Mid-Atlantic Humpback Whale Monitoring, Virginia Beach, Virginia: 2018/19 Annual Progress Report

Submitted to:

Naval Facilities Engineering Command Atlantic under Contract No. N62470-15-D-8006, Task Order 19F4005, issued to HDR, Inc.

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Cover Photo Credit:

Humpback whale (*Megaptera novaeangliae*) surfacing off the coast of Virginia Beach, Virginia. Cover photograph by Todd Pusser.

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Acronyms and Abbreviations

BSS	Beaufort sea state
°C	degrees Celsius
CBBT	Chesapeake Bay Bridge-Tunnel
CTD	Conductivity Temperature Depth
fps	frames per second
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
NMFS	National Marine Fisheries Service
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
UD	Utilization Distribution
VACAPES	Virginia Capes Operating Area
VAQS	Virginia Aquarium and Marine Science Center

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1. Introduction and Background

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 during the winter months (Katona and Beard 1990, Christensen et al. 1992, Palsbøll et al. 1997). Not all humpback whales, however, end up in the Caribbean waters. Some whales use the Mid-Atlantic region to over-winter (Barco et al. 2002). Norfolk, Virginia, is home to the world's largest U.S. Navy installation, 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.

In the past, humpback whale sighting information off the Virginia Beach area has been collected via various methods and sporadic 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. Such 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. Such data are 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 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 include the following:

- *Collect baseline occurrence data (location, sex, group size, 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 five dedicated field seasons of humpback whale research 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 and with a smaller number of sightings occurring outside this timeframe. The first season of dedicated humpback whale surveys began in January 2015 and was completed in May 2015 (see Aschettino et al. 2015). Additional humpback whale sighting information from bottlenose dolphin density surveys running concurrently off Virginia Beach (see Engelhaupt et al. 2016) was also incorporated into these analyses, and the first humpback whale sightings from those density surveys occurred in December 2014. Therefore, the first field season, encompassing sightings from both the dedicated humpback whale surveys and the bottlenose dolphin density 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-identification (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 the use of 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 further offshore. Nine satellite tags (six on humpback whales and three on fin whales) were deployed and three biopsy samples were collected during the 2017/18 season.

The 2018/19 field season began on 12 November 2018 and the last dedicated survey was conducted on 20 May 2019. One anomalous survey conducted on 31 July 2018 is also included in this field season. The objectives for the 2018/19 field season are similar to previous years, with a continued focus to increase survey effort in the W-50 MINEX region and further 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., 2019).

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 included 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 survey vessel was an 8.2-meter (m) fiberglass hybrid-foam-collar boat *Whale Research* (**Figure 2**), owned and operated by HDR. Surveys departed from Long Bay Pointe Marina, located in Lynnhaven Inlet, Virginia Beach. 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 recorded, but not presented in this report.

2.1 Photo-ID and Photogrammetry

Photographs of humpback, fin (*Balaenoptera physalus*) and minke (*Balaenoptera acutorostrata*) 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

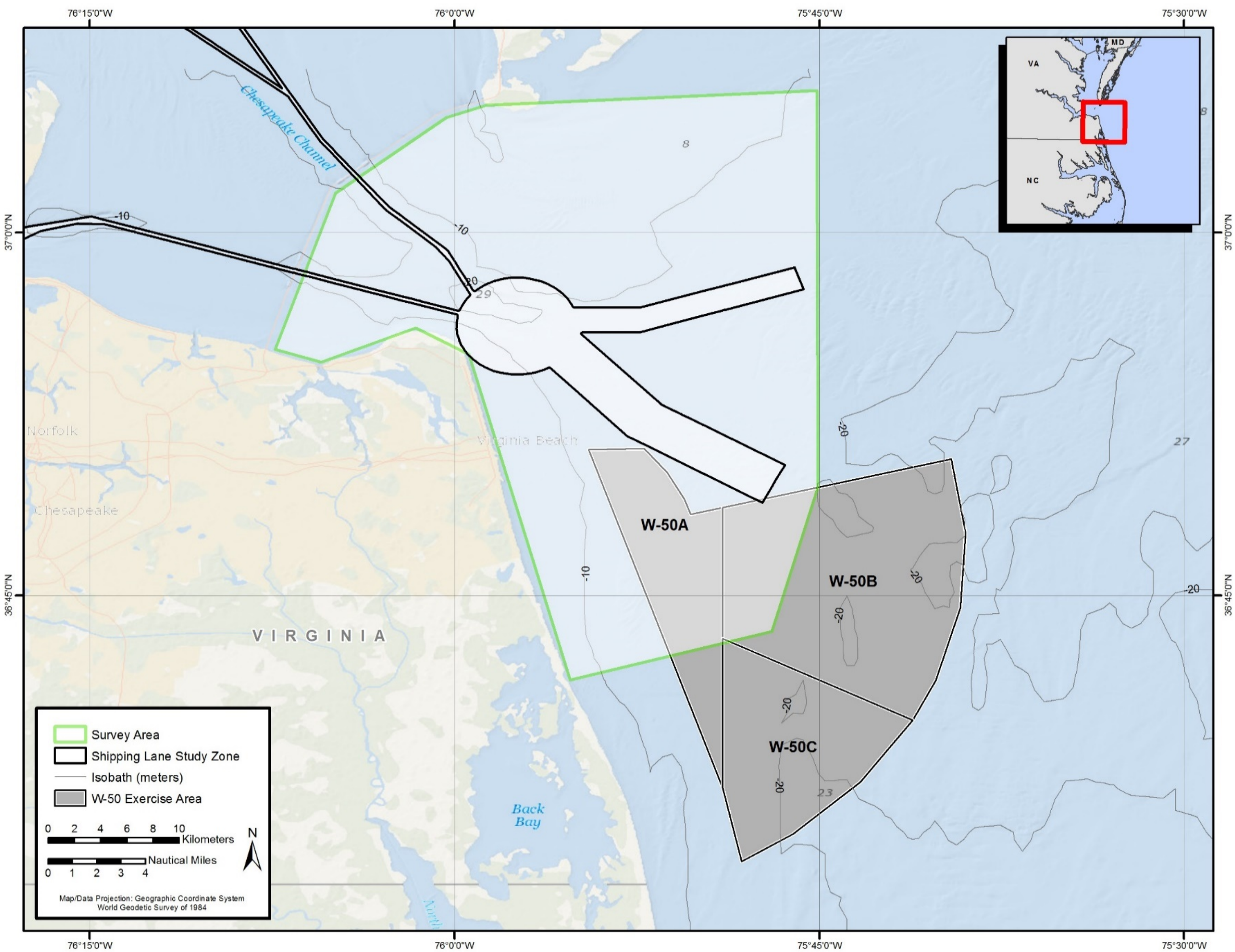

Figure 1. Map of the primary study area, as outlined by the green boundary, which includes waters in and around the mouth of the Chesapeake Bay as well as the W-50 MINEX region off Virginia Beach.

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

(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 (e.g., HDRVAMn001 or HDRVABa001) and compared with one another. At the end of the 2014/2015 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 (VAQS) 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 from all subsequent seasons were submitted to the MAHWC (see Mallette and Barco 2019).

During the 2018/19 season, the use of a small Unmanned Aerial System (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. Data was typically collected at flight heights between 15–30 m, depending on the behavior of the focal animal during the time of the encounter. The sUAS collected 4K UHD video at 30fps. The video has been archived for further analysis.

2.2 Biopsy Sampling

Biopsy samples were collected, when possible, from whales of interest. Biopsies were obtained using either a crossbow or biopsy rifle. In the first, Finn Larsen designed crossbow bolts outfitted with 25-millimeter, ethanol sterilized, stainless steel tips were projected by a 68-kilogram pull Barnett crossbow (Barnett Outdoors, LLC, Tarpon Springs, FL). 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 [°C]) 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°C) 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 will be sent to the University of Groningen for processing (at time of writing CITES permit was still in process).

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 Low Impact Minimally Percutaneous External-electronics Transmitter (LIMPET) configuration (Andrews et al. 2008). Up to 20 tags were available for the 2018/19 field season, including 15 SPOT6 tags, as well as 5 SPLASH10-F Fastloc® Global Positioning System (GPS) tags with location and dive capabilities. 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 DTags (see Shearer et al., 2019). 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 20 to 22 hours per day with an unlimited number of transmissions for SPOT6 tags and limited to 350 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 3 m and 60 s dive definition was established for humpback whales in which a dive needed to be both deeper than 3 m and longer than 60 s 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 above.

Figure 3. LIMPET SPOT6 tag being deployed on a humpback whale.

3. Results

3.1 Nearshore Surveys: 2018/19 Field Season

HDR conducted 28 nearshore surveys for humpback whales between 31 July 2019 and 20 May 2019, covering 3,147 kilometers (km) of trackline with over 170 hours of effort (**Table 1**). During these 28 surveys, there were 64 sightings of humpback whales totaling 80 individuals and 6 sightings of minke whales totaling 9 individuals (**Table 1, Figure 4, and Table A-1**). Of the 70 total large whale sightings during the 2018/19 field season, 34 (48.6 percent) occurred in the shipping lanes and 4 (5.7 percent) occurred in the W-50 MINEX zone (all humpback whales).

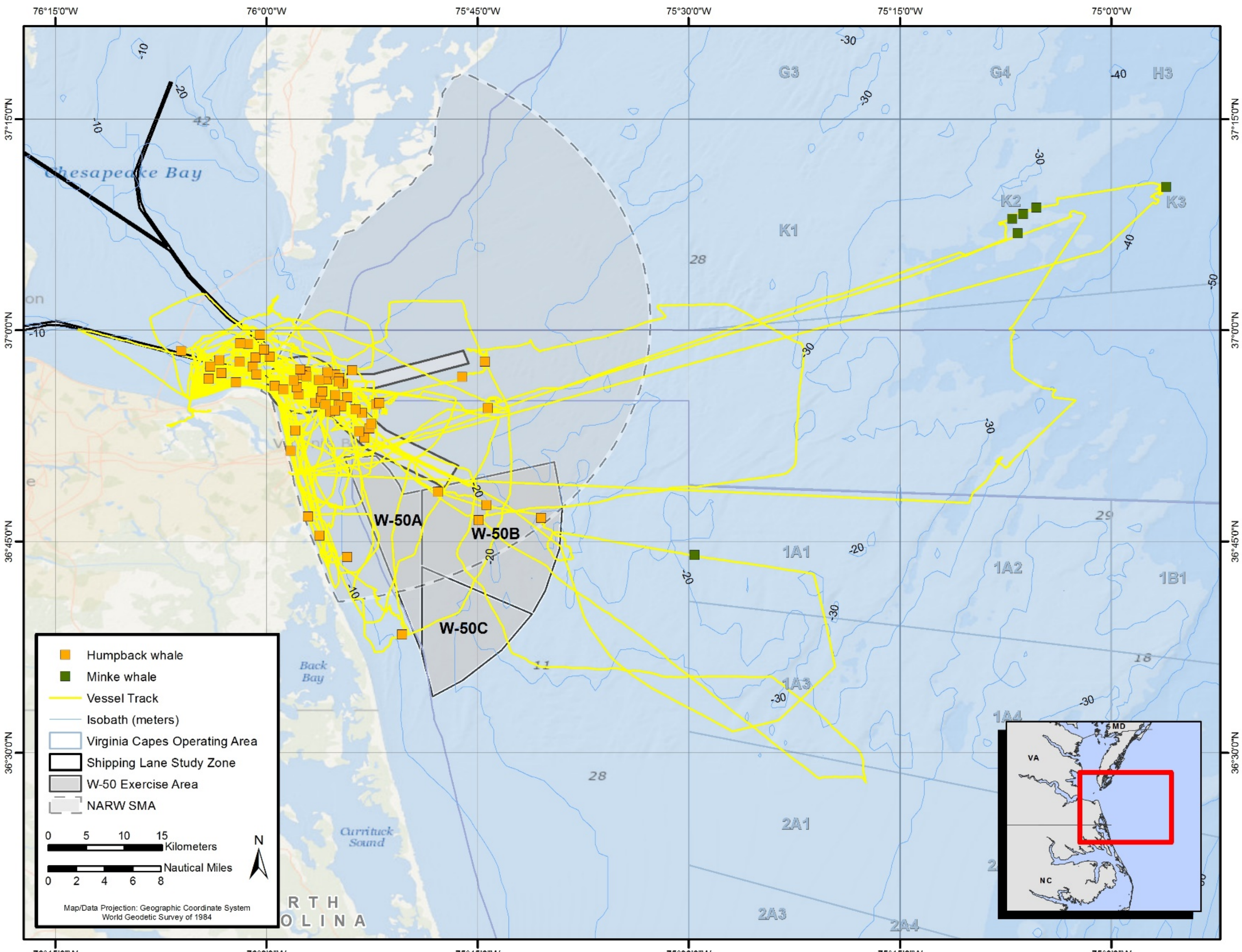

Figure 4. Survey tracks and locations of all humpback (n=64), and minke (n=6) whale sightings: 31 July 2018–20 May 2019.

Table 1. Summary of nearshore survey efforts off Virginia Beach, Virginia: 31 July 2018–20 May 2019.

Date	Survey Time (min)	Distance surveyed (km)	# Sightings Mn	# Individual Mn	# Sightings Ba	# Individual Ba
31-Jul-18	323	61.2	1	1	0	0
12-Nov-18	162	69.1	0	0	0	0
18-Nov-18	314	139.4	0	0	0	0
23-Dec-18	278	112.9	1	1	0	0
26-Dec-18	387	64	3	4	0	0
30-Dec-18	442	98.8	4	6	0	0
6-Jan-19	473	94	7	10	0	0
8-Jan-19	576	136.7	6	8	0	0
12-Jan-19	501	134	4	5	0	0
16-Jan-19	234	76	3	3	0	0
18-Jan-19	380	164	2	2	0	0
22-Jan-19	256	121.4	0	0	0	0
31-Jan-19	306	74	2	2	0	0
1-Feb-19	343	62	6	10	0	0
3-Feb-19	470	179	6	7	0	0
10-Feb-19	482	176.2	4	4	1	1
14-Feb-19	525	218	5	8	0	0
17-Feb-19	268	64	1	1	0	0
19-Feb-19	233	61	3	2	0	0
2-Mar-19	384	98.9	1	1	0	0
7-Apr-19	473	213	0	0	5	8
23-Apr-19	482	214	0	0	0	0
25-Apr-19	411	110	1	1	0	0
1-May-19	224	87	0	0	0	0
4-May-19	458	93	1	1	0	0
8-May-19	332	89	2	2	0	0
16-May-19	292	71	1	1	0	0
20-May-19	223	65	0	0	0	0
Total	**10,232**	**3,147**	**64**	**80**	**6**	**9**

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

3.2 Photo-ID and Photogrammetry Results

The 64 sightings of 80 total individual humpback whales resulted in 32 unique humpback whales (**Table A-1**). An additional five unique whales were identified during offshore surveys conducted as part of the Outer Continental Shelf Break Cetacean Study (**Table A-1**) (see Engelhaupt et al. 2019) for a total of 37 unique humpback whales identified during the 2018/19 field season. Twenty-six (70.0 percent) of those unique whales were categorized as juveniles based on their estimated size and the remaining seven (18.9 percent) were categorized as sub-adults or adults, one (2.7 percent) was classified as an adult, and three (8.1 percent) were not assigned an age class. Only five (13.5 percent) of the 37 individuals were re-sights to HDR's catalog; one individual (HDRVAMn012) was seen in all previous five seasons, three individuals (HDRVAMn007, HDRVAMn021, and HDRVAMn064) were seen in four of the last five seasons, and one individual (HDRVAMn093) was seen in the previous 2017/18 field season (**Table A-1**). The remaining 32 whales were new individuals added to HDR's growing catalog, which, to date, has 160 unique humpback whales (inclusive of identifications added from the Outer Continental Shelf Break Cetacean Study). Seventeen of the 37 (45.9 percent) humpback whales were seen on more than one occasion during the 2018/19 field season, which is greater than the previous season (21.9 percent during 2017/18), but fewer than the 2016/17 season (69.5 percent).

Evidence of human interaction, either via line entanglement scars or propeller scars, is apparent on at least 15 of the 160 (9.4 percent) humpback whales in HDR's catalog (**Table A-1**).

Drone footage was collected on numerous humpback whales. In the field, live footage was used to assist the research team in assessing overall body condition. The video data has been archived and the photogrammetry component is pending analysis.

3.3 Satellite Tagging Results

Twenty-three SPOT6 and three SPLASH10-F satellite tags were deployed during the 2016/17 field season (see Aschettino et al. 2017). Seven SPOT6 and two SPLASH10-F satellite tags were deployed during the 2017/18 field season. During the 2017/18 field season, three of the tags (one SPOT6 and two SPLASH10-F) were deployed on fin whales (see Aschettino et al. 2018). Eight SPOT6 and two SPLASH10-F satellite tags were deployed during the 2018/19 season (**Figures 5 through 14**). Tags transmitted between 3.2 and 13.3 days (mean = 10.4 days) during the 2018/19 field season (**Table 2**) which is shorter than 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). One whale (HDRVAMn146) was tagged during an offshore survey (see Engelhaupt et al. 2019). One whale (HDRVAMn093) was also previously tagged during the 2016/17 field season. Comparisons of the tag tracklines between seasons for the same individual show similarities in movements, although both tags had short durations (**Figure 15**). Whales tagged during the 2018/19 field season showed varied movement strategies, with some exclusively spending time in the primary study area and others moving out of the study area and further offshore or to the north or south (**Figures 5 through 14**). Distance traveled away from the initial tagging location ranged from 18 to 277 km (mean=110 km), the percent of time spent within the shipping channel study area ranged from 0 to 49 percent (mean=13.8 percent), and time spent within the W-50 area ranged from 0-14 percent (mean=3.9 percent) (**Table 3**). For the two whales tagged with SPLASH10-F tags, HDRVAMn152 logged 968 dives and HDRVAMn093 logged 290 dives (**Table 4**). Dive duration ranged from 01:59-09:37 (mean=3:01) for HDRVAMn152 and 00:59-05:05 (mean=1:48) for HDRVAMn093 (**Table 4**). Dive depth ranged from 3-32 m (mean=14.6 m) for HDRVAMn152 and from 3-30 m (mean=8.6 m) for HDRVAMn093 (**Table 4**).

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 12.4 percent (332 of 2,683) of all

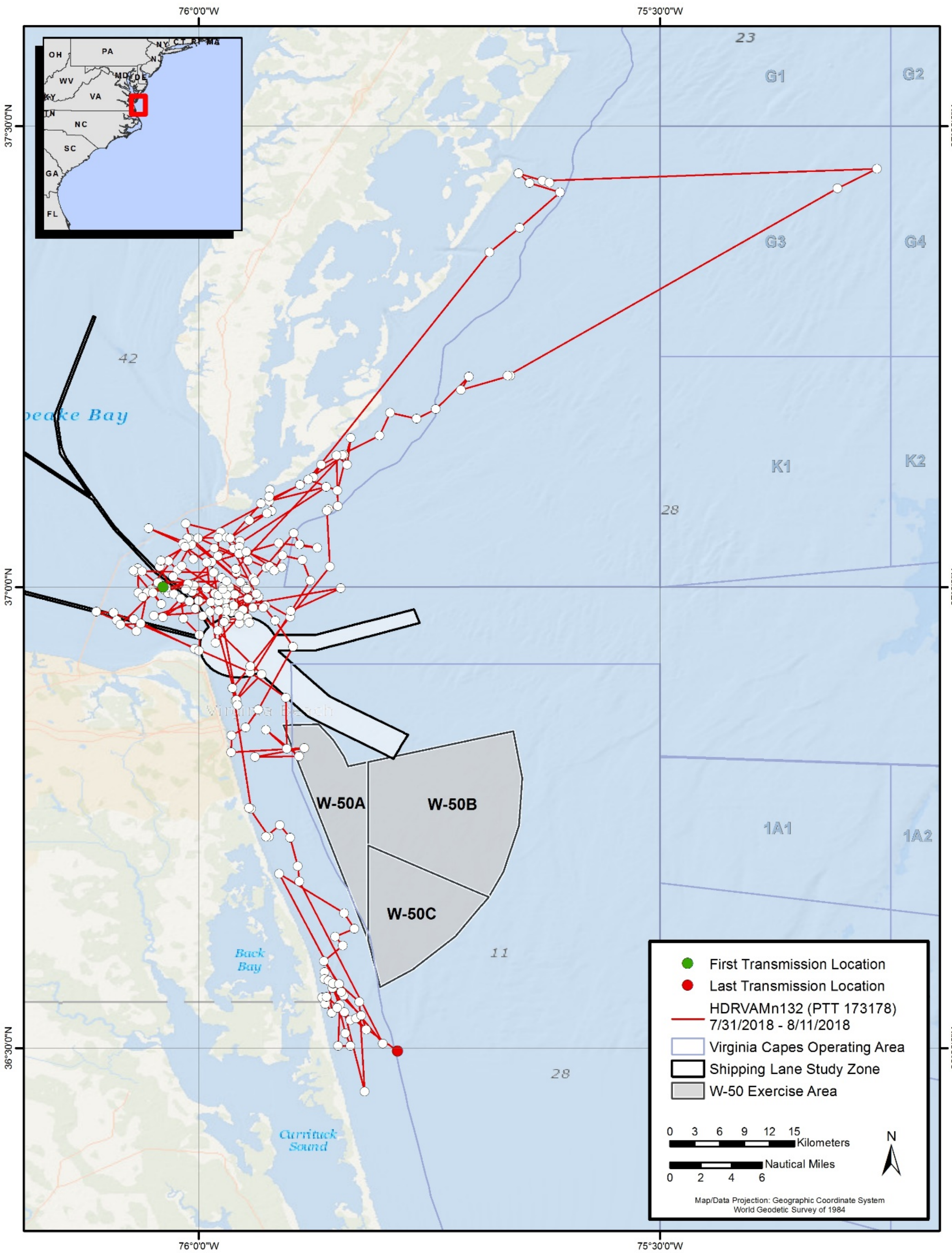

Figure 5. Filtered locations (white dots) and track of humpback whale HDRVAMn132 over 10.7 days of tag-attachment duration.

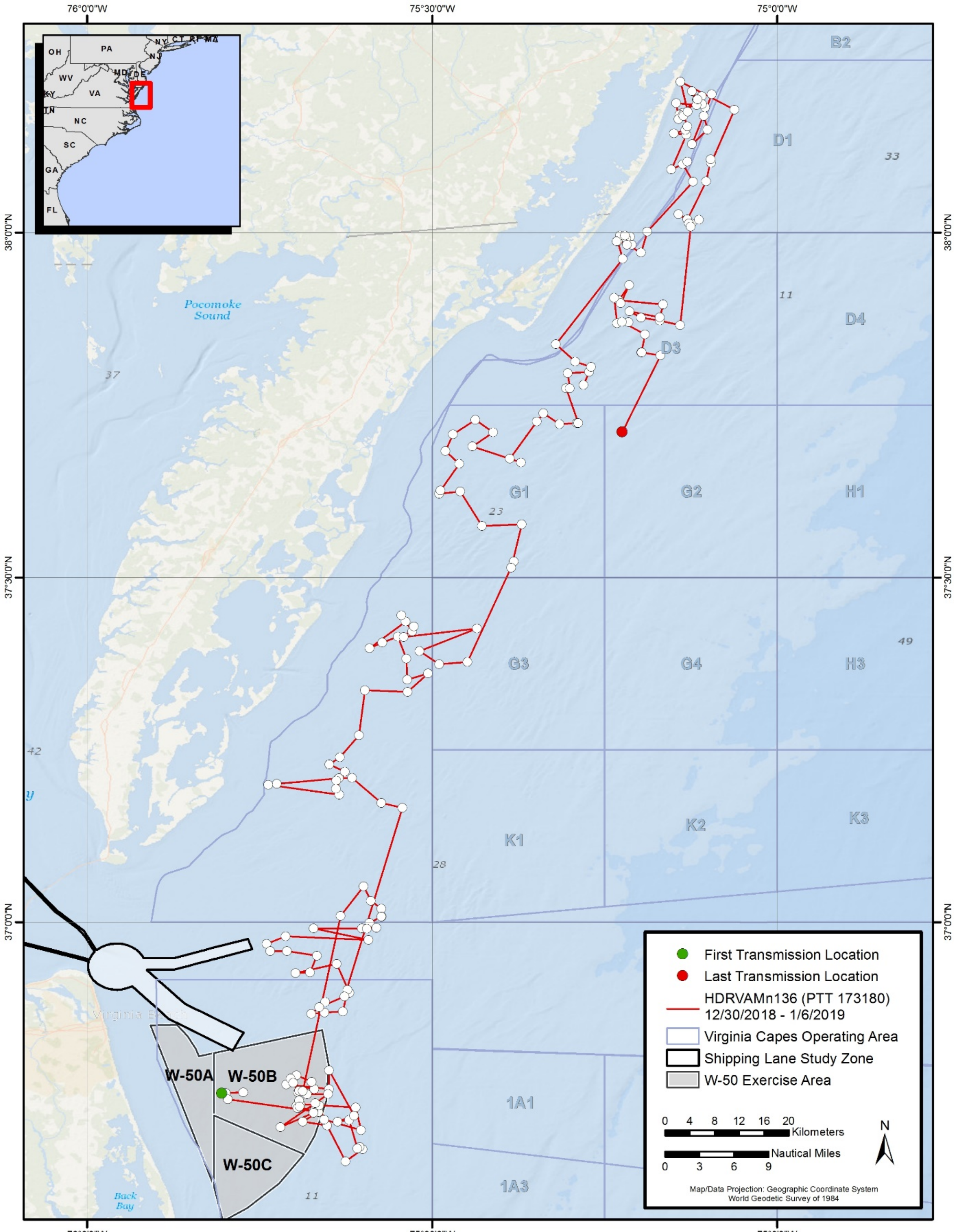

Figure 6. Filtered locations (white dots) and track of humpback whale HDRVAMn136 over 7.0 days of tag-attachment duration.

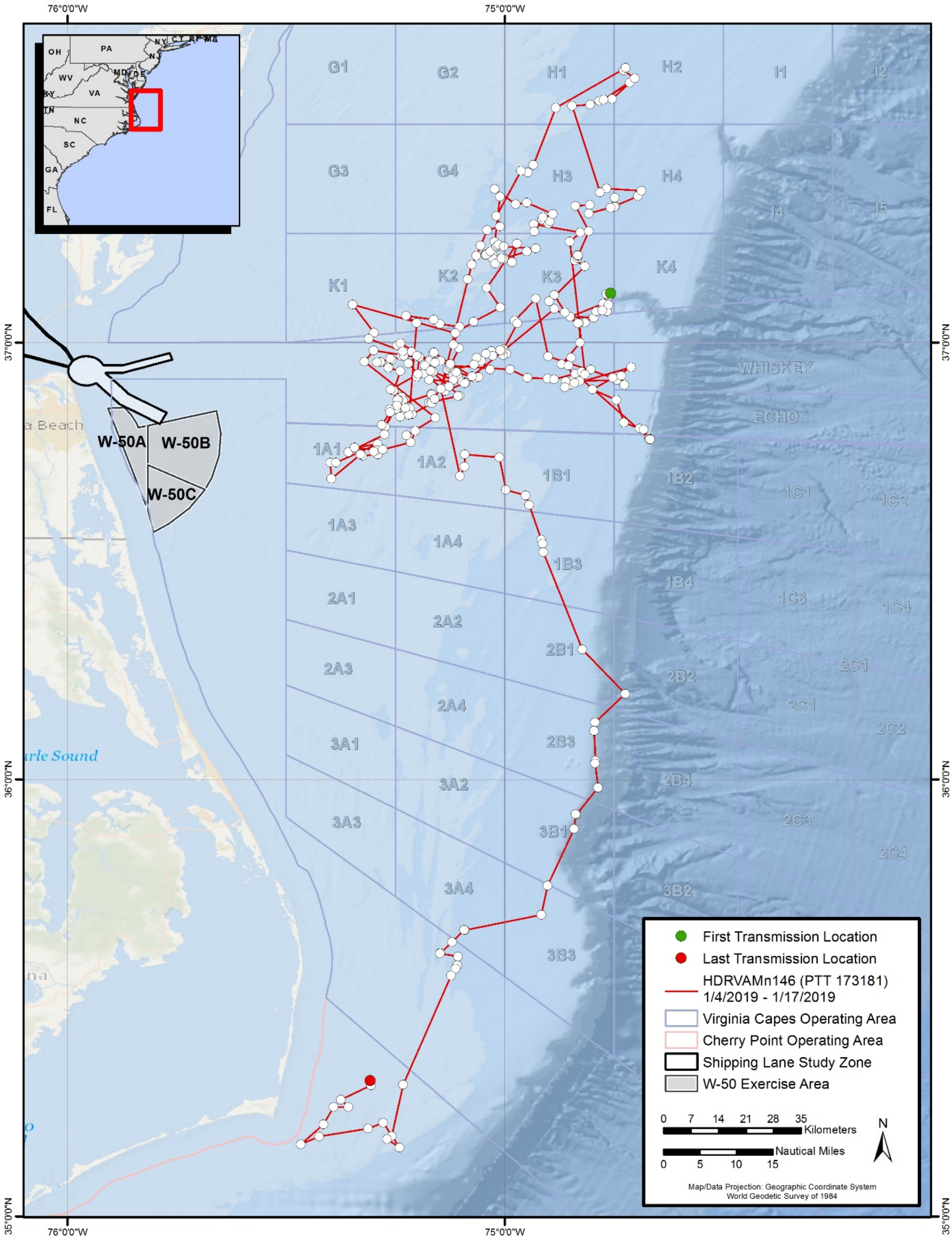

Figure 7. Filtered locations (white dots) and track of humpback whale HDRVAMn146 over 13.3 days of tag-attachment duration.

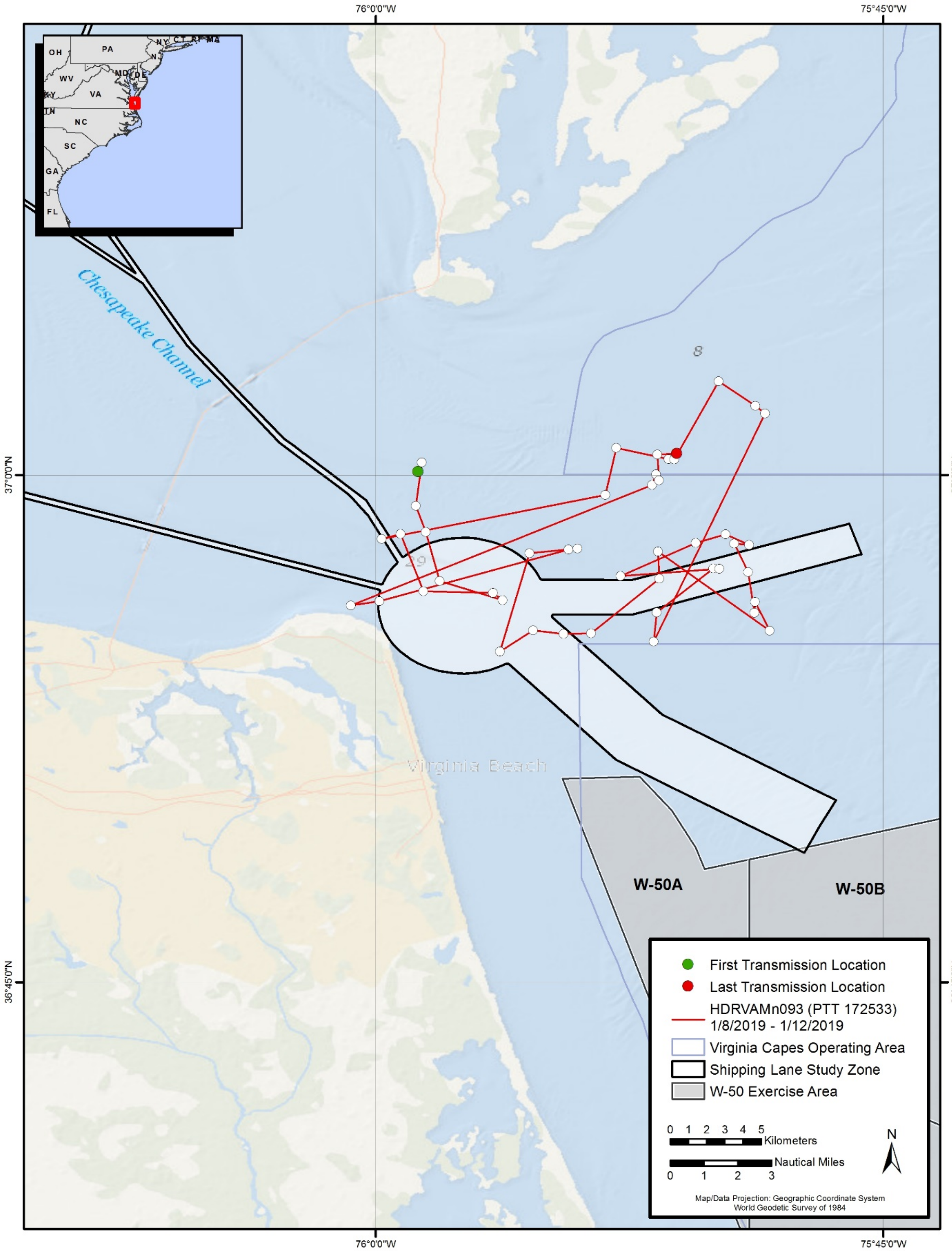

Figure 8. Filtered locations (white dots) and track of humpback whale HDRVAMn093 over 3.2 days of tag-attachment duration.

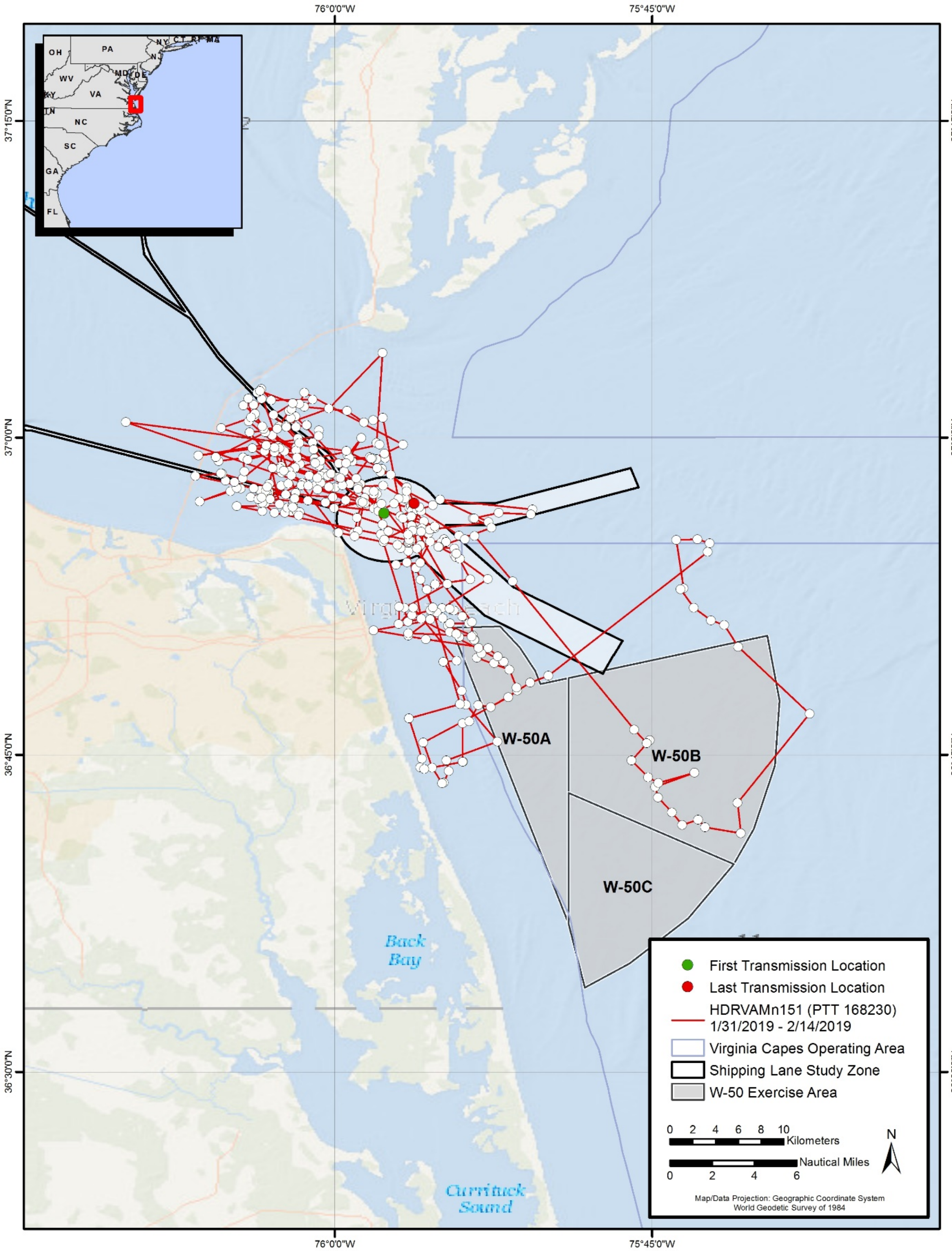

Figure 9. Filtered locations (white dots) and track of humpback whale HDRVAMn151 over 13.3 days of tag-attachment duration.

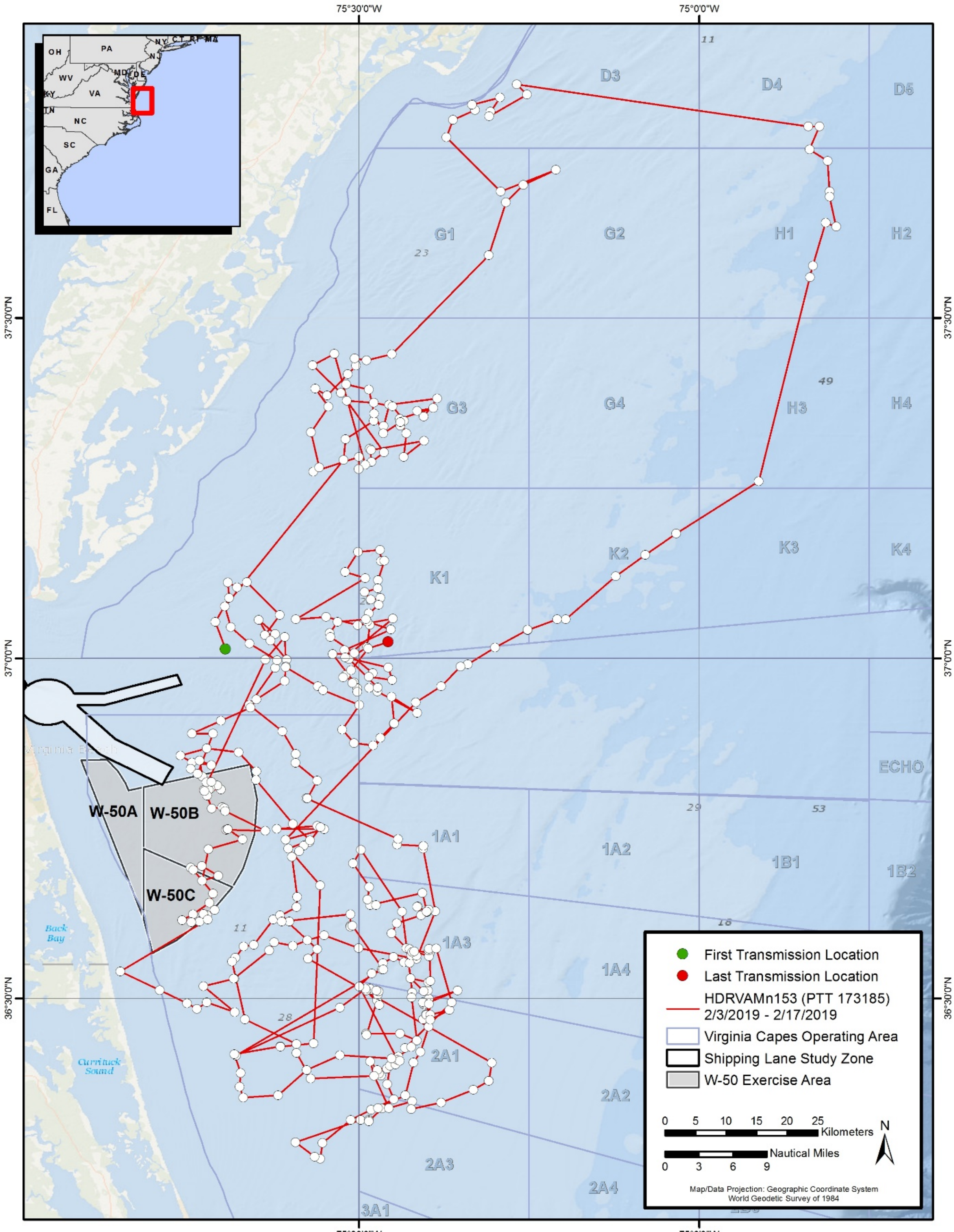

Figure 10. Filtered locations (white dots) and track of humpback whale HDRVAMn153 over 13.3 days of tag-attachment duration.

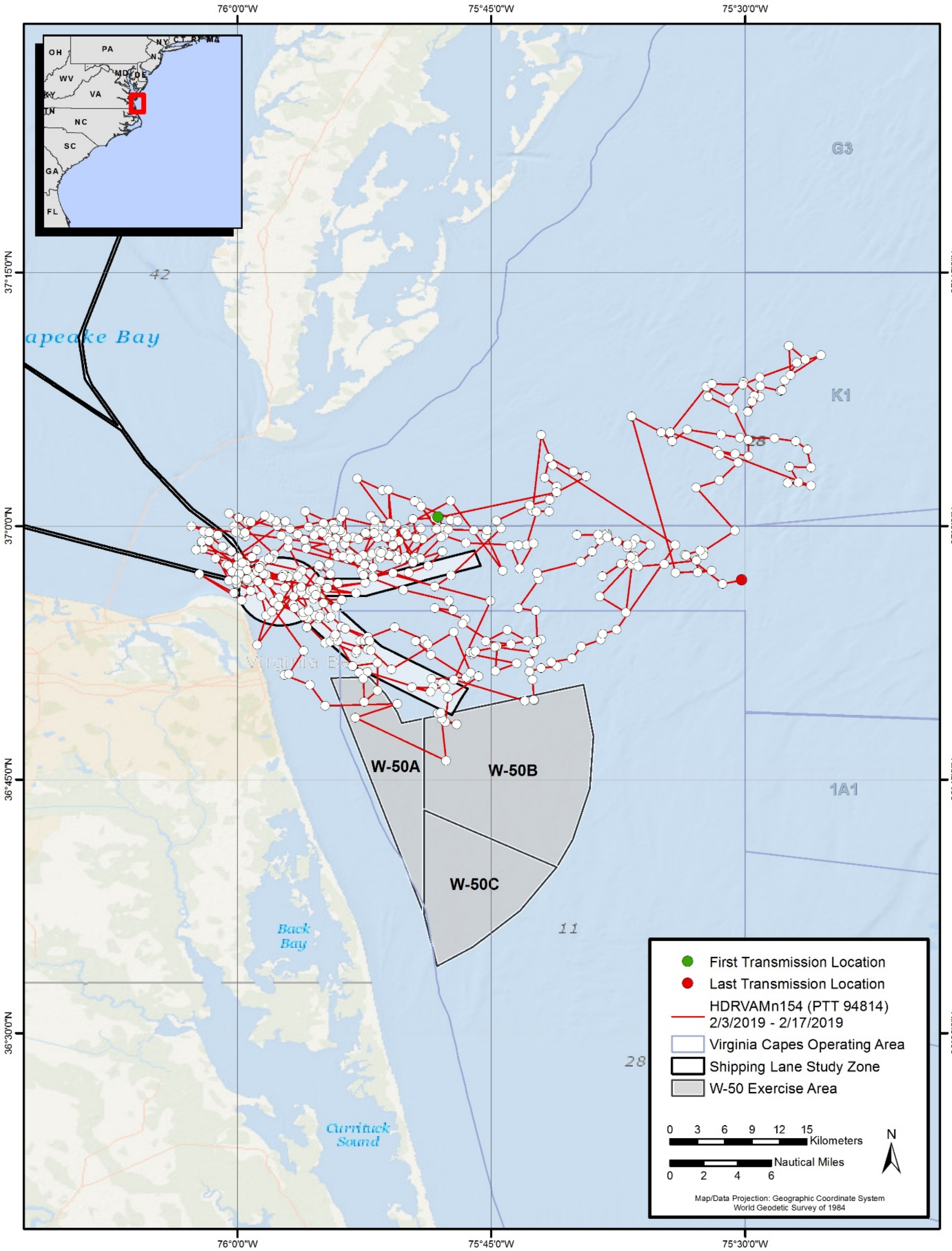

Figure 11. Filtered locations (white dots) and track of humpback whale HDRVAMn154 over 13.2 days of tag-attachment duration.

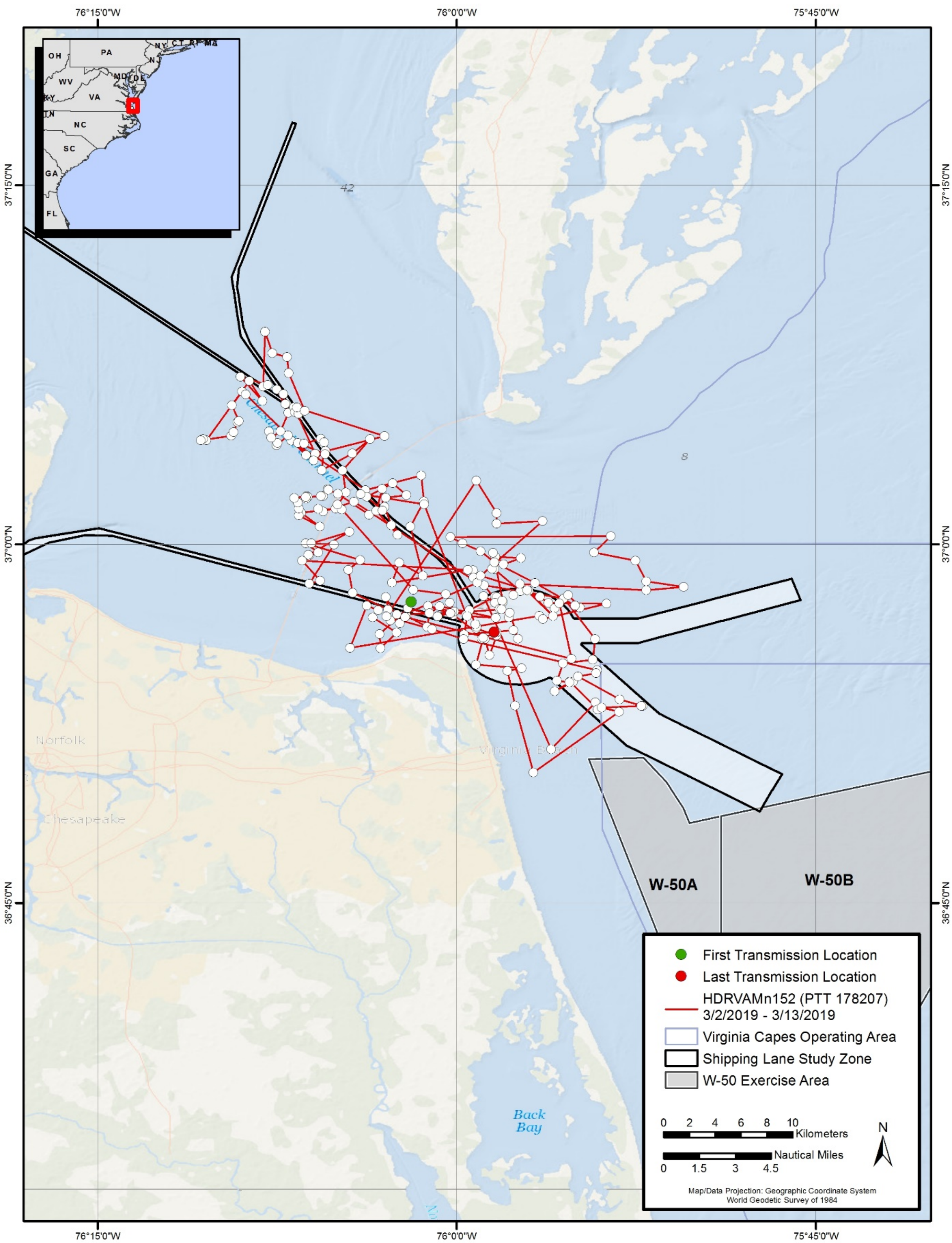

Figure 12. Filtered locations (white dots) and track of humpback whale HDRVAMn152 over 10.2 days of tag-attachment duration.

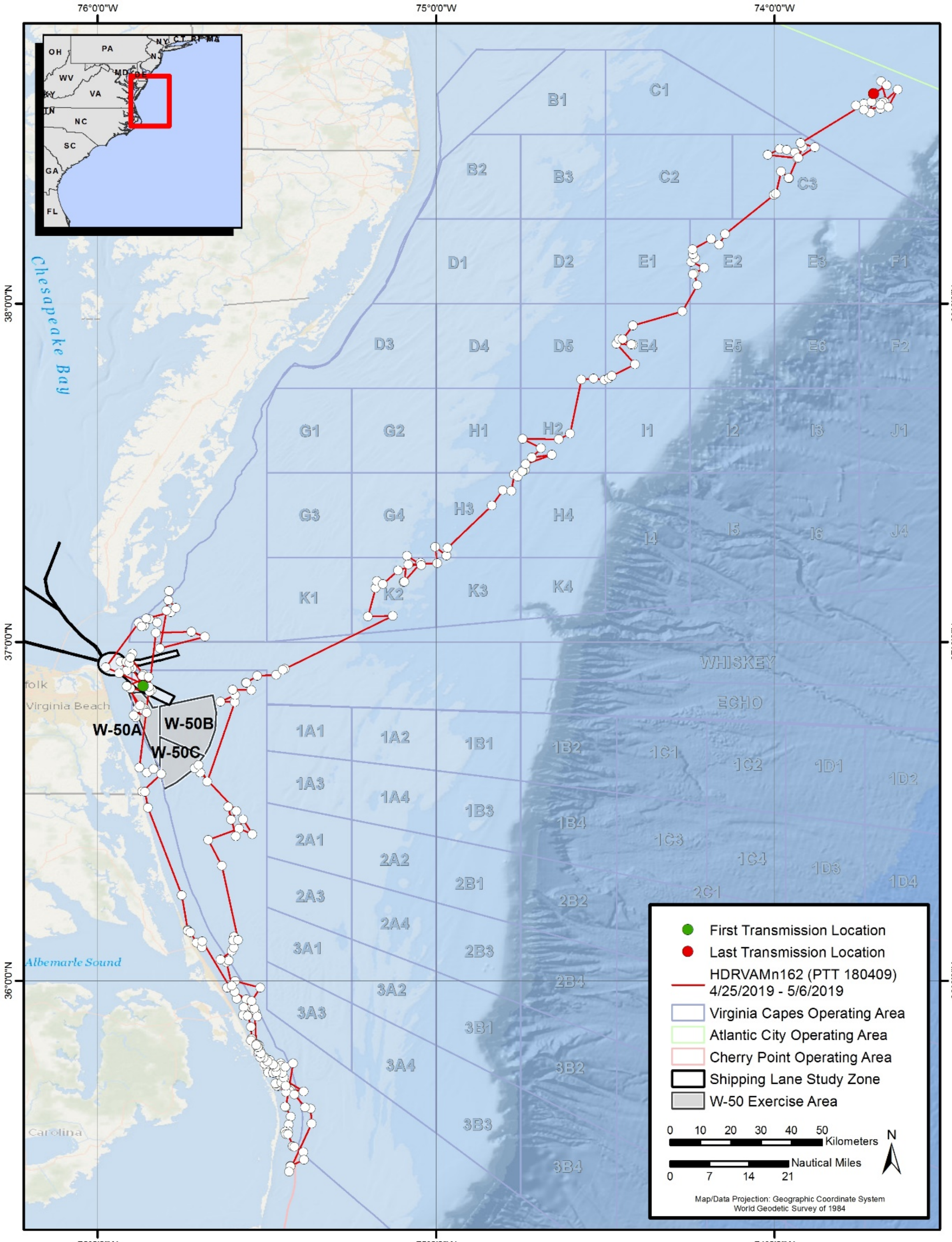

Figure 13. Filtered locations (white dots) and track of humpback whale HDRVAMn162 over 10.5 days of tag-attachment duration.

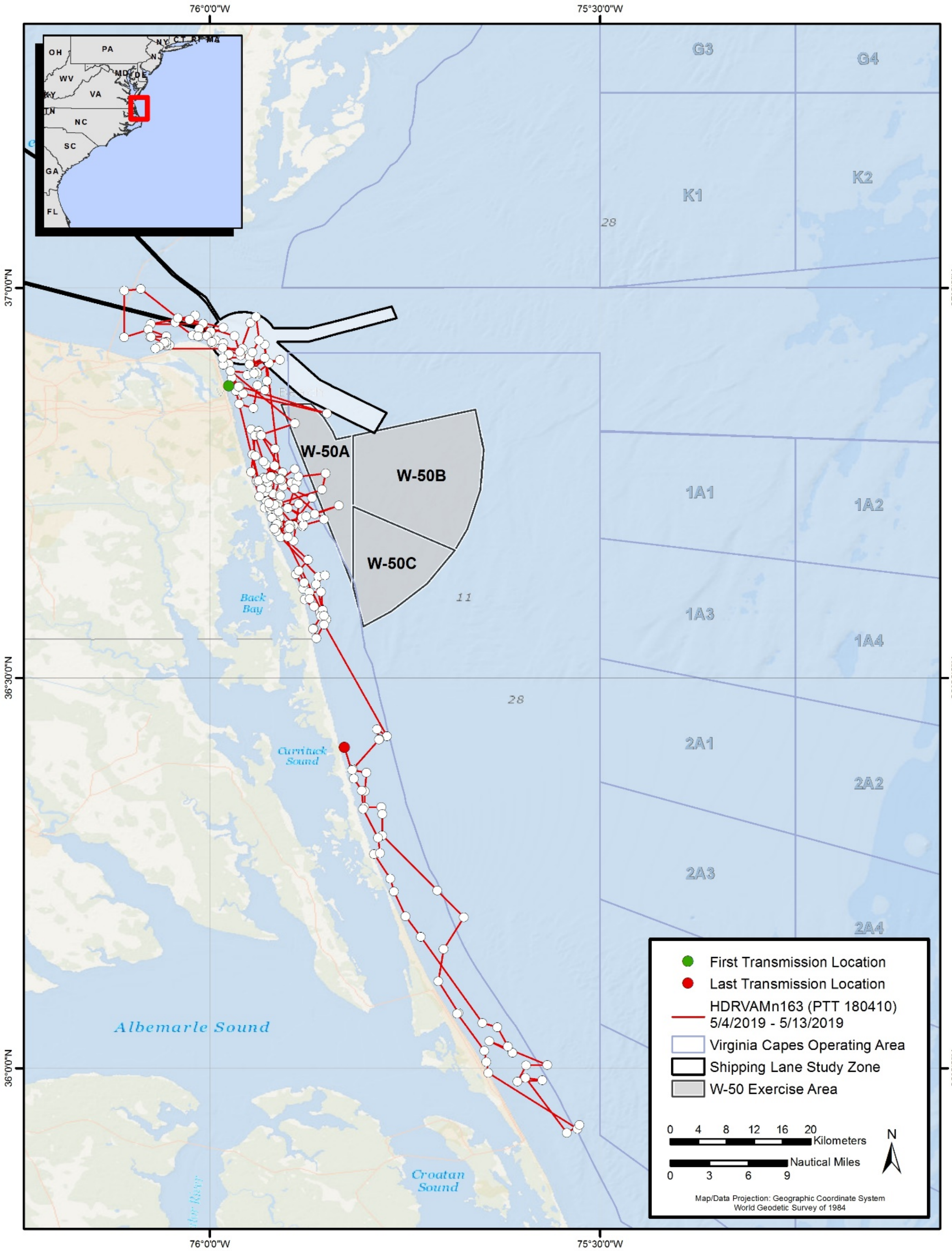

Figure 14. Filtered locations (white dots) and track of humpback whale HDRVAMn163 over 9.3 days of tag-attachment duration.

Table 2. Summary of satellite tag deployment details for all humpback whales tagged during the 2018/19 season.

Animal ID	Estimated Age Class	Tag Type	Argos ID	Deployment (GMT)	Deployment Latitude (°N)	Deployment Longitude (°W)	Last Transmission (GMT)	Days Transmitted
HDRVAMn132	Juvenile	SPOT6	171878	31-Jul-2018 17:47	36.9304	76.0794	11-Aug-2018 12:23	10.7
HDRVAMn136	Juvenile	SPOT6	173180	30-Dec-2018 19:33	36.7905	75.9082	06-Jan-2019 19:54	6.9
HDRVAMn146	Juvenile	SPOT6	173181	04-Jan-2019 19:21	37.0940	74.7657	18-Jan-2019 02:47	13.3
HDRVAMn093	Juvenile	SPLASH10-F	172533	08-Jan-2019 21:51	37.0005	76.0116	12-Jan-2019 01:23	3.2
HDRVAMn151	Juvenile	SPOT6	168230	31-Jan-2019 19:40	36.9438	75.9416	14-Feb-2019 02:13	13.3
HDRVAMn153	Juvenile	SPOT6	173185	03-Feb-2019 15:54	36.9747	75.7393	17-Feb-2019 03:29	13.3
HDRVAMn154	Juvenile	SPOT6	94814	03-Feb-2019 16:32	36.9769	75.7547	17-Feb-2019 00:37	13.2
HDRVAMn152	Juvenile	SPLASH10-F	178207	02-Mar-2019 19:52	36.9596	76.0598	13-Mar-2019 02:23	10.2
HDRVAMn162	Juvenile	SPOT6	180409	25-Apr-2019 17:49	36.8849	75.9584	06-May-2019 09:53	10.5
HDRVAMn163	Juvenile	SPOT6	180410	04-May-2019 13:03	36.8702	75.9731	13-May-2019 22:06	9.3

Table 3. Summary of results from satellite tag data for all humpback whales tagged during the 2018/19 season.

Animal ID	Argos ID	No. Locations Post Filtering	% Within Shipping Channels	% Within W-50	% Within VACAPES	Max Distance from Initial Location (km)	Mean Distance from Initial Location (km)
HDRVAMn132	171878	239	7.5	0.8	6.7	85.1	19.2
HDRVAMn136	173180	194	0	13.9	74.2	173.0	85.5
HDRVAMn146	173181	292	0	0	56.5	225.3	52.0
HDRVAMn093	172533	46	26.1	0	17.4	17.7	10.5
HDRVAMn151	168230	367	27.0	9.8	13.1	37.6	9.7
HDRVAMn153	173185	392	0	8.2	89.8	115.0	45.6
HDRVAMn154	94814	434	21.9	2.5	36.4	37.9	15.2
HDRVAMn152	178207	232	31.9	0	2.6	22.8	9.2
HDRVAMn162	180409	263	4.2	2.3	48.7	277.0	115.0
HDRVAMn163	180410	224	10.3	1.8	4.5	113.0	28.0

Table 4. Summary of dive data from SPLASH10-F satellite tags deployed on humpback whales during the 2018/19 season.

Animal ID	Argos ID	No. Dives Logged	Mean Dive Depth (m)	Max Dive Depth (m)	Mean Dive Duration (mm:ss)	Max Dive Duration (mm:ss)
HDRVAMn093	172533	290	8.6	30	01:48	05:05
HDRVAMn152	178207	968	14.6	32	03:01	09:37

filtered tag locations from this season's deployments were inside shipping channels, 4.4 percent (118/2,683) of locations were inside the W-50 MINEX zone, and 38.6 percent (1,035/2,683) of locations were within the VACAPES OPAREA. When compared to previous seasons, the percentage of time spent within the shipping channels and W-50 have decreased; however, three humpback whales tagged outside of the primary nearshore study area (HDRVAMn136, HDRVAMn146, HDRVAMn153) had zero tag locations in either the shipping channel study zone or W-50 region. Excluding these three tags brings the percentage of time that humpback whales in the nearshore area spent within the shipping channel study region up to 18.4 percent (332 of 1,805 filtered location) and slightly decreases time spent within the W-50 down to 3.3 percent (59 of 1,805 filtered locations).

3.4 Biopsy Results

Nine humpback whale biopsy samples were collected during the 2018/19 field season (**Table A-1**). Thirty-one samples from the 2014/2015 and 2015/2016 field season, comprised of 29 humpback and two fin (see Engelhaupt et al. 2017) 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. HDR is awaiting their Convention on International Trade in Endangered Species (CITES) export permit and will ship samples to the University of Groningen in the Netherlands for processing and integration into a larger North Atlantic humpback whale population study at the end of the 2018/19 field season.

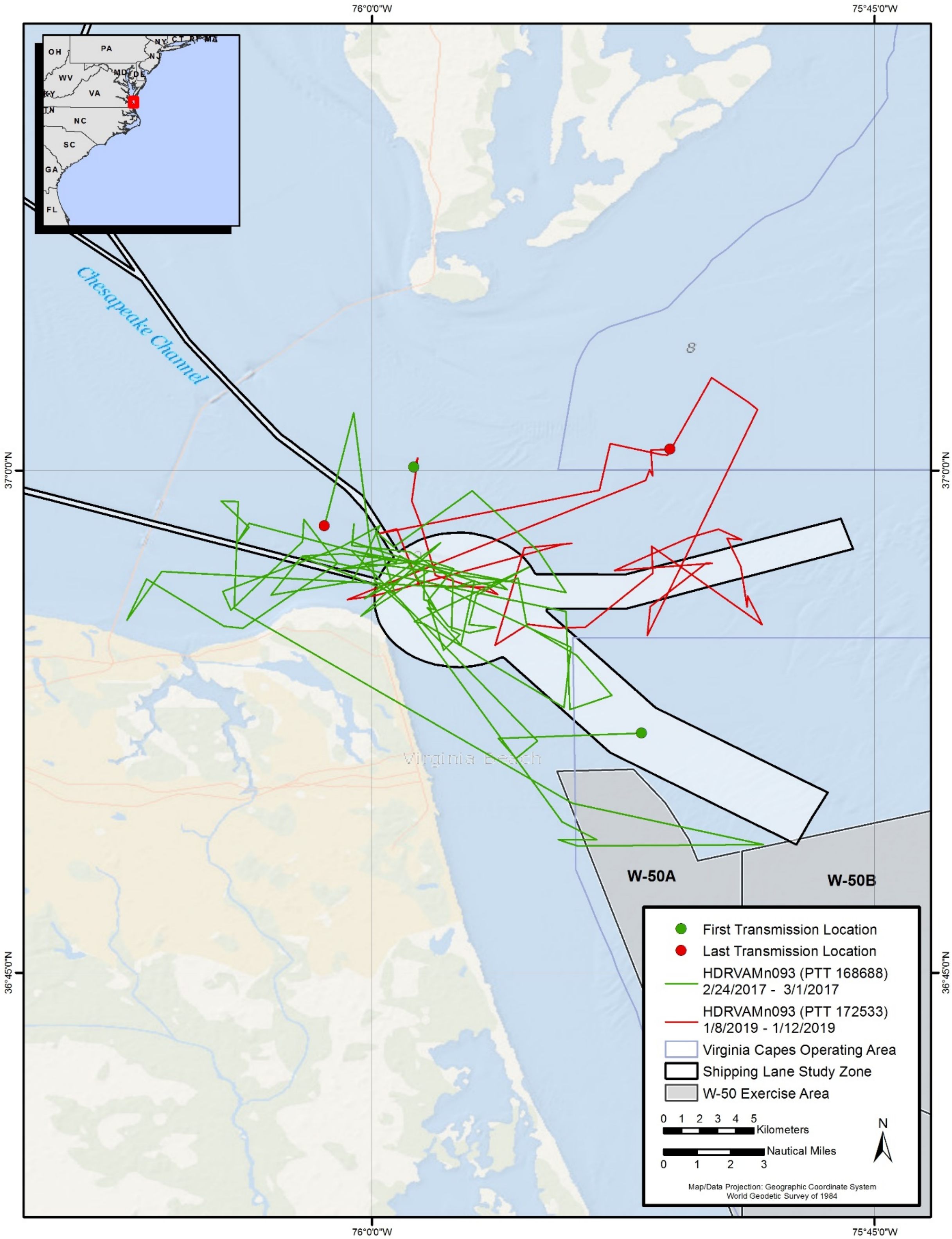

Figure 15. Comparison of tag tracklines for HDRVAMn093 from 2017 (green trackline, 5.2 days) and 2019 (red trackline, 3.2 days).

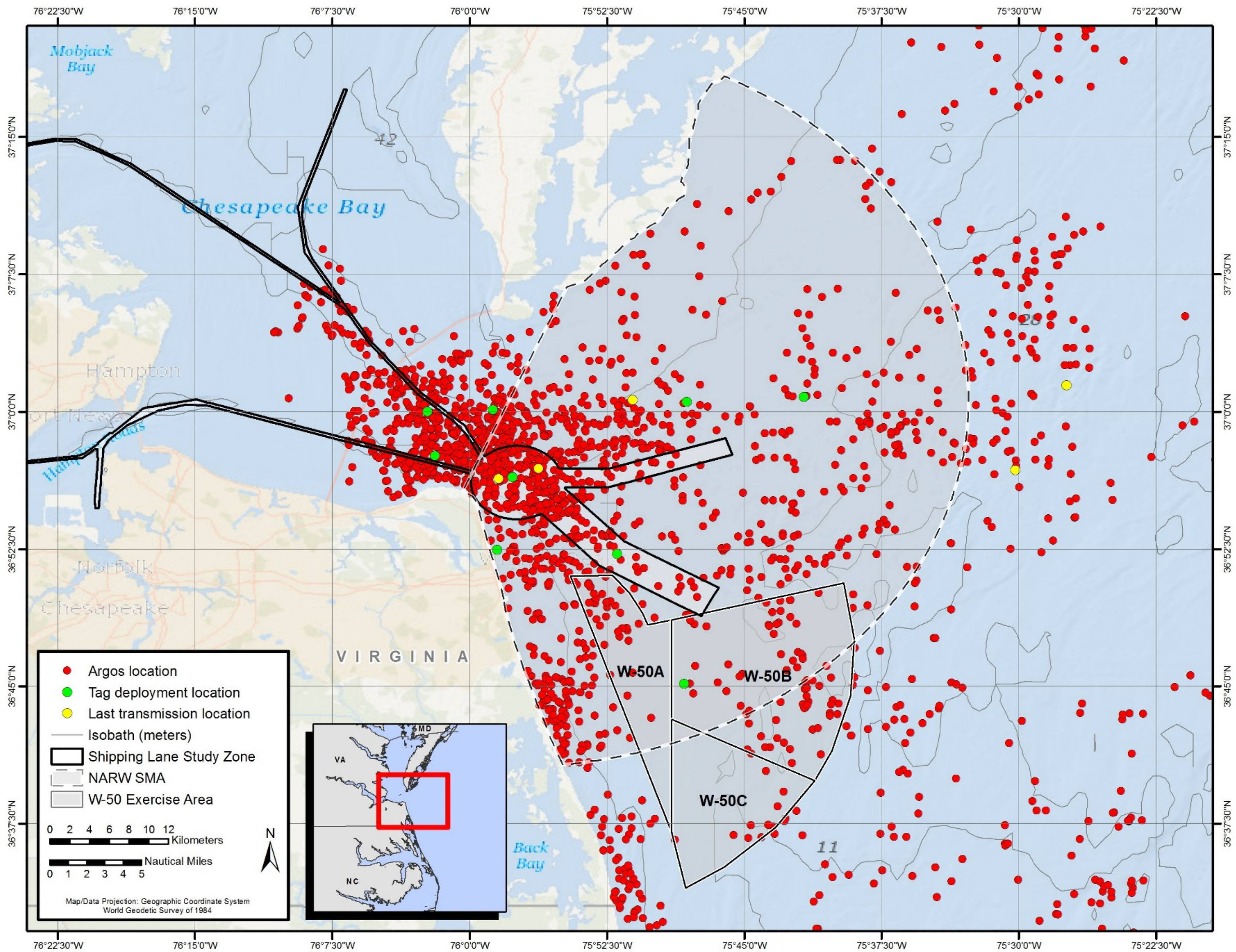

Figure 16. Filtered locations (red dots) of all humpback whale Argos locations in the immediate vicinity of shipping channels at the mouth of the Chesapeake Bay from tag data collected during the 2018/19 field season.

4. Discussion

Analyses of data from this 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 five 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, NMFS 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. 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 five 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 typically not re-sighted, suggesting that sightings early in the season may be whales that are more likely 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 has grown steadily over the course of this project, although plateaued during the 2017/18 field season. There were 31 unique humpback whales identified during the 2014/15 season, 37 during the 2015/16 field season (including 6 individuals seen during the 2014/2015 season) 59 during 2016/17 field season (including 15 re-sightings from the previous two seasons), 21 during the 2017/18 field season (including 7 re-sightings from the previous three seasons) and 37 from the 2018/19 field season (including 5 re-sightings from the previous four seasons). Part of this increase in 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 days and hours used 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 somewhat anomalous in terms of temperature. Multiple cold weather systems significantly impacted water temperature in and around the Chesapeake Bay and surrounding waters. The cold-water temperatures likely affected the 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 push effort further 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.

Integration of the drone during the 2018/19 season has allowed for additional opportunities to examine humpback whale body condition (**Figure 17**) and will also be used to estimate length and therefore will be a valuable tool during subsequent field seasons.

Figure 17. 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 four seasons of satellite tag deployments having taken place, 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 ESA-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 16**). Portions of the Chesapeake Bay, west of the Chesapeake Bay Bridge Tunnel (CBBT), were not utilized by any humpback whales during the 2015/16 and 2017/18 season, but were heavily utilized during the 2016/17 season, and only sparsely used during the 2018/19 season. Short-term distributional shifts related to oceanographic conditions may have caused prey to become more concentrated farther into the bay during the 2016/17, resulting in an increased presence of humpback whales in that area. The presence of humpback whales west of the CBBT raises additional concerns given the high traffic flow in that area, increased vessel speed allowed, and extent of marine-based training occurring at Joint Expeditionary Base Little Creek.

Survey effort in future years should continue to explore this region. Offshore waters have been used by some tagged whales during each of the four tagging seasons. Further analysis of water temperature from Conductivity, Temperature, and Depth 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.

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 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 taken into account 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 D-Tag efforts being conducted by Duke University (see Shearer et al., 2019).

The number of sightings of humpback whales and other species, as well as the level of interaction between whales and vessel traffic to date, support previous recommendations to continue this study using the same techniques described above 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 newly funded D-Tag effort 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 month) and additional information of all photo-identified baleen whales off Virginia Beach, Virginia: December 2014–May 2019.

HDR Catalog ID	2014	2015	2015	2015	2015	2015	2016	2016	2016	2016	2016	2016	2017	2017	2017	2017	2017	2017	2018	2018	2018	2018	2018	2018	2019	2019	2019	2019	2019	Total No. Days Seen	Total No. Seasons Seen	Biopsied? (Y/N)	Satellite Tagged? (Y/N)	Est. Age Class (A/J)	Prop scars or injuries? (Y/N/P)	Total No. Focal Follows	Total No. Focal Follow Minutes
	Season 1 (2014/15)				Season 2 (2015/16)						Season 3 (2016/17)					Season 4 (2017/18)							Season 5 (2018/19)														
	December	January	February	April	October	December	January	February	March	May	November	December	January	February	March	October	November	December	January	February	March	April	July	December	January	February	March	April	May								
Humpback Whales																																					
HDRVAMn003	1																													**1**	**1**	**N**	**N**	**A**	**N**	**0**	**-**
HDRVAMn004	1																													**1**	**1**	**N**	**N**	**A**	**N**	**0**	**-**
HDRVAMn005	1	1									2		3																	**7**	**2**	**Y**	**Y**	**A**	**N**	**1**	**64**
HDRVAMn006	1	1																												**2**	**1**	**N**	**N**	**J**	**N**	**1**	**69**
HDRVAMn007	1	2	1			1					1		3	3										1	4	3				**20**	**4**	**Y**	**Y**	**J**	**N**	**1**	**60**
HDRVAMn008		5																												**5**	**1**	**N**	**N**	**J**	**N**	**3**	**215**
HDRVAMn009		4																												**4**	**1**	**Y**	**N**	**J**	**N**	**2**	**112**
HDRVAMn010		1				2										1														**4**	**3**	**Y**	**Y(2)**	**J**	**N**	**1**	**76**
HDRVAMn011	1	3									1																			**5**	**2**	**Y**	**N**	**J**	**N**	**1**	**60**
HDRVAMn012		2	1				2					2	2	3				2							1	2				**17**	**5**	**Y**	**Y(2)**	**J**	**N**	**2**	**25**
HDRVAMn013	1	7	2																											**10**	**1**	**Y**	**N**	**J**	**N**	**4**	**357**
HDRVAMn014		5					1						1				1													**8**	**4**	**Y**	**N**	**J**	**N**	**1**	**60**
HDRVAMn015		2											1																	**3**	**2**	**Y**	**N**	**J**	**N**	**1**	**58**
HDRVAMn016		1																												**1**	**1**	**N**	**N**	**U**	**N**	**0**	**-**
HDRVAMn017		1																												**1**	**1**	**N**	**N**	**U**	**N**	**0**	**-**
HDRVAMn018		1																												**1**	**1**	**N**	**N**	**U**	**Y**	**0**	**-**
HDRVAMn019		1																												**1**	**1**	**N**	**N**	**U**	**N**	**0**	**-**
HDRVAMn020		1																												**1**	**1**	**N**	**N**	**U**	**N**	**0**	**-**
HDRVAMn021		2									1	2					1	1						3	4					**14**	**4**	**N**	**N**	**SA**	**N**	**1**	**78**
HDRVAMn022		2																												**2**	**1**	**N**	**N**	**J**	**N**	**1**	**85**
HDRVAMn023		1												2	1*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**4**	**2**	**Y**	**Y**	**J**	**N**	**1**	**80**
HDRVAMn024		2																												**2**	**1**	**Y**	**N**	**A**	**P**	**1**	**60**
HDRVAMn025		1																												**1**	**1**	**Y**	**N**	**U**	**N**	**1**	**62**
HDRVAMn027		2				2	1						1																	**6**	**2**	**Y**	**N**	**J**	**N**	**1**	**61**
HDRVAMn028		1																												**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn029			1																											**1**	**1**	**Y**	**N**	**J**	**P**	**1**	**63**
HDRVAMn030				1	1																									**2**	**2**	**N**	**N**	**A**	**N**	**1**	**62**
HDRVAMn031				1							1					1														**3**	**3**	**N**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn032				1																										**1**	**1**	**N**	**N**	**SA**	**N**	**1**	**-**
HDRVAMn033				1																										**1**	**1**	**N**	**N**	**J**	**N**	**0**	**63**
HDRVAMn034				1																										**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn035						2																								**2**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn036						2																								**2**	**1**	**N**	**N**	**J**	**N**	**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

HDR Catalog ID	2014	2015	2015	2015	2015	2015	2016	2016	2016	2016	2016	2016	2017	2017	2017	2017	2017	2017	2018	2018	2018	2018	2018	2018	2019	2019	2019	2019	2019	Total No. Days Seen	Total No. Seasons Seen	Biopsied? (Y/N)	Satellite Tagged? (Y/N)	Est. Age Class (A/J)	Prop scars or injuries? (Y/N/P)	Total No. Focal Follows	Total No. Focal Follow Minutes
	Season 1 (2014/15)				Season 2 (2015/16)						Season 3 (2016/17)					Season 4 (2017/18)							Season 5 (2018/19)														
	December	January	February	April	October	December	January	February	March	May	November	December	January	February	March	October	November	December	January	February	March	April	July	December	January	February	March	April	May								
Humpback Whales (continued)																																					
HDRVAMn037						2	1																							**3**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn039						1																								**1**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn041						1																								**1**	**1**	**N**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn042						4	2																							**6**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn043						1																								**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn044						1																								**1**	**1**	**Y**	**Y**	**J**	**Y**	**0**	**-**
HDRVAMn045						2	2	1	1																					**6**	**1**	**Y**	**Y**	**J**	**Y**	**0**	**-**
HDRVAMn046						2	2																							**4**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn047						1																								**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn048						2					1																			**3**	**2**	**Y**	**Y**	**SA/A**	**N**	**0**	**-**
HDRVAMn049						2					2	2	2			1				1†										**10**	**3**	**Y**	**Y(2)**	**SA/A**	**N**	**0**	**-**
HDRVAMn050						1	3																							**4**	**1**	**Y**	**N**	**J**	**N**	**0**	**-**
HDRVAMn051						1	2	5	1																					**9**	**1**	**Y**	**N**	**J**	**Y**	**0**	**-**
HDRVAMn052							3																							**3**	**1**	**Y**	**N**	**J**	**N**	**0**	**-**
HDRVAMn053							2																							**2**	**1**	**N**	**N**	**J**	**Y**	**0**	**-**
HDRVAMn054							3	2	2																					**7**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn055							2																							**2**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn056							2																							**2**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn057							1																							**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn058							1																							**1**	**1**	**N**	**N**	**J/SA**	**Y**	**0**	**-**
HDRVAMn059							1				2																			**3**	**2**	**Y**	**Y**	**SA**	**N**	**0**	**-**
HDRVAMn060							1																							**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn061								3																						**3**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn062								2	1																					**3**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn063								4																						**4**	**1**	**Y**	**Y**	**J**	**N**	**1**	**120**
HDRVAMn064								1	1		3	4	1	4			2							3	1					**20**	**4**	**Y**	**Y(2)**	**J**	**N**	**0**	**-**
HDRVAMn065									1				1	2																**4**	**2**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn066									2				2																	**4**	**2**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn068										1																				**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn069											1																			**1**	**1**	**Y**	**Y**	**SA**	**N**	**0**	**-**
HDRVAMn071											2																			**2**	**1**	**Y**	**Y**	**SA**	**N**	**0**	**-**
HDRVAMn072											1																			**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn073											1																			**1**	**1**	**N**	**N**	**SA**	**N**	**0**	**-**
HDRVAMn074											1																			**1**	**1**	**N**	**N**	**J**	**N**	**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

HDR Catalog ID	Season 1 (2014/15)				Season 2 (2015/16)						Season 3 (2016/17)					Season 4 (2017/18)							Season 5 (2018/19)							Total No. Days Seen	Total No. Seasons Seen	Biopsied? (Y/N)	Satellite Tagged? (Y/N)	Est. Age Class (A/J)	Prop scars or injuries? (Y/N/P)	Total No. Focal Follows	Total No. Focal Follow Minutes
	2014	2015	2015	2015	2015	2015	2016	2016	2016	2016	2016	2016	2017	2017	2017	2017	2017	2017	2018	2018	2018	2018	2018	2018	2019	2019	2019	2019	2019								
	December	January	February	April	October	December	January	February	March	May	November	December	January	February	March	October	November	December	January	February	March	April	July	December	January	February	March	April	May								
Humpback Whales (continued)																																					
HDRVAMn075											1																			**1**	**1**	**N**	**N**	**SA**	**N**	**0**	**-**
HDRVAMn076											1																			**1**	**1**	**N**	**N**	**SA**	**N**	**0**	**-**
HDRVAMn077											1																			**1**	**1**	**N**	**N**	**SA**	**N**	**0**	**-**
HDRVAMn078											1	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn079												1		2																**3**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn080												1																		**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn081												2	4	3																**9**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn082												1		3			*	-	-	-	-	-	-	-	-	-	-	-	-	**3**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn083												1	1																	**2**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn084												1	5	5																**11**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn085												1	4	3																**8**	**1**	**N**	**N**	**J**	**Y**	**0**	**-**
HDRVAMn086												1																		**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn087													3																	**3**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn088													4	2																**6**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn089													1																	**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn090													4	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**4**	**1**	**Y**	**Y**	**J**	**Y**	**0**	**-**
HDRVAMn091													3	2*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**5**	**1**	**N**	**N**	**SA**	**Y**	**0**	**-**
HDRVAMn092													2	4																**6**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn093													2	4											3	2				**11**	**2**	**Y**	**Y(2)**	**J**	**N**	**0**	**-**
HDRVAMn094													1																	**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn095													2																	**2**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn096													3	2																**5**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn097													1																	**1**	**1**	**N**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn098													3	5																**8**	**1**	**Y**	**N**	**J**	**N**	**0**	**-**
HDRVAMn099													2	4																**6**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn100													1*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn101													1																	**1**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn102													2	4	1															**7**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn103													1	3																**4**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn104													2	2																**4**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn105													1	2																**3**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn106													1	2																**3**	**1**	**N**	**N**	**J**	**P**	**0**	**-**
HDRVAMn107														2																**2**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn108														2																**2**	**1**	**N**	**N**	**J**	**N**	**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

HDR Catalog ID	December 2014	January 2015	February 2015	April 2015	October 2015	December 2015	January 2016	February 2016	March 2016	May 2016	November 2016	December 2016	January 2017	February 2017	March 2017	October 2017	November 2017	December 2017	January 2018	February 2018	March 2018	April 2018	July 2018	December 2018	January 2019	February 2019	March 2019	April 2019	May 2019	Total No. Days Seen	Total No. Seasons Seen	Biopsied? (Y/N)	Satellite Tagged? (Y/N)	Est. Age Class (A/J)	Prop scars or injuries? (Y/N/P)	Total No. Focal Follows	Total No. Focal Follow Minutes
	Season 1 (2014/15)				Season 2 (2015/16)						Season 3 (2016/17)					Season 4 (2017/18)							Season 5 (2018/19)														
Humpback Whales (continued)																																					
HDRVAMn109														2	1															**3**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn110														2																**2**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn111														1																**1**	**1**	**Y**	**N**	**SA/A**	**N**	**0**	**-**
HDRVAMn112														1																**1**	**1**	**Y**	**N**	**J**	**P**	**0**	**-**
HDRVAMn113																1														**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn114																	1		1											**2**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn115																	2													**2**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn116																	1													**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn117																	1													**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn118																		1												**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn119																		2												**2**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn120																		1												**1**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn121																		1												**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn122																		3												**3**	**1**	**Y**	**N**	**J**	**N**	**0**	**-**
HDRVAMn123																		1												**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn124																		1												**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn125																		2												**2**	**1**	**N**	**N**	**J**	**Y**	**0**	**-**
HDRVAMn126																				1†										**1**	**1**	**Y**	**Y**	**SA/A**	**N**	**0**	**-**
HDRVAMn127																						1†								**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn128																						1†								**1**	**1**	**N**	**N**	**A**	**N**	**0**	**-**
HDRVAMn129																						1†								**1**	**1**	**N**	**N**	**A**	**N**	**0**	**-**
HDRVAMn130																						1†								**1**	**1**	**N**	**N**	**J/SA**	**N**	**0**	**-**
HDRVAMn131																						1†								**1**	**1**	**N**	**N**	**U**	**N**	**0**	**-**
HDRVAMn132																							1							**1**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn133																								1†						**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn134																								1†						**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn135																								1	1					**2**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn136																								1						**1**	**1**	**N**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn137																								1	1					**2**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn138																								1						**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn139																									1					**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn140																									1					**1**	**1**	**N**	**N**	**U**	**N**	**0**	**-**
HDRVAMn141																									1					**1**	**1**	**N**	**N**	**U**	**N**	**0**	**-**
HDRVAMn142																									2	2				**4**	**1**	**N**	**N**	**J**	**N**	**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

HDR Catalog ID	2014	2015	2015	2015	2015	2015	2016	2016	2016	2016	2016	2016	2017	2017	2017	2017	2017	2017	2018	2018	2018	2018	2018	2018	2019	2019	2019	2019	2019	Total No. Days Seen	Total No. Seasons Seen	Biopsied? (Y/N)	Satellite Tagged? (Y/N)	Est. Age Class (A/J)	Prop scars or injuries? (Y/N/P)	Total No. Focal Follows	Total No. Focal Follow Minutes
	Season 1 (2014/15)				Season 2 (2015/16)						Season 3 (2016/17)					Season 4 (2017/18)							Season 5 (2018/19)														
	December	January	February	April	October	December	January	February	March	May	November	December	January	February	March	October	November	December	January	February	March	April	July	December	January	February	March	April	May								
Humpback Whales (continued)																																					
HDRVAMn143																									2					**2**	**1**	**N**	**N**	**J/SA**	**N**	**0**	**-**
HDRVAMn144																									1					**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn145																									1	1				**2**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn146																									1†					**1**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn147																									1					**1**	**1**	**N**	**N**	**J**	**Y**	**0**	**-**
HDRVAMn148																									1	2				**3**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn149																									1	3				**4**	**1**	**N**	**N**	**SA/A**	**N**	**0**	**-**
HDRVAMn150																									1					**1**	**1**	**N**	**N**	**SA/A**	**N**	**0**	**-**
HDRVAMn151																									1	1*	-	-	-	**2**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn152																										2	1			**3**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn153																										2				**2**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn154																										1				**1**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn155																													1†	**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn156																										2				**2**	**1**	**Y**	**N**	**SA/A**	**N**	**0**	**-**
HDRVAMn157																										1				**1**	**1**	**N**	**N**	**SA/A**	**N**	**0**	**-**
HDRVAMn158																										1				**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn159																										1				**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn160																										1				**1**	**1**	**N**	**N**	**A**	**N**	**0**	**-**
HDRVAMn161																											1			**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
HDRVAMn162																												1		**1**	**1**	**N**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn163																													2	**2**	**1**	**Y**	**Y**	**J**	**N**	**0**	**-**
HDRVAMn164																													1	**1**	**1**	**N**	**N**	**J**	**N**	**0**	**-**
Totals	**7**	**49**	**5**	**5**	**1**	**30**	**32**	**18**	**9**	**1**	**24**	**19**	**70**	**66**	**2**	**4**	**9**	**12**	**1**	**2**	**0**	**5**	**1**	**13**	**30**	**27**	**2**	**1**	**4**			**58**	**51**		**15**	**29**	**1951**
Fin Whales																																					
HDRVABp001		1																												**1**	**1**	**N**	**N**	**A**	**N**	**1**	**61**
HDRVABp002		1																												**1**	**1**	**N**	**N**	**C**	**N**	**0**	**-**
HDRVABp003		1																												**1**	**1**	**N**	**N**	**A**	**N**	**0**	**-**
HDRVABp009								2																						**2**	**1**	**N**	**N**	**SA/A**	**N**	**0**	**-**
HDRVABp010								2																						**2**	**1**	**N**	**N**	**SA/A**	**N**	**0**	**-**
HDRVABp011								1																						**1**	**1**	**N**	**N**	**A**	**N**	**0**	**-**
HDRVABp016														1†					1											**2**	**2**	**N**	**Y**	**SA**	**N**	**0**	**-**
HDRVABp020															1†				1											**2**	**2**	**N**	**Y**	**SA**	**N**	**0**	**-**
HDRVABp035																		1*	-	-	-	-	-	-	-	-	-	-	-	**1**	**1**	**N**	**N**	**SA**	**N**	**0**	**-**
HDRVABp037																			1											**1**	**1**	**N**	**N**	**SA**	**N**	**0**	**-**

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HDR Catalog ID	Season 1 (2014/15)				Season 2 (2015/16)						Season 3 (2016/17)					Season 4 (2017/18)							Season 5 (2018/19)							Total No. Days Seen	Total No. Seasons Seen	Biopsied? (Y/N)	Satellite Tagged? (Y/N)	Est. Age Class (A/J)	Prop scars or injuries? (Y/N/P)	Total No. Focal Follows	Total No. Focal Follow Minutes
	2014	2015	2015	2015	2015	2015	2016	2016	2016	2016	2016	2016	2017	2017	2017	2017	2017	2017	2018	2018	2018	2018	2018	2018	2019	2019	2019	2019	2019								
	December	January	February	April	October	December	January	February	March	May	November	December	January	February	March	October	November	December	January	February	March	April	July	December	January	February	March	April	May								
Fin Whales (continued)																																					
HDRVABp038																			1											**1**	**1**	**N**	**N**	**SA**	**N**	**0**	**-**
HDRVABp040																			1											**1**	**1**	**N**	**N**	**SA**	**N**	**0**	**-**
HDRVABp041																			1											**1**	**1**	**N**	**Y**	**SA**	**N**	**0**	**-**
HDRVABp042																			1											**1**	**1**	**N**	**N**	**SA**	**N**	**0**	**-**
Totals		**3**	**0**	**0**	**0**	**0**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**1†**	**1†**	**0**	**0**	**1**	**7**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**			**0**	**3**		**0**	**1**	**61**
Minke Whales																																					
HDRVABa003														1																**1**	**1**	**N**	**N**	**A**	**N**	**0**	**-**
HDRVABa004														1																**1**	**1**	**N**	**N**	**A**	**N**	**0**	**-**
HDRVABa009																												1		**1**	**1**	**N**	**N**	**A**	**N**	**0**	**-**
HDRVABa010																												1		**1**	**1**	**N**	**N**	**A**	**N**	**0**	**-**
HDRVABa011																												1		**1**	**1**	**N**	**N**	**A**	**N**	**0**	**-**
HDRVABa012																												1		**1**	**1**	**N**	**N**	**A**	**N**	**0**	**-**
Totals		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**			**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