first, Finn Larsen designed crossbow bolts outfitted with 25-millimeter, ethanol sterilized, stainless steel tips, 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 × 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 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. Additional gender analyses were performed; however, matching to the larger archive of over 9,000 North Atlantic humpback samples will not be completed until the spring of 2021.

2.3 Satellite Tagging

Satellite-tagging has been a primary component of the project since the 2015/16 field season, initially using location-only 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). Both SPOT6 and SPLASH10-F Fastloc® GPS tags with location and dive capabilities were available for use during the 2019/20 field season. The SPLASH10-F tags were intended to be deployed during windows of opportunity during which researchers from Duke University might also be in the area and could potentially ‘double-tag’ whales using Digital Acoustic Recording Tags (DTAGs) (see Shearer et al. 2020). Tags were remotely deployed using a DAN-INJECT JM25 pneumatic projector (www.dan-inject.com). Two 6.8-centimeter surgical-grade titanium darts with six backwards-facing petals were used to attach tags to the dorsal fin or just below the dorsal fin (**Figure 3**). Given existing information on 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 in 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 limited to 800–1,200 transmissions per day for SPLASH10-F tags. In order to constitute a "dive" for the Wildlife Computers generated behavior and time-series data outputs of the SPLASH10-F tags, a 2-m and 120-second dive definition was established for humpback whales in which a dive needed to be both deeper than 2 m and longer than 120 seconds in order 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., those on land) were manually removed using tools provided within Movebank (www.movebank.og). Biopsy samples were collected from most tagged whales using the same protocol described previously and conductivity, temperature, and depth (CTD) casts were typically taken following a tag deployment.

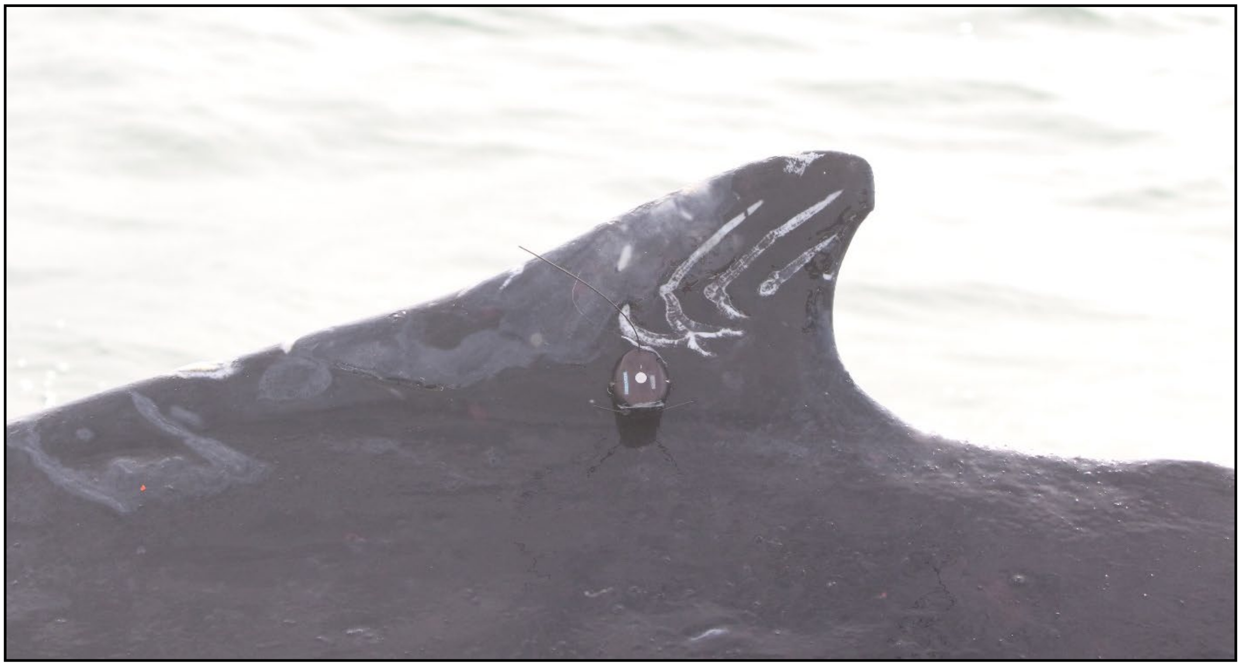

Figure 3. LIMPET SPLASH10-F tag on a humpback whale immediately after deployment.

3. Results

3.1 Nearshore Surveys: 2019/20 Field Season

Survey efforts typically begin once humpbacks sightings are reported by the local whale watch operations and other mariners. For the 2019/20 season, this first survey took place on 21 December 2019 following reports of a humpback whale seen in the area the day prior. In total, HDR conducted 15 nearshore surveys for humpback whales between 21 December 2019 and 27 March 2020, covering 1,382 kilometers (km) of trackline with nearly 100 hours of effort (**Table 1**). During these 15 surveys, there were 44 sightings of humpback whales totaling 60 individuals, two minke whale sightings totaling two individuals, and one sighting of a single fin whale (**Table 1, Figure 4, and Table A-1**). Of the 47 total large whale sightings during the 2019/20 field season, 30 (63.8 percent) occurred in the shipping lanes, although HDR's survey effort for the 2019/20 season focused largely on this area because of the multi-tagging collaboration effort with Duke University.

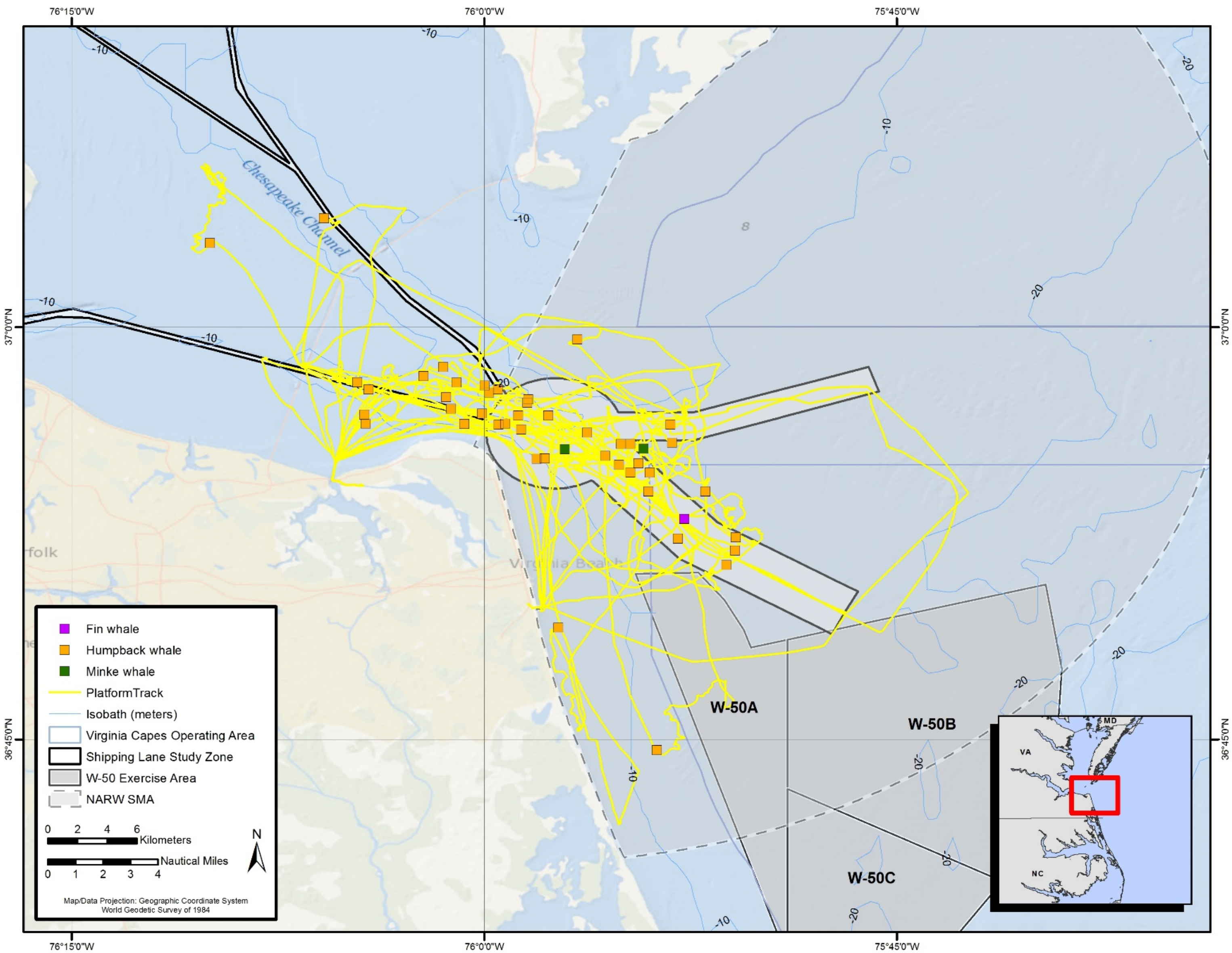

Figure 4. Survey tracks and sighting locations of all humpback (*n*=44), minke (*n*=2), and fin (*n*=1) whales for the 2019/20 field season.

Table 1. Summary of nearshore survey efforts off Virginia Beach, Virginia for the 2019/20 field season.

Date	Survey Time (min)	Distance surveyed (km)	# Sightings Mn	# Individual Mn	# Sightings Ba	# Individual Ba	# Sightings Bp	# Individual Bp
21-Dec-19	223	68	1	1	0	0	0	0
28-Dec-19	428	83	2	3	1	1	0	0
2-Jan-20	445	94	3	3	0	0	0	0
15-Jan-20	564	115	4	6	0	0	0	0
31-Jan-20	303	86	1	1	0	0	0	0
3-Feb-20	502	123	5	5	0	0	0	0
8-Feb-20	374	82	3	3	1	1	1	1
15-Feb-20	408	81	8	18	0	0	0	0
18-Feb-20	500	128	2	2	0	0	0	0
23-Feb-20	424	117	1	1	0	0	0	0
26-Feb-20	362	67	1	1	0	0	0	0
1-Mar-20	433	60	6	8	0	0	0	0
4-Mar-20	391	103	2	3	0	0	0	0
11-Mar-20	459	129	4	4	0	0	0	0
27-Mar-20	148	46	1	1	0	0	0	0
Total	**5,964**	**1,382**	**44**	**60**	**2**	**2**	**1**	**1**

Key: min = minute(s); km = kilometer(s); Mn = *Megaptera novaeangliae*; Ba = *Balaenoptera acutorostrata*; Bp = *Balaenoptera physalus*

3.2 Photo-ID and Photogrammetry Results

The 44 sightings of 60 total individual humpback whales resulted in 28 unique identified humpback whales (**Table A-1, Figure 5**). Fifteen (53.6 percent) of those unique whales were categorized as juveniles based on their estimated size and the remaining 13 (46.4 percent) were categorized as sub-adults or adults. Only four (14.3 percent) of the 28 individuals were re-sights to HDR's catalog; three individuals had been seen in four of the last five seasons (HDRVAMn007, HDRVAMn021, and HDRVAMn064) and one individual had been seen in three of the last five seasons (HDRVAMn093) (**Table A-1**). The remaining 24 whales were new individuals added to HDR's growing catalog, which to date, has 182 unique humpback whales (inclusive of identifications added from the Outer Continental Shelf Break Cetacean Study) (Engelhaupt et al. 2020) (**Figure 5**). Twelve of the 28 (42.9 percent) humpback whales were seen on more than one occasion during the 2019/20 field season, which is similar to the previous season (44.7 percent), greater than the 2017/18 season (21.9 percent), and fewer than the 2016/17 season (69.5 percent).

Evidence of human interaction, either via presumed line entanglement scars or propeller scars, is apparent on at least 18 of the 182 (9.9 percent) humpback whales in HDR's catalog (**Table A-1**).

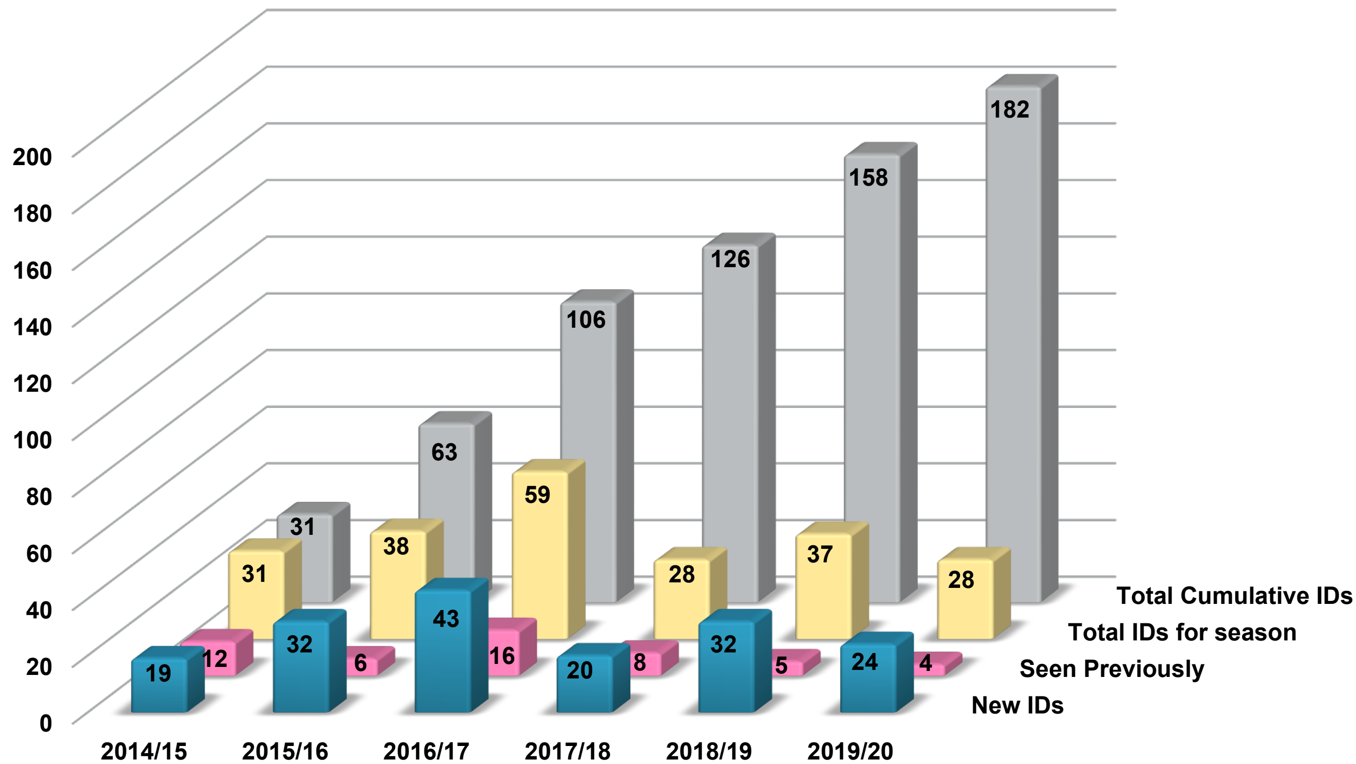

Figure 5. Humpback whale identifications over six seasons with the yellow bars indicating the total number of IDs for the season, red bars indicating the number of those IDs that were seen in previous seasons, and blue bars indicating the number of new IDs added to the catalog. Gray bars indicate the total number of cumulative unique IDs.

Drone video was collected on numerous humpback whales and the lengths of 30 individuals were calculated (**Table 2**). Each of these whales has a unique ID in the HDR humpback catalog and had previously been assigned an age-class based on subjective size assessments from the research vessel platform. The length of the research vessel was often used 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. From the calculations of the sUAS footage, the measured humpbacks ranged in size from 6.9 to 10.1 m in total length, with a mean value of 8.5 m and a median length of 8.6 m. All whales that measured 9.8 m or greater (n=6) had been classified as sub-adults or adults in the field. All but one of the whales that measured 8.7 m or less (n=17) had been classified as juveniles in the field. Whales that ranged from 8.8 to 9.6 m (n=7) were classified as either juvenile (n=2), juvenile/sub-adult (n=1), sub-adult (n=3), or sub-adult/adult (n=1) 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.

Table 2. Overall lengths of all humpback whales measured using drone photogrammetry.

Humpback Whale ID	Overall Length based on photogrammetry (m)	Total Number of Measurements Used	Total Unique Measurement Days	Age-class Assigned Based on Initial Visual Assessment
HDRVAMn166	6.9	6	1	Juvenile
HDRVAMn163	7.0	3	1	Juvenile
HDRVAMn152	7.1	7	2	Juvenile
HDRVAMn165	7.1	8	1	Juvenile
HDRVAMn189	7.5	5	1	Juvenile
HDRVAMn154	7.5	3	1	Juvenile
HDRVAMn175	7.6	2	1	Juvenile
HDRVAMn183	7.7	3	1	Sub-adult
HDRVAMn177	7.8	14	3	Juvenile
HDRVAMn178	7.8	1	1	Juvenile
HDRVAMn164	8.0	7	1	Juvenile
HDRVAMn093	8.2	4	1	Juvenile
HDRVAMn187	8.4	10	2	Juvenile
HDRVAMn151	8.4	2	1	Juvenile
HDRVAMn173	8.5	7	3	Juvenile
HDRVAMn147	8.7	5	1	Juvenile
HDRVAMn184	8.7	7	1	Juvenile
HDRVAMn186	8.8	12	3	Sub-adult
HDRVAMn140	8.8	1	1	Sub-adult
HDRVAMn142	8.8	2	1	Juvenile/Sub-adult*
HDRVAMn170	8.9	4	1	Sub-adult or adult
HDRVAMn174	9.1	3	1	Juvenile
HDRVAMn185	9.3	1	1	Sub-adult
HDRVAMn153	9.6	5	1	Juvenile
HDRVAMn172	9.8	9	3	Sub-adult or adult
HDRVAMn181	9.8	4	1	Sub-adult
HDRVAMn012	10.0	1	1	Sub-adult**
HDRVAMn021	10.0	4	2	Sub-adult**
HDRVAMn007	10.1	13	3	Sub-adult**
HDRVAMn149	10.1	2	1	Sub-adult or adult

* assessed as two different age classes within same season; **most recent assessment; assigned a different age class in previous years

3.3 Satellite Tagging Results

Nine SPLASH10-F satellite tags were deployed on humpback whales (**Figures 6 through 15**), as well as one SPLASH10 tag deployed on a fin whale, during the 2019/20 season. These tags transmitted between 2.7 and 39.9 days (mean=12.5 days) (**Table 3**) which is similar to the mean duration of all tags previously deployed during this project (12.8 days, *n*=51 tags). Tracklines from all tagged whales are available on Movebank (www.movebank.org) and the Animal Telemetry Network (https://atn.ioos.us/). One whale (HDRVAMn093) was also previously tagged during the 2016/17 and 2018/19 field season. Comparisons of the tag tracklines between seasons for the same individual show similarities in movements in and around the shipping channels and mouth of the Chesapeake Bay during 2016/17 and 2018/19 and no time spent in the shipping channels during the 2019/20 deployment. Movements from 2019/20 were within the W-50 MINEX and VACAPES OPAREA primarily (**Figure 16**). Whales tagged during this field season showed varied movement patterns, with some exclusively spending time in the primary study area and others moving out of the study area and farther offshore or to the north or south. Two individuals, HDRVAMn186 and HDRVAMn187 moved well into the Chesapeake Bay and in the case of HDRVAMn187, spent 24 days in this area moving as far as 72 km into the Bay during the nearly 40-day tag deployment (**Figure 14)**. The fin whale, HDRVABp086, was tagged just north of the W-50 MINEX region and spent some time in the primary study zone before working north and into the mouth of the Delaware Bay before looping offshore and back off the eastern shore of Virginia (**Figure 15**).

Distance traveled away from the initial tagging location ranged from 19 to 244 km (mean=87.2 km), the percentage of time spent within the shipping channel study area ranged from 0 to 44.9 percent (mean=18.4 percent), and time spent within the W-50 area ranged from 0 to 21.1 percent (mean=5.6 percent) (**Table 4**). For the humpback whales tagged with SPLASH10-F tags, over 11,000 dives were recorded (**Table 5**). Mean dive duration ranged from 02:25 to 03:43. Mean dive depth ranged from 12.6 to 16.3m with a maximum dive depth of 74 m by one individual (**Table 5**). For the fin whale tagged with a SPLASH10 tag, 960 dives were logged over 14.7 days. Mean dive depth was 9.2 m, maximum dive depth was 30 m. Mean dive duration was 03:54 and maximum dive duration was 12:54 (**Table 5**). Dives in 2018/19 (n=290) were shallower (mean=8.6 m) and shorter (mean=01:48) (see Aschettino et al. 2020b) than during 2019/20 where the mean depth of dives (n=230) was 12.6 m and mean duration was 03:43. These differences may be due to different foraging strategies in different areas or may be a product of a small dataset with short tag durations.

When zooming in on the primary study area at the mouth of the Chesapeake Bay using tag data collected from this field season, the importance of this area to humpbacks whales is still apparent (**Figure 16**), as in previous years. Approximately 18.4 percent (492/3,321) of all filtered tag locations from this season's deployments were inside shipping channels, 5.6 percent (95/3,321) of locations were inside the W-50 MINEX zone, and 34.3 percent (1,083/3,321) of locations were within the VACAPES OPAREA.

3.4 Biopsy Results

Seven humpback whale biopsy samples were collected during the 2019/20 field season (**Table A-1**). Thirty-one samples from the 2014/15 and 2015/16 field season, comprised of 29 humpback and two fin whale samples, were sent to Duke University for stable isotope and gender analysis at the end of the 2016/2017 field season. See Waples 2017 for a report of findings from these analyses. In 2020, 63 humpback and eight fin whale samples (including samples from the 29 humpbacks and two fin whales sent to Duke University) were sent to the University of Groningen in the Netherlands for processing and integration into a larger North Atlantic humpback whale population study. Gender results have been provided and have shown roughly equal sex ratios of humpback whales (32 ♂ and 31♀) and a skewed gender ratio of 6:1

males vs female fin whales (two fin whale samples had been collected from the same individual). Genetic matching to the larger North Atlantic humpback whale catalog will take place in early 2021 and results should be available by the summer of 2021.

Table 3. Summary of satellite tag deployment details for all baleen whales tagged during the 2019/20 season.

Animal ID	Estimated Age Class	Tag Type	Argos ID	Deployment (GMT)	Deployment Latitude (°N)	Deployment Longitude (°W)	Last Transmission (GMT)	Days Transmitted
HDRVAMn093	Juvenile	SPLASH10-F	173232	12/28/2019 15:50	36.7537	75.8826	12/31/2019 14:26	2.7
HDRVAMn166	Juvenile	SPLASH10-F	178208	12/28/2019 18:38	36.9357	75.9048	1/5/2020 02:59	7.6
HDRVAMn172	Sub-adult / Adult	SPLASH10-F	177052	1/15/2020 18:00	36.9238	75.9125	1/24/2020 02:22	8.4
HDRVAMn173	Juvenile	SPLASH10-F	177053	2/3/2020 13:59	36.9206	75.9502	2/13/2020 03:50	9.5
HDRVAMn175	Juvenile	SPLASH10-F	179197	2/3/2020 20:21	36.9555	75.9730	2/18/2020 14:52	14.8
HDRVAMn177	Juvenile	SPLASH10-F	180779	2/8/2020 19:01	36.9230	75.9054	2/19/2020 15:37	10.8
HDRVAMn184	Juvenile	SPLASH10-F	180778	2/18/2020 19:31	36.9196	75.8877	2/27/2020 16:12	8.7
HDRVAMn187	Juvenile	SPLASH10-F	180780	3/1/2020 21:34	36.9473	75.9992	3/12/2020 12:44	10.6
HDRVAMn186	Juvenile	SPLASH10-F	180781	3/4/2020 16:46	37.0908	76.1670	4/13/2020 13:47	39.9
HDRVABp086	Sub-adult / Adult	SPLASH10	177047	2/8/2020 11:58	36.8884	75.8539	2/23/2020 14:14	14.7

Table 4. Summary of results from satellite tag data for all baleen whales tagged during the 2019/20 season.

Animal ID	Argos ID	No. Locations Post Filtering	Percent Within Shipping Channels	Percent Within W-50	Percent Within VACAPES	Max Distance from Initial Location (km)	Mean Distance from Initial Location (km)
HDRVAMn093	173232	53	0.0	18.9	81.1	38.6	23.4
HDRVAMn166	178208	130	13.9	0.0	0.0	27.8	11.5
HDRVAMn172	177052	194	44.9	21.1	29.9	38.6	10.7
HDRVAMn173	177053	239	25.9	8.4	33.1	29.6	12.2
HDRVAMn175	179197	428	26.9	3.5	44.4	125.3	24.3
HDRVAMn177	180779	281	31.3	0.0	13.9	19.1	9.3
HDRVAMn184	180778	250	31.2	3.6	37.2	45.3	20.4
HDRVAMn187	180780	314	7.6	0.0	0.0	64.9	32.0
HDRVAMn186	180781	1128	1.6	0.0	32.3	244.1	62.1
HDRVABp086	177047	304	0.7	0.0	71.4	238.4	124.3

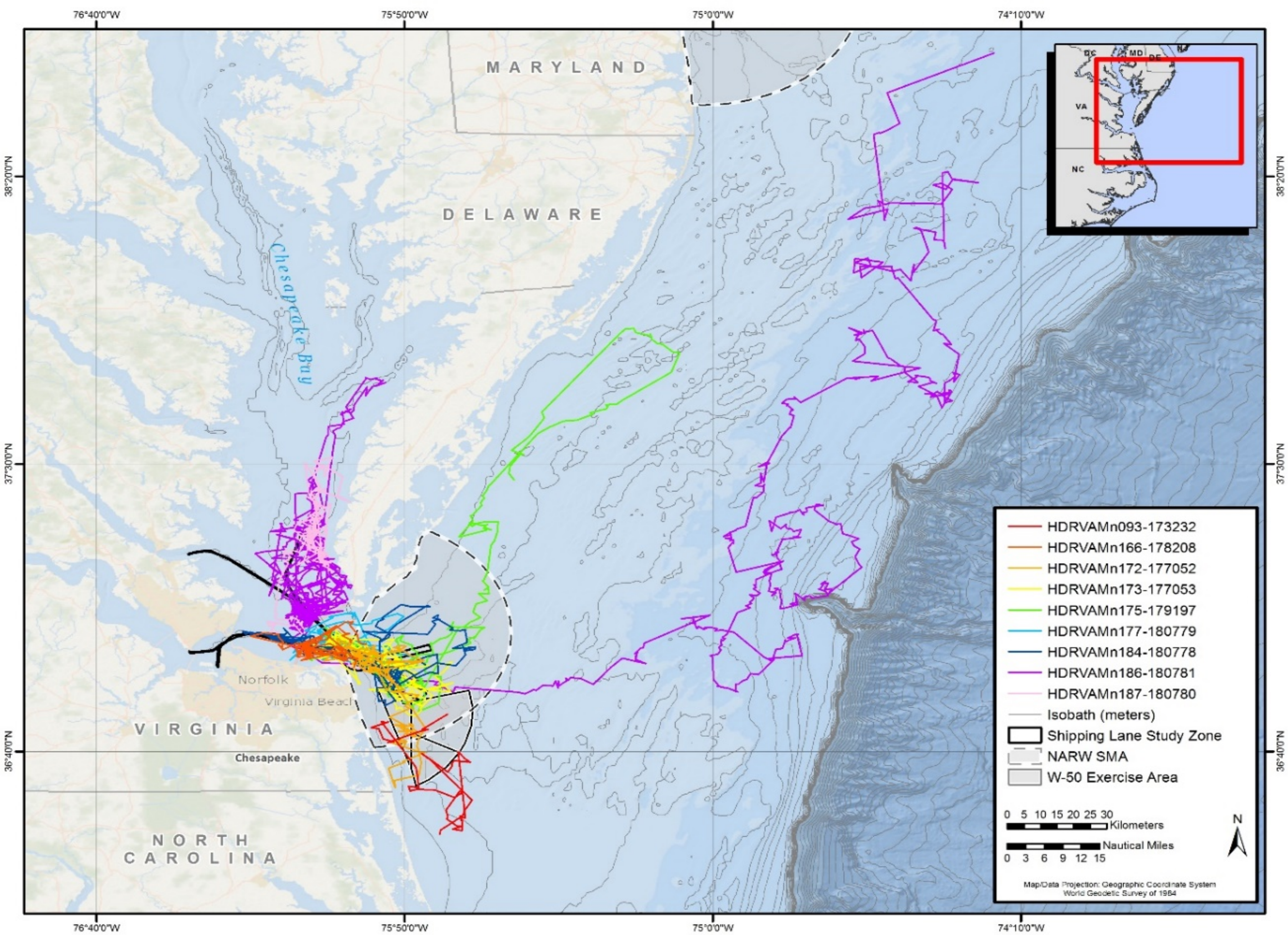

Figure 6. Argos tracks for all humpback whales tagged (n=9) during the 2019/20 field season.

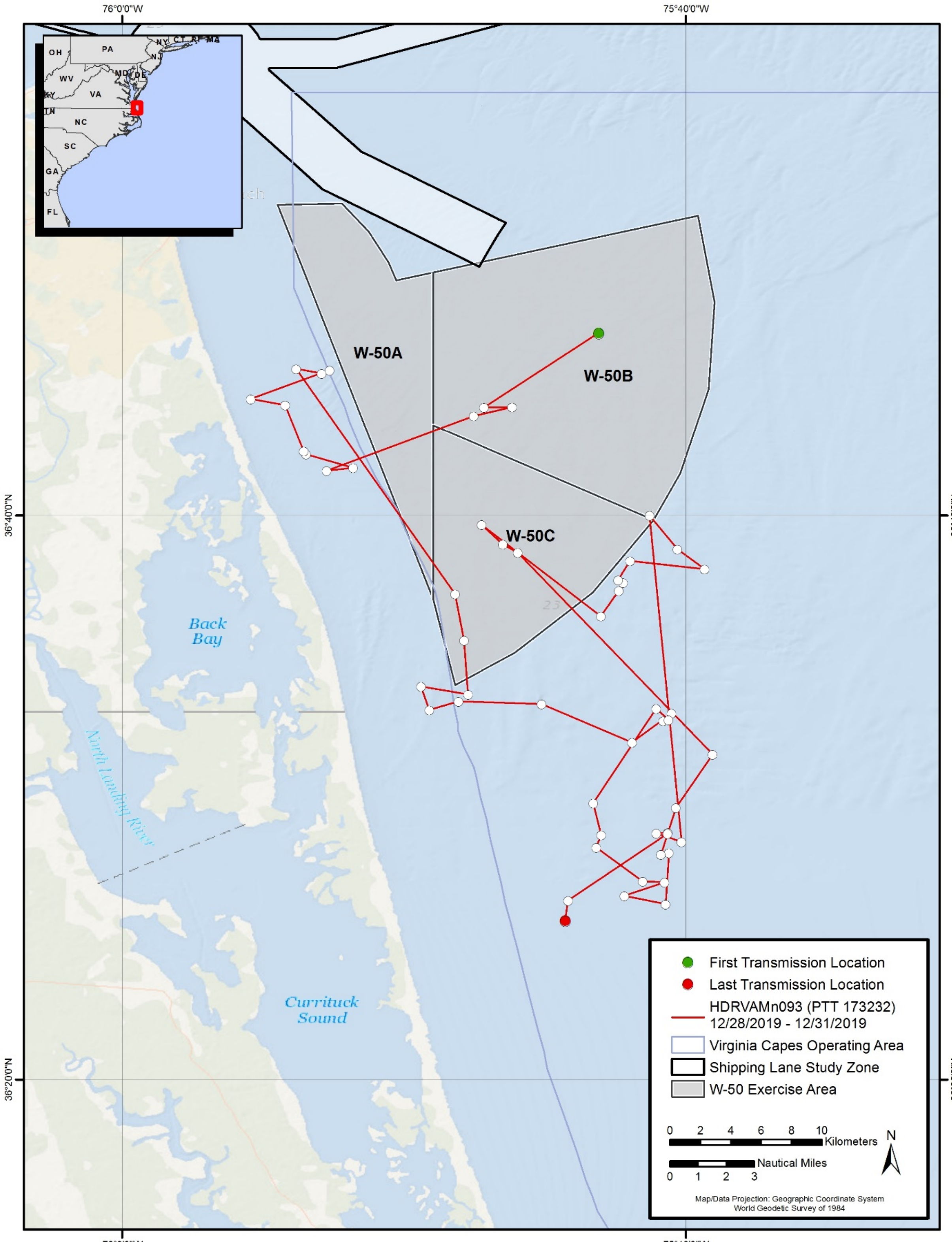

Figure 7. Filtered locations (white dots) and track of humpback whale HDRVAMn093, tagged on 28 December 2019, over 2.7 days of tag-attachment duration.

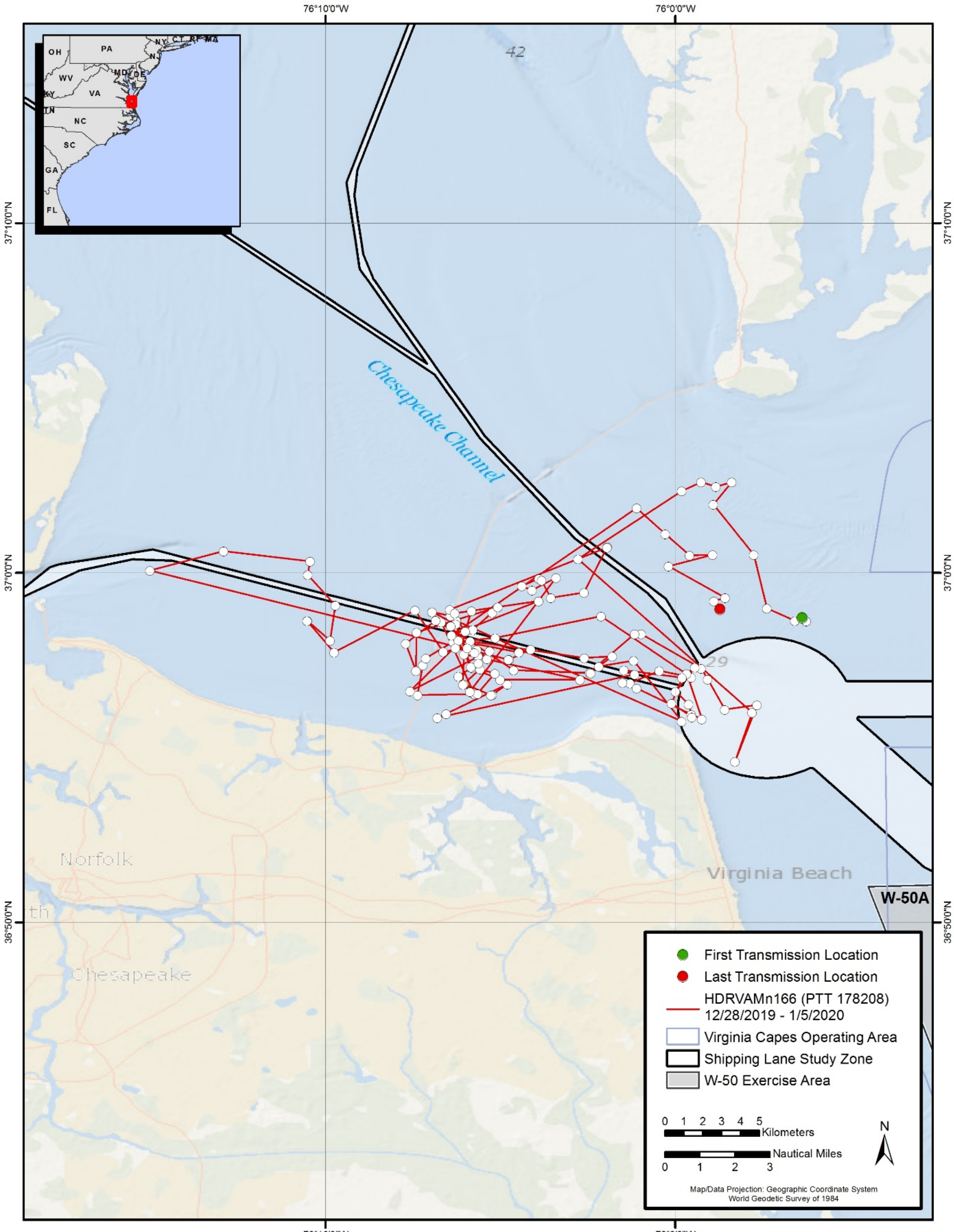

Figure 8. Filtered locations (white dots) and track of humpback whale HDRVAMn166, tagged on 28 December 2019, over 7.4 days of tag-attachment duration.

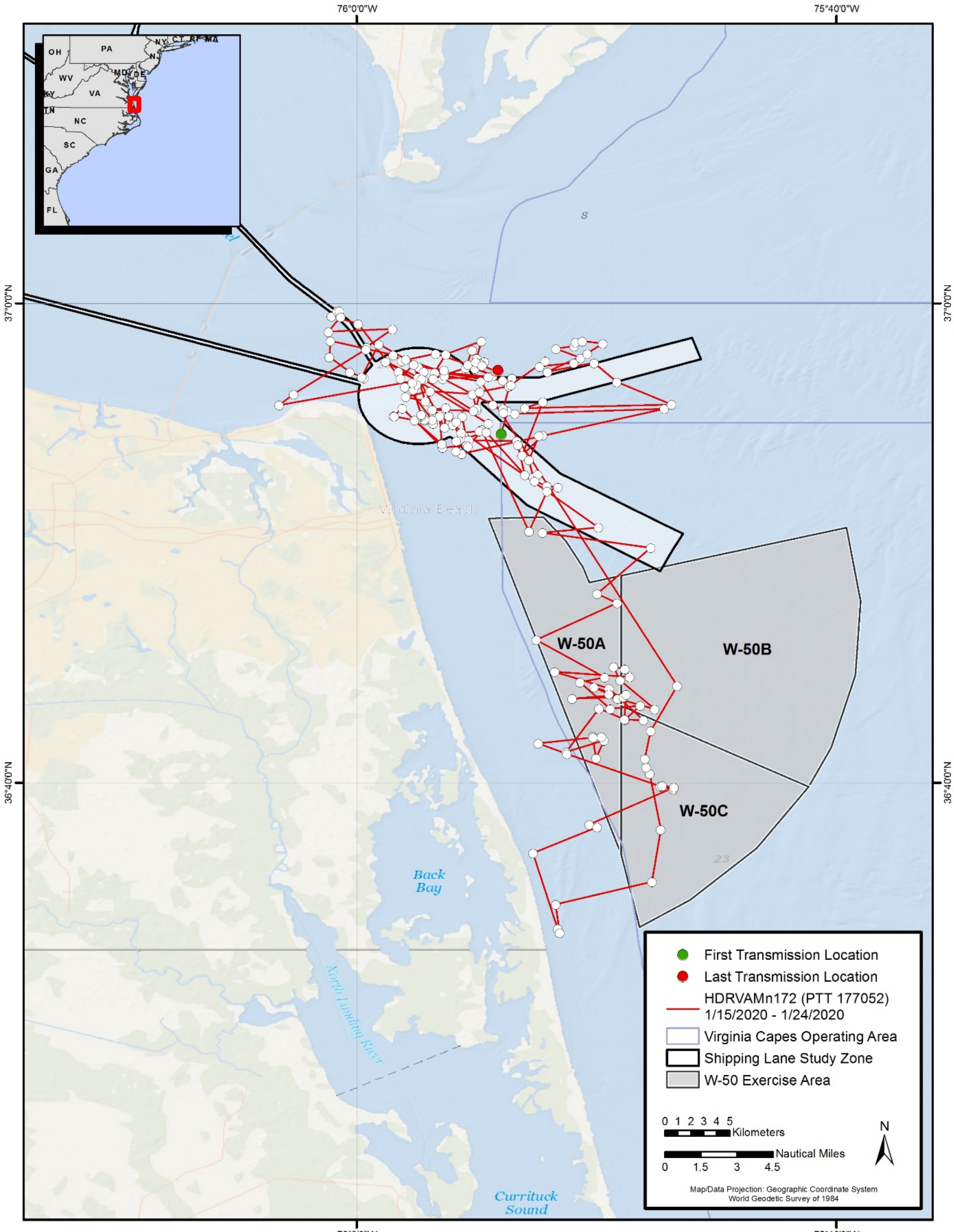

Figure 9. Filtered locations (white dots) and track of humpback whale HDRVAMn172, tagged on 15 January 2020, over 8.4 days of tag-attachment duration.

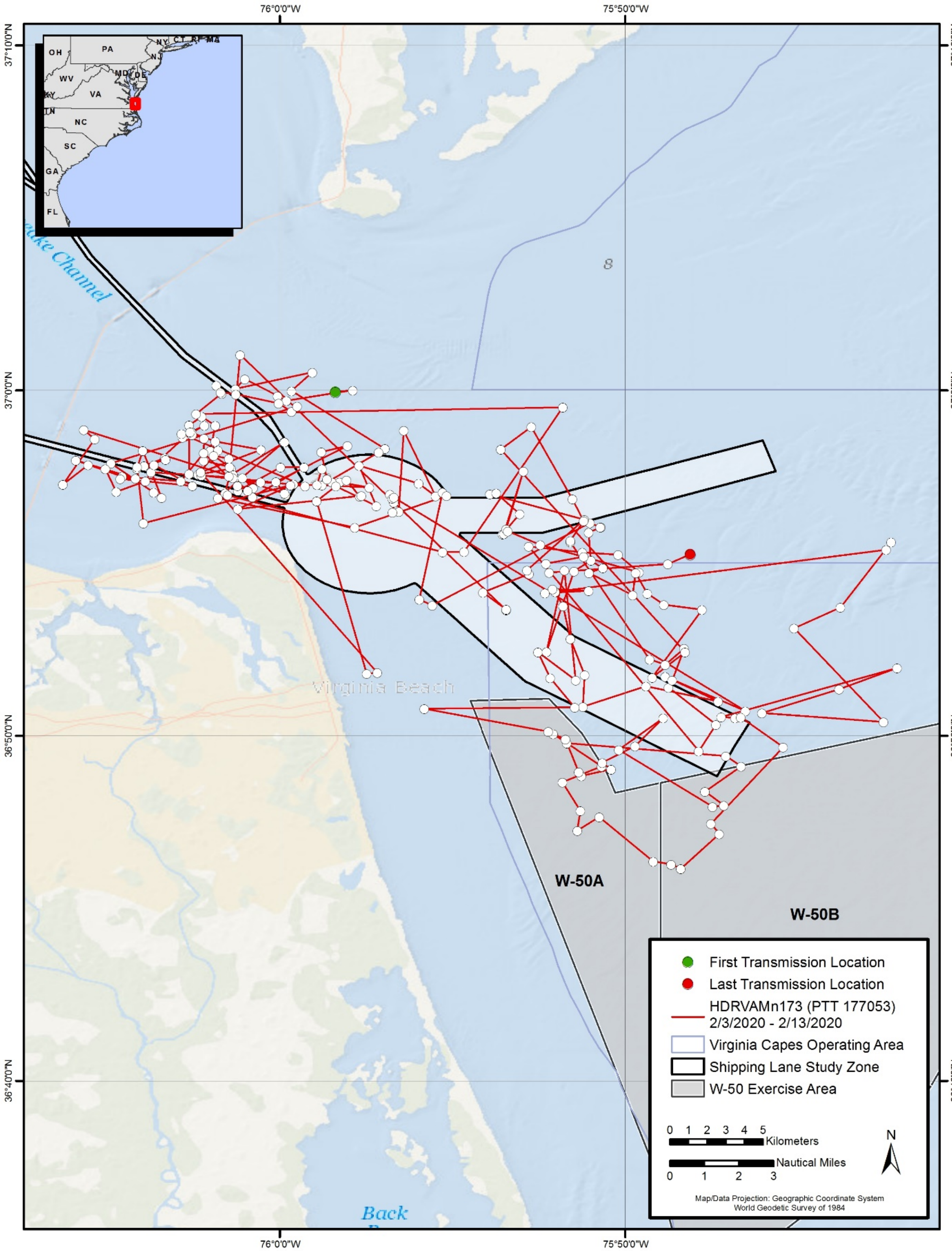

Figure 10. Filtered locations (white dots) and track of humpback whale HDRVAMn173, tagged on 3 February 2020, over 9.5 days of tag-attachment duration.

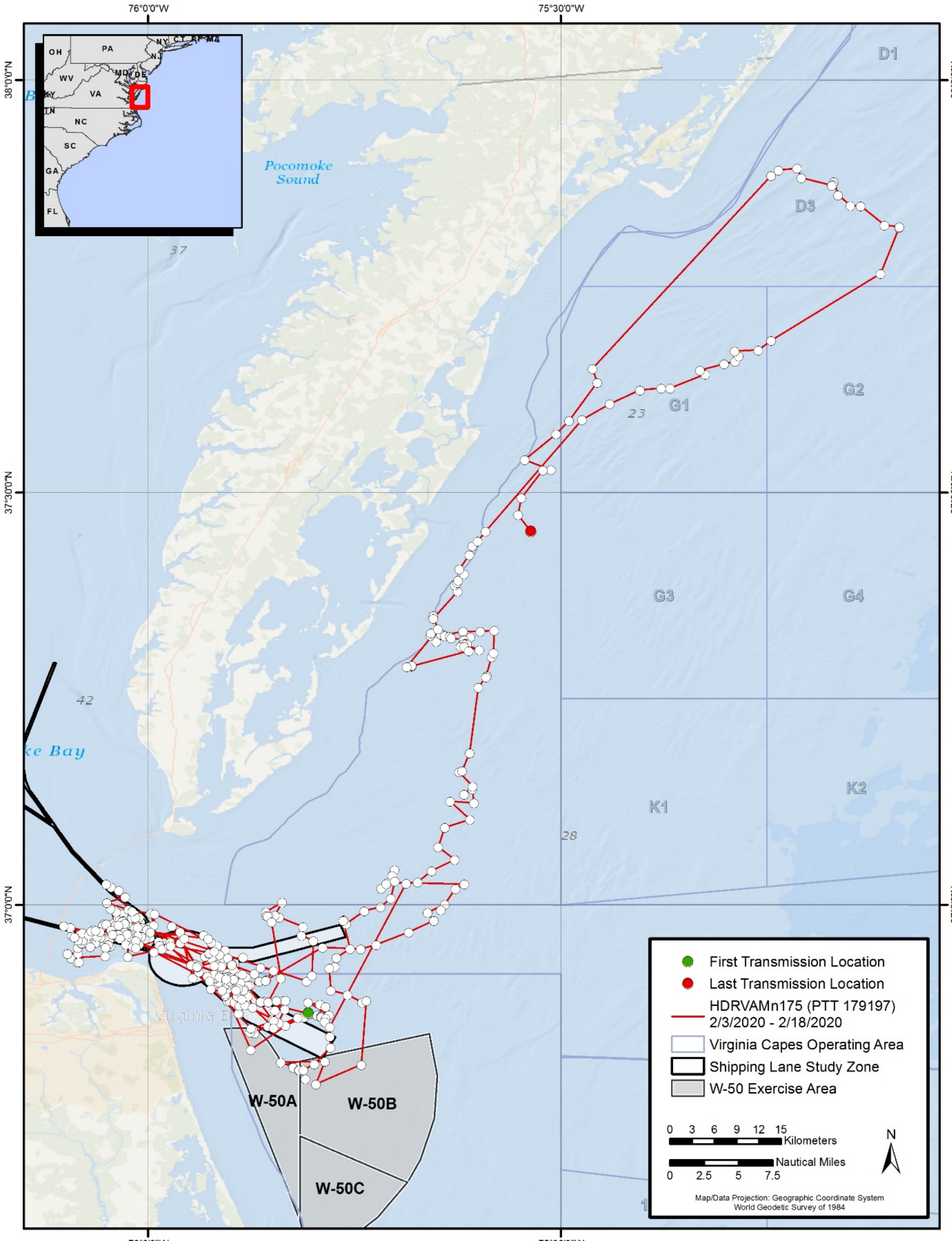

Figure 11. Filtered locations (white dots) and track of humpback whale HDRVAMn175, tagged on 3 February 2020, over 14.8 days of tag-attachment duration.

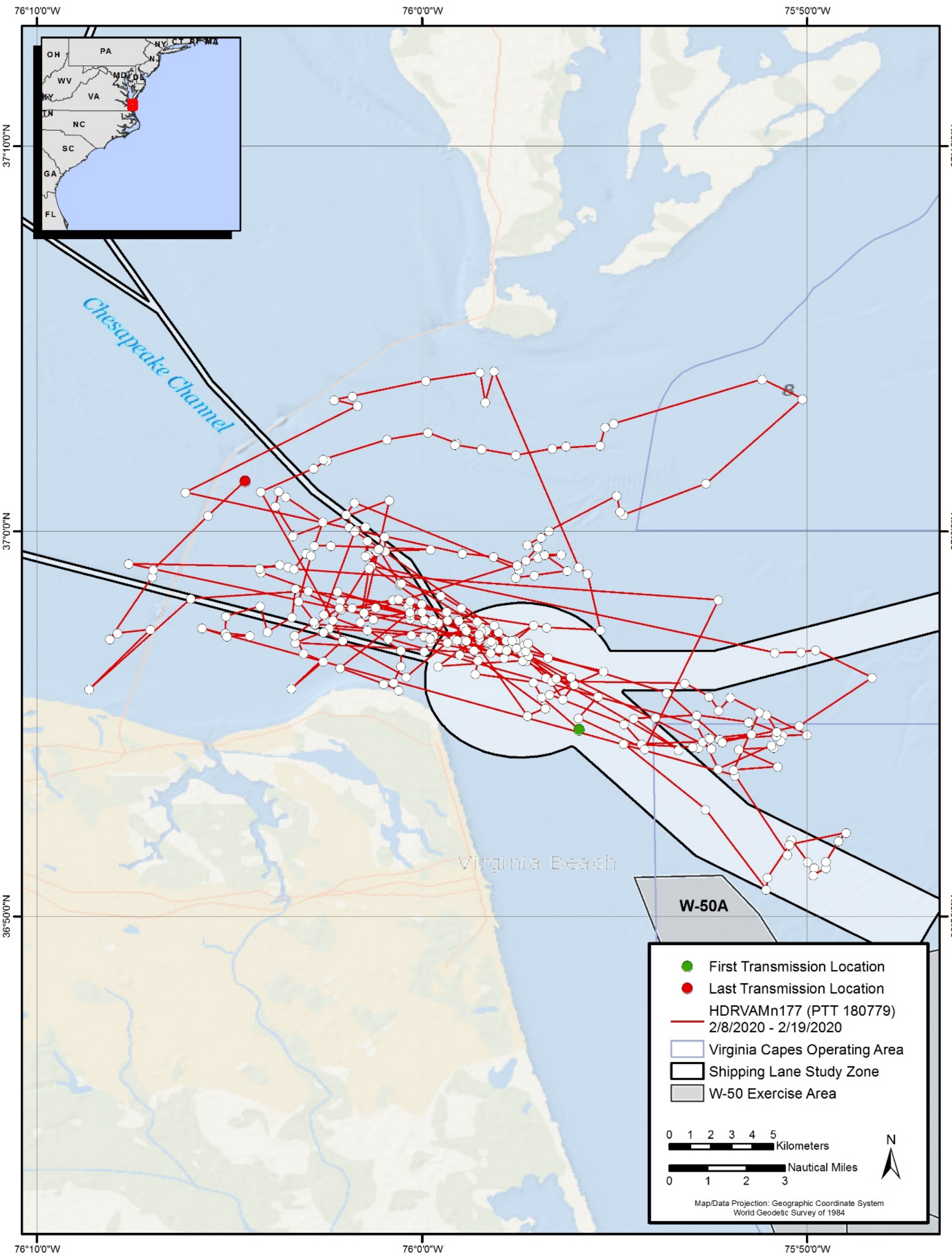

Figure 12. Filtered locations (white dots) and track of humpback whale HDRVAMn177, tagged on 8 February 2020, over 10.8 days of tag-attachment duration

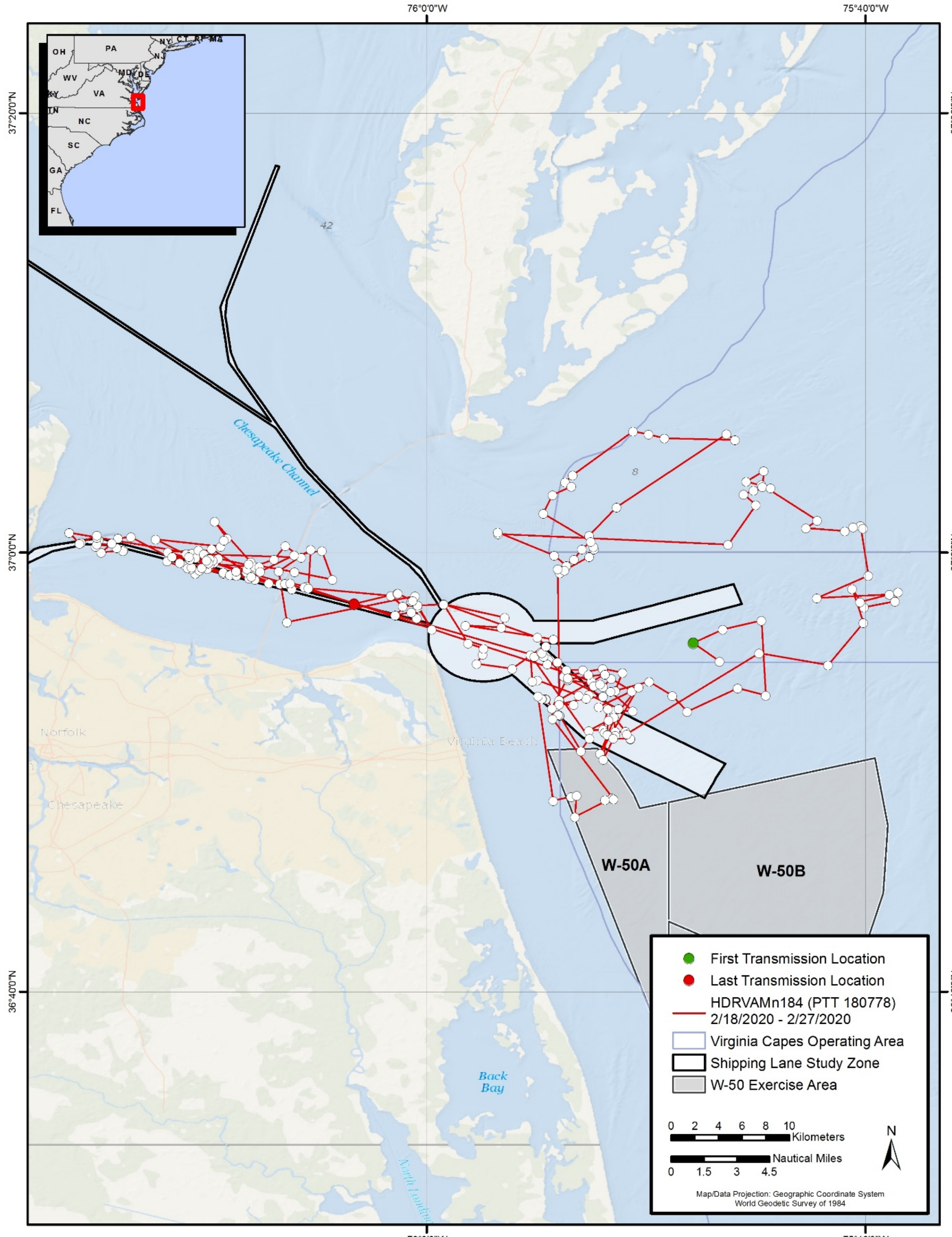

Figure 13. Filtered locations (white dots) and track of humpback whale HDRVAMn184, tagged on 18 February 2020, over 8.8 days of tag-attachment duration.

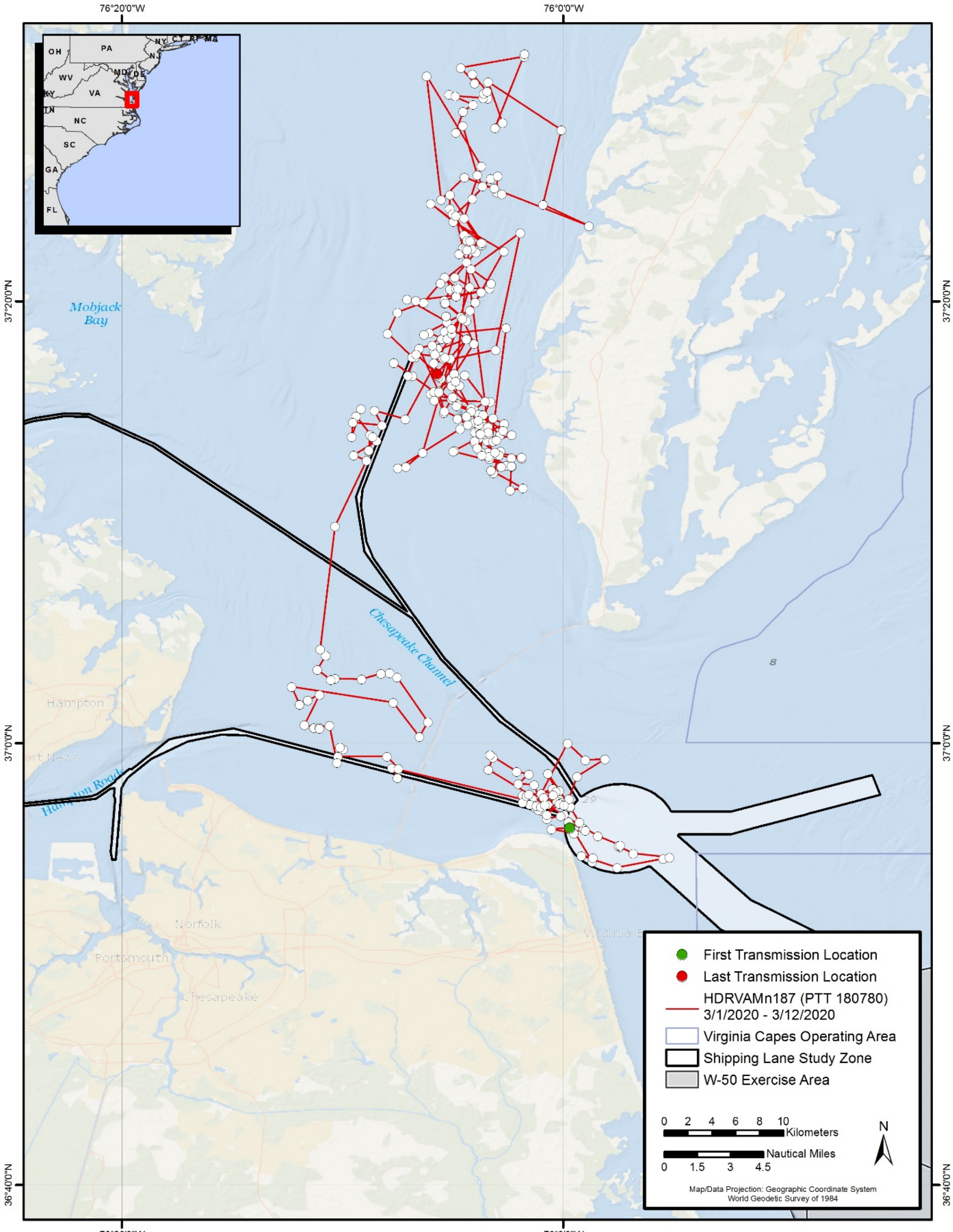

Figure 14. Filtered locations (white dots) and track of humpback whale HDRVAMn187, tagged on 1 March 2020, over 10.6 days of tag-attachment duration.

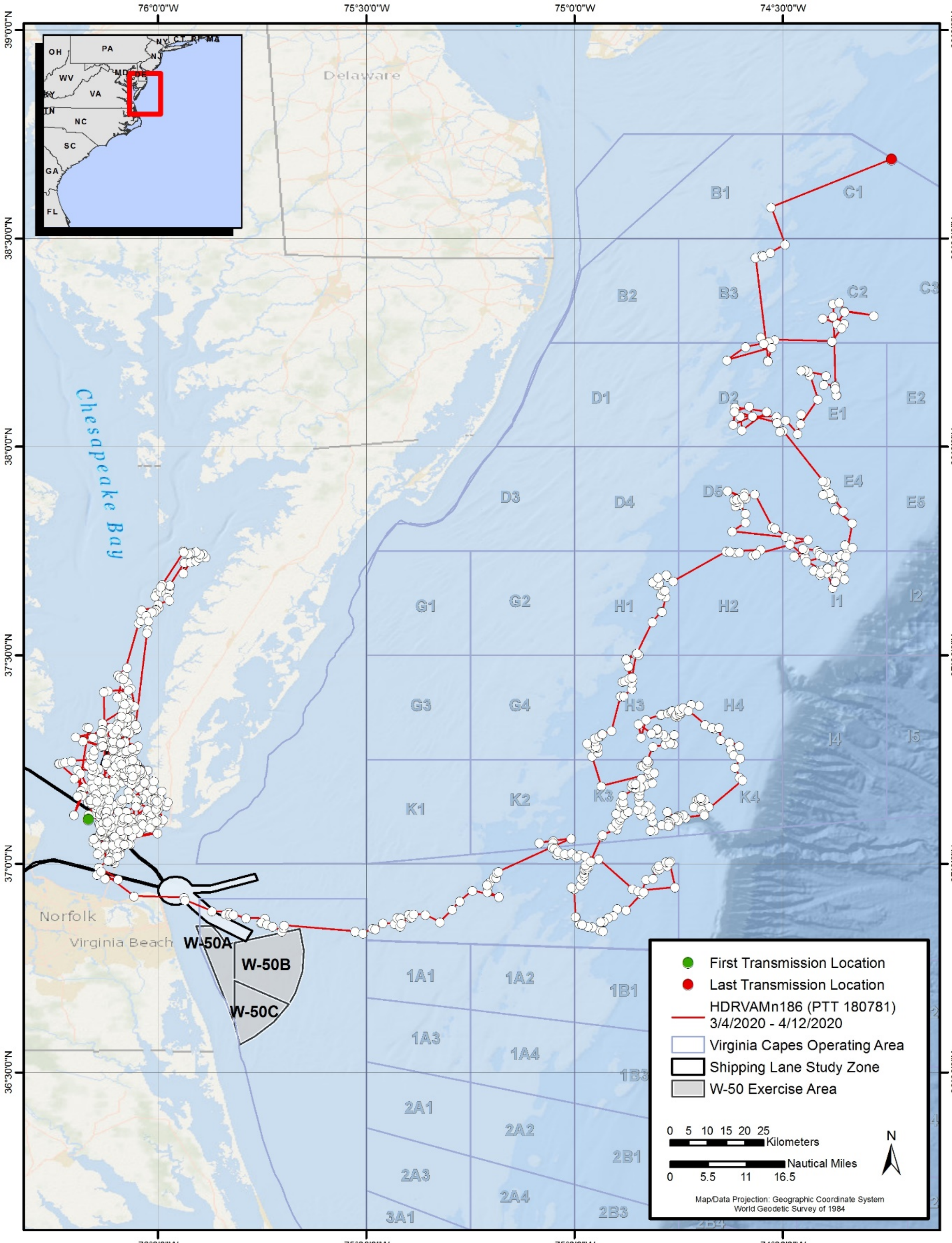

Figure 15. Filtered locations (white dots) and track of humpback whale HDRVAMn186, tagged on 4 March 2020, over 39.9 days of tag-attachment duration.

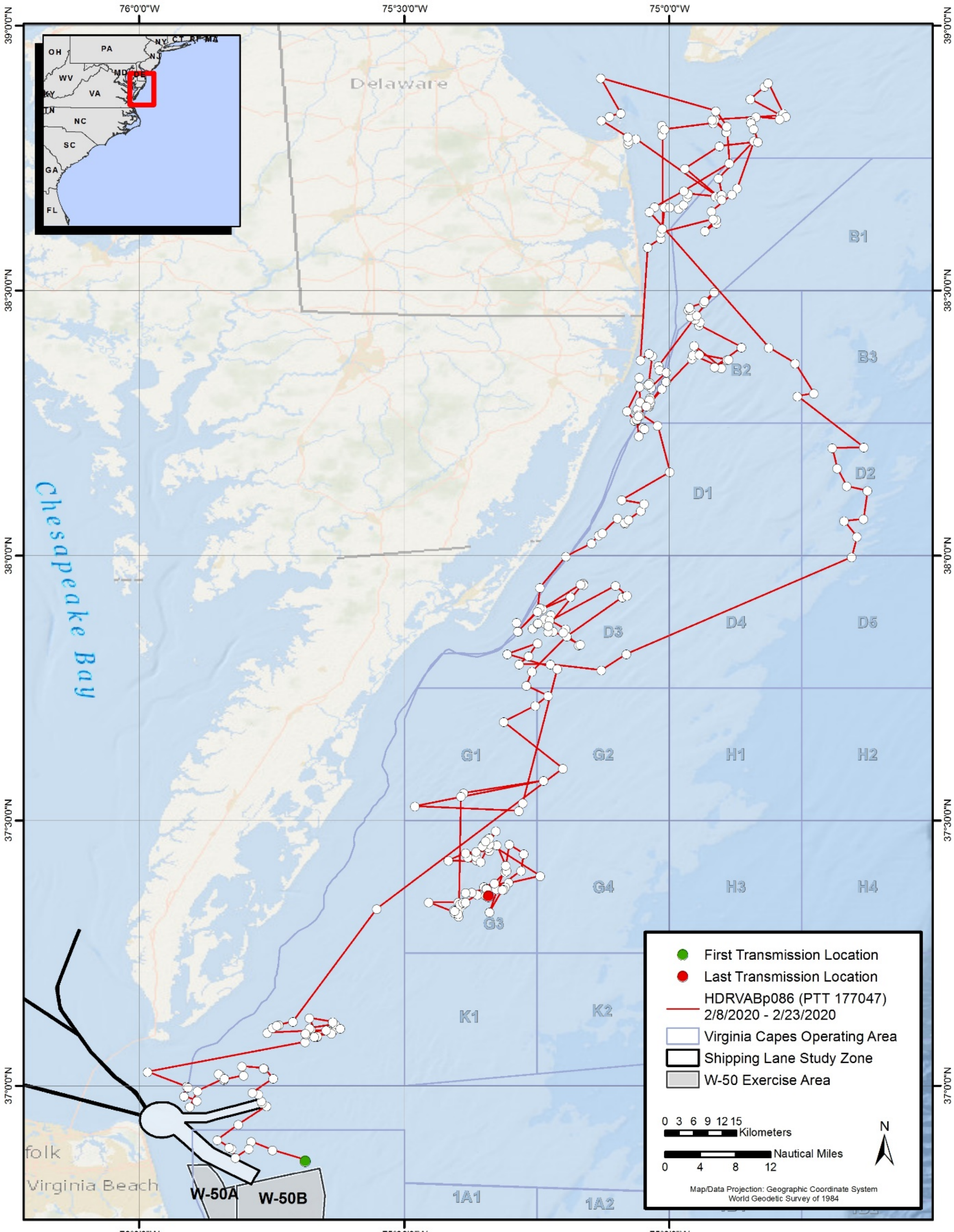

Figure 15. Filtered locations (white dots) and track of fin whale HDRVABp086, tagged on 8 February 2020, over 14.7 days of tag-attachment duration.

Table 5. Summary of dive depth and duration data collected from all tagged baleen whales during the 2019/20 season.

Animal ID	Species	Argos ID	No. Dives Logged	Mean Dive Depth (m)	Max Dive Depth (m)	Mean Dive Duration (mm:ss)	Max Dive Duration (mm:ss)
HDRVAMn093	Humpback whale	173232	230	12.6	26.0	03:43	09:21
HDRVAMn166	Humpback whale	178208	190	14.5	30.0	02:25	04:13
HDRVAMn172	Humpback whale	177052	890	14.5	29.0	02:56	06:45
HDRVAMn173	Humpback whale	177053	680	15.0	28.0	02:38	05:37
HDRVAMn175	Humpback whale	179197	2065	14.7	32.0	03:14	10:51
HDRVAMn177	Humpback whale	180779	1475	16.2	31.0	02:41	07:01
HDRVAMn184	Humpback whale	180778	914	16.3	28.0	03:01	06:07
HDRVAMn187	Humpback whale	180780	1210	16.2	36.0	03:16	06:13
HDRVAMn186	Humpback whale	180781	4054	16.0	74.0	03:04	07:07
HDRVABp086	Fin whale	177047	960	9.2	30.0	03:54	12:53

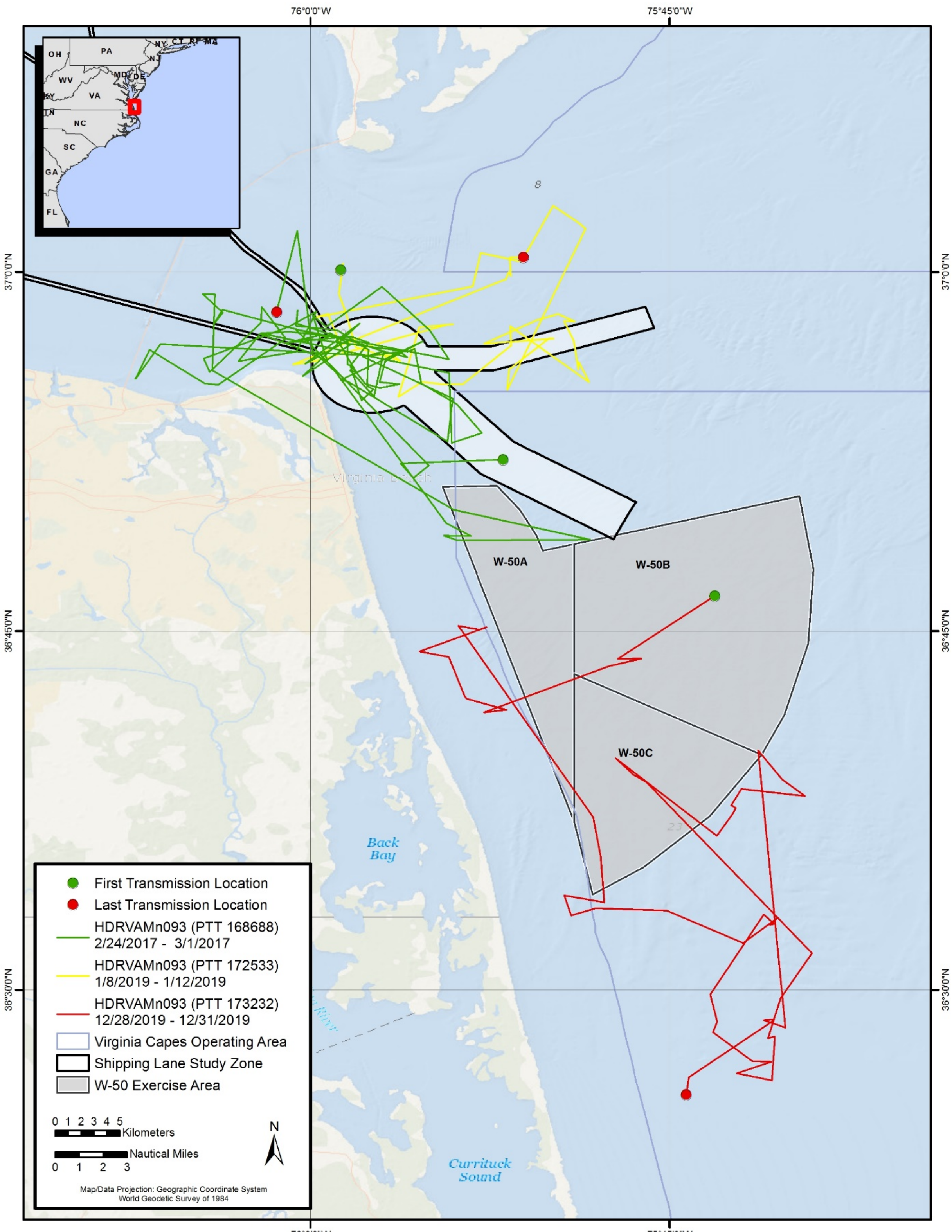

Figure 16. Comparison of tag tracks for HDRVAMn093 from 2017 (green trackline, 5.2 days), 2019 (yellow trackline, 3.2 days), and 2019 (red trackline 2.7 days).

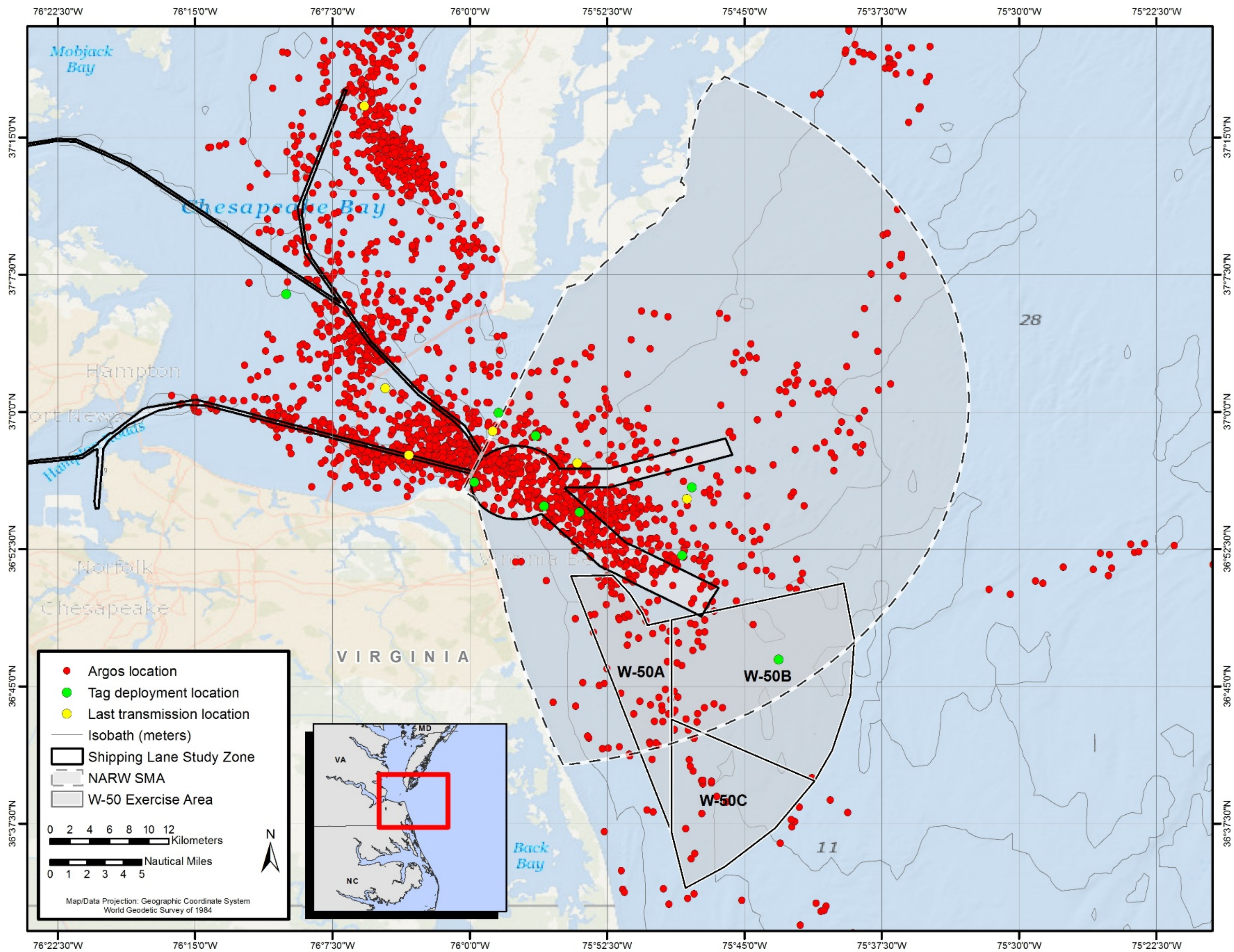

Figure 17. Filtered locations (red dots) of all humpback whale Argos locations in the immediate vicinity of shipping channels at the mouth of the Chesapeake Bay from tag data collected during the 2019/20 field season.

4. Discussion

Analyses of data from this multi-year project are on-going; however, results show site fidelity in the study area for many individuals and a high level of occurrence within the shipping channels—an important high-use area by both the U.S. Navy and commercial shipping traffic. These findings are supported by information collected during the first six years of this study, including photo-ID, focal follows, and satellite-tagging results. A smaller number of animals are also spending time close to, or within, the W-50 MINEX box and an increasing number of individuals are also spending time in the offshore VACAPES range complex and are presumably within hearing range of underwater detonation training exercises.

Interactions with vessels, both large and small, are a significant cause for concern for both humpback and endangered fin whales in the study area. In April 2017, the National Marine Fisheries Service declared an Unusual Mortality Event (UME) for humpback whales in the Atlantic from Maine to North Carolina based on elevated mortalities of this species since January 2016. At the time of this report, 146 humpback whales are included in this UME and 49 (29.5 percent) of those have occurred in Virginia or North Carolina (NOAA 2021). Given this UME designation, a group of subject matter experts will look further at what is causing or contributing to the increased number of deaths of humpback whales in this area. While the UME team will look at humpback whales of all age classes, approximately three-quarters of the humpback whales identified during the six years of effort on this project appear to be juveniles that are spending more time in 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 seasons and those individuals are typically not re-sighted, suggesting that sightings early in the season may be whales that may be passing through the area rather than whales that may remain in the primary study area for longer durations. The large percentage of juveniles observed in this study matches both historic stranding data (e.g., Wiley et al. 1995) and observational data (e.g., Swingle et al. 1993) for the area.

The number of humpback whale identifications per season grew steadily over the course of the first three years of this project, dropped during the 2017/18 field season, increased slightly for the 2018/19 season before dropping slightly for the current 2019/20 season (**Figure 5**). Because these surveys are not intended to support density or abundance estimates, trends in sightings across years cannot be evaluated statistically, though there may be some subjective inferences to 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 two months earlier than the 2014/15 season and one 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 with staying with one whale over a longer period of time rather than collecting as many identification photographs of animals in 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 when multiple cold weather systems significantly impacted water temperature in and around the Chesapeake Bay and surrounding areas. Based on our experience, when water temperatures drop the whales seem to be less numerous or absent all together despite continued survey effort. We presume that the cold-water temperatures likely affect prey distribution in 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) in 2019/20 compared to the previous 2018/19 season which may also account for the smaller number of identifications.

Integration of the drone component to the study beginning in 2018 has allowed for additional opportunities to examine humpback whale body condition (**Figure 18**) and has also been used to estimate length, and therefore will continue to be a valuable tool during subsequent field seasons. Following the methodology described in Dawson et al. (2017), HDR recently retrofitted the DJI Phantom 4 Pro V2.0 and installed a custom Light Detection and Ranging altimeter. This upgrade increases the precision (within 5 cm) and consistency of the sUAS altimetry measurements to minimize possible error in measured animal lengths. The photogrammetry techniques remain the same, however, with greater accuracy than the stock DJI barometer. To continue collecting consistent imagery data with precise altimetry measurements, as well as transition to a Department of Defense compliant platform following recent 2020 National Defense Authorization Act restrictions, HDR is acquiring a new American-made sUAS with improved capabilities such as a LiDAR sensors, longer flight times, and a higher resolution camera.

Figure 18. Still image of humpback whale HDRVAMn152 collected from a sUAS. A portion of the tail flukes are missing which can be observed from this view.

With five seasons of satellite tag deployments completed, trends are emerging, as is the variability both between individuals and between seasons. The mouth of the Chesapeake Bay, and shipping lanes in particular, continue to be an area heavily utilized by humpback whales. From November through April, there is a ship-speed reduction rule in effect at the mouth of the Chesapeake Bay as part of the Seasonal Management Area (SMA) set up to protect Endangered Species Act-listed North Atlantic right whales (*Eubalaena glacialis*). These speed restrictions require all vessels 65 feet (19.8 m) or longer to travel at 10 knots (18.5 km/h) or less. The SMA in this study area begins at the mouth of the Chesapeake Bay and extends outwards to 37 km, however, as Argos locations from tagged humpback whales have shown, these boundaries do not necessarily protect all large whales using the area (**Figure 17**). Portions of the Chesapeake Bay, west of the Chesapeake Bay Bridge Tunnel, were not utilized by any tagged humpback whales during the 2015/16 and 2017/18 season, but were heavily utilized during the 2016/17 season, only sparsely used during the 2018/19 season, and heavily utilized again during the 2019/20 season. Short-term distributional shifts related to oceanographic conditions may have caused prey to become concentrated farther into the bay during the 2016/17 and 2019/20 seasons, resulting in an increased presence of humpback whales in that area. The presence of humpback whales west of the Chesapeake Bay Bridge Tunnel raises additional concerns given the high traffic flow in that area, increased vessel speeds allowed, and extent of marine-based training occurring out of Joint Expeditionary Base Little Creek.

Survey effort in future years should continue to explore this region, as well as into further offshore waters that have been used by some tagged whales during each of the five tagging seasons. 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 out of the nearshore area. Efforts for the 2020/21 season will focus on pushing farther into the mid-shelf waters when not supporting the nearshore collaborative efforts with Duke University. During the 2020/21 season, HDR will also deploy DTAGs on baleen whales utilizing the MINEX and mid-shelf areas. This addition will allow us to better detail fine-scale movement, dive patterns, foraging behavior, and acoustic measurements to add to the existing medium-duration dataset.

State-Space Modeling and home range analysis 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 (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 which is 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 for this population. Other strategies included looping down the Outer Banks to feed and then returning north, foraging deeper into the Chesapeake Bay, and long directed movements northwards along the coast and the shelf break before recruiting to additional locations where area-restricted search behavior was performed. Updating these analyses with the inclusion of additional tags will provide a more robust picture of humpback whale habitat use in the 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 depth and duration will be looked at more closely and in association with the concurrent DTAG efforts being conducted by Duke University (see Shearer et al. 2020).

The number of sightings of humpback whales and other species, 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 in order to better understand movement patterns. Continued photo-ID effort will build a more complete picture of inter-annual site fidelity to this region. The inclusion of Wildlife Computer's 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 that 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 in 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 (by number of days seen per season) and additional information of all photo-identified baleen whales off Virginia Beach, Virginia: December 2014–March 2020.

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	Total No. Days Seen	Total No. Seasons Seen	Biopsied? (Y/N) Gender (M/F/U)	Satellite Tagged? (Y/N)	Est. Age Class (A/SA/J)	Prop scars or injuries? (Y/N/P)	Total No. Focal Follows	Total No. Focal Follow Minutes
Humpback Whales:														
HDRVAMn003	1						1	1	N/U	N	A	N	0	-
HDRVAMn004	1						1	1	N/U	N	A	N	0	-
HDRVAMn005	2		5				7	2	Y/F	Y	A	N	1	64
HDRVAMn006	2						2	1	N/U	N	J	N	1	69
HDRVAMn007	4	1	7		8	1	21	5	Y/F	Y	J	N	1	60
HDRVAMn008	5						5	1	N/U	N	J	N	3	215
HDRVAMn009	4						4	1	Y/F	N	J	N	2	112
HDRVAMn010	1	2		1			4	3	Y/M	Y(2)	J	N	1	76
HDRVAMn011	4		1				5	2	Y/F	N	J	N	1	60
HDRVAMn012	3	2	7	3	3		17	5	Y/F	Y(2)	J	N	2	25
HDRVAMn013	10						10	1	Y/F	N	J	N	4	357
HDRVAMn014	5	1	1	1			8	4	Y/F	N	J	N	1	60
HDRVAMn015	2		1				3	2	Y/F	N	J	N	1	58
HDRVAMn016	1						1	1	N/U	N	U	N	0	-
HDRVAMn017	1						1	1	N/U	N	U	N	0	-
HDRVAMn018	1						1	1	N/U	N	U	Y	0	-
HDRVAMn019	1						1	1	N/U	N	U	N	0	-
HDRVAMn020	1						1	1	N/U	N	U	N	0	-
HDRVAMn021	2		3	2	6	1	14	5	N/U	N	SA	N	1	78
HDRVAMn022	2						2	1	N/U	N	J	N	1	85
HDRVAMn023	1		3*	-	-	-	4	2	Y/M	Y	J	N	1	80
HDRVAMn024	2						2	1	Y/M	N	A	P	1	60
HDRVAMn025	1						1	1	Y/M	N	U	N	1	62
HDRVAMn027	2	3	1	1†			7	4	Y/F	N	J	N	1	61
HDRVAMn028	1						1	1	N/U	N	J	N	0	-
HDRVAMn029	1						1	1	Y/M	N	J	P	1	63
HDRVAMn030	1	1					2	2	N/U	N	A	N	1	62
HDRVAMn031	1		1	1			3	3	Y/M	Y	J	N	0	-
HDRVAMn032	1						1	1	N/U	N	SA	N	1	-
HDRVAMn033	1						1	1	N/U	N	J	N	0	63
HDRVAMn034	1						1	1	N/U	N	J	N	0	-
HDRVAMn035		2					2	1	N/U	N	J	N	0	-
HDRVAMn036		2					2	1	N/U	N	J	N	0	-
HDRVAMn037		3					3	1	N/U	N	J	N	0	-
HDRVAMn039		1					1	1	Y/M	Y	J	N	0	-
HDRVAMn041		1					1	1	Y/M	Y	J	N	0	-
HDRVAMn042		6					6	1	N/U	N	J	N	0	-
HDRVAMn043		1					1	1	N/U	N	J	N	0	-
HDRVAMn044		1					1	1	Y/F	Y	J	Y	0	-
HDRVAMn045		6					6	1	Y/M	Y	J	Y	0	-
HDRVAMn046		4					4	1	N/U	N	J	N	0	-
HDRVAMn047		1					1	1	N/U	N	J	N	0	-
HDRVAMn048		2	1				3	2	Y/M	Y	SA/A	N	0	-
HDRVAMn049		2	6	1, 1†			10	3	Y/F	Y(2)	SA/A	N	0	-
HDRVAMn050		4					4	1	Y/M	N	J	N	0	-
HDRVAMn051		9					9	1	Y/M	N	J	Y	0	-
HDRVAMn052		3					3	1	Y/F	N	J	N	0	-
HDRVAMn053		2					2	1	N/U	N	J	Y	0	-
HDRVAMn054		7					7	1	Y/M	Y	J	N	0	-
HDRVAMn055		2					2	1	N/U	N	J	N	0	-
HDRVAMn056		2					2	1	N/U	N	J	N	0	-
HDRVAMn057		1					1	1	N/U	N	J	N	0	-
HDRVAMn058		1					1	1	N/U	N	J/SA	Y	0	-
HDRVAMn059		1	2				3	2	Y/M	Y	SA	N	0	-
HDRVAMn060		1					1	1	N/U	N	J	N	0	-
HDRVAMn061		3					3	1	Y/M	Y	J	N	0	-
HDRVAMn062		3					3	1	N/U	N	J	N	0	-
HDRVAMn063		4					4	1	Y/M	Y	J	N	1	120
HDRVAMn064		2	12	2	3	2	21	5	Y/F	Y(2)	J	N	0	-
HDRVAMn065		1	3				4	2	N/U	N	J	N	0	-
HDRVAMn066		2	2				4	2	Y/M	Y	J	N	0	-
HDRVAMn067		1†					1	1	N/U	N	J	N	0	-
HDRVAMn068		1					1	1	N/U	N	J	N	0	-
HDRVAMn069			1				1	1	Y/F	Y	SA	N	0	-
HDRVAMn071			2				2	1	Y/M	Y	SA	N	0	-
HDRVAMn072			1				1	1	N/U	N	J	N	0	-
HDRVAMn073			1				1	1	N/U	N	SA	N	0	-
HDRVAMn074			1				1	1	N/U	N	J	N	0	-
HDRVAMn075			1				1	1	N/U	N	SA	N	0	-
HDRVAMn076			1				1	1	N/U	N	SA	N	0	-
HDRVAMn077			1				1	1	N/U	N	SA	N	0	-
HDRVAMn078			1*	-	-	-	1	1	N/U	N	J	N	0	-
HDRVAMn079			3				3	1	N/U	N	J	N	0	-

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	Total No. Days Seen	Total No. Seasons Seen	Biopsied? (Y/N) Gender (M/F/U)	Satellite Tagged? (Y/N)	Est. Age Class (A/SA/J)	Prop scars or injuries? (Y/N/P)	Total No. Focal Follows	Total No. Focal Follow Minutes
Humpback Whales: (continued)														
HDRVAMn080			1				1	1	N/U	N	J	N	0	-
HDRVAMn081			9				9	1	Y/F	Y	J	N	0	-
HDRVAMn082			4		-	-	3	1	Y/F	Y	J	N	0	-
HDRVAMn083			2				2	1	N/U	Y	J	N	0	-
HDRVAMn084			11				11	1	Y/F	Y	J	N	0	-
HDRVAMn085			8				8	1	N/U	N	J	Y	0	-
HDRVAMn086			1				1	1	N/U	N	J	N	0	-
HDRVAMn087			3				3	1	N/U	N	J	N	0	-
HDRVAMn088			6				6	1	Y/M	Y	J	N	0	-
HDRVAMn089			1				1	1	N/U	N	J	N	0	-
HDRVAMn090			4*	-	-	-	4	1	Y/M	Y	J	Y	0	-
HDRVAMn091			5*	-	-	-	5	1	Y/M	N	SA	Y	0	-
HDRVAMn092			6				6	1	Y/F	Y	J	N	0	-
HDRVAMn093			6		4	1	11	3	Y/F	Y(3)	J	N	0	-
HDRVAMn094			1				1	1	N/U	N	J	N	0	-
HDRVAMn095			2				2	1	Y/M	Y	J	N	0	-
HDRVAMn096			5				5	1	Y/M	N	J	N	0	-
HDRVAMn097			1				1	1	N/U	Y	J	N	0	-
HDRVAMn098			8				8	1	Y/F	N	J	N	0	-
HDRVAMn099			6				6	1	Y/F	Y	J	N	0	-
HDRVAMn100			1*	-			1	1	N/U	N	J	N	0	-
HDRVAMn101			1				1	1	Y/M	Y	J	N	0	-
HDRVAMn102			7				7	1	Y/M	Y	J	N	0	-
HDRVAMn103			4				4	1	N/U	N	J	N	0	-
HDRVAMn104			4				4	1	Y/F	Y	J	N	0	-
HDRVAMn105			3				3	1	Y/F	Y	J	N	0	-
HDRVAMn106			3				3	1	N/U	N	J	P	0	-
HDRVAMn107			2				2	1	N/U	N	J	N	0	-
HDRVAMn108			2				2	1	N/U	N	J	N	0	-
HDRVAMn109			3				3	1	Y/M	N	J	N	0	-
HDRVAMn110			2				2	1	N/U	N	J	N	0	-
HDRVAMn111			1				1	1	Y/F	N	SA/A	N	0	-
HDRVAMn112			1				1	1	Y/M	N	J	P	0	-
HDRVAMn113				1			1	1	N/U	N	J	N	0	-
HDRVAMn114				2			2	1	N/U	N	J	N	0	-
HDRVAMn115				2			2	1	N/U	N	J	N	0	-
HDRVAMn116				1			1	1	N/U	N	J	N	0	-
HDRVAMn117				1			1	1	N/U	N	J	N	0	-
HDRVAMn118				1			1	1	N/U	N	J	N	0	-
HDRVAMn119				2			2	1	N/U	N	J	N	0	-
HDRVAMn120				1			1	1	Y/M	Y	J	N	0	-
HDRVAMn121				1			1	1	N/U	N	J	N	0	-
HDRVAMn122				3			3	1	Y/M	N	J	N	0	-
HDRVAMn123				1			1	1	N/U	N	J	N	0	-
HDRVAMn124				1			1	1	N/U	N	J	N	0	-
HDRVAMn125				2			2	1	N/U	N	J	Y	0	-
HDRVAMn126				1†			1	1	Y/M	Y	SA/A	N	0	-
HDRVAMn127				1†			1	1	N/U	N	J	N	0	-
HDRVAMn128				1†			1	1	N/U	N	A	N	0	-
HDRVAMn129				1†			1	1	N/U	N	A	N	0	-
HDRVAMn130				1†			1	1	N/U	N	J/SA	N	0	-
HDRVAMn131				1†			1	1	N/U	N	U	N	0	-
HDRVAMn132					1		1	1	Y/F	Y	J	N	0	-
HDRVAMn133					1†		1	1	N/U	N	J	N	0	-
HDRVAMn134					1†		1	1	N/U	N	J	N	0	-
HDRVAMn135					2		2	1	N/U	N	J	N	0	-
HDRVAMn136					1		1	1	N/U	Y	J	N	0	-
HDRVAMn137					2		2	1	N/U	N	J	N	0	-
HDRVAMn138					1		1	1	N/U	N	J	N	0	-
HDRVAMn139					1		1	1	N/U	N	J	N	0	-
HDRVAMn140					1		1	1	N/U	N	U	N	0	-
HDRVAMn142					4		4	1	N/U	N	J	N	0	-
HDRVAMn143					2		2	1	N/U	N	J/SA	N	0	-
HDRVAMn144					1		1	1	N/U	N	J	N	0	-
HDRVAMn145					2		2	1	N/U	N	J	N	0	-
HDRVAMn146					1†		1	1	Y/M	Y	J	N	0	-
HDRVAMn147					1		1	1	N/U	N	J	Y	0	-
HDRVAMn148					3		3	1	N/U	N	J	N	0	-
HDRVAMn149					4		4	1	N/U	N	SA/A	N	0	-
HDRVAMn150					1		1	1	N/U	N	SA/A	N	0	-
HDRVAMn151					2*	-	2	1	Y/F	Y	J	N	0	-
HDRVAMn152					3		3	1	Y/M	Y	J	N	0	-
HDRVAMn153					2		2	1	Y/F	Y	J	N	0	-
HDRVAMn154					1		1	1	Y/F	Y	J	N	0	-
HDRVAMn155				1†			1	1	N/U	N	J	N	0	-
HDRVAMn156					2		2	1	Y/F	N	SA/A	N	0	-

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	Total No. Days Seen	Total No. Seasons Seen	Biopsied? (Y/N) Gender (M/F/U)	Satellite Tagged? (Y/N)	Est. Age Class (A/SA/J)	Prop scars or injuries? (Y/N/P)	Total No. Focal Follows	Total No. Focal Follow Minutes
Humpback Whales: (continued)														
HDRVAMn157					1		1	1	N/U	N	SA/A	N	0	-
HDRVAMn158					1		1	1	N/U	N	J	N	0	-
HDRVAMn159					1		1	1	N/U	N	J	N	0	-
HDRVAMn160					1		1	1	N/U	N	A	N	0	-
HDRVAMn161					1		1	1	N/U	N	J	N	0	-
HDRVAMn162					1		1	1	N/U	Y	J	N	0	-
HDRVAMn163					2		2	1	Y/U	Y	J	N	0	-
HDRVAMn164					1		1	1	N/U	N	J	N	0	-
HDRVAMn165					1		1	1	N/U	N	J	N	0	-
HDRVAMn166						3	3	1	Y/U	Y	J	N	0	-
HDRVAMn167						1	1	1	N/U	N	J	Y	0	-
HDRVAMn168						1	1	1	N/U	N	SA/A	N	0	-
HDRVAMn169						1	1	1	N/U	N	J	N	0	-
HDRVAMn170						2	2	1	N/U	N	SA/A	N	0	-
HDRVAMn171						1	1	1	N/U	N	J	N	0	-
HDRVAMn172						3	3	1	Y/U	Y	SA/A	N	0	-
HDRVAMn173						4	4	1	Y/U	Y	J	N	0	-
HDRVAMn174						3	3	1	N/U	N	J	Y	0	-
HDRVAMn175						1	1	1	Y/U	Y	J	N	0	-
HDRVAMn176						1	1	1	N/U	N	J	N	0	-
HDRVAMn177						4	4	1	N/U	Y	J	N	0	-
HDRVAMn178						1	1	1	N/U	N	J	N	0	-
HDRVAMn179						1	1	1	N/U	N	SA	Y	0	-
HDRVAMn180						1	1	1	N/U	N	J	N	0	-
HDRVAMn181						1	1	1	N/U	N	J	N	0	-
HDRVAMn182						2	2	1	Y/U	N	SA	N	0	-
HDRVAMn183						1	1	1	N/U	N	SA	N	0	-
HDRVAMn184						4	4	1	Y/U	Y	J	N	0	-
HDRVAMn185						1	1	1	N/U	N	SA	N	0	-
HDRVAMn186						2	2	1	Y/U	Y	SA	N	0	-
HDRVAMn187						2	2	1	N/U	Y	SA	N	0	-
HDRVAMn188						1	1	1	N/U	N	SA	N	0	-
HDRVAMn189						1	1	1	N/U	N	J	N	0	-
	66	**91**	**168**	**38**	**69**	**48**			**69**	**54/60**		**15**	**29**	**1951**
Fin Whales														
HDRVABp001	1						1	1	N/U	N	A	N	1	61
HDRVABp002	1						1	1	N/U	N	C	N	0	-
HDRVABp003	1						1	1	N/U	N	A	N	0	-
HDRVABp009		2					2	1	N/U	N	SA/A	N	0	-
HDRVABp010		2					2	1	N/U	N	SA/A	N	0	-
HDRVABp011		1					1	1	N/U	N	A	N	0	-
HDRVABp016			1†	1			2	2	N/U	Y	SA	N	0	-
HDRVABp020			1†	1			2	2	N/U	Y	SA	N	0	-
HDRVABp035				1*	-	-	1	1	N/U	N	SA	N	0	-
HDRVABp037				1			1	1	N/U	N	SA	N	0	-
HDRVABp038				1			1	1	N/U	N	SA	N	0	-
HDRVABp040				1			1	1	N/U	N	SA	N	0	-
HDRVABp041				1			1	1	N/U	Y	SA	N	0	-
HDRVABp042				1			1	1	N/U	N	SA	N	0	-
HDRVABp060						1	**1**	**1**	**Y/U**	**Y**	**SA/A**	**N**	**0**	**-**
	3	**5**	**2†**	**7**	**0**	**1**			**0**	**4**		**0**	**1**	**61**
Minke Whales														
HDRVABa003			1				1	1	N/U	N	A	N	0	-
HDRVABa004			1				1	1	N/U	N	A	N	0	-
HDRVABa009					1		1	1	N/U	N	A	N	0	-
HDRVABa010					1		1	1	N/U	N	A	N	0	-
HDRVABa011					1		1	1	N/U	N	A	N	0	-
HDRVABa012					1		1	1	N/U	N	A	N	0	-
HDRVABa013						1	1	1	N/U	N	A	N	0	-
		0	**2**	**0**	**4**	**2**			**0**	**0**		**0**	**0**	**0**

Key: * = deceased; †= sighting occurred on offshore survey; Y = yes; N = no; P = possible; A = adult; SA = sub-adult; J = juvenile; C = calf; U = unknown

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