Sea Turtle Tagging and Tracking in Chesapeake Bay and Coastal Waters of Virginia: 2015 Annual Progress Report

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Tagging a loggerhead turtle *(Caretta caretta)* (bottom right). Cover photo taken by Virginia Aquarium & Marine Science Center Foundation under NMFS Permit 16134.

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Acronyms and Abbreviations

°C	degrees Celsius
cm	centimeter(s)
EST	Eastern Standard Time
GPS	Global Positioning System
hr	hour(s)
JEB	Joint Expeditionary Base
kg	kilogram(s)
km	kilometer(s)
LC	Little Creek
m	meter(s)
min	minute(s)
mm	millimeter(s)
NAVFAC	Naval Facilities Engineering Command
NMFS	National Marine Fisheries Service
NNB	Norfolk Naval Base
PCV	Packed cell volume of blood
PIT	passive integrated transponder
PTT	platform transmitter terminal
SCL	straight carapace length
SD	standard deviation
SMRU	Sea Mammal Research Unit
SRDL	satellite-relay data logger
SSSM	switching state-space model
TEWG	Turtle Expert Working Group
U.S.	United States
UD	utilization distribution
USFWS	U.S. Fish & Wildlife Service
VAQF	Virginia Aquarium & Marine Science Center Foundation
VCU	Virginia Commonwealth University

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1. Background and Introduction

Five species of sea turtles occur in the Chesapeake Bay and the coastal waters of Virginia with varying regularity. They include the loggerhead turtle (*Caretta caretta*), Kemp's ridley turtle (*Lepidochelys kempii*), green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*), and hawksbill turtle (*Eretmochelys imbricata*). Loggerhead and Kemp's ridley turtles are the most abundant and regularly occurring species in Virginia (Musick and Limpus 1997, Swingle et al. 2010, 2011, 2012, 2013, 2014). Until 2015, green turtles and leatherback turtles were observed annually, but were far less abundant in the region (Swingle et al. 2010, 2011, 2012, 2013, 2014, 2015). In 2015, a fall mortality event of unknown origin resulted in 69 green turtle strandings, 23 percent of the 295 total strandings for the year (Swingle et al. 2016). Mean annual Virginia green turtle strandings for the previous 5 years was 11 (standard deviation [SD]=3, range=4–17; Virginia Aquarium & Marine Science Center Foundation [VAQF] unpublished data). The hawksbill turtle is the rarest species, with only two records in Virginia (Keinath et al. 1991). Cheloniid, or hardshell, sea turtles which excludes leatherback turtles, in Virginia are migratory, appearing in the region in the late spring when water temperatures rise to approximately 20 degrees Celsius (°C) and leaving in the fall when water temperatures decrease (Mansfield et al. 2009).

The majority of stranded sea turtles in Virginia are juvenile loggerheads. From 2011 to 2015, the average size of non-hatchling loggerheads was 70.1 centimeters (cm) (SD=16.3) straight carapace length (SCL, measured from the nuchal notch to the posterior tip) with a range of 46.2 to 116.1 cm (Swingle et al. 2012, 2013, 2014, 2015, 2016). A few strandings occur in January of most years but they are considered to be from the previous year's season. The first loggerhead strandings of the spring season usually occur in the second half of May, but loggerheads have been sighted and incidentally captured in early April. Stranded Kemp's ridley turtles are also predominantly juveniles, ranging from 17.7 to 67.8 cm SCL with a mean of 35.0 cm (SD=9.7) from 2011 to 2015. Kemp's ridleys usually first appear in the stranding record in the second half of May but have stranded in the first half of the month. Stranded green turtles are almost exclusively juveniles with only one adult turtle in the stranding record in the past 20 years (VAQF unpublished data). From 2011 to 2015, stranded green turtles ranged in size from 23.5 to 35.9 cm SCL with a mean of 28.5 cm (SD=2.6). Green turtles tend to enter the stranding record later in the year than loggerhead and Kemp's ridley turtles, with the first strandings usually occurring in July, but there are several records of a green turtle earlier in the season. From 2011 to 2015, leatherback turtles stranded in all months from May through October but were relatively uncommon in the stranding record with only 17 total strandings. Most of the leatherback strandings occurred in May (n=4) and June (n=7) and were live animals entangled in pound nets. Length measurements were only collected for five dead stranded leatherbacks; the mean SCL was 146.1 cm (SD=6.7) and the range was 137.8 to 156.4 cm.

In the past 10 years, strandings of both Kemp's ridley and green turtles have been increasing, while loggerhead numbers have been relatively stable (Barco et al. 2015). All three species have nested in Virginia, but only loggerheads nested annually with an average of fewer than 10 nests per year in the past 10 years (Ruth Boettcher, Virginia Department of Game and Inland Fisheries, pers. comm.). For all three species, the stranding record includes more female than male turtles; of turtles where sex could be determined, 61 percent were identified as female and 39 percent as male. More general species information can be found in the Federal recovery plans (National Marine Fisheries Service [NMFS] and U.S. Fish & Wildlife Service [USFWS] 1991a, 1991b, 1993, 2008; NMFS et al. 2010).

Some sea turtles exhibit site fidelity to areas with high prey abundance (Broderick et al. 2007, Shaver and Rubio 2008, Marcovaldi et al. 2010). It is well documented that Virginia coastal and estuarine waters are important seasonal developmental (foraging) habitats for juvenile loggerhead and Kemp's ridely turtles (Lutcavage and Musick 1985, Keinath et al. 1987, Mansfield 2006, Seney and Musick 2005, 2007, Mansfield et al. 2009). Individual juvenile loggerhead and Kemp's ridley turtles have been known to return to the same seasonal foraging areas, such as Chesapeake Bay, for many years (Lutcavage and Musick 1985, Mansfield 2006). The Chesapeake Bay is a temperate habitat and annual temporal changes in ambient water temperature limit cheloniid sea turtle residency times from May to October (Mansfield et al. 2009).

Due to a lack of understanding about which habitat features constitute preferred foraging areas for loggerhead sea turtles, no key foraging areas for northwest Atlantic loggerheads have been identified by the National Marine Fisheries Service (NMFS; NMFS 2013). In this report, researchers have examined foraging behavior with satellite telemetry data using a switching state-space model (SSSM) approach. The SSSM has been used to characterize sea turtle foraging behavior using satellite telemetry data (Jonsen et al. 2006, 2007, Eckert et al. 2008, Maxwell et al. 2011, Hart et al. 2012, Shaver et al. 2013). The SSSM approach interpolates missing points based on a set time-step, chooses the "best" point within a time step, and identifies behavioral states for each location point based on animal's movement patterns. For this analysis, we used a SSSM approach to characterize each interpolated location point as either "foraging" or "migrating."

The home range of an animal can be defined as the area traversed by the animal during its normal activities of foraging, mating, and caring for young (Burt 1943). Kernel density models can be produced from location points to identify the home range of an animal. Several geospatial methods have been developed to quantify home ranges using telemetry data, but utilization distributions may provide the most informative measure of use in habitat-selection studies (Millspaugh et al. 2006). The utilization distribution (UD) was developed to quantify the "area traversed" and the "normal activity" of an animal's home range (Van Winkle 1975). The UD can be described as a bivariate density function that assesses the probability that an animal will relocate at any place according to the coordinate (x, y) of the place (Silverman 1986). Home range is estimated from UDs by creating isopleths (contour lines) based on the summed values at each grid intersection in the UD (Worton 1989). Isopleths can be calculated to represent different probabilities of habitat use. The core area of a home range (usually within the 50 percent isopleth) can be defined as those parts of the home range that an animal uses more often than not, if the utilization would be uniformly distributed across the animal's entire home range (Powell 2000).

The ultimate goal of this study is to provide the United States (U.S.) Navy with the necessary data to help identify seasonal areas where cheloniid sea turtles are likely to occur in order to inform U.S. Navy environmental planning efforts. This project focuses on the three cheloniid sea turtle species commonly seen in Virginia. There are three aspects of this project:

- Characterizing broad-scale movement patterns using satellite telemetry
- Characterizing turtle presence in areas utilized by the U.S. Navy in the lower Chesapeake Bay and nearby Atlantic Ocean (**Figure 1**) using the both satellite and acoustic telemetry;
- Comparing locations among the two sets of data generated by the telemetry transmitters—detection data from acoustic transmitters and global positioning system (GPS) location data from GPS-equipped satellite transmitters.

2. Methods

2.1 Access to Turtles

In 2015, turtles for this project were acquired in three ways: direct capture by researchers, incidental capture in commercial fisheries and trawl operations associated with dredging, or rehabilitation and release of stranded animals. Turtles acquired via direct or incidental capture were taken under the authority of NMFS Research Permit No. 16134. Researchers used dip-netting in the spring for direct captures of wild turtles. For dip-netting, a larger vessel was used as an observation platform to sight turtles resting at the surface. Once a turtle was sighted, a smaller vessel was deployed to approach and capture the turtle using a large dip net.

Incidentally captured turtles could be acquired in one of two ways: captured incidental to commercial pound net (fish trap) operations or caught in trawl operations in conjunction with dredging. Researchers worked with two pound-net fishermen on the eastern shore of Virginia and one at the southern shore of the Chesapeake Bay mouth in order to gain access to incidentally caught turtles. In 2015, they did not receive any calls from fishers on the eastern shore but worked closely with the western shore fisher. In 2015, dredge operations associated with maintaining the York Spit Channel in Chesapeake Bay were underway during sea turtle season. After documenting takes, the dredge was required to have a trawler in place in front of the dredge to relocate turtles in danger of being caught in the dredge's drag heads. The researchers worked with observers operating the trawler to coordinate transfer of any uninjured captured turtles for tagging.

Stranded turtles that had been rehabilitated and released were also affixed with tags under the blanket USFWS permit to NMFS. This included turtles that stranded in Virginia and were rehabilitated at the Virginia Aquarium in 2014 and 2015, and turtles that did not strand in Virginia, but were rehabilitated by Virginia Aquarium.

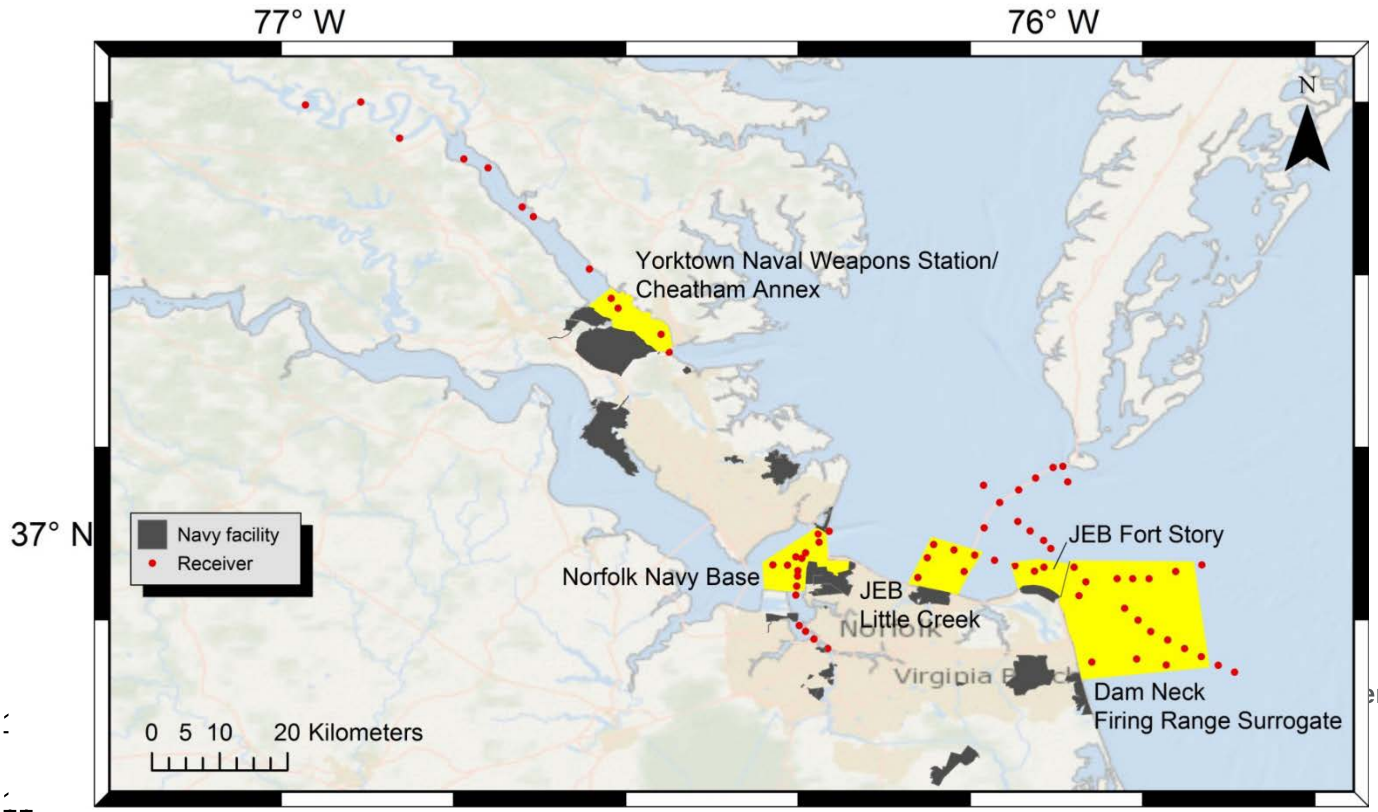

Figure 1: Military zones of interest (yellow) in Virginia waters where elements of the acoustic receiver array were located.

2.2 Tagging and Health Assessment

All turtles directly or incidentally captured were assessed to determine their general state of health and suitability for research tagging. In the case of rehabilitated animals, the Virginia Aquarium veterinarian certified that each turtle was ready to be released into the wild and that any tags placed on rehabilitated turtles were suitable for the weight and behavior of the individual. Morphometric measurements and biological samples were collected for all turtles tagged as part of this project. Curved and straight measurements of the carapace, as well as total body weight, were also collected. Photographs were taken from dorsal, ventral, lateral, and frontal views. Images of appendages, wounds, and abnormalities were also collected. We collected blood for on-site health assessment of non-stranded turtles, and, as required by the NMFS permit, conducted a packed cell volume (PCV) reading from centrifuged microhematocrit tubes (e.g. not from portable blood analyzer made for mammalian blood) prior to tagging. All PCV values were above the minimum of 13 percent. Blood analysis results will be compiled and reported in the final report submitted in 2016. Body temperature, heart and respiration rate were also collected for non-stranded turtles. Inconel® alloy flipper tags and Biomark® FDX-B passive integrated transponder (PIT) tags (Biomark, Boise, Idaho), either packaged as individual sterile tags or in a preloaded tray, were applied to all turtles larger than 30 cm SCL that did not have existing tags. All PIT and flipper tag identification numbers were sent to Peter J. Eliazar at the Archie Carr Center for Sea Turtle Research at the University of Florida, Department of Biology, who maintains the national sea turtle tagging database.

Tag types

Both satellite and acoustic telemetry were used in the study. The researchers used the following three satellite tag models in 2015:

1. Sea Mammal Research Unit (SMRU, University of St. Andrews, Scotland) 9000x satellite relay data logger (SRDL) tags with Argos transmitter, time-depth-recorder, ambient temperature sensor, *Fastloc*® GPS receiver, and data-logger. The *Fastloc*® GPS system can record GPS locations much more frequently and accurately than locations estimated from the Argos system and uplink those locations via the Argos transmitter.
2. Wildlife Computers (Redmond, WA) data-logging SPLASH tags with Argos transmitter, pressure sensor, and ambient temperature sensor.
3. Wildlife Computers SPOT tags with Argos transmitter and ambient temperature sensor.

Researchers deployed SMRU tags on turtles that weighed more than 30 kilograms (kg), while the lighter Wildlife Computers tags were deployed on smaller turtles weighing between 7 and 30 kg. SMRU tags were programed during manufacturing, and Wildlife Computers tags were programed by VAQF personnel prior to deployment. All satellite tags were programed to collect continuous location and sensor data. SPLASH tags were programed to record the percentages of time over 6-hour (hr) periods that turtles spent within defined ambient water temperature and depth intervals. The temperature intervals were defined by every 2°C from 8°C to 32°C, and >32°C. The programed depth intervals (in meters [m]) were: <1, 1–2, 2–3, 3–4, 4–5, 5–10, 10–20, 20–30, 30–40, 40–50, 50–100, 100–150, 150–200; and >200. The SMRU SRDL tags were programed to collect dive profiles, transmitting the locations and times of each dive's start and end times, 5 depths during the dive, dive durations, and temperature and depth percentage histograms programed the same as the SPLASH tags. SPOT tags do not have pressure sensors, therefore, no dive information was collected. SPOT tags do have ambient water temperature sensors and were programed to record the percentages of time over 6-hr periods that turtles spent in 2°C temperature intervals from 12 to 32°C. Researchers also deployed Microwave Telemetry (Columbia, Maryland) 9.5-gram platform transmitter terminal (PTT) -100 solar tags as an experiment on smaller Kemp's ridley turtles.

Researchers deployed two models of VEMCO (Bedford, Nova Scotia, Canada) acoustic coded transmitters (V13-1H and V16P-1H) in 2015. The V13P transmitters were 13 millimeters (mm) in diameter and 36 mm long, and weighed 11 grams. The V16P transmitters were 16 mm in diameter and 57 mm long, and weighed 20 grams. Both types of transmitters transmit a 69-kilohertz "ping" that encodes the identity and pressure (later converted to depth) of the transmitter. Signals from acoustic transmitters on turtles were recorded by VEMCO acoustic receivers maintained by the U.S. Navy (**Figure 1**). Data were compiled by the Naval Facilities Engineering Command (NAVFAC), Atlantic in Norfolk, Virginia, and analyzed by VAQF. The array was divided into regional zones, including four military zones and Chesapeake Bay receivers that were not in a military zone (**Figure 1**). Compiled records were stored at VAQF in a Microsoft Access™ database.

Prior to tag attachment, the carapace of each turtle was prepared by removing epibiota and dead scute tissue with putty knives and coarse (60 to 100 grit) sandpaper. After sanding, the scutes were wiped clean and washed with acetone. Biologists used Sika Anchorfix-1™ (Sika Corporation, Lyndhurst, New Jersey) epoxy for all satellite tag attachments. They set the satellite tag on the second vertebral scute. The epoxy was shaped to create a teardrop-shaped footprint with the broad, rounded part of the teardrop facing cranially and the narrow, pointed part facing caudally. For acoustic transmitters, the biologists introduced a wire-tagging method in 2015 due to poor transmitter retention in 2013 and 2014 on smaller turtles (Hart et al. 2012). Transmitters were attached to the left or right rear marginal carapace. The scutes were prepared as above and then wiped with 10 percent betadine solution left on the surface for several minutes, followed by an isopropyl alcohol wipe. This process was repeated twice on the dorsal and ventral side of the marginal tagging site. The transmitter was attached by drilling two holes through the carapace 0.5 to 1.0 cm from the edge with a 5/16-inch titanium drill bit. The transmitter was attached to the turtle by threading coated steel wire through or around the transmitter, tightening the wire and crimping it with standard fishing crimps. Once the wire was secure, the biologists treated the drilled area with antibiotic ointment and stabilized the transmitter using Sonic Weld™ epoxy, covering any sharp wire ends.

Acoustic Telemetry Detection Experiment and GPS/Acoustic Detection Matching Study

The biologists employed two methods to investigate the range and detection accuracy of the acoustic receivers. On 17 August 2015, they conducted a detection experiment to determine: 1) the range of external V16 transmitters attached to sea turtles, and 2) whether detection would be affected by a sea turtle's bony carapace and plastron if placed internally. They also used the results of the detection experiment to compare GPS locations from satellite telemetry with acoustic detections at nearby receivers.

For the detection experiment, the transmitters were V16-1H range testing transmitters designed to emit a signal every 30 seconds, and the transmitters were activated 15 seconds apart so that the two signals did not cancel each other. The researchers deployed a series of eight receivers at increasing distances from the transmitters—at 0, 200, 300, 400, 500, 600, 700, and 1,000 m. Each receiver was attached to a weighted unit at the seafloor. The transmitters were activated 15 seconds apart in order to prevent interference between the signals. One transmitter was inserted into the left inguinal area of a deceased juvenile loggerhead turtle (**Figure 2**). The tagged turtle carcass and the second transmitter were affixed to the line above the anchored receiver at 0 m distance. Dr. Matt Balazik from Virginia Commonwealth University (VCU) provided the receivers and assisted with the experiment. The experiment ran for approximately 48 hours; data were then downloaded and analyzed by distance from the transmitter. In 2013 and 2014, 10 loggerhead turtles were released with both an SMRU SRDL tag and a VEMCO acoustic transmitter. Researchers conducted a spatial and temporal comparison of the GPS locations and acoustic detections. They filtered GPS locations to only include those with a fix on more than four GPS satellites and within 5 kilometers (km) of an acoustic receiver using ArcGIS 10.2 (ESRI, Redlands, CA) and Spatial Analyst. All GPS locations more than 5 km from a receiver were eliminated and the remaining locations were matched with detections that were within 1 hr of each GPS transmission time (**Figure 3**).

Figure 2: A) Deceased loggerhead turtle used for detection experiment with internal transmitter partially inserted into the left inguinal region (to view the placement of the transmitter). It was inserted ~ 2 cm for the experiment, and B) Matt Balazik (VCU) preparing to deploy the 0-m receiver for the detection experiment. The receiver was weighted on the bottom with the turtle and transmitter suspended approximately 1.5 m above it.

Satellite Telemetry Data Collection and Analysis—historic and pre-2015 tags

All PTT data were published via the SEATURTLE.ORG Satellite Tracking and Analysis Tool (projects 222 and 866) as well as on the Ocean Biogeographic Information System-Spatial Ecological Analysis of Megavertebrate Populations (datasets 978 and 410). A Movebank (movebank.org) study was also created, and a live feed was set up that automatically decoded and stored all Argos and GPS locations. VAQF historical tag data were manually imported into the Movebank study to be used with data collected from the live feeds. The researchers combined GPS

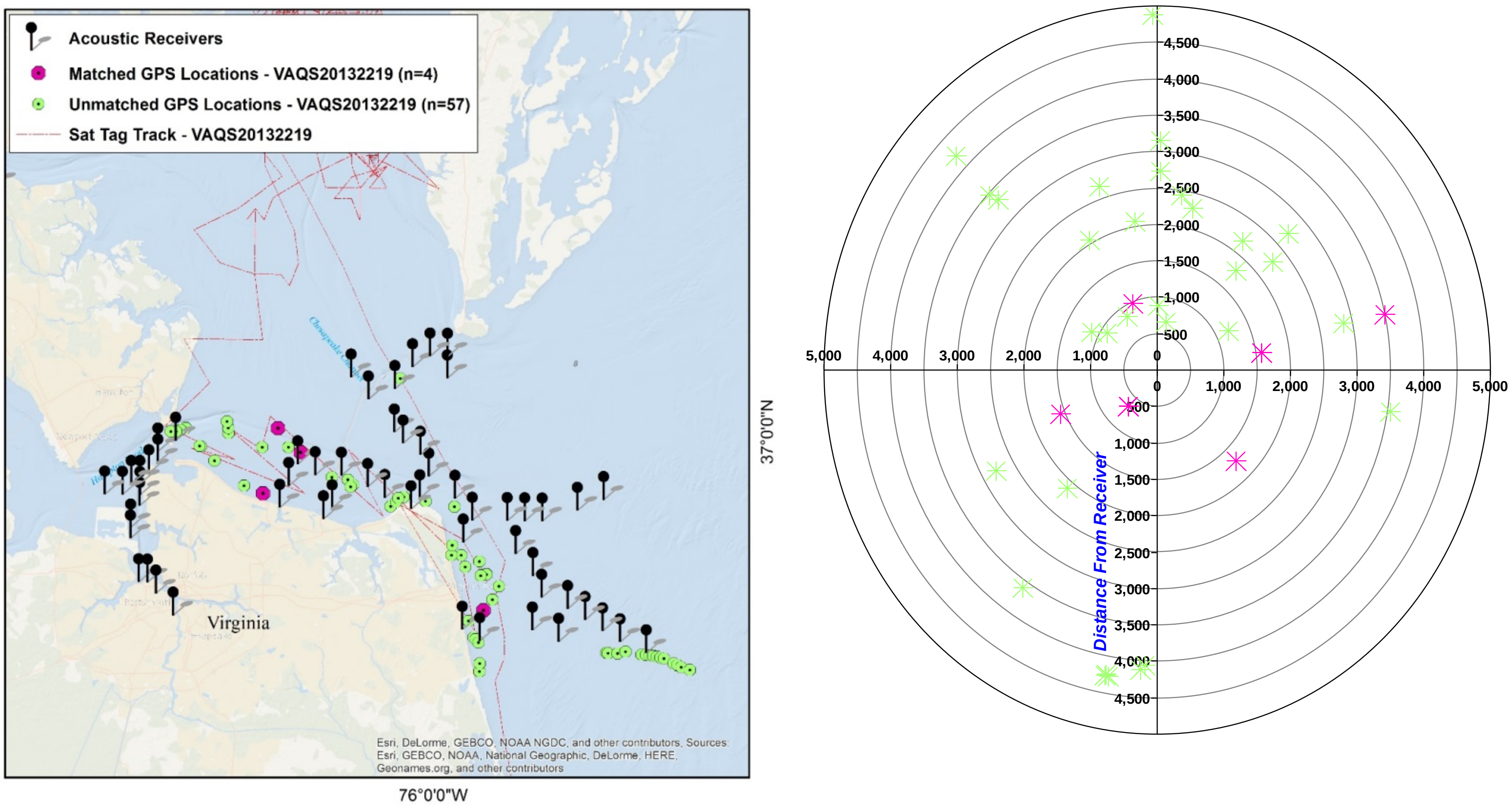

Figure 3: Example of how GPS and acoustic receivers were matched. A) GPS locations transmitted from the SMRU transmitter on VAQS20132219. All points are within 5 km from an acoustic receiver. GPS locations were matched to acoustic recorder detections that occurred within 1 hour of the point. B) The distance (m) and angle of each GPS location (star) in relation to the nearest acoustic receiver (0,0).

and Argos locations to leverage the precision of the GPS data and quantity of the Argos data. Proxy Argos attributes were added to the GPS data in order to identify spatial outliers with the Douglas Argos Filter Algorithm (version 8.50) using the parameters suggested by the Turtle Expert Working Group (Douglas et al. 2012, TEWG 2009). The researchers then added a bathymetry attribute to the filtered location data by extrapolating the grid values from the ETOPO1 Global Relief Model (Amante and Eakins 2009). All locations that had elevations greater than 0.5 m were removed from the data (Amante and Eakins 2009). Additionally, points were removed that were visually deemed to be implausible by creating a trackline using the date/time field to connect the points. Three PTTs stopped transmitting data for more than 7 days and then resumed transmission. For analysis, the researchers considered all points separated by 7 or more days to be a separate deployment to account for breaks in date/time fields. They used the filtered data from 2007 to 2015 to create a point count grid that showed the number of records in each 15 × 15-km grid.

Switching State-Space Model and Home Range Analysis Methods

Argos satellite data were collected with irregular time-steps and had inherent error (Vincent et al. 2002). A switching State-Space model (SSSM is recommended as the best interpolating method for pre-filtered Argos telemetry data (Johnson et al. 2006). For this analysis, the researchers used SSSM modeling to assign a behavior state of “migrating” or “foraging” to each location point using a random walk algorithm (Jonsen et al. 2005; Eckert et al 2008; Breed et al. 2009; Shaver et al. 2013). The researchers used tag data that had been collected from 2007 to 2015, as part of Navy projects and from other VAQF projects to populate a SSSM model that characterized the behavior of loggerhead turtles that were tracked for longer than 28 days (*n*=32) (**Table 1**). They used R Statistical Package and WinBugs to interpolate all location points into 6-hr time steps and assign a behavior code of “migrating” or “foraging” to each interpolated location (R Core Development Team 2011).

In order to understand seasonal changes in foraging behavior, researchers conducted a home-range analysis using the points coded as “foraging” by the SSSM for each turtle in each month for which they had tag data. The analysis was limited to data collected from loggerheads that transmitted at least one Argos point per day on more than 28 consecutive days (*n*=32). The eight loggerhead turtles that were not used in the analysis had too few points to be representative of the actual animal behavior. The numbers of tagged Kemp’s ridleys and green turtles were too low to conduct similar home range analyses. The researchers used the “adehabitat HR Package for R” statistical software version 2.153 to calculate UDs and create isopleth polygons from the UD grids (Calenge 2006). UDs and isopleths (25, 50, and 75 percent) were created for each animal during each calendar month of the year for which they had tracking data. They then used ArcGIS10™ to convert each polygon into individual raster grids with a cell size of 50 × 50-m. The value of each 50 × 50-m cell equaled the value of the polygon(s) in which it was included. For example, a cell included inside of a 75 percent isopleth polygon received a value of 75, and a cell included within a 25 percent isopleth polygon which was also nested within the same animal’s 50 and 75 percent isopleth polygons received a value of 150 (25+50+75). For each month, all isopleth polygons for every turtle were overlaid and the nested and intersecting polygon values were summed (**Figure 4**). For example, a grid cell in the 75 percent area for one turtle and the 50 percent area for a different turtle would have a summed

Table 1: Tagged loggerhead turtles that were included in the switching state-space model and the foraging point home-range analysis (*n*=32).

Animal ID	Deploy Date	SCL (cm)	Source of Turtle	Days Tracked	Tag Manufacturer	Funding
MMSC-09-123	09/28/10	85.0	stranded—vessel strike	50	Telonics	VAQF
VAQS20102031	06/28/11	72.0	stranded—cold stun	91	SMRU	NMFS
VAQS20112019	08/02/11	79.0	stranded—disease	175	SMRU	NMFS
VAQS20112004	08/30/11	68.0	stranded—entanglement	159	SMRU	NMFS
VAQS20112013	10/19/11	99.0	stranded—entanglement	170	SMRU	NMFS
MMSC-11-179	11/22/11	62.0	stranded—vessel strike	187	WC	NMFS
VAQS20112059	07/14/12	77.0	stranded—vessel strike	505	SMRU	NMFS
VAQS20122090	07/28/12	58.0	stranded—hook & line	51	WC	NMFS
VAQS20122096	09/08/12	77.0	stranded—entanglement	159	WC	NMFS
VAQS20122108	10/06/12	64.0	stranded—hook & line	106	WC	NMFS
VAQR201301	05/23/13	60.4	capture—dip net	125	WC	NMFS
VAQR201302	05/23/13	71.0	capture—dip net	277	SMRU	NMFS
VAQR201303	05/23/13	64.3	capture—pound net	328	SMRU	NMFS
VAQS20132003	06/06/13	68.0	stranded—cold stun	55	SMRU	NMFS
VAQS20132005	06/06/13	66.7	stranded—cold stun	368	SMRU	NMFS
VAQR201309	06/13/13	59.0	capture—pound net	59	WC	NMFS
VAQS20132006	06/14/13	48.0	stranded—cold stun	109	WC	NMFS
VAQS20122177	06/16/13	78.0	stranded—cold stun	148	SMRU	NMFS
VAQR201307	06/27/13	55.0	capture—pound net	38	WC	NMFS
VAQS20122176	07/06/13	64.0	stranded—cold stun	68	SMRU	NMFS
VAQR201312	07/22/13	62.7	capture—entrapped	178	SMRU	NMFS
VAQS20122163	08/28/13	66.0	stranded—hook & line	374	SMRU	NMFS
VAQR201315	09/08/13	79.6	capture—pound net	346	SMRU	NMFS
VAQR201313	09/20/13	63.8	capture—pound net	31	WC	NMFS
VAQS20132106	09/29/13	70.0	stranded—hook & line	345	SMRU	NAVY
NAIB1240CC	10/21/13	CBD	stranded—hook & line	181	SMRU	NAVY
VAQS20132086	10/21/13	57.0	stranded—hook & line	250	WC	NAVY
VAQS20132102	10/21/13	62.0	stranded—hook & line	187	WC	NAVY
VAQS20132126	10/21/13	66.0	stranded—hook & line	210	SMRU	NMFS
VAQR201401	06/05/14	79.1	capture—dip net	136	WC	NAVY
VAQS20132225	06/13/14	74.0	stranded—vessel strike	196	SMRU	NAVY
VAQS20132052	09/06/14	67.0	stranded—vessel strike	37	WC	NAVY

Key: SCL=straight carapace length; SMRU=Sea Mammal Research Unit; WC=Wildlife Computers value of 125. This resulted in 12 raster grids, with each 50 × 50-m cell having a summed value indicating a relative level of foraging for all turtles tracked in that calendar month.

The number and dispersion of foraging points in the home range analysis affected the size of a turtle's 75, 50 and 25 percent isopleth polygons. Thus the sizes of individual turtles' isopleth polygons allowed for individuals with a higher number of foraging points, over a longer period of time to contribute more relative foraging value to the analysis. Not all transmitters transmitted in every month, so the numbers of isopleth polygons used to calculate the relative foraging values varied from month to month. In order to compare foraging levels between months with different numbers of turtles, researchers calculated a percentage value for each grid cell. Specifically, each relative foraging value, in each cell, was divided by the sum of all the cell values to compute an index of relative foraging for that cell. This allowed them to compare the cell values, from all 12 monthly foraging grids, based on the index value as a standardized unit. The index of relative foraging cell values in each monthly grid were reclassified into five bins using ArcGIS10™ equal-interval classification scheme. Maps were created for each month, depicting the index of relative foraging (i.e., low, medium-low, medium, medium-high, and high). The resulting maps show how foraging areas shift seasonally over a broad geographic area. Because the months were standardized in relation to each other, the absolute value of each relative foraging level is not the same among the months.

3. Results

Twenty-two acoustic transmitters and 14 satellite tags were deployed on 15 loggerheads (7 acoustic, 8 satellite), 21 Kemp's ridleys (14 acoustic, 6 satellite) and 1 green turtle (acoustic) in 2015 (**Tables 2 and 3, Appendix A)**. Researchers conducted 5 dip-net trips between 15 May and 10 June, capturing 2 turtles each on 3 of the trips, for a total of 5 Kemp's ridley and 1 loggerhead turtle. In addition, they deployed tags on 3 loggerhead and 1 Kemp's ridley turtle incidentally caught in pound nets and 1 loggerhead caught in a trawl operation associated with dredging in the York Spit Channel. Finally, they deployed tags on 19 stranded and rehabilitated turtles, 16 of which had been incidentally hooked by recreational fishers. The remaining 3 turtles stranded due to cold stun (loggerhead and green) or illness (loggerhead).

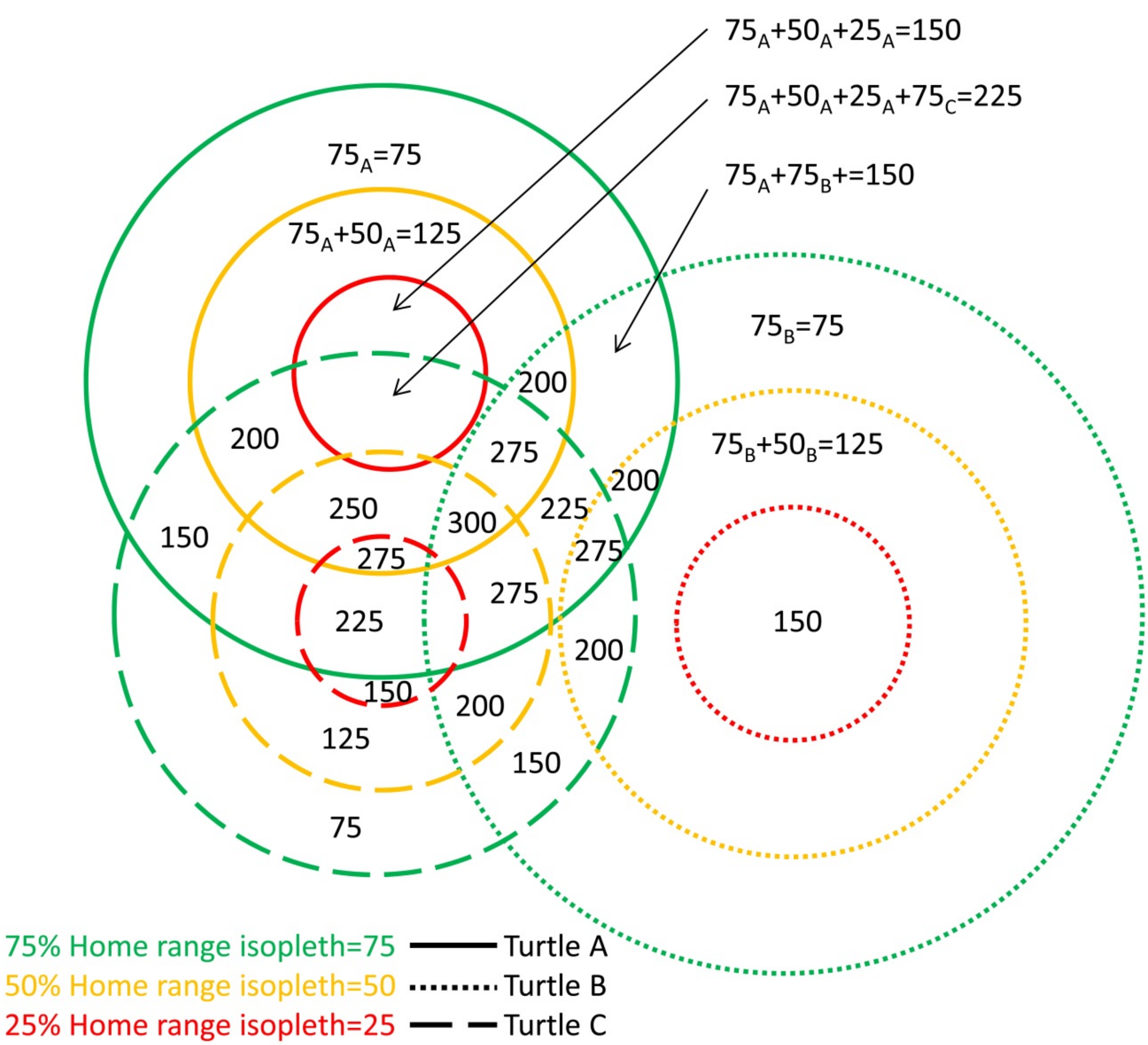

Figure 4: Example of how nested and intersecting isopleth polygons were summed to create relative foraging values. Each color represents a different percent isopleth with a different foraging value for each of three different individuals (differentiated by the line type).

Table 2: Acoustic transmitter deployments for the project by species and month.

Acoustic Transmitters	Green	Kemp's ridley	Loggerhead	Total
2013				
Jul	2	-	-	**2**
Aug	-	1	1	**2**
Sep	-	-	5	**5**
Oct	-	-	4	**4**
Nov	-	-	1	**1**
Year Total	**2**	**1**	**11**	**14**
2014				
May	-	1	-	**1**
Jun	1	7	3	**11**
Jul	-	3	2	**5**
Aug	1	2	-	**3**
Sep	-	1	1	**2**
Oct	-	1	1	**2**
Year Total	**2**	**15**	**7**	**24**
2015				
Mar	1*	2*	-	**3***
Apr	-	-	-	**0**
May	-	3	3	**6**
Jun	-	9	2	**11**
Jul	-	-	2	**2**
Aug	-	-		**1**
Sep	-	-		**1**
Year Total	**1***	**14**	**7**	**22**
Project Total	**5**	**30**	**25**	**60**

*Released from a vessel offshore of North Carolina

Table 3: 2015 satellite tag deployments for the project by species and month.

Satellite tags	Green	Loggerhead	Kemp's ridley	Total
2013				
Aug	-	-	-	-
Sep	-	2	-	2
Oct	-	3	-	3
Nov	-	1	-	1
Year Total	**0**	**6**	**0**	**6**
2014				
Jun	-	3	-	3
Jul	-	-	1	1
Aug	-	-	-	-
Sep	-	1	1	2
Oct	-	1	1	2
Year Total	**0**	**5**	**3**	**8**
2015				
Mar	**-**	2*	-	2*
Apr	**-**	-	-	-
May	**-**	3	5	7
Jun	**-**	-	1	-
Jul	**-**	2	-	2
Aug	**-**	1	-	1
Sep	**-**	’-	-	-
Year Total	**0**	**8**	**6**	**14**
Project Total	**0**	**19**	**9**	**28**

*Released from a vessel offshore of North Carolina

3.1 Acoustic Transmitter Tagging Results

Acoustic Telemetry Detection Experiment and GPS/Acoustic Detection Matching Study

Although we attempted to place receivers at exact distances during the detection experiment, the actual receiver placement was 0 m, 120 m, 245 m, 355 m, 460 m, 610 m, 670 m, and 900 m from the transmitters. The depth of the receivers varied from 6.7 to 9.8 m, and the substrate appeared to be sand and silt. During the 48 hr of the study, water temperature averaged 26.4°C (SD=0.49), mean wind speed was 3.6 m/second (SD=1.5) with occasional gusts to 9.7 m/second and wind direction was variable, predominantly southeast. Detection was approximately 95 percent for both transmitters at 0 m, 87 percent and 77 percent, respectively, for the external and internal transmitters at 120 m, 70 and 60 percent at 245 m, 60 and 52 percent at 355 m, less than 50 percent for both transmitters at 610 m, and less than 20 percent for both at 670 m. Neither transmitter was detected at 900 m. The 50 percent detection range was approximately 415 m for the external transmitter. The internal transmitter had a slightly lower detection rate than the external transmitter, but it was no more than a 10 percent decrease over the external transmitter (**Figure 5**).

Of the 10 turtles deployed with both tag types, only 3 had acoustic detections on the U.S. Navy array within 1 hr of a GPS location (**Table 4**). Two of the undetected transmitters were deployed on animals recovered from pound nets located on the eastern shore of Virginia that were found deceased within 7 days of release. Six of the undetected animals were either not within 5 km of a receiver during the time the satellite tags were transmitting, or they were within detection range for less than 48 hr. One of the undetected turtles (VAQS20132225) was estimated to be within 5 km of a receiver on 25 days during a 4-month period, but was not detected by an acoustic receiver.

Because the detection experiment results suggested that no acoustic signals were detected more than 900 m from the receiver, the researchers further limited the matched data points to 1,500 m resulting in 76 matches between a GPS point and a receiver. Of the matched points, there were 19 (25 percent) GPS locations that matched a detection on the closest acoustic receiver. VAQS20132225 had 26 GPS points within 1,500 m of a receiver, five of which were less than 900 m, but there still were no detections. If they presume that the acoustic transmitter was not functioning on that turtle, there were 55 matched points within 1,500 m, making the percent detected 35 percent. Initially, the researchers used a 1-hr timeframe to match detections to GPS points, but turtles swimming constantly can cover a lot of distance in 60 minutes (min), so they re-ran the analysis limiting the detections to those that were with 2 min and 1,500 m of a GPS point. This resulted in 51 matched points, 10 of which (20 percent) were detected (**Figure 6**). The range of distance from the receivers for detected matches was 625 to 1,801 m, with a mean of 1,287 m (SD=396), and the range and mean for undetected matches was 229 to 1,192 m, with a mean of 774 m (SD=270).

Nineteen of the 23 acoustic transmitters deployed in 2015 (83 percent) were detected by a receiver in the Navy's receiver array in the Chesapeake Bay (**Table 5**). Three of the turtles (2 Kemp's ridleys and 1 green) were released off North Carolina in March 2015 in hopes that they would migrate into Chesapeake Bay in the spring. None of these turtles were detected. Eliminating the North Carolina releases, the detection rate for turtles released in Virginia in 2015

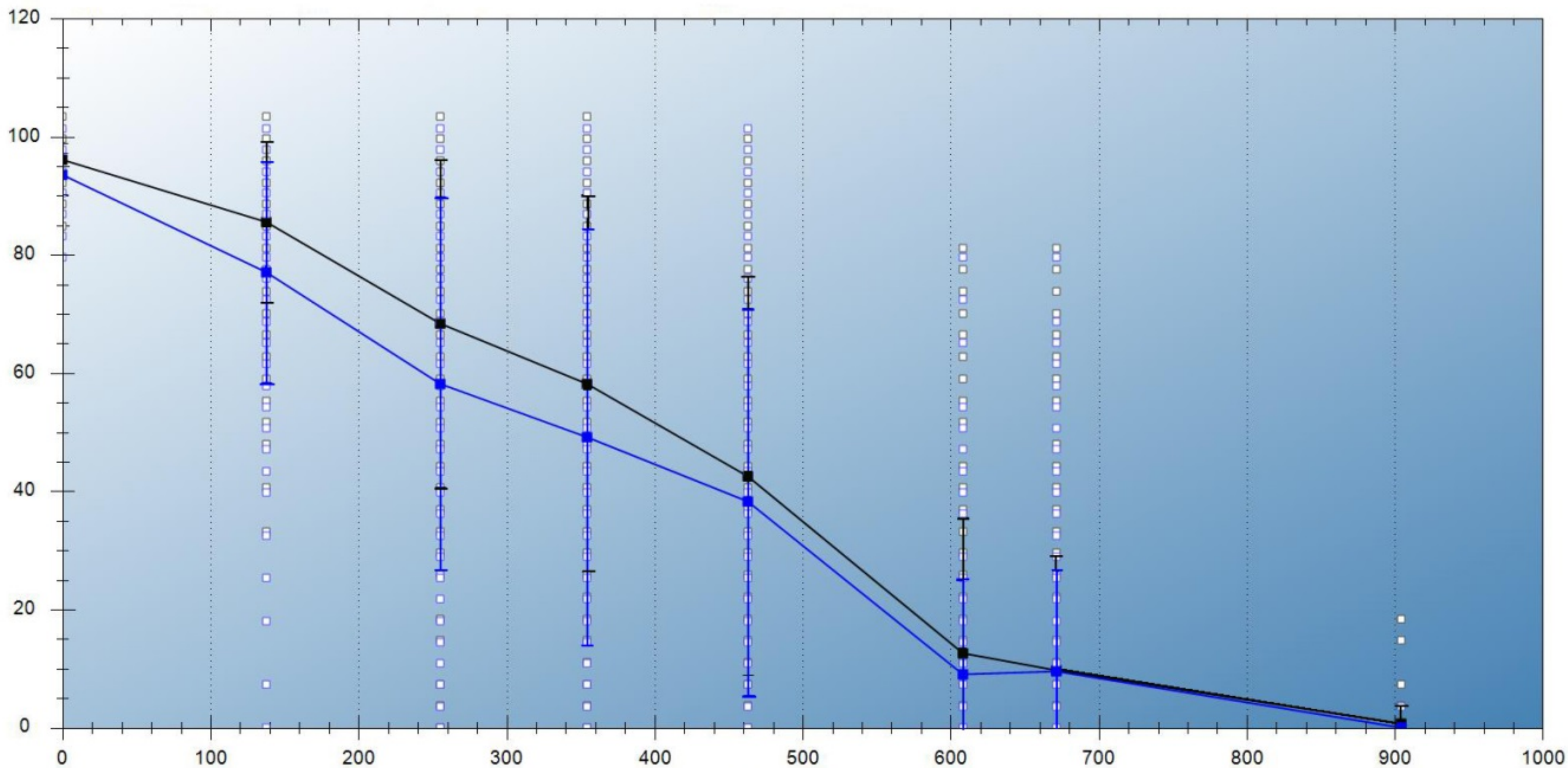

Figure 5: Results of detection experiment. The black line represents the detection percent curve for the transmitter that was external to the turtle, and the blue line represents the detection percent curve for the transmitter inserted in the loggerhead turtle. The open white squares represent detections of each transmitter. At 900 m the percent of signals detected was 0 for both transmitters, and at 415 m, 50% of signals were detected for the external transmitter.

Table 4: Sea turtles that were tagged in 2015 with both a SMRU GPS tag and a VEMCO acoustic transmitter. The "GPS Records" column contains the number of GPS records that were within 5 km of a Navy receiver, the "Detection" column refers to the number of acoustic tag detections recorded, and the "Matched points" column refers to number of GPS records that were ≤5 km of a Navy receiver, and the Matched & Detected column includes GPS points matched to a Navy receiver where an acoustic detection of the animal occurred within one hour of the GPS point. The "Outcome" column describes (if known) why the VEMCO tag was not detected by the array.

Animal ID	GPS Records	Detections	Matched points	Matched & Detected	Outcome
NAIB1240CC	-	28	-	-	GPS records not in area
VAQR201315	27	-	-	-	not detected—mostly out of area
VAQR201318	-	-	-	-	not detected—carcass found after 7 days
VAQR201319	-	-	-	-	not detected—carcass found after 7 days
VAQS20122163	27	382	2	2	
VAQS20132106	300	393	160	13	
VAQS20132126	0	-	-	-	not detected—out of area
VAQS20132219	67	19	10	4	
VAQS20132225	54	-	-	-	not detected—reason unknown
VAQS20142147	37	-	-	-	not detected—mostly out of area

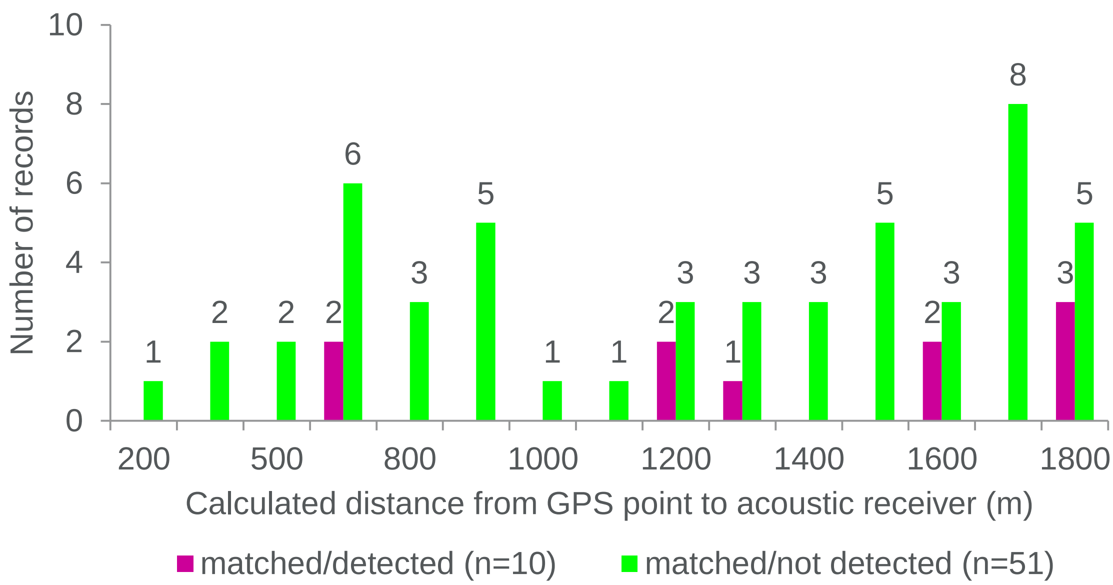

Figure 6: GPS points that were matched to a receiver with an acoustic detection within 2 min of the GPS point (matched/detected; purple) compared with matched points at similar distances that were not detected (matched/not detected; green).

was 95 percent (19 of 20), higher than the overall detection rate for 2013–2014, which was 71 percent. For loggerhead turtles, the mean number of days from release to last detection was 70 days (SD=63), similar to 2013–2014 when the mean days post-release was 82. For Kemp's ridley turtle analyses in this section, the researchers eliminated one turtle (VAQS20152018) whose late fall/early winter data suggested that it was behaving abnormally or may have died. The number of detections for that animal (n=6,547), days detected (n=157), and days post-release (n=217) were substantially higher than the mean and range for other Kemp's ridley turtles released in 2015. The 2015 Kemp's ridley turtle (without VAQS20152018) mean time from release to last detection of 80 days (SD=69) was also higher than the 2013–2014 mean of 21 days, but the difference was not significant (Wilcoxon rank sum test, p=0.1995). In 2013–2014, 9 of the 11 Kemp's ridleys that were detected had detections on only 2 or fewer days, and 5 of the 16 (31 percent) released in Virginia were never detected. In 2015, 4 of the 11 Kemp's ridleys were detected on 2 or fewer days, and of the 13 released in Virginia, 11 were detected (85 percent). The number of different days on which turtles were detected differed significantly between the two groups (Wilcoxon rank sum test, p=0.03).

Table 5: Summary statistics by species for acoustic telemetry in 2015. All detections were on the Navy acoustic receiver array. In 2015, researchers changed the method of transmitter attachment for smaller turtles, and transmitter duration was similar to that of larger turtles.

Parameter	Green	Kemp's ridley†	Loggerhead
Number tagged	1*	15 (2*)	7
Number detected	0	11	7
Not detected	100%	30%	0%
For all detected turtles:			
Maximum days detected post-release		151	180
Average (SD) days detected post-release		80 (69)	70 (63)
Maximum number of detections		280	504
Average (SD) number of detections		70 (89)	146 (200)
Maximum days detected		11	36
Average (SD) days detected		5 (3)	10 (13)

*Released in North Carolina in March 2015

†In order not to skew the data, Kemp's ridley numbers do not include one individual (VAQS20152018) with unusually high detections that most likely perished and may not have been behaving normally.

Table 6: 2015 acoustic detections on the Navy acoustic receiver array by month. Detections were highest in October of each year.

Month	Number of	Number detected	Number	% Detected

	detections		deployed*	
Jan†	10	1	0	NA
Feb–Apr	0	NA	2**	NA
May	13	4	6	67%
Jun	1133	10	16	63%
Jul	811	5	22	23%
Aug	1164	5	12	42%
Sep	854	5	3	>100%
Oct	1072	7	1	>100%
Nov^	287	3	1	>100%
Dec^	0	NA	0	

* Number deployed 60 days prior to last day of month
† Kemp's ridley released in 2014
^ Detections from a shed transmitter or deceased turtle that remained stationary at one receiver were eliminated
** Released offshore North Carolina in March

In addition to the turtles released in 2015 in Virginia, one Kemp's ridley turtle released in 2014 was detected in January of 2015 near Norfolk Naval Base (NNB), and one loggerhead tagged in South Carolina was detected in the acoustic receiver array. Turtles were detected in all months except February–April (**Table 6**). Detections in January of 2015 were of a Kemp's ridley turtle tagged in 2014.

Location of detections

In 2015, turtles were detected on 46 of the 62 Navy acoustic receivers in the lower Chesapeake Bay, including the James River, 3 stations in the Elizabeth River, and the Atlantic Ocean. For the following analyses, researchers included data for Kemp's ridley VAQS20152018 through 18 November 2015, after which time there were no other turtles detected in the area.

Turtles were detected in all military zones except the Naval Weapons Station zone (**Tables 7** through **11; Figures 7** and **8**). No turtles were detected in the York, Chickahominy, or Pamunkey rivers. Detection levels were relatively low, fewer than 500 detections, for the zones associated with Joint Expeditionary Base (JEB)-Fort Story (n=337) and the Firing Range Surrogate for Naval Air Station Oceana Dam Neck Annex (n=481). Detections were slightly higher for the JEB-Little Creek (LC; n=579) and Chesapeake Bay not associated with a military zone (n=671), and highest in the NNB zone (NNB; n=1,227). The highest monthly detections in the JEB-LC and NNB zones were in May, followed closely by September in the NNB zone. For Chesapeake Bay, JEB-Fort Story and the Firing Range Surrogate, the highest detections were in October.

Of the 46 acoustic receivers that detected turtles, 15 detected only one turtle (**Table 12**). Two receivers, both in the Firing Range Surrogate, detected more than five different turtles. No receivers detected all three species, but 21 receivers detected both Kemp's ridley and loggerhead turtles. Of the nine receivers that detected five or more turtles, two each were in the JEB-LC, Chesapeake Bay, and Fort Story zones, and three were in the Firing Range Surrogate zone.

Acoustic-tagged Kemp's ridley turtles were released in March (n=2), May (n=3), and June (n=9) (see **Table 2**). The highest numbers of detections were in the NNB zone in June and September (**Figure 7**). Detections in the Firing Range Surrogate zone occurred in May and June, which were probably associated with releases in the ocean waters off Virginia Beach, and in October which were probably associated with migration out of the region. Of the six Kemp's ridleys detected in October and November, the last detection for five was in the Atlantic Ocean, suggesting that they retained their transmitters as they migrated from the area. The turtle whose last detection was not in the ocean was the suspected compromised animal that spent most of November to January in the Elizabeth River.

Loggerhead turtles were tagged in May (n=3), June (n=2), and July (n=2). They were detected in all of the lower Chesapeake Bay and Atlantic Ocean military zones (**Figure 8**). The JEB-Fort Story and Firing Range Surrogate had higher numbers of detections than the JEB-LC and NNB zones. This is different from the previous year, when the JEB-LC and NNB zones had higher detections than the more eastern zones. Detections in the JEB-Fort Story and Firing Range Surrogate zones were highest in October. Although somewhat lower, detections in the JEB-LC

Table 7: Detections on acoustic receivers in the Norfolk Naval Base zone. The legend below indicates color-coding for numbers of detections.

2015	Region	Receiver	Military Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Kemp's	Eliz. River	NH8	Norfolk Naval Base	10	-	-	-	-	50	-	12	113	-	-	-	**175**
ridley	James River	NH10	Norfolk Naval Base	-	-	-	-	-	-	-	-	77	-	-	-	**77**
		NH12	Norfolk Naval Base	-	-	-	-	-	5	-	-	130	-	-	-	**135**
		NH14	Norfolk Naval Base	-	-	-	-	-	106	-	44	94	-	-	-	**244**
		NN8	Norfolk Naval Base	-	-	-	-	-	2	-	-	-	-	-	-	**2**
		NN5	Norfolk Naval Base	-	-	-	-	-	311	-	-	17	58	-	-	**386**
		NN2	Norfolk Naval Base	-	-	-	-	-	2	-	1	27	6	-	-	**36**
		NN 3ER NOAA	Norfolk Naval Base	-	-	-	-	-		-	33	32	20	-	-	**85**
		NN 1ER FWS	Norfolk Naval Base	-	-	-	-	-	55	11	-	1	1	-	-	**68**
		NN DAN FWS	Norfolk Naval Base	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		NN 22 NOAA	Norfolk Naval Base	-	-	-	-	-	3	-	-	3	5	-	-	**11**
Sub-Total				**10**	**0**	**0**	**0**	**0**	**534**	**11**	**90**	**494**	**90**	**0**	**0**	**1219**
Loggerhead	Eliz. River	NH8	Norfolk Naval Base	-	-	-	-	-	-	-	-	-	-	-	-	**0**
	James River	NH10	Norfolk Naval Base	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		NH12	Norfolk Naval Base	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		NH14	Norfolk Naval Base	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		NN8	Norfolk Naval Base	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		NN5	Norfolk Naval Base	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		NN2	Norfolk Naval Base	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		NN 3ER NOAA	Norfolk Naval Base	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		NN 1ER FWS	Norfolk Naval Base	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		NN DAN FWS	Norfolk Naval Base	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		NN 22 NOAA	Norfolk Naval Base	-	-	-	-	-	-	-	8	-	-	-	-	8
Sub-Total				**0**	**0**	**0**	**0**	**0**	**0**	**0**	**8**	**0**	**0**	**0**	**0**	**8**
Total				**10**	**0**	**0**	**0**	**0**	**534**	**11**	**98**	**494**	**90**	**0**	**0**	**1227**

# Detections			
(light blue)	1-10	(light pink)	51-100
(light green)	11-20	(pink)	101-250
(yellow)	21-50	(red)	> 250

Table 8: Detections on acoustic receivers in Chesapeake Bay not associated with a military zone. The legend below indicates color coding for number of detections.

Species	Region	Receiver	Military Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Kemp's	Chesapeake	2CH off Hen	None	-	-	-	-	-	4	-	-	-	-	-	-	**4**
ridley	Bay	B11	None	-	-	-	-	-	23	-	-	-	2	-	-	**25**
		B5	None	-	-	-	-	-	3	-	-	-	3	2	-	**8**
		B7	None	-	-	-	-	-	5	-	-	-	-	2	-	**7**
		B9	None	-	-	-	-	-	12	-	-	-	31	1	-	**44**
		CBBT1	None	-	-	-	-	-	3	-	-	-	-	-	-	**3**
		CBBT2	None	-	-	-	-	-	-	-	-	-	3	-	-	**3**
Sub-total				**0**	**0**	**0**	**0**	**5**	**50**	**1**	**0**	**0**	**39**	**5**	**0**	**94**
Species	**Region**	**Receiver**	**Military Zone**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Loggerhead	Chesapeake	2CH off Hen	None	-	-	-	-	-	-	-	-	4	85	-	-	**89**
	Bay	B11	None	-	-	-	-	-	-	5	-	-	-	24	-	**29**
		B13	None	-	-	-	-	-	-	-	-	1	-	11	-	**12**
		B15	None	-	-	-	-	-	-	-	-	-	1		-	**1**
		B5	None	-	-	-	-	-	-	-	1	-	3	3	-	**7**
		B7	None	-	-	-	-	-	-	-	-	-	-	6	-	**6**
		B9	None	-	-	-	-	-	-	-	-	-	21	5	-	**26**
		TS1	None	-	-	-	-	-	-	6	14	14	1	-	-	**35**
		TS3	None	-	-	-	-	-	-	19	6	47	2	-	-	**74**
		TS5	None	-	-	-	-	-	-	3	4	-	8	-	-	**15**
Sub-total				**0**	**0**	**0**	**0**	**0**	**3**	**128**	**109**	**99**	**183**	**49**	**0**	**571**
Total				**0**	**0**	**0**	**0**	**5**	**53**	**129**	**109**	**99**	**222**	**54**	**0**	**671**

# Detections			
	1-10		51-100
	11-20		101-250
	21-50		> 250

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Table 9: 2015 detections on acoustic receivers associated with Joint Expeditionary Base-Little Creek. JEB-Little Creek receivers had the second highest numbers of detections in a military zone after the Norfolk Naval Base. The legend below indicates color coding for number of detections.

Species	Region	Receiver	Military Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Kemp's	Chesapeake	LC1	Little Creek	-	-	-	-	-	28	1	-	-	-	-	-	**29**
ridley	Bay	TS11	Little Creek	-	-	-	-	-	-	-	-	-	38	-	-	**38**
		LC2	Little Creek	-	-	-	-	-	82	-	-	-	-	-	-	**82**
		TS9	Little Creek	-	-	-	-	-	-	-	-	-	9	-	-	**9**
		TS7	Little Creek	-	-	-	-	-	1	-	-	-	3	-	-	**4**
		CBBT4	Little Creek	-	-	-	-	-	101	-	-	-	-	-	-	**101**
		CBBT5	Little Creek	-	-	-	-	5	34	-	-	-	-	-	-	**39**
Sub-Total				**0**	**0**	**0**	**0**	**5**	**246**	**1**	**0**	**0**	**50**	**0**	**0**	**302**
Loggerhead	Chesapeake	LC1	Little Creek	-	-	-	-	-	-	-	-	-	2	-	-	**2**
	Bay	TS11	Little Creek	-	-	-	-	-	-	-	-	-	-	-	-	
		LC2	Little Creek	-	-	-	-	-	3	-	8	-	-	-	-	**11**
		TS9	Little Creek	-	-	-	-	-	-	-	-	-	53	-	-	**53**
		TS7	Little Creek	-	-	-	-	-	-	-	9	-	7	-	-	**16**
		CBBT4	Little Creek	-	-	-	-	-	-	45	34	24	-	-	-	**103**
		CBBT5	Little Creek	-	-	-	-	-	-	50	33	9	-	-	-	**92**
Sub-total				**0**	**0**	**0**	**0**	**0**	**3**	**95**	**84**	**33**	**62**	**0**	**0**	**277**
Total				**0**	**0**	**0**	**0**	**5**	**249**	**96**	**84**	**33**	**112**	**0**	**0**	**579**

# Detections			
(light blue)	1-10	(light pink)	51-100
(light green)	11-20	(pink)	101-250
(yellow)	21-50	(red)	> 250

Table 10: 2015 detections on acoustic recievers associated with Joint Expeditionary Base-Fort Story. The legend below indicates color coding for number of detections.

Species	Region	Receiver	Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Kemp's	Chesapeake	T3	Fort Story	-	-	-	-	-	-	-	-	-	-	-	-	**0**
ridley	Bay	2C off Hen	Fort Story	-	-	-	-	-	-	-	-	-	7	-	-	**7**
		TS1	Fort Story	-	-	-	-	-	1	-	-	-	4	-	-	**5**
		B3	Fort Story	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		2CH off Hen	Fort Story	-	-	-	-	-	1	-	-	-	-	-	-	**1**
Sub-Total				**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**11**	**0**	**0**	**13**
Loggerhead	Chesapeake	TS3	Fort Story	-	-	-	-	-	-	19	6	47	2	-	-	**74**
	Bay	2C off Hen	Fort Story	-	-	-	-	-	-	-	5	9	80	29	-	**123**
		TS1	Fort Story	-	-	-	-	-	-	6	14	14	1	-	-	**35**
		B3	Fort Story	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		2CH off Hen	Fort Story	-	-	-	-	-	3	-	-	4	85	-	-	**92**
Sub-Total				**0**	**0**	**0**	**0**	**0**	**3**	**25**	**25**	**74**	**168**	**29**	**0**	**324**
Total				**0**	**0**	**0**	**0**	**0**	**5**	**25**	**25**	**74**	**179**	**29**	**0**	**337**

# Detections			
(light blue)	1-10	(light pink)	51-100
(light green)	11-20	(pink)	101-250
(yellow)	21-50	(red)	> 250

Table 11: 2015 detections on acoustic receivers in the Atlantic Ocean in the Naval Air Station Ocean Dam Neck Annex Firing Range Surrogate. The highest number of individual turtles were detected in this zone. The legend below indicates color coding for number of detections.

Species	Region	Receiver	Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Kemp's	Atlantic	CB	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
ridley	ridley	CB1	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		CB3	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		CB5	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		NCB	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		CB7	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		RAOutside	Firing Range S.	-	-	-	-	7	-	-	-	-	-	-	-	**7**
		CB9	Firing Range S.	-	-	-	-	-	-	-	-	16	-	-	-	**16**
		NCC	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		CB11	Firing Range S.	-	-	-	-	-	-	-	-	8	-	-	-	**8**
		RA	Firing Range S.	-	-	-	-	-	12	-	-	-	-	-	-	**12**
		CB13	Firing Range S.	-	-	-	-	-	5	-	-	39	-	-	-	**44**
		NCD	Firing Range S.	-	-	-	-	-	1	-	-	-	-	-	-	**1**
		NCE	Firing Range S.	-	-	-	-	-	1	-	-	-	-	-	-	**1**
		CB15	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		CH	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		RI2	Firing Range S.	-	-	-	-	-	15	-	-	-	-	-	-	**15**
		RI	Firing Range S.	-	-	-	-	-	35	-	-	-	-	-	-	**35**
		RRI	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		CH1	Firing Range S.	-	-	-	-	-	22	-	-	-	1	-	-	**23**
Sub-Total				**0**	**0**	**0**	**0**	**7**	**91**	**0**	**0**	**63**	**1**	**0**	**0**	**162**
Loggerhead	Atlantic	CB	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
	Ocean	CB1	Firing Range S.	-	-	-	-	1	-	-	-	-	-	-	-	**1**
		CB3	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		CB5	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		NCB	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		CB7	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		RAOutside	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		CB9	Firing Range S.	-	-	-	-	-	-	2	-	-	23	-	-	**25**
		NCC	Firing Range S.	-	-	-	-	-	-	-	-	-		-	-	**0**
		CB11	Firing Range S.	-	-	-	-	-	-	-	-	-	59	-	-	**59**
		RA	Firing Range S.	-	-	-	-	-	-	-	-	-		-	-	**0**
		CB13	Firing Range S.	-	-	-	-	-	-	11	-	9	121	-	-	**141**

Species	Region	Receiver	Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Loggerhead (continued)																
		NCD	Firing Range S.	-	-	-	-	-	-	1	-	-	-	-	-	**1**
		NCE	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		CB15	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		CH	Firing Range S.	-	-	-	-	-	-	3	-	4	-	-	-	**7**
		RI	Firing Range S.	-	-	-	-	-	-	1	-	-	-	-	-	**1**
		RI2	Firing Range S.	-	-	-	-	-	-	8	1		-	-	-	**9**
		RRI	Firing Range S.	-	-	-	-	-	-	-	-	-	-	-	-	**0**
		CH1	Firing Range S.	-	-	-	-	-	-	50	16	9	-	-	-	**75**
Sub-Total				**0**	**0**	**0**	**0**	**1**	**0**	**76**	**17**	**22**	**203**	**0**	**0**	**319**
Total				**0**	**0**	**0**	**0**	**8**	**91**	**76**	**17**	**85**	**204**	**0**	**0**	**481**

# Detections	
1-10	51-100
11-20	101-250
21-50	> 250

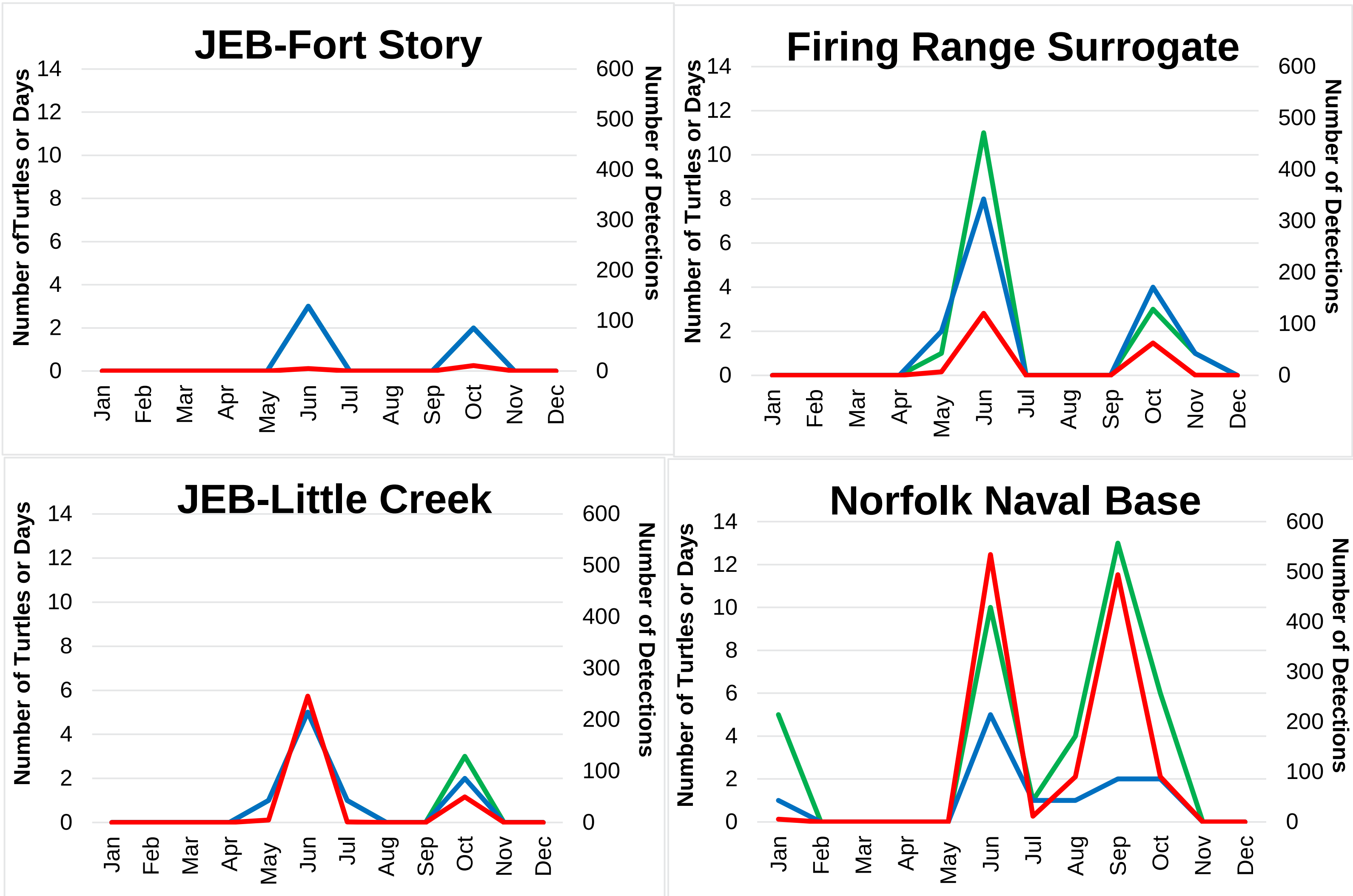


Figure 7: Kemp's ridley turtle detection data by month for the military zones from January through December 2015. There were no detections in the Naval Weapons Station Yorktown/Cheatham Annex zone. Green line=# days/month, blue line=# of turtles/month, and red line=#detections/month on second Y axis. All turtles except one detected in January were released in 2015.

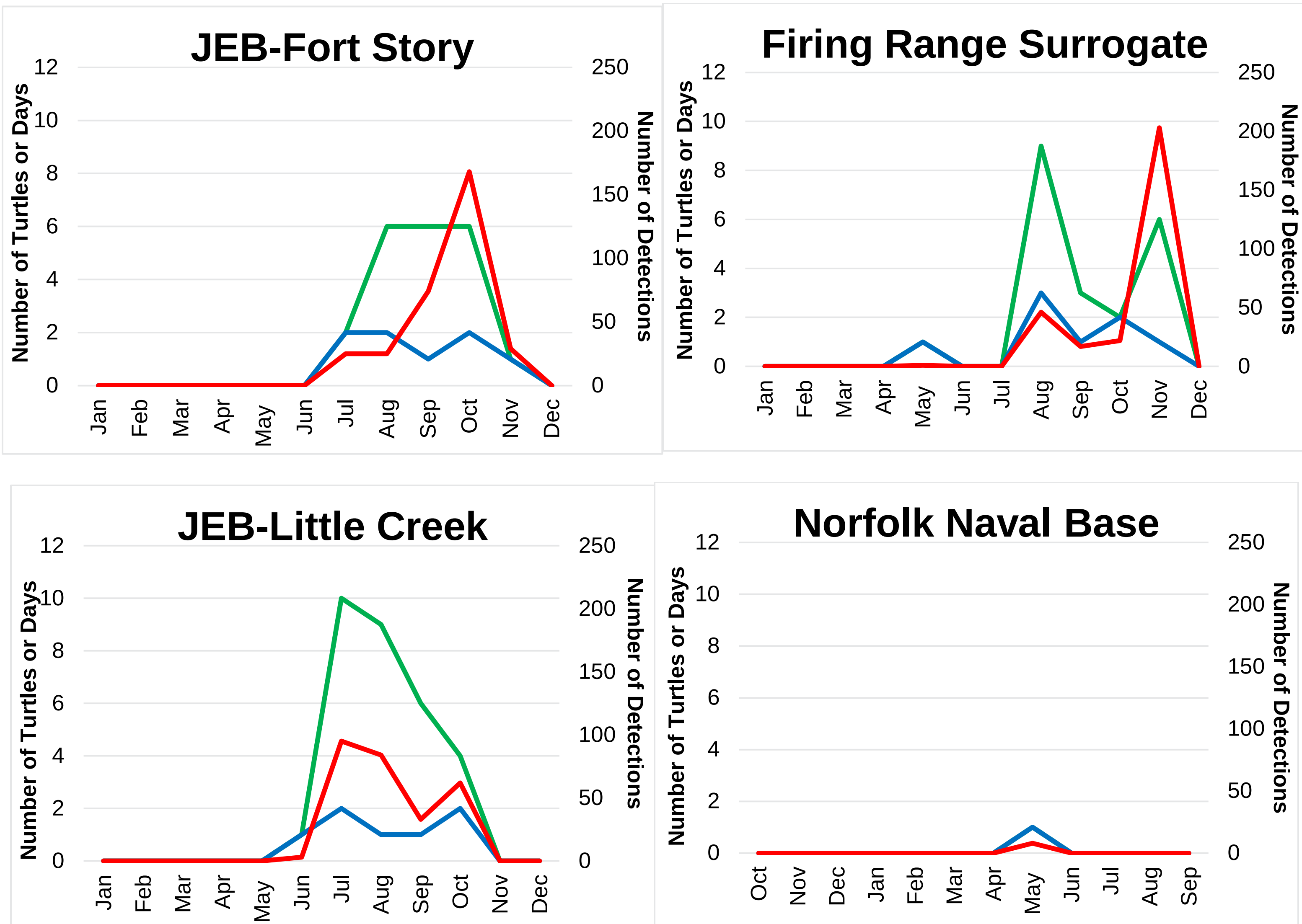


Figure 8: Loggerhead turtle detection data by month for military zones from January through December 2015. Green line=# days/month, blue line=# of turtles/month, and red line=#detections/month on second Y axis. There were no detections in the Naval Weapons Station Yorktown/Cheatham Annex zone. All detections were of loggerhead turtles released in 2015.

Table 12: Numbers of different turtles detected by each receiver in the Navy acoustic receiver array in 2015. The highlighted receivers were the two that detected the highest numbers of turtles in 2013–2014 (*n*=9).

Region	Military Zone	Receiver	Kemp's ridley	Loggerhead	Total individuals
Atlantic Ocean	Firing Range Surrogate	CB1	1	0	1
		CB9	1	2	3
		CB11	1	1	2
		CB13	2	4	6
		CH	2	0	2
		CH1	3	4	7
		NCD	1	1	2
		NCE	0	1	1
		RA	0	1	1
		RAOut	0	2	2
		RI	1	2	3
		RI2	1	4	5
Atlantic Ocean Chesapeake Bay	JEB-Fort Story	2C off Hen	2	2	4
		2CH off Hen	3	2	5
		TS1	3	2	5
		TS3	2	0	2
Chesapeake Bay	JEB-Little Creek	CBBT4	2	2	4
		CBBT5	1	4	5
		LC1	1	4	5
		LC2	1	2	3
		TS7	2	2	4
		TS9	1	2	3
		TS11	0	2	2
Chesapeake Bay	None	B5	2	3	5
		B7	1	2	3
		B9	2	3	5
		B11	2	1	3
		B13	1	0	1
		B15	1	0	1
		CBBT1	0	1	1
		CBBT2	0	1	1
		CC LS	0	1	1
		TS5	3	0	3
James River	Norfolk Naval Base	NH8	0	3	3
		NH10	0	1	1
		NH12	0	1	1
		NH14	0	1	1
		NN 1ER FWS	0	4	4
		NN 22 NOAA	1	3	4
		NN 3ER NOAA	0	3	3
		NN2	0	2	2
		NN5	0	3	3
		NN8	0	1	1
Elizabeth River	None	APM1	0	1	1
		NH29	0	1	1
		NH32	0	1	1

zone were higher in July and August than in September and October. There were fewer than 10 detections in NNB from one turtle on 1 day in August.

Movement patterns

The researchers identified turtles with higher numbers of detection rates, days detected, and days from release to last detection for further investigation into movement patterns. For 2015, they focused primarily on seven Kemp's ridley turtles and one incidentally captured loggerhead turtle. Duration in a zone was defined as the time from first to last detection with no more than 60 min between detections. All durations in a 24-hour period were summed for a total of time spent in a zone each day. For the duration calculations, a single detection in a zone was assumed to be a 5-min duration. Because receivers were far enough apart that a turtle could remain in a zone without being detected, duration as defined here should be considered a minimum estimate.

The turtle with the highest number of detections, days detected, and days from release to last detection was VAQS20152018, a 26.7-cm Kemp's ridley weighing 3.01 kg that was foul-hooked from a pier on the southern Virginia Beach oceanfront on 23 May 2015. Other than a low albumin level, the turtle appeared to be in good condition and was released from a vessel off the Virginia Beach oceanfront on 29 May with a VEMCO V13-1H acoustic transmitter. From release to data download on 3 January 2016, this turtle had 6,547 detections on 157 different days, for a total of 217 days post-release (**Figure 9**). More than 50 percent of the detections occurred at one station, labeled APM1, at the mouth of the Elizabeth River. From 19 September 2015 to July 2016, the turtle was only detected at the APM1 receiver. For the turtle to be transmitting through the winter, when water temperatures were too cold for long-term survival, the turtle must have been dead or the transmitter fell off the turtle. Prior to mid-September, however, the turtle behaved normally, although the number of detections and days detected was still very high compared to other turtles. It was first detected in the Firing Range Surrogate zone briefly on the day it was released followed by a brief detection in the JEB-Fort Story zone 2 days later and the JEB-LC zone the next day, where it was detected for two durations totaling over 4 hr. Over the next 3 days, it was detected in the NNB, zone followed by no detections for 5 days, then 3 more days in the NNB zone. Following 2 days with no detections, it was detected on 16 June in the Elizabeth River on the APM1 receiver for the first time (**Figure 10**). From 16 June to 24 August, it moved back and forth between the three Elizabeth River receivers, then briefly back into the James River and the NNB zone. From 19 September through the end of the calendar year, it was only detected at the AMP1 receiver with several breaks of up to 17 days when there were no detections. The number of detections on the APM1 receiver increased dramatically starting on 8 December and remained high until 31 December when there were no detections. The water temperature at a nearby weather station, Sewells Point, was 11.3°C on 8 December. The last detection of any other turtle in Virginia was on 18 November, when water temperature at a nearby weather station was 15.0°C.

Five of the Kemp's ridley turtles with the highest numbers of detections and days detected post-release exhibited similar movement patterns. VAQS20152009, VAQS20152016, VAQS20152023, VAQS20152039, and VAQS20152058 were all hooked on fishing piers in Hampton Roads in May and June. Four of the turtles appeared in the Firing Range Surrogate

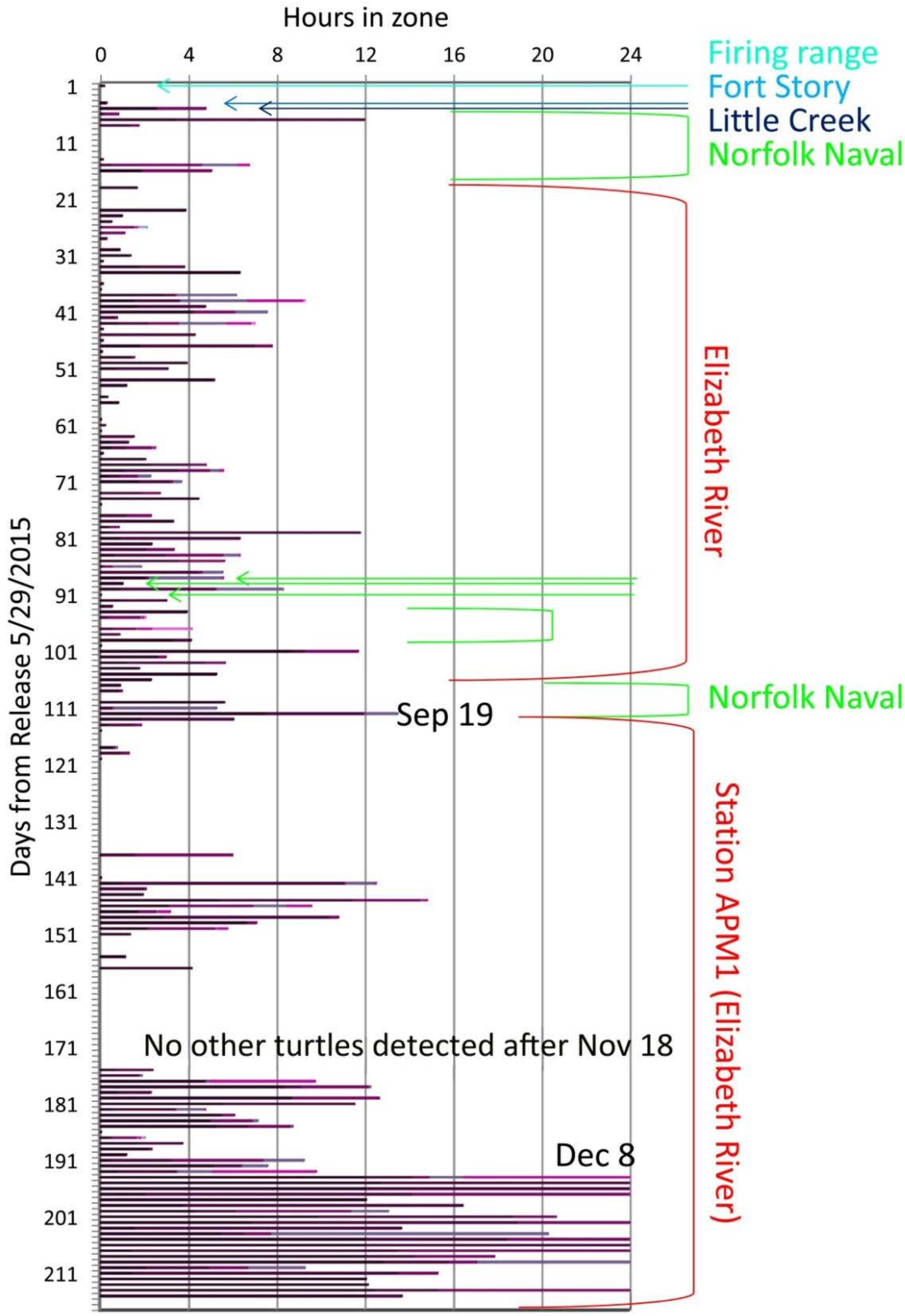


Figure 9: Kemp's ridley turtle VAQS20152018 was detected 6,547 times on 111 different days, and the last detection in 2015 was 217 days post-release. Over half of the detections occurred at a single receiver in the Elizabeth River (see Figure 10). The different colors in the bars represent separate time periods (durations) where the turtle was detected in the zone with no more than 60 minutes between detections. A single detection was assumed to equal 5 minutes. Although the transmitter is still transmitting, if the transmitter is still attached to the turtle, it is assumed to be deceased.

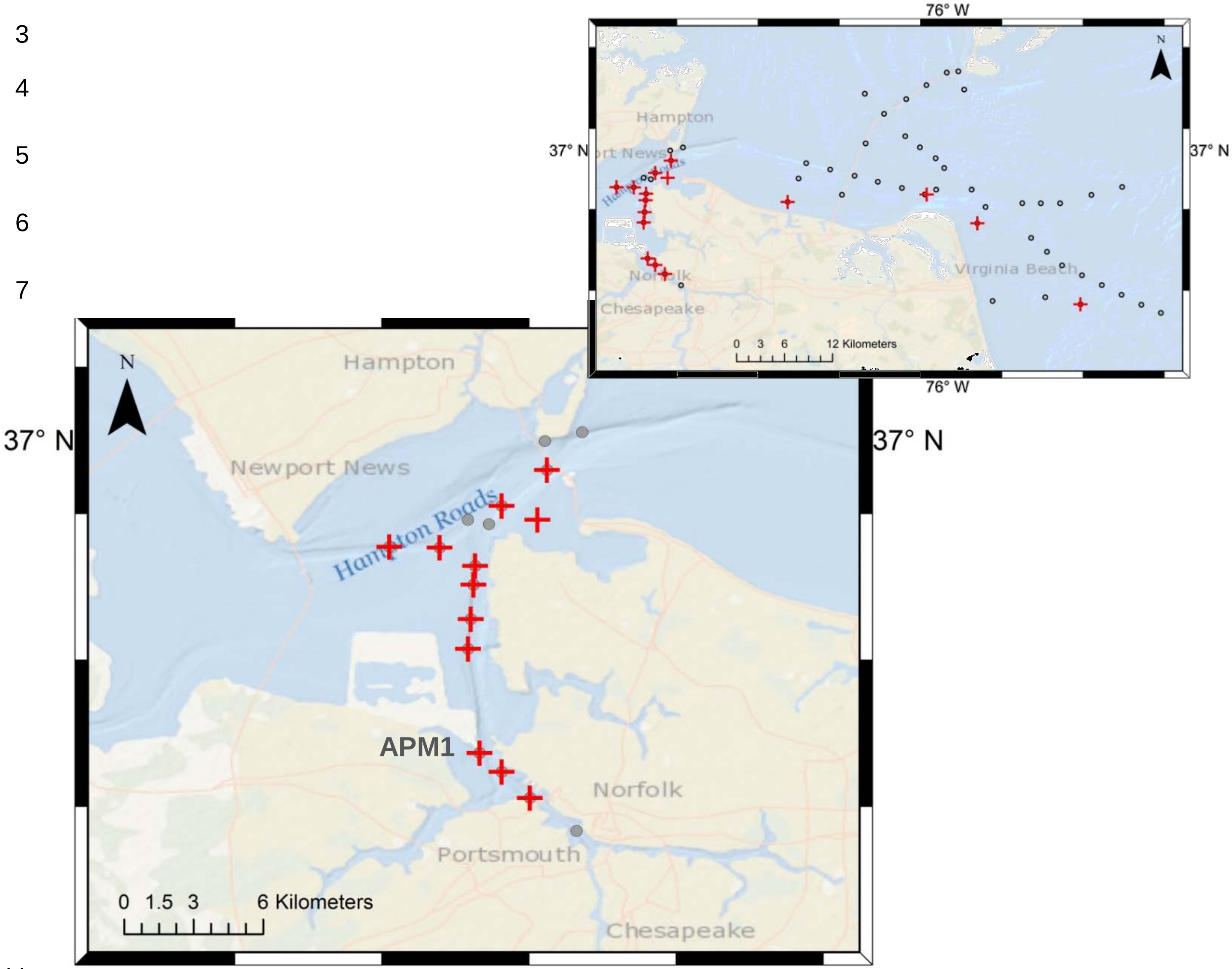


Figure 10: All acoustic detection locations (red crosses, inset) and acoustic detection locations in Hampton Roads and the Elizabeth River for Kemp's ridley VAQS20152018. Over half of the 6,547 detections for this individual occurred at the station labeled AMP1 at the mouth of the southern branch of the Elizabeth River. The transmitter was still being detected in July 2016.

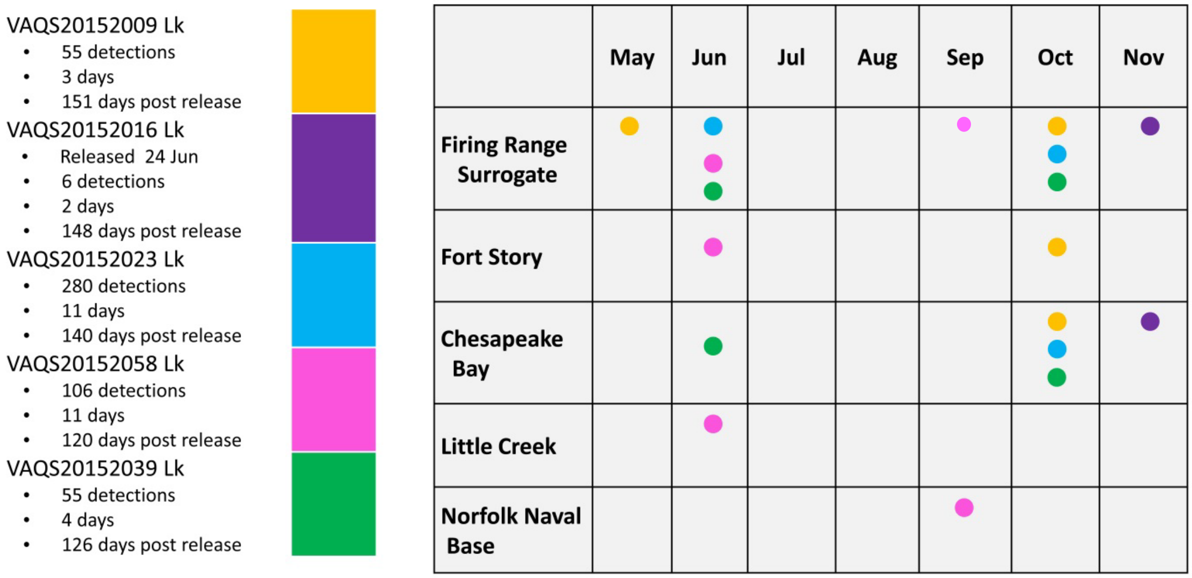


Figure 11: Movement patterns for five tagged Kemp's ridley turtles that apparently moved away from the acoustic array for the warmest months of the year. All of the turtles were last detected in the Atlantic Ocean or lower Chesapeake Bay. Each turtle is represented by a different color seen in the legend. Detections within a zone during a month are represented by corresponding colored dots.

zone near the time of release; some then appeared in other nearby zones before a period of not being detected (Figure 11). One turtle released in June was not detected until November when it was in the Chesapeake Bay zone. After 88 to 149 days with no detections, all were detected in lower Hampton Roads and lastly in the Firing Range Surrogate zone. These data suggest that these turtles moved into the Chesapeake Bay north of the U.S. Navy receiver array for the bulk of the foraging season.

Researchers also looked at the pattern of movement for VAQR201509, a loggerhead turtle incidentally caught in a pound net. The turtle had a healing wound on its caudal carapace consistent with a boat strike. It was detected 353 times on 36 different days, and the last detection was 96 days post-release (**Figure 12**). This turtle spent most of its time in the lower Chesapeake Bay, possibly continuing to forage from the pound nets in the area. This appeared to be the case for two other incidentally caught loggerhead turtles (VAQR201508 and VAQR201510) that were from the same pound nets and satellite tagged (**Figure 13**). Fishers contacted the researchers several times noting that they saw the tagged turtles and eventually recovered one of the transmitters that was attached with epoxy, detached from the turtle in one of their nets.

The final movement pattern analysis conducted was on VAQS20152027, a Kemp's ridley turtle that was hooked at a fishing pier between the JEB-LC and NNB zones on 29 May and was released off the Virginia Beach oceanfront on 10 June. The turtle was first detected in the Firing Range Surrogate zone on 11 and 12 June, followed by a day with no detections, then 2 days in

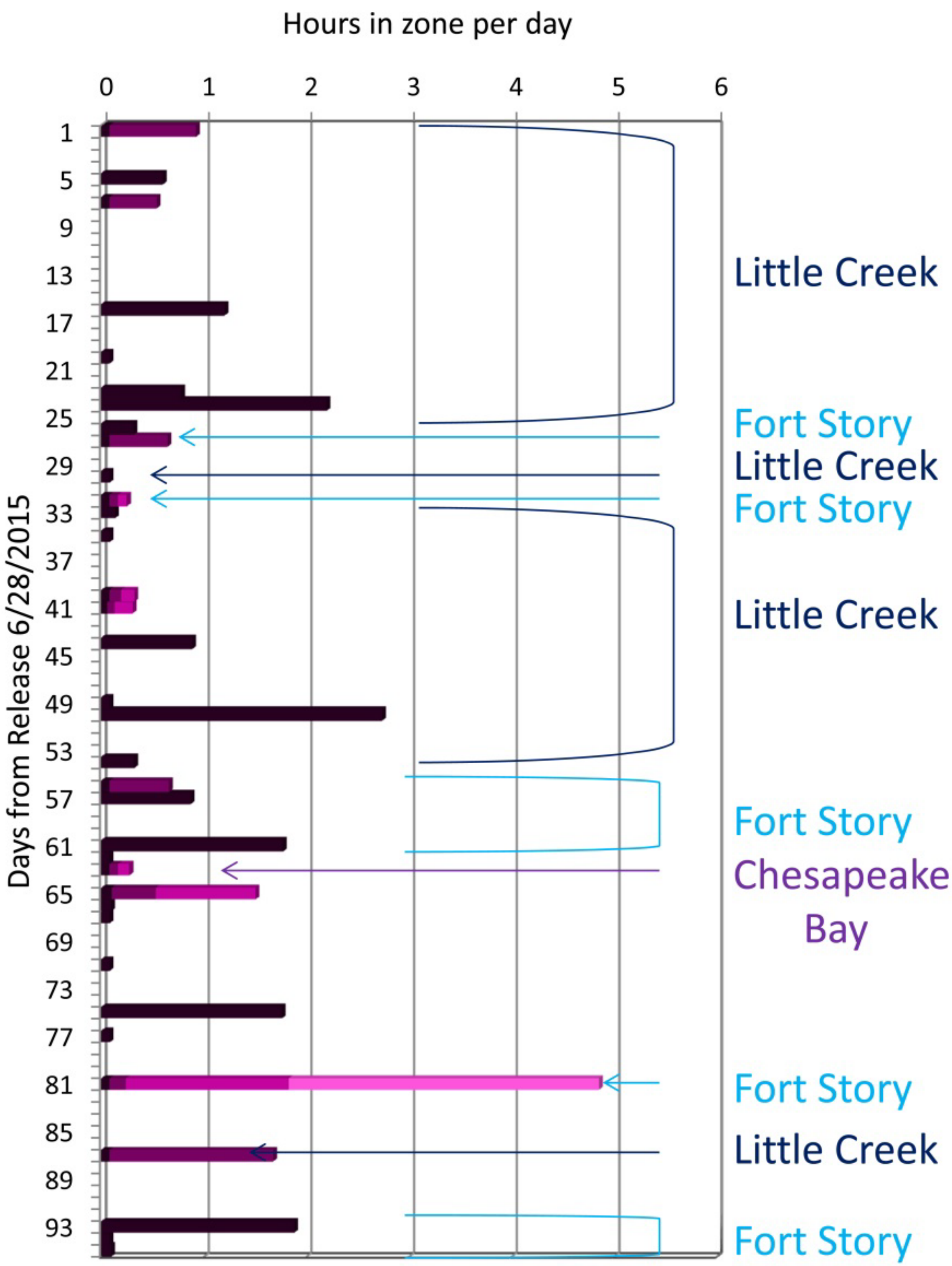


Figure 12: Loggerhead turtle VAQR201509 was detected 353 times on 36 different days, and the last detection in 2015 was 96 days post-release. The pattern of movement is primarily in the lower Chesapeake Bay, but appears to indicate that the turtle was behaving normally.

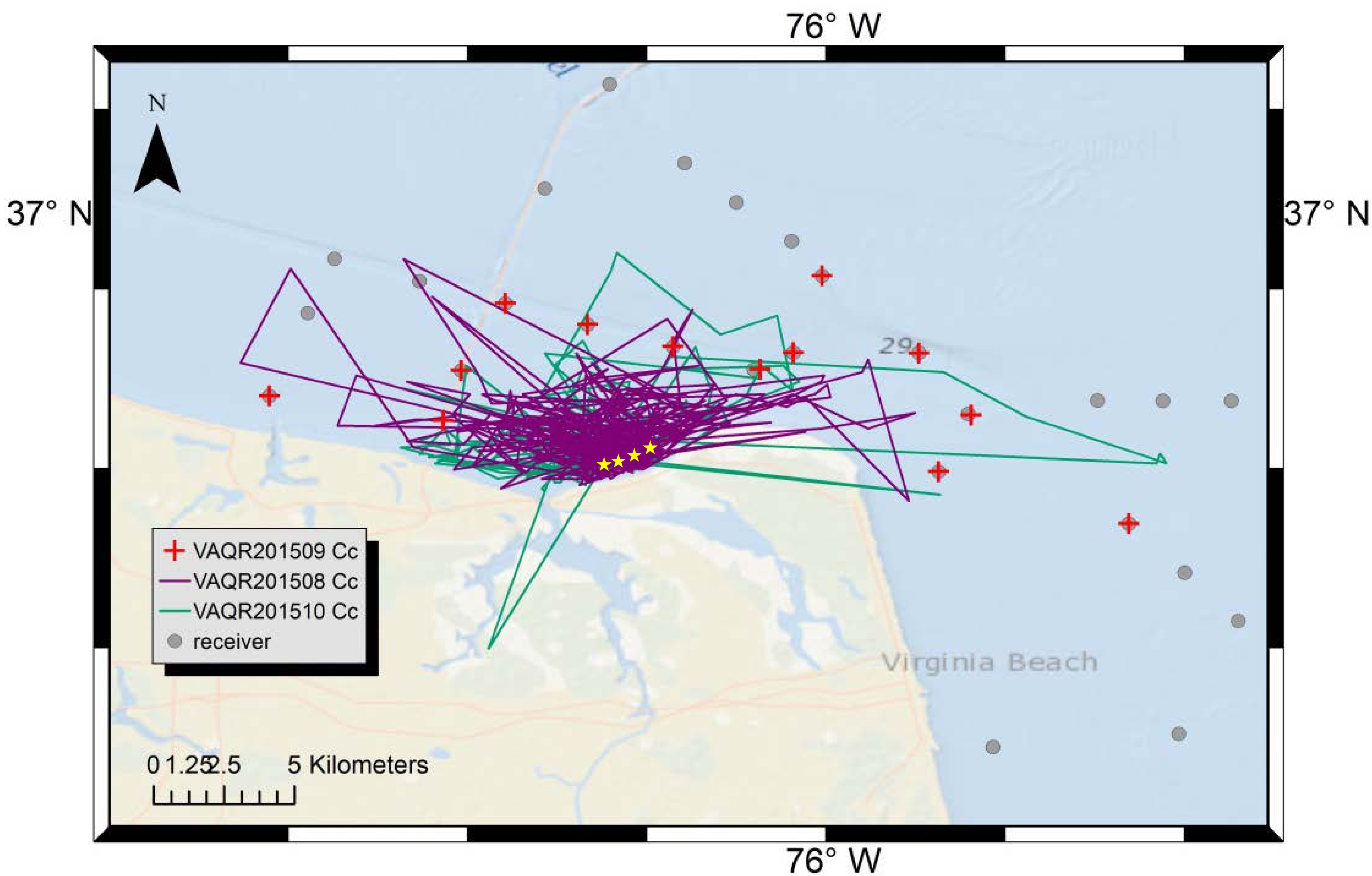


Figure 13: Detections of loggerhead VAQR201509 and two satellite-tagged loggerhead turtles incidentally caught in the same pound nets (indicated by yellow stars). The distribution patterns of the three turtles are similar using the two tracking methods.

the JEB-LC zone (**Figure 14**). After 6 days with no detections, it was detected in the NNB zone briefly on 22 June, followed by no detections for 12 days, brief detections in the NNB zone, and brief detections in the JEB-LC zone. The turtle could have been moving north into the Chesapeake Bay as it left the JEB-LC zone, or perhaps to the eastern shore of Virginia.

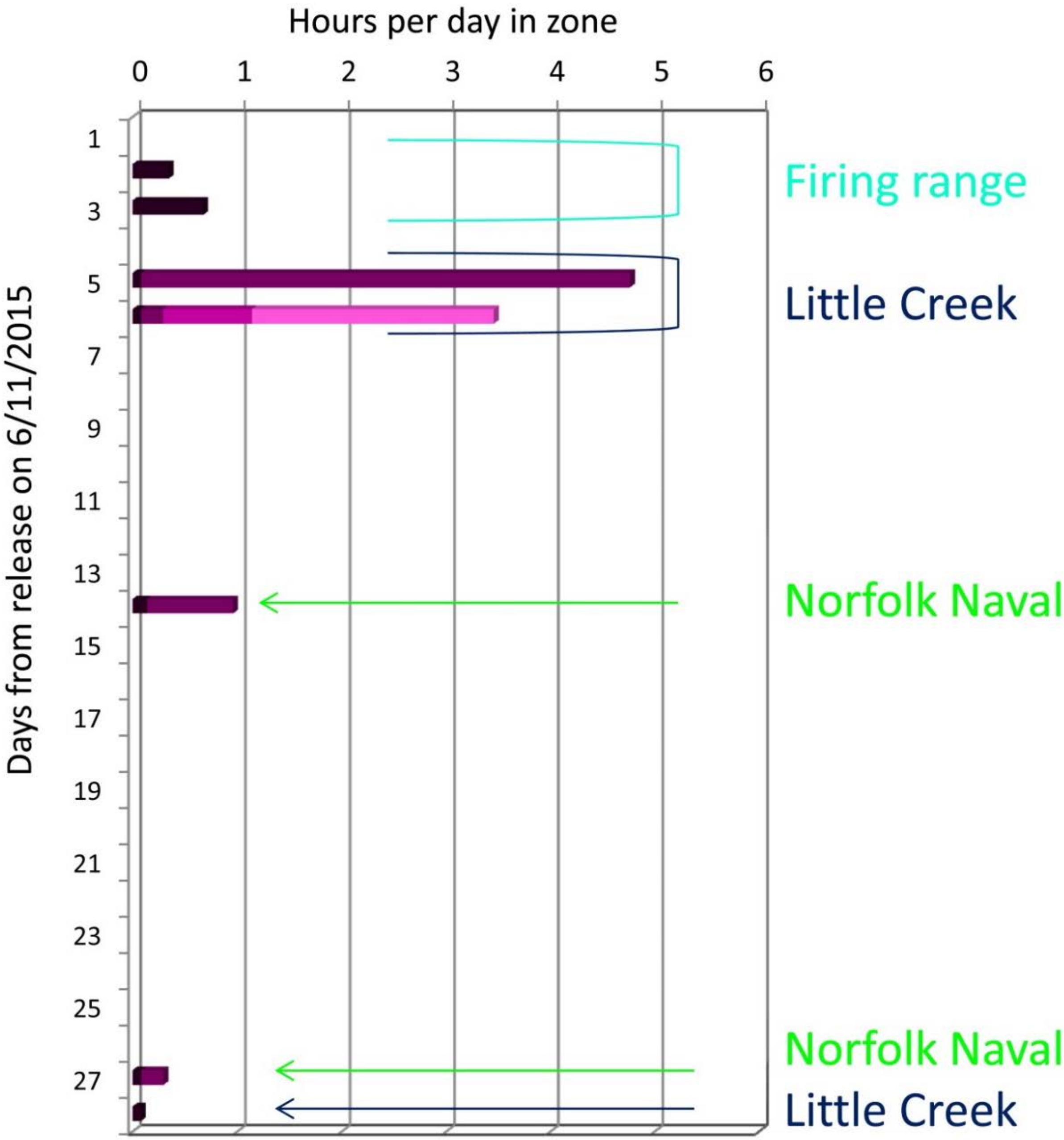


Figure 14: Kemp's ridley turtle VAQS20152027 was detected 180 times on 7 different days, and the last detection in 2015 was 27 days post-release. The turtle was not detected on most of the days it was in Virginia, in contrast to the turtle in Figure 9, which was detected in a similar area.

3.2 Satellite-Telemetry Tagging Results and Analysis

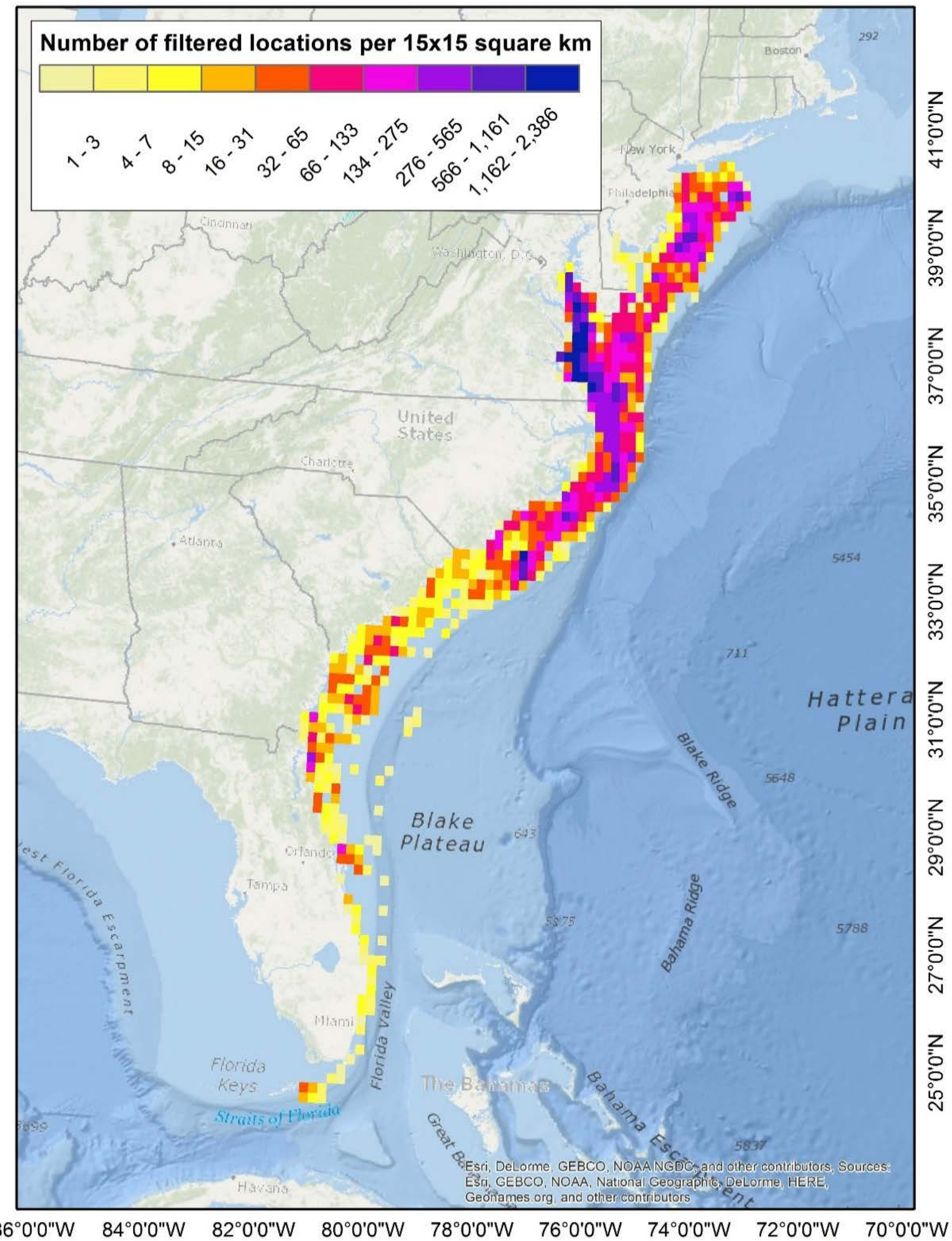
Data collection and processing

A total of 6,623 raw locations (Argos=6,007; GPS=616) were collected from 15 tags deployed on sea turtles released in North Carolina and Virginia in 2015. As of 31 December 2015, the entire study database consisted of 68 deployments from 61 animals (50 loggerhead turtles, 9 Kemp's ridleys, and 2 greens). Twenty-eight of these tags were funded by the U.S. Navy, and 33 were funded by other grants awarded to VAQF. Fifty-seven of the tags (49 loggerheads, 6 Kemp's ridleys, and 2 greens) transmitted for more the 20 days, while four tags transmitted for fewer than 21 days (3 Kemp's ridleys and 1 green). From the 57 animals transmitting more than 20 days, we have collected a total of 113,373 raw locations (Argos=102,620; GPS=10,753). The Douglas Filter identified 6,520 location points as outliers and 23,488 were manually filtered. The remaining 83,365 locations will be used to interpolate tracks with the SSSM. We created a point-count raster grid, with all filtered and interpolated locations from the 57 sea turtles that transmitted more than 20 days. The resulting grid had a total of 145,408 15 ×15-km cells where at least one turtle was present (**Figure 15**). The minimum, maximum, and mean number of off locations per cell were 1; 2,386; and 300, respectively. The point count maps show that areas Cape Hatteras, in Onslow Bay, and in Chesapeake Bay had the highest numbers of non-Virginia locations for sea turtles tagged in Virginia.

Switching State-Space and Home-range Model Results

Data from 32 tagged loggerheads (**Appendix A**) was used to create monthly foraging grids. Data from an additional 13 loggerheads will be added to the home-range analysis in 2016 (**Table 13**). Of the 24,085 filtered and interpolated points, 19,575 locations were identified at "foraging" locations. A total of 18,229 foraging location points was used to calculate the UDs and isopleth rasters. The number of turtles used to create the foraging grids varied from month-to-month depending on how many turtles were tracked during a particular month. February, March, April, and May had the fewest turtles used in the model.

According to the monthly foraging grids, no foraging activity occurred north of 36.55°N latitude during January, February, March, or April (**Figure 16**). During these months, most of the higher foraging activity took place off Cape Hatteras and in Onslow Bay. Foraging in Virginia and Maryland began in May and was most concentrated around the mouth of the Chesapeake Bay (**Figure 17**). Foraging was identified continually in Chesapeake Bay from May to November with varying levels of intensity. Use of ocean waters off Virginia and Maryland varied throughout the season as tagged turtles moved up and down the coast. As the year progressed, medium, medium-high and high foraging levels shifted from the mouth of Chesapeake Bay and Virginia coastal ocean waters in May to mid-Bay (primarily Virginia waters) in June (**Figure 18**) and July (**Figure 19**) to the entire Bay (including Maryland waters) and Virginia coastal ocean waters in August (**Figure 20**). The medium to high foraging levels reached a northern peak in August and began to move south in September (**Figure 21**). Additionally, in the spring and early summer, foraging activity in federal waters shifted north along the coasts of Virginia, Maryland, Delaware,



and New Jersey. In August, medium to high foraging levels were more dispersed than July or

Figure 15: Number of filtered locations (GPS and Argos) in 15 × 15-km grids from 57 tags deployed by VAQF from 2007 to 2015 that transmitted for longer than 28 days.

Table 13: Tagged loggerhead turtles to be added to the switching state-space analysis in 2016.

Animal ID	Deploy Date	SCL (cm)	Days Tracked	Funding
VAQS20092046	07/10/09	66.0	81	VAQS
VAQS20092050	08/12/09	54.0	33	VAQS
VAQS20102146	06/28/11	ND	21	VAQS
VAQR201501	05/16/15	69.4	111	NMFS
VAQS20132141	11/25/13	71.3	228	NAVY
VAQS20132219	06/14/14	57.5	452	VAQS
VAQS20142177	03/17/15	66.0	25	NAVY
VAQR201502	05/16/15	59.0	39	NAVY
VAQR201506	05/30/15	84.2	48	NAVY
VAQR201510	07/02/15	65.1	28	NAVY
VAQR201508	07/02/15	72.5	24	NAVY
VAQR201512	08/06/15	88.9	30	NAVY
VAQS20142147	10/21/14	61.3	307	NAVY

September and covered areas throughout Chesapeake Bay, especially in the western portion of both Virginia and Maryland Bay waters. By August, a high level of foraging was seen in the waters offshore of the mid-Atlantic as well. In September inshore and offshore medium-high foraging activity shifted towards the mouth of Chesapeake Bay and more southern mid-Atlantic waters (off Virginia and Maryland). September was the first month that turtles began to move south of the Virginia/North Carolina line. By October, all medium to high foraging levels were focused around the mouth of Chesapeake Bay, Virginia, coastal waters and offshore of Cape Hatteras (**Figure 22**). This trend continued into November and by December all tagged turtles had moved south of the Virginia/North Carolina border (**Figures 23** and **24**).

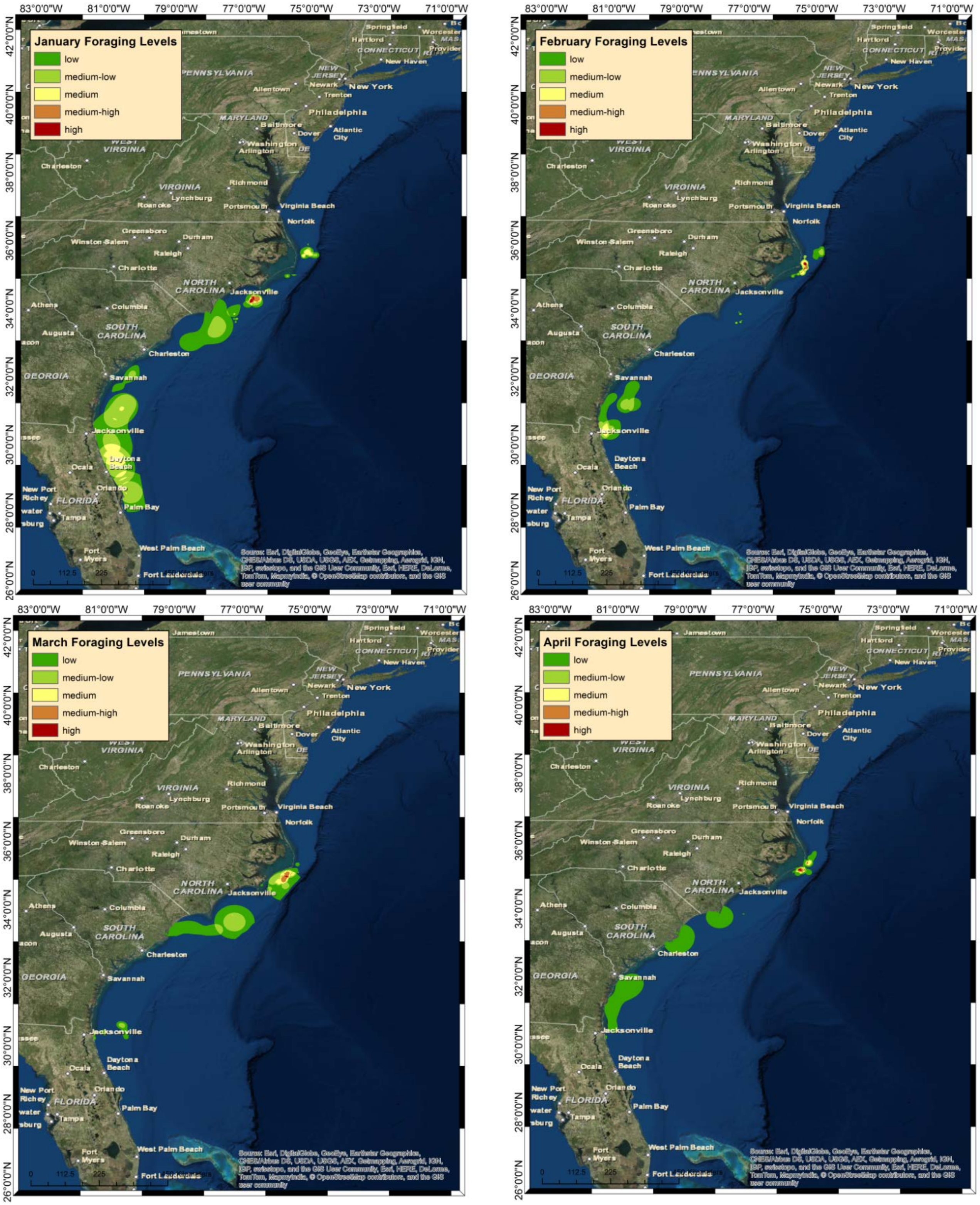


Figure16. Index of relative foraging for loggerhead sea turtles tagged in Virginia for January (top left), February (top right), March (bottom left) and April (bottom right). These maps are based on foraging points from 17, 14, 8, and 11 turtles, respectively.

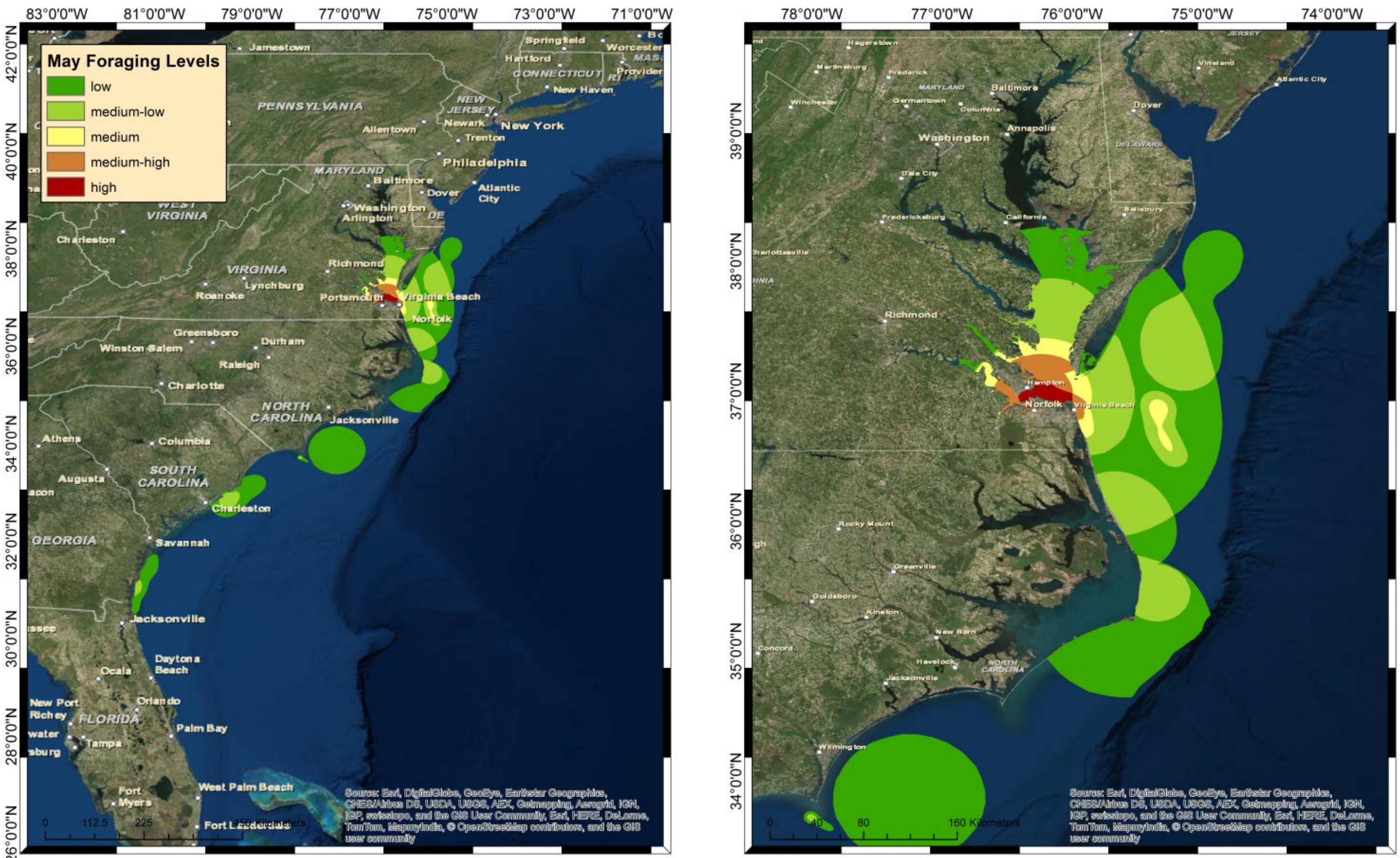


Figure17: Full (left) and regional (right) views of index of relative foraging developed from loggerhead turtles tracked in May (*n*=14) from 2007 to 2015.

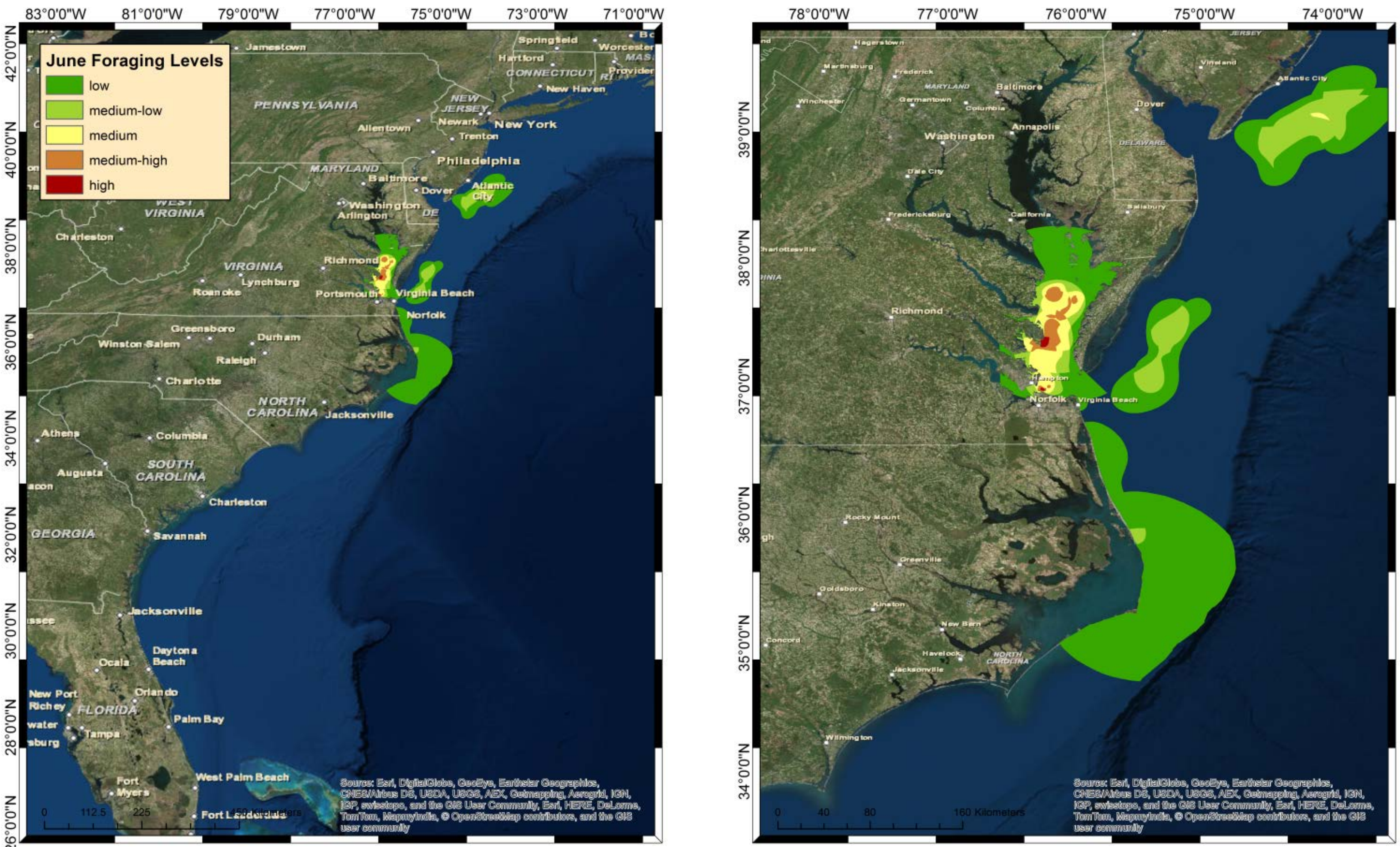


Figure18: Full (left) and regional (right) views of index of relative foraging developed from loggerhead turtles tracked in June (*n*=20) from 2007 to 2015.

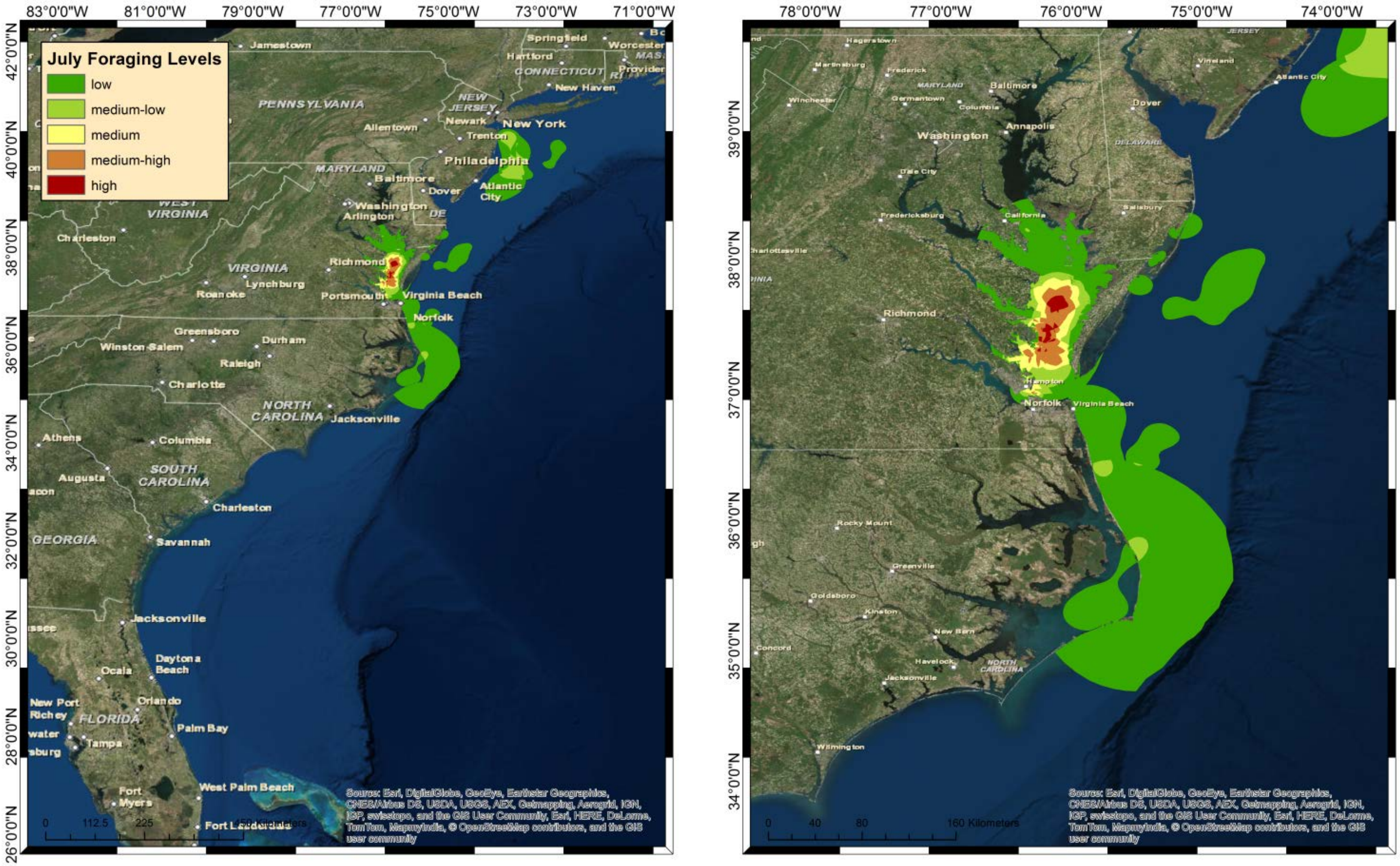


Figure 19: Full (left) and regional (right) views of index of relative foraging developed from loggerhead turtles tracked in July (*n*=22) from 2007 to 2015.

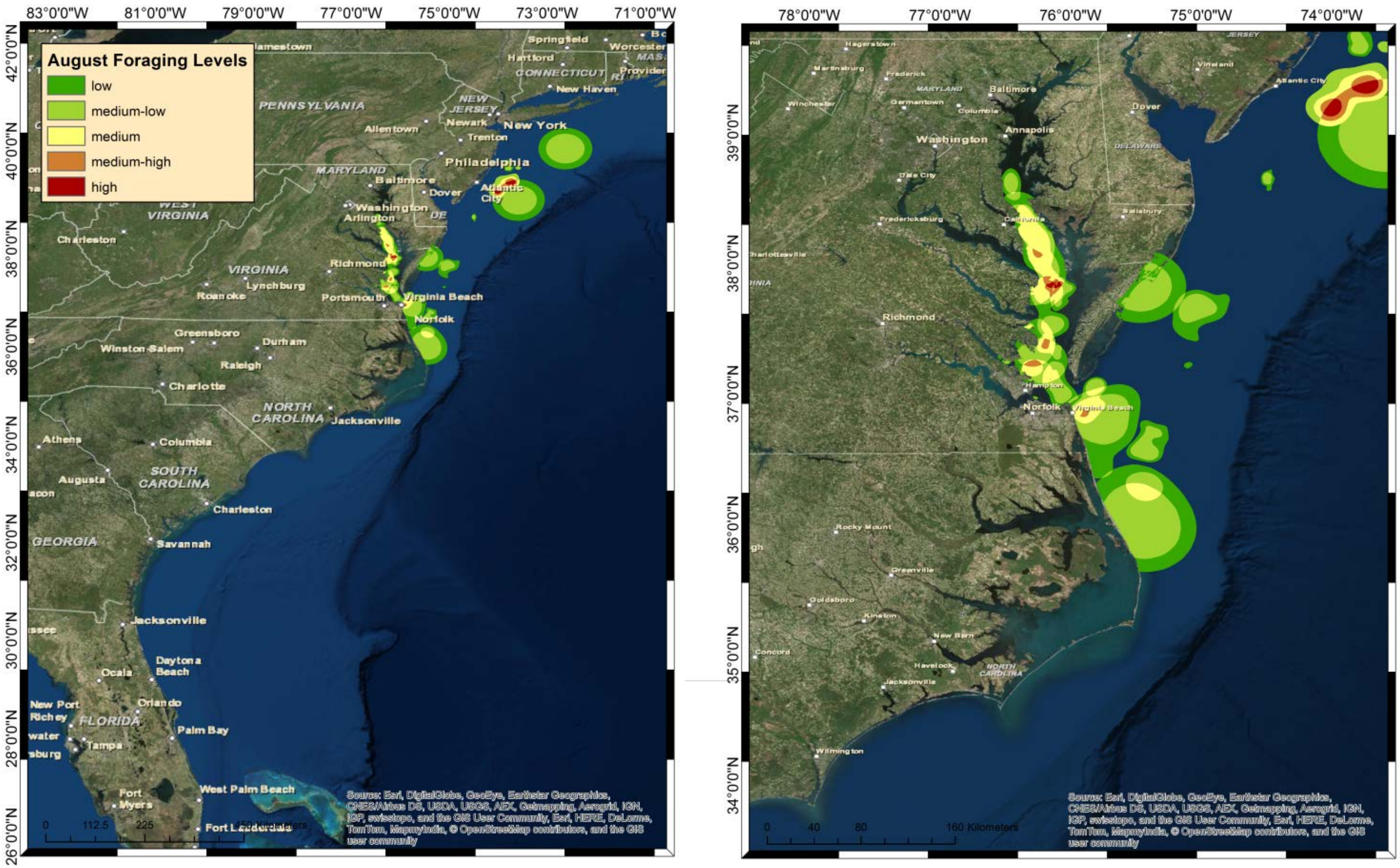


Figure 20: Full (left) and regional (right) views of index of relative foraging developed from loggerhead turtles tracked in August (*n*=25) from 2007 to 2015.

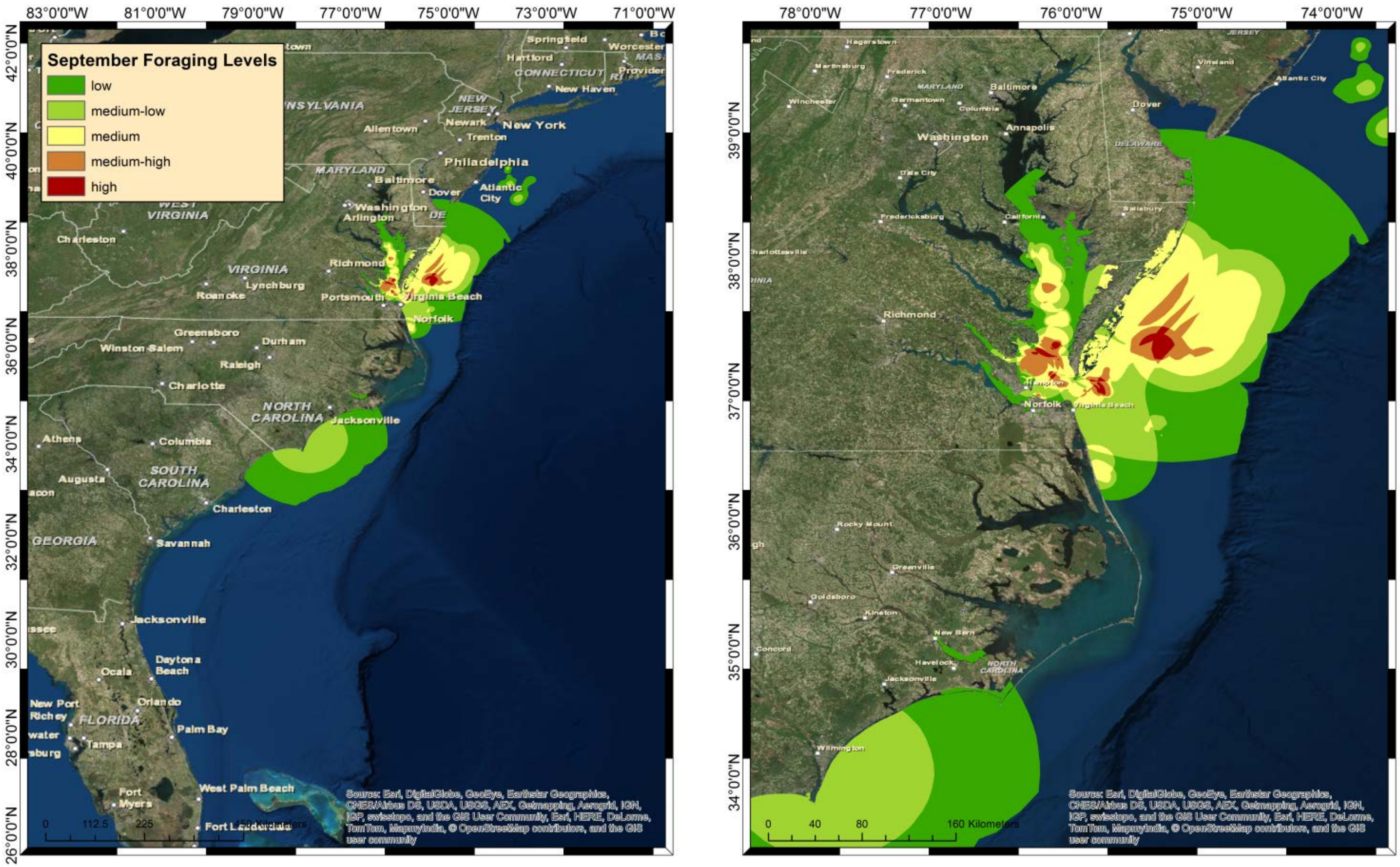


Figure 21: Full (left) and regional (right) views of index of relative foraging developed from loggerhead turtles tracked in September (*n*=25) from 2007 to 2015.

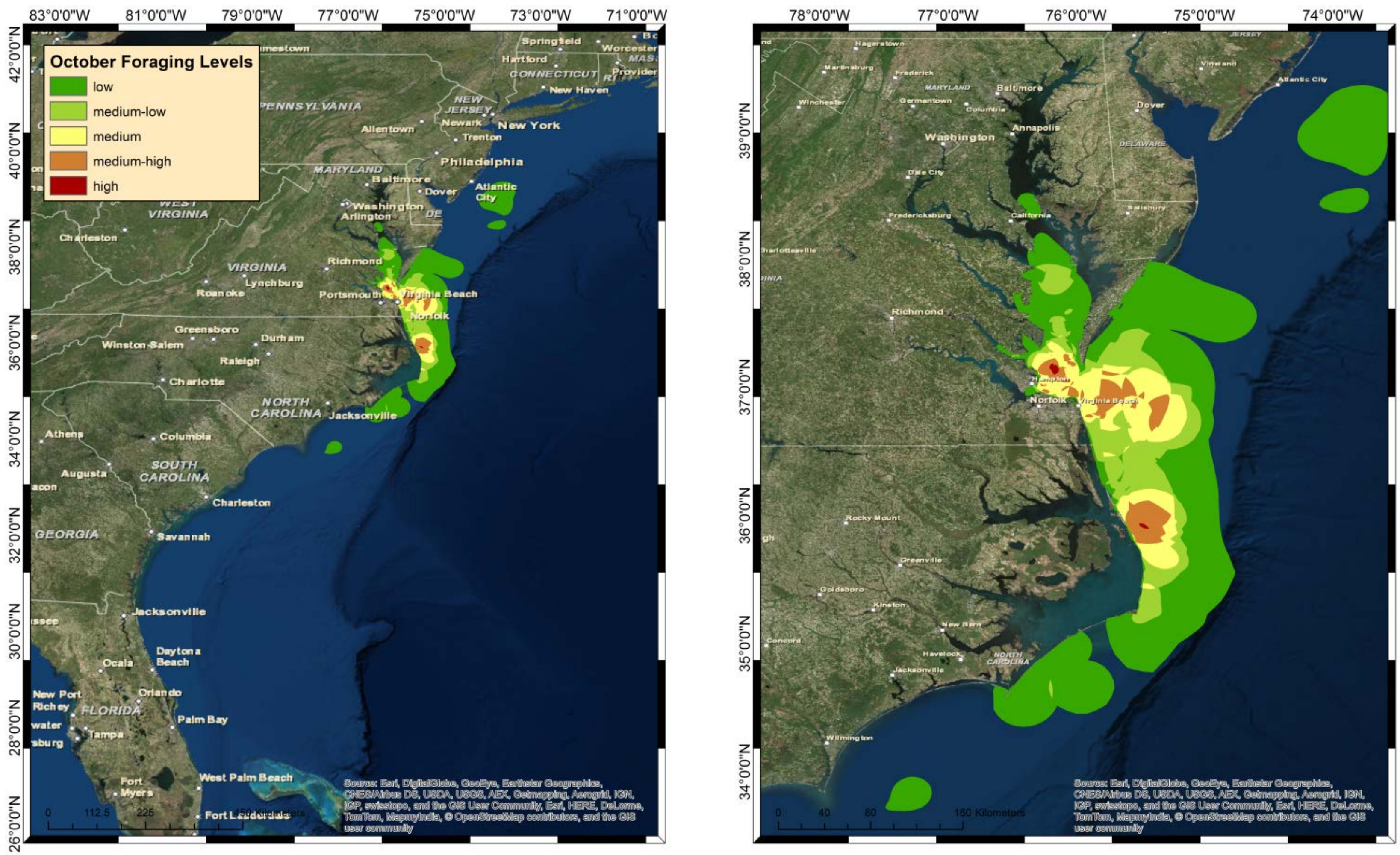


Figure 22: Full (left) and regional (right) views of index of relative foraging developed from loggerhead turtles tracked in October (*n*=18) from 2007 to 2015.

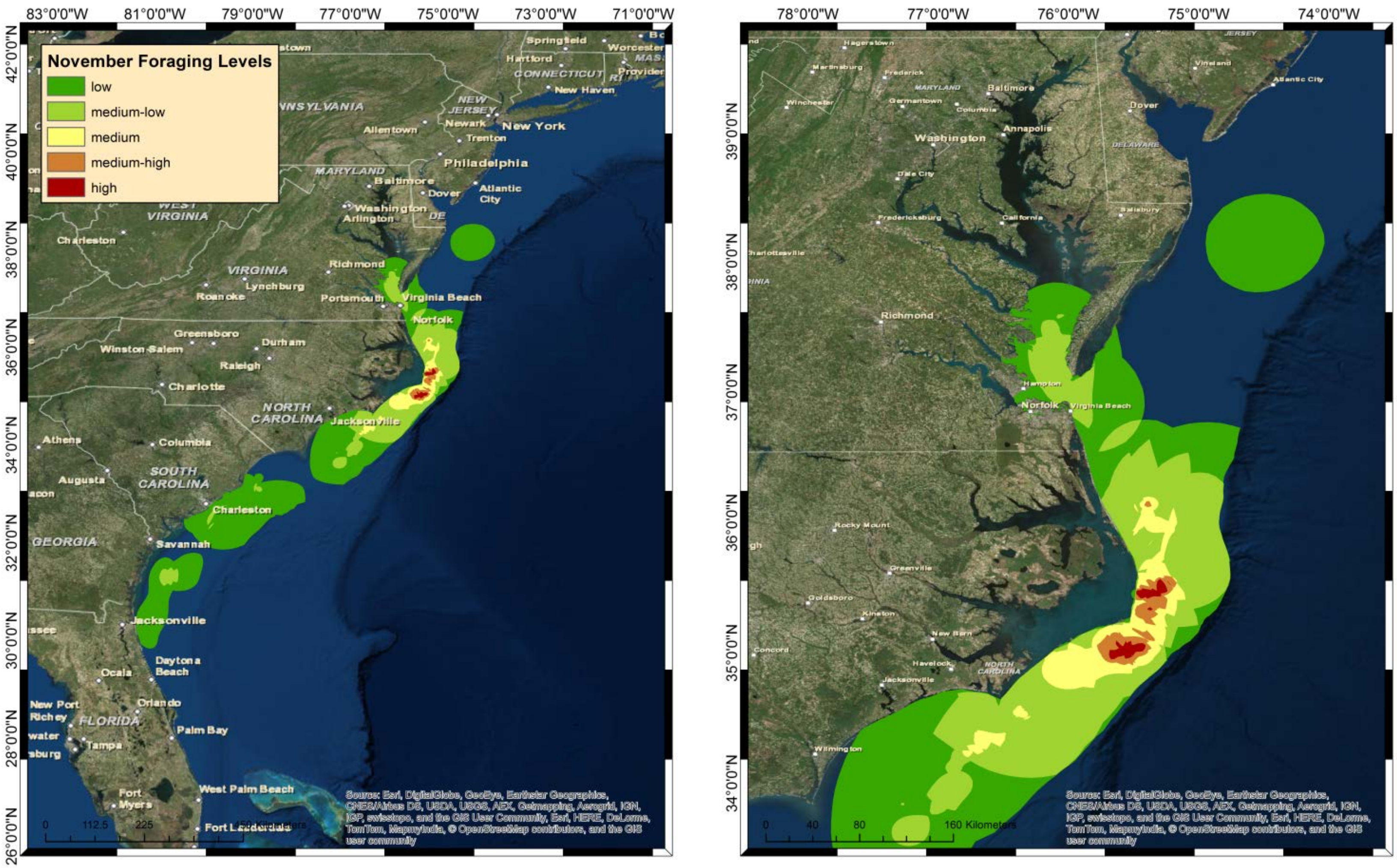


Figure 23: Full (left) and regional (right) views of index of relative foraging developed from loggerhead turtles tracked in November (*n*=19) from 2007 to 2015.

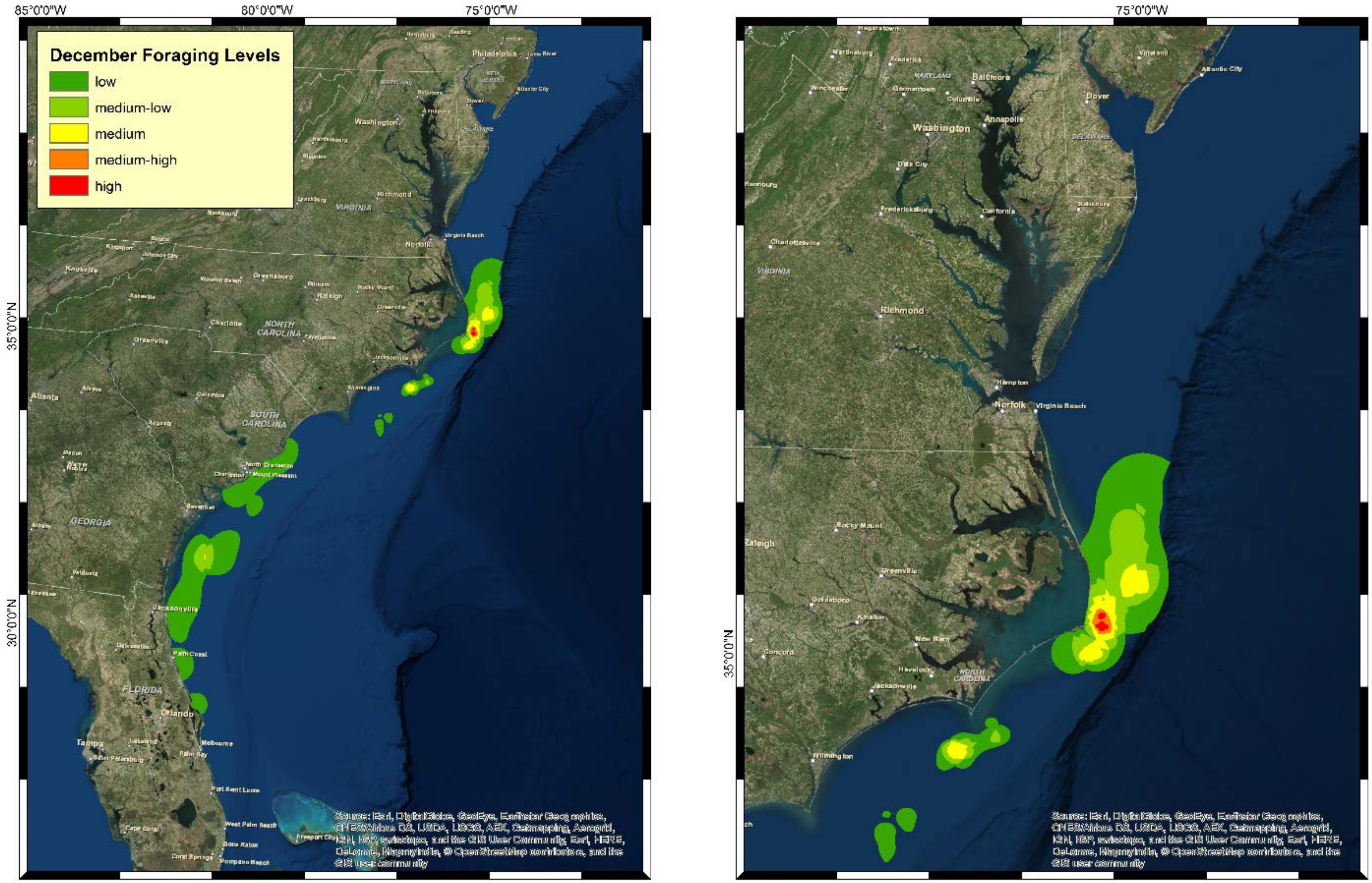


Figure 24: Full (left) and regional (right) views of index of relative foraging developed from loggerhead turtles tracked in December (*n*=16) from 2007 to 2015.

4. Discussion

4.1 Acoustic Telemetry Data

Acoustic Telemetry Detection Experiment and GPS/Acoustic Detection Matching Study

The detection range experiment revealed disappointing results, with the range of the larger V16 transmitters resulting in no detections beyond 900 m and a 50 percent detection rate at approximately 415 m. The larger transmitters produce a stronger signal, suggesting that the maximum and 50 percent detection range for the V13 transmitters placed on smaller Kemp's ridley and green turtles is shorter.

The weather and water conditions were favorable for the duration of the experiment, so researchers doubt that the weather had a negative effect on the detection range. Most of the receivers were, however, in relatively shallow water; so increasing depth possibly allows for increased range. The data from the GPS/acoustic detection matching analysis suggest that some turtles are detected at more than 1,500 m. Assuming a maximum swimming speed of 3 km/hr (reviewed in Wyneken 1997), a turtle swimming directly toward a receiver could cover 100 m in 2 min. There were 3 detections of matched records within 2 min at 1,800 m and 2 at 1,600 m, suggesting that a few detections did occur at a minimum of 1,500 to 1,700 m, far greater than the zero percent detection at 900m suggested by the range study (see **Figure 6**).

Number of deployments and detections

In 2013 and 2014, researchers were disappointed with the detection rate and apparent transmitter retention for Kemp's ridley turtles. With the wire attachment technique employed in 2015, both the detection rate and the retention time (measured as days from release to last detection in Virginia) increased, and turtles tagged in 2015 may be detected in future seasons extending those times even more. In addition to improved transmitter attachment, researchers also improved the dip-net capture rate and plan to continue capturing Kemp's ridley turtles in 2016 using the same technique.

Patterns of appearance in the military zones differed between 2013–2014 and 2015. These differences may, in part, be a reflection of the different transmitter attachment techniques resulting in better transmitter retention in 2015. The 2015 acoustic telemetry data suggest that some Kemp's ridley turtles, like satellite-tagged loggerhead turtles, move deeper into the Chesapeake Bay than can be detected by the U.S. Navy receiver array, appearing in the array just after release and again as they migrate south in the fall.

The acoustic array has also allowed researchers to detect presumably compromised turtles that did not migrate yet were never recovered as stranded animals. This occurred with two Kemp's ridley turtles detected in 2015. One was released in 2015 and the other was released in 2014 and detected in January of 2015.

Movement patterns

The higher numbers of detections, days detected, and days post-release in 2015 allowed receivers to capture many of the acoustic tagged turtles as they left Chesapeake Bay. For the ten turtles with detections in September, October, or November (4 loggerheads and 6 Kemp's ridleys), the last detection for all but one was in the lower Chesapeake Bay or Atlantic Ocean, suggesting that the turtles were leaving the area with functioning transmitters. The one turtle that was in the Elizabeth River through December was probably compromised by mid-November and likely dead from 8 December through the rest of the year. Although it had a very high number of detections prior to mid-November, the turtle's detection pattern was not unlike two loggerheads tagged in 2013–2014 that had high detection numbers in the NNB zone.

4.2 Satellite Telemetry Data

The point-count grid (see **Figure 15**) revealed that Chesapeake Bay and North Carolina waters were high-use areas for sea turtles captured or stranded and released in Virginia. As data-collection technology and analysis methods have become more sophisticated, it is possible to answer questions about finer-scale temporal and spatial presence combined with specific animal behavior. The seasonal foraging grids developed here are both spatially and temporally more fine-scaled than the point-count grid and incorporate behavioral information into the analysis. According to the index of relative foraging developed by the authors, higher loggerhead turtle relative foraging activity occurred in Chesapeake Bay, particularly from May through October. Loggerhead foraging occurred in Virginia ocean waters in May, August, September, and October, but not in June or July. Several of the loggerhead turtles tagged in offshore Virginia waters moved north and appeared to forage off Delaware and New Jersey during the summer months before moving south to forage in Virginia ocean waters in the late summer and fall.

Although the analyses did not measure or compare absolute foraging activity across months, higher relative foraging distribution was concentrated in mouth of Chesapeake Bay in the spring, shifted to the middle and upper Bay, including southern Maryland waters, in the summer and back to the mouth of the Bay again in the fall. Additionally, researchers observed that higher relative foraging was more discretely distributed in the spring and fall as opposed to broadly dispersed throughout Chesapeake Bay, especially along the western shore, in August. By combining SSSM modeling and home-range analysis, researchers have been able to examine the distribution of foraging activity on a seasonal basis. The relative foraging polygons will be provided to state and federal agencies to be included in their GIS databases. They will be available when agencies are consulting in regards to management actions that are predicted to impact sea turtles.

5. Summary and Future Work

The data collected during this project provide important information on the locations of sea turtles in relation to military facilities and training areas using two tagging methods. The acoustic transmitters provide detailed information on the use of waters adjacent to U.S. Navy facilities in Virginia by sea turtles. Not only are researchers able to detect the presence of turtles in a military zone, but they can track the approximate duration of a stay within that zone, as well as movement in and out of the area during migration. Data from 2015 gave the researchers more information on the range of the tagged turtles and the areas they appear in. Next steps for these data will be to integrate 2013–2014 and 2015 data for a more thorough analysis of occurrence in military zones.

The switching state-space analysis of the historic and early U.S. Navy satellite-tag data has provided a behavioral component to the track data and will inform both the U.S. Navy and state and federal protected-species managers. By identifying foraging versus migratory behavior, researchers will be able to better understand the presence of turtles in military zones and how they might use the habitat. The next steps for the satellite data are to add newer tags to the SSSM foraging analysis and conduct a similar UD/home range analysis on the points identified as migrating behavior. Biologists have plans to continue to deploy satellite tags on Kemp's ridley and green turtles in order to build a database and conduct similar analyses for these species.

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Details of Turtles Included in this Project

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Details of turtles released with tags in 2015 for the project. SCL is the straight carapace length measured from notch to tip.

Field Number	Species	Source	Release Date	SCL (cm)	Tag ID/PTT	Tag Manufacturer	Tag Model
VAQS2014242	Green	stranded/cold stun	3/16/2015	31.0	A69-1601-24788	VEMCO	V16
NEST-14-427	Kemp's ridley	stranded/cold stun	3/16/2015	28.6	A69-1601-24785	VEMCO	V16
VAQR201503	Kemp's ridley	captured/dip net	5/18/2015	35.2	148882	Microwave Telemetry	9.5g Solar
VAQR201504	Kemp's ridley	captured/dip net	5/18/2015	33.6	148880	Microwave Telemetry	9.5g Solar
VAQR201505	Kemp's ridley	captured/dip net	5/28/2015	50.5	148886	Wildlife Computers	SPLASH
VAQR201507	Kemp's ridley	captured/pound net	6/13/2015	24.7	A69-1601-34722	VEMCO	V13-1x
VAQS20142244	Kemp's ridley	stranded/cold stun	5/17/2015	44.0	148889	Wildlife Computers	SPLASH
VAQS20152008	Kemp's ridley	stranded/hooked	5/17/2015	38.1	148881	Microwave Telemetry	9.5g Solar
VAQS20152009	Kemp's ridley	stranded/hooked	5/29/2015	43.3	A69-9002-10953	VEMCO	V16P-1H
VAQS20152012	Kemp's ridley	stranded/hooked	5/21/2015	46.8	A69-9002-10955	VEMCO	V16P-1H
VAQS20152015	Kemp's ridley	stranded/hooked	6/3/2015	48.6	A69-9002-10952	VEMCO	V16P-1H
VAQS20152016	Kemp's ridley	stranded/hooked	6/24/2015	31.9	A69-1601-34714	VEMCO	V13-1H
VAQS20152018	Kemp's ridley	stranded/hooked	5/29/2015	26.7	A69-1601-34715	VEMCO	V13-1H
VAQS20152022	Kemp's ridley	stranded/hooked	6/13/2015	25.3	A69-1601-34718	VEMCO	V13-1H
VAQS20152023	Kemp's ridley	stranded/hooked	6/13/2015	26.4	A69-1601-34719	VEMCO	V13-1H
VAQS20152024	Kemp's ridley	stranded/hooked	6/10/2015	30.7	A69-1601-34717	VEMCO	V13-1H
VAQS20152027	Kemp's ridley	stranded/hooked	6/10/2015	35.3	A69-1601-34716	VEMCO	V13-1H
VAQS20152039	Kemp's ridley	stranded/hooked	6/24/2015	28.3	A69-1601-34723	VEMCO	V13-1H
VAQS20152049	Kemp's ridley	stranded/hooked	6/25/2015	35.0	150767	Wildlife Computers	SPOT
VAQS20152051	Kemp's ridley	stranded/hooked	6/24/2015	27.7	A69-1601-34720	VEMCO	V13-1H
VAQS20152058	Kemp's ridley	stranded/hooked	6/24/2015	30.0	A69-1601-34721	VEMCO	V13-1H
VAQR201501	Loggerhead	captured/dip net	5/15/2015	69.4	112298	Wildlife Computers	SPOT
VAQR201502	Loggerhead	captured/dip net	5/15/2015	57.0	148887	Wildlife Computers	SPLASH
VAQR201506	Loggerhead	captured/dip net	5/28/2015	82.6	148888	Wildlife Computers	SPLASH
VAQR201508	Loggerhead	captured/pound net	7/1/2015	72.5	148883	SMRU	SRDL
VAQR201509	Loggerhead	captured/pound net	6/27/2015	53.4	A69-9002-10958	VEMCO	V16P-1H
VAQR201510	Loggerhead	captured/pound net	7/1/2015	64.0	148884	SMRU	SRDL
VAQR201512	Loggerhead	capture/dredge trawl	8/6/2015	88.9	148888	SMRU	SRDL

Field Number	Species	Source	Release Date	SCL (cm)	Tag ID/PTT	Tag Manufacturer	Tag Model
VAQS20142177	Loggerhead	stranded/vessel strike	3/16/2015	64.0	138113	Wildlife Computers	SPLASH
VAQS20142235	Loggerhead	stranded/cold stun	3/16/2015	69.7	120348	SMRU	SRDL
VAQS20142236	Loggerhead	stranded/cold stun	5/21/2015	74.0	A69-9002-10951	VEMCO	V16P-1H
VAQS20152048	Loggerhead	stranded/sick	9/15/2015	49.1	A69-9002-10954	VEMCO	V16P-1H
VAQS20152062	Loggerhead	stranded/hooked	7/23/2015	59.7	A69-9002-10950	VEMCO	V16P-1H
VAQS20152063	Loggerhead	stranded/hooked	7/23/2015	64.8	A69-9002-10959	VEMCO	V16P-1H
VAQS20152072	Loggerhead	stranded/hooked	6/24/2015	57.0	A69-9002-10956	VEMCO	V16P-1H
VAQS20152086	Loggerhead	stranded/hooked	8/15/2015	67.2	A69-9002-10957	VEMCO	V16P-1H

Field Number	Total Detections	Days Detected	Duration (days)	Last Detection Location	# Navy Receivers	Days Tracked
VAQS2014242	0	NA	NA	NA	NA	-
NEST-14-427	0	NA	NA	NA	NA	-
VAQR201503	-	-	-	-	-	110
VAQR201504	-	-	-	-	-	1
VAQR201505	-	-	-	-	-	43
VAQR201507	0	NA	NA	NA	NA	-
VAQS20142244	-	-	-	-	-	58
VAQS20152008	-	-	-	-	-	37
VAQS20152009	55	3	151	Atlantic Ocean	7	-
VAQS20152012	5	1	2	Chesapeake Bay	1	-
VAQS20152015	1	1	4	Chesapeake Bay	1	-
VAQS20152016	6	2	148	Atlantic Ocean	4	-
VAQS20152018	6547*	157	222	Elizabeth River	16	-
VAQS20152022	52	4	6	Atlantic Ocean	5	-
VAQS20152023	280	11	140	Atlantic Ocean	15	-
VAQS20152024	15	2	4	Chesapeake Bay	4	-
VAQS20152027	180	7	27	Chesapeake Bay	6	-
VAQS20152039	55	4	126	Atlantic Ocean	8	-
VAQS20152049	-	-	-	-	-	10
VAQS20152051	0	NA	NA	NA	NA	-
VAQS20152058	106	11	120	Atlantic Ocean	13	-
VAQR201501	-	-	-	-	-	111
VAQR201502	-	-	-	-	-	39
VAQR201506	-	-	-	-	-	48
VAQR201508	-	-	-	-	-	24
VAQR201509	353	36	96	Chesapeake Bay	13	-
VAQR201510	-	-	-	-	-	28

Field Number	Total Detections	Days Detected	Duration (days)	Last Detection Location	# Navy Receivers	Days Tracked
VAQR201512	-	-	-	-	-	30
VAQS20142177	-	-	-	-	-	25
VAQS20142235	-	-	-	-	-	309
VAQS20142236	1	1	8	Atlantic Ocean	1	-
VAQS20152048	504	15	180	Atlantic Ocean	15	-
VAQS20152062	5	1	2	Chesapeake Bay	1	-
VAQS20152063	33	2	90	Chesapeake Bay	10	-
VAQS20152072	97	6	3	Atlantic Ocean	3	-
VAQS20152086	31	8	112	Atlantic Ocean	2	-

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