Atlantic Fleet Training and Testing (AFTT)

2015 Annual Monitoring Report



Prepared For and Submitted To

National Marine Fisheries Service

Office of Protected Resources

Prepared by

Department of the Navy

In accordance with 50 C.F.R. §216.245(e)

July 2016

Citation for this report is as follows:

DoN (Department of the Navy). 2016. *Marine Species Monitoring Report for the U.S. Navy's Atlantic Fleet Training and Testing (AFTT) – 2015 Annual Report*. U.S. Fleet Forces Command, Norfolk, Virginia. July 2016.

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From left to right:

Short-beaked common dolphin (*Delphinus delphis*) offshore of Virginia Beach. Photographed by Jessica Aschettino, taken under National Marine Fisheries Service Scientific Permit No. 16239.

Loggerhead turtle (*Caretta caretta*) in process of being released after tagging. Photo courtesy of Virginia Aquarium, taken under National Marine Fisheries Service Scientific Permit No. 16134

Cuvier's beaked whale (*Ziphius cavirostris*) off Cape Hatteras. Photographed by Heather Foley, Duke University, taken under National Marine Fisheries Service Scientific Permit No. 14809 (Douglas Nowacek) and National Marine Fisheries Service General Authorization Letter of Confirmation 16185 held by Duke University.

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ACRONYMS AND ABBREVIATIONS

AFAST	Atlantic Fleet Active Sonar Training
AFTT	Atlantic Fleet Training and Testing
AMAPPS	Atlantic Marine Assessment Program for Protected Species
AMAR	Autonomous Multi-channel Acoustic Recorder
AMR	Adaptive Management Review
ARS	Acoustic Reference Source
ASW	Anti-Submarine Warfare
AUTEC	Atlantic Undersea Test and Evaluation Center
BSE	bay, sound, and estuary
CHSRA	Cape Hatteras Special Research Area
CRC	Cascadia Research Collective
BSS	Beaufort sea state
CI	Confidence Interval
CNO	Chief of Naval Operations
CREEM	Centre for Research into Ecological and Environmental Monitoring
CV	Coefficient of Variation
DEUO	common dolphins, striped dolphins, and unidentified odontocetes
DMON	digital acoustic monitoring
DMP	Data Management Plan
DOD	Department of Defense
DoN	Department of the Navy
DPM	detection-positive minutes
DTAG	digital acoustic tag
EAR	ecological acoustic recorder
EEZ	Exclusive Economic Zone
EIMS	Environmental Information Management System
ESA	Endangered Species Act
EWS	Early Warning System
FACSFAC	Fleet Area Control and Surveillance Facility
FS	Fort Story
GEE	generalized estimating equations
GIS	Geographic Information System
GOMEX	Gulf of Mexico
GPS	global positioning system
HARP	high-frequency acoustic recording/recorder package
HF	high-frequency
HMM	hidden Markov models
hr	hour(s)
HSTT	Hawaii-Southern California Training and Testing
Hz	hertz
ICMP	Integrated Comprehensive Monitoring Program
ITS	Incidental Take Statement
JAX	Jacksonville (Florida)
JEB	Joint Expeditionary Base
JLOTS	Joint Logistics Over The Shore
kHz	kilohertz
km	kilometer(s)
km^2	square kilometer(s)
LC	Little Creek
LF	low-frequency
LFDCS	low-frequency detection and classification system

LIMPET	Low Impact Minimally Percutaneous External-electronics Transmitter
LMR	Living Marine Resources
LOA	Letter of Authorization
LTSA	long-term spectral averages
m	meter(s)
M3R	Marine Mammal Monitoring on Navy Ranges
MARU	Marine Autonomous Recording Unit
MFA	mid-frequency active
min	minute(s)
MINEX	Mine-neutralization Exercise
MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act
MSM	Marine Species Monitoring
N45	Energy and Environmental Readiness Division
NAS	Naval Air Station
NAVFAC	Naval Facilities Engineering Command
NEFSC	Northeast Fisheries Science Center
NMFS	National Marine Fisheries Services
NMSDD	Navy Marine Species Density Database
NNB	Norfolk Naval Base
NOAA	National Oceanic and Atmospheric Administration
NSN	Naval Station Norfolk
NSWC	Naval Surface Warfare Center
OBIS-SEAMAP	Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations
OPAREA	Operating Area
OSI	Oceanwide Science Institute
PAM	passive acoustic monitoring
PAX	Patuxent River (Maryland)
PCoD	Population Consequences of Disturbance
photo-ID	photo-identification
QC	quality control
R&D	Research and Development
ROCCA	Real-time Odontocete Call Classification Algorithm
R/V	Research Vessel
sec	second(s)
SEFSC	Southeast Fisheries Science Center
SPOT	Smart Position and Temperature
SSSM	switching state-space model
SYSCOM	systems command
U.S.	United States
UNCW	University of North Carolina at Wilmington
UNDET	underwater detonation
USWTR	Undersea Warfare Training Range
VACAPES	Virginia Capes
VAQF	Virginia Aquarium Foundation
WMD	whistle and moan detector

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SECTION 1 – INTRODUCTION

This report contains a summary of marine species monitoring activities funded by the United States (U.S.) Navy within the Atlantic Fleet Training and Testing (AFTT) Study Area during 2015. The U.S. Navy conducts marine mammal and sea turtle monitoring for compliance with the Letters of Authorization (NMFS 2013a, 2013b) and Biological Opinion (NMFS 2013c) issued under the Marine Mammal Protection Act of 1972 (MMPA) and the Endangered Species Act of 1973 (ESA) for training and testing in the AFTT Study Area. This report also reflects an evolution in the approach to monitoring reports for this area. Concurrent with Phase II of the U.S. Navy's Marine Species Monitoring (MSM) Program, the U.S. Navy and the National Marine Fisheries Service (NMFS) have agreed to assess compliance based on demonstrated progress towards addressing scientific objectives, rather than on specific monitoring requirements for each range complex from effort-based metrics. This report summarizes the progress, accomplishments, and results from projects currently being conducted in the AFTT Study Area. Additional details on each project are available in individual technical reports linked directly from the corresponding sub-section of this report.

1.1 Background

The AFTT Study Area includes only the at-sea components of the range complexes and testing ranges in the western Atlantic Ocean and encompasses the east coast of North America and the Gulf of Mexico (**Figure 1**). The Study Area covers approximately 2.6 million square nautical miles of ocean area, and includes designated U.S. Navy operating areas (OPAREAs) and special use airspace. The Study Area also includes several U.S. Navy testing ranges and range complexes, as well as Narragansett Bay, lower Chesapeake Bay, St. Andrew Bay, and pierside locations where sonar maintenance and testing occurs.

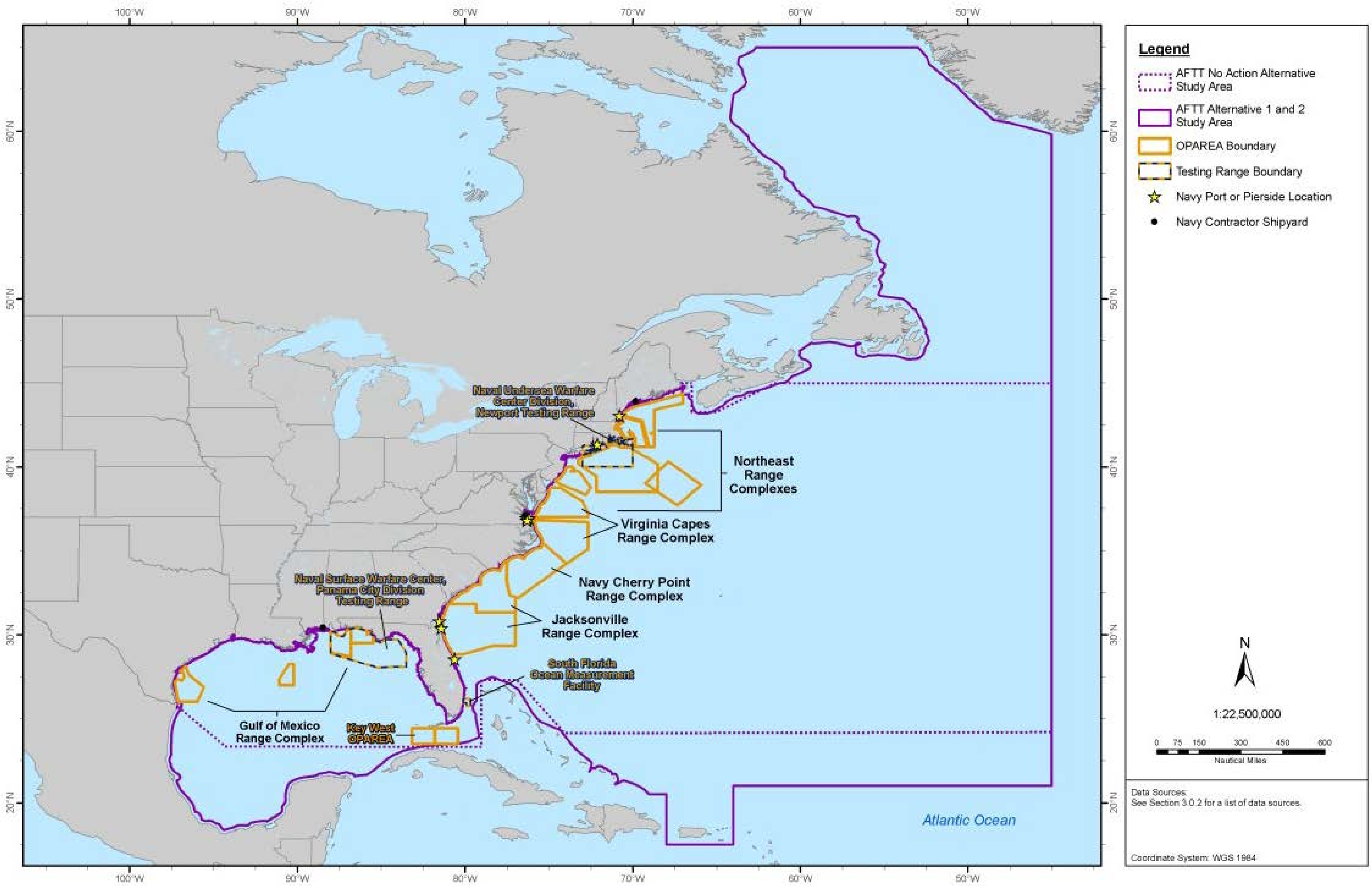

Figure 1. AFTT Study Area.

In order to issue an Incidental Take Statement (ITS) for an activity that has the potential to affect protected marine species, NMFS must set forth "requirements pertaining to the monitoring and reporting of such taking" (50 Code of Federal Regulations § 216.101(a)(5)(a)). A request for a Letter of Authorization (LOA) must include a plan to meet the necessary monitoring and reporting requirements, while increasing the understanding, and minimizing the disturbance, of marine mammal and sea turtle populations expected to be present. While the ESA does not have a specific monitoring requirement, the Biological Opinion issued in November 2013 by NMFS for the AFTT Study Area includes terms and conditions for continued monitoring in this region (NMFS 2013c).

The U.S. Navy previously submitted annual monitoring and mission activities reports for AFTT as well as for the Atlantic Fleet Active Sonar Training (AFAST) and the East Coast/Gulf of Mexico (GOMEX) Range Complexes to NMFS for 2009 through 2014 (DoN 2009, 2010a, 2010b, 2010c, 2010d, 2010e, 2011a, 2011b, 2011c, 2011d, 2012a, 2012b, 2012c, 2012d; 2013a, 2013b, 2014a, 2014b, 2014c, 2015a, 2015b).

The U.S. Navy has invested nearly $22 million (**Table 1**) in monitoring activities in the AFTT Study Area since 2009. Additional information on the program is available on the U.S. Navy's Marine Species Monitoring Program website (http://www.navymarinespeciesmonitoring.us). The website serves as an online portal for information on the background, history, and progress of the program, and it also provides access to reports, documentation, data, and updates on current monitoring projects and initiatives.

Table 1. Annual funding for the U.S. Navy's Marine Species Monitoring Program in the AFTT Study Area (formerly AFAST and East Coast/GOMEX Range Complexes) during FY09-FY15.

Fiscal Year (01 Oct–30 Sept)	Funding Amount
FY09	$1,555,000
FY10	$3,768,000
FY11	$2,749,000
FY12	$3,483,000
FY13	$3,775,000
FY14	$3,311,000
FY15	$3,700,000
Total	**$22,341,000**

Key: FY = Fiscal Year

In addition to the Fleet-funded monitoring program, the Office of Naval Research Marine Mammals and Biology Program and the Office of the Chief of Naval Operations (CNO) Energy and Environmental Readiness Division's (N45) Living Marine Resources (LMR) Program support coordinated Science & Technology and Research & Development focused on understanding the effects of sound on marine mammals, including physiological, behavioral, ecological, and population-level effects (DoN 2010f). These programs currently fund several significant ongoing projects relative to potential operational impacts to marine mammals within some U.S. Navy range complexes. Additional information on these programs and other ocean resources-oriented initiatives can be found at the U.S. Navy's Green Fleet – Energy, Environment, and Climate Change website.

1.2 Integrated Comprehensive Monitoring Program

The Integrated Comprehensive Monitoring Program (ICMP) provides the overarching framework for coordination of the U.S. Navy's marine species monitoring efforts (DoN 2010g) and serves as a planning tool to focus U.S. Navy monitoring priorities pursuant to ESA and MMPA requirements. The purpose of the ICMP is to coordinate monitoring efforts across all regions and to allocate the most appropriate level and type of monitoring effort for each range complex based on a set of standardized objectives, regional expertise, and resource availability. Although the ICMP does not identify specific monitoring or field projects, it provides a flexible, scalable, and adaptable framework for such projects using adaptive management and strategic planning processes that periodically assess progress and reevaluate objectives.

The ICMP is evaluated through the Adaptive Management Review (AMR) process to: (1) assess progress, (2) provide a matrix of goals and objectives for the following year, and (3) make recommendations for refinement and analysis of the monitoring and mitigation techniques. This process includes conducting an annual AMR meeting at which the U.S. Navy and NMFS jointly consider the prior-year goals, monitoring results, and related scientific advances to determine if monitoring plan modifications are warranted to more effectively address program goals. Modifications to the ICMP that result from AMR discussions are incorporated by an addendum or revision to the ICMP. As a planning tool, the ICMP will be routinely updated as the program evolves and progresses. The most significant addition in 2013/2014 was the development of the Strategic Planning Process (DoN 2013d), which serves to guide the investment of resources to most efficiently address ICMP objectives and intermediate scientific objectives developed through this process. More details on the Strategic Planning Process are provided in **Section 4**.

Under the ICMP, U.S. Navy-funded monitoring relating to the effects of U.S. Navy training and testing activities on protected marine species should be designed to accomplish one or more top-level goals as described in the current version of the ICMP (DoN 2010g):

(a) An increase in an understanding of the likely occurrence of marine mammals and/or ESA-listed marine species in the vicinity of the action (i.e., presence, abundance, distribution, and/or density of species).

(b) An increase in an understanding of the nature, scope, or context of the likely exposure of marine mammals and/or ESA-listed species to any of the potential stressors associated with the action (e.g., sound, explosive detonation, or expended materials), through better understanding of one or more of the following: (1) the nature of the action and its surrounding environment (e.g., sound-source characterization, propagation, and ambient noise levels); (2) the affected species (e.g., life history or dive patterns); (3) the likely co-occurrence of marine mammals and/or ESA-listed marine species with the action (in whole or part); and/or (4) the likely biological or behavioral context of exposure to the stressor for the marine mammal and/or ESA-listed marine species (e.g., age class of exposed animals or known pupping, calving, or feeding areas).

(c) An increase in our understanding of how individual marine mammals or ESA-listed marine animals respond (behaviorally or physiologically) to the specific stressors associated with the action (in specific contexts, where possible, e.g., at what distance or received level).

(d) An increase in our understanding of how anticipated individual responses, to individual stressors or anticipated combinations of stressors, may impact either: (1) the long-term fitness and survival of an individual; or (2) the population, species, or stock (e.g., through effects on annual rates of recruitment or survival).

(e) An increase in our understanding of the effectiveness of mitigation and monitoring measures, including increasing the probability of detecting marine mammals to better achieve the above goals (through improved technology or methods), both generally and more specifically within the safety zone (thus allowing for more effective implementation of the mitigation). Improved detection technology will be rigorously and scientifically validated prior to being proposed for mitigation, and should meet practicality considerations (engineering, logistic, and fiscal).

(f) A better understanding and record of the manner in which the authorized entity complies with the Incidental Take Authorization and Incidental Take Statement.

CNO-N45 is responsible for maintaining and updating the ICMP, as necessary, reflecting the results of regulatory agency rulemaking, AMRs, best available science, improved assessment methods, and more effective protective measures. This is done as part of the AMR process, in consultation with U.S. Navy technical experts, Fleet Commanders, and Echelon II Commands as appropriate.

1.3 Report Objectives

This report presents the progress, accomplishments, and results of marine species monitoring activities in the AFTT Study Area in 2015 and has two primary objectives:

1. Summarize findings from the U.S. Navy-funded marine mammal and sea turtle monitoring conducted in the AFTT Study Area during 2015, as well as monitoring data analyses performed during this time period. Detailed technical reports for these efforts are referenced throughout this report and provided as supporting documents.
2. Continue the AMR process by providing an overview of monitoring initiatives, progress, and evolution of the ICMP and Strategic Planning Process for U.S. Navy marine species monitoring. These initiatives continue to shape the evolution of the U.S. Navy MSM Program for 2016 and beyond to improve our understanding of the occurrence and distribution of marine mammals and sea turtles in the AFTT Study Area and their exposure and response to sonar and explosives training and testing activities.

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SECTION 2 – MARINE SPECIES MONITORING ACTIVITIES

2.1 Occurrence, Distribution, and Population Structure

In 2005, the U.S. Navy contracted with a consortium of researchers from Duke University, the University of North Carolina at Wilmington (UNCW), the University of St. Andrews, and NMFS's Northeast Fisheries Science Center (NEFSC) to conduct a pilot study and subsequently develop a survey and monitoring plan. The plan included a recommended approach for data collection at the proposed site of the Undersea Warfare Training Range (USWTR) in Onslow Bay off the coast of North Carolina. The identified methods included surveys (aerial/shipboard, frequency, spatial extent, etc.), passive acoustic monitoring (PAM), photo-identification (photo-ID), and data analysis (e.g., standard line-transect, spatial modeling) appropriate to establish a fine-scale seasonal baseline of protected marine species distribution and abundance. As a result, a protected marine species monitoring program was initiated in June 2007 in Onslow Bay. Due to a re-evaluation of the proposed location for USWTR, the preferred location was changed to the Jacksonville Operating Area (JAX OPAREA). Therefore, a parallel monitoring program was initiated in January 2009 at the proposed USWTR site in the JAX OPAREA off the coast of Jacksonville, Florida. In addition to supporting the Jacksonville USWTR site monitoring, the program was also refined to support the monitoring requirements set forth in the Incidental Take Statements and Terms and Conditions for AFAST and the East Coast Range Complexes issued in 2009. In 2011, the program expanded beyond the previous Onslow Bay focus site to include a region of U.S. Navy training activity off the coast of Cape Hatteras to the north. This study area also serves to complement a pilot whale behavioral study initiated in that region at the same time. The overall approach to program design and methods has been consistent with the work that had been performed over the previous 6 years, and work across the locations continues to evolve in response to the AMR process and changing priorities.

In 2015, the longitudinal baseline study consisted of year-round multi-disciplinary monitoring through the use of aerial and vessel-based visual surveys, photo-ID, biopsy sampling, and PAM with high-frequency acoustic recording packages (HARPs). Monthly visual surveys were conducted year-round (weather permitting) using established track lines and standard Distance-sampling techniques. A summary of accomplishments and basic results of these monitoring efforts for the reporting period is presented in the following subsections.

All previous annual reports on this component of the baseline monitoring program are available through the U.S. Navy's MSM Program web portal (http://www.navymarinespeciesmonitoring.us/).

Although the initial intent of the Onslow Bay and JAX monitoring program was to support development of the planned USWTR, the program evolved into established long-term study sites addressing intermediate scientific objectives within the ICMP framework for AFTT. The monitoring work at these sites provides a longitudinal baseline of data on marine species occurrence, distribution, abundance, and behavior in key U.S. Navy training areas and serves as a reference for addressing questions concerning exposure, response, and consequences.

2.1.1 Visual Baseline Aerial Surveys

Visual aerial surveys were conducted at four study sites in the AFTT Study Area in 2015. All aerial surveys were flown along established tracklines using line-transect aerial survey designs and standard Distance-sampling protocols. During the current reporting period (January–December 2015), the long-term survey programs in both the Cherry Point/Virginia Capes (VACAPES) OPAREAs (i.e., Norfolk Canyon and Cape

Hatteras sites) and Jacksonville OPAREA were continued (**Sections 2.1.1.1** and **2.1.1.2,** respectively; **Figures 2a** and **2b**, respectively) and two additional aerial monitoring efforts were recently initiated. One effort is in nearshore waters of the VACAPES OPAREA (**Section 2.1.2.3**), while the other will provide quantitative data and information on the seasonal occurrence, distribution, and density of marine mammals and sea turtles in Chesapeake Bay waters near Naval Air Station (NAS) Patuxent River (**Section 2.1.2.4**).

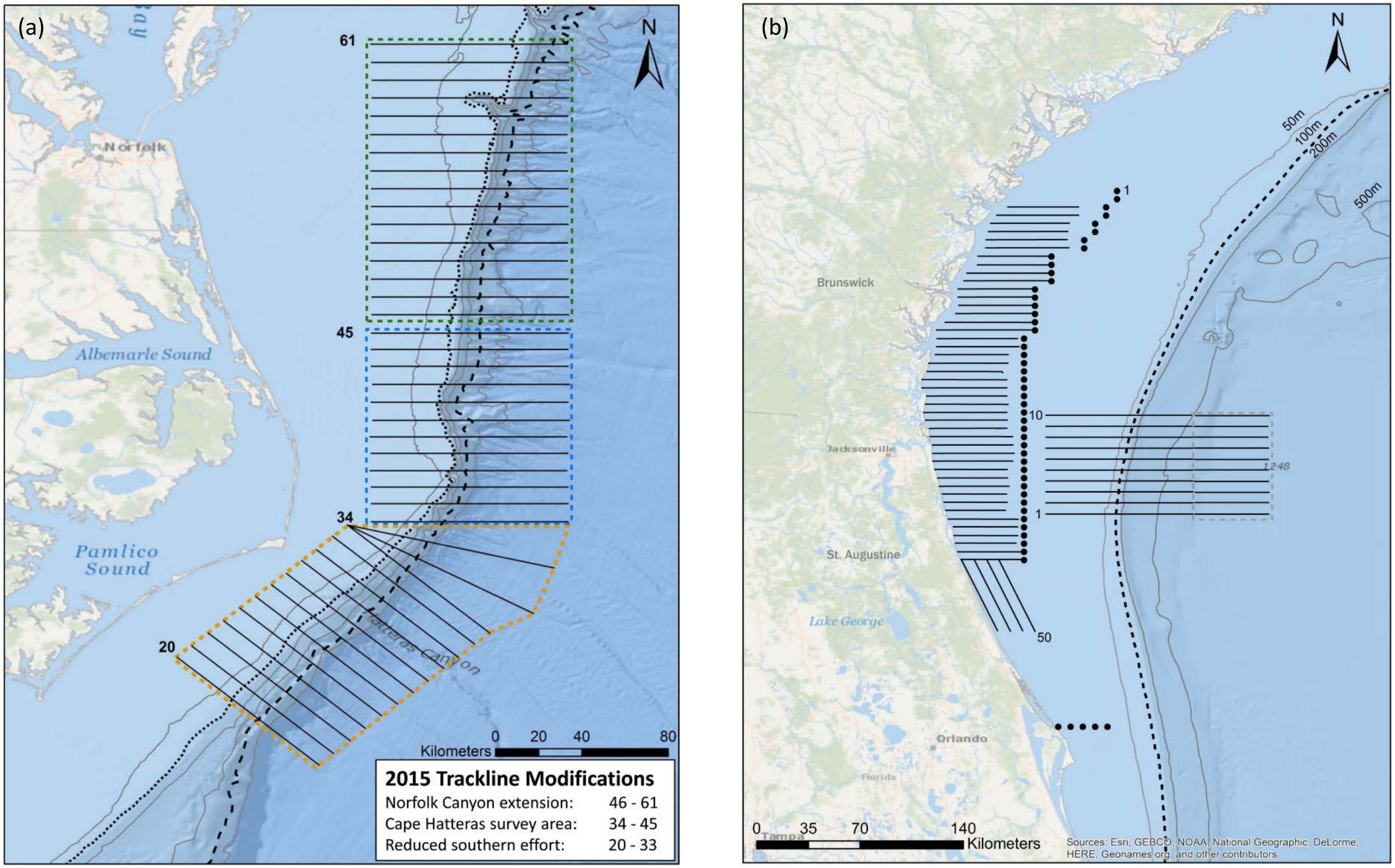


Figure 2. Cape Hatteras and Norfolk Canyon (2a) and Jacksonville (2b) survey areas showing established tracklines used for longitudinal baseline monitoring. Cape Hatteras, North Carolina, survey area (2a) modifications for the 2015 survey season are shown. Aerial surveys at the JAX location (2b) are coordinated with the North Atlantic right whale Early Warning System (EWS, the nearshore lines) surveys to maximize coverage of potential right whale ocurrence within the region. Tracklines 1-10 that compose the Jacksonville, Florida survey site and the EWS survey lines. Gray box highlights additional survey tracklines. Black dots indicate EWS offshore extensions that were added this reporting period.

2.1.1.1 Cherry Point and VACAPES Offshore Aerial Surveys

Aerial survey efforts were initiated in the waters off Cape Hatteras, North Carolina, in May 2011 to assess the distribution and abundance of offshore cetacean species and sea turtles. Beginning in 2015, the survey area was extended north following the shelf break include the Norfolk Canyon region (**Figure 2b**). This expansion resulted in a greater portion of the survey area falling within the airspace of the U.S. Navy's Fleet Area Control and Surveillance Facility (FACSFAC) in VACAPES. These survey areas overlap both the Cherry Point and VACAPES OPAREAs.

Researchers from UNCW conducted 16 days of aerial survey effort across the Cape Hatteras and Norfolk Canyon regions during 2015. The goal was to conduct at least 2 days of effort per month in each region, covering a subset of the 28 tracklines over the area, however this was only accomplished for 5 months (July, August, September, October, and November). In January, March, April, May, June, and December, a single day of effort was completed. Unfavorable weather conditions and/or complications with the aircraft prohibited survey effort in February

A total of 107 tracklines (67,531 kilometers [km]) was covered in the Cape Hatteras and Norfolk Canyon survey areas (**Table 2**). Survey conditions ranged from Beaufort sea state (BSS) 0 to 6, with nearly 80 percent of effort in BSS 3 or lower. Cetacean sighting rates (sightings/1,000 km surveyed) decreased as BSS increased—38.40 in BSS 1, 21.05 in BSS 2, 21.91 in BSS 3, 12.07 in BSS 4, and 9.21 in BSS 5. Sightings per 1,000 km flown ranged from zero to 48.04 across months surveyed.

Table 2. Effort summary for aerial surveys conducted in the Cape Hatteras and Norfolk Canyon survey areas in 2015.

Number of Survey Days	16
Total Hr Underway*	85
Total Tracklines Covered	107
Total Km Covered	67,531

* Total hours (hr) underway reported as Hobbs hr = total engine time

A total of 160 sightings of 5,243 individual cetaceans representing 13 species was recorded (**Table 3** and **Figure 3**), including fin whale (*Balaenoptera physalus*; 1 sighting of 1 individual), humpback whale (*Megaptera novaeangliae*; 2 sightings of 3 individuals); minke whale (*Balaenoptera acutorostrata*; 2 sightings of 2 individuals), bottlenose dolphins (*Tursiops truncatus*; 54 sightings of 1,030 individuals), short-finned pilot whales (*Globicephala macrorhynchus*; 33 sightings of 795 individuals), Cuvier's beaked whales (*Ziphius cavirostris*; 9 sightings of 24 individuals), Atlantic spotted dolphins (*Stenella frontalis*; 24 sightings of 1,407 individuals), unidentified beaked whales (*Mesoplodon* sp.; 2 sightings of 8 individuals), short-beaked common dolphins (*Delphinus delphis*; 9 sightings of 576 individuals), sperm whales (*Physeter macrocephalus*; 3 sightings of 3 individuals), Clymene dolphins (*Stenella clymene,* 3 sightings of 465 individuals), Risso's dolphins (*Grampus griseus*; 9 sightings of 163 individuals), striped dolphins (*Stenella coeruleoalba,* 6 sightings of 748 individuals), *Kogia* sp. (2 sightings of 6 individuals), and True's beaked whale (*Mesoplodon mirus,* 1 sightings of 2 individuals). Fourteen off-effort sightings were recorded: fin whale (1 sighting of 2 individuals), Risso's dolphin (1 sighting of 15 individuals), short-finned pilot whale (1 sighting of 6 individuals), Atlantic spotted dolphin (5 sightings of 107 individuals), bottlenose dolphin (4 sightings of 68 individuals), and Cuvier's beaked whale (2 sightings of 8 individuals). A sighting was considered off effort if it occurred while transiting to or from the survey area or during a cross-leg tracklines. Any cetaceans that the survey team encountered while investigating a separate sighting cue were also labeled off effort. If two species were seen associated with the same sighting cue both were considered to be on effort. The off-effort sightings are included in the tables and maps for each species but are excluded from any calculations.

Table 3. Sightings from aerial surveys conducted in the Cape Hatteras and Norfolk Canyon survey areas in 2015. On- and off-effort sightings are represented by #/# (on-/off-effort sightings).

Common Name	Scientific Name	Number of Sightings	Number of Individuals
Minke whale	*Balaenoptera acutorostrata*	2/0	2/0
Fin whale	*Balaenoptera physalus*	1/1	1/2
Humpback whale	*Megaptera novaeangliae*	2/0	3/0
Short-beaked common dolphin	*Delphinus delphis*	9/0	576/0
Risso's dolphin	*Grampus griseus*	9/1	163/15
Short-finned pilot whale	*Globicephala macrorhynchus*	33/1	795/6
Unidentified beaked whale	*Mesoplodon* sp.	2/0	8/0
Sperm whale	*Physeter macrocephalus*	3/0	3/0
Pygmy/Dwarf sperm whale	*Kogia* sp.	2/0	6/0
Atlantic spotted dolphin	*Stenella frontalis*	24/5	1,407/107
Clymene dolphin	*Stenella clymene*	3/0	465/0
Striped dolphin	*Stenella coeruleoalba*	6/0	748/0
Bottlenose dolphin	*Tursiops truncatus*	54/4	1,040/68
Cuvier's beaked whale	*Ziphius cavirostris*	9/2	24/8
True's beaked whale	*Mesoplodon mirus*	1/0	2/0
Loggerhead turtle	*Caretta caretta*	108/0	148/0
Leatherback turtle	*Dermochelys coriacea*	10/1	10/1
Unidentified turtle		4/0	5/0
Great white shark	*Carcharodon carcharias*	1/0	1/0
Basking shark	*Cetorhinus maximus*	1/0	1/0
Whale shark	*Rhincodon typus*	1/0	1/0
Unidentified shark		20/0	35/0
Manta ray	*Manta birostris*	33/0	48/0
Cownose ray	*Rhinoptera bonasus*	19/0	4,085/0
Unidentified ray		3/0	6/0
Ocean sunfish	*Mola mola*	18/0	21/0

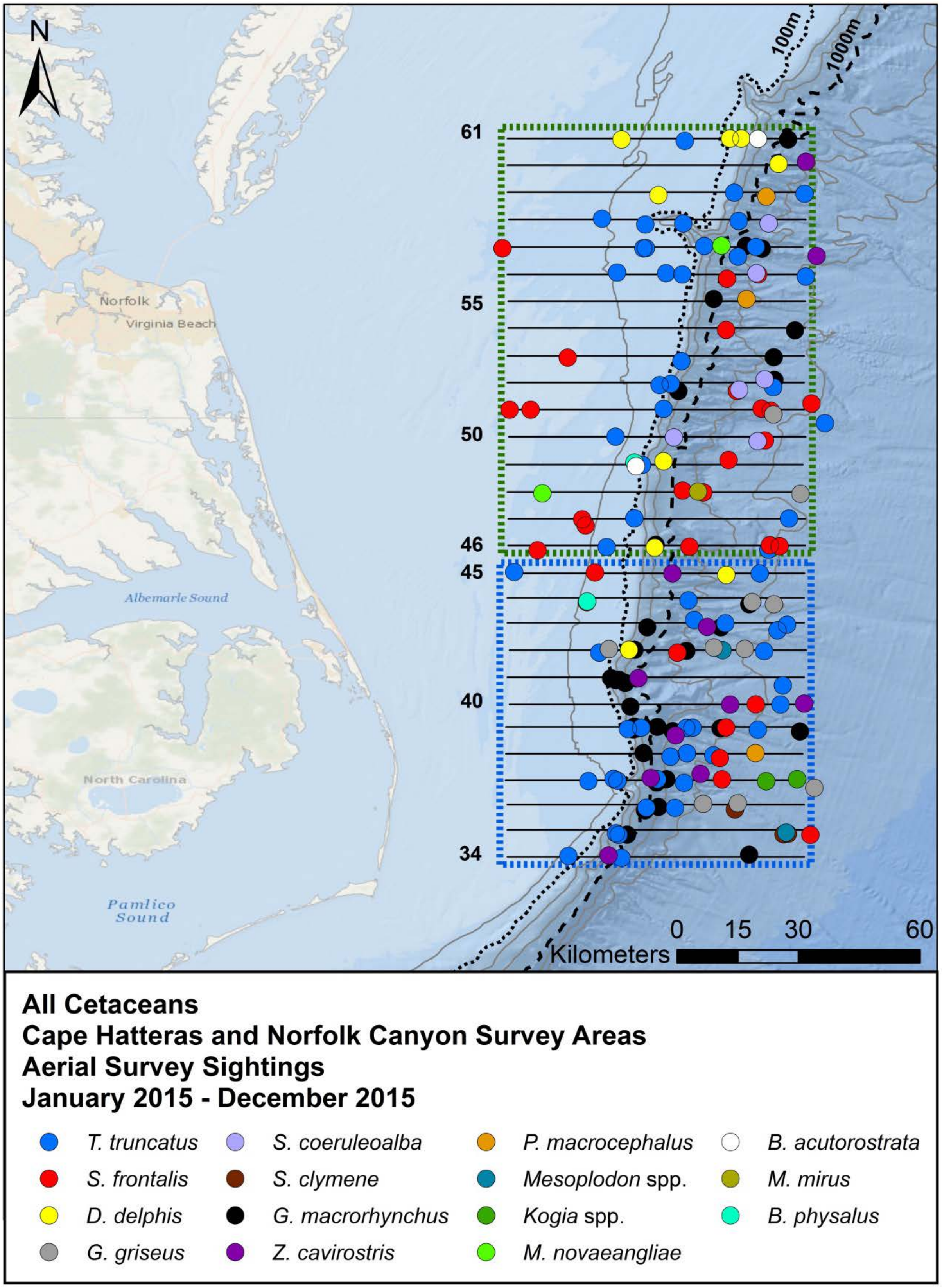


Figure 3. All cetacean sightings during aerial surveys in the Cape Hatteras (blue box) and Norfolk Canyon (green box) survey areas in 2015. All sightings were made on effort.

One hundred twenty-two sightings of 163 individual sea turtles occurred during the reporting period (**Table 3** and **Figure 4**). Loggerhead turtles (*Caretta caretta*) represented the majority (90 percent) of total sea turtles sighted. The vast majority of loggerhead turtle sightings were over the continental shelf inshore of the 100-meter (m) isobath. The only other sea turtle species identified in the Cape Hatteras and Norfolk Canyon survey areas was the leatherback turtle (*Dermochelys coriacea*; 6.1 percent of total sea turtles sighted). Leatherback turtles were observed from the inshore waters out to beyond the 2,000-m isobath. For the remaining 4 percent of sightings, species identification could not be made with 100 percent certainty and they are listed as "unidentified sea turtles." Sighting rates were negatively correlated with BSS, with rates sharply declining at BSS higher than 2. Sea turtles were recorded in every month surveyed except for January, with highest sightings per 1,000 km flown in August and September.

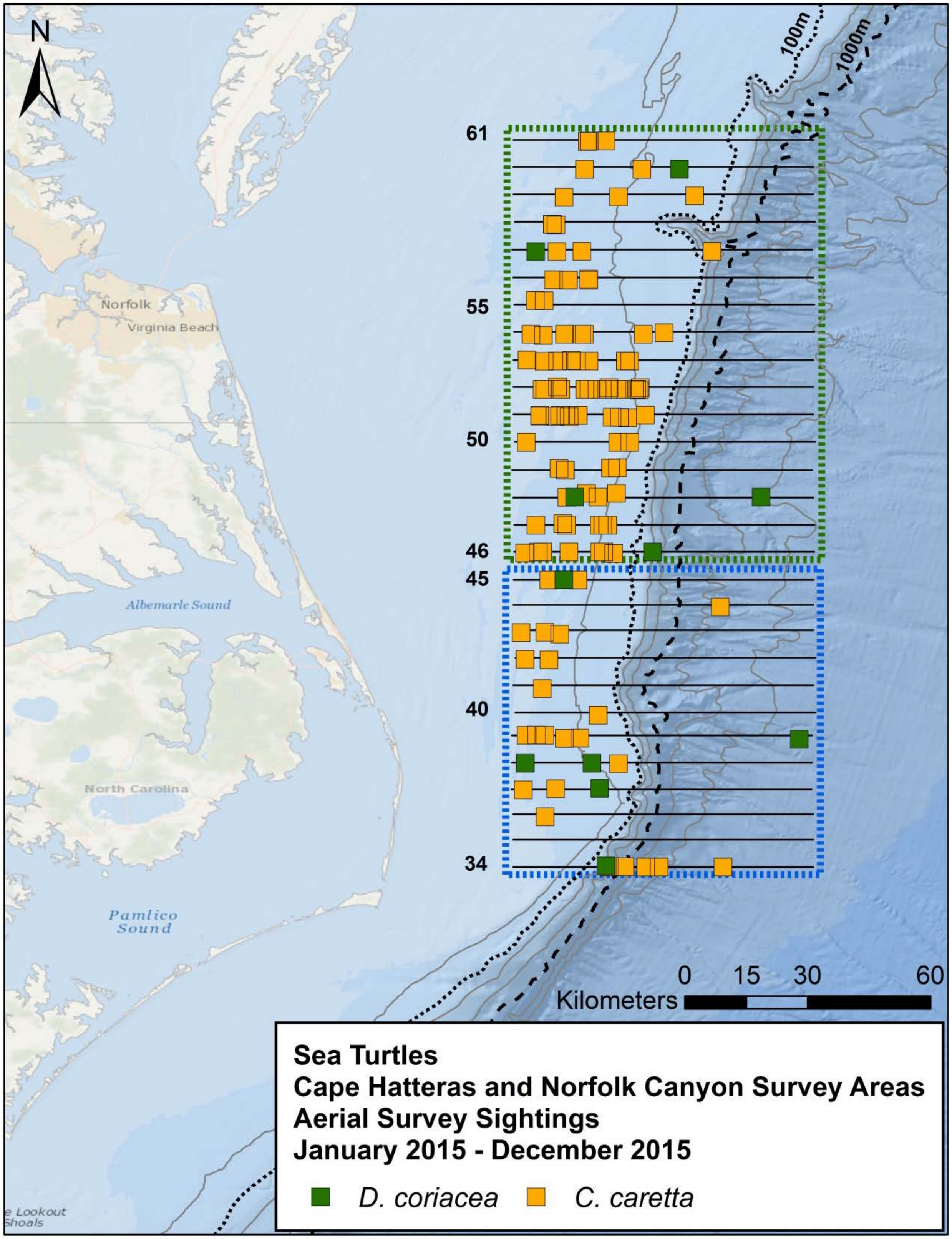


Figure 4. Locations of sea turtle sightings during aerial surveys in the Cape Hatteras (blue box) and Norfolk Canyon (green box) survey areas in 2015. All sightings were made on effort.

In addition to cetaceans and sea turtles, other pelagic marine vertebrates were observed (**Table 3** and **Figure 5**). Forty-one sightings of sharks or rays (i.e., elasmobranch fishes) were recorded during the reporting period, largely inshore of the 1,000-m isobath. Three species of sharks could be identified to species from the air: great white shark (*Carcharodon carcharias; n*=1), four basking sharks (*Cetorhinus maximus*; *n*=4), and one whale shark (*Rhincodon typus*; *n*=1). Two species of rays were identified to species: manta rays (*Manta birostris; n*=48) and cownose rays (*Rhinoptera bonasus*; *n*=4,000+). In addition, 18 ocean sunfish (*Mola mola*) were recorded, with the majority offshore of the 100-m isobath.

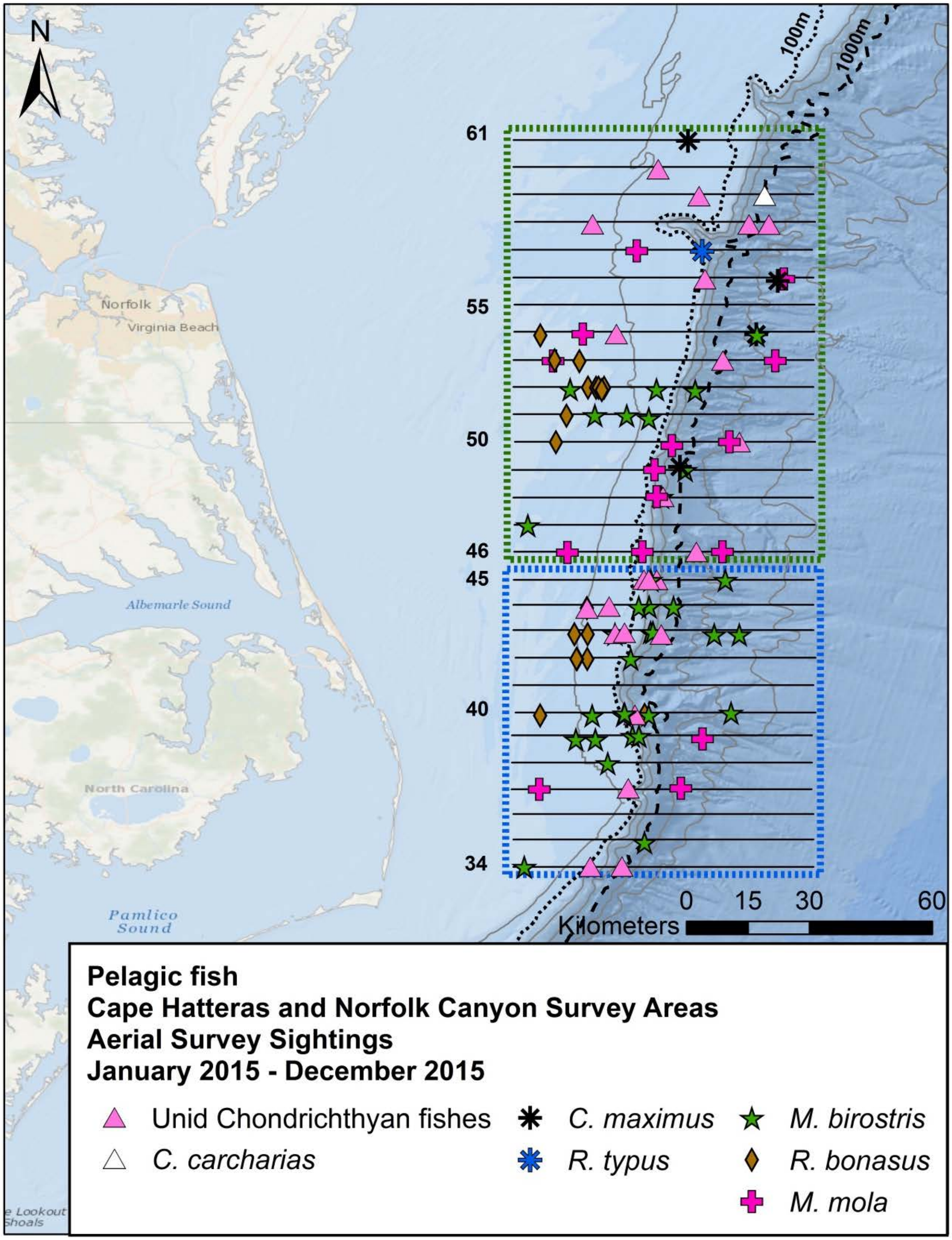


Figure 5. Pelagic fish sightings during aerial surveys in the Cape Hatteras (blue box) and Norfolk Canyon (green box) survey areas in 2015. All sightings were made on effort.

For more information on this study, refer to the annual progress report for this project (McAlarney et al. 2016).

2.1.1.2 Jacksonville OPAREA Offshore Aerial Surveys

Researchers from UNCW conducted 7 days of aerial survey effort covering 62 tracklines and 4,393 km **(Table 4**) at the planned USWTR site within the Jacksonville OPAREA in 2015. The goal was to survey the entire site (10 tracklines) (January through June). Beginning in July (with additional funding) the goal was to survey twice per calendar month, which was achieved in 2 (August and October) of the 4 months surveyed. In March, 10 tracklines were flown and in April, 12 tracklines were flown. During the months of July, September, November, and December, no surveys were conducted due to limited pilot availability or unfavorable weather conditions. Survey conditions ranged from BSS 1 to 5, with the majority of the surveys flown in BSS 3 (45 percent). Cetacean sighting rates dropped off dramatically at BSS greater than 3, and slightly at BSS 1 and 2, but the latter phenomenon is likely the result of limited survey time spent in these conditions rather than decreased detectability of cetaceans.

Table 4. Effort summary for aerial surveys conducted in the JAX survey area, January–December 2015.

Number of Survey Days	7
Total Hr Underway*	41.3
Total Tracklines Covered	62

*Total hours (hr) underway reported as Hobbs hr = total engine time

A total of 39 sightings of 508 cetaceans was recorded while on effort in the study area (**Table 5** and **Figure 6**). The numbers of cetacean sightings varied by month, with the highest numbers of encounters occurring in March and August. Four species of cetaceans were observed while on effort, including: bottlenose dolphin (17 sightings of 143 individuals), Atlantic spotted dolphin (17 sightings of 320 individuals), short-finned pilot whale (1 sighting of 1 individual), and rough-toothed dolphin (*Steno bredanensis*; 1 sighting of 35 individuals). Identification to species could not be determined for three sightings of delphinids. Two off-effort sightings were recorded: Risso's dolphin (1 sighting of 1 individual) and Atlantic spotted dolphin (1 sighting of 45 individuals).

Table 5. Sightings from aerial surveys conducted in the JAX survey area in 2015. On- and off-effort sightings are represented by #/# (on-/off-effort sightings).

Common Name	Scientific Name	Number of Sightings	Number of Individuals
Risso's dolphin	*Grampus griseus*	0/1	0/6
Short-finned pilot whale	*Globicephala macrorhynchus*	1/0	1/0
Rough-toothed dolphin	*Steno bredanensis*	1/0	35/0
Atlantic spotted dolphin	*Stenella frontalis*	17/1	320/45
Bottlenose dolphin	*Tursiops truncatus*	17/0	143/0
Unidentified delphinid		3/0	9/0
Loggerhead turtle	*Caretta caretta*	93/0	133/0
Leatherback turtle	*Dermochelys coriacea*	15/0	16/0
Unidentified turtle		11/0	12/0
Great white shark	*Carcharodon carcharias*	1/0	1/0
Unidentified shark		20/0	24/0
Manta ray	*Manta birostris*	5/0	7/0
Ocean sunfish	*Mola mola*	2/0	2/0

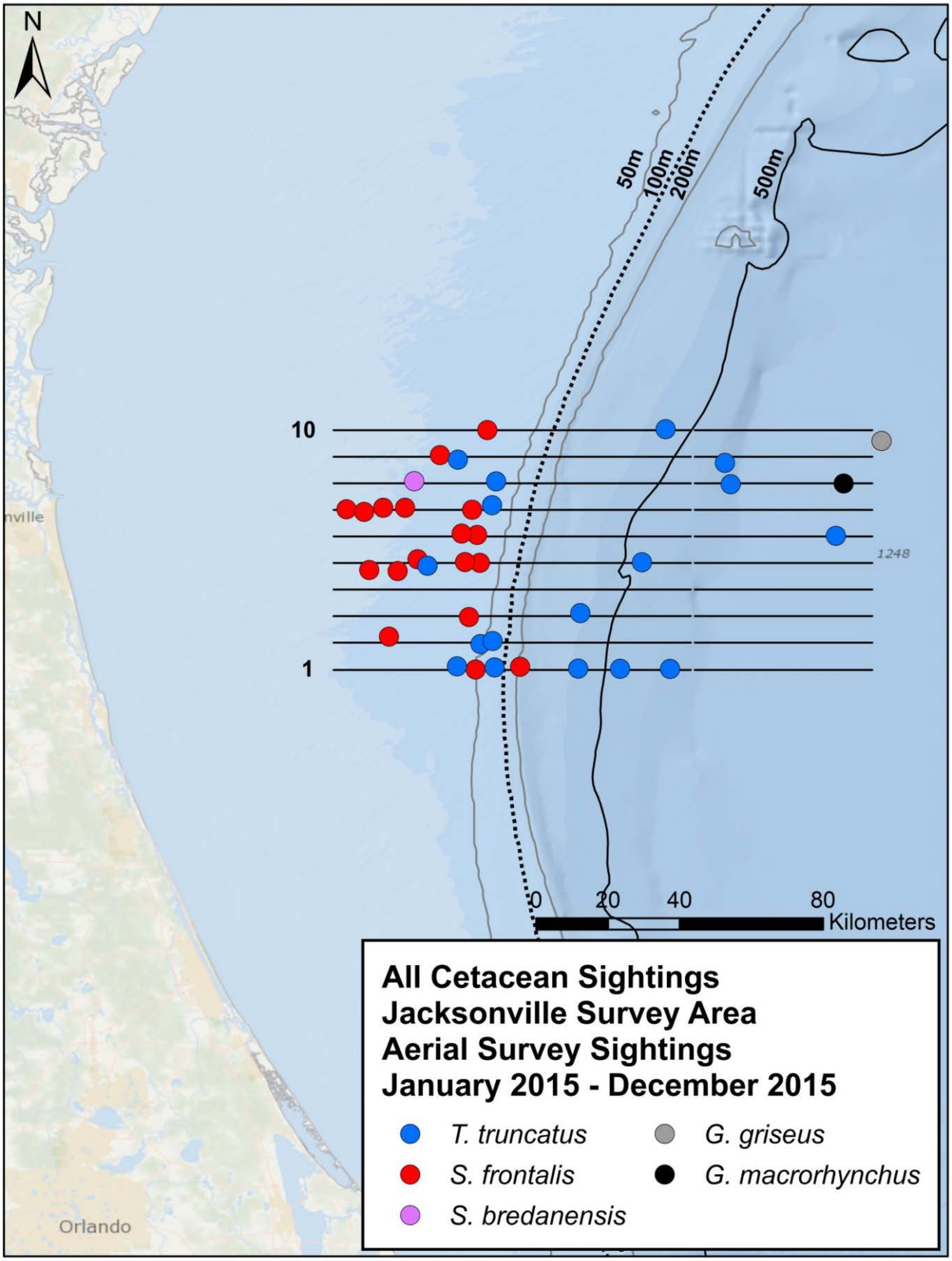


Figure 6. Cetacean sightings during aerial surveys in the JAX survey area in 2015. All sightings were made on effort.

During January–December 2015, a total of 161 individual sea turtles was recorded during aerial surveys in JAX in 2015 (**Table 5**). Sighting rates were negatively correlated with BSS, with rates declining at higher sea states. Sea turtles were observed every day of survey effort, with the highest sighting rates occurring in March. Observation rates ranged from a low of 2.13/1,000 km flown in April to a high of 124.61/1,000 km in March. Loggerhead turtles constituted the majority of sea turtles sighted (82.6 percent; *n*=133), followed by leatherback turtles (9.9 percent; *n*=16). Turtles labeled as unidentified (7.5 percent; *n*=12) were typically either of small size, submerged, or too far away for the observers to make an accurate identification to species. Loggerhead turtles were predominantly recorded in the shallower waters over the continental shelf, although a small number of individuals occurred beyond the continental shelf break (**Figure 7**). Leatherbacks were predominantly recorded in the shallower waters over the continental shelf, although a small number of individuals occurred beyond the shelf break (**Figure 7**).

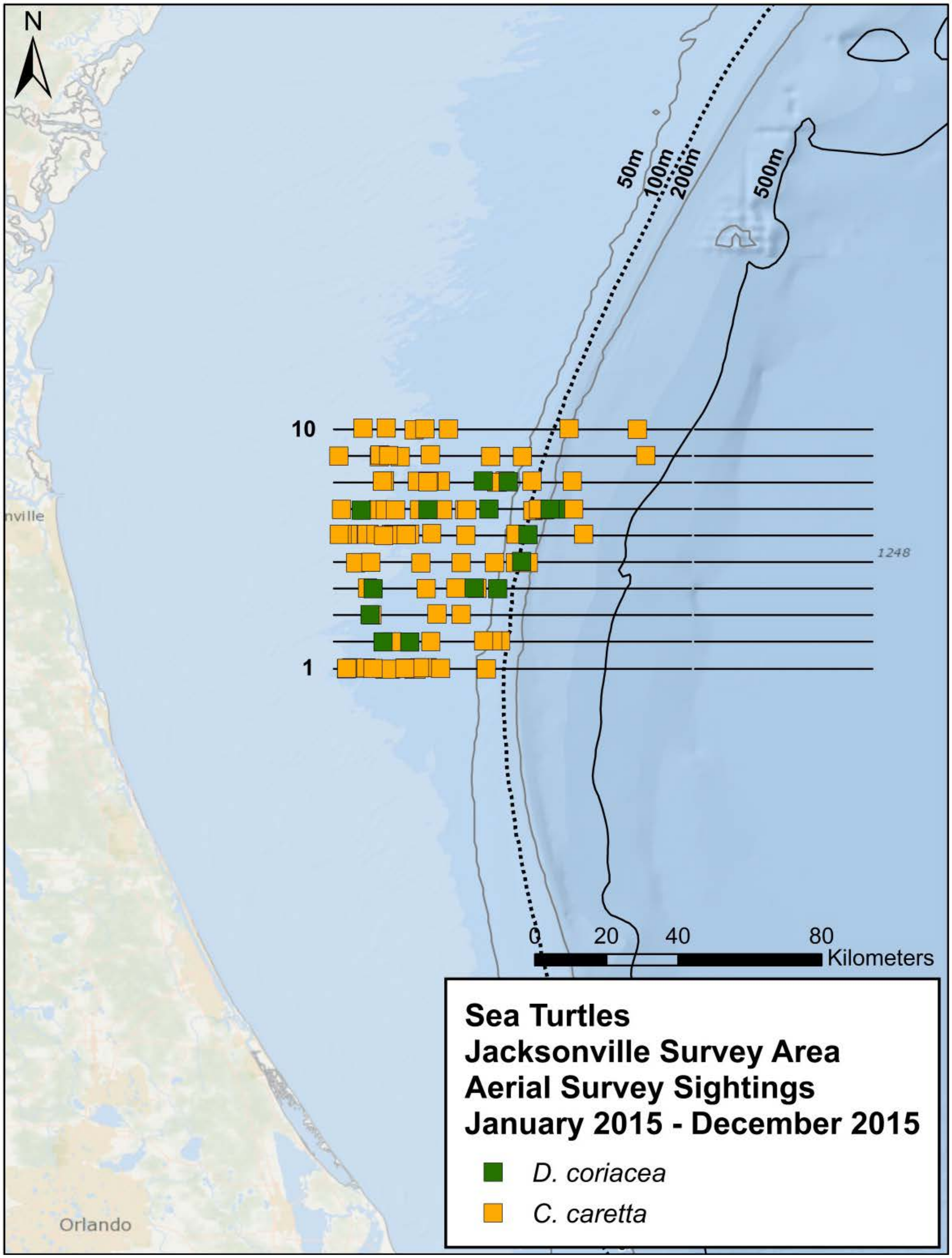


Figure 7. All sea turtle sightings during aerial surveys in the JAX survey area in 2015. All sightings were made on effort.

In addition to cetaceans and sea turtles, other pelagic marine vertebrates were observed, including sharks and rays (i.e., elasmobranch fishes) (**Table 5** and **Figure 8).** Two ocean sunfish (*Mola mola*) were sighted over the continental shelf in March. Seven manta rays were sighted, scattered throughout the survey site with 86 percent of individuals occurring in March. A total of 21 sharks was recorded during 2015, six of these could be identified as hammerhead sharks (*Spyhrna* sp.) based on head shape, but since none of these sightings could be identified to species they were recorded as unidentified sharks. One great white shark was sighted in October 2015. Sharks showed no discernable spatial or temporal trends in occurrence.

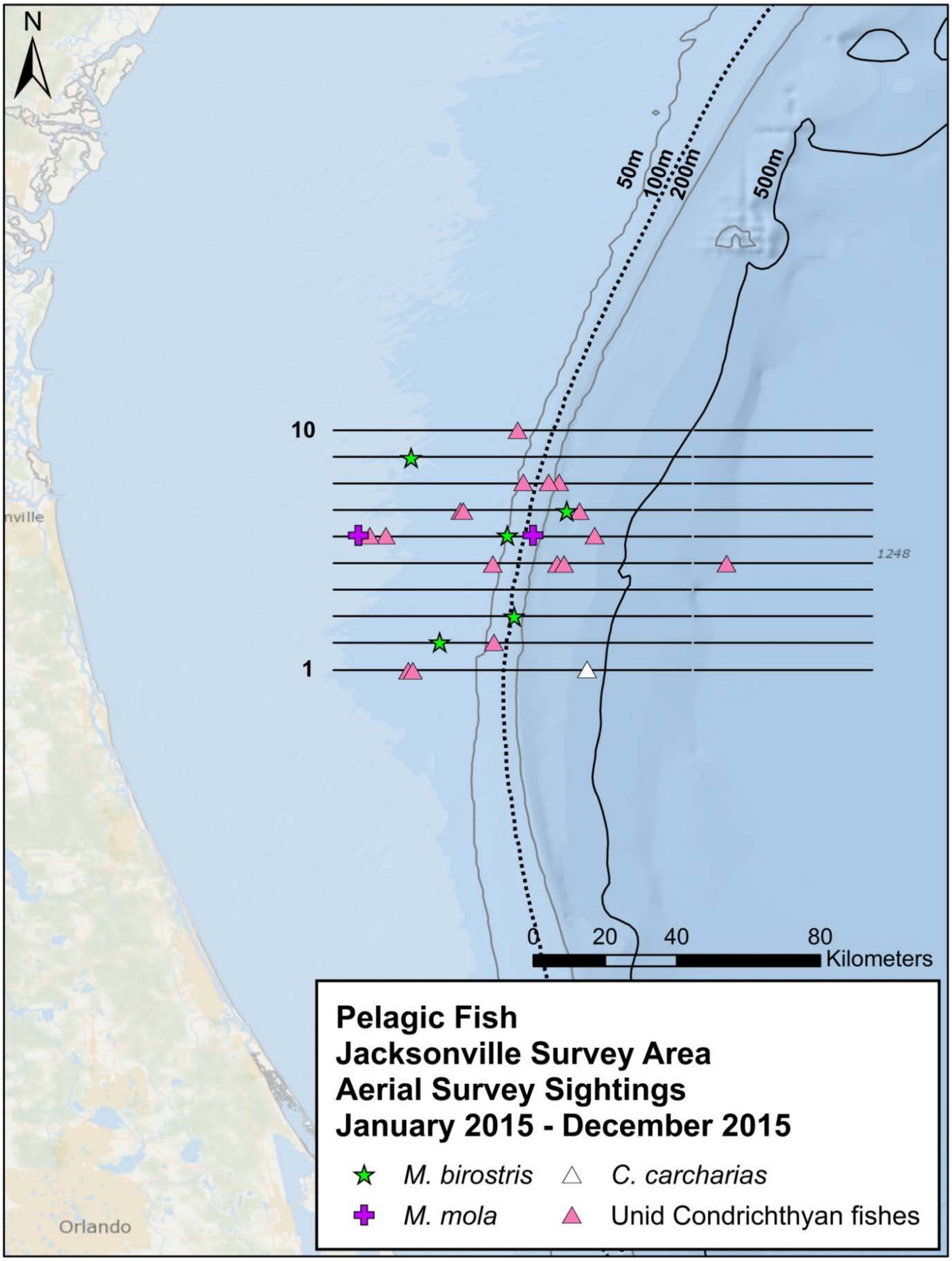


Figure 8. Pelagic fish sightings during aerial surveys in the JAX survey area in 2015. All sightings were made on effort.

For more information on this study, refer to the annual progress report for this project (Cummings et al. 2016).

2.1.1.3 VACAPES Nearshore Aerial Surveys

From November 2012 to December 2014, the Virginia Aquarium Foundation (VAQF) conducted line-transect aerial surveys with the objective of documenting large whales in the vicinity of the Virginia Wind Energy Area, although surveys were not flown every month or with consistent effort between years (Mallette et al. 2014, 2015). This was funded through the Virginia Coastal Zone Management Program. The U.S. Navy's Marine Species Monitoring Program funded the continuation of these surveys to be begin in early 2016. A modified design for coordinated inshore (VAQF) and offshore (UNCW) aerial surveys was developed, based upon recommendations from the Centre for Research into Ecological and Environmental Modeling (CREEM). CREEM advised periodic overlap of the survey areas between the offshore and coastal transect lines to calibrate for survey origin difference and integrate data between sites.

Based on the CREEM recommendations, VAQF will alternate between two different aerial survey designs, using standard line-transect methods to document the occurrence of marine mammals and sea turtles. The two designs differ in whether they overlap by 10 km with the UNCW offshore survey lines (**Figure 9**) or not at all (**Figure 10**). Eighteen survey days per year are planned, with two per month in November–April and one per month in May–October. The plan is for one overlapping survey in each quarter or season, with the remainder non-overlapping.

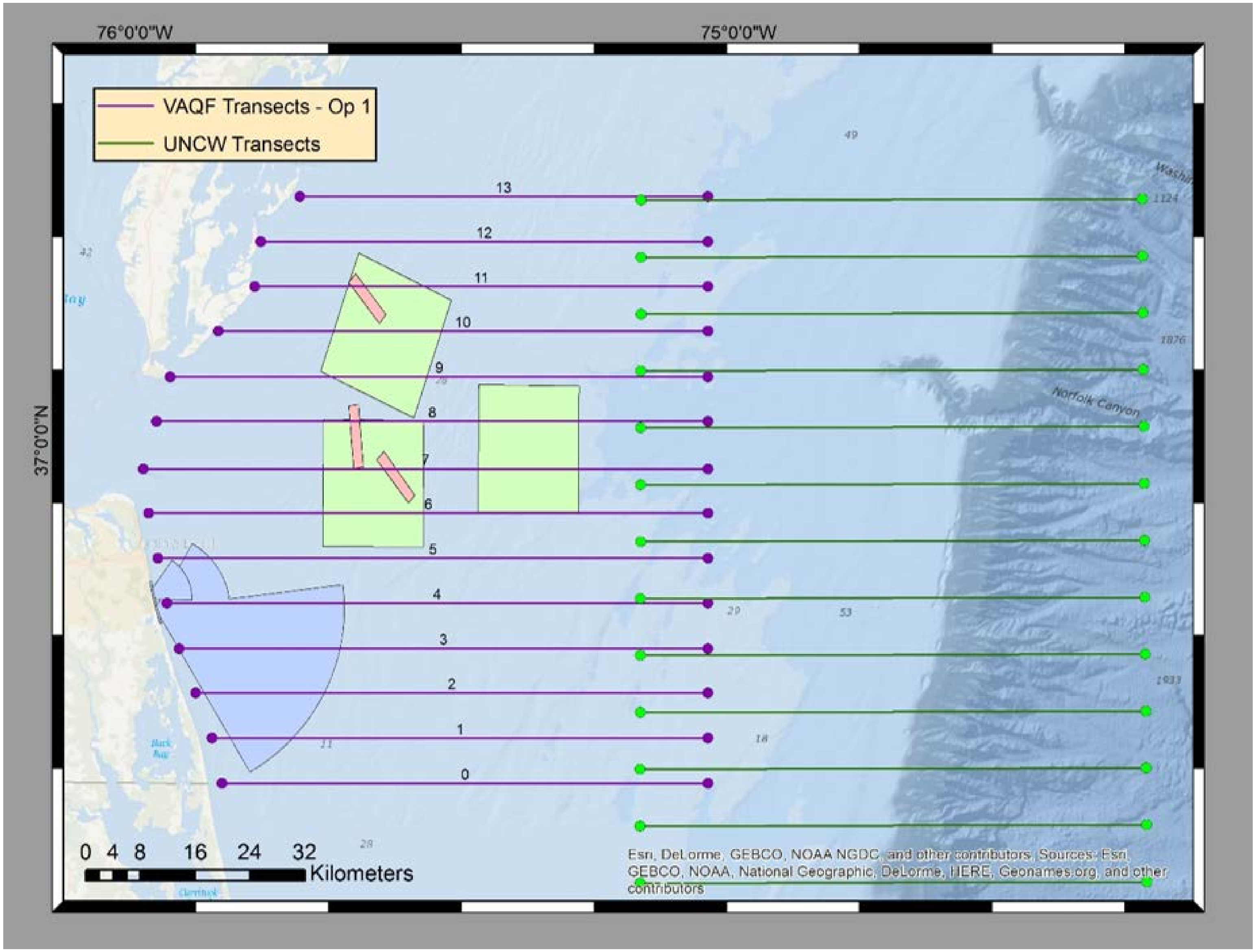


Figure 9. VAQF coastal transect lines (purple) with a 10-km overlap with the western end of the UNCW offshore transect lines (green). The VACAPES SONAR training area is represented by pink polygons, the VACAPES Mine Warfare areas are represented by green polygons, and the Dam Neck ranges are represented by blue polygons.

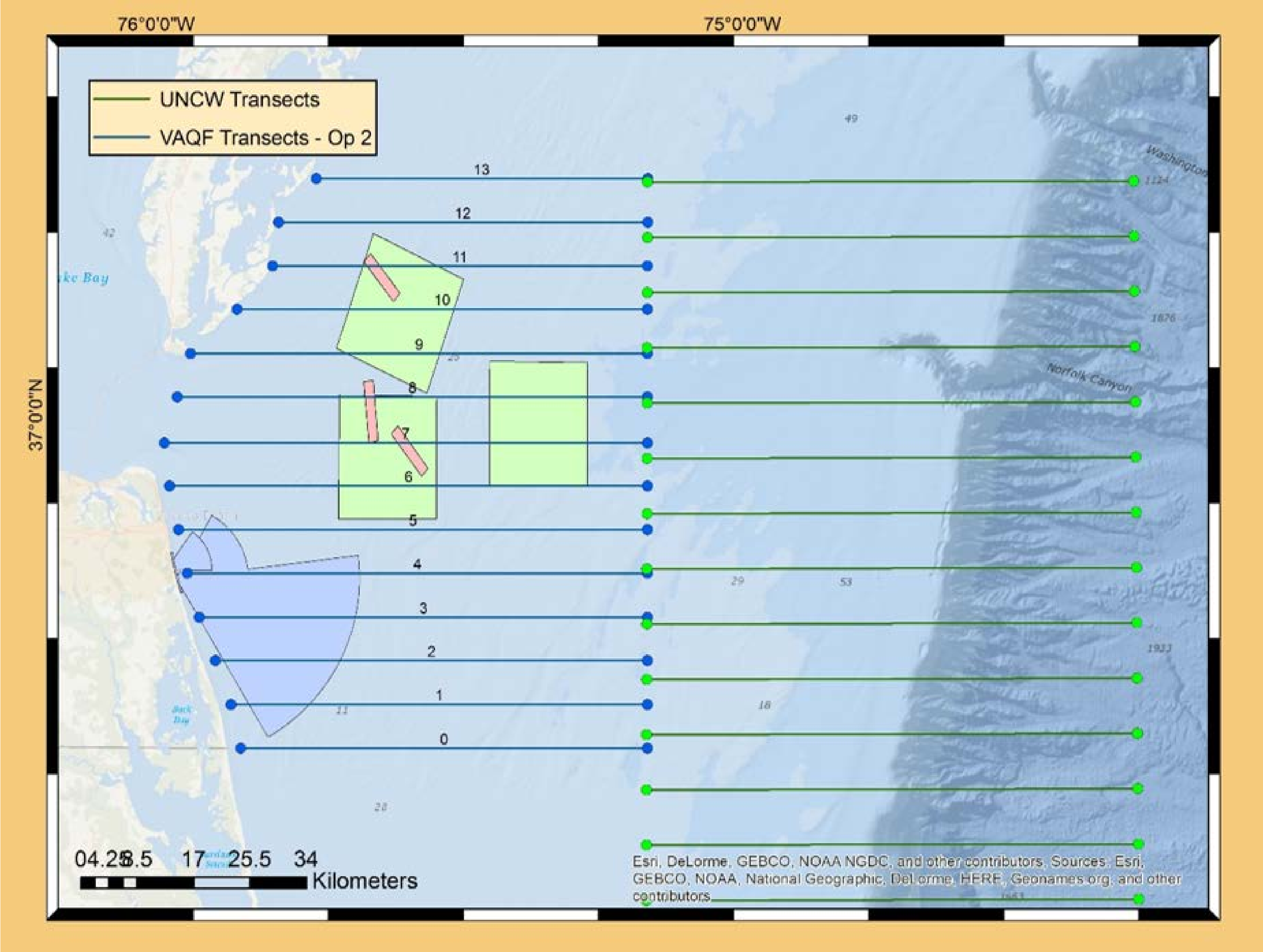


Figure 10. VAQF coastal transect lines (blue) with no overlap with the UNCW offshore transect lines (green).

For more information on this study, refer to the annual progress report for this project (Mallette et al. 2016).

2.1.1.4 Chesapeake Bay (NAS Patuxent) Aerial Surveys

Researchers from UNCW conducted 9 days of monthly aerial survey effort covering 5,222 km over the waters of the Chesapeake Bay and the mouth of the Potomac River, surrounding the Naval Air Station Patuxent site **(Table 6, Figure 11**) beginning in April 2015. Survey conditions ranged from BSS 1 to 5.

Table 6. Effort summary for aerial surveys conducted in the Patuxent River survey area in 2015.

Number of Survey Days	9
Total Hr Underway*	47.2
Total Km Surveyed	5,222

* Total hours (hr) underway reported as Hobbs hr = total engine time

Between April 2015 and December 2015, five on-effort (*n*=36 individuals) and three off-effort (*n*=28 individuals) sightings of bottlenose dolphins were recorded (**Figures 11** through **13, Table 7**). All on-effort sightings occurred between April and July, and all were in the southern portion of the survey area near the confluence of the Potomac River with the Chesapeake Bay. All off-effort sightings occurred between September and December. Two of these were in Ingram Bay, approximately 13 km south of the west end of trackline 1.

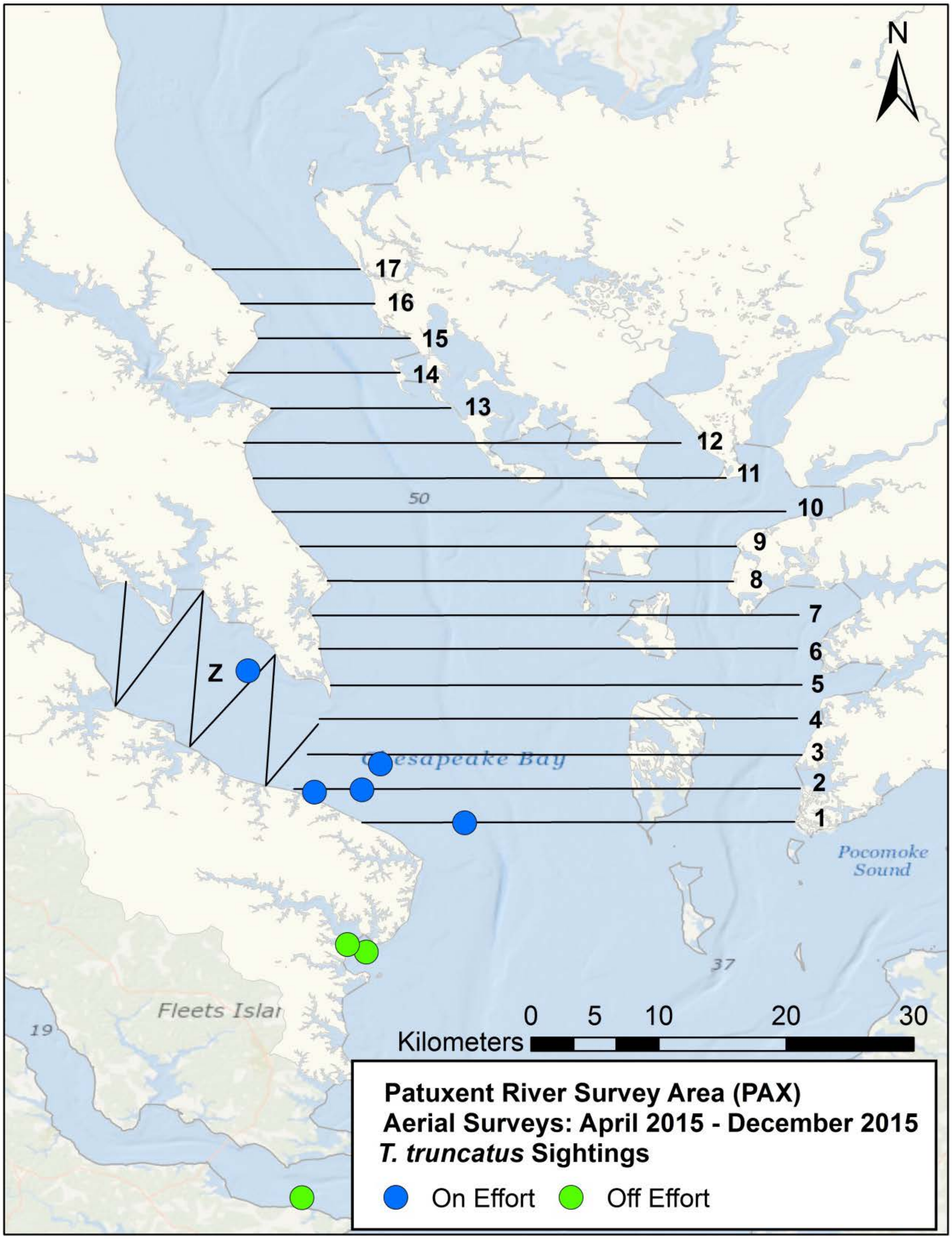


Figure 11. All bottlenose dolphin sightings from aerial surveys conducted in the Patuxent River survey area from April through December 2015.

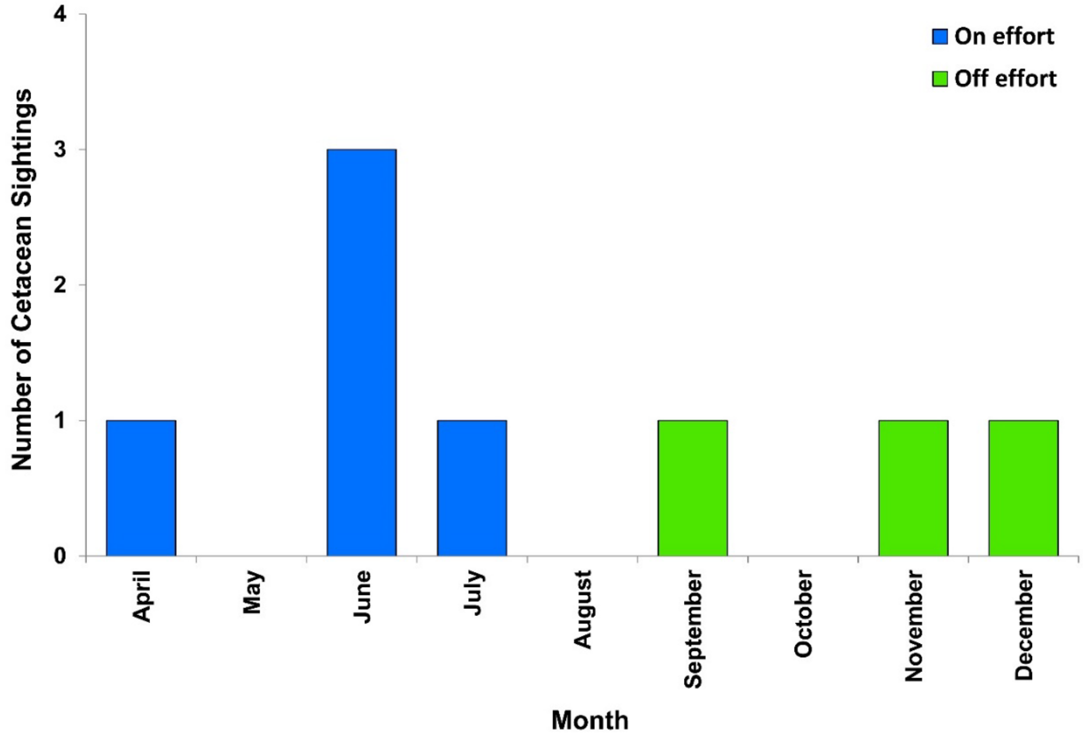


Figure 12. Bottlenose dolphin sightings per month from April through December 2015 during aerial surveys in the Patuxent River survey area.

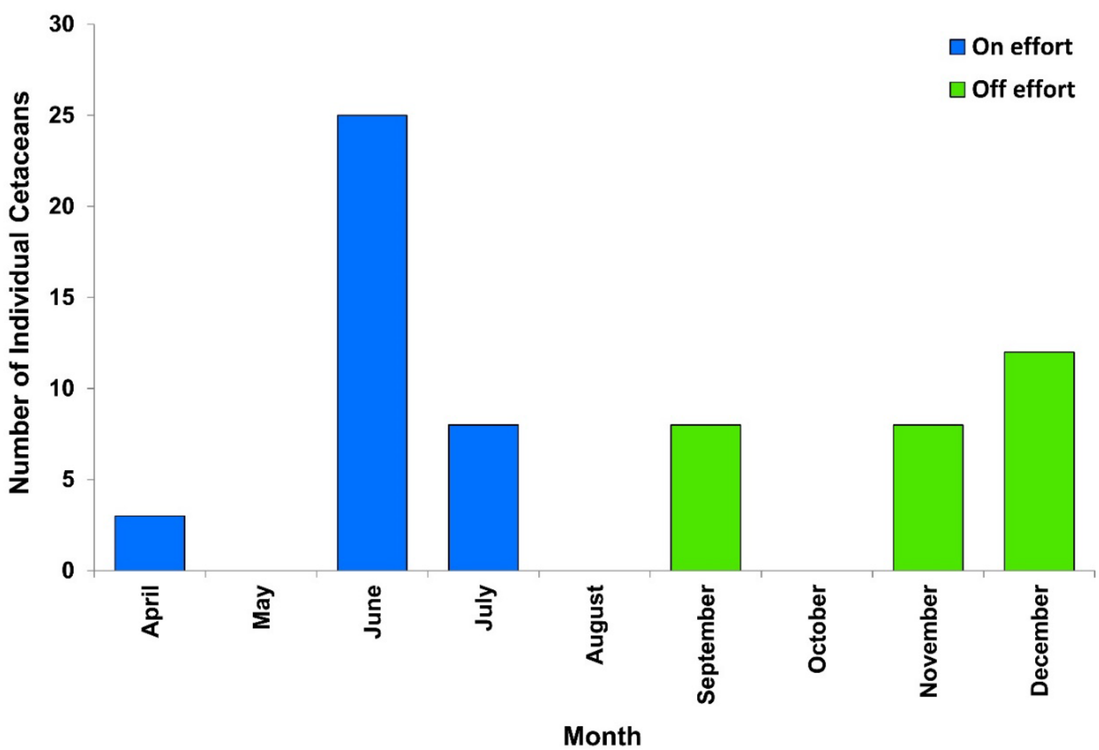


Figure 13. Numbers of individual bottlenose dolphins observed per month from April through December 2015 during aerial surveys in the Patuxent River survey area.

Table 7. Sightings from aerial surveys conducted in the Patuxent River survey area, April through December 2015. On- and off-effort sightings are represented by #/# (on-/off-effort sightings).

Common Name	Scientific Name	Number of Sightings	Number of Individuals
Bottlenose dolphin	*Tursiops truncatus*	5/3	36/28
Loggerhead turtle	*Caretta caretta*	21/0	28/0
Unidentified turtle		1/0	1/0
Cownose ray	*Rhinoptera bonasus*	18/0	405/0

All sea turtle sightings occurred during the months of May through August, and all were south of trackline 10 in the Chesapeake Bay (**Figures 14** through **16**, **Table 7**). Of the 22 sea turtle sightings, all but one were positively identified as loggerhead turtles.

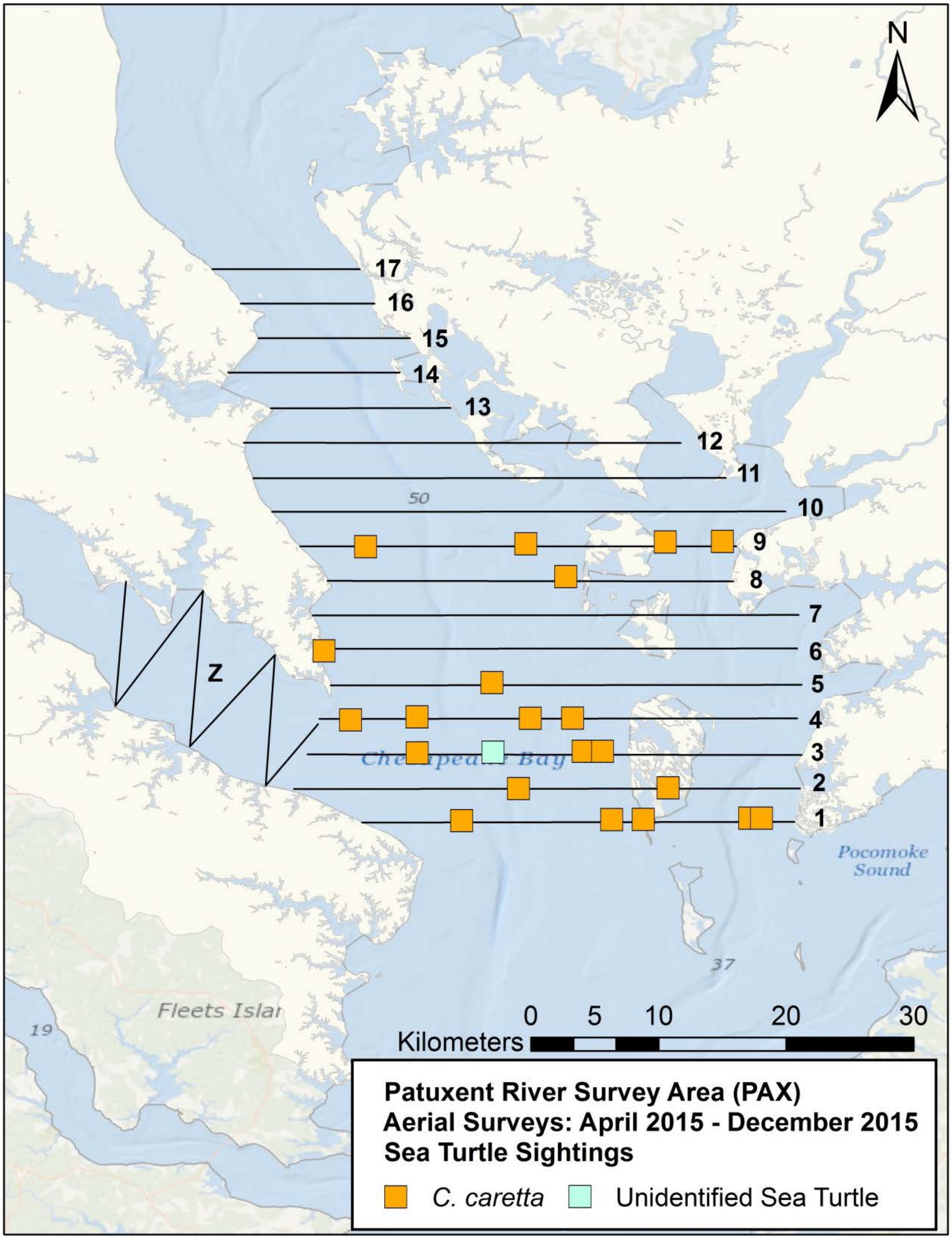


Figure 14. Sea turtle sightings from aerial surveys conducted in the Patuxent River survey area from April through December 2015.

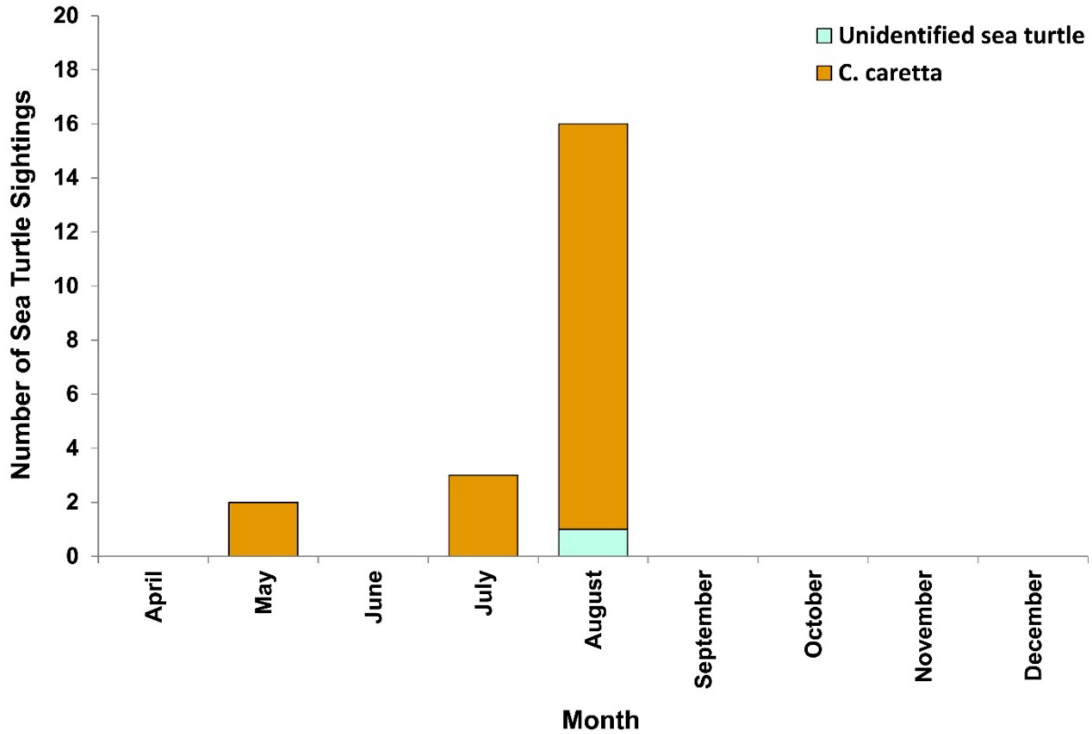


Figure 15. Sea turtle sightings per month from April through December 2015 during aerial surveys in the Patuxent River survey area.

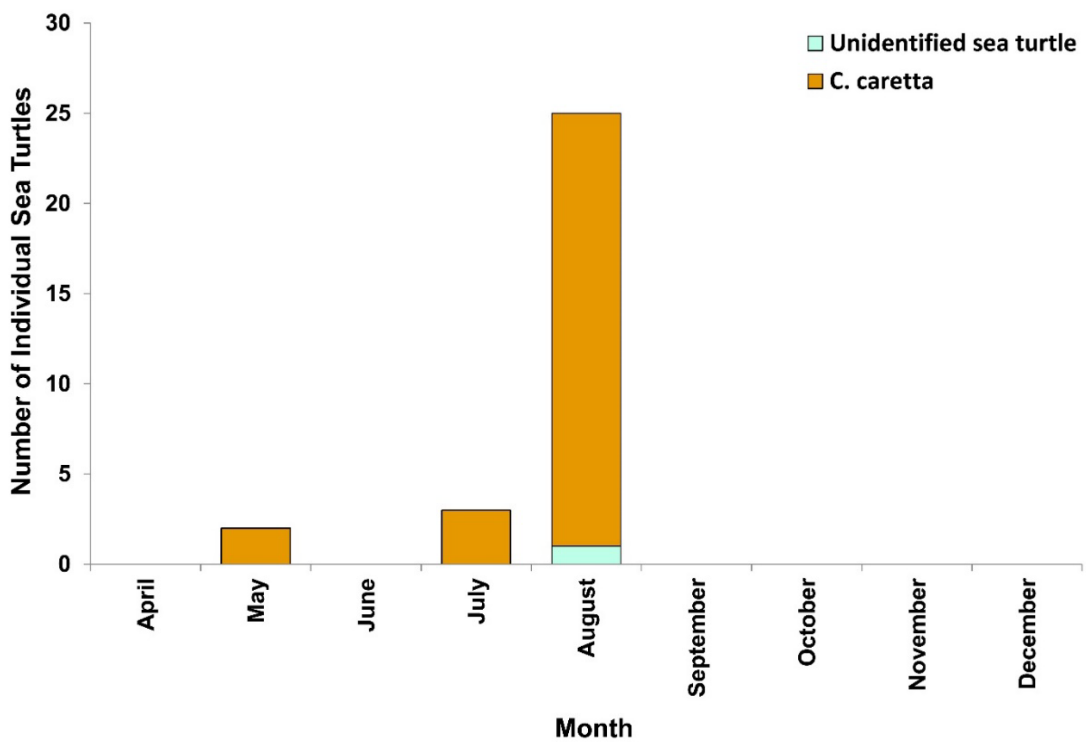


Figure 16. Numbers of individual sea turtles observed per month from April through December 2015 during aerial surveys in the Patuxent River survey area.

Chondrichthyan fishes were observed across the range of the study area from May through December 2015. All chondrichthyan fishes were identified as either cownose rays or unidentified rajiform (i.e., rays) (**Figure 17**).

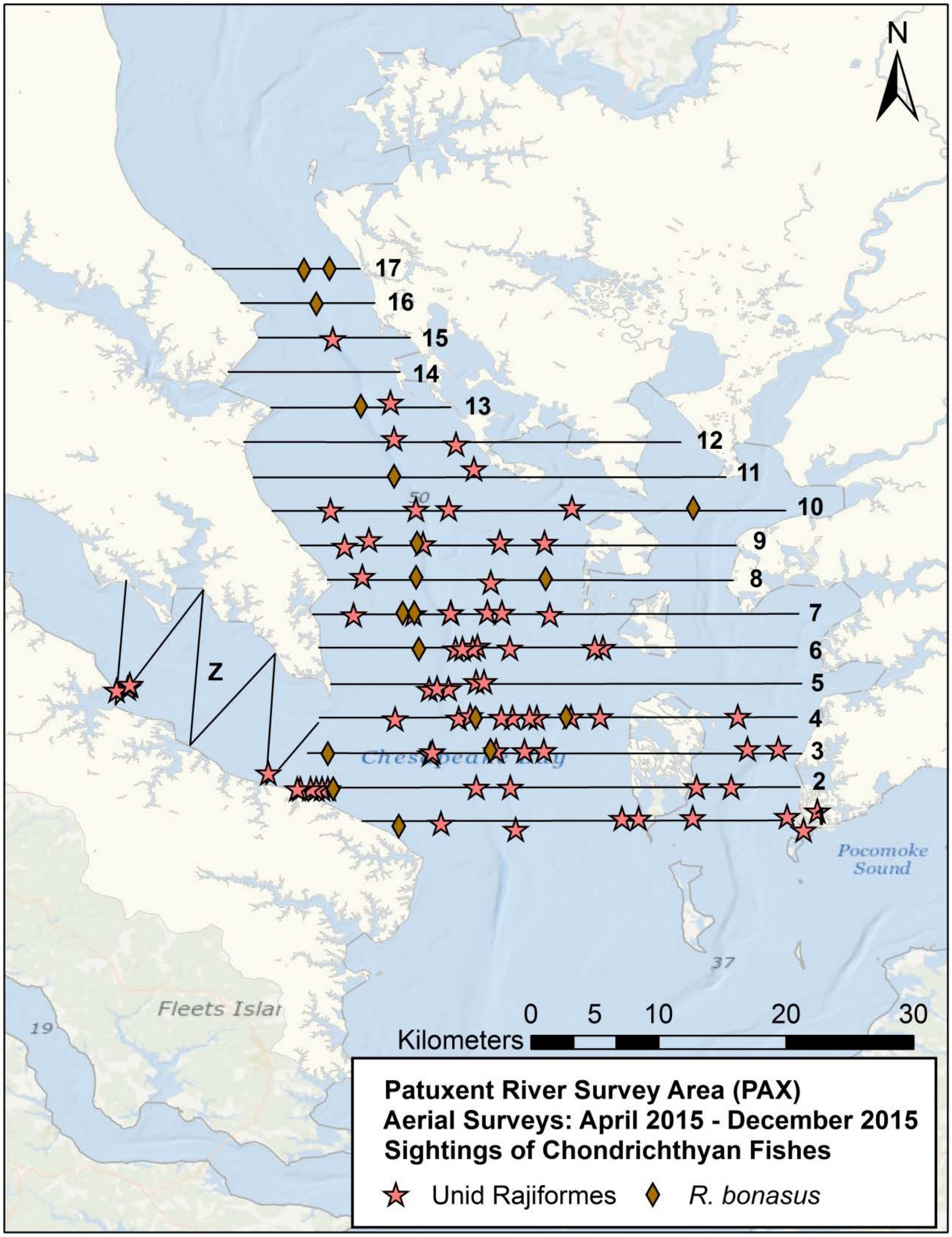


Figure 17. Elasmobranch fish sightings from aerial surveys conducted in the Patuxent River survey area from April through December 2015.

For more information on this study, refer to the annual progress report for this project (Richlen et al. 2016a).

2.1.2 Visual Baseline Vessel Surveys

Visual vessel surveys were conducted at multiple locations in the AFTT Study Area off the mid-Atlantic and southeastern U.S. during 2015 - the long-term survey programs in the Cape Hatteras, Onslow Bay, and JAX OPAREAs were continued (**Sections 2.1.2.1** through **2.1.2.3**), as were the more recent efforts initated during 2014 off Virginia Beach, Virginia; 2015 at NAS PAX; and Panama City, Florida (**Sections 2.1.2.4** through **2.1.2.6**). Additionally, **Section 2.1.2.7** presents information from U.S. Navy-funded pinniped haulout surveys conducted off Narragansett, Rhode Island and in the Chesapeake Bay, Virginia.

2.1.2.1 Cape Hatteras Survey Area

Nineteen days of fieldwork were conducted in the Cape Hatteras survey area in 2015 (April through June, and October through December 2015) (**Figure 18** and **Table 8**) (Foley et al. 2016a). Vessel survey effort in Cape Hatteras during 2015 focused on supplementing the tagging effort (refer to **Section 2.2.1**, Foley et al 2016b), with additional photo-ID and biopsy surveys. Fourteen days focused on tagging—10 days were dedicated to the satellite-tagging project and 4 days to the deep diver project (**Figure 18**). On 25 May 2015 and 02 June 2015, two survey vessels were used—the Research Vessel (R/V) *R.T. Barber* and the R/V *Exocetus*. Fieldwork conducted during 2015 yielded 990.8 km and 134.5 hr of effort (**Table 8**) in BSS 1 to 5. In April 2015, approximately 13 hr of opportunistic survey effort was conducted during the transits between two HARP deployment/recovery locations off Cape Hatteras and Virginia Beach. Survey effort was focused along the continental shelf break between Cape Hatteras and Norfolk Canyon. Survey effort and sightings data are reported here due to the ecological relevance of the shelf break to several deep diving marine mammal species that inhabit these waters.

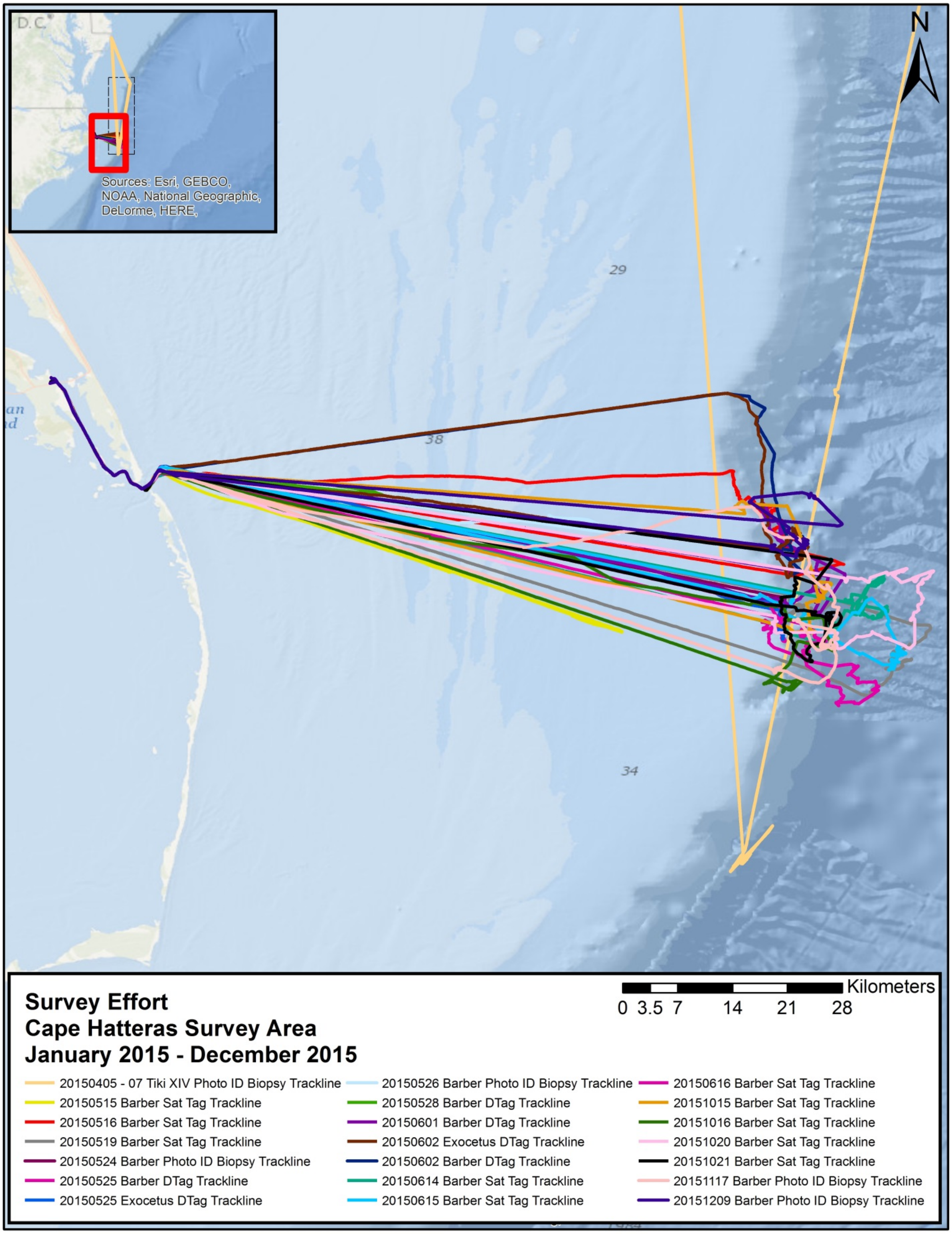


Figure 18. Survey effort on the R/V *Barber* and R/V *Exocetus* in the Cape Hatteras survey area in 2015.

Table 8. Effort details for vessel surveys conducted in the Cape Hatteras survey area in 2015. All sightings were made on effort.

Number of Survey Days	19
Total Survey Time (hr:min)	251:28
Time On Effort (hr:min)	134:30
Total Km Surveyed	991

Key: hr = hour(s); km = kilometer(s); min = minute(s)

Eight species of cetaceans were encountered including 71 sightings of deep-diving odontocetes: short-finned pilot whale (*n*=53); Cuvier's beaked whale (*n*=13); sperm whale (*n*=4), and unidentified beaked whale (*n*=1), as well as bottlenose dolphin (*n*=47); Risso's dolphin (*n*=2); short-beaked common dolphin (*n*=4); Atlantic spotted dolphin (*n*=3); *Kogia* sp. (*n*=1), unidentified baleen whale (*n*=1), unidentified delphinid (*n*=1), and unidentified small whale (*n*=1) (**Table 9** and **Figure 19**). There also were four sightings of leatherback turtles and two sightings of loggerhead turtles (**Table 9** and **Figure 20**).

Table 9. Sightings from field work conducted in the Cape Hatteras survey area in 2015. All sightings were made on effort.

Common Name	Scientific Name	Number of Sightings	Number of Individuals
Short-finned pilot whale	*Globicephala macrorynchus*	53	1,555
Cuvier's beaked whale	*Ziphius cavirostris*	13	57
Sperm whale	*Physeter macrocephalus*	4	12
Unidentified baleen whale		1	1
Pygmy/Dwarf sperm whale	*Kogia* sp.	1	1
Bottlenose dolphin	*Tursiops truncatus*	47	408
Risso's dolphin	*Grampus griseus*	2	2
Short-beaked common dolphin	*Delphinus delphis*	4	*
Atlantic spotted dolphin	*Stenella frontalis*	3	105
Unidentified beaked whale		1	2
Unidentified delphinid		1	1
Unidentified small whale		1	1
Loggerhead turtle	*Caretta caretta*	2	2
Leatherback turtle	*Dermochelys coriacea*	4	4

* Group sizes for three sightings were not estimated; for the fourth, the group size was 150 individuals. We were unable to provide an estimate for several of the *Delphinus* groups, since the dolphins covered too wide a geographic extent.

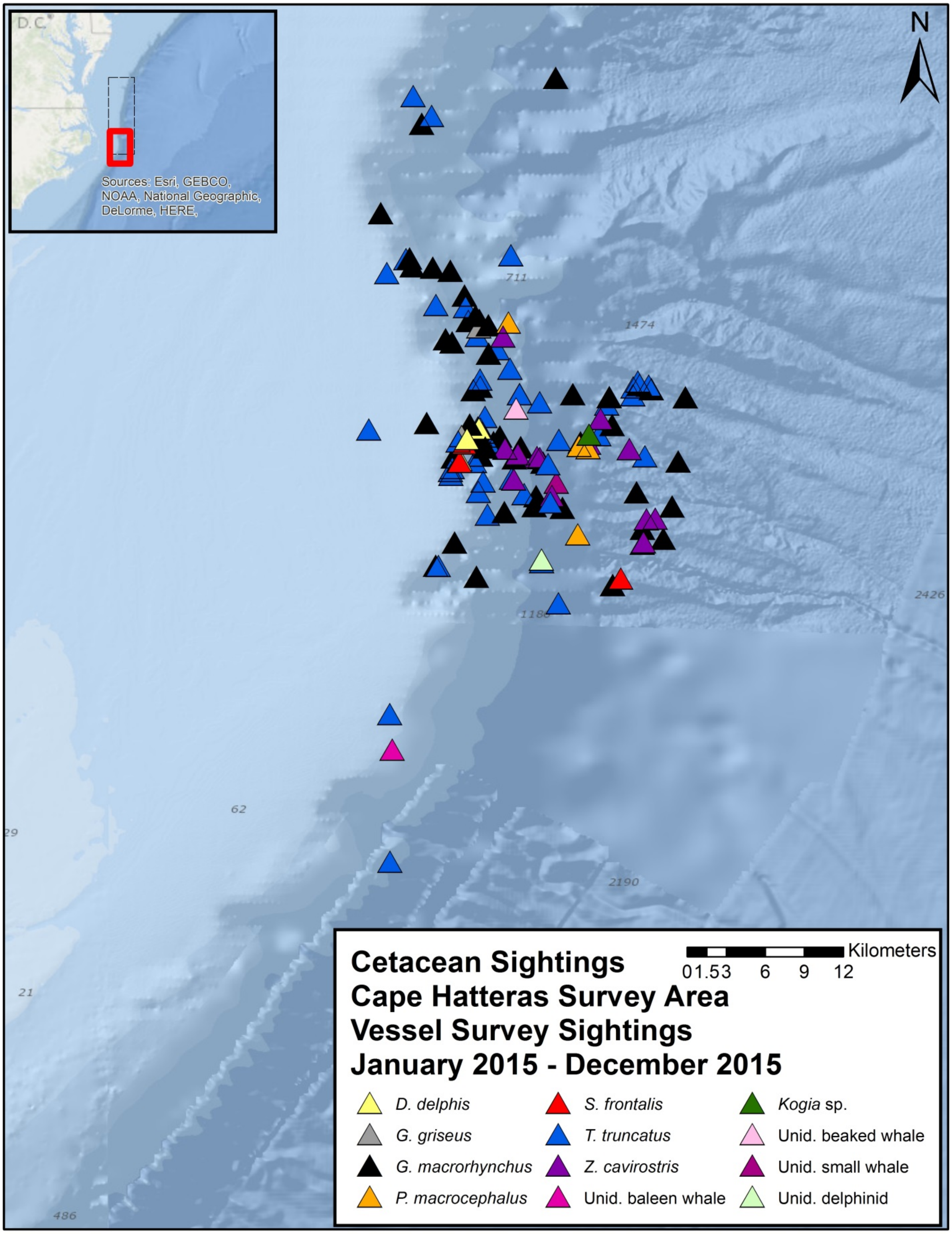


Figure 19. Locations of all cetacean sightings observed during fieldwork in the Cape Hatteras survey area in 2015. All sightings were made on-effort.

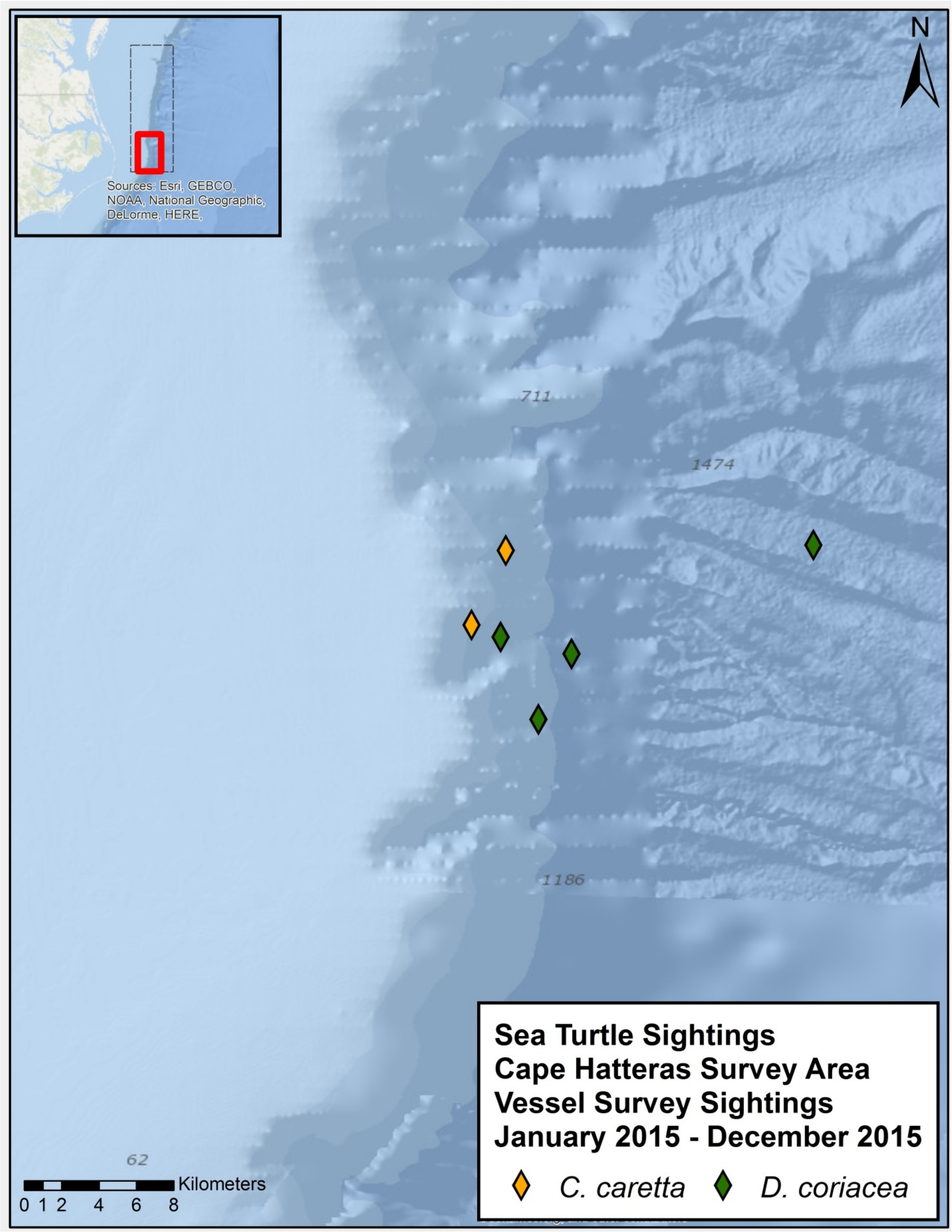


Figure 20. Distribution of sea turtle sightings made during vessel surveys in the Cape Hatteras survey area in 2015.

Thirty-four tags were deployed during the reporting period. Four DTAGs were attached on short-finned pilot whales, while 30 satellite tags were placed on short-finned pilot whales, bottlenose dolphins, Cuvier's beaked whales, and a sperm whale in the reporting period (see **Section 2.3.1** of this report for more information).

Twenty biopsy samples were collected from four species of cetaceans. Biopsied species included two deep-diving odontocete species: short-finned pilot whale (*n*=14) and Cuvier's beaked whale (*n*=2). Tissue samples also were taken from short-beaked common dolphin (*n*=1), Atlantic spotted dolphin (*n*=2), and bottlenose dolphin (*n*=1) (**Table 10** and **Figure 21**). Voucher specimens of these samples are archived with NMFS/Southeast Fisheries Science Center (SEFSC) in Lafayette, Louisiana. Samples are being analyzed by SEFSC for sex determination and population structure.

Table 10. Biopsy samples taken from animals in the Cape Hatteras survey area, January–December 2015.

Common Name	Scientific Name	Samples
Atlantic spotted dolphin	*Stenella frontalis*	2
Bottlenose dolphin	*Tursiops truncatus*	1
Cuvier's beaked whale	*Ziphius cavirostris*	2
Short-beaked common dolphin	*Delphinus delphis*	1
Short-finned pilot whale	*Globicephala macrorhynchus*	14

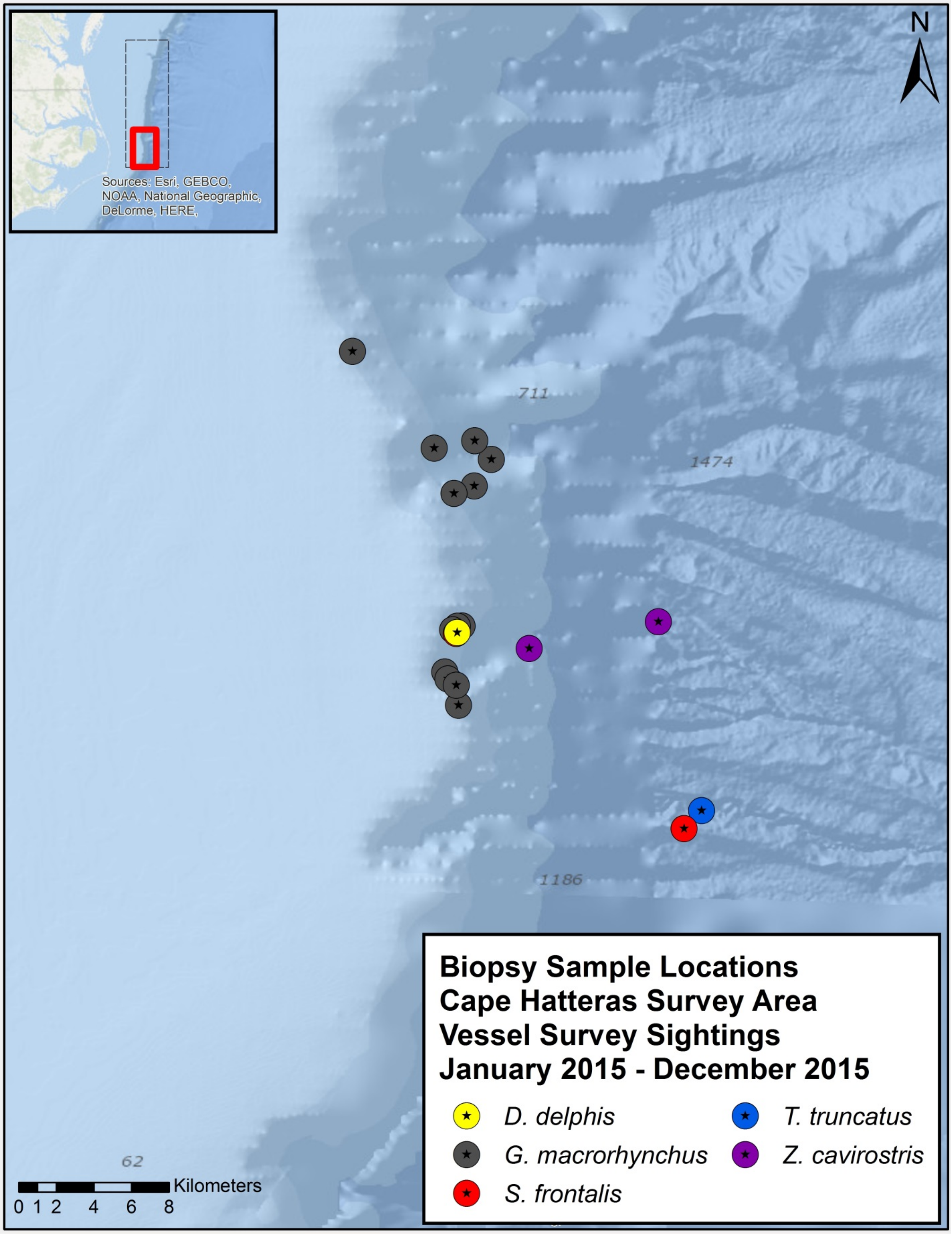


Figure 21. Distribution of biopsy sample locations collected during fieldwork in the Cape Hatteras survey area in 2015.

To date, photo-ID catalogs for 10 species have been assembled, with 76 individuals re-sighted across all species (**Table 11**). Over 10,000 digital images were collected to confirm species identification and identify individual animals during fieldwork in 2015. Images of 2,013 newly identified animals were added to seven existing photo-ID catalogs of bottlenose dolphins, Atlantic spotted dolphins, short-finned pilot whales, sperm whales, Cuvier's beaked whales, short-beaked common dolphins, and Risso's dolphins. In 2015, a new photo-ID catalog was established for *Kogia* spp. that were observed in the Cape Hatteras study area.

Table 11. Comparison of photographs taken of animals in the Cape Hatteras survey area in 2015 with existing photo-ID catalogs, showing matches made so far between this year's photos and the catalogs.

Common Name	Scientific Name	Photos Taken (2015)	Catalog Size to Date	Matches to Date
Bottlenose dolphin	*Tursiops truncatus*	938	221	9
Short-finned pilot whale	*Globicephala macrorhynchus*	8,068	367	61
Risso's dolphin	*Grampus griseus*	39	8	0
Fin whale	*Balaenoptera physalus*	0	1	0
Short-beaked common dolphin	*Delphinus delphis*	20	30	1
Atlantic spotted dolphin	*Stenella frontalis*	52	24	0
Sperm whale	*Physeter macrocephalus*	345	13	1
Cuvier's beaked whale	*Ziphius cavirostris*	807	42	4
Pygmy/Dwarf sperm whale	*Kogia* sp.	77	1	0
Humpback whale	*Megaptera novaeangliae*	0	2	0

Photo-analysis of the images taken in the Cape Hatteras survey area is ongoing. To date, nine bottlenose dolphins have been photographed on multiple occasions, spanning several years (**Table 12**). Bottlenose dolphin Ttr 1-001 was first photographed on 20 July 2009, re-sighted on 30 May 2011, and then photographed for a third time on 27 June 2011. Ttr 6-018 and Ttr 9-013 were photographed together in both March 2012 and May 2013. Ttr 6-020 was observed in May 2011 and then again in October 2013. Ttr 7-031 and Ttr 7-038 were photographed on two separate occasions in 2011 and Ttr 7-058 was observed twice within 2013. Ttr 9-016 was initially photographed in 2011 and then again in June 2014. Ttr 9-027, first observed on 11 June 2014 (TtTag015), was observed a second time on 16 June 2014.

Table 12. Photo-ID matches of individual odontocete cetaceans, excluding pilot whales, in the Cape Hatteras survey area.

ID*	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Ttr 1-001				X		X^y				
Ttr 6-018^							X	X		
Ttr 6-020						X		X		
Ttr 7-031						X^y				
Ttr 7-038						X^y				
Ttr 7-058								X^y		
Ttr 9-013^							X	X		
Ttr 9-016						X			X	
Ttr 9-027 (TtTag015)									X^m	
Dde 7-002		X					X			
Pma-004								X^m		
Zca-001r								X		X
Zca-003r (ZcTag029)									X^m	
Zca-005r									X^y	
Zca-006 (ZcTag040)									X	X

* – Ttr=bottlenose dolphin; Dde=short-beaked common dolphin; Pma=sperm whale; Zca=Cuvier's beaked whale
^{m} – re-sighted within same month
^{y} – re-sighted within same year
^ – observed together in multiple sightings

A single match of a common dolphin off Cape Hatteras has been made; Dde 7-002 was first photographed on 27 May 2007 and then re-sighted nearly 5 years later on 15 March 2012 (**Table 12**).

A single sperm whale match has been made; Pma-004 was observed on 27 and 29 May in 2013.

Four Cuvier's beaked whale matches have been made to date; two were made during this reporting period. Zca_003r was satellite-tagged on 13 May 2014 (ZcTag029) and photographed again 5 days later. Zca_005r was photographed in May and October 2014. Zca_006 was first photographed on 26 May 2014 and was DTAGged at that time, although the tag was never recovered. On 14 June 2015 it was re-sighted and satellite-tagged (ZcTag040) (**Figures 22** and **23**). The final match is individual Zca_001r, who was photographed in a group of four animals on 05 October 2013 and was photographed again on 14 June 2015 in a group of five to seven whales. This individual represents our longest re-sight of a beaked whale and is also an inter-seasonal match (**Table 12**).

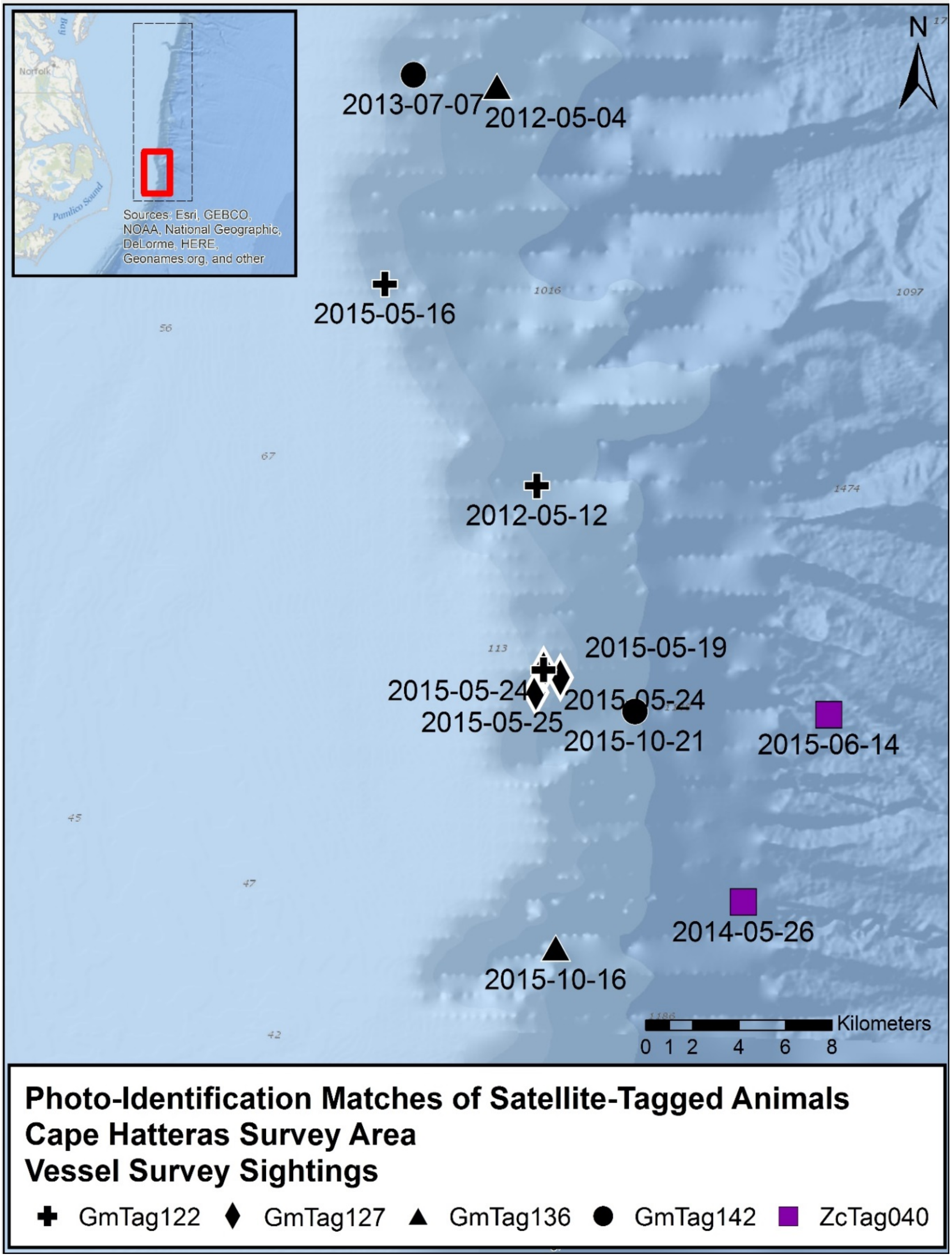


Figure 22. Photo-ID matches of individuals observed in 2015, with dates previously sighted, during fieldwork in the Cape Hatteras survey area.

Figure 23. Photo-ID match of a Cuvier's beaked whale observed during fieldwork in the Cape Hatteras survey area in both 2014 and 2015.

Observers continue to be surprised by the relatively high re-sighting rate of short-finned pilot whales in the Hatteras study area. To date more than 16 percent (61 of 367) of the pilot whales in the catalog have been re-sighted, compared to 2014 when the re-sight rate of pilot whales was only 10 percent (25 of 229).

Four of the 19 short-finned pilot whales equipped with satellite tags in 2015 were either re-sighted or matched to the existing catalog (**Figure 24**). GmTag127 was satellite-tagged on 19 May 2015 and then re-sighted on both 24 and 25 May 2015. GmTag136 was DTAGged in May 2012, re-sighted for the first time in May 2015 and subsequently re-sighted and satellite-tagged in October 2015. GmTag142 was first photographed in July 2010; it was seen again in July 2013 and then satellite-tagged in October 2015. GmTag 122 was first seen in May 2012; it was satellite-tagged on 16 May 2015 and then sighted for a third time on 24 May 2015. Interestingly, Gma_2-011 (a female) was seen in the same three sightings as GmTag122 over the 3-year span.

Figure 24. Photo-ID matches of short-finned pilot whales observed in the Cape Hatteras survey area in 2015

Re-sightings of short-finned pilot whales span up to nearly 9 years, with several individuals observed on multiple occasions and in different seasons. One pair, Gma_151d and Gma_7-138, were photographed in the same sighting in May of 2007 and in another sighting over 6 years later in October 2013. In addition, the longest match to date was recently made, with Gma_008d initially sighted in September 2006 and re-sighted in May 2015. This year a match was also made to an individual, Gma_9-027, who has been photographed in five separate sightings between May 2008 and May 2015.

Cumulative

Total survey effort conducted since the beginning of the monitoring program, including all AFTT protected species monitoring and Deep Diver tagging effort for the Cape Hatteras survey area, is reported in **Table 13**. The annual numbers of sightings by species for both cetaceans and sea turtles in the Cape Hatteras survey area are presented in **Tables 14** and **15**, respectively. The number of biopsy samples collected to date in the Cape Hatteras survey area is reported in **Table 16**. **Table 17** summarizes the catalog sizes and matches by species to date and numbers of images taken during the reporting period in the Cape Hatteras survey area.

Table 13. Duration and distance surveyed during Year 1 (July 2009–December 2010), Year 2 (January–December 2011), Year 3 (January–December 2012), Year 4 (January–December 2013), Year 5 (January–December 2014), and Year 6 (January-December 2015) in the Cape Hatteras survey area.

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
Survey Hours	26	180	87	63	122	135	613
Km Surveyed	296	1,097	1,049	879	929	991	5,241

Table 14. Numbers of cetacean sightings for each species observed during Year 1 (July 2009–December 2010), Year 2 (January–December 2011), Year 3 (January–December 2012), Year 4 (January–December 2013), Year 5 (January–December 2014), and Year 6 (January–December 2015) of vessel surveys in the Cape Hatteras survey area.

Species	Sightings					
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Balaenoptera physalus	0	0	1	2	0	0
Delphinus delphis	0	6	11	3	4	4
Globicephala macrorhynchus	9	33	52	35	26	53
Grampus griseus	1	2	2	0	1	2
Kogia sp.	0	0	0	0	0	1
Mesoplodon sp.	0	0	0	1	0	0
Physeter macrocephalus	0	1	4	3	2	4
Stenella frontalis	0	8	2	3	3	3
Stenella/Delphinus mix	0	1	0	0	0	0
Tursiops truncatus	23	27	54	38	14	47
Tursiops/Stenella mix	0	1	0	0	0	0
Ziphius cavirostris	0	3	1	2	16	13
Unidentified baleen whale	0	0	0	0	0	1
Unidentified beaked whale	0	0	0	4	3	1
Unidentified small whale	0	0	0	0	0	1
Unidentified delphinid	1	0	3	1	0	1
Total:	**34**	**82**	**130**	**92**	**69**	**131**

Table 15. Numbers of sea turtle sightings for each species observed during Year 1 (July 2009–December 2010), Year 2 (January–December 2011), Year 3 (January–December 2012), Year 4 (January–December 2013), Year 5 (January–December 2014), and Year 6 (January–December 2015) of vessel surveys in the Cape Hatteras survey area.

Species	Sightings					
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Caretta caretta	2	0	2	7	0	2
Chelonia mydas	0	0	0	1	0	0
Dermochelys coriacea	0	0	0	0	0	4
Unidentified sea turtle	0	0	1	0	0	0
Total:	2	0	3	8	0	6

Table 16. Biopsy samples collected to date in the Cape Hatteras survey area during Year 1 (July 2009–December 2010), Year 2 (January–December 2011), Year 3 (January–December 2012), Year 4 (January–December 2013), Year 5 (January–December 2014), and Year 6 (January–December 2015).

Species	Year 2	Year 3	Year 4	Year 5	Year 6	Total
Balaenoptera physalus	0	0	3	0	0	3
Delphinus delphis	0	5	2	0	1	8
Globicephala macrorhynchus	4	33	10	5	14	66
Grampus griseus	0	0	2	0	0	2
Physeter macrocephalus	0	0	1	1	0	2
Stenella frontalis	6	0	2	2	2	12
Tursiops truncatus	14	10	13	2	1	40
Ziphius cavirostris	0	0	2	0	2	4

Table 17. Summary of images collected during all vessel surveys in the Cape Hatteras survey area, January 2009–December 2015, with photo-ID catalog sizes and matches to date.

Species	2009-2014		2015	
	Catalog Size	Matches	Catalog Size	Matches
Balaenoptera physalus	1	0	1	0
Delphinus delphis	27	1	30	1
Globicephala macrorhynchus	229	25	367	61
Grampus griseus	7	0	8	0
Kogia sp.	0	0	1	0
Megaptera novaeangliae	3	0	2	0
Physeter macrocephalus	5	1	13	1
Stenella frontalis	23	0	24	0
Tursiops truncatus	198	9	221	9
Ziphius cavirostris	13	2	42	4

For more information on this study, refer to the annual progress report for this project (Foley et al. 2016a).

2.1.2.2 Onslow Bay Survey Area

Vessel survey effort in Onslow Bay during in 2015 consisted of two opportunistic survey days (1 day in August and 1 day in November) (**Figure 25** and **Table 18**). The August survey was focused on testing the feasibility of deploying a four-element distributed hydrophone array from the research vessel. The November survey occurred following two consecutive days of reported fin whale sightings within a few miles of the Beaufort Inlet. Fieldwork conducted during 2015 yielded 122 km and 9 hr of effort (**Table 18**) in BSS 0 to 5.

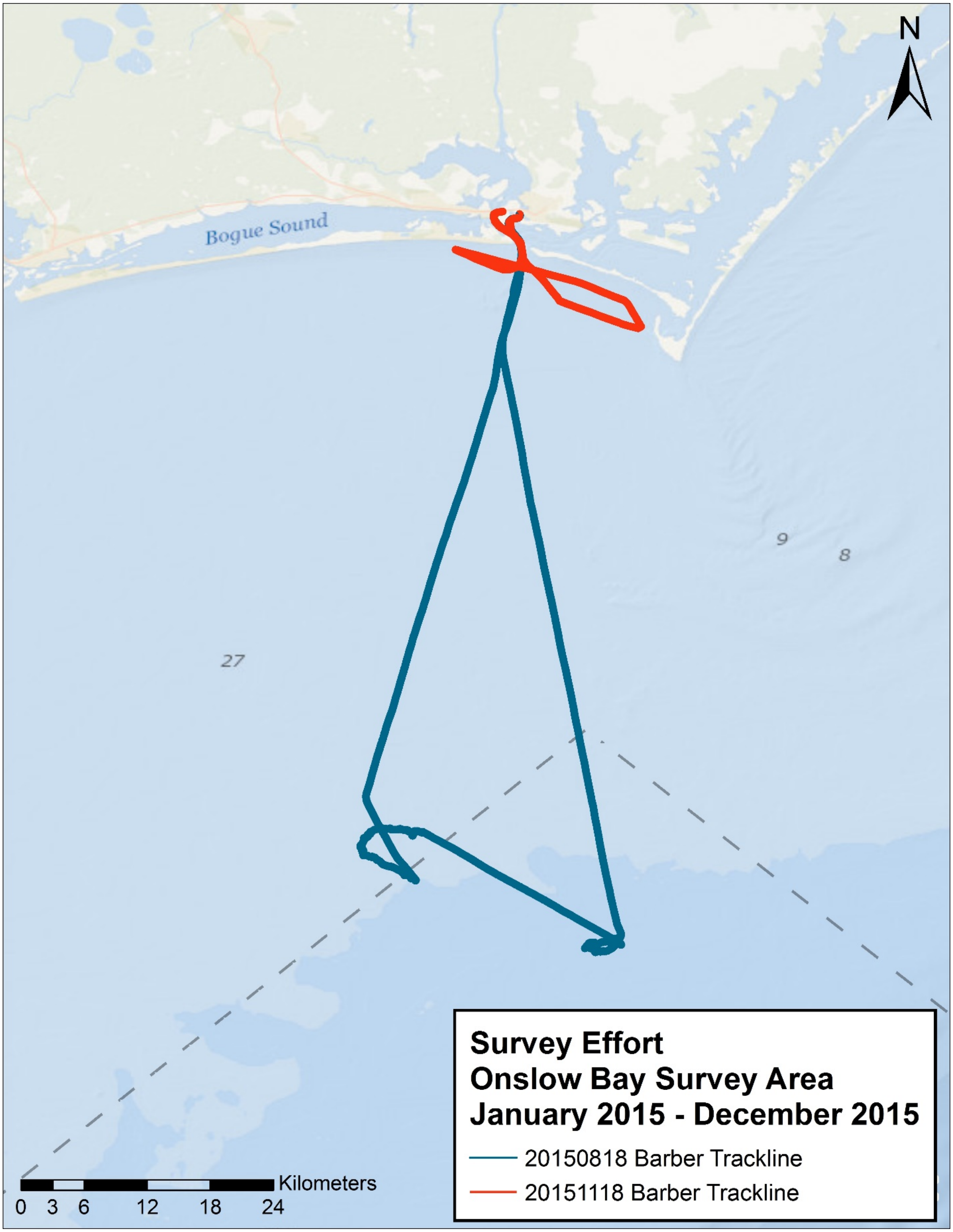


Figure 25. Survey effort during vessel surveys in the Onslow Bay survey area in 2015.

Table 18. Effort summary for vessel surveys conducted in the Onslow Bay survey area in 2015.

Number of Survey Days	2
Total Survey Time (hr:min)	12:27
Time On Effort (hr:min)	9:05
Total Km Surveyed	122.1

Key: hr = hour(s); km = kilometer(s); min = minute(s)

Five sightings of two cetacean species were recorded during these vessel surveys: bottlenose dolphin (*n*=3) and Atlantic spotted dolphin (*n*=2) (**Table 19** and **Figure 26**). No sea turtles were sighted during these vessel surveys.

Table 19. Sightings from field work conducted in the Onslow Bay survey area in 2015. All sightings were made on effort.

Common Name	Scientific Name	Number of Sightings	Number of Individuals
Atlantic spotted dolphin	*Stenella frontalis*	2	17
Bottlenose dolphin	*Tursiops truncatus*	3	17

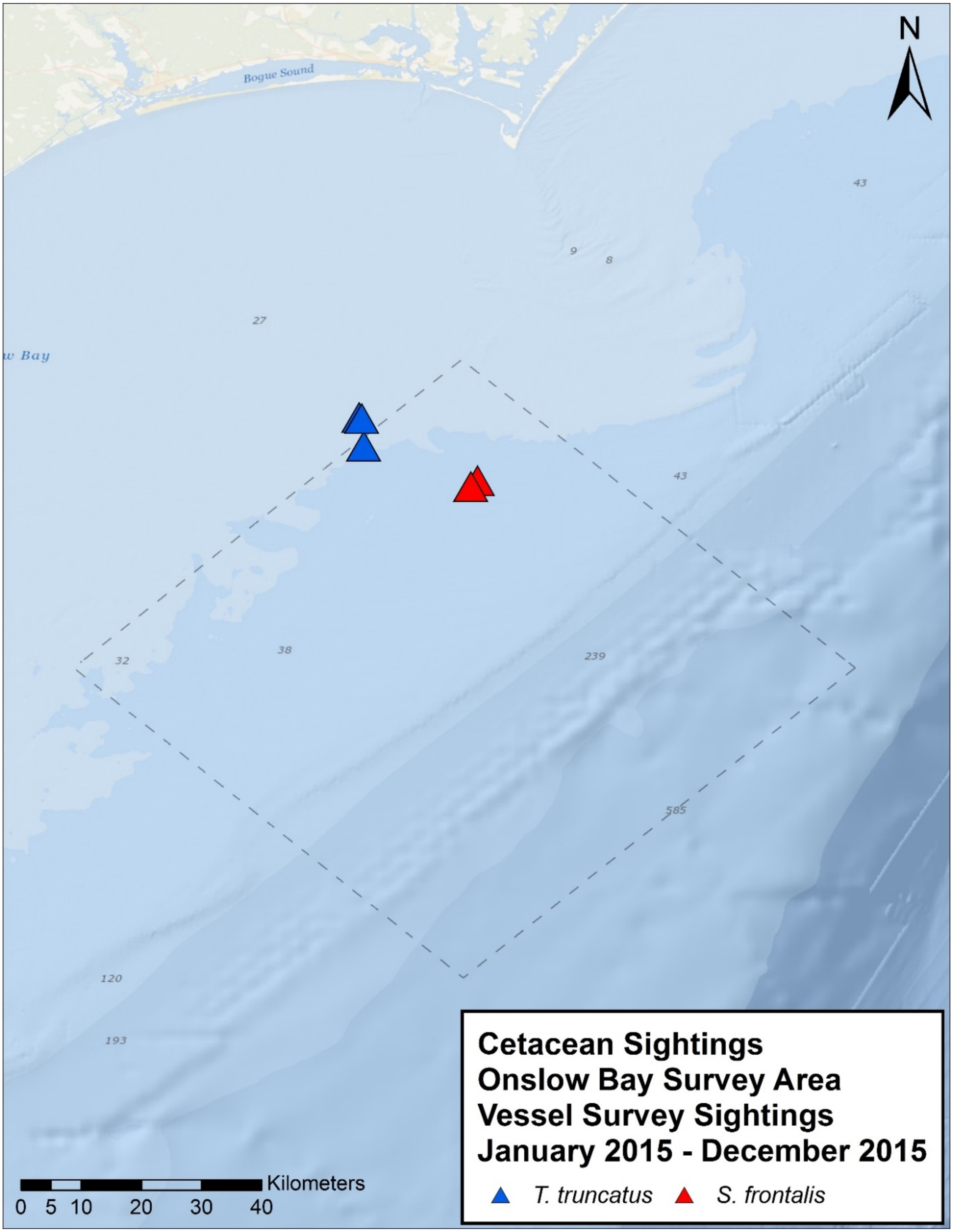


Figure 26. Distribution of all cetacean sightings made during vessel surveys in the Onslow Bay survey area in 2015.

Since the inception of the monitoring program in Onslow Bay in 2007, eight bottlenose dolphins and four Atlantic spotted dolphins have been re-sighted, although there were no resightings in 2015 **(Table 20** and **Figure 27)**, representing approximately 6 percent of the catalogs for bottlenose dolphins (8 of 133) and 5 percent (4 of 86) for Atlantic spotted dolphins. Re-sightings of bottlenose dolphins and Atlantic spotted dolphins in Onslow Bay span up to six and ten years, respectively. Two bottlenose dolphins (Ttr_7-015 and Ttr_8-009) were seen together in both April 2009 and 2010. One bottlenose dolphin (Ttr_1-004) has now been photographed on three separate occasions, in October 2009, April 2010 and January 2012. Furthermore, one Atlantic spotted dolphin (Sfr_8004) biopsied and photographed on 12 September 2011 was matched to an animal photographed on 28 June 2001 and on 24 June 2002 during surveys conducted in nearshore coastal waters of Onslow Bay. An additional Atlantic spotted dolphin from the same 12 September 2011 group was matched to Sfr_9-023_MCB, photographed a month earlier on 19 August 2011 during surveys in the coastal waters off Marine Corps Base Camp Lejeune, North Carolina. Spotted dolphin Sfr 7-013 was first observed during an offshore AFTT Onslow Bay vessel survey on 12 September 2011 and was re-sighted on 25 July 2013 during an acoustic vessel survey in coastal waters of Camp Lejeune. These numerous re-sightings over multiple years and across seasons supports the existence of considerable fine-scale population structure and some degree of residency for both bottlenose and spotted dolphins in Onslow Bay. To date, no individuals of any other species have been re-sighted, although the number of sightings and catalog sizes for these species are very small. Images of the dorsal fins of stranded pelagic cetaceans in North Carolina are regularly compared with the existing photo-ID catalogs for Onslow Bay, but to date there have been no matches.

Table 20. Summary of photographs taken of animals in the Onslow Bay survey area in 2015, along with photo-ID catalog sizes and total numbers of matches from 2015 and 2007–2015.

Species	Common Name	Images	Catalog Size	Matches	
		2015		2015	To date
Globicephala macrorhynchus	Short-finned pilot whale	0	23	0	0
Grampus griseus	Risso's dolphin	0	22	0	0
Stenella frontalis	Atlantic spotted dolphin	126	86	0	4
Tursiops truncatus	Bottlenose dolphin	169	133	0	8
Steno bredanensis	Rough-toothed dolphin	0	12	0	0

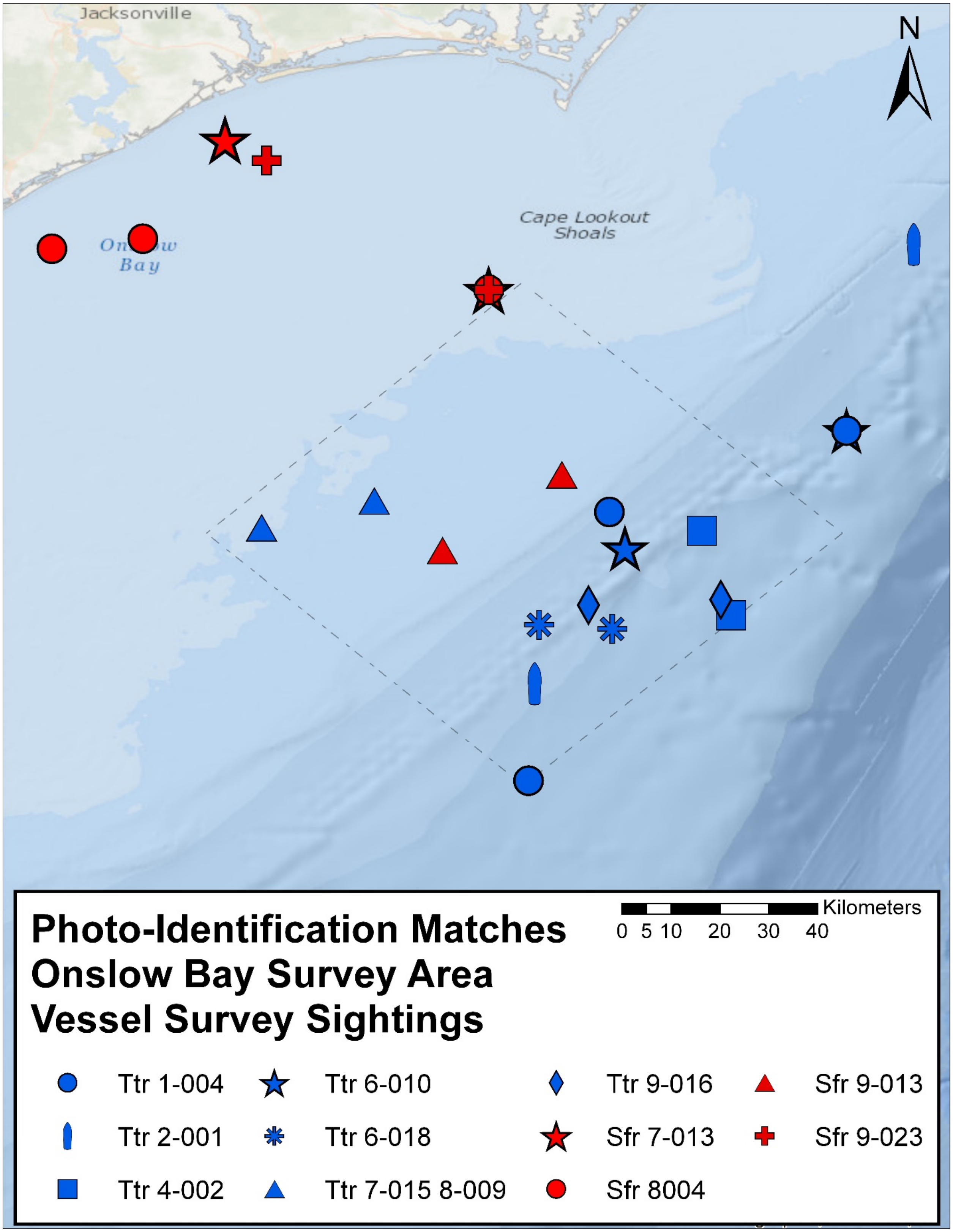


Figure 27. Locations of individual photo-matched dolphins within the Onslow Bay survey area.

Cumulative

Total vessel survey effort conducted since the beginning of the monitoring program in the Onslow Bay survey area is reported in **Table 21**. The annual numbers of sightings by species for both cetaceans and sea turtles in the Onslow Bay survey area are presented in **Tables 22** and **23**, respectively. The numbers of biopsy samples collected to date in the Onslow Bay survey area are reported in **Table 24**. **Table 25** summarizes the numbers of photo-ID images taken, catalog sizes, and matches by species to date in the Onslow Bay survey area. Small vessel surveys in this area have since been discontinued.

Table 21. Duration and distance surveyed during Year 1 (June 2007–June 2008), Year 2 (July 2008–June 2009), Year 3 (July 2009–June 2010), Year 4 (July 2010–December 2011), Year 5 (January–December 2012), Year 6 (January–December 2013), and Year 8 (January–December 2015) in the Onslow Bay survey area.

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 8	Total
Survey Hours	171	109	106	54	32	15	9.	496
Kilometers Surveyed	2,334	1742	1,556	754	497	186	122	7,191

Table 22. Numbers of cetacean sightings for each species observed during Year 1 (June 2007–June 2008), Year 2 (July 2008–June 2009), Year 3 (July 2009–June 2010), Year 4 (July 2010–December 2011), Year 5 (January–December 2012), Year 6 (January–December 2013), and Year 8 (January–December 2015) in the Onslow Bay survey area.

Species	Sightings						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 8
Globicephala macrorhynchus	1	0	2	0	0	1	0
Grampus griseus	3	0	3	0	1	0	0
Mesoplodon sp.	0	0	0	0	2	0	0
Stenella frontalis	6	17	17	9	1	0	2
Steno bredanensis	0	0	1	0	0	0	0
Tursiops truncatus	23	14	29	7	7	6	3
Unidentified delphinid	3	2	3	0	0	0	0
Unidentified small whale	0	0	0	0	1	0	0
Total:	**36**	**33**	**55**	**16**	**12**	**7**	**5**

Table 23. Numbers of sea turtle sightings for each species observed during Year 1 (June 2007–June 2008), Year 2 (July 2008–June 2009), Year 3 (July 2009–June 2010), Year 4 (July 2010–December 2011), Year 5 (January–December 2012), Year 6 (January–December 2013), and Year 8 (January–December 2015) in the Onslow Bay survey area.

Species	Sightings						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 8
Caretta caretta	19	49	47	3	2	1	0
Dermochelys coriacea	0	0	2	0	0	0	0
Unidentified sea turtle	1	0	1	0	0	0	0
Total:	**20**	**49**	**50**	**3**	**2**	**1**	**0**

Table 24. Biopsy samples collected to-date [Year 4 (July 2010–December 2011), Year 5 (January–December 2012), Year 6 (January–December 2013), and Year 8 (January–December 2015)] in the Onslow Bay survey area.

Species	Year 4	Year 5	Year 6	Year 8	Total
Globicephala macrorhynchus	0	0	3	0	3
Grampus griseus	0	5	0	0	5
Stenella frontalis	2	2	0	0	4
Tursiops truncatus	0	8	7	0	15

Table 25. Summary of images collected during all vessel surveys in the Onslow Bay survey area during Year 1 (June 2007–June 2008), Year 2 (July 2008–June 2009), Year 3 (July 2009–June 2010), Year 4 (July 2010–December 2011), Year 5 (January–December 2012), Year 6 (January–December 2013), and Year 8 (January–December 2015), with photo-ID catalog sizes (C) and numbers of matches (M) to date.

Species	Year 1		Year 2		Year 3		Year 4		Year 5		Year 6		Year 8	
	Catalog Size	Matches	Catalog Size	Matches	Catalog Size	Matches	Catalog Size	Matches	Catalog Size	Matches	Catalog Size	Matches	Catalog Size	Matches
Globicephala macrorhynchus	8	0	8	0	16	0	16	0	16	0	23	0	23	0
Grampus griseus	5	0	5	0	7	0	7	0	22	0	22	0	22	0
Stenella frontalis	3	0	29	0	49	1	68	2	78	3	78	4	86	4
Steno bredanensis	0	0	0	0	12	0	12	0	12	0	12	0	12	0
Tursiops truncatus	52	0	78	0	106	5	112	5	139	7	126	8	133	8

For more information on this study, refer to the annual progress report for this project (Foley et al. 2016a).

2.1.2.3 Jacksonville OPAREA Survey Area

Researchers conducted vessel surveys in the JAX survey area during 2015 to investigate residency and population structure of odontocetes. Seven biopsy and photo-ID surveys were conducted in the JAX survey area during April, July through September, and December 2015 (**Figure 28**). A total of 858.2 km and 44.2 hr of trackline effort was conducted (**Table 26**) in BSS 0 to 5.

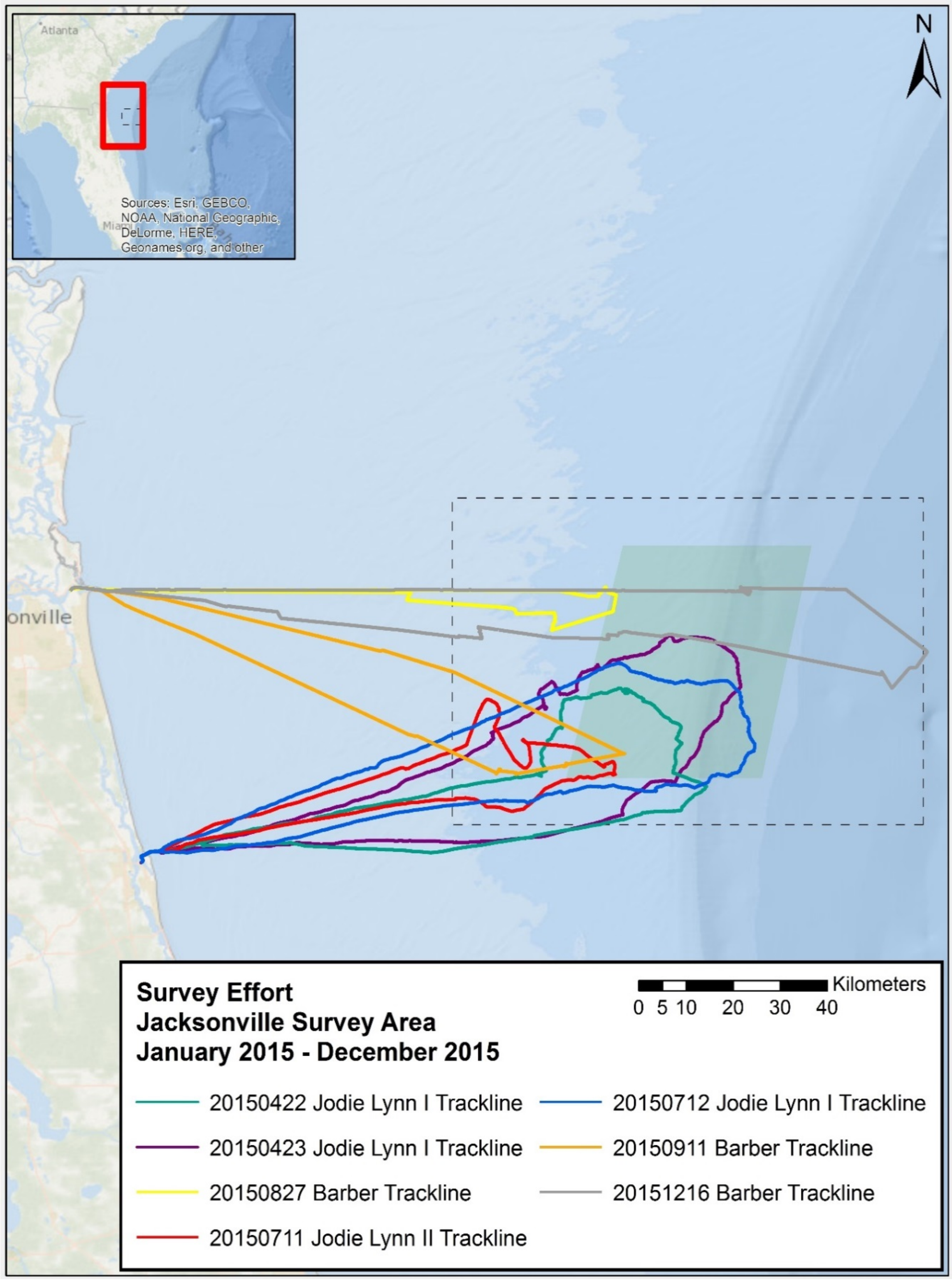


Figure 28. Survey effort during vessel surveys in the JAX survey area in 2015. The dashed line outlines the JAX survey area, while the shaded box is the planned USWTR site.

Table 26. Effort details for vessel surveys conducted in the JAX survey area in 2015.

Number of Surveys	7
Total Survey Time (hr:min)	68:32
Time On Effort (hr:min)	44:12
Total Km Surveyed	858.2

Key: hr = hour(s); km = kilometer(s); min = minute(s)

Seventeen cetacean sightings of three species were recorded during these vessel surveys. As in previous years, bottlenose (*n*=8) and Atlantic spotted dolphin (*n*=8) were frequently observed, in addition to a single sighting of Risso's dolphin (**Table 27**). Similar to observations in previous years, bottlenose dolphins were encountered throughout the JAX survey area, including deeper pelagic waters, whereas Atlantic spotted dolphins were restricted to the relatively shallow shelf waters and Risso's dolphins were found in large groups in deeper pelagic waters (**Figure 29**).

Table 27. Sightings from vessel surveys conducted in the JAX survey area in 2015. All sightings were made on effort.

Common Name	Scientific Name	Number of Sightings	Number of Individuals
Risso's dolphin	*Grampus griseus*	1	40
Atlantic spotted dolphin	*Stenella frontalis*	8	354
Bottlenose dolphin	*Tursiops truncatus*	8	36
Leatherback turtle	*Dermochelys coriacea*	2	2
Loggerhead turtle	*Caretta caretta*	23	24

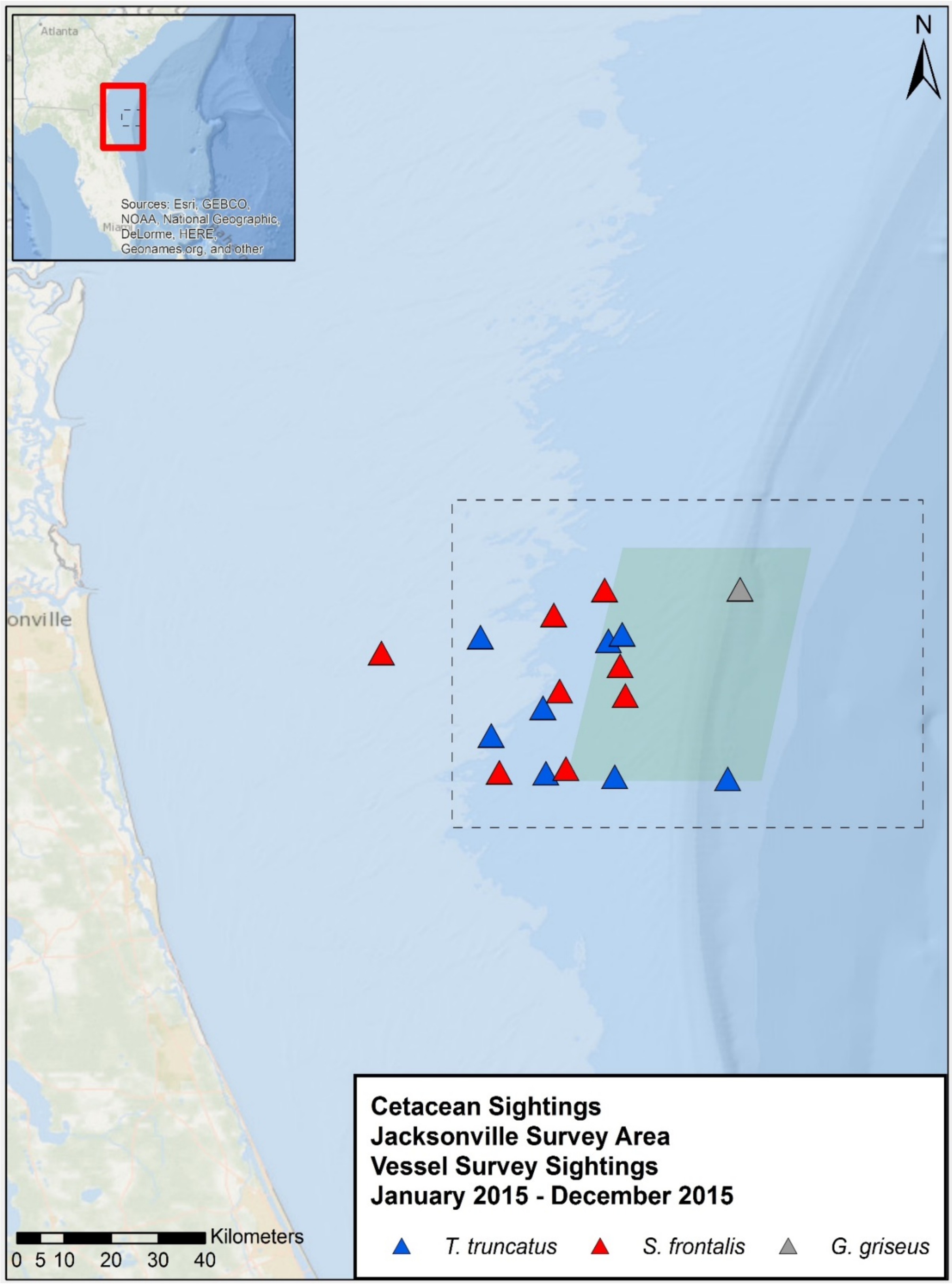


Figure 29. Locations of cetacean sightings from vessel surveys conducted in the JAX survey area in 2015. All sightings were made on effort. The dashed line outlines the JAX survey area, while the shaded box is the planned USWTR site.

Twenty-five sightings of two sea turtle species (loggerhead turtle and leatherback turtle) were recorded. As in years past, the loggerhead turtle was the most frequently recorded species (*n*=23); a small number of sightings of leatherback turtle (*n*=2) were also observed (**Table 27** and **Figure 30**).

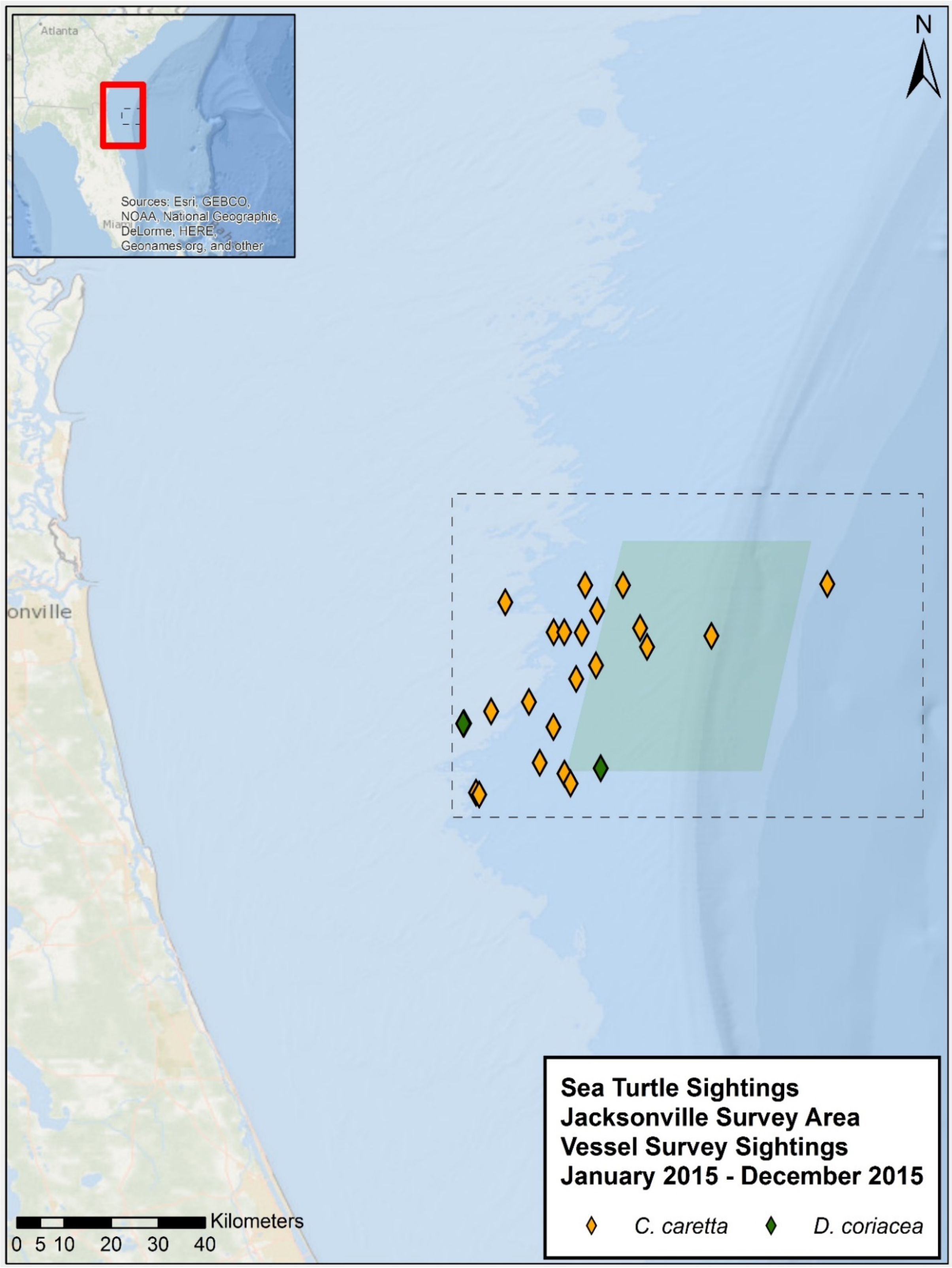


Figure 30. Locations of sea turtle sightings from vessel surveys conducted in the JAX survey area in 2015. All sightings were made on effort.The dashed line outlines the JAX survey area, while the shaded box is the planned USWTR site.

Eight biopsy samples were collected from Atlantic spotted dolphin (*n*=3) and bottlenose dolphin (*n*=5) (**Table 28** and **Figure 31**). Skin samples will be analyzed for sex determination. Voucher specimens of these samples are archived with the SEFSC in Lafayette, Louisiana.

Table 28. Biopsy samples collected from animals in the JAX survey area in 2015.

Common Name	Scientific Name	No. Samples
Atlantic spotted dolphin	*Stenella frontalis*	3
Bottlenose dolphin	*Tursiops truncatus*	5

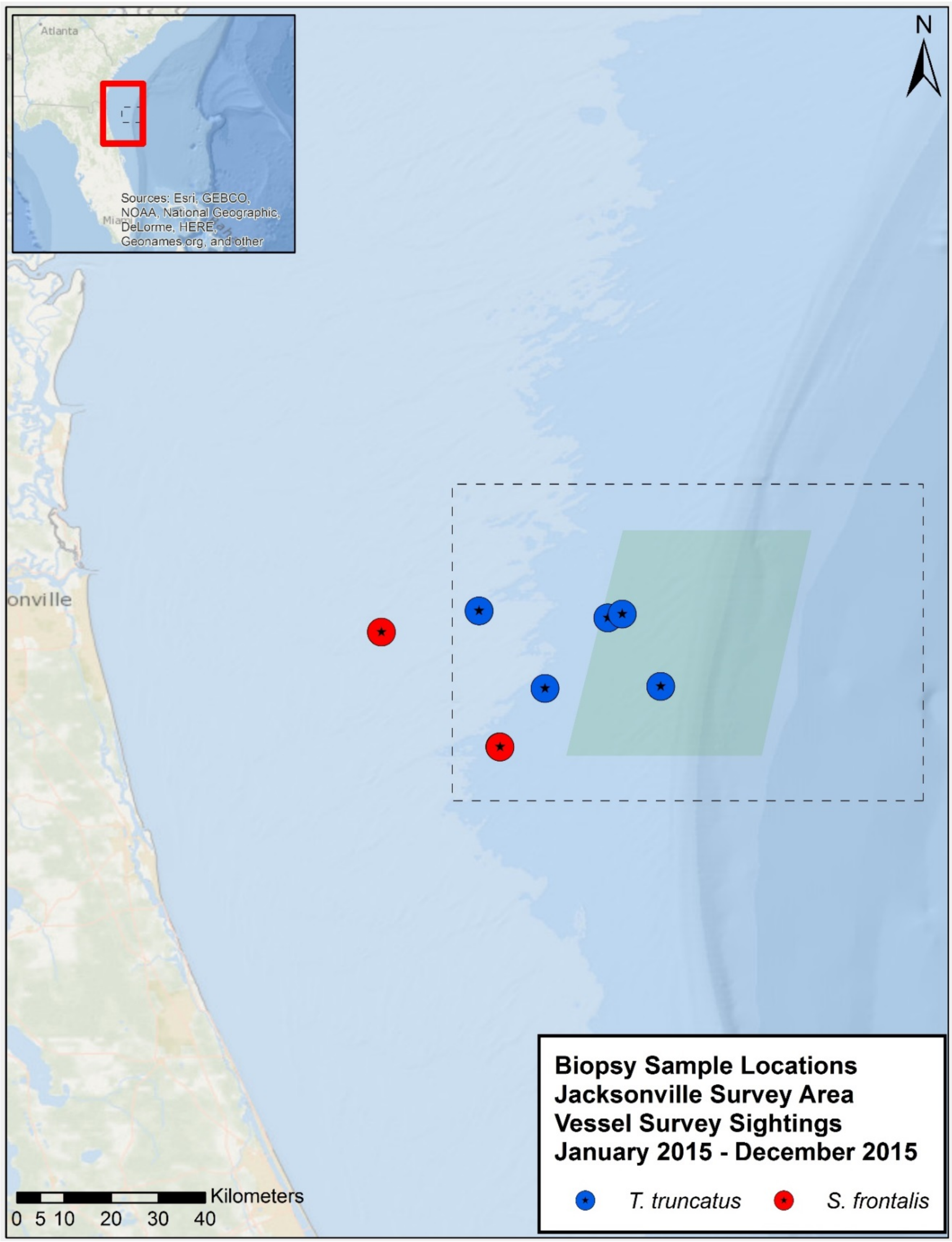


Figure 31. Locations of biopsy sampling of Atlantic spotted, bottlenose, and Risso's dolphins in the JAX survey area in 2015. The dashed line outlines the JAX survey area, while the shaded box is the planned USWTR site.

Approximately 1,300 digital images for species confirmation and individual identification were taken in 2015 of three species (bottlenose dolphin, Atlantic spotted dolphin, and Risso's dolphin), with no new photo-ID matches. A total of 40 newly-identified dolphins was added to existing photo-ID catalogs. Photo-ID catalogs for bottlenose and Atlantic spotted dolphins in JAX currently consist of 100 and 118 individuals, respectively (**Table 29**). Two individual Atlantic spotted dolphins have been resighted within the JAX study area (**Figure 32**). Sfr 3-001 was observed first on 10 October 2010 and again on 19 March 2011; Sfr 8-005 was photographed during surveys on two consecutive days: 18 March 2011 and 19 March 2011 (**Table 30**). In addition, two bottlenose dolphins were re-sighted together on 25 January 2012 and 18 July 2013 (**Table 30** and **Figure 32**). The Risso's dolphin photo-ID catalog consists of 36 individuals; however, no re-sightings were identified through 2015 (**Table 29**).

Table 29. Summary of photographs taken of animals in the JAX survey area in 2015 with photo-ID catalog sizes and total number of matches across all years of photo-ID effort.

Species	Common Name	Images	Catalog Size	Matches
		2015		
Globicephala macrorhynchus	Short-finned pilot whale	0	12	0
Grampus griseus	Risso's dolphin	367	36	0
Stenella frontalis	Atlantic spotted dolphin	380	118	2
Tursiops truncatus	Bottlenose dolphin	530	100	2

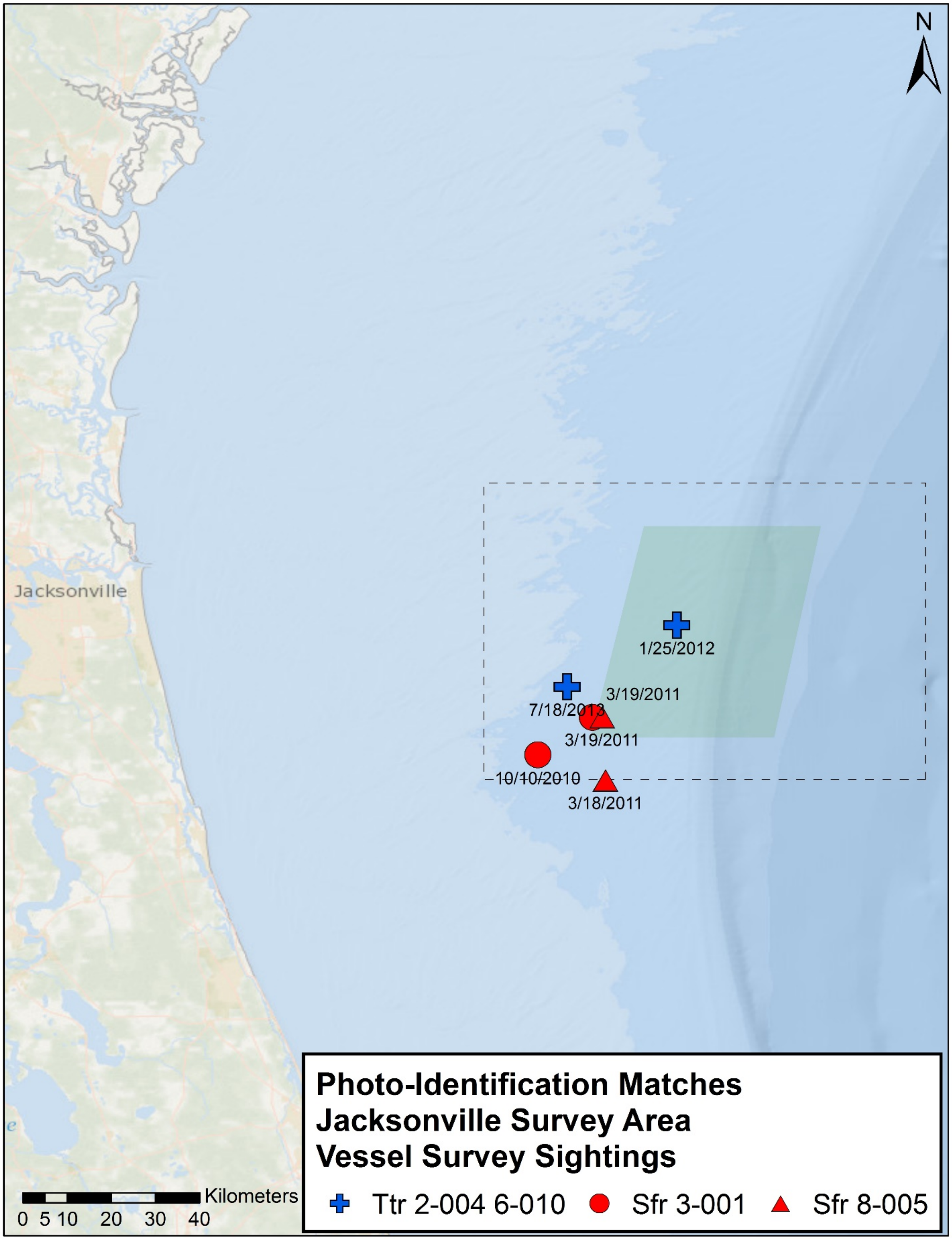


Figure 32. Locations of photo-matched dolphins within the JAX survey area across all years The dashed line outlines the JAX survey area, while the shaded box is the planned USWTR site. Table 30. Photo-ID

matches of bottlenose dolphins (Ttr) and Atlantic spotted dolphins (Sfr) observed in the JAX survey area.

ID	Jacksonville, Florida						
	2009	2010	2011	2012	2013	2014	2015
Ttr 2-004^				X	X		
Ttr 6-010^				X	X		
Sfr 3-001		X	X				
Sfr 8-005			X[m]				

^Observed together in multiple sightings
[m]Re-sighted within same month

Cumulative

Total survey effort conducted since the beginning of the monitoring program for the JAX survey area is reported in **Table 31**. The annual numbers of sightings by species for both cetaceans and sea turtles in the JAX survey area are presented in **Tables 32** and **33**, respectively. The numbers of biopsy samples collected to date in the JAX survey area are reported in **Table 34. Table 35** summarizes the numbers of photo-ID images, catalog sizes, and matches by species to date.

Table 31. Duration and distance surveyed during Year 1 (July 2009–December 2010), Year 2 (January–December 2011), Year 3 (January–December 2012), Year 4 (January–December 2013), Year 5 (January–December 2014), and Year 6 (January-December 2015) in the JAX survey area.

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
Survey Hours	127	21	59	59	67	44	377
km Surveyed	2,074	346	937	1,022	1,227	858	6,464

Table 32. Numbers of cetacean sightings for each species observed during Year 1 (July 2009–December 2010), Year 2 (January–December 2011), Year 3 (January–December 2012), Year 4 (January–December 2013), Year 5 (January–December 2014), and Year 6 (January-December 2015) in the JAX survey area.

Species	Sightings					
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Eubalaena glacialis	0	0	0	0	1	0
Globicephala macrorhynchus	3	0	0	0	0	0
Grampus griseus	2	0	0	1	1	1
Stenella frontalis	35	6	14	9	20	10
Tursiops truncatus	19	6	23	15	18	10
Tursiops/Stenella mix	0	0	0	0	1	0
Unidentified delphinid	13	0	4	3	4	0
Total:	**72**	**12**	**41**	**28**	**45**	**21**

Table 33. Numbers of sea turtle sightings for each species observed during Year 1 (July 2009–December 2010), Year 2 (January–December 2011), Year 3 (January–December 2012), Year 4 (January–December 2013), Year 5 (January–December 2014), and Year 6 (January-December 2015) in the JAX survey area.

Species	Sightings					
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Caretta caretta	52	20	41	33	31	22
Dermochelys coriacea	8	3	4	1	3	2
Lepidochelys kempii	1	0	1	0	0	0
Unidentified turtle	8	3	3	1	0	0
Total:	**69**	**26**	**49**	**35**	**34**	**24**

Table 34. Biopsy samples collected to date in the JAX survey area. Year 1 (July 2009–December 2010), Year 2 (January–December 2011), Year 3 (January–December 2012), Year 4 (January–December 2013), Year 5 (January–December 2014), and Year 6 (January-December 2015).

Species	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
Grampus griseus	0	0	0	1	2	0	3
Stenella frontalis	0	0	19	6	19	3	44
Tursiops truncatus	0	0	12	5	10	5	27

Table 35. Summary of images collected during all vessel surveys in the JAX survey area, January 2009–December 2015, with photo-ID catalog sizes (C) and numbers of matches (N) to date. Year 1 (July 2009–December 2010), Year 2 (January–December 2011), Year 3 (January–December 2012), Year 4 (January–December 2013), Year 5 (January–December 2014), and Year 6 (January-December 2015).

Species	Year 1		Year 2		Year 3		Year 4		Year 5		Year 6	
	C	M	C	M	C	M	C	M	C	M	C	M
Globicephala macrorhynchus	0	0	0	0	0	0	12	0	12	0	12	0
Grampus griseus	1	0	1	0	1	0	7	0	22	0	36	0
Stenella frontalis	0	0	41	0	60	2	77	2	111	2	118	2
Tursiops truncatus	0	0	21	0	41	0	52	2	80	2	100	2

For more information on this study, refer to the annual progress report for this project (Foley et al. 2016a).

2.1.2.4 Virginia Beach and MINEX

Since August 2012, HDR has been conducting vessel surveys and passive acoustic monitoring near Naval Station Norfolk (NSN) and Virginia Beach to assess the occurrence, distribution, and density of marine mammals. The primary goal of this project was to understand the seasonal occurrence and densities of bottlenose dolphins in the area so that the U.S. Navy can make more informed decisions on proposed training and testing activities and minimize potential impacts to marine mammals in this area. Fieldwork for this project was completed in August 2015 and included line-transect surveys, photo-ID surveys, and PAM using both Ecological Acoustic Recorders and C-PODs. This section includes a summary of the progress and results from the entire 3-year study period. Refer to **Section 2.3.3** of this report for presentation of the PAM results.

The study area included waters around NSN, Joint Expeditionary Base Little Creek (JEB-LC), JEB Fort Story (JEB-FS), the Virginia Beach waterfront, and the VACAPES Mine-neutralization Exercise (MINEX) W-50 training range. The two primary survey zones included the COASTAL/INSHORE and OFFSHORE/MINEX zones (**Figure 33**). The INSHORE zone was a 310.4-square kilometer (km^2) strip extending from the shoreline to 3.7 km offshore. This zone included the Chesapeake Bay waters near NSN and waters off JEB-LC and JEB-FS and extended down the Atlantic coast towards the Virginia/North Carolina border. The MINEX zone encompassed Atlantic waters from 3.7 to 25.7 km from shore and included almost the entire VACAPES MINEX W-50a and W-50b training areas. A total of 33 INSHORE and 28 MINEX line-transect surveys was conducted between August 2012 and August 2015. Total on-effort coverage included 3,634 km in the INSHORE zone and 2,916 km in the MINEX zone.

Totals of 546 marine mammal sightings and 111 sea turtle sightings were recorded during the line-transect surveys (**Figures 33** and **34**). The majority (approximately 95 percent; *n*=517) of marine mammal sightings were of bottlenose dolphins. Humpback whale (*n*=26), harbor porpoise (*Phocoena phocoena*) (*n*=1), and short-beaked common dolphin (*n*=1) were also sighted (**Figure 33**). The one group of unidentified dolphins recorded was most likely short-beaked common dolphins; however, species identification could not be confirmed. Researchers sighted 91 marine mammal groups in the MINEX zone and 455 groups in the INSHORE zone (**Table 36**). Sea turtle sightings included loggerhead (*n*=71), leatherback (*n*=15), Kemp's ridley (*Lepidochelys kempii*) (*n*=1), unidentified (*n*=8), and unidentified hardshell (*n*=11) turtles (**Figure 34**). The researchers made 84 sea turtle sightings in the MINEX zone and 27 sea turtle sightings in the INSHORE zone (**Table 36**)

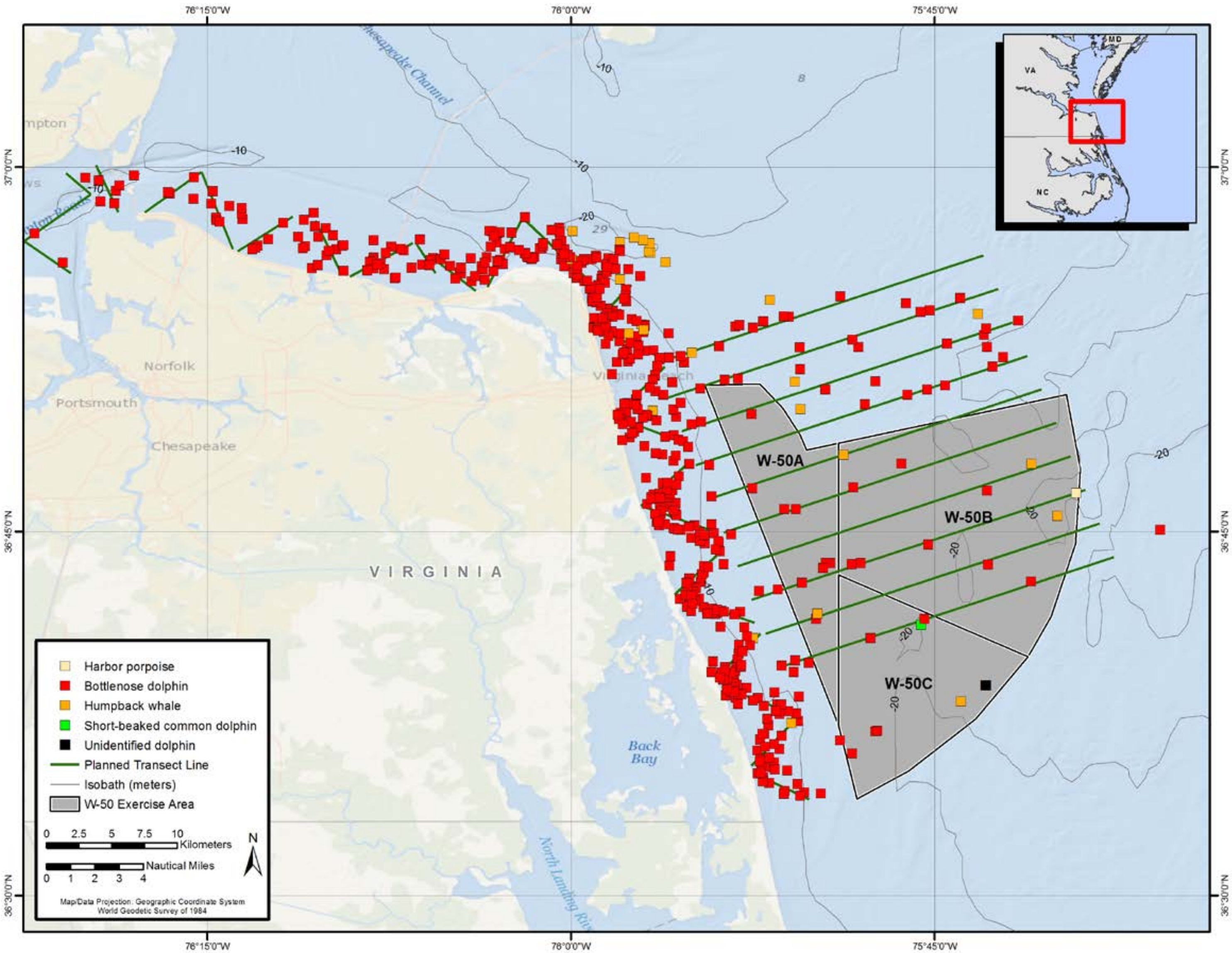


Figure 33. Marine mammal sightings during all line-transect vessel surveys near NSN and Virginia Beach between August 2012 and August 2015. Transect lines were modified after Year 1 of the study; only transect lines from Year 2 and Year 3 of the study are shown.

Table 36. Summary of marine mammal and sea turtle sightings near NSN and Virginia Beach from August 2012 through August 2015.

Zone	Season	Survey Days	Distance On effort (km)	Cetacean Sightings	Cetacean Individuals*	Sea Turtle Sightings	Sea Turtle Individuals*
INSHORE	Fall	9	1,022.9	227	2,550	9	9
INSHORE	Winter	8	794.3	30	318	0	0
INSHORE	Spring	9	1,020.8	65	710	0	0
INSHORE	Summer	7	796.3	133	2,198	18	18
MINEX	Fall	7	754.5	26	493	14	14
MINEX	Winter	6	600.3	9	25	0	0
MINEX	Spring	6	596.2	33	366	20	20
MINEX	Summer	9	965.0	23	291	50	50

*Total individuals are sum of best group size estimates

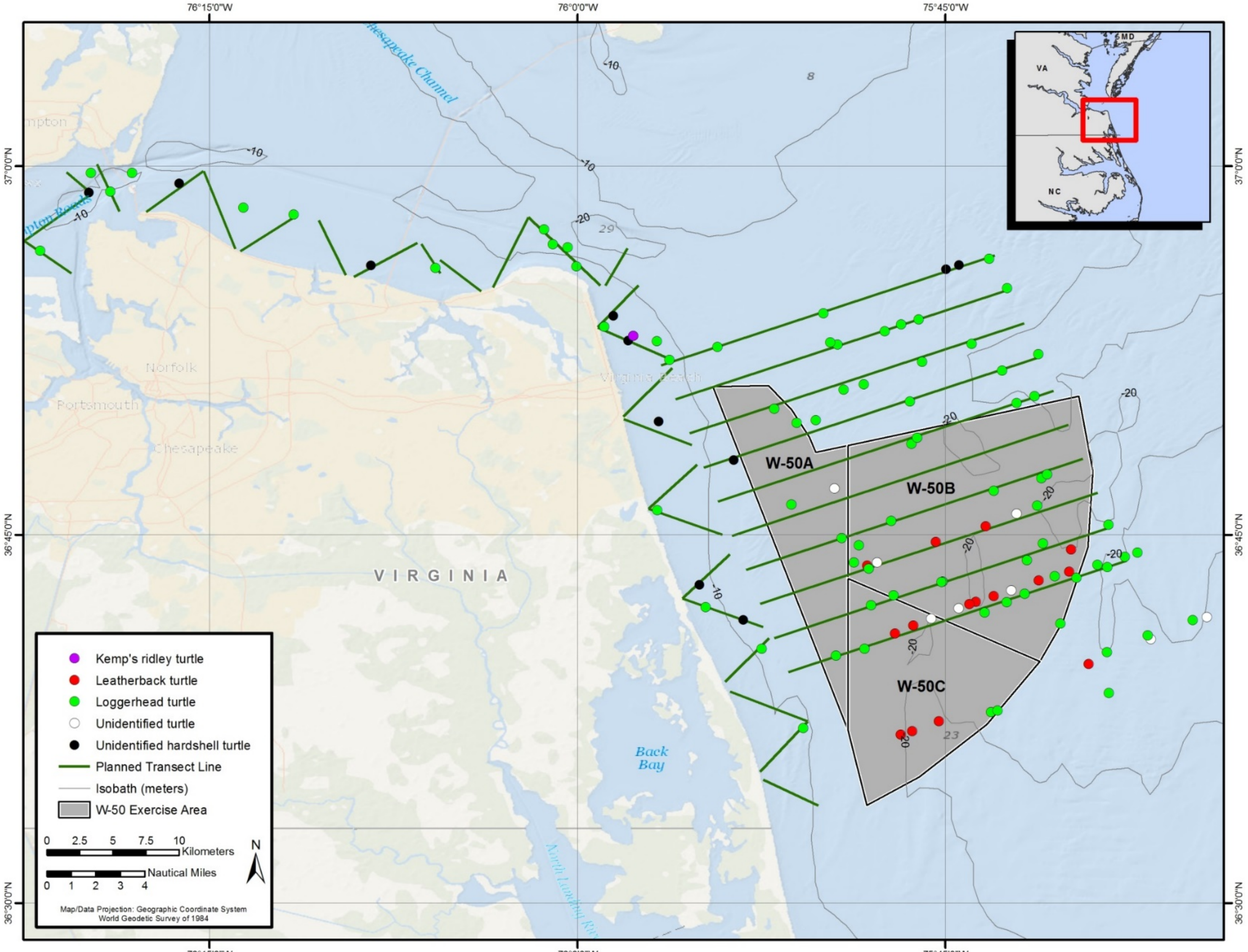


Figure 34. Sea turtle sightings during all line-transect vessel surveys in coastal waters around NSN and Virginia Beach, Virginia, August 2012–December 2015. Transect lines were modified after Year 1 of the study; only transect lines from Year 2 and Year 3 of the study are shown.

Conventional Distance-sampling methods were used to generate density and abundance estimates from the line-transect survey data. Seasonal estimates were generated based on the following definitions: spring (March–May), summer (June–August), fall (September–November), and winter (December–February). Density and abundance estimates could only be generated for bottlenose dolphins. The sample sizes for humpback whale, short-beaked common dolphin, and harbor porpoise sightings were too small to fit a detection function and produce reliable estimates of density and abundance for these species.

Bottlenose dolphin density (individuals per km2) and abundance (N) estimates were generated using 413 sightings and 3,535.3 km of effort in the INSHORE zone, and 77 sightings and 2,478.3 km of effort in the MINEX zone. All sightings and effort used in this analysis were recorded during acceptable sighting conditions (i.e., BSS 0–3). Data were pooled to model the detection function and then stratified by season and zone. Bottlenose dolphin density varied both spatially and seasonally with the highest densities estimated in the INSHORE zone during the fall and summer. Density and abundance estimates for this zone ranged from 3.88 individuals/km^2 (N=1,203; Coefficient of Variation [CV]=25%) in fall and 3.55 individuals/km^2 (N=1,101; CV=22%) in summer to 1.00 individuals/km^2 (N=311; CV=32%) in spring and 0.63 individuals/km^2 (N=195; CV=63%) in winter. Density and abundance estimates for the MINEX zone were calculated as 2.14 individuals/km^2 (N=1,277; CV=91%) in fall, 0.06 individuals/km^2 (N=37; CV=124%) in winter, 1.53 individuals/km^2 (N=913; CV=38%) in spring, and 1.39 individuals/km^2 (N=829; CV=69%) in summer. However, the fall and winter estimates are considered unreliable due to the extremely high CVs. Additional analyses using density-surface modeling techniques may provide more reliable and precise seasonal estimates for this zone. Additional density and abundance estimates were generated for specific areas and seasons within each zone and during different time periods (see Engelhaupt et al. 2016).

For more information on this study, refer to the annual progress report for this project (Engelhaupt et al. 2016).

Photo-identification Effort

Twenty-seven photo-ID surveys were completed between August 2012 and August 2015 (**Figure 35**). A total of 193 bottlenose dolphin groups was sighted. Monthly surveys were not always possible due to poor weather conditions. An electronic photo-ID catalog was created using images of bottlenose dolphin dorsal fins collected from both the dedicated photo-ID and line-transect surveys to provide insight into stock structure. The cataloging effort is ongoing; the catalog currently contains 606 identified individuals and includes photos taken through October 2013 during both photo-ID and line-transect surveys. There is no sign of a plateau in the number of identified dolphins in the study area. Re-sighting rates across surveys were low. Excluding same-day re-sightings, there have been 86 matches of catalogued individuals, which include a second re-sighting of 14 individuals. Most re-sightings occurred within the same year, and all were recorded less than 23 km from the initial sighting. Dolphins sighted in the Chesapeake Bay and along the Cape Henry region were not re-sighted along the Atlantic side of Virginia Beach in the southern portion of the study area. Additional survey effort and photo-ID analyses are required to discern sub-stock differentiation or any patterns in movements and site fidelity. Photos collected through August 2013 have been submitted for matching to NMFS' existing Mid-Atlantic Bottlenose Dolphin Catalog (Urian et al. 1999).

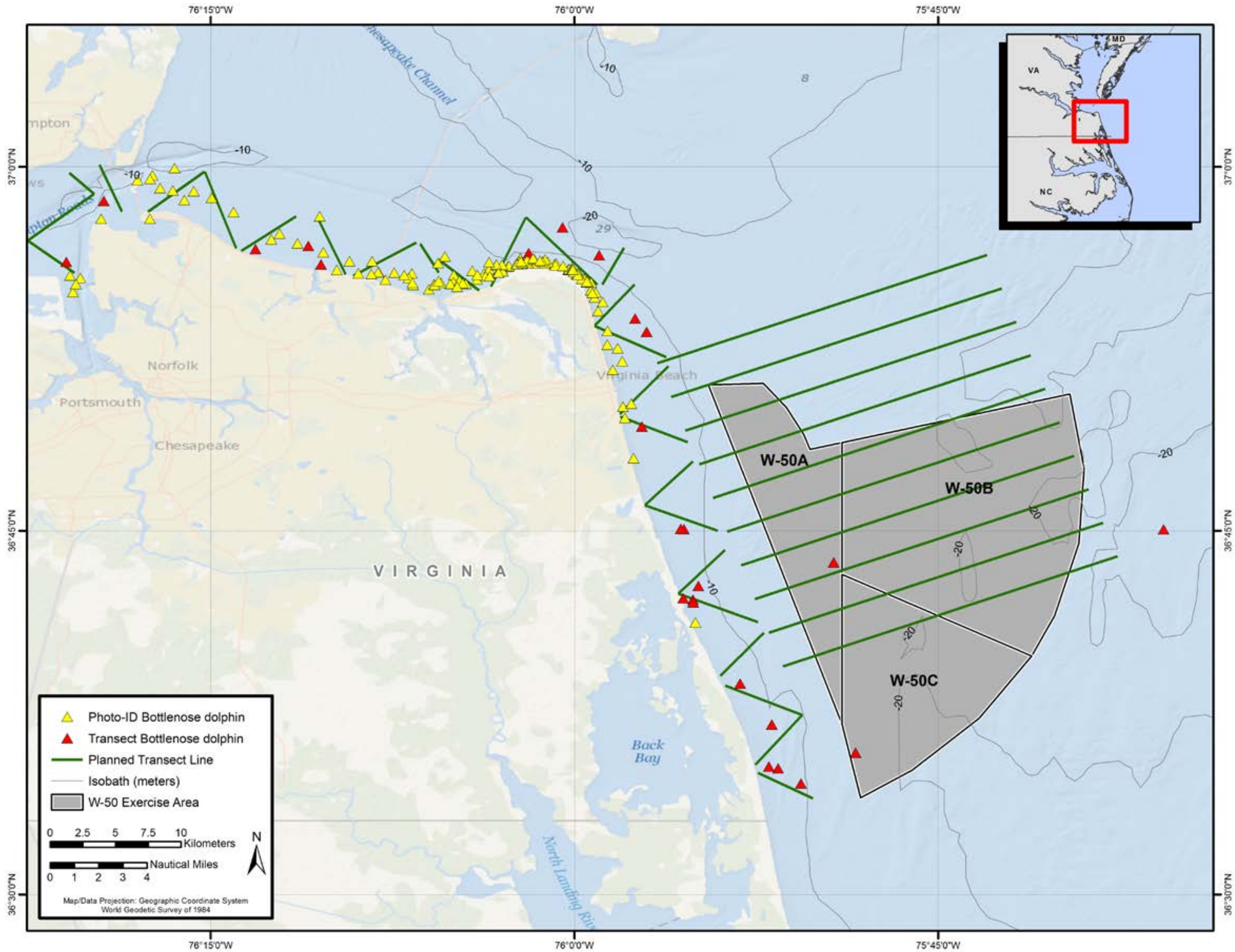


Figure 35. Group sighting locations in photo-ID catalog for bottlenose dolphins near NSN and Virginia Beach, differentiating photos taken during photo-ID survey and line-transect surveys. Transect lines were modified after Year 1 of the study; only transect lines from Year 2 and Year 3 of the study are shown.

For more information on this study, refer to the annual progress report for this project (Engelhaupt et al. 2016).

2.1.2.5 Chesapeake Bay (NAS Patuxent) Vessel Surveys

As noted in **Section 2.1.1.4**, a study was initiated in 2015 to provide quantitative data and information on the seasonal occurrence, distribution, and density of marine mammals and sea turtles in Chesapeake Bay waters near NAS PAX. Information on the passive acoustic monitoring and aerial surveys associated with this study is found in **Sections 2.3.4** and **2.1.1.4**, respectively.

During each vessel trip to deploy and/or recover the sensors (C-PODs) used in the PAM component of the study, HDR researchers maintain a visual lookout for dolphins. Time and weather permitting, efforts were taken to obtain dolphin photographs for photo-ID. During the initial C-POD deployments on 11 and 12 July 2015, 283 km were surveyed (approximately 17 hr total duration). On 11 July 2015, the survey effort focused primarily on tracklines between each of the C-POD locations but also into the Patuxent River based on a reported bottlenose dolphin sighting in that area. No dolphins were seen on 11 July 2015. On 12 July 2015, a portion of the Patuxent River was again surveyed before the vessel made its way into the Chesapeake Bay. One dolphin sighting was made just west of the main channel in Chesapeake Bay between NAS PAX and Barren Island (refer to **Figure 75** located in **Section 2.3.4**). The group consisted of approximately 35 dolphins; photos were collected of all individuals present. The photos have since been sorted and prepared for cataloging. These data will be archived and available for future analysis and/or collaboration with researchers from Georgetown University and the Mid-Atlantic Bottlenose Dolphin Photo-Identification Catalog. During a second field effort to recover and re-deploy the C-PODs on 23 and 24 November 2015, 216 km were surveyed (approximately 11 hr in total duration); however, sub-optimal weather conditions precluded a full survey effort.

A recent collaboration was established with researchers from Georgetown University (Potomac-Chesapeake Dolphin Project) who are also conducting bottlenose dolphin surveys in the Potomac River. Joint efforts may be undertaken to combine data and to maintain a catalog of all photographed individuals in the NAS PAX region. Photo-IDs will also be compared with HDR's bottlenose dolphin photo-ID catalog from Norfolk and Virginia Beach, Virginia (Engelhaupt et al. 2015, 2016), which are also included as part of the Mid-Atlantic Bottlenose Dolphin Photo-Identification Catalog. Photographs are currently being analyzed and will be reported on in next year's annual report.

For more information on this study, refer to the annual progress report for this project (Richlen et al. 2016a).

2.1.2.6 Panama City Vessel Surveys

Bottlenose dolphins inhabit the bay and coastal waters of the Florida Panhandle (reviewed in Waring et al. 2016). Currently, NMFS has delineated one coastal (Northern Coastal Stock) and nine bay, sound, and estuary (BSE) dolphin stocks within the nearshore waters of the Florida Panhandle (Waring et al. 2016). Two of these BSE stocks, Choctawhatchee Bay and Apalachicola Bay, have been studied for 1- to 2-year intervals using photo-ID surveys to estimate seasonal dolphin abundance and to provide insights into stock structure (Conn et al. 2011, Tyson et al. 2011, respectively). The St. Joseph Bay Stock, subject of the only long-term study of dolphins in the Florida Panhandle, has been studied since 2004 to determine seasonal abundance and distribution patterns (Balmer et al. 2008), assess dolphin health (Schwacke et al. 2010), and identify contaminant levels (Wilson et al. 2012, Balmer et al. 2015). Although these studies provided valuable information for BSE stock assessment in the Florida Panhandle, little is known about the distribution and movement patterns of dolphins that are part of the Northern Coastal Stock, with stock boundaries extending from the Big Bend region of Florida (84°W longitude) to the Mississippi River Delta (Waring et al. 2016). Seasonal influxes of dolphins into the St. Joseph Bay region occurred during spring and fall, during which abundance increased two to three fold. Additionally, extended movements of several radio-transmitter-tagged (Trac Pac, Fort Walton Beach, Florida) individuals, such as one dolphin that travelled from St. Joseph Bay to Destin, Florida (approximately 100 km), suggest that the Northern Coastal Stock not only seasonally co-occurs with BSE stocks, but that coastal dolphins may have extended ranging patterns significantly greater than BSE dolphins (Balmer et al. 2008).

The Naval Surface Warfare Center (NSWC) Panama City Division Testing Range is located in the nearshore and offshore waters of the Florida Panhandle and Alabama, extending from the coast to over 220 km seaward, and inclusive of St. Andrew Bay, Florida. Limited data exists on the St. Andrew Bay Stock and adjacent Northern Coastal Stock. Blaylock and Hoggard (1994) conducted aerial line transect surveys in the fall of 1992 and 1993 and estimated the abundance of the St. Andrew Bay Stock to be 124 (59 to 259; 95% [Confidence Interval [CI]). Bouveroux et al. (2014) conducted photo-ID surveys in a portion of the St. Andrew Bay Stock's boundaries and adjacent coastal waters, and found that abundance ranged from 89 (71 to 161; 95% CI) to 183 (169 to 208; 95% CI). At present, there is no current abundance estimate encompassing the entire St. Andrew Bay Stock. Furthermore, it is unclear if the Northern Coastal Stock follows a similar pattern to what is observed in the St. Joseph Bay region with seasonal influxes into estuarine and coastal waters.

Photo-ID surveys have been used extensively on marine mammals to estimate abundance with capture-recapture analyses, identify habitat use, and determine distribution patterns (Hammond 1990). Robust design population models use closed population parameters to estimate seasonal abundance (primary sessions) in a study area by conducting multiple, short-term photo-ID surveys (secondary sessions) and accounting for variations in capture probabilities using aspects of an open population model (reviewed in Pine et al. 2003). Abundance estimates of nearshore bottlenose dolphins have been determined using Robust design models with parameters that best fit the targeted population or stock (e.g., Wilson et al. 1999; Read et al. 2003; Balmer et al. 2013).

The goals of this new study, initiated in 2015 as part of the US Navy's monitoring program, were to determine abundance, habitat use, and distribution patterns of bottlenose dolphins in St. Andrew Bay and adjacent coastal waters in the NSWC Panama City Division over two seasons. During fall in the St. Joseph Bay region, the observed two- to three-fold increase in abundance was attributed to Northern Coastal Stock dolphins entering St. Joseph Bay waters. St. Joseph Bay summer abundance was low, and animals sighted during this season were suggested to be representative of the BSE Stock. Thus, the seasons selected for surveying in St. Andrew Bay were July 2015 (summer) and September 2015 (fall) to determine abundance for the BSE Stock and provide insight into abundance and movements of Northern Coastal Stock dolphins. Specific study objectives were as follows:

1. Identify which marine mammal species occur seasonally within St. Andrew Bay and nearby coastal waters.
2. Calculate seasonal resighting rates for individual dolphins and develop a site-fidelity index for dolphins to assess long-term residence in the future.
3. Determine distribution patterns for dolphins within and between St. Andrew Bay and coastal waters.
4. Estimate seasonal abundance across the two primary seasons of summer and fall 2015.

5. Correlate dolphin presence with particular environmental parameters (e.g., water depth, water temperature, water salinity) and broad habitat types (e.g., shallow bay, channel, seagrass bed, surf zone, open water).

Capture-recapture photo-ID surveys were conducted during summer (July) and fall (October) of 2015. For estuarine waters, contour transects (i.e., transects that follow a particular geographic feature) were followed either 500 m from the shoreline or along the 1-m depth contour. Contour transects in coastal waters were followed approximately 500 m and 3 km off the coastline (**Figure 36**).

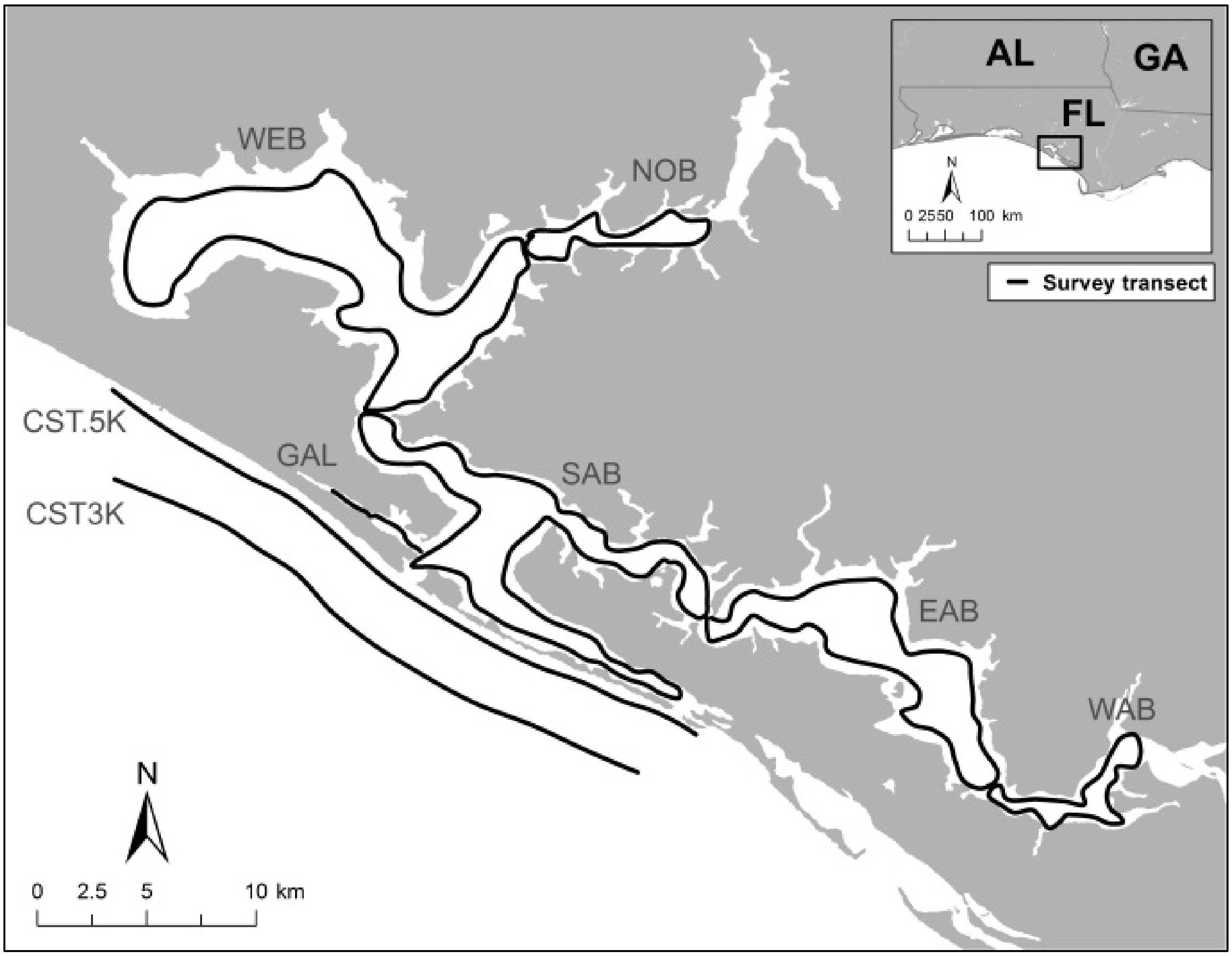


Figure 36. St. Andrew Bay photo-ID study area with survey transects. SAB=St. Andrew Bay, NOB=North Bay, WEB=West Bay, EAB=East Bay, WAB=Walker Bayou, GAL=Grand Lagoon, CST.5K=coastal 500-m transect, CST3K=coastal 3-km transect. The GAL transect was not surveyed in the fall survey.

The survey design was re-examined immediately prior to and during the summer 2015 survey. The Grand Lagoon transect was omitted from the fall 2015 survey to maximize coverage across the entire study area because heavy vessel traffic and no-wake zones in Grand Lagoon impeded survey efficiency and few sightings were made along the transect. The bay and coastal transects were divided into two separate survey regions to allow for the bay transects to be completed more efficiently and for the coastal transects to be covered when weather conditions were optimal.

Following the Robust design (Pollock 1982), survey effort was temporally divided into primary and secondary periods. The two primary periods were summer and fall. Within each primary period, three secondary periods were completed in which all transects were surveyed. Once a secondary period was completed, survey effort ceased for approximately 1 day to allow for sufficient population mixing (Rosel et al. 2011). All transects were surveyed a total of six times (six secondary periods) across the two primary periods (July and October 2015). All surveys were conducted in a BSS of 3 or less to optimize sighting conditions.

The survey vessel was a 6.3-m, center-console, Zodiac rigid-hulled inflatable boat with twin 90-horsepower Yamaha four stroke outboard engines. Survey speed was maintained at approximately 30 km/hr while searching for dolphins. At least three observers were on board each day, and each observer covered 60 degrees of the 180-degree forward of the vessel beam. During each survey, a sighting was recorded when any dolphin was encountered. Sighting data were recorded onto a data sheet that included time, geographic location (global positioning system (GPS) coordinates), total number of dolphins, group behaviors, and various observational and environmental parameters. A Canon EOS-1Ds camera with a 100- to 400-millimeter telephoto lens was used to capture dorsal fin images of each individual in the group. Effort was made to photograph all dolphins within a sighting (full photo coverage). Conditions that could preclude full coverage would include: 1) prolonged adverse behavioral reactions by one or more dolphins in the group; 2) sighting duration under 45 minutes (min); and 3) adverse weather conditions.

The July 2015 field work consisted of 16 field days (13–25 and 27–29 July 2015), spanning 109.15 field hr and 1,803.65 km surveyed. The initial survey design was to include the bay and coastal waters as a single secondary session in which all transects were surveyed. All three secondary sessions in bay and coastal waters were completed. A total of 118 sightings was recorded, including 338 adult dolphins, 43 calves, and one neonate (**Figure 37**). Biopsy sampling resulted in collection of 34 samples, which included 32 from estuarine waters and 2 from coastal waters (**Figure 38**).

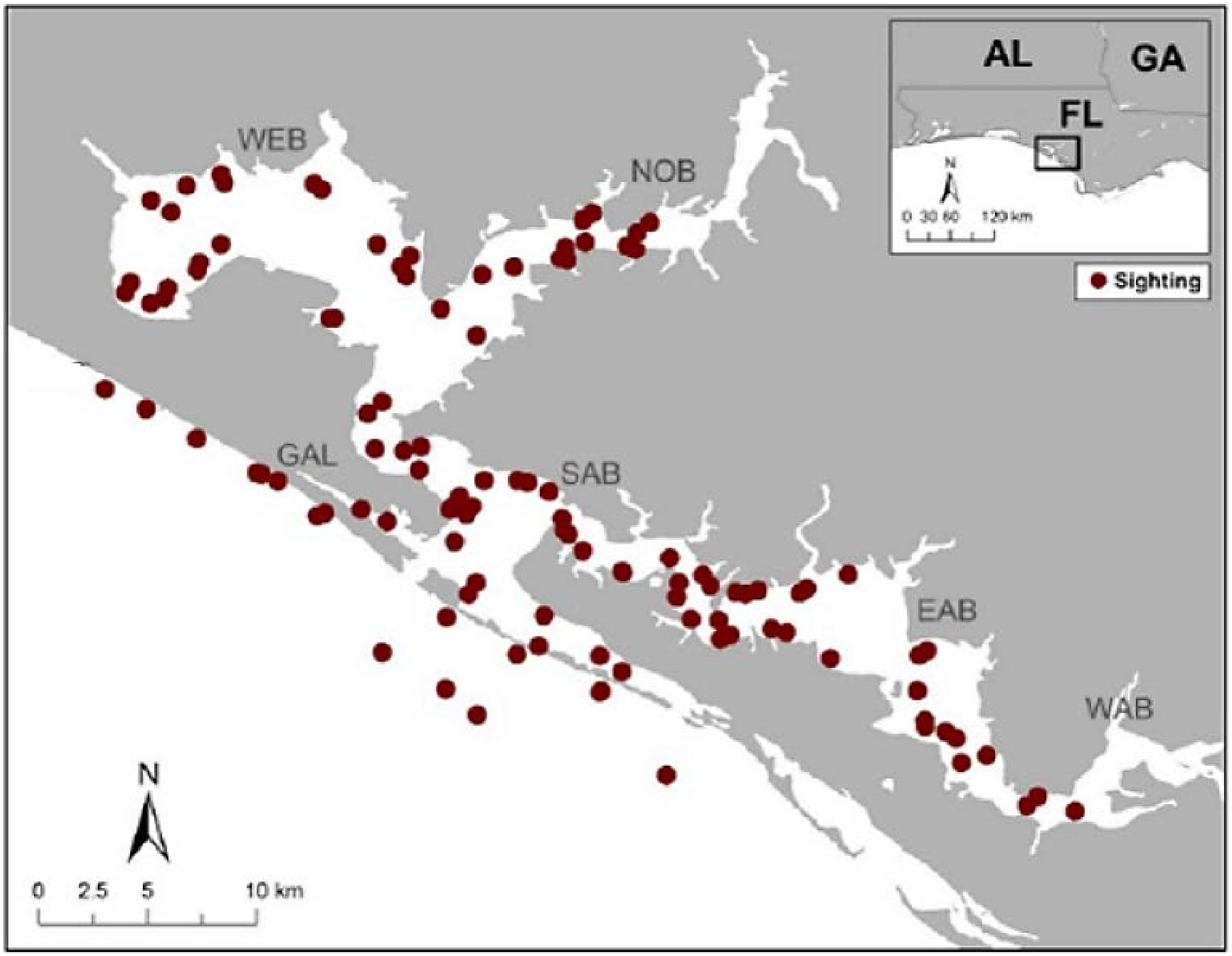


Figure 37. Bottlenose dolphin sightings in July 2015. Survey transects included: SAB=St. Andrew Bay, NOB=North Bay, WEB=West Bay, EAB=East Bay, WAB=Walker Bayou, GAL=Grand Lagoon.

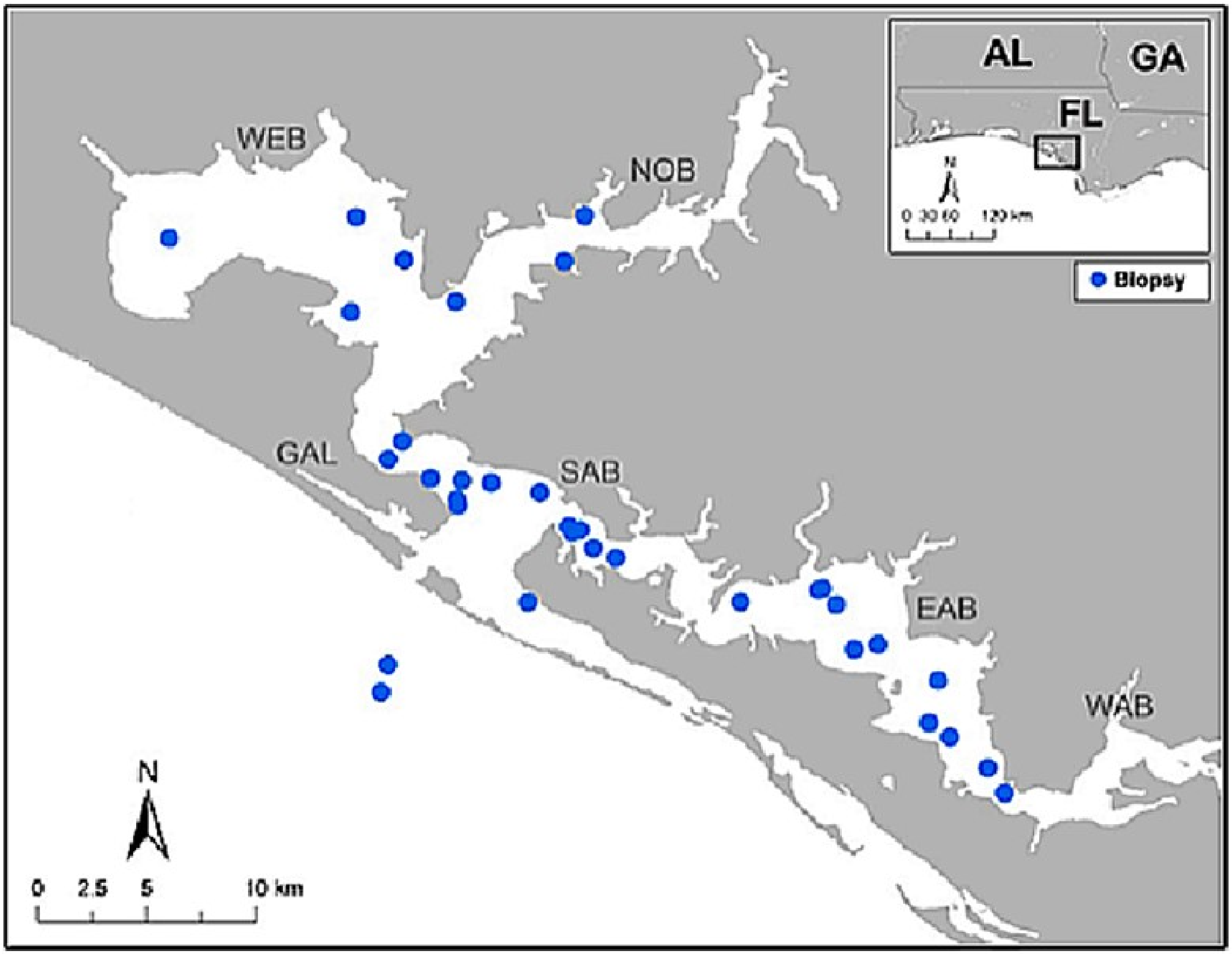


Figure 38. Biopsy sampling locations in July 2015. Survey transects included: SAB=St. Andrew Bay, NOB=North Bay, WEB=West Bay, EAB=East Bay, WAB=Walker Bayou, GAL=Grand Lagoon.

In July 2015, weather conditions did not permit the coastal transects to be covered in an equivalent timeframe to the bay transects. As a consequence, the bay and coastal transects were divided into two separate survey regions, which allowed for the bay transects to be completed more efficiently and the coastal transects to be covered when weather conditions were optimal. Relatively low numbers of dolphins were sighted along the coast, which parallels results by Balmer et al. (2008) in St. Joseph Bay, who identified low numbers of dolphins occurring in the summer. These animals sighted along the coastal transects of this St. Andrew Bay study in summer 2015 were likely long-term residents to the region. Approximately six of the dolphins sighted were identified as food-provisioned individuals. These animals were sighted primarily around the entrance to St. Andrew Bay. However, one provisioned animal was sighted in the southeastern corner of the study area in Walker Bayou.

Dolphins were observed foraging throughout the study area. Three distinctive individuals were observed routinely feeding along the seawall in the National Oceanic and Atmospheric Administration (NOAA)/NMFS basin in Panama City.

The fall 2015 field work comprised 12 field days (12–23 October 2015), spanning 84.69 hr and 1,402.88 km surveyed. All three secondary sessions in bay and coastal waters were completed in 7 field days. A total of 97 bottlenose dolphin sightings was recorded, including 458 adults, 39 calves, and one neonate (**Figure 39**). Biopsy sampling targeted bay waters where more samples were needed (North Bay, West Bay, and Walker Bayou), resulting in collection of 17 samples across 5 field days (**Figure 40**).

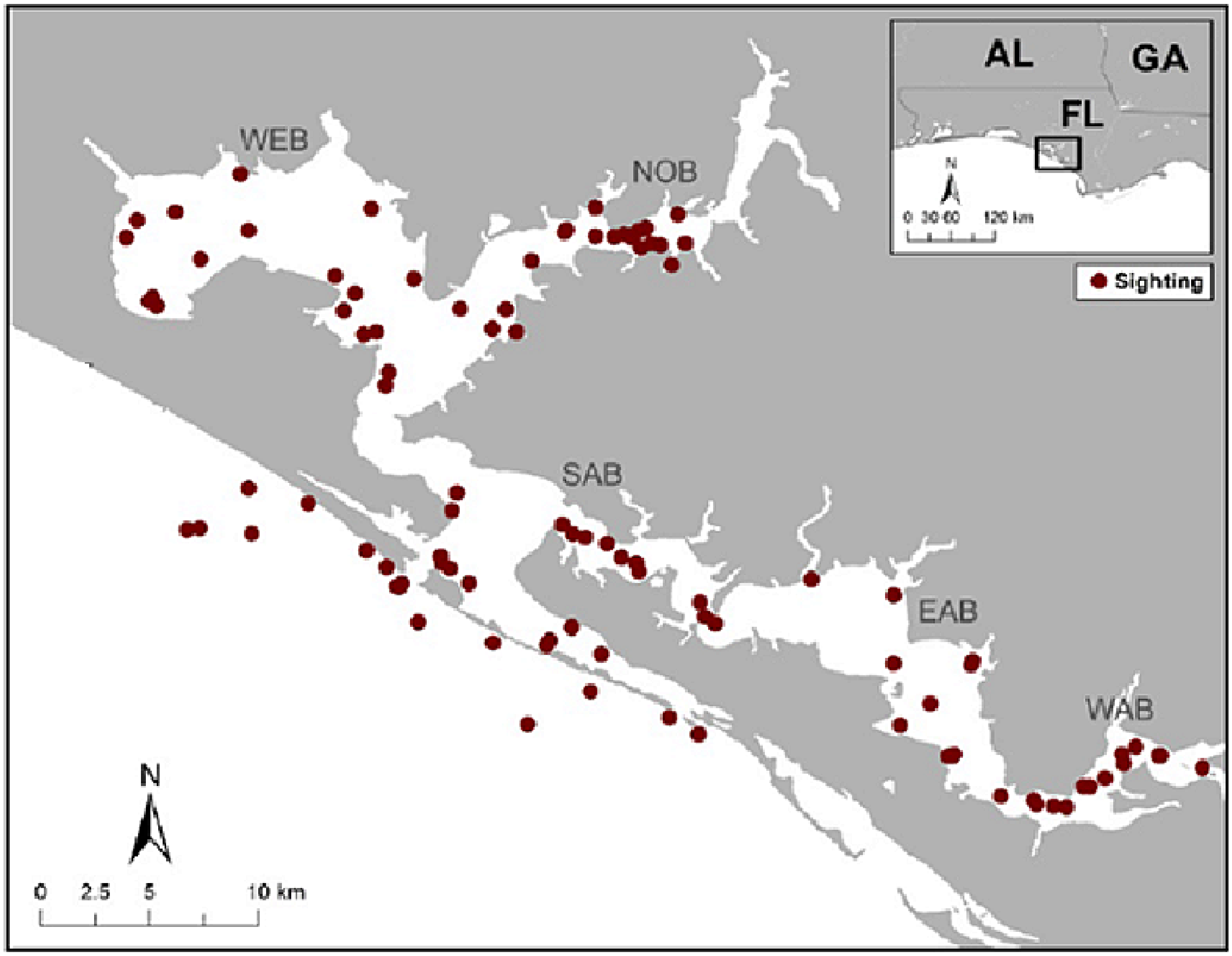


Figure 39. Bottlenose dolphin sightings in October 2015. Survey transects included: SAB=St. Andrew Bay, NOB=North Bay, WEB=West Bay, EAB=East Bay, WAB=Walker Bayou.

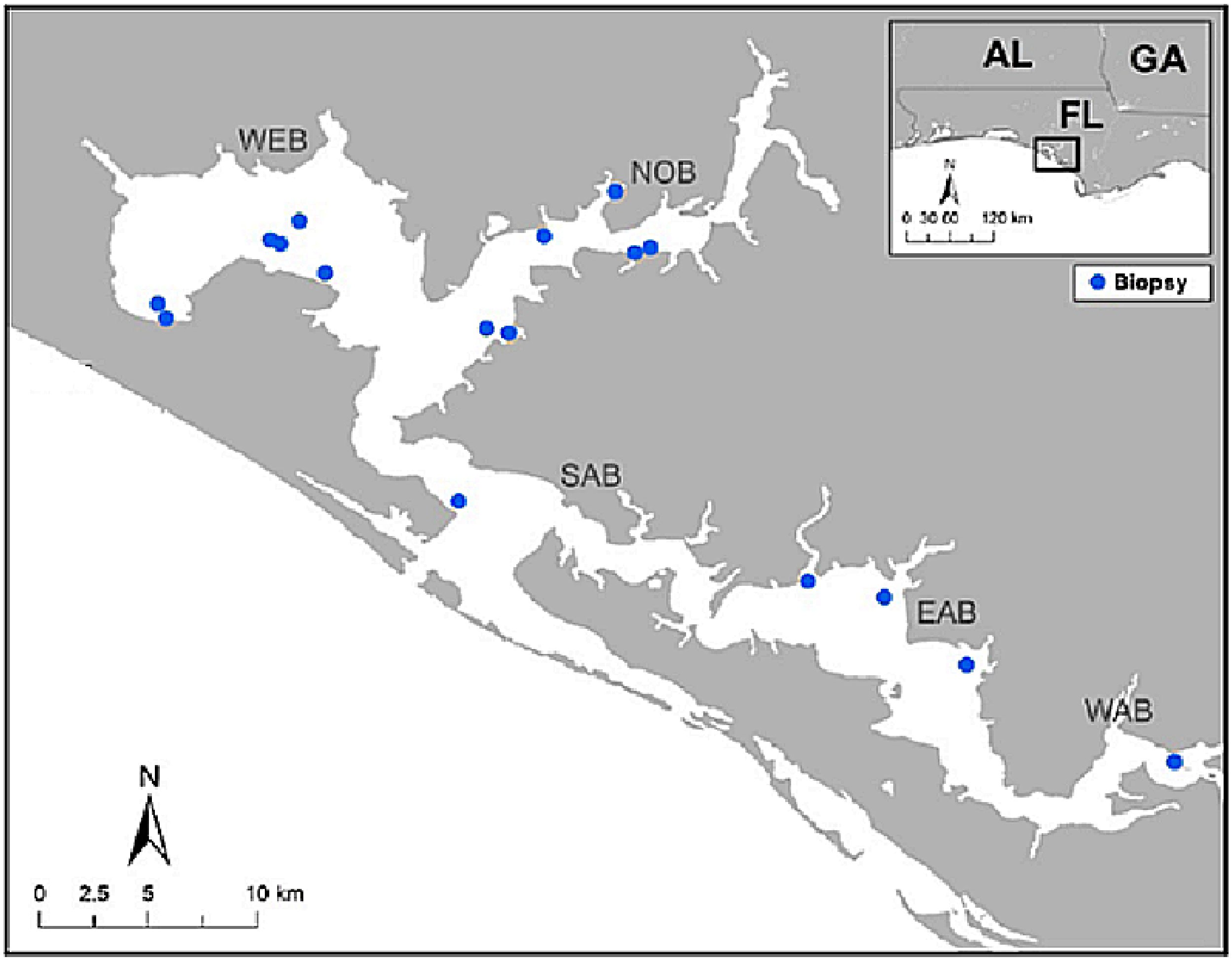


Figure 40. Remote biopsy sampling locations in October 2015. Survey transects included: SAB=St. Andrew Bay, NOB=North Bay, WEB=West Bay, EAB=East Bay, WAB=Walker Bayou.

Severe weather in fall 2015 was not an issue, which allowed for longer daily field hours even with shorter available daylight. Due to the favorable weather, NOAA completed the photo-ID component of the project in 7 days, allowing for additional surveys during which remote biopsy samples were collected. Fifty-one biopsy samples were collected in summer and fall 2015, with two known duplicates and 49 probable unique samples. By subarea, sample sizes were: St. Andrew Bay (*n*=16), East Bay (*n*=13), West Bay (*n*=13), North Bay (*n*=6), coastal (*n*=2), and Walker Bayou (*n*=1).

More dolphins were sighted in coastal waters during the fall than in summer. However, based on preliminary field observations, the number of animals sighted in coastal waters of the St. Andrew Bay study area was likely lower than the influx of animals observed in the St. Joseph Bay region during previous fall seasons. Dolphins were sighted in all parts of the study area and in areas with relatively low salinities (approximately 15 to 20 parts per thousand), such as North Bay and Walker Bayou in July and October. No provisioned animals were observed in October. However, several sightings were made where animals patrolled behind fishing boats and swim-with-dolphin tours actively targeting dolphin groups. These animals were sighted primarily around the entrance to St. Andrew Bay. Red tide was prevalent in the region during surveys, particularly on the inside of Shell Island, where large, multi-species fish kills were observed in October 2015.

2.1.3 Pinniped Haulout Visual Surveys

Harbor seal (*Phoca vitulina concolor*) and gray seal (*Halichoerus grypus*) distribution along the U.S. Atlantic coast has shifted in recent years, with an increased number of seals reported in southern New England and the mid-Atlantic region (Kenney 2014; Waring et al. 2016). Data from NOAA surveys have previously shown New Jersey as the southern extent for harbor and gray seals (NOAA 2015), with occasional sightings and strandings reported as far south as Florida and North Carolina for harbor and gray seals, respectively (Waring et al. 2016). NOAA now reports that a small group of harbor seals has also been reported in Virginia and Rhode Island, but there has been no systematic documentation of non-stranded animals.

This study aims to document seal presence at select haul out locations in Narragansett Bay and lower Chesapeake Bay, in order to acquire a better understanding of the seals' seasonal occurrence, habitat use, and haul-out patterns in these areas, which are important to U.S. Navy training and testing. Identification and comparison of individual seals, using photo-ID, will provide valuable baseline information for the future assessment of relative abundance, seal movements, and site fidelity along the northeast and mid-Atlantic coasts of the United States

A series of systematic land-based counts of all seal species will be conducted at one haul-out location in Narragansett Bay and four haul-out locations in the lower Chesapeake Bay. The number of seals hauled out and in the water will be recorded during each count throughout the season. Photographs of seals will be collected between counts for a capture-recapture study. Photographs will be used to develop local catalogs and will also be compared to regional catalogs.

Chesapeake Bay Progress Report: The initial pilot study was completed in May 2015. During 13 survey days, from November 2014 to May 2015, a total of 1 gray seal and 112 harbor seals were sighted among the haul-out sites. Seals were observed on all survey days except one. Highest counts were recorded in February and March. During the 2015-2016 field season, surveys were conducted from October 2015 to May 2016. A total of 184 harbor seals and 1 gray seal were sighted from December 2015 to April 2016. Seals were observed on 15 of the 21 (71.4 percent) survey days. Similar to the 2014–2015 season, highest counts were recorded in the months of February and March. Preliminary photo-identification was conducted via visual matching. The results confirm the presence of matches within the photo database in multiple years, indicating some degree of site fidelity. Counts and photo-ID data collection will continue for the 2016–2017 field season. A proof-of-concept tagging effort is also being planned for the beginning of the season to investigate seal movement and habitat use in the vicinity of U.S. Navy training areas in Virginia.

Narragansett Bay Progress Report: The initial pilot study was completed in May 2015. The haul out site near Naval Station Newport was observed on 36 days during the 2014-2015 season. Harbor seals were observed on 24 of those days. The maximum number of seals hauled out was 44 seals on 16 April 2015 and the average for the season was 15 seals. Additionally, a local non-profit organization, Save the Bay, provided seal sighting data from 1992-2013 that includes 112 locations throughout Rhode Island waters. That data was analyzed for historical and spatial patterns. During the 2015-2016 field season, seals were present from November 2015 until April 2016. Over 25 survey days, a total of 553 harbor seals were observed. Seals were observed on 23 of the 25 (92 percent) survey days. Similar to the 2014–2015 season, highest counts were recorded in the months of February and March. The highest count on 17 March 2016 was 46 seals hauled out and 3 in the water. The average number of seals observed for the season was 22.

Preliminary photo-identification was conducted with WILD-ID analysis software (Bolger et al. 2012). The results confirm the presence of matches within the photo database, indicating some degree of site fidelity. This was confirmed with visual matching of photographs. WILD-ID may not be the best software to make population level assessments, although it can answer some questions regarding site fidelity and preference. Currently, the Extract-Compare software (Hiby 2015) package is being used to analyze the same photo database and compare the results. Counts, photo-ID, data collection, and analysis will continue for the 2016–2017 field season.

2.2 Tagging Studies

During the reporting period, the U.S. Navy supported tagging studies of toothed whales (**Section 2.2.1**), baleen whales (**Sections 2.2.2** and **2.2.3**), and sea turtles (**Section 2.2.4**).

2.2.1 Tagging of Deep-Diving Odontocete Cetaceans–Hatteras

Tagging activities were conducted off Cape Hatteras between January 2015 and December 2015 during both the deep divers and satellite-tagging projects, building on previous years of work. This constituted the third year of the deep divers project, which focused on the distribution and ecology of several deep-diving odontocete species, including: beaked (*Z. cavirostris* and *Mesoplodon* spp.), short-finned pilot, and sperm whales. To achieve a more robust picture of the medium-term movement patterns of these and other odontocete cetaceans in the Cape Hatteras survey area, a satellite-tagging component commenced in 2014.

Researchers from Cascadia Research Collective (CRC) and Duke University tagged deep-diving odontocete cetaceans with satellite tags and DTAGs, respectively. Tagging of odontocete cetaceans by CRC complemented ongoing research by Duke University off Cape Hatteras by providing information on the movement and diving behavior of these species over the medium term (weeks to months). Shorter-term dive behavior (i.e., hours to days) can be collected using DTAGs, and longer-term movement information (i.e., months to years) using photo-ID techniques (see **Section 2.1.2.1** of this report; Foley et al. 2016b). Attempts were made in the field to obtain digital images of all tagged animals to ensure that connections could be drawn between the photo-ID and satellite-tagging work. Photographic matches of tagged animals and their associates are presented in the annual progress report of the Duke program (Foley et al. 2016a).

2.2.1.1 Satellite-tagging

During the first year of satellite tagging in 2014, remotely deployed Low Impact Minimally Percutaneous External-electronics Transmitter (LIMPET) tags were used to obtain movement data from short-finned pilot whales (*n*=16), bottlenose dolphins (*n*=5), Cuvier's beaked whales (*n*=3), and short-beaked common dolphin (*n*=1) ranging over periods from 1 to 194 days.

Tagging efforts by CRC were conducted in May, June, and October 2015 in the Cape Hatteras survey area (**Figure 41**). Thirty tags were deployed on four species of odontocete cetaceans (**Table 37**), and one additional location-only tag was lost during a deployment attempt. Satellite-tags were deployed on short-finned pilot whales (*n*=19), Cuvier's beaked whales (*n*=6), bottlenose dolphins (*n*=4), and sperm whale (*n*=1). Nine tags transmitted dive data (Wildlife Computers, Mk10A tags): four on Cuvier's beaked whales, four on short-finned pilot whales, and one on a sperm whale. All other satellite tags were location-only (Wildlife Computers, Smart Position and Temperature [SPOT]5 tags). A summary of these deployments is provided in **Table 37**.

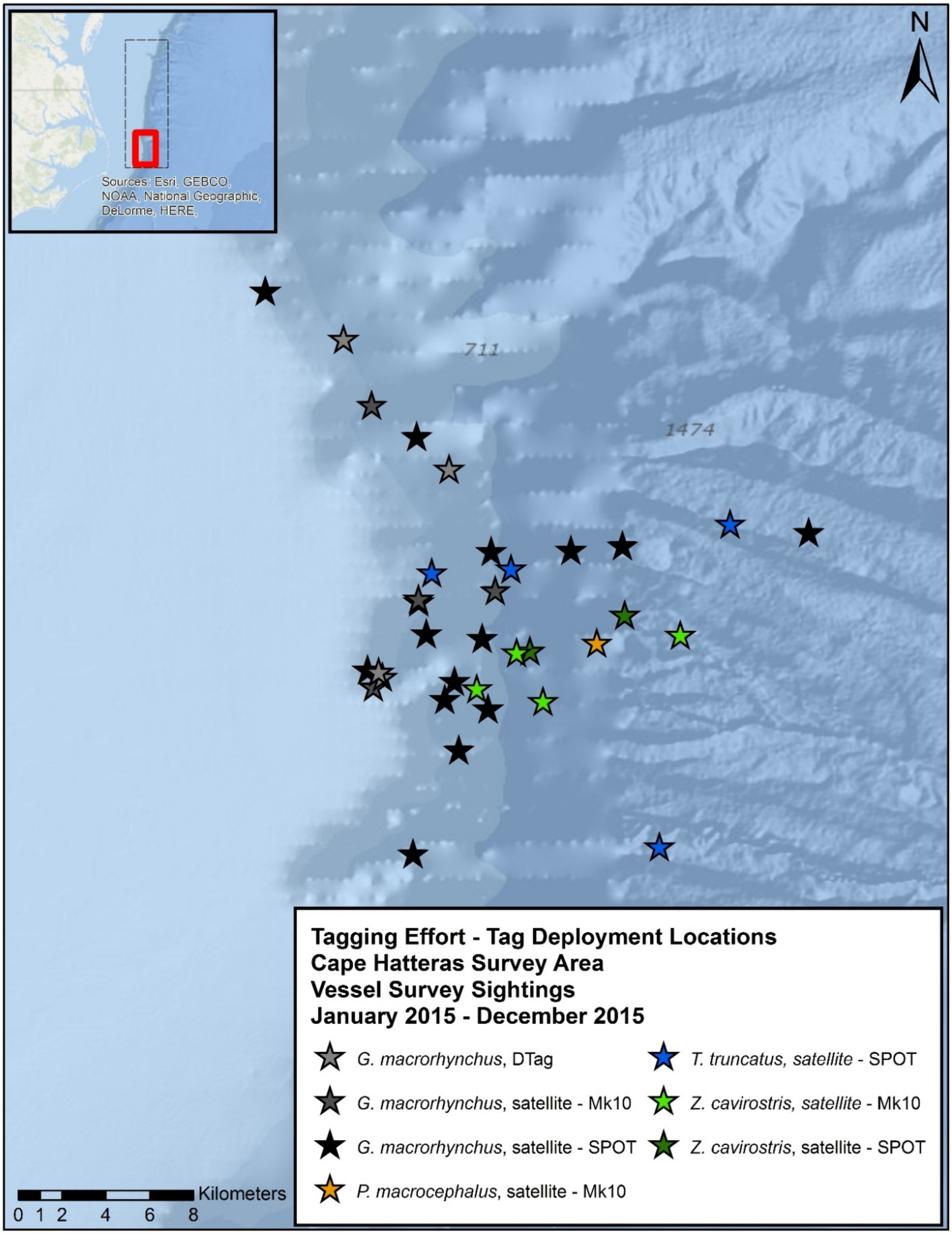


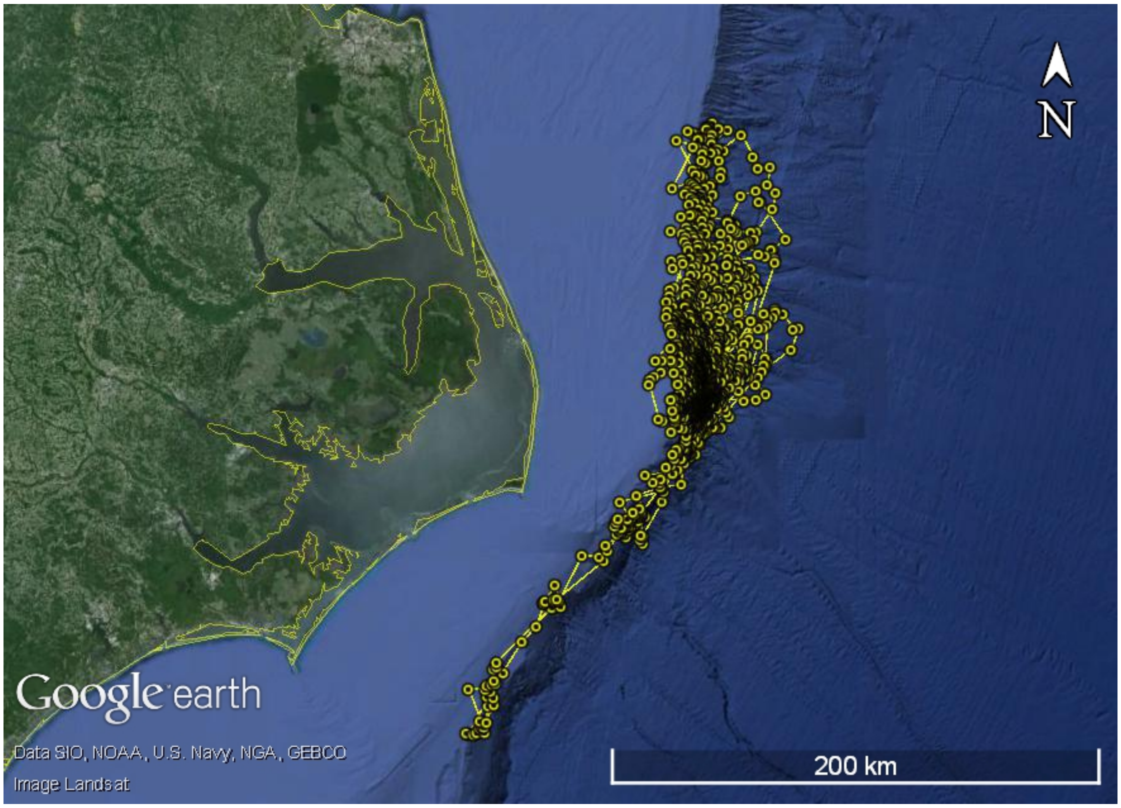
Figure 41. Locations of tag deployments in the Cape Hatteras survey area in 2015.

Table 37. Summary of satellite tag deployments in the Cape Hatteras survey area in 2015. Durations with an asterisk (*) are still transmitting as of 31 January 2016.

Species[1]	Tag ID	Tag Type	Deployment Date	Date of Last Transmission	Tag Duration (days)	Deployment Latitude	Deployment Longitude
Tt	TtTag024	SPOT5	05/19/2015	06/6/2015	18.4	35.54	-74.70
Tt	TtTag026	SPOT5	10/15/2015	11/03/2015	19.9	35.66	-74.76
Tt	TtTag027	SPOT5	10/20/2015	11/17/2015	28.8	35.68	-74.67
Tt	TtTag028	SPOT5	10/21/2015	11/11/2015	22.7	35.66	-74.79
Pm	PmTag026	Mk10-A	06/14/2015	06/25/2015	12.8	35.63	-74.72
Zc	ZcTag038	Mk10-A	06/14/2015	08/09/2015	56.4	35.60	-74.74
Zc	ZcTag039	SPOT5	06/14/2015	07/23/2015	39.4	35.64	-74.71
Zc	ZcTag040	Mk10-A	06/14/2015	06/16/2015	2.0	35.63	-74.69
Zc	ZcTag041	Mk10-A	10/15/2015	11/18/2015	34.3	35.61	-74.77
Zc	ZcTag042	Mk10-A	10/21/2015	12/19/2015	59.2	35.62	-74.75
Zc	ZcTag043	SPOT5	10/21/2015	12/16/2015	56.8	35.63	-74.75
Gm	GmTag122	SPOT5	05/16/2015	07/15/2015	58.1	35.78	-74.86
Gm	GmTag123	Mk10-A	05/16/2015	05/30/2015	14.0	35.73	-74.81
Gm	GmTag124	SPOT5	05/16/2015	07/15/2015	60.9	35.71	-74.79
Gm	GmTag125	SPOT5	05/19/2015	10/05/2015	139.2	35.63	-74.79
Gm	GmTag126	SPOT5	05/19/2015	07/02/2015	44.6	35.65	-74.79
Gm	GmTag127	Mk10-A	05/19/2015	06/18/2015	30.8	35.65	-74.79
Gm	GmTag128	SPOT5	06/16/2015	07/24/2015	38.7	35.58	-74.78
Gm	GmTag129	SPOT5	06/16/2015	06/24/2015	8.8	35.60	-74.77
Gm	GmTag130	SPOT5	06/16/2015	01/01/2016	199.1	35.61	-74.78
Gm	GmTag131	SPOT5	06/16/2015	09/18/2015	94.1	35.61	-74.78
Gm	GmTag134	SPOT5	10/15/2015	12/11/2015	57.4	35.67	-74.76
Gm	GmTag135	Mk10-A	10/15/2015	11/15/2015	31.2	35.65	-74.76
Gm	GmTag136	SPOT5	10/16/2015	01/31/2016*	106.3*	35.54	-74.80
Gm	GmTag137	SPOT5	10/20/2015	01/31/2016*	102.4*	35.62	-74.81
Gm	GmTag138	Mk10-A	10/20/2015	11/14/2015	25.0	35.61	-74.81
Gm	GmTag139	SPOT5	10/20/2015	12/23/2015	64.2	35.67	-74.63
Gm	GmTag140	SPOT5	10/20/2015	11/01/2015	12.6	35.67	-74.71
Gm	GmTag141	SPOT5	10/20/2015	11/23/2015	34.2	35.67	-74.73
Gm	GmTag142	SPOT5	10/21/2015	01/31/2016*	101.4*	35.63	-74.77

Gm = *Globicephala macrorhynchus* (short-finned pilot whale); Pm = *Physeter macrocephalus* (sperm whale); Tt = *Tursiops truncatus* (bottlenose dolphin); Zc = *Ziphius cavirostris* (Cuvier's beaked whale). Mk10-A = location and dive data tag; SPOT5 = Smart Position and Temperature (location only).

Data were obtained from four tagged bottlenose dolphins that appeared to be acting independently over the duration of tag overlap. The four location-only tags had attachment durations ranging from 18.4 to 28.8 days. The tagged bottlenose dolphins displayed high site fidelity, remaining on the edge and slope of the continental shelf off Pamlico Sound in North Carolina (**Figure 42**). Only one (TtTag028) of the four tagged bottlenose dolphins spent much time on the continental shelf, and the individuals remained a median distance offshore ranging from 35 to 58 km, indicating they are all part of the western North Atlantic offshore stock of bottlenose dolphins (Waring et al. 2015). The kernel density map shows the core of the home ranges for those individuals is on the continental slope off northern Pamlico Sound (**Figure 43**).



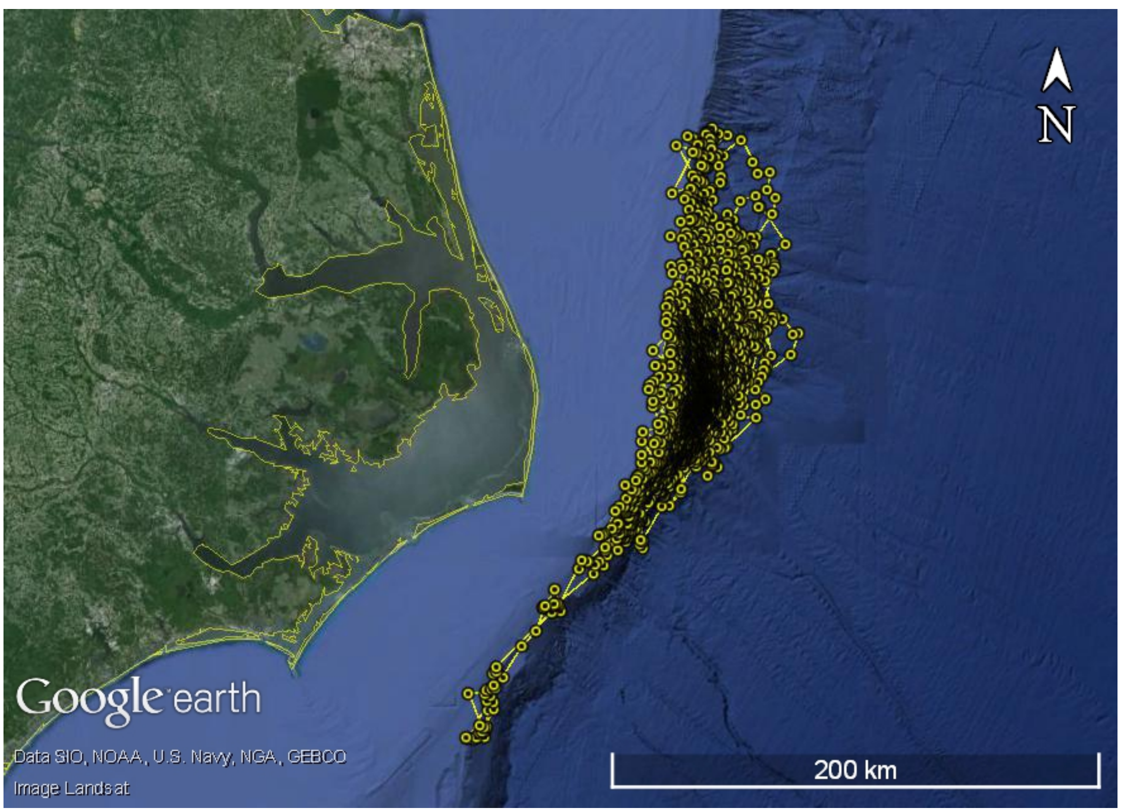


Figure 42. Top. Filtered locations of all four satellite tagged bottlenose dolphins tagged off North Carolina in 2015. Bottom. Filtered locations from tagged bottlenose dolphins from 2014 (*n*=5) and 2015 (*n*=4). Consecutive locations for each individual joined by a yellow line in both maps.

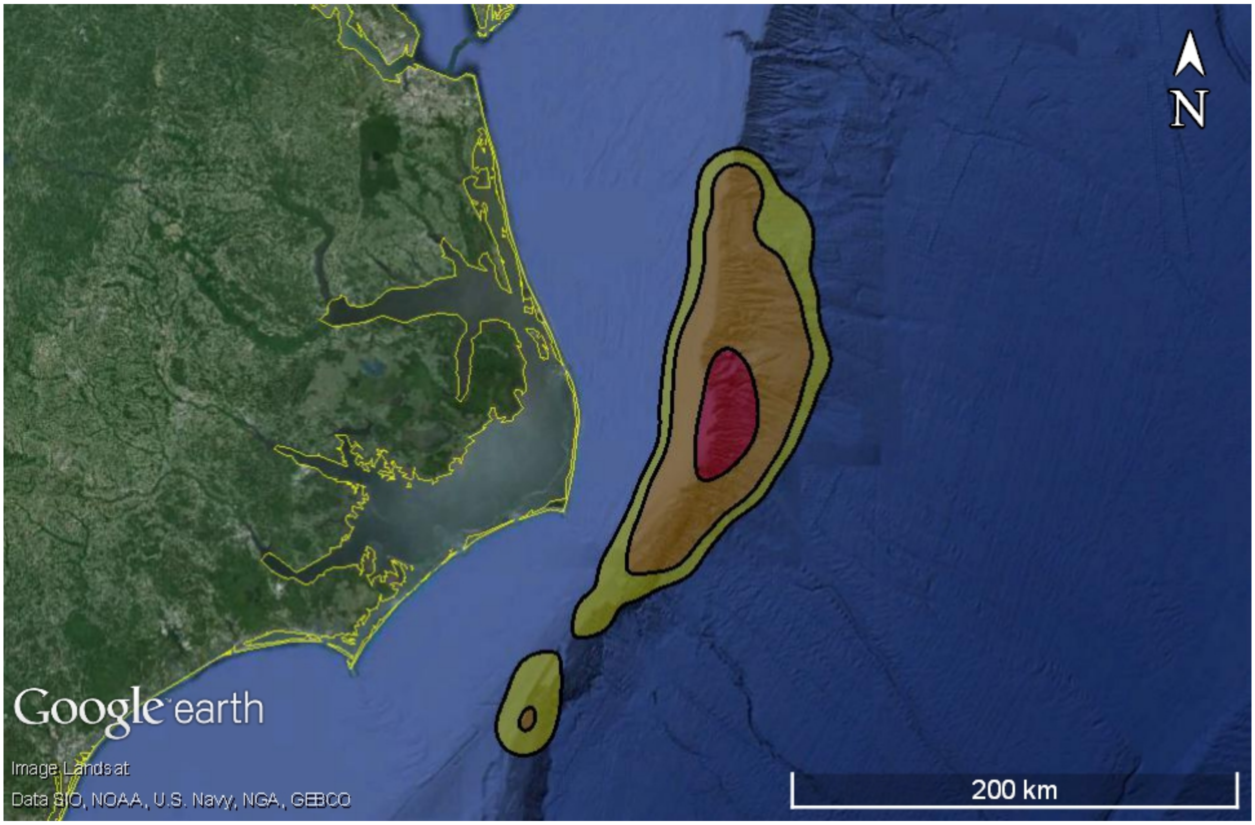


Figure 43. Probability-density representation of bottlenose dolphin location data from all individuals tagged in 2014 (*n*=5) and 2015 (*n*=4).The red area indicates the 50% density polygon (the "core range"), the orange represents the 95% polygon, and the yellow represents the 99% polygon.

A single depth-transmitting tag was deployed on a sperm whale, and location data were obtained over a 13-day period. The cumulative distance moved by this individual was 676 km, yet the individual remained a mean distance of 71.5 km from the tagging location (maximum of 164.5 km) (**Figure 44**). The median depth of tagged animal locations over the 13-day span was 2,673 m.

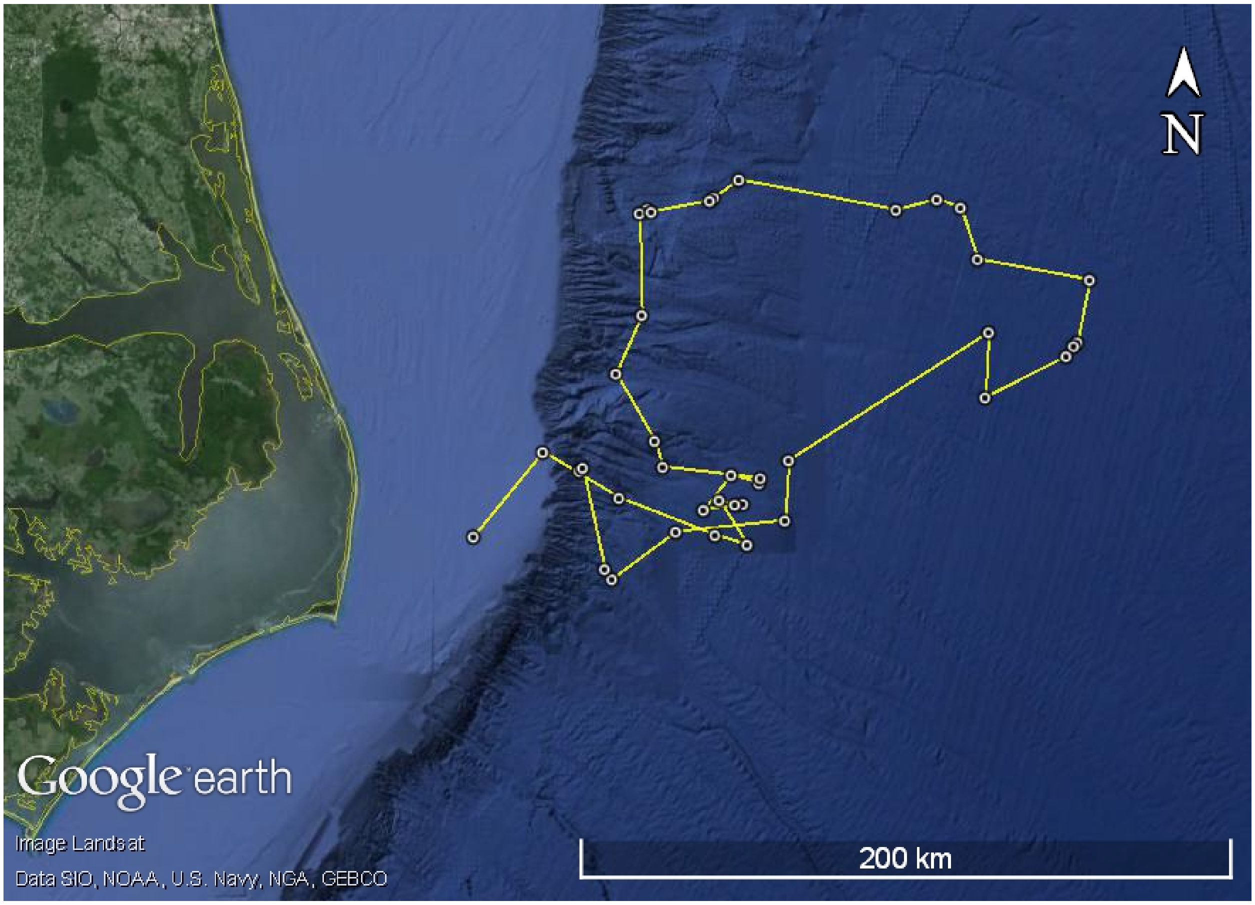


Figure 44. All filtered locations of a sperm whale tagged off North Carolina over a 13-day period, with consecutive locations joined by a line. The individual was tagged in waters over the continental slope, with the last transmission being in waters over the continental shelf.

Six Cuvier's beaked whales were tagged in 2015 - two location-only tags and four location and depth tags. The tags had attachment durations ranging from 2 to 59 days. All locations were in or near the core area of three Cuvier's beaked whales tagged in 2014, staying near the continental slope off Pamlico Sound (**Figure 45**). None of the animals tagged in 2015 traveled north or south outside the core area, providing more evidence of a resident, rather than a widely-ranging population, and in general, depths used by Cuvier's beaked whales in 2015 (Baird et al. 2016) were slightly shallower than those in 2014 (Baird et al. 2015). The extensive dive-data records obtained from four individuals in 2015 and two individuals in 2014 will allow for a comparison of diving patterns of this species with data obtained elsewhere (i.e., Hawaii, California, Italy; Baird et al. 2006, 2008; Schorr et al. 2014; Tyack et al. 2006). A probability-density distribution from tag data obtained in both 2014 (Baird et al. 2015) and 2015 suggests that the core ranges for individuals tagged off Hatteras are relatively small (**Figure 46**).

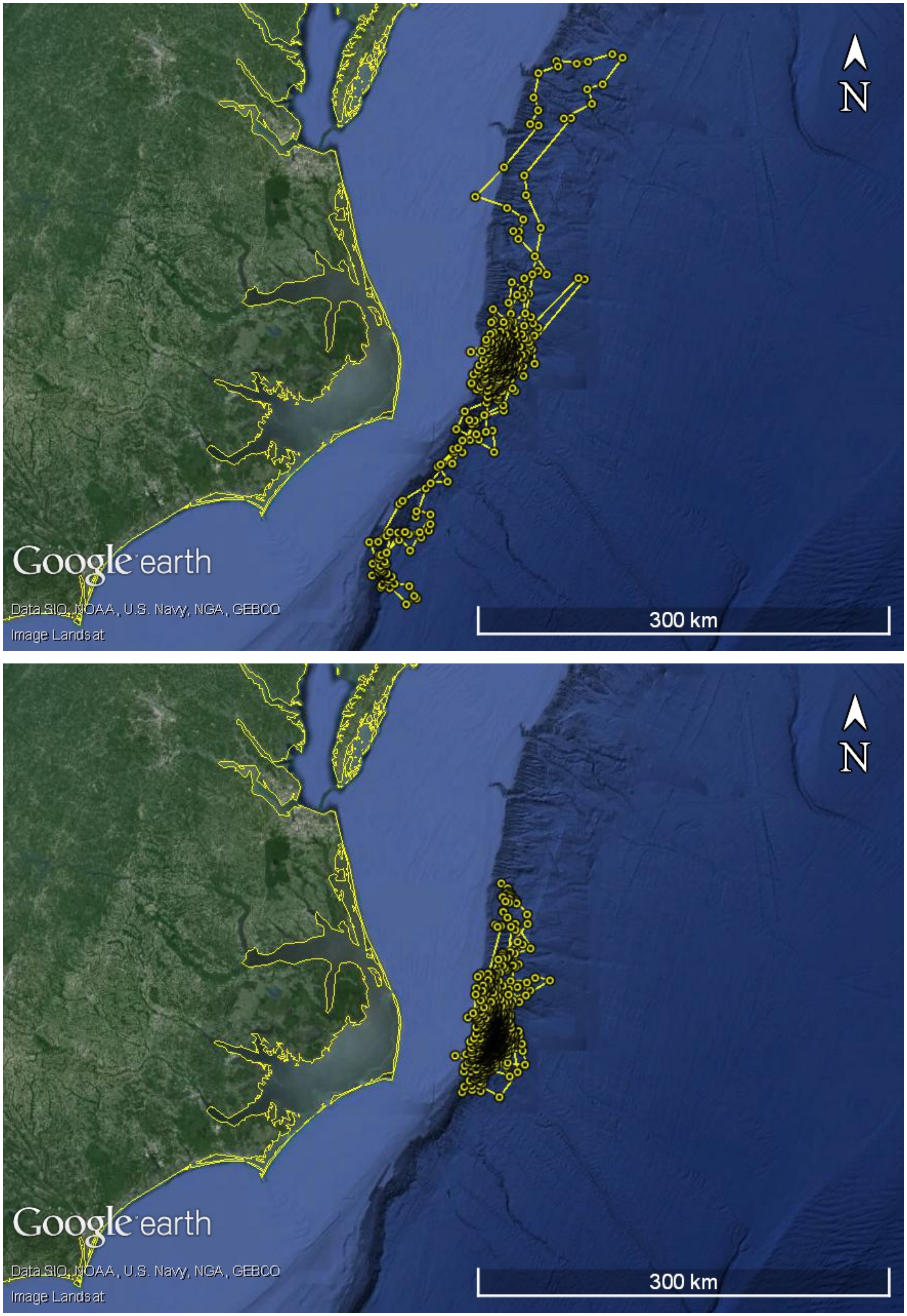


Figure 45. All filtered locations of Cuvier's beaked whales tagged in 2014 (top, *n*=3) and 2015 (bottom, *n*=6), with consecutive locations joined by lines.

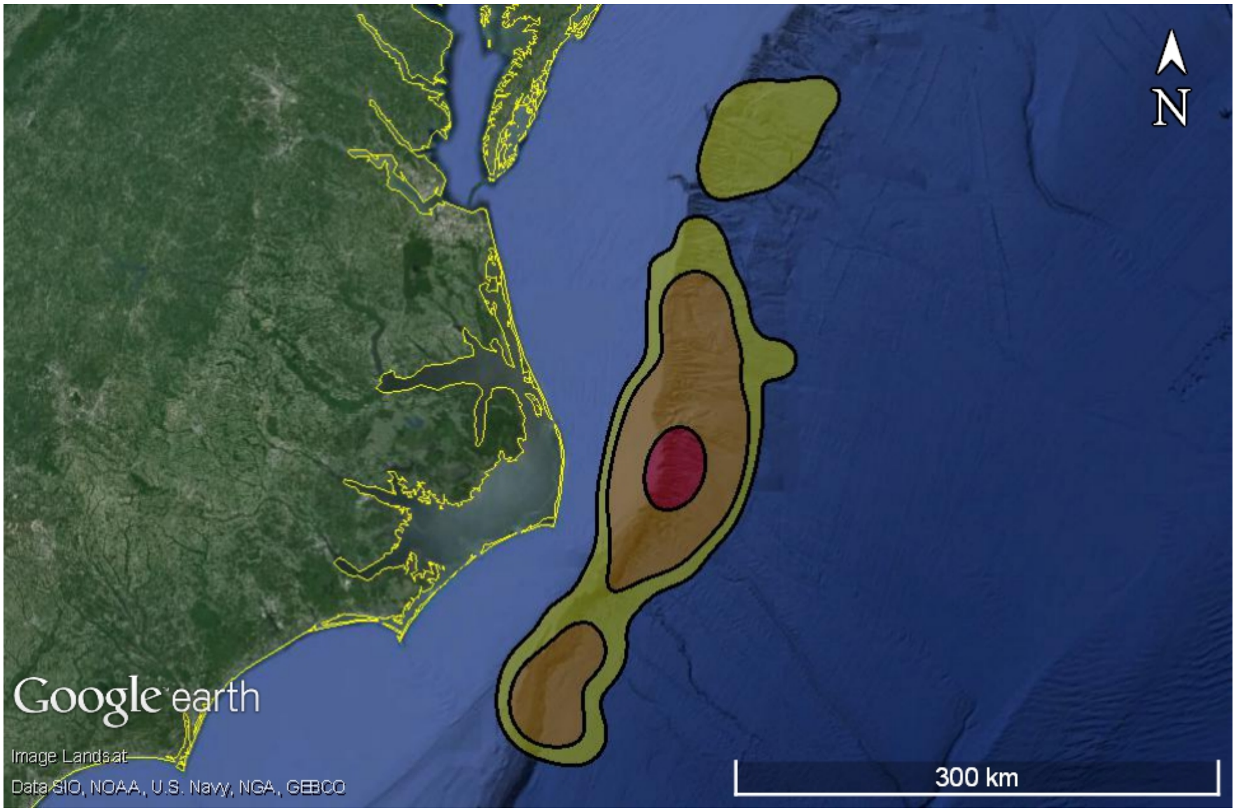


Figure 46. Probability-density representation of Cuvier's beaked whale location data from all individuals tagged in 2014 (*n*=3) and 2015 (*n*=6). The red area indicates the 50% density polygon (the "core range"), the orange represents the 95% polygon, and the yellow represents the 99% polygon.

Nineteen satellite tags were deployed on short-finned pilot whales, of which 15 were location-only tags and four were location and depth tags. The attachment durations ranged from 9 to 199 days (median=57 days). Three tags were still transmitting as of 31 January 2016, so the maximum deployment should be considered preliminary until the last of the currently deployed tags ceases transmitting. While photo-ID work suggests that short-finned pilot whales display a high degree of site fidelity off Cape Hatteras, satellite-tagging demonstrates that these animals cover a significant range along the continental slope, from Powell Canyon (south of Georges Bank) in the north, to off Cape Fear in the south, with movements at least occasionally beyond of the Exclusive Economic Zone (EEZ). It is worth noting that while many individuals traveled considerable distances from their tagging locations, none of them went far south of Onslow Bay. There were high concentrations of locations in the canyons along the shelf break, including Norfolk Canyon, Washington Canyon, Baltimore Canyon, Wilmington Canyon, and Hudson Canyon. Unlike most of the other pilot whales that stayed along the continental slope, GmTag139 travelled across deep water to the New England Seamount Chain, and GmTag142 made several offshore excursions, while spending most of its time along the continental slope. The considerable variability in movement patterns and habitat use likely reflects patterns that vary by social group and demographic category, and understanding site fidelity and association patterns determined through photo-ID will help in interpreting such variability. A map showing combined track and location data from all pilot whales tagged in 2014 (*n*=18) and 2015 (*n*=19) is shown in **Figure 47**. A probability-density representation is shown in **Figure 48**, demonstrating a core range for the tagged short-finned pilot whales off Cape Hatteras, North Carolina.

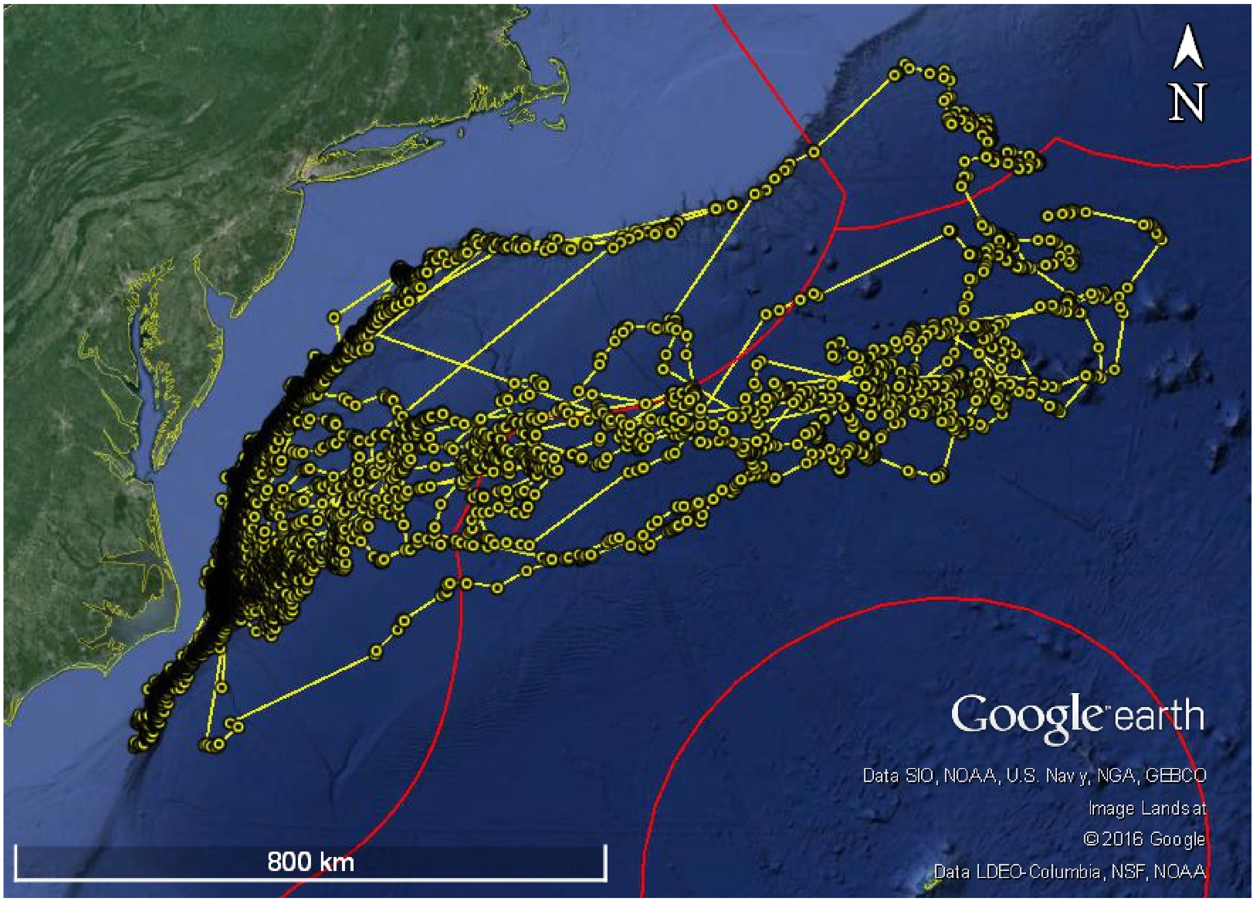


Figure 47. Map showing filtered locations of short-finned pilot whales tagged off North Carolina in 2014 and 2015. See Baird et al. 2015 for details of deployments in 2014. The Exclusive Economic Zone boundaries for the United States, Canada, and Bermuda are shown with solid red lines.

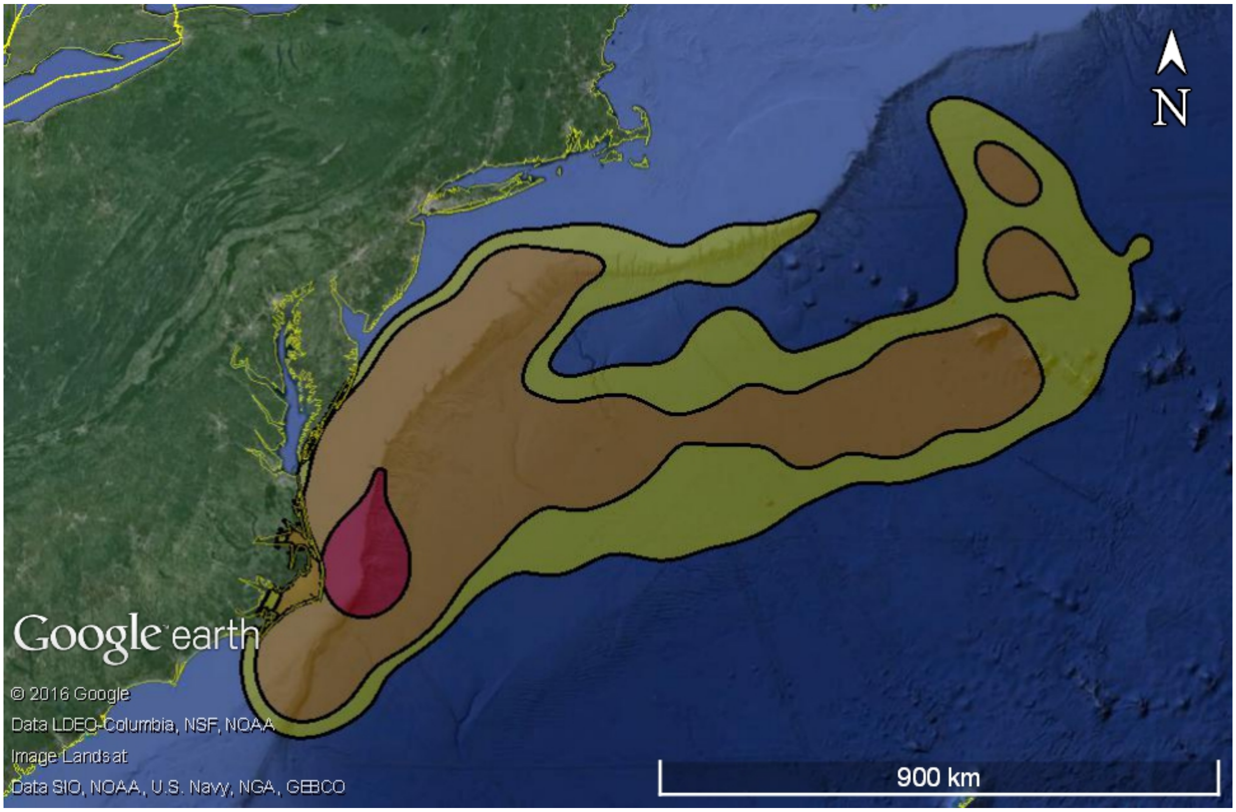


Figure 48. A probability-density representation of short-finned pilot whale location data from all individuals tagged in 2014 (*n*=17) and 2015 (*n*=19).The red area indicates the 50% density polygon (the "core range"), the orange represents the 95% polygon, and the yellow represents the 99% polygon.

Even though short-finned pilot whales cover a much larger range, their core range (**Figure 48**) appears to be centered in the same area as the bottlenose dolphins (**Figure 43**) and Cuvier's beaked whales (**Figure 46**), though it is a much larger area that extends up into Virginia. Unlike the other whales and dolphins, the 90 percent and 95 percent polygons extend much farther, along the continental slope all the way into Canadian waters, and out across the abyssal plain to the New England Seamount chain. Even though additional research is necessary to determine the structure and home range of these stocks, the importance of the continental slope to the east of Pamlico Sound is becoming apparent.

For more information on this study, refer to the annual progress report for this project (Baird et al. 2016).

2.2.1.2 DTAGs

During 2015 Duke University deployed four DTAGs on short-finned pilot whales in the Cape Hatteras study area. Two of these DTAGs were deployed on 25 May 2015. The first tagged animal, Gm_15_145a, jettisoned the DTAG off after approximately 1 hr. The second DTAG was attached to Gm_15_145b for approximately 6.5 hr, during which a behavioral focal follow was conducted and a biopsy sample obtained. This individual exhibited eleven foraging dives, all containing terminal echolocation buzzes indicative of foraging attempts. All of these dives were shallower than 400 m (**Figure 49**). The dives occurred in bouts interspaced by periods of surface time.

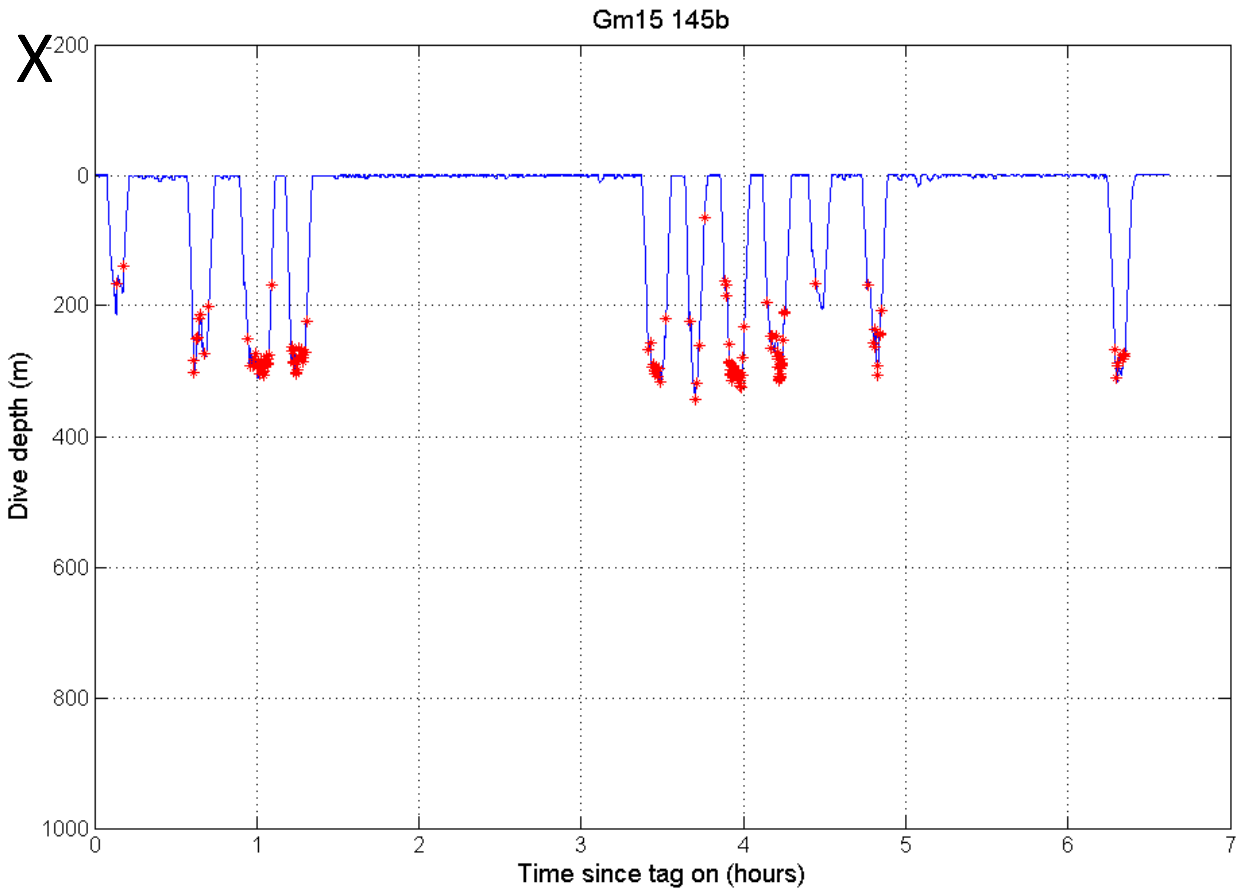


Figure 49. Dive profile of Gm_15_145b from 25 May 2015 DTAG record. Red symbols designate foraging buzzes.

On 01 June 2015, a DTAG was deployed on short-finned pilot whale, Gm_15_152a; unfortunately, the duration of this deployment was only 7 min. The following day, both the R/V *R.T. Barber* and R/V *Exocetus* were employed to deploy a DTAG on short-finned pilot whale Gm_15_153a for approximately 3.75 hr. A behavioral focal follow was conducted for the duration of the tagging, and a biopsy sample was obtained from the individual. The individual exhibited eight foraging dives, all containing terminal echolocation buzzes indicative of foraging attempts. All eight dives were deeper than 600 m and lasted approximately 20 min each, followed by short surface intervals (**Figure 50**).

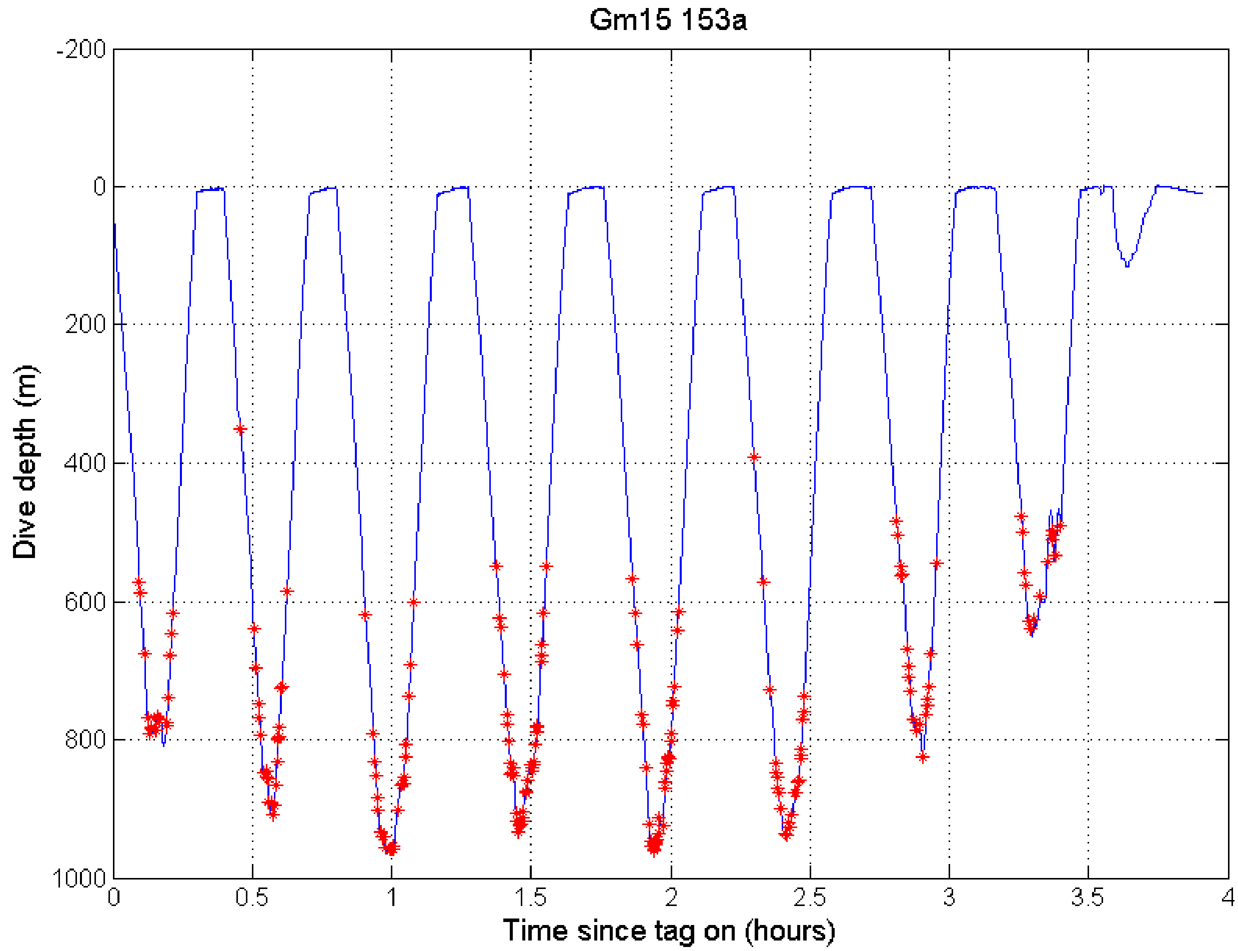


Figure 50. Dive profile of Gm_15_153a from 02 June 2015 DTAG record. Red symbols designate foraging buzzes.

For more information on this study, refer to the annual progress report for this project (Foley et al. 2016b).

2.2.2 North Atlantic Right Whale Tagging

North Atlantic right whales (*Eubalaena glacialis*) migrate to coastal waters off Florida and Georgia during the winter months. The planned construction and operation of a USWTR off the Atlantic coast of Florida could result in interactions with the right whale on its winter calving ground. Aerial- and vessel-based visual surveys **(Sections 2.1.1.2** and **2.1.2.2**, respectively) and passive acoustic monitoring (**Section 2.3.4**) are currently being used to detect right whales in the coastal waters of Florida and Georgia, as well as offshore areas in or near the planned USWTR.

Researchers proposed a targeted tagging program to collect data on horizontal movements, dive profiles, and vocal behavior from individual right whales in February and March 2015. These objectives were accomplished using DTAGs (anticipated tag duration from 1 to 36 hr) that included Fastloc® GPS technology, time-depth recorders, three-dimensional movement measurements, and acoustic recordings.

The field team, consisting of team members from Duke University and Syracuse University, operated out of Fernandina Beach, Florida, in the Jacksonville Study Area, from February through early March 2015. Weather conditions were suitable for tagging operations on 8 days during this time. One tag was successfully deployed Although survey effort was comparable to previous years, the number of animals on the winter grounds sighted by intensive aerial surveys was substantially lower during the 2014–2015 season than in past years (**Table 38**), and only a single tag was successfully deployed on 21 February 2015. Analyses of the data, including dive statistics and acoustic data, are ongoing.

Table 38. Compilation of right whale sightings off the southeastern U.S. from 2007 to 2015. Source: New England Aquarium/North Atlantic Right Whale Consortium.

Calving Season[1]	Numbers of Aerial Survey Sightings	Numbers of Whales Sighted[2]	Numbers of Calves	Numbers of Individual Whales Identified
2007	419	918	23	112
2008	617	1,410	23	153
2009	848	1,853	39	198
2010	523	1,240	19	216
2011	265	610	22	142
2012	130	339	7	68
2013	184	355	20	41
2014	141	275	11	42
2015	75	149	17	30

[1]The calving season includes November and December of the previous calendar year.
[2]Numbers of whales sighted includes duplicates

Analysis of the tag data from 2015 indicates that the animal tagged on 21 February 2015, a mother with a calf, moved east after tag deployment and then switched to a more northwesterly direction (**Figure 51**). The total time recorded by the tag was 23 hr and 20 min. A 4.5-hr behavioral focal follow was conducted on the tagged animal and her calf. The pair spent 4 hr and 23 min of that time in a state of rest, with the remainder of the time spent nursing and travelling.

Figure 51. Surface positions for the track of the mother right whale tagged on 21 February 2015. The inset map shows the position of the enlarged map in red, relative to the training range location.

Audio recordings were browsed visually and aurally in RavenPro 1.5 (Cornell Bioacoustics Research Program, Ithaca, New York) for evidence of any right whale vocalizations. There was a complete absence of detectable right whale calls over a full 24-hr period of recording. Additional sounds such as anthropogenic noise from nearby ships and vocalizations from fish and other cetacean species were noted.

Given the low numbers of both whales and tagging attempts and successes, additional analysis tasks augmented this project, including the following:

1. Sound propagation modeling (ongoing): Completing preliminary work to understand the propagation conditions is an integral part in developing detection probabilities.
2. Detectors for North Atlantic right whale calls (ongoing): Creating and testing algorithms for detection and classification of right whale calls to augment detection.
3. Individual distinctiveness of right whale calls: Collaborated with Jess McCordic on individual distinctiveness paper submitted to *Endangered Species Research*, which included mother-calf data from 2014.
4. Other analyses using the acoustic data from 2014 (ongoing): Working on quantitative repertoire analysis using tag data and compiling a vocal ontogeny paper.
5. Mother versus non-mother dive patterns: Preparing a paper on these patterns, which will be augmented by tags already deployed in 2016.

Additional fieldwork is planned for February-March 2016. The focus of this research is to increase the sample size of tagged individuals, with an emphasis on single animals (not mother-calf pairs) when feasible. A fourth year of data collection may be proposed to further assess movement and dive patterns, as well as acoustic behavior. Additionally, in future years other analyses may be pursued using the data collected by this project, including new analyses that complement completed and ongoing data-collection efforts (e.g., merging vocalization rates with propagation modeling to estimate detection probabilities for right whales in the area).

For more information on this study, refer to the annual progress report for this project (Nowacek et al. 2016).

2.2.3 Mid-Atlantic Humpback Whale Monitoring

Since January 2015, HDR has been monitoring humpback whales in the mid-Atlantic region to assess their occurrence, habitat use, and behavior in order to establish baseline information about this species in U.S. Navy training and testing areas and near shipping lanes off Virginia. Although humpback whales are the target of this study, data on other high-priority species of baleen whales were also collected when possible. The study primarily included vessel surveys in nearshore and offshore waters of Virginia Beach in addition to a single aerial survey. Surveys were conducted in conjunction with photo-ID, focal-follow, biopsy-sampling, and satellite-tagging techniques. The nearshore study area included waters in and around the mouth of the Chesapeake Bay and the W-50A MINEX range off Virginia Beach. The offshore study area extended to the continental shelf and included Norfolk Canyon. During the initial offshore survey, an aerial team flew in coordination with the vessel team to facilitate sighting and localization of humpback whales and other high-priority species. However, because this effort was deemed to be logistically inefficient, the aerial survey component of the study was removed to allow for additional offshore vessel surveys. The satellite-tagging component was added for the winter 2015-16 field season to examine the movement patterns of humpback whales off Virginia Beach, specifically in areas of high shipping traffic and U.S. Navy training areas.

HDR conducted 16 inshore surveys for humpback whales between 02 January 2015 and 31 May 2015 (**Figure 52**) and 25 inshore surveys between 01 December 2015 and 22 March 2016 (**Figure 53**). Six offshore vessel surveys and one associated aerial survey were conducted between 12 April and 21 October 2015 (**Figures 54** and **55**), however these offshore efforts have since become the basis of a pilot project focusing specifically on offshore cetacean occurrence that will be expanded on in 2016.

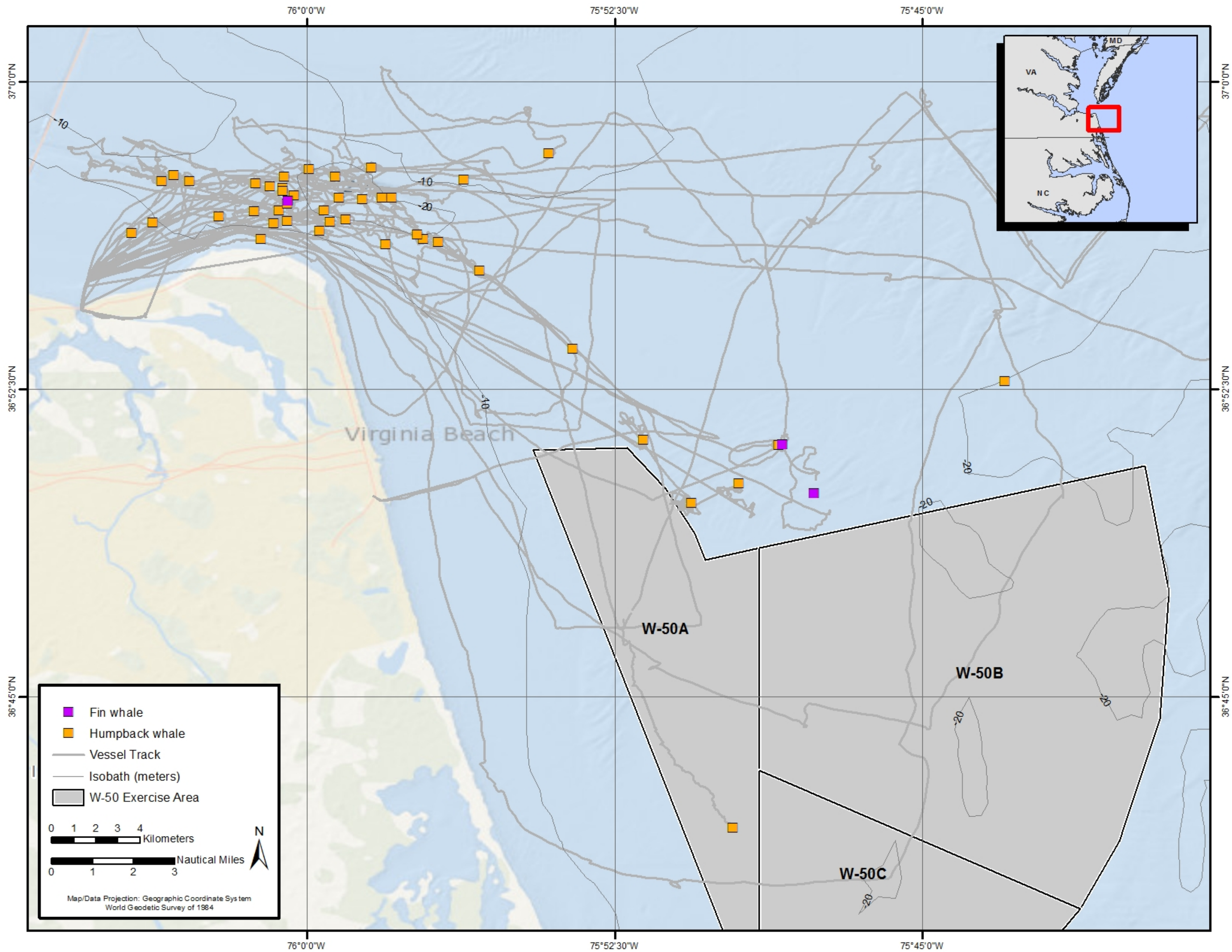


Figure 52. Nearshore survey tracks and locations of all humpback (*n*=46) and fin whale (*n*=3) sightings: January–May 2015.

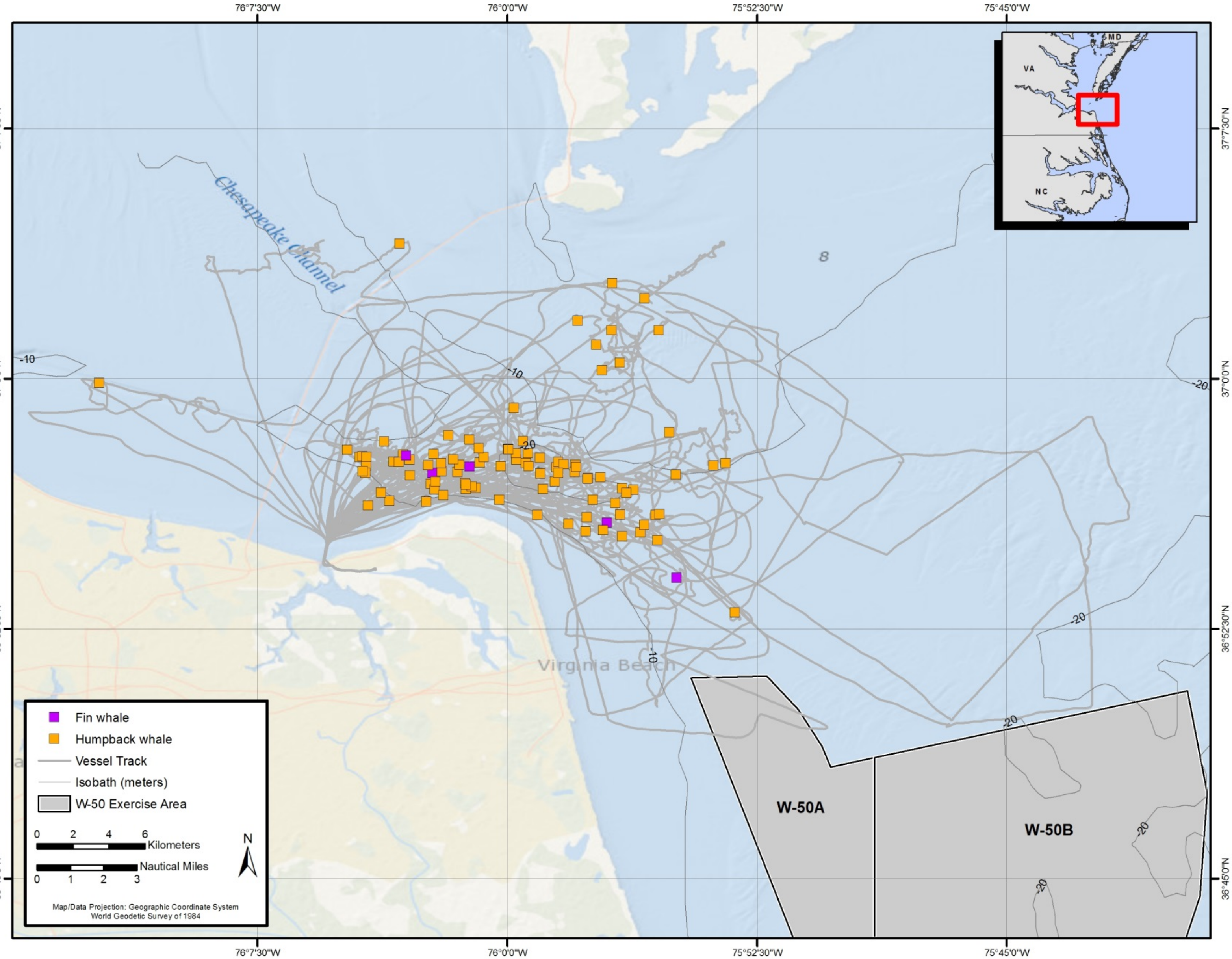


Figure 53. Nearshore survey tracks and locations of all humpback (*n*=95) and fin whale (*n*=5) sightings: December 2015—March 2016.

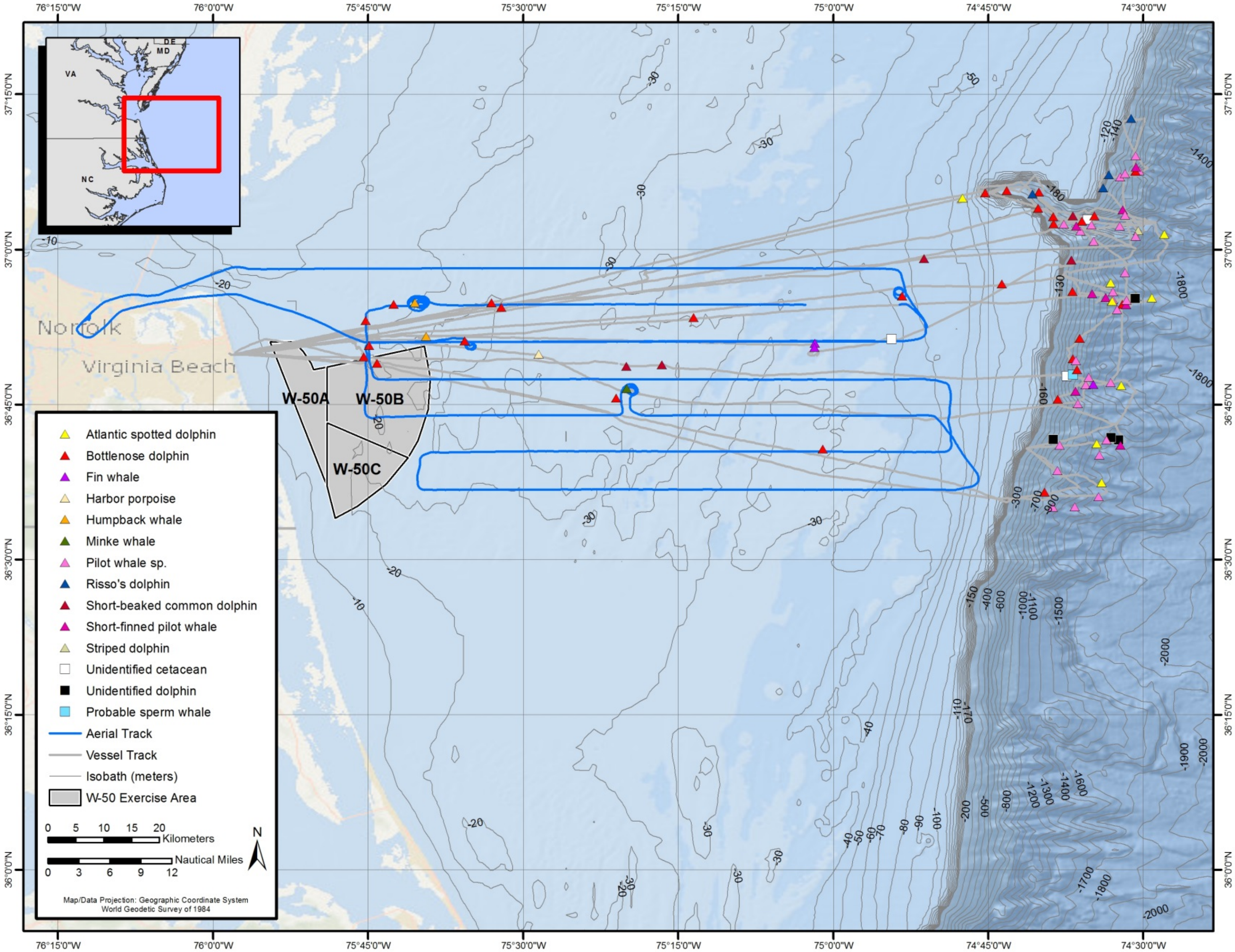


Figure 54. Sightings of marine mammals and survey tracks from six offshore vessel surveys (12 April–21 October 2015) and one aerial survey (12 April 2015).

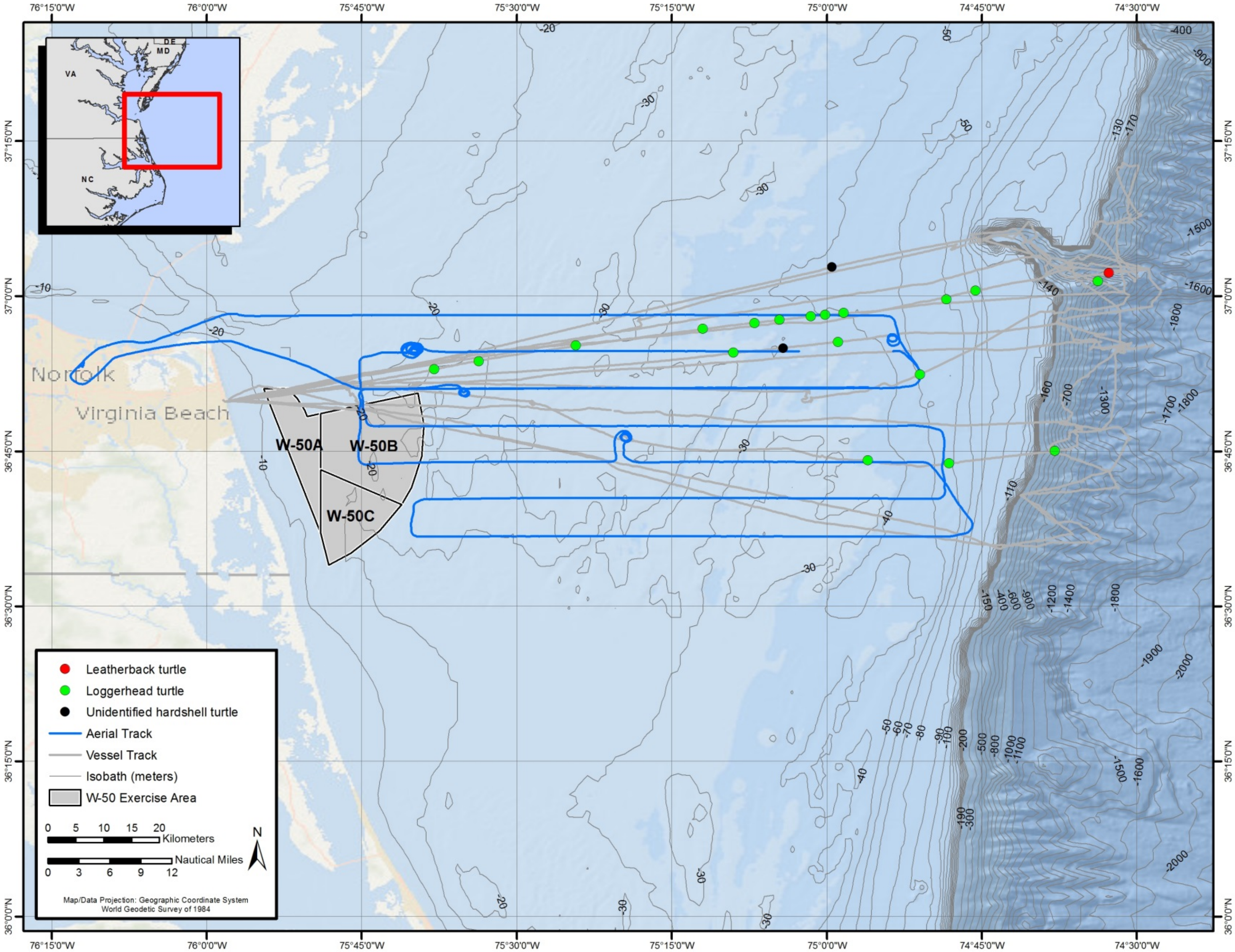


Figure 55. Sightings of sea turtles with vessel tracks from six offshore vessel surveys (12 April–21 October 2015) and one aerial survey (12 April 2015).

There were 141 sightings of humpback whales and 8 sightings of fin whales recorded during the nearshore surveys, including both field seasons (**Figures 52** and **53**). An additional 14 sightings of humpback whales were recorded during another U.S. Navy-funded monitoring project conducted during the same time frame and area (see Engelhaupt et al. 2015, Engelhaupt et al. 2016) for a total of 155 humpback and 8 fin whale sightings. Humpback whales were distributed throughout the study area including a defined shipping-lane zone (within 100 yards of inbound and outbound shipping lanes as defined by the traffic-separation scheme) and the W-50 MINEX range. Of the 63 large whale sightings recorded during January—May 2015, over 50 percent occurred in the shipping-lane study zone. Both humpback and fin whales were also sighted during the offshore vessel and aerial surveys, which resulted in a total of 90 marine mammal sightings (**Figure 54**). Confirmed species included bottlenose dolphin (*n*=26), Atlantic spotted dolphin (n=9), short-finned pilot whale (*n*=7), short-beaked common dolphin (*n*=5), Risso's dolphin (*n*=4), fin whale (*n*=3), humpback whale (*n*=2), striped dolphin (*n*=2), minke whale (*n*=1), and harbor porpoise (*n*=1). There were also sightings of unidentified pilot whale (*n*=23), unidentified dolphin (*n*=5), probable sperm whale (*n*=1), and unidentified cetacean (*n*=1). A total of 21 sea turtle sightings was also recorded on an opportunistic basis during the offshore surveys, including leatherback, loggerhead, and unidentified hardshell turtles (**Figure 55**).

During this project and the concurrent U.S. Navy-funded bottlenose dolphin monitoring project (**Section 2.1.2.4**, Engelhaupt et al. 2016), focal follows were performed on 30 humpback whales, 3 fin whales, and 1 minke whale for a total of 31 hr and 54 min of effort. These data are currently being examined for any emerging patterns in habitat utilization and primary behaviors. Similar to the sightings data, the focal follow data show occurrence in the shipping lane study zone and the W-50 MINEX Zone.

Photo-ID from this project has resulted in 61 unique humpback whales being identified. More than half of the individuals seen during the 2014/2015 field season were seen on multiple occasions, with eight whales seen four or more times during that season and five seen again during the 2015/2016 field season. One individual was seen on 12 different occasions in 2015; only two of these were same-day re-sightings. All fluke and dorsal images were submitted for matching to other local and regional catalogs. Twelve of the whales were previously sighted off Virginia Beach based on comparisons with the Mid-Atlantic Humpback Whale Catalog, and 10 were matched to the North Atlantic Humpback Whale Catalog. The lone humpback whale observed during the offshore vessel survey matched to an individual in the HDR humpback whale catalog, HDRVA030, last seen nearshore 193 days prior (on 11 April 2015).

To date, twenty-one biopsy samples have been collected from humpback whales, with sufficient skin on 18 samples for both genetic and stable isotope analyses. Two fin whale biopsies were also collected during offshore vessel surveys. Biopsy samples are expected to be analyzed in 2016.

During December 2015, SPOT-6 Argos-linked satellite tags were deployed humpback whales; the tags transmitted between 5.6 and 17.6 days (**Table 39**). Initial results show the tagged whales utilizing much of the study area. For example, individual HDRVA048 used portions of the W-50 MINEX range, shipping channels, and the VACAPES OPAREA, traveling north into deep waters of Baltimore Canyon before coming back south to Washington Canyon, before the tag stopped transmitting (**Figure 56**).

Table 39. Summary of satellite tag deployments on humpback whales beginning December 2015.

Animal ID	Tag Type	Argos ID	Deployment (GMT)	Last Transmission (GMT)	Days Transmitted
HDRVA039	SPOT-6	157916	12/07/2015 18:06	12/21/2015 23:25	14.2
HDRVA010	SPOT-6	157915	12/09/2015 14:05	12/20/2015 03:09	10.5
HDRVA041	SPOT-6	157917	12/09/2015 15:42	12/21/2015 17:56	12.1
HDRVA044	SPOT-6	157918	12/10/2015 21:01	12/16/2015 12:37	5.6
HDRVA045	SPOT-6	157919	12/20/2015 18:14	01/01/2016 07:43	11.6
HDRVA048	SPOT-6	157920	12/20/2015 21:30	01/07/2016 11:40	17.6
HDRVA061	SPOT-6	157921	2/6/2016 11:35	2/28/2016 00:21	21.3
HDRVA054	SPOT-6	157922	2/6/2016 13:19	2/9/2016 23:53	3.3
HDRVA063	SPOT-6	157923	2/9/2016 16:15	3/1/2016 09:46	20.7

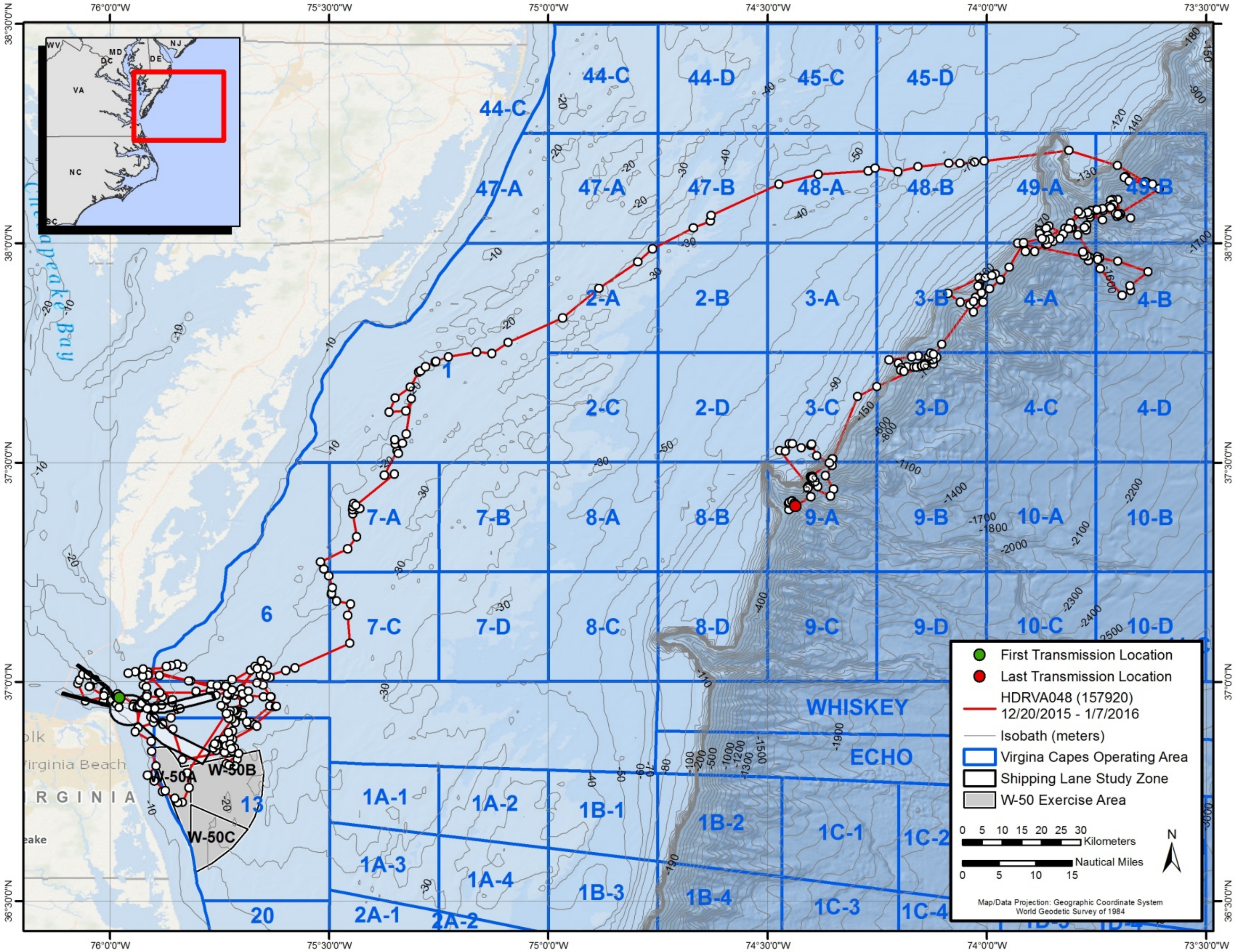


Figure 56. Filtered locations of humpback whale HDRVA048 over 18 days of tag-attachment duration, with consecutive locations joined by a line.

Data analysis for this project is ongoing. Preliminary results of the sighting, photo-ID, focal follow, and tagging data suggest some site fidelity to the study area for individual humpback whales and a high level of occurrence within the shipping channels, which are important high-use areas for both the U.S. Navy and commercial shipping traffic. A few animals are also spending time in or near the W-50 MINEX range and the broader VACAPES OPAREA, where they are presumably within the hearing range of underwater detonation training exercises. Vessel interactions in the study area are a concern, particularly for humpback whales. Three humpback whales were identified with boat injuries ranging from relatively minor to likely fatal. Over 8 percent of the individual humpback whales in the HDR catalog have scars or injuries indicative of propeller or vessel strikes.

For more information on this study, refer to the annual progress report for this project (Aschettino et al. 2016).

2.2.4 Sea Turtle Tagging–Chesapeake Bay and Coastal Virginia

Since July 2013, VAQF and Naval Facilities Engineering Command (NAVFAC) Atlantic have been tagging and tracking sea turtles in lower Chesapeake Bay and coastal Virginia waters. The goal of this collaborative project is to assess the occurrence, habitat use, and behavior of loggerhead, green, and Kemp's ridley turtles in this region to inform Department of Defense (DOD) sea turtle protection efforts (Barco and Lockhart 2016). Research methods include the use of satellite telemetry to characterize broad-scale movement patterns and the use of both satellite and acoustic telemetry data to characterize the occurrence of turtles in specific military zones. Researchers are also comparing the location information among the three datasets generated by the tags: (1) detection data from acoustic tags, (2) Argos location data from satellite transmitters, and (3) GPS location data from GPS-equipped satellite transmitters. This project also leverages the use of the U.S. Navy's existing underwater passive acoustic receiver array. This array records the presence of sea turtles using small acoustic tags. For these acoustic tags, the biologists introduced a wire-tagging method in 2015 due to poor tag duration in 2013 and 2014 on smaller turtles, and tag duration then was similar to that of larger turtles. Each tag transmits a specific coded signal that is used to identify the individual as it moves from one location to another. As the turtle moves around areas where receiver arrays are present, the arrays detect the pings from the tags and record the information, which is later downloaded by researchers for analysis. For these turtles, the acoustic tag also emits a signal that indicates the approximate depth of the turtle when it is in range of the array.

In 2015, turtles for this project were acquired via direct captures using dip netting, incidental captures during commercial pound net or trawling operations, and strandings that were rehabilitated at the Virginia Aquarium & Marine Science Center.

2.2.4.1 Acoustic Tag Detection Assessment

On 17 August 2015, researchers conducted an experiment to investigate the range and detection accuracy of the acoustic receivers. The goal of this experiment was to determine the range of external V16 acoustic tags (VEMCO, Bedford, Nova Scotia) attached to sea turtles and whether detection would be affected by a sea turtle's bony carapace and plastron if placed internally. Results of this experiment were also used to compare GPS locations from satellite telemetry with acoustic detections at nearby receivers. Use of the V16 tags resulted in no acoustic signals being detected beyond 900 m from the receiver and a 50 percent detection rate at approximately 415 m. These larger tags produce a stronger signal, suggesting that the maximum and 50 percent detection range for the V13 tags placed on smaller Kemp's ridley and green turtles is less. Although weather and water conditions were favorable for the duration of the experiment, most of the receivers were in relatively shallow water. Greater depths may allow for larger detection ranges. Results from the GPS/acoustic detection matching analysis suggest that some turtles are detected at distances greater than 1,500 m.

2.2.4.2 Tagging Results

During 2015, 23 acoustic tags were deployed on 15 Kemp's ridley turtles, 7 loggerhead turtles, and 1 green turtle (**Table 40**). A total of 14 satellite tags were deployed on 8 loggerhead turtles and 6 Kemp's ridley turtles (**Table 41**).

Table 40. Acoustic tag deployments on sea turtles in Virginia during 2013—2015.

Acoustic Tags	Green Turtles	Kemp's Ridley Turtles	Loggerhead Turtles	Total
2013				
Jul	2	-	-	**2**
Aug	-	1	1	**2**
Sep	-	-	5	**5**
Oct	-	-	4	**4**
Nov	-	-	1	**1**
2013 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**
2014 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**
2015 Total	**1***	**15**	**7**	**23**
Project Total	**5**	**31**	**25**	**61**

*Released from a vessel offshore North Carolina

Table 41. Satellite tag deployments on sea turtles in Virginia during 2013—2015.

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

*Released from a vessel offshore North Carolina

Acoustic Telemetry

Nineteen of the 23 (83 percent) acoustic tags deployed in 2015 were detected by a U.S. Navy receiver in the array (**Table 42**). 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; however, none of these turtles were detected. Additionally, researchers eliminated one Kemp's ridley turtle (VAQS20152018) from analyses, since its late fall/early winter data suggested that this individual was behaving abnormally or may have died. Detections were highest in August followed by June and October. The detection rate for turtles released in Virginia in 2015 was 95 percent (19 of 20), which was higher than the overall detection rate of 71 percent for 2013—2014. Turtles were detected on 46 of the 62 U.S. Navy receivers in the lower Chesapeake Bay, James River, Elizabeth River, and Atlantic Ocean. Sea turtles were detected in all military zones except the Naval Weapons Station zone (**Figure 57**). Kemp's ridley turtles were detected in the Firing Range Surrogate, JEB-FS, and JEB-LC zones with the highest number of detections recorded in the Norfolk Naval Base (NNB) zone (**Figure 58**). Of the six Kemp's ridley turtles detected in October and November, the last detection for five of these was in the Atlantic Ocean, suggesting that the turtles retained their tags as they migrated from the area. The sixth turtle, an animal that most likely perished, spent most of November to January in the Elizabeth River. The 2015 acoustic telemetry data suggests 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 at release and as they migrate south in the fall. Loggerhead turtles were detected in all of the lower Chesapeake Bay and the Atlantic Ocean military zones (**Figure 59**). In contrast to the 2014 results, detections of loggerhead turtles during 2015 were higher in the JEB-FS and Firing Range Surrogate zones than the JEB-LC and NNB zones.

Table 42. Detections of acoustic-tagged turtles on the U.S. Navy receiver array during 2015.

Month	Number of Detections	Number Detected	Number Deployed*	% Detected
Jan†	10	1	0	N/A
Feb-Apr	0	N/A	2**	N/A
May	13	4	6	67
Jun	1,133	10	16	63
Jul	811	5	22	23
Aug	1,164	5	12	42
Sep	854	5	3	>100
Oct	1,072	7	1	>100
Nov^	287	3	1	>100
Dec^	0	N/A	0	N/A

* Number deployed 60 days prior to last day of month

† Kemp's ridley turtle released in 2014

^ Detections from a shed tag or deceased turtle that remained stationary at one receiver were eliminated

** Released offshore of North Carolina in March

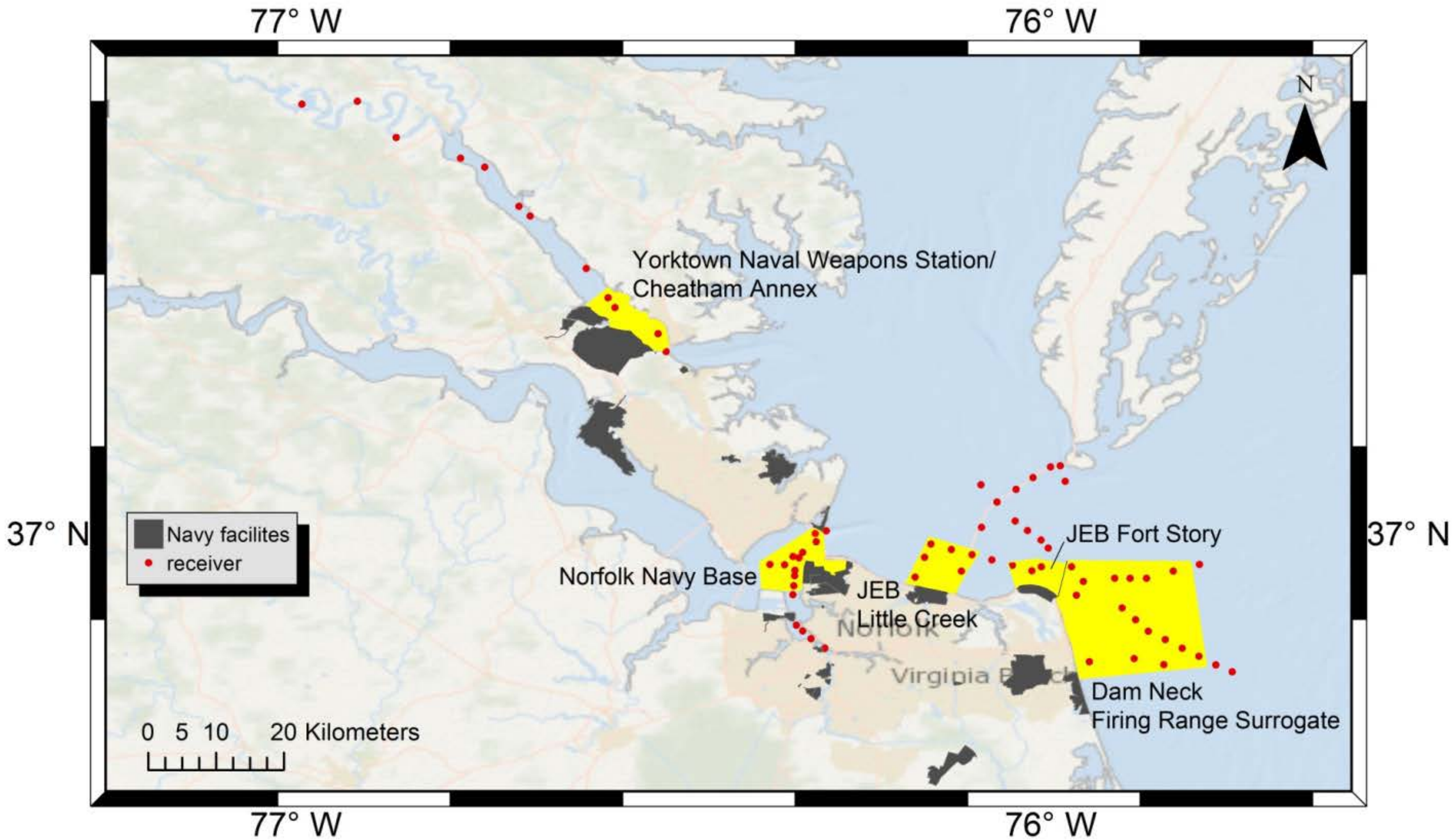


Figure 57. Military zones of interest within Chesapeake Bay where an acoustic receiver array is located (Courtesy of Christian Hager, Chesapeake Scientific).

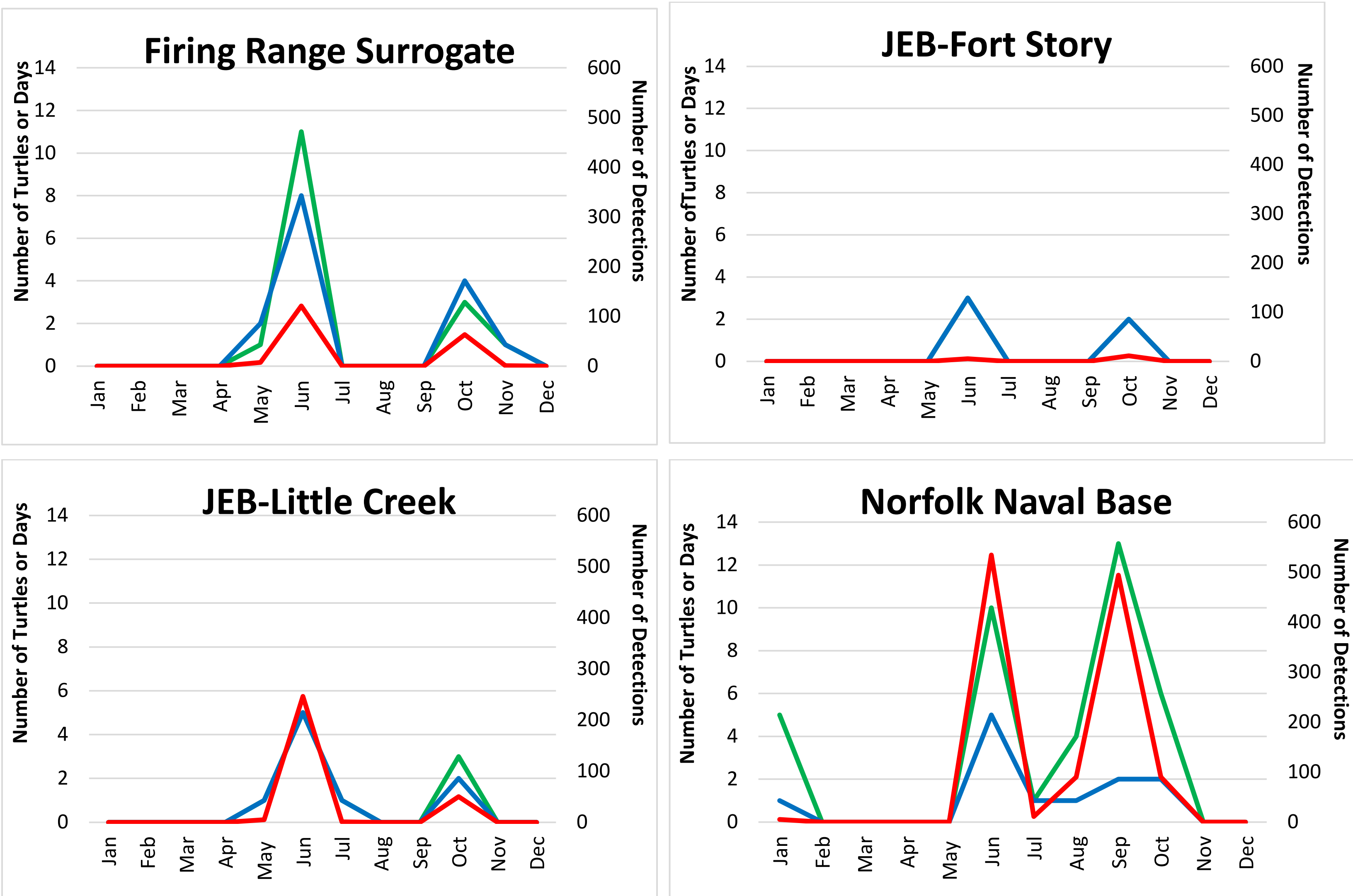


Figure 58. Total numbers of Kemp's ridley turtle detections by month for each geographic zone, January–December 2015. There were no detections in the Naval Weapons Station Yorktown/Cheatham Annex zone. Green line=# days/month, blue line=# of turtles/month, and red line=#detections/month on second Y axis. All turtles except one detected in January were released in 2015.

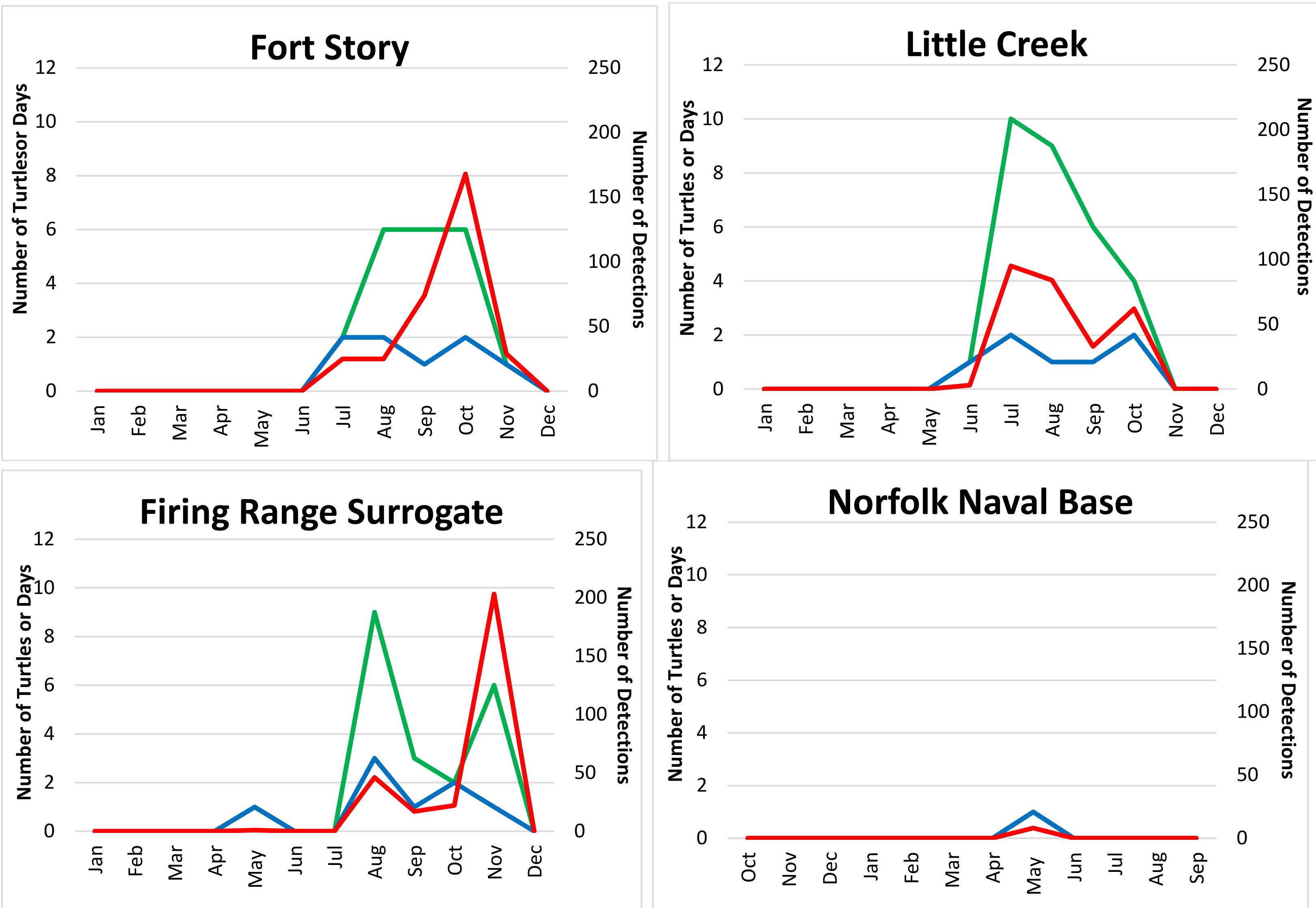


Figure 59. Total numbers of loggerhead detections by month for each geographic zone, January–December 2015. There were no detections in the Naval Weapons Station Yorktown/Cheatham Annex zone. Green line=# days/month, blue line=# of turtles/month, and red line=#detections/month on second Y axis. All detections were of loggerhead turtles released in 2015.

Satellite Telemetry

Researchers used the satellite telemetry data to examine seasonal foraging behavior by applying a switching state-space model (SSSM) approach and calculating monthly home ranges using only the satellite telemetry points that were identified by the SSSM as foraging behavior. The monthly foraging home ranges from each tagged turtle were combined to identify relative levels of foraging for turtles tagged and released in Virginia and North Carolina waters. The SSSM was applied to 40 turtles; of these 40 turtles, 32 loggerhead turtles (data collected from 2007**–**2015) were used to create the monthly foraging grids. 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 loggerhead 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. The numbers of tagged Kemp's ridley and green turtles were too low to conduct a meaningful home-range analysis for these species.

Based on the model-derived index of foraging, the highest loggerhead turtle foraging activity was in Chesapeake Bay, particularly from May through October (**Figures 60** to **65**). Loggerhead turtle 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. Medium to high foraging activity was concentrated in the mouth of Chesapeake Bay in the spring; shifted to the middle and upper Bay, including southern Maryland waters, in the summer; and returned to the mouth of the Bay again in the fall. Foraging behavior was more discrete in the spring and fall but was dispersed throughout the entire Bay, especially along the western shore, in August. Detailed maps depicting the index of foraging (low, medium-low, medium, medium-high, and high) for each month can be found in Barco and Lockhart (2016).

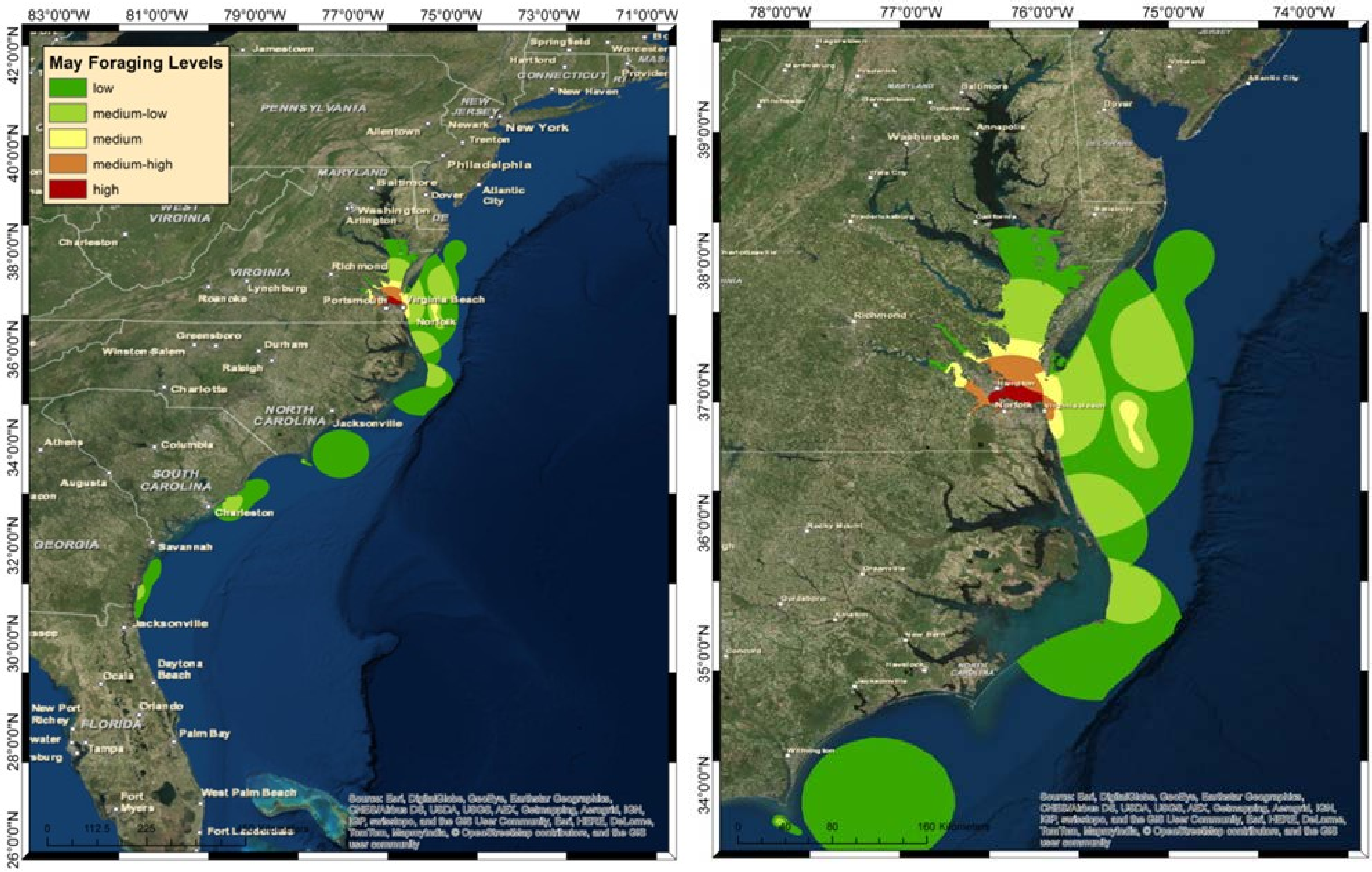


Figure 60. Full (left) and regional (right) view of index of foraging developed from loggerhead turtles tracked in May (*n*=14) from 2007—2015.

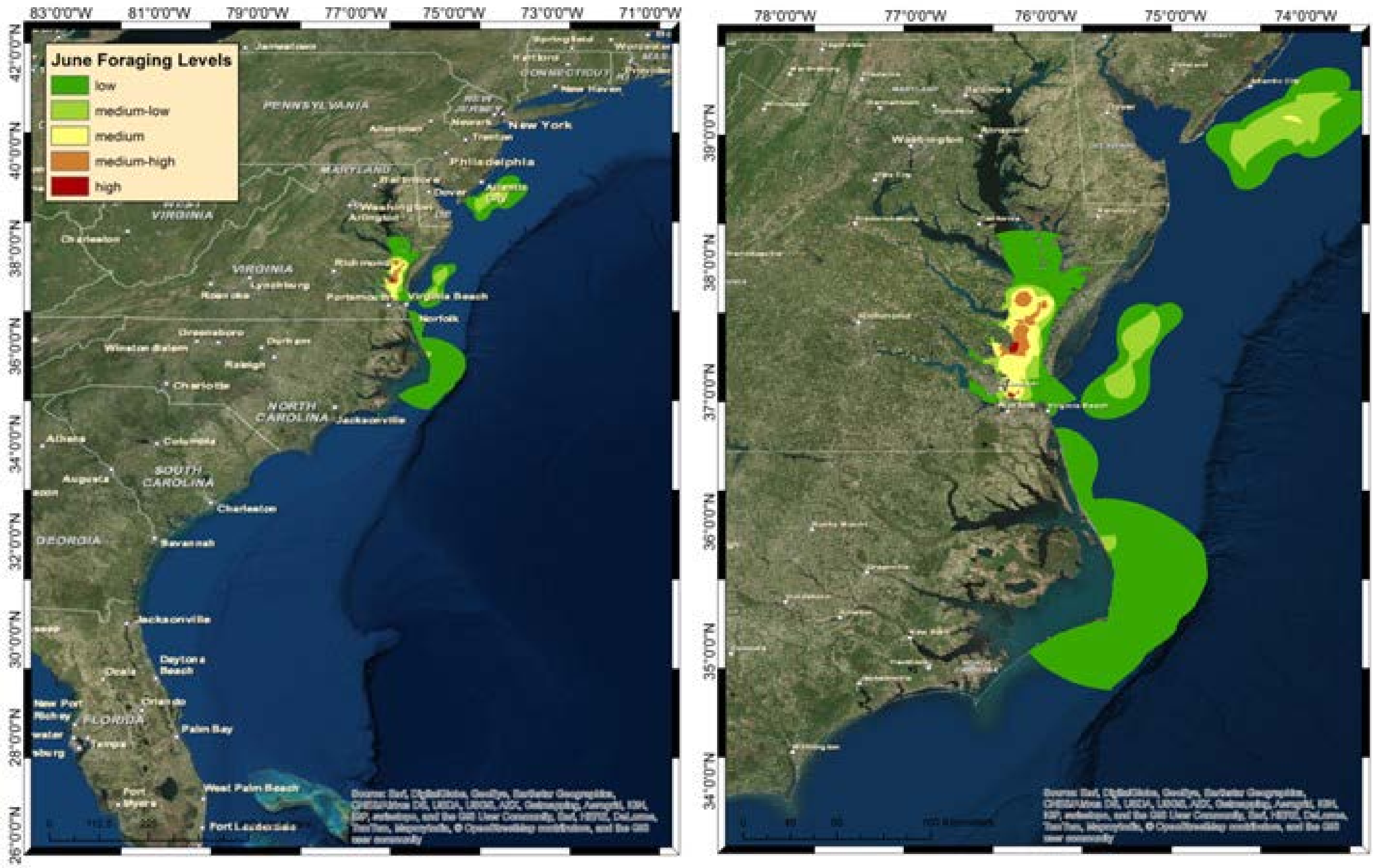


Figure 61. Full (left) and regional (right) view of index of foraging developed from loggerhead turtles tracked in June (*n*=20) from 2007—2015).

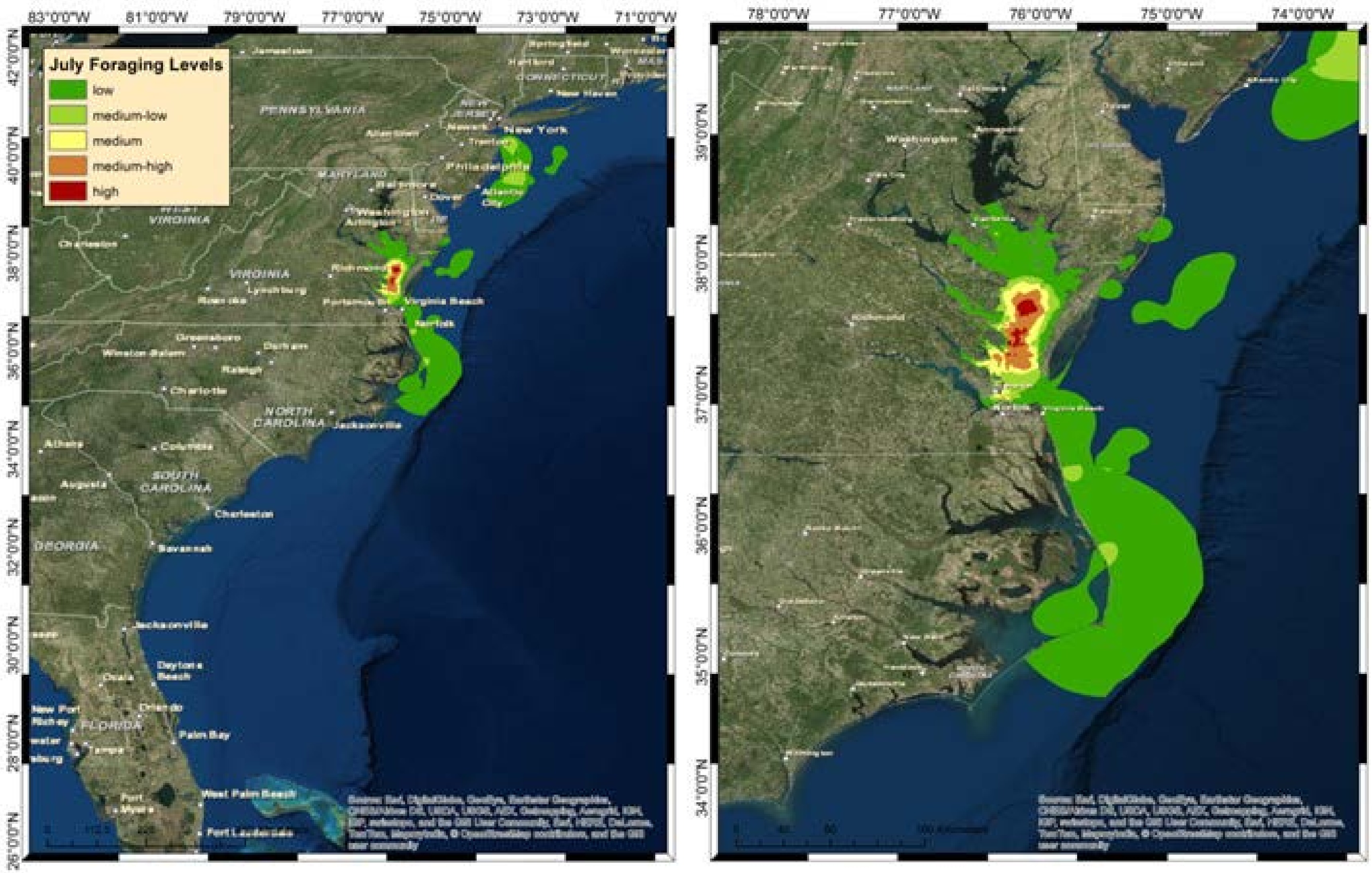


Figure 62. Full (left) and regional (right) view of index of foraging developed from loggerhead turtles tracked in July (*n*=22) from 2007—2015.

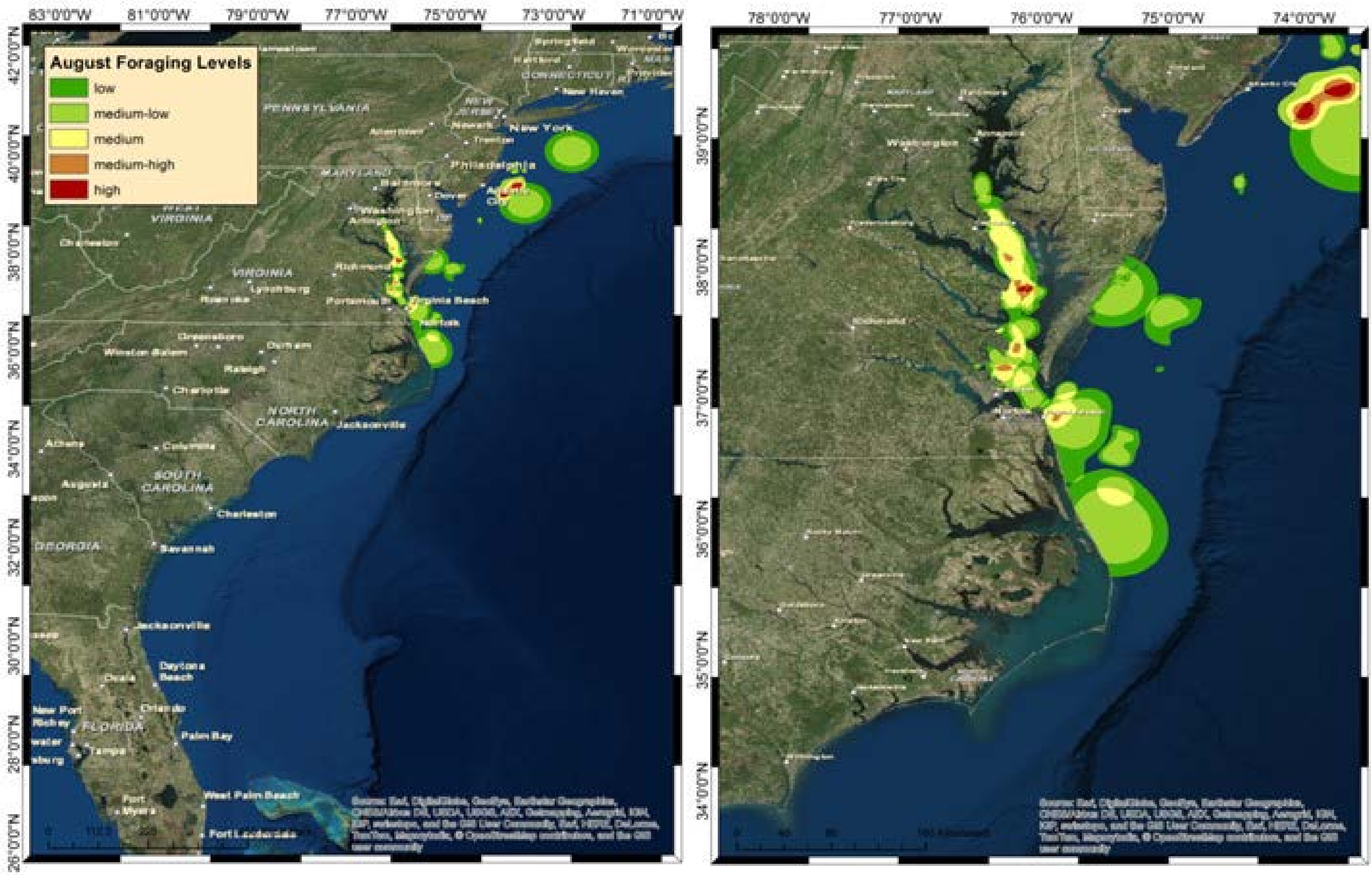


Figure 63. Full (left) and regional (right) view of index of foraging developed from loggerhead turtles tracked in August (*n*=25) from 2007—2015.

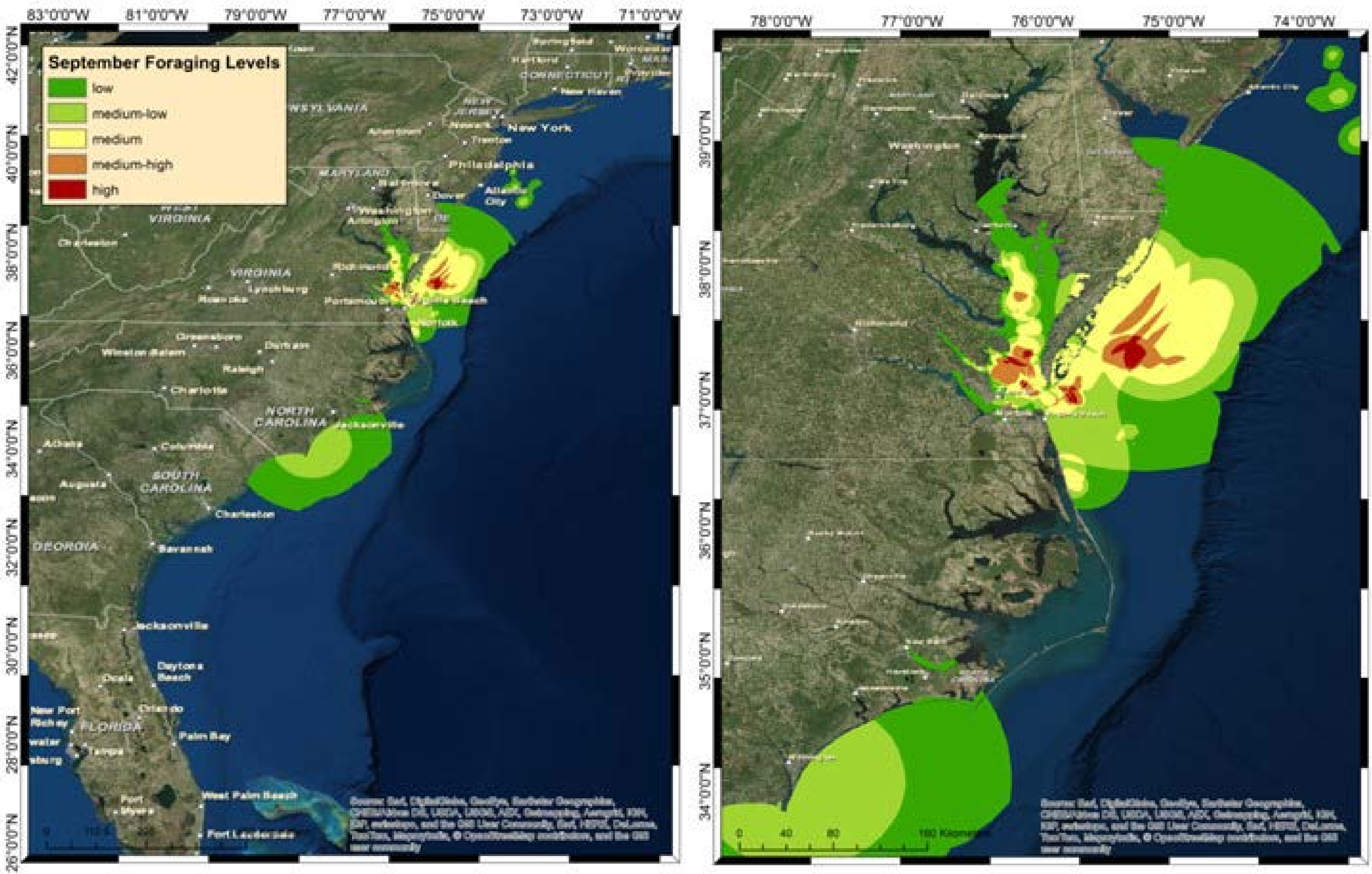


Figure 64. Full (left) and regional (right) view of index of foraging developed from loggerhead turtles tracked in September (*n*=25) from 2007—2015.

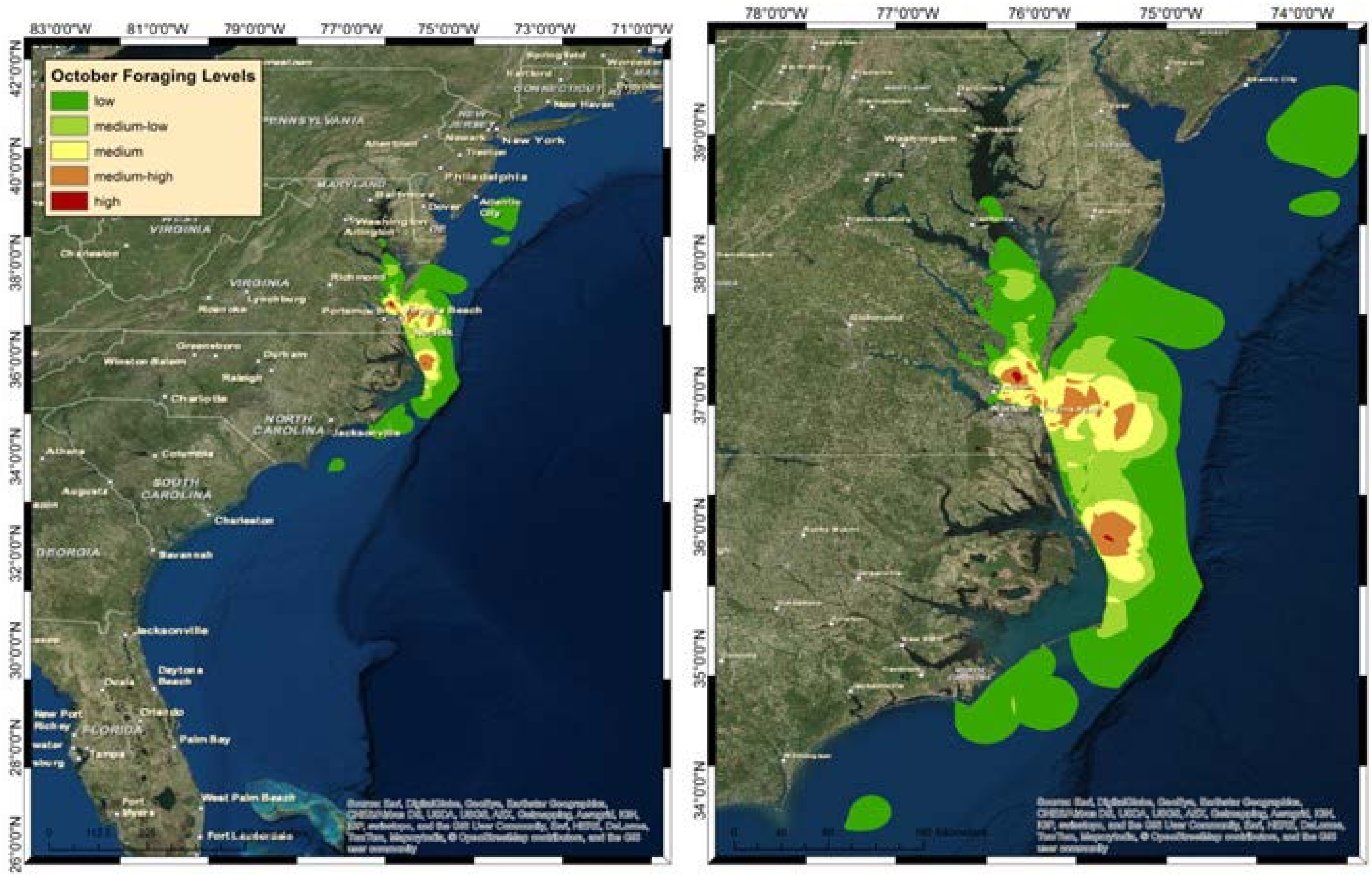


Figure 65. Full (left) and regional (right) view of index of foraging developed from loggerhead turtles tracked in October (*n*=18) from 2007—2015. Warmer colors represent higher level of foraging.

The 2015 tagging data provided new information on the range and distribution of sea turtles in and near military zones. Future analyses will combine the data from all three years of the study (2013—2015) to provide a more thorough assessment of sea turtle occurrence in military zones. In addition, more recent satellite tag data will be incorporated into the SSSM foraging analysis. Researchers also plan 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.

The 2015 tagging data provided new information on the range and distribution of sea turtles in and near military zones. Future analyses will combine the data from all three years of the study (2013—2015) to provide a more thorough assessment of sea turtle occurrence in military zones. In addition, more recent satellite tag data will be incorporated into the SSSM foraging analysis. Researchers also plan 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.

Satellite tag data can be viewed online at (http://www.seaturtle.org/tracking/?project_id=917) and the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP) NAVFAC collaborative project page (http://seamap.env.duke.edu/partner/NAVY).

For more information, refer to the annual progress report for this project (Barco and Lockhart 2016).

2.3 Passive Acoustic Monitoring

PAM is conducted in the AFTT Study Area, both for baseline monitoring and behavioral-response studies. As part of a multi-institutional monitoring plan for Onslow Bay, an acoustic monitoring effort was initiated in 2007 by Duke University with assistance from Scripps Institution of Oceanography. In 2008, the preferred USWTR site changed from Onslow Bay, North Carolina to Jacksonville, Florida. While acoustic monitoring continued in Onslow Bay, it also began in Jacksonville in 2009, once again led by Duke with assistance from Scripps. Later, acoustic monitoring expanded to Cape Hatteras (2012) and Norfolk Canyon (2014), as part of the U.S. Navy's MSM Program for AFTT. For all locations, the primary goal of the acoustic monitoring effort has been to determine patterns of occurrence and distribution of cetacean species in the area. In order to determine which species were present, another goal was to identify species-specific characteristics of the vocalizations of marine mammal species in each area. Acoustic monitoring in each area (except for Norfolk Canyon) originally consisted of recordings made by a towed hydrophone array during boat-based surveys and autonomous passive acoustic recorders (e.g., HARPs). Acoustic monitoring by Duke continues to include HARPs. Since 2012, PAM in the mid-Atlantic region has included the use of Ecological Acoustic Recorders (EARs) and C-PODs. Work also continued this year to model predictions of marine mammal vocal behavior in response to mid-frequency active (MFA) sonar exercises by the U.S. Navy.

2.3.1 High-Frequency Acoustic Recording Packages

During 2015, passive acoustic data were collected at the Norfolk Canyon, Cape Hatteras, and Jacksonville sites using autonomous bottom-mounted recorders (i.e., HARPs).

2.3.1.1 Norfolk Canyon

Data Collection (Norfolk Canyon)

The HARP initially deployed on 19 June 2014 near Norfolk Canyon at a depth of 982 m at 37.16623° N, 74.46692° W (Site A) was recovered on 07 April 2015 (**Table 43** and **Figure 66**), yielding a deployment period of over 290 days (approximately 10 months). The HARP was programmed to sample continuously at 200 kilohertz (kHz).

Table 43. Deployment details for the Norfolk Canyon HARP data set analyzed and detailed in this report.

Site	Deployment Date	Retrieval Date	Recording Start Date	Recording End Date	Latitude (N)	Longitude (W)	Depth (m)	Sampling Rate	Duty Cycle
01A	19-Jun-14	07-Apr-15	19-Jun-14	5-Apr-15	37.16623	74.46692	982	200 kHz	continuous

Key: Apr = April; Jun = June; kHz = kilohertz; m = meter(s) N/A = not applicable

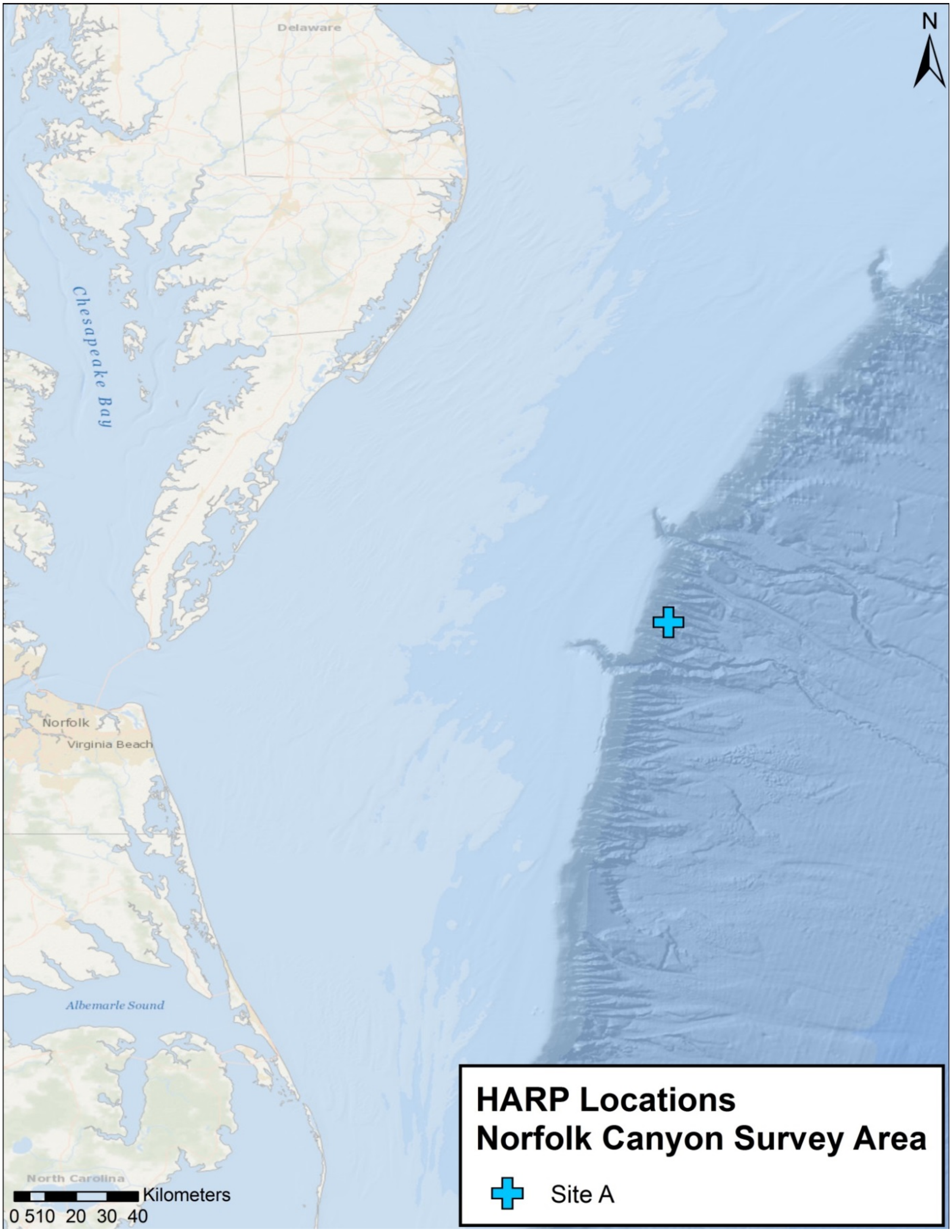


Figure 66. Location of the HARP deployment site in Norfolk Canyon.

Data Analysis (Norfolk Canyon)

The June 2014–April 2015 deployment yielded 6,951 hr of recording time. The data have been analyzed for marine mammal and anthropogenic sounds (minus odontocete whistles) and are reported here as a summary of Debich et al. (in prep). Odontocete whistle analysis of this dataset is ongoing and will be reported on during the next annual report.

Mysticetes detected included blue, fin, minke, sei (*Balaenoptera borealis*), and humpback whales (**Table 44**). Blue whale (*Balaenoptera musculus*) calls were detected only on 2 days. Fin whale 40-Hz calls were detected in low numbers, with peaks in hourly call detections between November and December. Fin whale 20-Hz pulses (as measured by the acoustic index) were detected throughout the deployment, with a peak in calling in December. Compared to the Cape Hatteras and Onslow Bay HARP deployment sites during the winter, very few minke whale pulse trains were detected at Norfolk Canyon. Sei whale downsweeps were detected mainly between November and April, with peaks in occurrence in December 2014 and April 2015. Humpback whale calls were detected only on 2 days during this deployment, once in August and once in November.

Table 44. Summary of detections of marine mammal vocalizations at Site A in Norfolk Canyon for June 2014–April 2015. Fin whale 20-Hz pulses are not included as they were reported as an acoustic index and not logged with a start and end time as individual detection events.

Species	Call Type	Total Duration of Vocalizations (hours)*	Percent of Recording Duration*	Days with Vocalizations	Percent of Total Recording Days
Blue whale	A and B calls	3.0	0.04	2	0.7
Fin whale	40 Hz	50.0	0.7	26	8.9
Minke whale	pulse train (slow-down, speed-up, regular)	23.0	0.3	11	3.8
Sei whale	downsweep	152.0	2.2	59	20.3
Humpback whale	variable	0.03	0.0005	2	0.7
Unidentified odontocete	clicks	1058.7	15.2	282	96.9
Kogia sp.	clicks	1.7	0.02	59	20.3
Risso's dolphin	clicks	12.0	0.2	15	5.2
Sperm whale	clicks	787.5	11.3	160	55.0
Cuvier's beaked whale	clicks	16.8	0.2	59	20.3
Gervais' beaked whale	clicks	9.5	0.1	43	14.8
Possible Sowerby's beaked whale	clicks	19.1	0.3	103	35.4

Key: Hz=Hertz; sp.=species. * = For all mysticetes except humpback whales, total duration of vocalizations (hours) and percent of recording duration are based on data analyzed in hourly bins; for humpback whales and odontocetes, total duration of vocalizations (hours) and percent of recording duration are based on data analyzed in minute bins.

Detected odontocetes included unidentified odontocetes, *Kogia* sp., Risso's dolphins, sperm whales, Cuvier's beaked whales, Gervais' beaked whales (*Mesoplodon europaeus*), and possible Sowerby's beaked whales (*Mesoplodon bidens*) (**Table 44**). Most of the odontocete detections were assigned to the unidentified odontocete category, with the unidentified clicks being divided into five main groups based on spectral patterns. Altogether, these unidentified clicks were present nearly continuously throughout the deployment. Details on each of the five groups of clicks and which species may have produced them will be presented in Debich et al. (in prep). Clicks produced by *Kogia* sp. were also detected throughout the deployment, but in very low numbers. Risso's dolphin clicks were detected in the months of August, September, January, and March, with a peak in detections in September. Sperm whales were detected throughout the deployment during both day and night, with peaks in click detections in August 2014 and April 2015.

There also were several click detections that were assigned to beaked whales. Cuvier's beaked whale clicks occurred during this deployment, with detections mainly between the end of December and March. Gervais' beaked whale clicks were also detected, with most detections between the end of November and mid-February. Finally, most beaked whale detections were a higher-frequency click type, possibly from Sowerby's beaked whale. These detections occurred throughout the deployment, with peaks between December and March.

Detected anthropogenic sounds included MFA sonar, low-frequency active sonar, and seismic survey airguns. MFA and low-frequency active sonar was detected during all months.

2.3.1.2 Cape Hatteras

Data Collection (Cape Hatteras)

Following on from two previous deployments (09 October 2012–29 May 2013; 29 May 2013–08 May 2014), the HARP at Cape Hatteras Site A was deployed twice more. After being deployed on 08 May 2014 at a depth of approximately 850 m at 35.34445° N, 74.84805° W, it was recovered after 334 days and redeployed on 06 April 2015 at a depth of approximately 980 m (**Table 45** and **Figure 67**). This instrument is still in the field and is expected to be recovered during early 2016. The HARP was programmed to sample continuously at 200 kHz for all deployments.

Table 45. Deployment details for the Hatteras HARPs analyzed and detailed in this report.

Site	Deployment Date	Retrieval Date	Recording Start Date	Recording End Date	Latitude (N)	Longitude (W)	Depth (m)	Sampling Rate	Duty Cycle
02A	09-Oct-12	29-May-13	09-Oct-12	09-May-13	35.34060	74.85590	970	200 kHz	continuous
03A	29-May-13	08-May-14	29-May13	15-Mar-14	35.34445	74.85210	970	200 kHz	continuous
04A	08-May-14	06-Apr-15	09-May-14	11-Dec-14	35.34677	74.84805	850	200 kHz	continuous
05A	06-Apr-15	N/A	07-Apr-15	N/A	35.34218	74.85726	980	200 kHz	continuous

Key: Apr=April; Dec=December; kHz=kilohertz; m=meter(s); Mar=March; N/A=not applicable; Oct=October

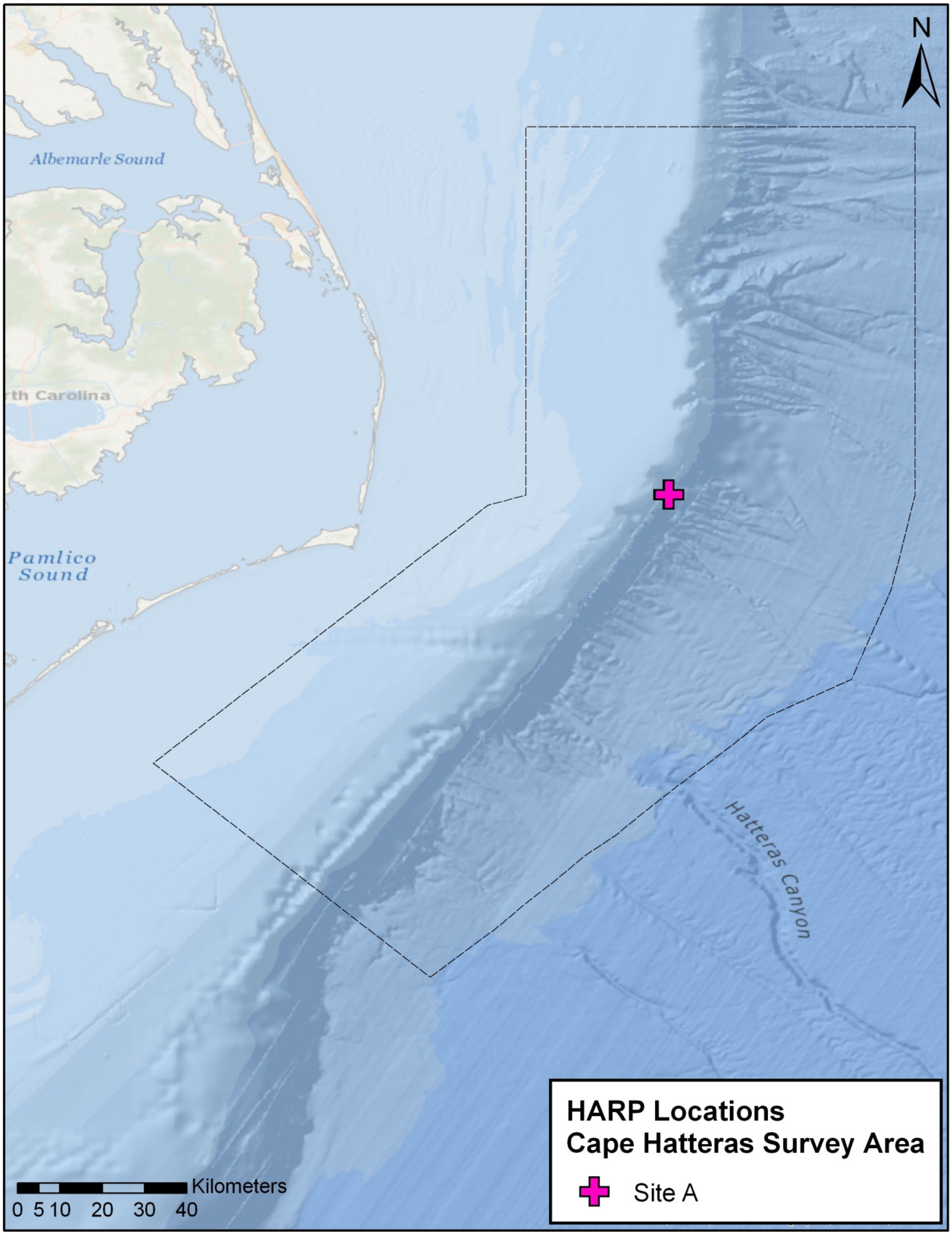


Figure 67. Location of the HARP deployment site in the Cape Hatteras survey area.

Data Analysis (Cape Hatteras)

Data from three deployments at Site A in Cape Hatteras have been analyzed for marine mammal and anthropogenic sounds (minus odontocete whistles) and are reported here as a summary of Debich et al. (in prep). Odontocete whistle analysis of this dataset is ongoing and will be reported on during the next annual report. The October 2012–May 2013 deployment yielded 5,093 hr of recording time over 212 days. The May 2013–May 2014 deployment yielded 6,965 hr of recording time over 290 days. The May 2014–April 2015 deployment yielded 5,207 hr of recording time over 217 days.

Mysticetes detected included blue, fin, minke, sei, North Atlantic right, and humpback whales (**Tables 46, 47** and **48**). Blue whales were present primarily in October and November, but continued to be detected through April. Fin whale 40-Hz calls were detected in low numbers throughout the October 2012–May 2013 and May 2013–March 2014 datasets. There were no fin whale 40-Hz calls detected in the May–December 2014 dataset. Fin whale 20-Hz pulses (as measured by the acoustic index) were detected throughout the deployments, with peaks in calling in December and January. Minke whale pulse trains showed a strong seasonal pattern, with a peak in detections between December and February. Sei whale downsweeps were detected throughout the deployment, with peaks in occurrence between December and March. North Atlantic right whale up-calls were detected on only a few days. The timing coincides with the migration of this species in the spring and fall. Humpback whale calls were detected in low numbers during these deployments, with a peak in occurrence in March 2013.

Table 46. Summary of detections of marine mammal vocalizations at Site A in Cape Hatteras for October 2012–May 2013. Fin whale 20-Hz pulses are not included as they were reported as an acoustic index and not logged with a start and end time to individual detection events.

Species	Call Type	Total Duration of Vocalizations (hours)*	Percent of Recording Duration*	Days with Vocalizations	Percent of Total Recording Days
Blue whale	A and B calls	157.0	3.1	42	19.7
Fin whale	40 Hz	37.0	0.7	16	7.5
Minke whale	pulse train (slow-down, speed-up, regular)	1,880.0	36.9	128	60.1
Sei whale	downsweep	214.0	4.2	57	26.8
North Atlantic right whale	up-call	7.0	0.1	2	0.9
Humpback whale	variable	17.9	0.4	25	11.7
Unidentified odontocete	clicks	3,072.8	60.3	213	100
Kogia sp.	clicks	2.6	0.05	37	17.4
Risso's dolphin	clicks	0.02	0.0003	1	0.5
Sperm whale	clicks	818.3	16.1	150	70.4
Cuvier's beaked whale	clicks	334.9	6.6	206	96.7
Gervais' beaked whale	clicks	13.0	0.3	42	19.7
Blainville's beaked whale	clicks	0.07	0.001	1	0.47

Key: Hz=Hertz; sp.=species. * For all mysticetes except humpback whales, total duration of vocalizations (hours) and percent of recording duration are based on data analyzed in hourly bins; for humpback whales and odontocetes, total duration of vocalizations (hours) and percent of recording duration are based on data analyzed in minute bins.

Table 47. Summary of detections of marine mammal vocalizations at Site A in Cape Hatteras for May 2013–March 2014. Fin whale 20-Hz pulses are not included as they were reported as an acoustic index and not logged with a start and end time as individual detection events.

Species	Call Type	Total Duration of Vocalizations (hours)*	Percent of Recording Duration*	Days with Vocalizations	Percent of Total Recording days
Blue whale	A and B calls	26.0	0.4	16	5.5
Fin whale	40 Hz	8.0	0.1	5	1.7
Minke whale	pulse train (slow-down, speed-up, regular)	1,781.0	25.7	121	41.6
Sei whale	downsweep	113.0	1.6	37	12.7
North Atlantic right whale	up-call	1.0	0.01	1	0.3
Humpback whale	variable	0.3	0.005	2	0.7
Unidentified odontocete	clicks	2,351.8	33.9	286	98.3
Kogia sp.	clicks	3.9	0.06	67	23.0
Risso's dolphin	clicks	2.9	0.04	3	1.0
Sperm whale	clicks	1,330.7	19.2	196	67.4
Cuvier's beaked whale	clicks	446.0	6.4	272	93.5
Gervais' beaked whale	clicks	42.8	0.6	121	41.6
Blainville's beaked whale	clicks	0.5	0.007	4	1.4
Possible Sowerby's beaked whale	clicks	0.1	0.001	1	0.3

Key: Hz=Hertz; sp.=species. * For all mysticetes except humpback whales, total duration of vocalizations (hours) and percent of recording duration are based on data analyzed in hourly bins; for humpback whales and odontocetes, total duration of vocalizations (hours) and percent of recording duration are based on data analyzed in minute bins.

Table 48. Summary of detections of marine mammal vocalizations at Site A in Cape Hatteras for May–December 2014. Fin whale 20-Hz pulses are not included as they were reported as an acoustic index and not logged with a start and end time as individual detection events.

Species	Call Type	Total Duration of Vocalizations (hours)*	Percent of Recording Duration*	Days with Vocalizations	Percent of Total Recording Days
Blue whale	A and B calls	22.0	0.4	4	1.8
Minke whale	pulse train (slow-down, speed-up, regular)	237.0	4.6	35	16.1
Sei whale	downsweep	15.0	0.3	7	3.2
North Atlantic right whale	up-call	2.0	0.04	1	0.5
Humpback whale	variable	0.5	0.009	5	2.3
Unidentified odontocete	clicks	1122.6	21.6	210	96.8
Kogia sp.	clicks	1.9	0.04	39	18.0
Risso's dolphin	clicks	5.9	0.1	5	2.3
Sperm whale	clicks	571.4	11.0	97	44.7
Cuvier's beaked whale	clicks	231.2	4.4	210	96.8
Gervais' beaked whale	clicks	29.2	0.6	87	40.1
Blainville's beaked whale	clicks	0.1	0.002	2	0.9

Key: Hz=Hertz; sp.=species. * For all mysticetes except humpback whales, total duration of vocalizations (hours) and percent of recording duration are based on data analyzed in hourly bins; for humpback whales and odontocetes, total duration of vocalizations (hours) and percent of recording duration are based on data analyzed in minute bins.

Detected odontocetes included unidentified odontocetes, *Kogia* sp., Risso's dolphins, sperm whales, Cuvier's beaked whales, Gervais' beaked whales, Blainville's beaked whales (*Mesoplodon densirostris*), and possibly Sowerby's beaked whales (**Tables 46, 47,** and **48**). Most of the odontocete detections were assigned to the unidentified odontocete category, with the unidentified clicks being present nearly continuously throughout each recording period. The unidentified clicks were divided into five main groups based on spectral patterns. Details on each of the five groups of clicks and which species may have produced them will be discussed in Debich et al. (in prep). Clicks produced by *Kogia* sp. were detected during all deployments, with a peak in occurrence during the winter months. Risso's dolphin clicks were detected sporadically, with more detections during the night. Sperm whales were detected throughout all three deployments during both day and night, with peaks in click detections between January and February, as well as between June and August.

There were also several click detections that were assigned to beaked whales. Cuvier's beaked whale clicks occurred regularly throughout all three deployments, with a slight increase in detections between September and December. Gervais' beaked whale clicks occurred less frequently than Cuvier's beaked whale clicks. Most Gervais' beaked whale detections occurred between June and July and between November and March. Unlike for Cuvier's beaked whales, there were very few detections of Gervais' beaked whales between August and November. Blainville's beaked whale clicks were detected only on a few days during each deployment. Finally, higher-frequency beaked whale clicks, possibly from Sowerby's beaked whale, were detected only on one day, 04 March 2013.

Detected anthropogenic sounds included MFA sonar and seismic survey airguns. MFA sonar was detected during all months.

2.3.1.3 Jacksonville OPAREA

Data Collection (JAX)

A small-mooring HARP was deployed at Site D in 806 m at 30.15060 N, 79.77005 W on 23 August 2014 and recovered on 02 July 2015 (**Table 49** and **Figure 68**). The deployment period was 314 days. The HARP was then deployed that same day in approximately 800 m at 30.1489 N, 79.7711 W (**Table 49** and **Figure 68**). This HARP is still out in the field, and it is scheduled to be recovered in April 2016. Both HARPs were set to sample continuously at 200 kHz. There were two previous deployments at Site C in shallower water (94 and 88 m) on the shelf (**Table 49** and **Figure 68**).

Table 49. HARP datasets from the JAX survey area analyzed and detailed in this report.

Site	Deployment Date	Retrieval Date	Recording Start Date	Recording End Date	Latitude (N)	Longitude (W)	Depth (m)	Sampling Rate	Duty Cycle
9C	12-May-13	17-Feb-14	13-May-13	20-Jun-13	30.33287	-80.20071	94	200 kHz	continuous
10C	17-Feb-14	23-Aug-14	17-Feb-14	23-Aug-14	30.32643	-80.20493	88	200 kHz	continuous
11D	23-Aug-14	02-Jul-15	23-Aug-14	22-May-15	30.15060	-79.77005	~806	200 kHz	continuous
12D	02-Jul-15	N/A	03-Jul-15	N/A	30.1489	79.7711	800	200 kHz	continuous

Key: Aug=August; Feb=February; Jul=July; kHz = kilohertz; m = meter(s); N/A = not applicable

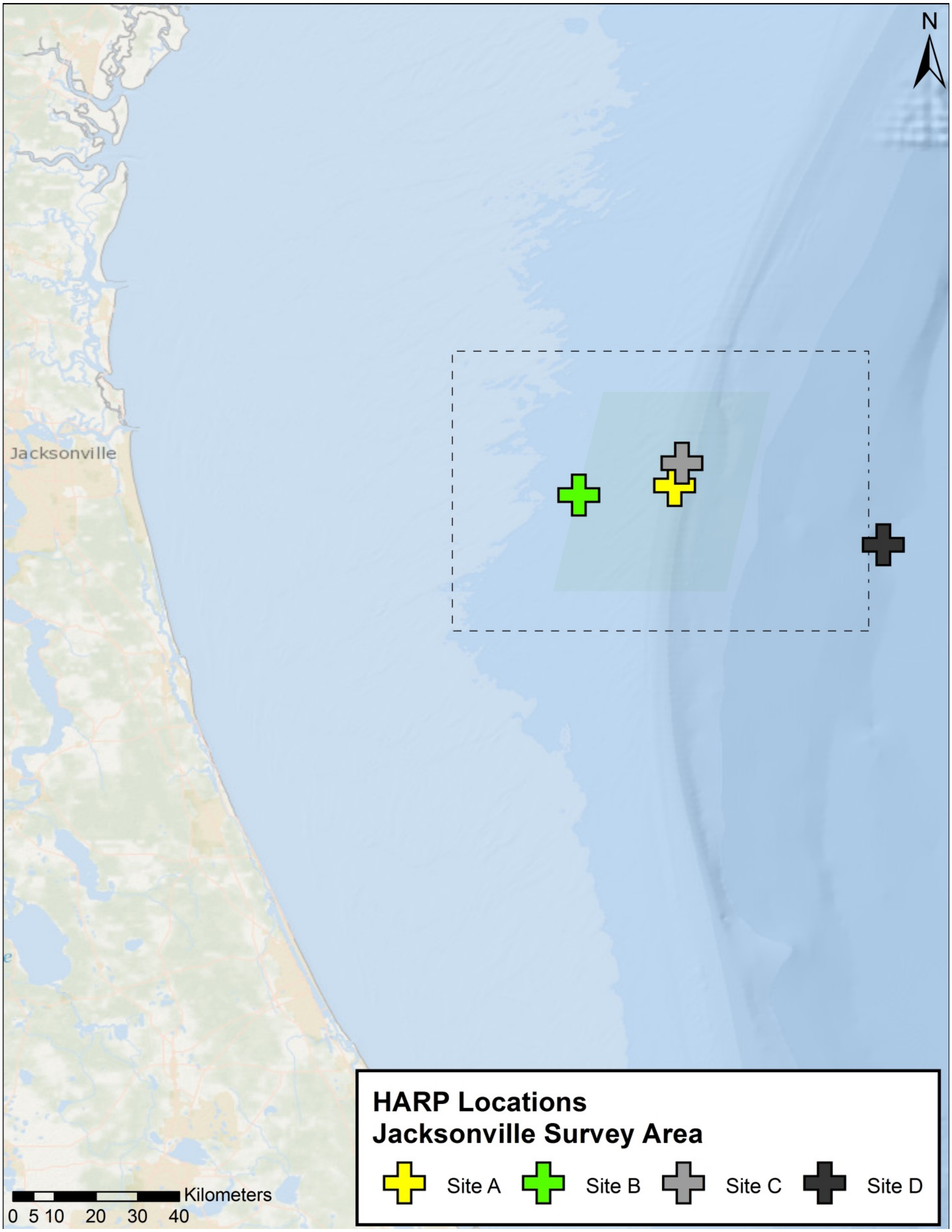


Figure 68. Locations of HARP deployment sites in the JAX survey area.

Data Analysis and Results (JAX)

Data from the August 2014–July 2015 Site D deployment in JAX are currently being analyzed and will be reported on in next year's annual report. Data from the two deployments (May 2013–February 2014 and February–August 2014) at Site C were analyzed for marine mammal and anthropogenic sounds. The May 2013–February 2014 deployment yielded 926.5 hr of recording time over 39 days, while the February–August 2014 deployment yielded 4,488.3 hr over 188 days, **Table 49**) Technical malfunctions resulted in loss of data for the period from 08 June 2013 through 16 February 2014 (Debich et al. 2015).

Data analysis consisted of analyst scans of long-term spectral averages (LTSAs) and spectrograms, and automated computer algorithm detection when possible. Three frequency bands were analyzed for marine mammal vocalizations and anthropogenic sounds: (1) low-frequency (between 10 and 300 Hz), (2) mid-frequency (between 10 and 5,000 Hz), and (3) high-frequency (between 1 and 100 kHz). See Debich et al. (2015) for a more detailed description of analysis methods.

Detected odontocete vocalizations included clicks and whistles, which were detected during both deployments (**Tables 50** and **51**). Most of these detections were assigned to the 'unidentified odontocete' category. There was a distinct diel pattern for unidentified clicks, with more echolocation activity at night, likely due to nighttime foraging, while there was no discernible diel pattern for unidentified odontocete whistles. Only one known odontocete species was detected–Risso's dolphin, which was only in the February–August 2014 dataset. Low numbers of Risso's dolphins were detected in July 2014 (**Table 51**). There were too few Risso's dolphin detections to determine a diel pattern.

Table 50. Summary of detections of marine mammal vocalizations at Site C in JAX for May–June 2013. For odontocetes, total duration of vocalizations (hours) and percent of recording duration are based on data analyzed in minute bins.

Species	Call Type	Total Duration of Vocalizations (hours)	Percent of Recording Duration	Days with Vocalizations	Percent of Total Recording Days
Unidentified odontocete	clicks, whistles, burst-pulses	166.6	21.5	39	100

Table 51. Summary of detections of marine mammal vocalizations at Site C in JAX for February–August 2014.

Species	Call Type	Total Duration of Vocalizations (hours)*	Percent of Recording Duration*	Days with Vocalizations	Percent of Total Recording Days
Fin whale	20 Hz	8.0	0.2	2	1.1
Minke whale	pulse train (slow-down, speed-up, regular)	166.0	3.7	27	14.4
Humpback whale	song or non-song (not separated)	3.8	0.1	46	24.5
Possible mysticete	5-pulse signal	580.0	12.9	82	43.6
Unidentified odontocete	clicks, whistles	2210.7	49.3	186	98.9
Risso's dolphin	clicks	1.0	0.02	1	0.5

Key: Hz=Hertz; sp.=species. * For all mysticetes except humpback whales, total duration of vocalizations (hours) and percent of recording duration are based on data analyzed in hourly bins; for humpback whales and odontocetes, total duration of vocalizations (hours) and percent of recording duration are based on data analyzed in minute bins.

Mysticetes were only detected in the February–August 2014 dataset, with calls from fin, minke, and humpback whales (**Table 51**). Fin whale 20-Hz pulses were detected in late February 2014; there was no discernible diel period. Minke whale pulse trains were detected in February and March 2014, with no discernible diel pattern to the vocalizations. Humpback whales were detected in February through June, with a peak in detections in late March and slightly more calling during daytime hours. These results for the humpback whale are similar to earlier reports (Debich et al. 2013; Johnson et al. 2014). In addition, a 5-pulse low-frequency signal was also detected, with a peak in detections in July. Most 5-pulse signal detections occurred slightly before sunset and during nighttime hours. This call is presumed to be produced by a mysticete due to its character, prevalence, and intensity.

Detected anthropogenic sounds included broadband ship noise, MFA sonar, and echosounders. MFA sonar was detected during all months with recordings, with a peak in June 2013.

For more information on this study, refer to the annual progress report for this project (Hodge et al. 2016). A metadata viewer including links to individual technical reports of HARP deployments is available at: http://www.navymarinespeciesmonitoring.us/data-access1/passive-acoustic-data/harp-reports/.

2.3.2 EARs Monitoring of Dolphins in the VACAPES MINEX W-50 Training Range

MINEX activities that utilize underwater detonations (UNDET) have the potential to injure or kill marine mammals occurring in close proximity. To better understand the impact of MINEX training on marine mammals, an effort was begun in August 2012 by Oceanwide Science Institute (OSI) to monitor odontocete activity at the VACAPES MINEX site using passive acoustic methods. The initial objectives of the project were to establish the daily and seasonal patterns of occurrence of dolphins in the VACAPES W-50 MINEX training area, to detect explosions related to MINEX activities, and to determine whether dolphins in the area showed evidence of a response to MINEX events.

Between 2012 and 2013, two Ecological Acoustic Recorders (EARs) programmed to achieve continuous monitoring were deployed and refurbished approximately every 2 months. The data were analyzed manually for the daily presence of dolphins, and their acoustic activity was quantified in detail for the period prior to, during, and after MINEX training events, which can occur on the range multiple times per month. The results indicated that dolphins occurred near the training area year-round, with approximately 97 percent of monitored days containing some dolphin acoustic signals. However, there was clear seasonal variability, with a consistent period of low occurrence or reduced acoustic activity during winter months, and the lowest levels occurring in February. The data also revealed that dolphins exhibited an acoustic or behavioral response following an UNDET event. Acoustic activity levels approximately 1 km from the 'epicenter' of training exercises were on average lower during both the day of an exercise and the day following the exercise, suggesting that animals either reduced their signaling, left the area, or both. Conversely, dolphin acoustic activity levels during the second day following an exercise were higher than either the day before, the day of or the first day after an exercise. It is still unclear how long the observed responses persist until normal (day before an exercise) behavior is re-established.

A second phase of the project began in September 2013 to determine whether the responses observed represented a shift in acoustic behavior or a spatial redistribution of animals. Alternating 2-month deployments in 2013-2015 consisted of two different array configurations. In the first configuration, four EARs were arranged in a linear array at distances of 1 km (site B), 3 km (site E, H, or K), 6 km (site F, I, or

L), and 12 km (site G, J, or M) from the primary MINEX W-50 training location in order to examine whether or not animals are redistributing along the coast or offshore in response to training events (**Figure 69**) In the second configuration, EARs were arranged in a localization array in an effort to establish the distances that animals occur from MINEX training activities (**Figure 70**).

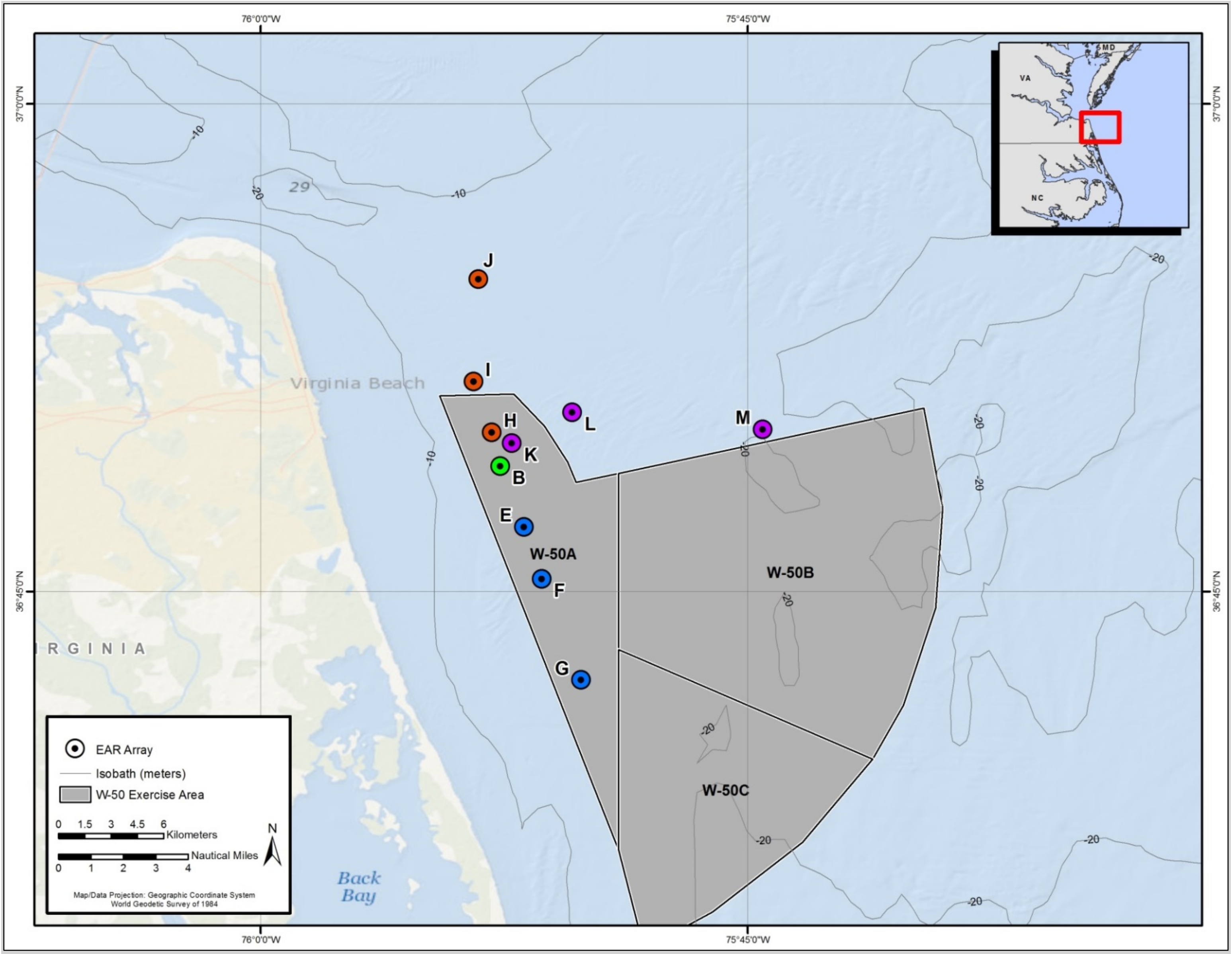


Figure 69. Spatial configurations of three linear arrays deployed during the second year of the project. Site B remained constant and north is shown as red (B–H–I–J), east as purple (B–K–L–M), and south as blue (B–E–F– G).

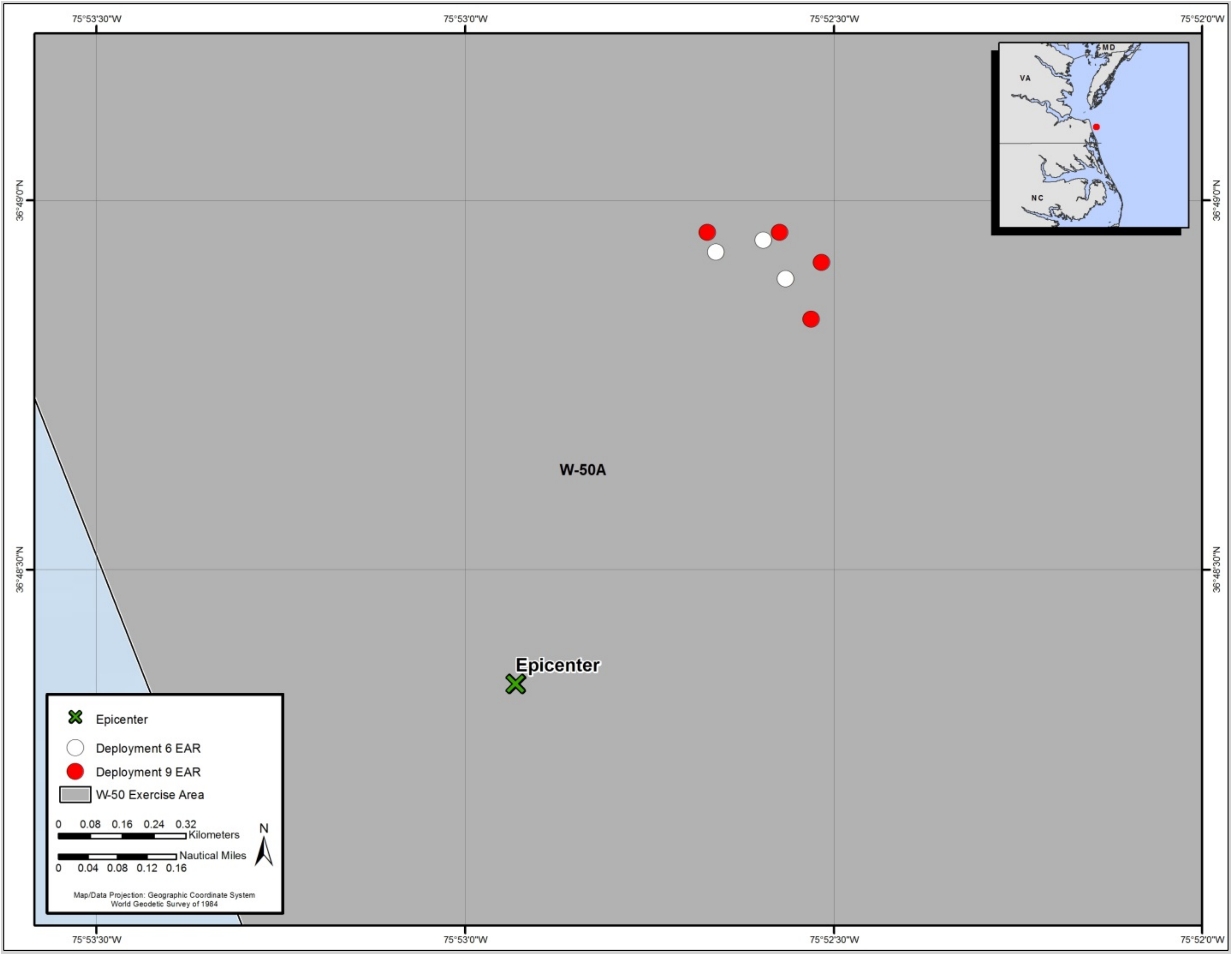


Figure 70. Spatial configurations of the two localization EAR arrays relative to the location of the epicenter of MINEX training activities. The white markers represent deployment 6 and the red markers represent deployment 9.

2.3.2.1 Dolphin Occurrence Near 'Epicenter' Area of W-50

During the 3 years of monitoring analyzed to date, a clear seasonal trend was observed in the mean number of daily detections each month (**Figure 71**). Dolphins were most commonly detected between the months of April and October. Detections dropped substantially between November and March and were the lowest during the month of February. However, it should be noted that although the number of daily detections decreased during winter months, dolphins were still detected in the area nearly daily throughout the year. This finding is consistent with seasonal trends in bottlenose dolphin abundance off Virginia Beach reported by Barco et al. (1999) and Engelhaupt et al. (2015). Year to year, differences were observed between a few of the same months, suggesting some inter-annual variability of the occurrence of dolphins in the area immediately around the 'epicenter' of MINEX training.

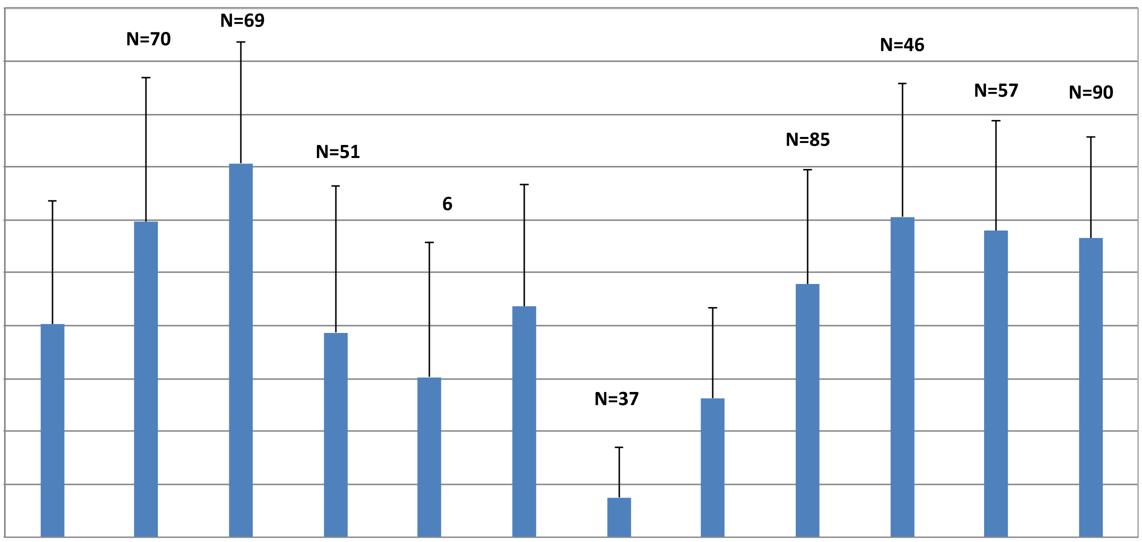


Figure 71. Mean number of daily dolphin detections averaged by month for the 3 years of data collection. Error bars represent one standard deviation. 'N' values give the number of days that were monitored during each month.

2.3.2.2 Dolphin Acoustic Response to Explosions

In total, 63 explosions were detected in the data analyzed between 15 August 2012 and 30 August 2015 representing 34 MINEX training events. The hourly sums of acoustic activity of dolphins the day prior, the day of, and the two days after training events are shown in **Figure 72**. During the day prior to an event, dolphins were most active during mid-day (11:00–12:00) and nighttime hours (19:00–04:00). On the day of MINEX training and the following day, the daytime peak in activity was reduced or absent, although the nighttime peak persisted. A paired t-test comparison of the averaged 24 hourly bins of the day before and the day of the exercise revealed a significant difference (t=2.7072, DF=23, p=0.013). Conversely, a paired t-test comparison of the averaged 24 hourly bins of the day of the exercise and first day after the exercise was not significant (t=1.1574, DF=23, p=0.259). In contrast to the reduced or absent daytime peak, the nighttime peak in activity persisted following MINEX training events, suggesting that the animals in the area resumed normal activity during these hours. This trend also suggests that the decreased activity observed during daylight hours of the following day might represent avoidance of the area. During the second day following a training event the acoustic activity levels were significantly higher than the levels observed during the day before the event (paired t-test, *t*=11.0757, *DF*=23, *p*<0.001), suggesting that animals were more active and/or abundant in the area during this time than during the baseline period (the day before an exercise).

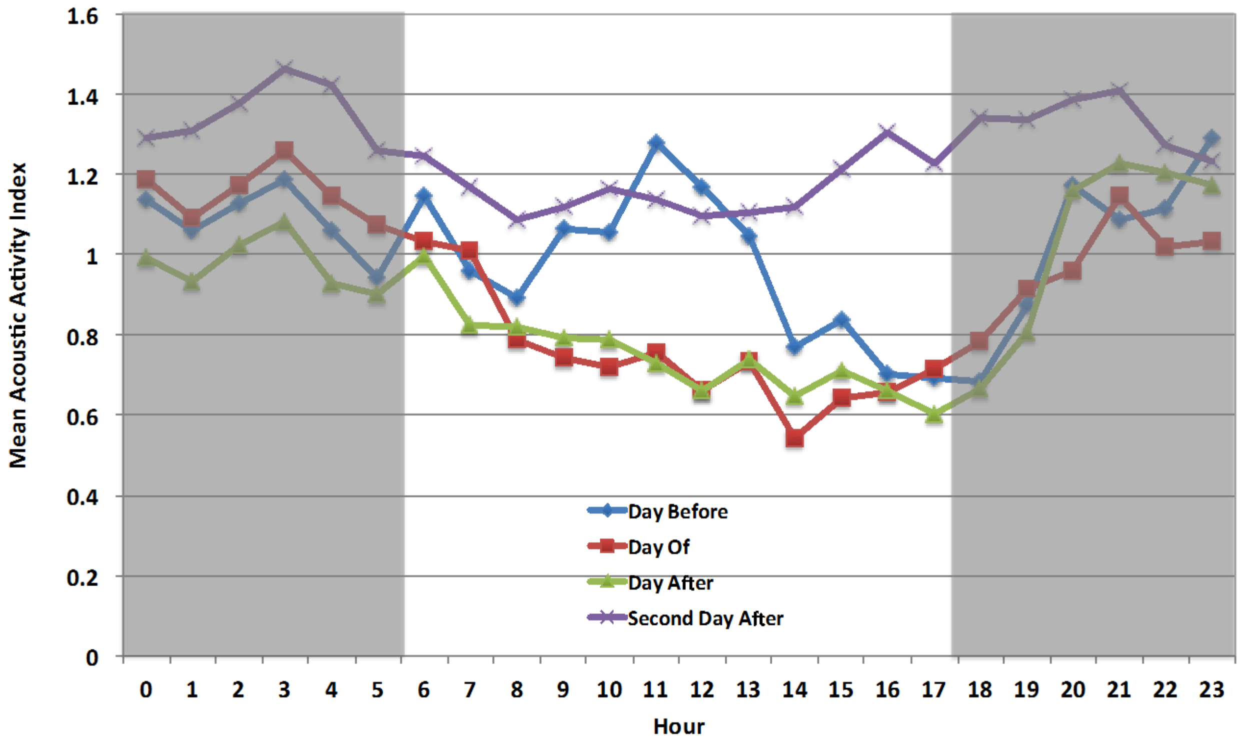


Figure 72. The hourly dolphin acoustic activity observed over the 24-hour period of the days before (*n*=28), the days of (*n*=34), and the first (*n*=30) and second (*n*=25) days after a MINEX training event at site B. Shaded periods represent twilight/nighttime hours, averaged over the year.

Figure 73 presents the 24-hr dolphin acoustic activity observed on the linear-array EARs as a function of the distance from the epicenter of MINEX training for the days before, of, and after a MINEX training event. For the pooled 3-km data (*n*=13 MINEX events), an increase was noted in the acoustic activity between the day before and both the day of and the day after a MINEX event (paired t-tests of mean hourly bins, *p*=0.009 and *p*<0.001, respectively). No inference was attempted on the pooled data from the 6-km sites because of the small sample size (*n*=4) due to instrument problems at this site during two deployments. For the pooled data from 12 km away (*n*=10), no statistically significant differences were found between the days before, during, and after an exercise.

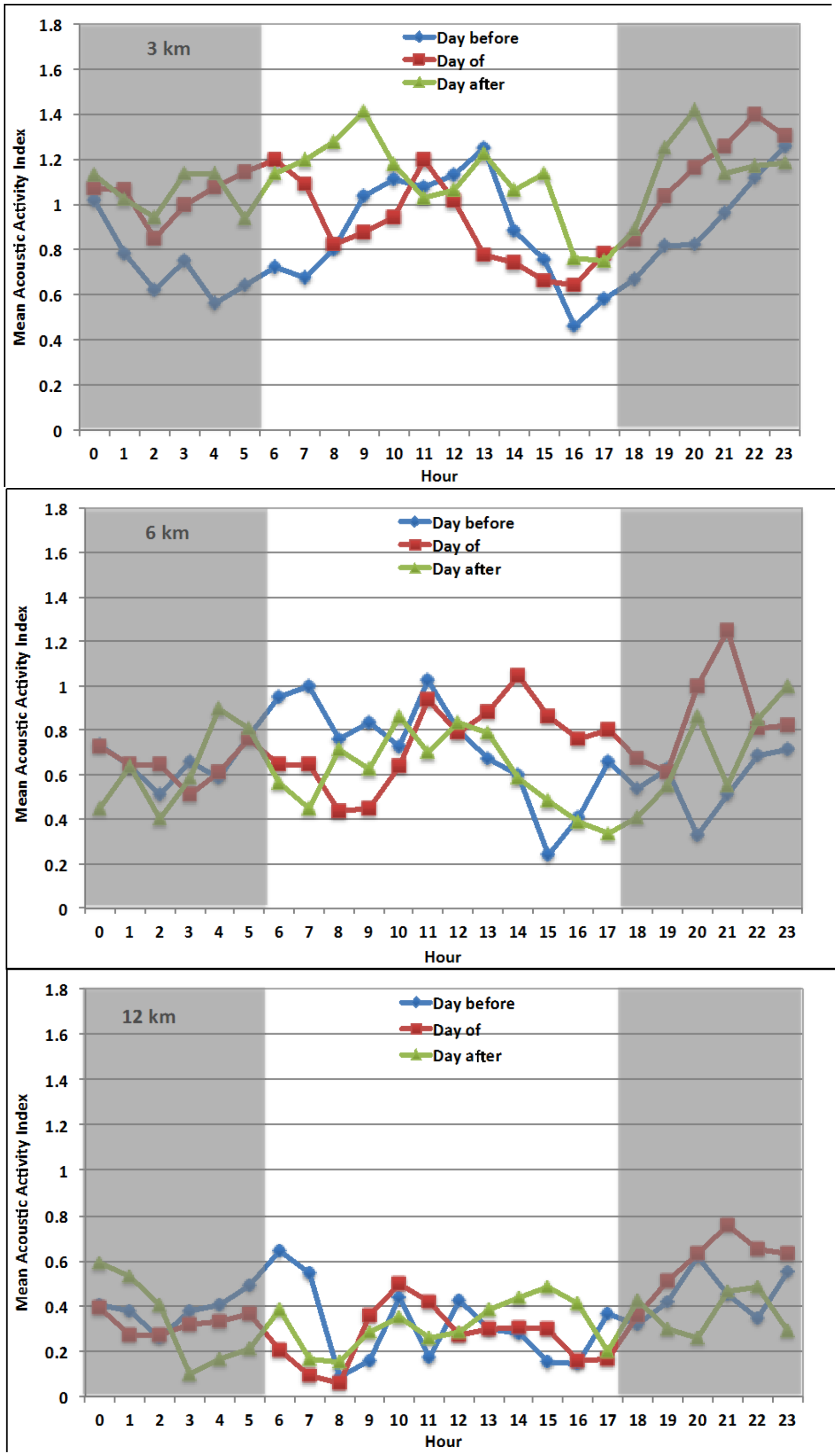


Figure 73. The hourly dolphin acoustic activity observed over the 24-hr period of the days before, the days of, and the days after a MINEX training event pooled across sites 3 km (*n*=13), 6 km (*n*=4) and 12 km (*n*=8) from the epicenter of training activities, regardless of directional orientation of array.

These findings suggest that dolphins are periodically exposed to noise from UNDETs, although it is not clear yet at what range. Based on 3 years of monitoring data, there is strong evidence that dolphins respond behaviorally to MINEX training events. Following an UNDET, acoustic activity decreases during the subsequent hours. It is still not clear whether this represents a suppression of acoustic activity by the animals, individuals moving away from the area, or both. In captive animals, stressful events can lead to periods of reduced or no acoustic activity lasting hours or even days (Sidorova et al. 1990, Castellote and Fossa 2006). It is not known whether free-ranging animals respond similarly. However, the data produced by the EAR array deployments are beginning to shed some light on this question. The sample sizes are still too small to draw any clear conclusions, but the data examined to date do suggest that dolphins may follow a pattern of re-distribution away from the epicenter after a MINEX training event. There is some evidence that dolphins are more acoustically active or abundant 3 km from the epicenter during the day of and the day after an exercise, but additional data must be obtained and analyzed to increase the available sample size. One additional linear array is presently deployed that will hopefully add additional sample points for the analyses presented here and also allow a more detailed examination of the occurrence of dolphins in relation to direction from the epicenter (i.e., north, south, and east). One final round of EAR deployments is scheduled to take place in 2016, which is planned as a localization array.

For more information on this study, refer to the annual progress report for this project (Lammers et al. 2016). The reader is also referred to **Section 2.3.3** for analyses of C-PODs deployed off the coast of Virginia that provide information complementary to the study using EARs.

2.3.3 C-POD Monitoring off Virginia Beach

As noted earlier in **Section 2.1.2.4**, a combination of visual surveys and PAM was used to gather important baseline information on the occurrence, distribution, and density of marine mammals near NSN and adjacent areas. C-POD automated acoustic recorders (www.chelonia.co.uk) were deployed at four locations: MINEX W-50 training range (1 site), JEB-FS, NSN (2 sites), and JEB-LC (1 site; **Figure 74** and **Table 52**). Deployment locations were determined based on the likelihood of overlap between dolphin occurrence and U.S. Navy activities. In total there were seven successful deployments at JEB-LC, five at NSN, and one at the MINEX site. JEB-FS had one moderately successful deployment (**Table 52**). Data were collected year-round at the NSN and JEB-LC sites, but coverage was intermittent for the other two sites.

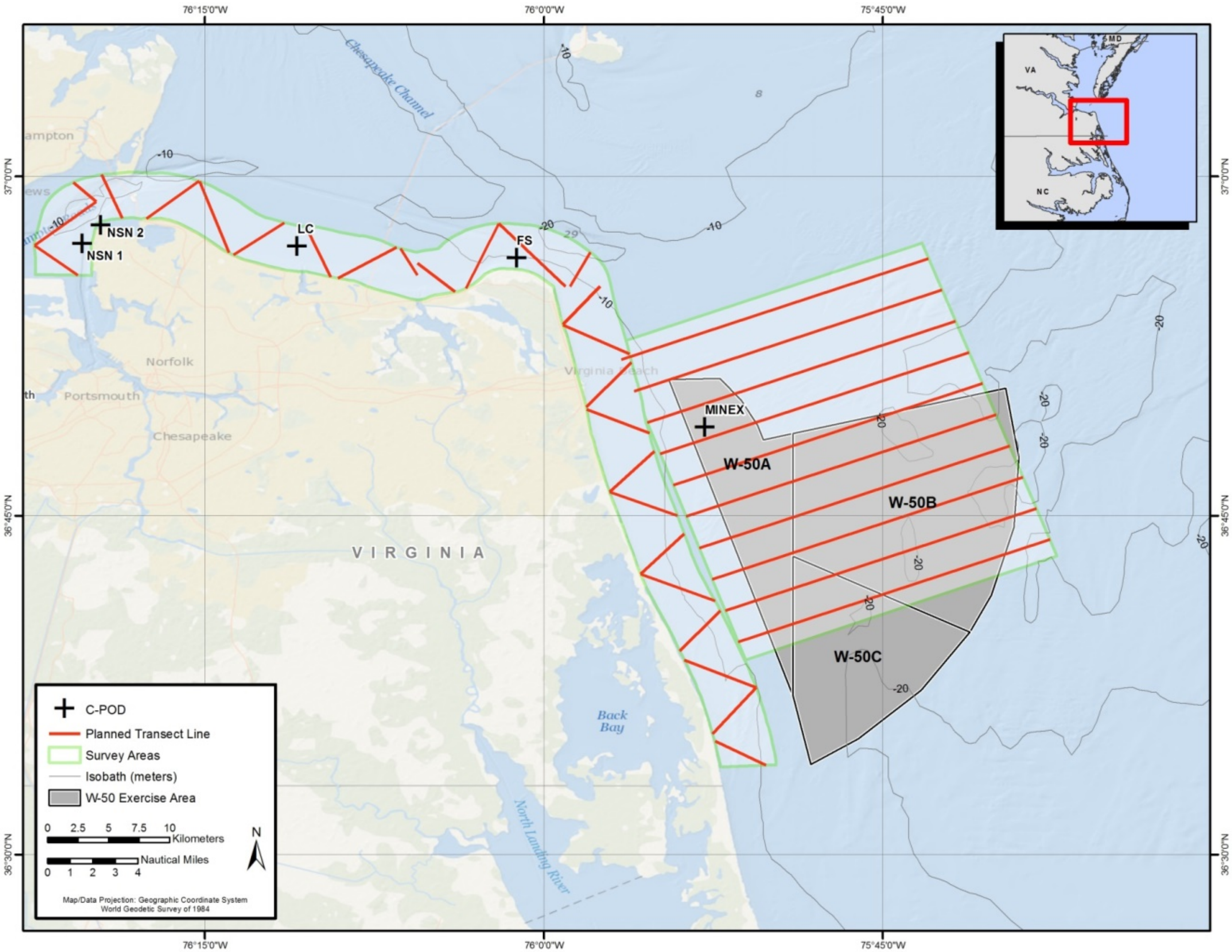


Figure 74. Locations of C-POD deployments off Naval Station Norfolk, Little Creek, and Fort Story, and in the MINEX training range.

Table 52. Deployment details of C-POD automated acoustic recorders.

Deployment Date	Location	Coordinates	Total Days of Logged Data
06 Aug 2012	MINEX	36º 49.905'N, 75º 52.860'W	67
16 Aug 2012	JEB-FS	36º 56.411'N, 76º 01.165'W	57
16 Aug 2012	NSN	36º 57.061'N, 76º 20.444'W	Not recovered
16 Aug 2012	JEB-LC	36º 56.929'N, 76º 10.937'W	52
7 Dec 2012	NSN	36º 57.056'N, 76º 20.498'W	100
7 Dec 2012	JEB-LC	36º 56.940'N, 76º 10.872'W	130
17 Apr 2013	NSN	36º 57.071'N, 76º 20.510'W	Not recovered
17 Apr 2013	JEB-LC	36º 56.936'N, 76º 10.869'W	151
20 Sep 2013	JEB-LC	36º 56.927'N 76º 10.951'W	142
09 Feb 2014	JEB-LC	36º 56.952'N 76º 10.957'W	Not recovered
15 Aug 2014	JEB-LC	36º 56.956'N 76º 10.767'W	181
29 Sep 2014	NSN	36º 57.900'N 76º 19.700'W	114
23 Jan 2015	NSN	36º 57.900'N 76º 19.700'W	128
25 Apr 2015	JEB-LC	36º 56.469'N 76º 10.812'W	130
29 May 2015	NSN	36º 57.900'N 76º 19.700'W	87
29 Aug 2015	NSN	36º 57.900'N 76º 19.700'W	140
30 Aug 2015	JEB-LC	36º 56.477'N 76º 10.807'W	141

Key: JEB-FS = Joint Expeditionary Base Fort Story; JEB-LC = Joint Expeditionary Base Little Creek; MINEX = Mine-neutralization Exercise; NSN = Naval Station Norfolk

C-POD acoustic-detection data were analyzed for the relative presence of echolocation clicks. The detection distance of the C-PODs is thought to be within 1 km (Chelonia Limited Cetacean Monitoring Systems 2014); however, the exact location and number of echolocating animals cannot be determined from the C-PODs alone. Bottlenose dolphins were detected at each deployment location during all deployments from August 2012 through August 2015. Detection data provided some information which was not recorded during visual surveys conducted at the same time. For instance, detections were recorded at both NSN sites during winter, but no dolphins were sighted near the NSN deployment sites during the monthly winter visual line-transect surveys (see **Section 2.1.2.4**). Analysis of the detection data also revealed a diel pattern of occurrence. There were increased detections during nighttime hours at three of the deployment sites. This may indicate an increase in echolocation activity for enhanced navigation during darkness rather than an increase in the number of dolphins.

NSN—Based on the detection-positive minutes (DPM) recorded, the presence of echolocating bottlenose dolphins increased at NSN during the fall. Although detections were recorded year-round, dolphin presence was only consistent during the fall and summer. The year-round presence of dolphins in this area is a cause for concern since the NSN houses a large portion of the U.S. Navy's fleet and has pier construction activities.

JEB-LC—A total of 1,323,269 DPM for bottlenose dolphins was recorded during the seven deployments at JEB-LC. DPM was higher and more consistent at this location during the fall and summer even though detections were recorded during all seasons. The year-round presence of dolphins in this area is a concern since JEB-LC is a busy port for the U.S. Navy.

JEB-FS—The acoustic data recorded in this area support the large number of bottlenose dolphin sightings recorded near Cape Henry during the visual surveys. However, the C-POD at this location went adrift during deployment between 16 August and 15 October 2012 and was recovered in North Carolina. It continued to log data while adrift; therefore, the detections cannot be attributed to a specific fixed location, and a valid comparison to the visual survey data cannot be made.

MINEX—During the 69 days of deployment from 06 August through 13 October 2012, a total of 7,244 DPM for bottlenose dolphins was recorded, with no significant temporal occurrence trends evident aside from a slight increase in DPM during mid-August. The number of acoustic dolphin detections logged in this area (dolphin DPM percentage=7.51 percent) supports the updated visual survey results, which showed an increase in bottlenose dolphin abundance in the MINEX transect coverage area from 829 dolphins during summer to 1,277 dolphins during fall.

For more information on this study, refer to the annual progress report for this project (Engelhaupt et al. 2016).

2.3.4 C-POD Monitoring in Chesapeake Bay (NAS Patuxent)

As noted in **Section 2.1.4**, a monitoring project was initiated in 2015 to provide quantitative data and information on the seasonal occurrence, distribution, and density of marine mammals and sea turtles in Chesapeake Bay waters near NAS PAX. HDR is conducting PAM using C-PODs (passive acoustic data loggers, chelonia.co.uk) to complement the aerial surveys being conducted by UNCW (see **Section 2.1.1.4**) by assessing the seasonality and occurrence of echolocating cetaceans in the study area. Additionally, HDR has collected opportunistic sighting photographs of bottlenose dolphins during the first C-POD deployment and will continue to collect photo-ID data if additional sightings occur during subsequent field efforts to recover and deploy C-PODs (see **Section 2.1.2.5**).

On 11 July 2015, five C-PODs were deployed to detect the presence of echolocating bottlenose dolphins that may be occurring in the study area (**Figure 75**) and to complement the NAS PAX aerial surveys (**Section 2.1.1.4**). The C-PODs were recovered/redeployed on 23 and 24 November 2015. Subsequent trips will be made every 4 months for the remainder of the 2-year project. Preliminary results from the first deployment show that all C-PODs have recorded good-quality data and all were still logging data when recovered in late November 2015.

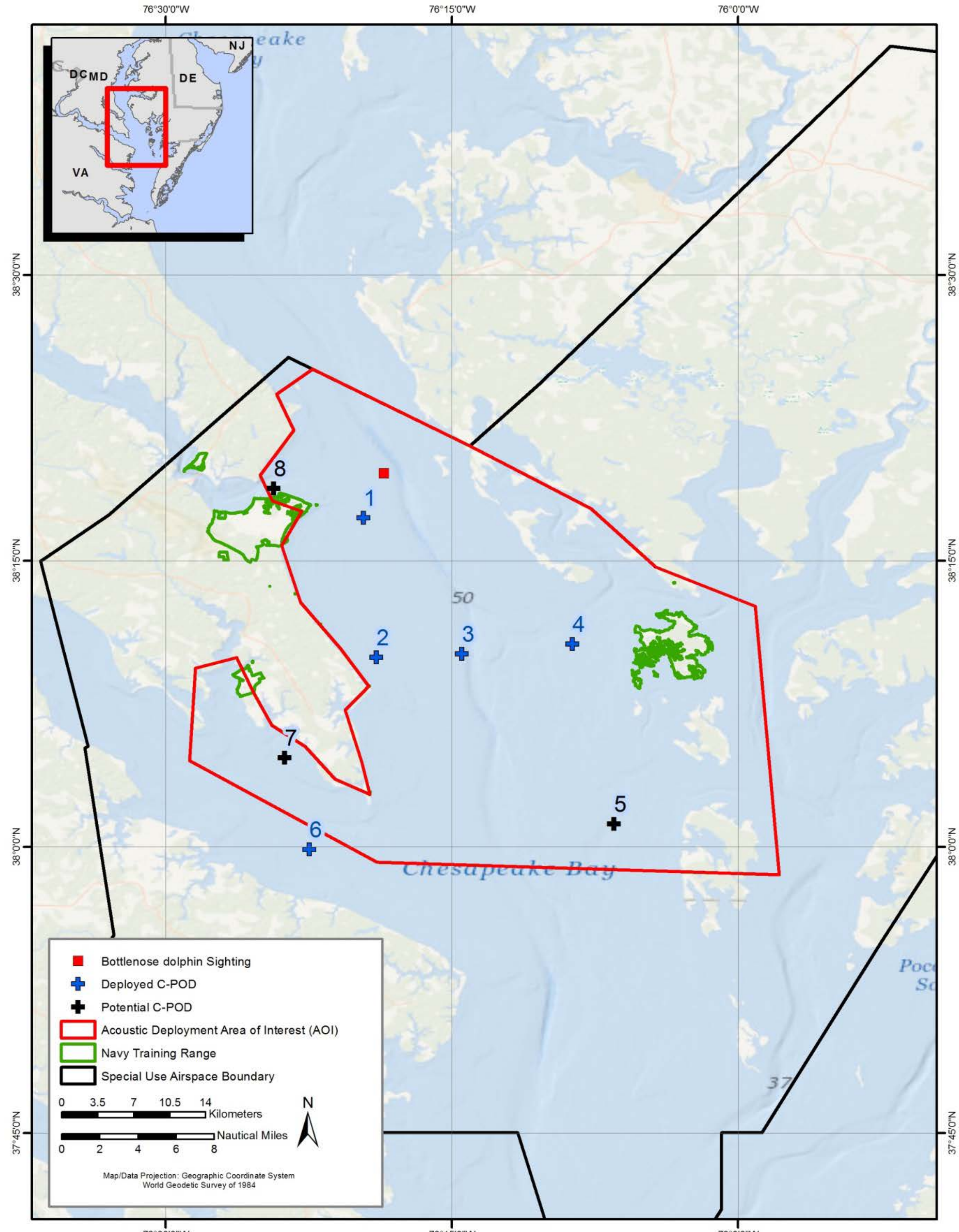


Figure 75. Locations of C-POD deployments around NAS PAX (blue +) and alternative sites for potential future deployments (black +). The red square indicates the location of a dolphin sighting during the first C-POD deployment on 12 July 2015.

Dolphins were detected on each of the C-PODs. In general, the C-PODs had very low DPM and the data were able to be visually inspected for data validation. Only three DPM were removed due to being false positives, and all data presented here are verified to be correctly classified as dolphins. Dolphin occurrence, as expected, was higher during the first part of the deployment, indicating a summer presence in the NAS PAX area (**Figures 76** and **77**). The DPM decreased in the fall and no detections were made towards the end of the first deployment (November 2015). There was a diel pattern evident, with more DPM during nighttime periods (**Figure 78**). Each of the DPM figures (**Figures 73** and **74**) aggregates dolphin detections across all five sites to demonstrate overall occurrence and acoustic detection trends.

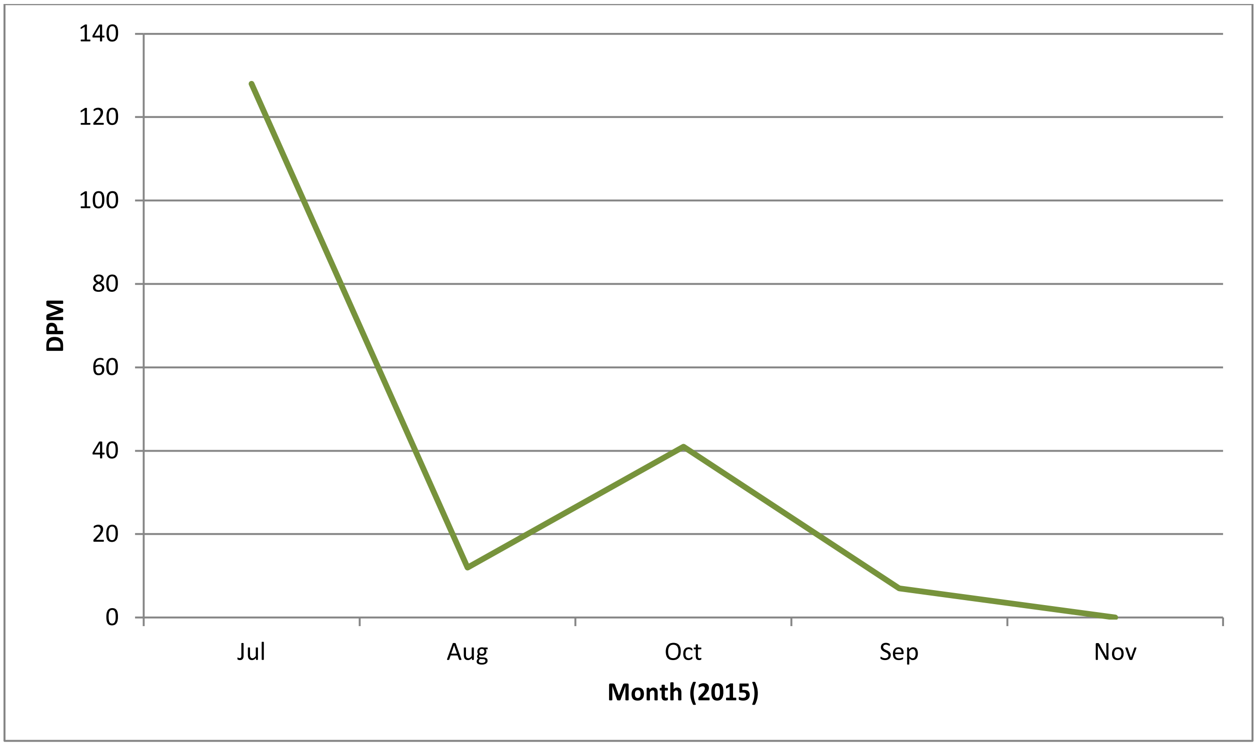


Figure 76. Numbers of dolphin DPMs, summed across all NAS PAX sites by month, for the duration of the first deployment, 11 July–24 November 2015 (*n*=188).

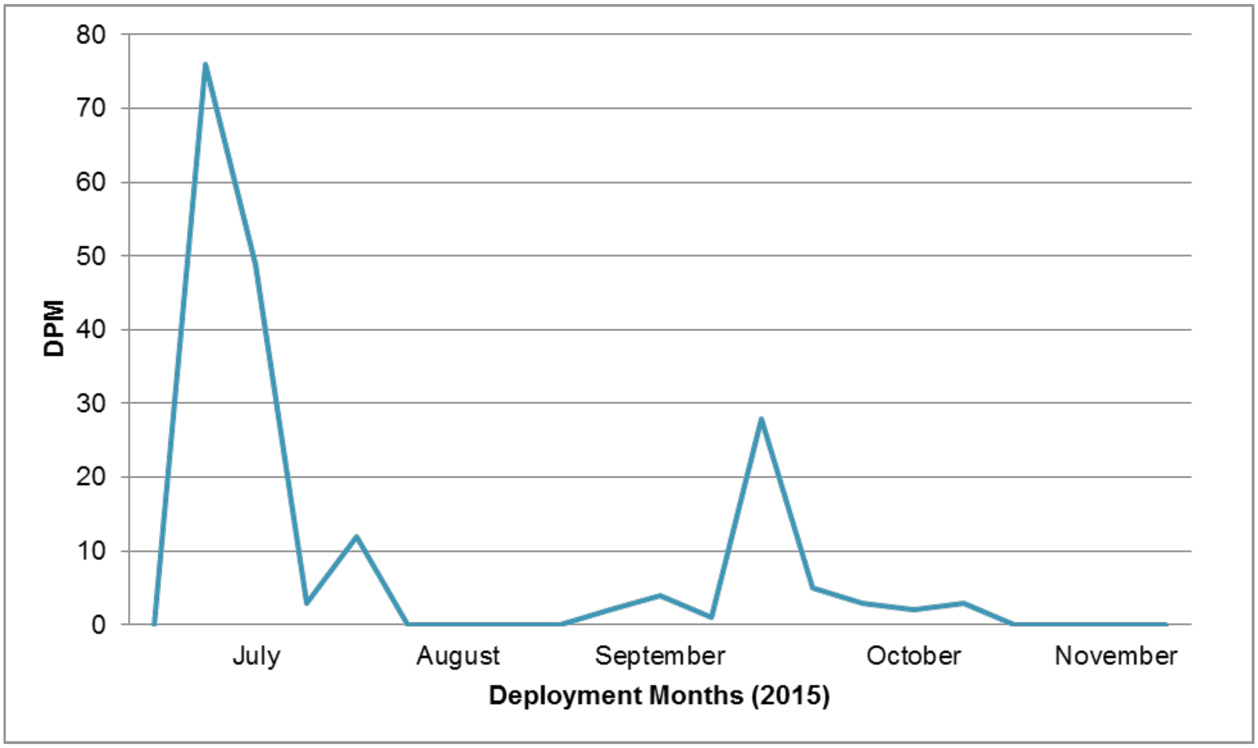


Figure 77. Weekly dolphin detection-positive minutes for the duration of the first C-POD deployment, 11 July–24 November 2015 (total *n*=188).

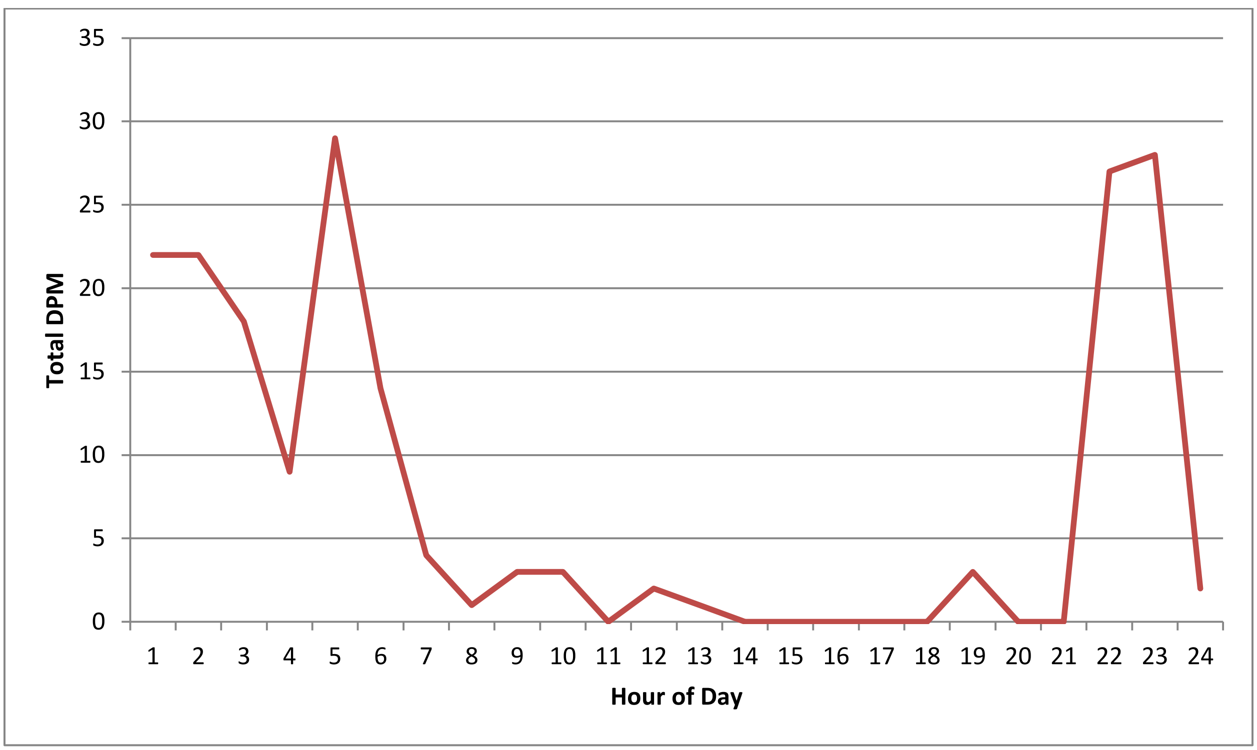


Figure 78. Dolphin DPMs per hour of the day summed across all PAX sites for the duration of the first deployment, 11 July–24 November 2015 (*n*=188).

For more information, refer to the annual progress report for this project (Richlen et al. 2016a).

2.3.5 Marine Autonomous Recording Units–Right Whales in the Cape Hatteras Survey Area

In fall 2013, a PAM effort was initiated by Duke University and NMFS/NEFSC to detect North Atlantic right whales migrating past Cape Hatteras during their seasonal movements to and from winter breeding grounds in Florida. The objectives of this project are to investigate the timing of North Atlantic right whale migration through the mid-Atlantic region, as well as the relative distance from shore and acoustic behavior of migrating whales. This effort will help to fill a data gap in the central portion of the potential migratory corridor, and contribute to a broader understanding of the seasonal occurrence of North Atlantic right whales along the U.S. Atlantic Coast. The project is ongoing; details are provided here on passive acoustic data collection and analysis between October 2014 and December 2015.

Passive acoustic data were collected using five Marine Autonomous Recording Units (MARUs) deployed in a linear configuration across the continental shelf at Cape Hatteras on 06 October 2014 (**Figure 79** and **Table 53**). MARU 03-3 surfaced during a strong storm on 07 December 2014. This unit was tracked via the ARGOS satellite system as it drifted south to near the Bahamas. A recovery effort was launched from Great Abaco Island, and the MARU was successfully retrieved on 31 March 2015. The remaining four units were recovered off Cape Hatteras on 09 March 2015, and were replaced with five new units in the same locations (**Table 53**). No MARUs from this deployment were lost, and all five units were recovered from the deployed locations on 20 August 2015, completing data collection for the project.

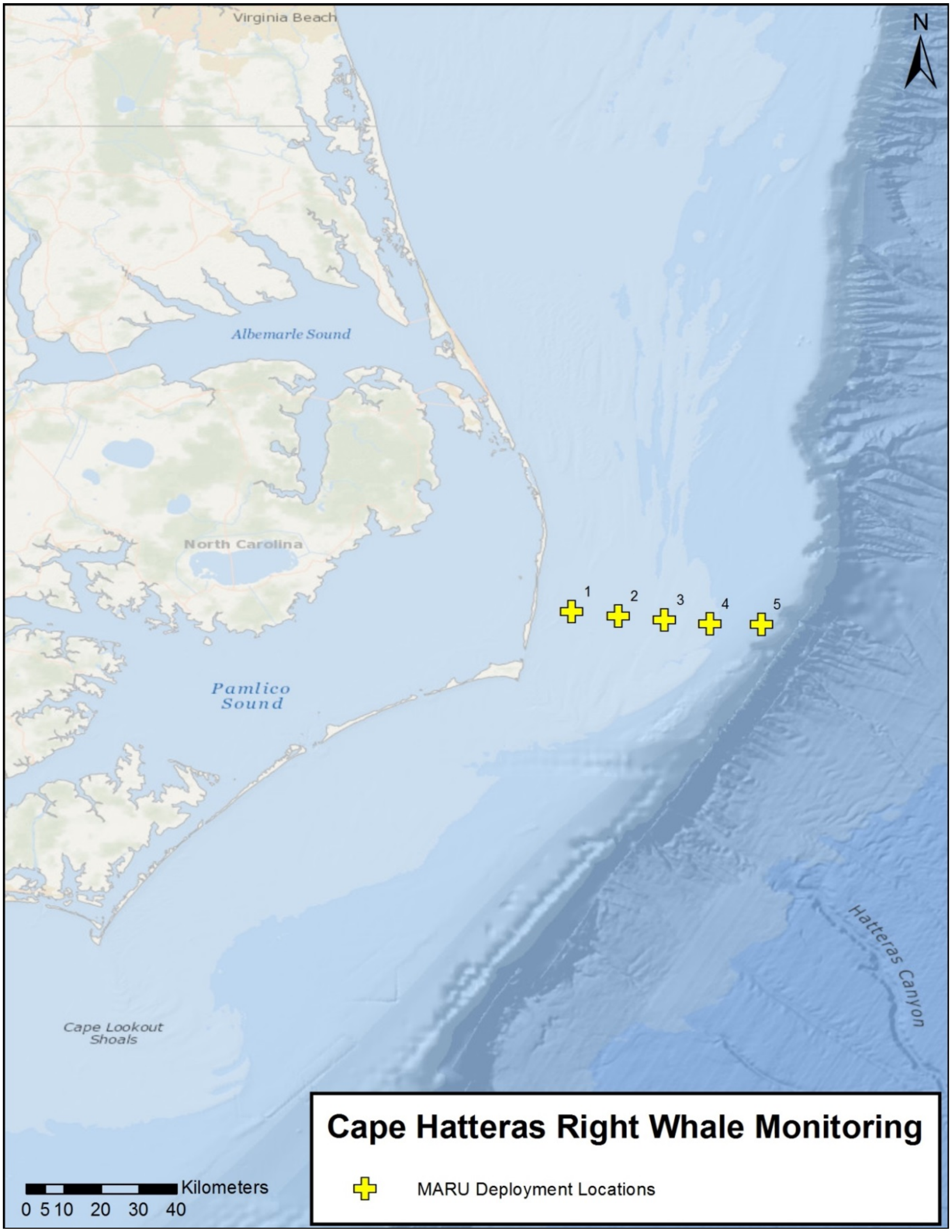


Figure 79. Locations of the MARU deployment sites off Cape Hatteras.

Table 53. Hatteras03 and Hatteras04 MARU deployments at Cape Hatteras, North Carolina, in fall 2014 and spring 2015.

Site	Deployment Date	Retrieval Date	In-water Recording Start Date	Recording End Date	Latitude (N)	Longitude (W)	Depth (m)	Sampling Rate	Duty Cycle
03-1	06-Oct-14	09-Mar-15	06-Oct-14	09-Mar-15	35.40077	75.40158	21	2 kHz	continuous
03-2	06-Oct-14	09-Mar-15	06-Oct-14	09-Mar-15	35.36869	75.28465	25	2 kHz	continuous
03-3	06-Oct-14	31-Mar-15	06-Oct-14	07-Dec-14	35.36739	75.17415	28	2 kHz	continuous
03-4	06-Oct-14	09-Mar-15	06-Oct-14	09-Mar-15	35.36174	75.07080	31	2 kHz	continuous
03-5	06-Oct-14	09-Mar-15	06-Oct-14	09-Mar-15	35.36113	74.94650	90	2 kHz	continuous
04-1	09-Mar-15	20-Aug-15	09-Mar-15	20-Aug-15	35.40117	75.40137	20	2 kHz	continuous
04-2	09-Mar-15	20-Aug-15	09-Mar-15	20-Aug-15	35.36884	75.28403	22	2 kHz	continuous
04-3	09-Mar-15	20-Aug-15	09-Mar-15	20-Aug-15	35.36747	75.17331	33	2 kHz	continuous
04-4	09-Mar-15	20-Aug-15	09-Mar-15	20-Aug-15	35.36181	75.07053	35	2 kHz	continuous
04-5	09-Mar-15	20-Aug-15	09-Mar-15	20-Aug-15	35.36148	74.94601	91	2 kHz	continuous

Key: Aug = August; Feb = February; kHz = kilohertz; m = meter(s); Mar = March; N/A = not available; Oct = October

The Hatteras03 deployment in fall 2014 resulted in 153 full recording days on four MARUs, and 61 usable recording days on MARU 03-3 before it went adrift. The Hatteras04 deployment in spring 2015 resulted in 163 full recording days on all five MARUs.

Data from all recovered MARUs from the Hatteras03 (fall 2014) deployment were analyzed for North Atlantic right whale up-calls. Analysis of the Hatteras04 dataset is still in progress; the results for that dataset are not reported here. An automated low-frequency detection and classification system (Baumgartner and Mussoline 2011) was used to scan the recordings for potential right whale up-calls.

Up-calls were detected on 62 of 153 total recording days (41 percent of days) in the Hatteras03 dataset. Up-calls were detected between 27 October 2014 and 08 March 2015. There were unique detections across all five sites, with the highest occurrence of up-call detections at Site 2, peaking in early January (**Figure 80**). Detections at sites 4 and 5 occurred later in the season, with a peak at Site 5 in mid-February (**Figure 80**). Analysis of the diel occurrence of detected up-calls showed an increase in calling activity during the late afternoon and evening hours (**Figure 81**).

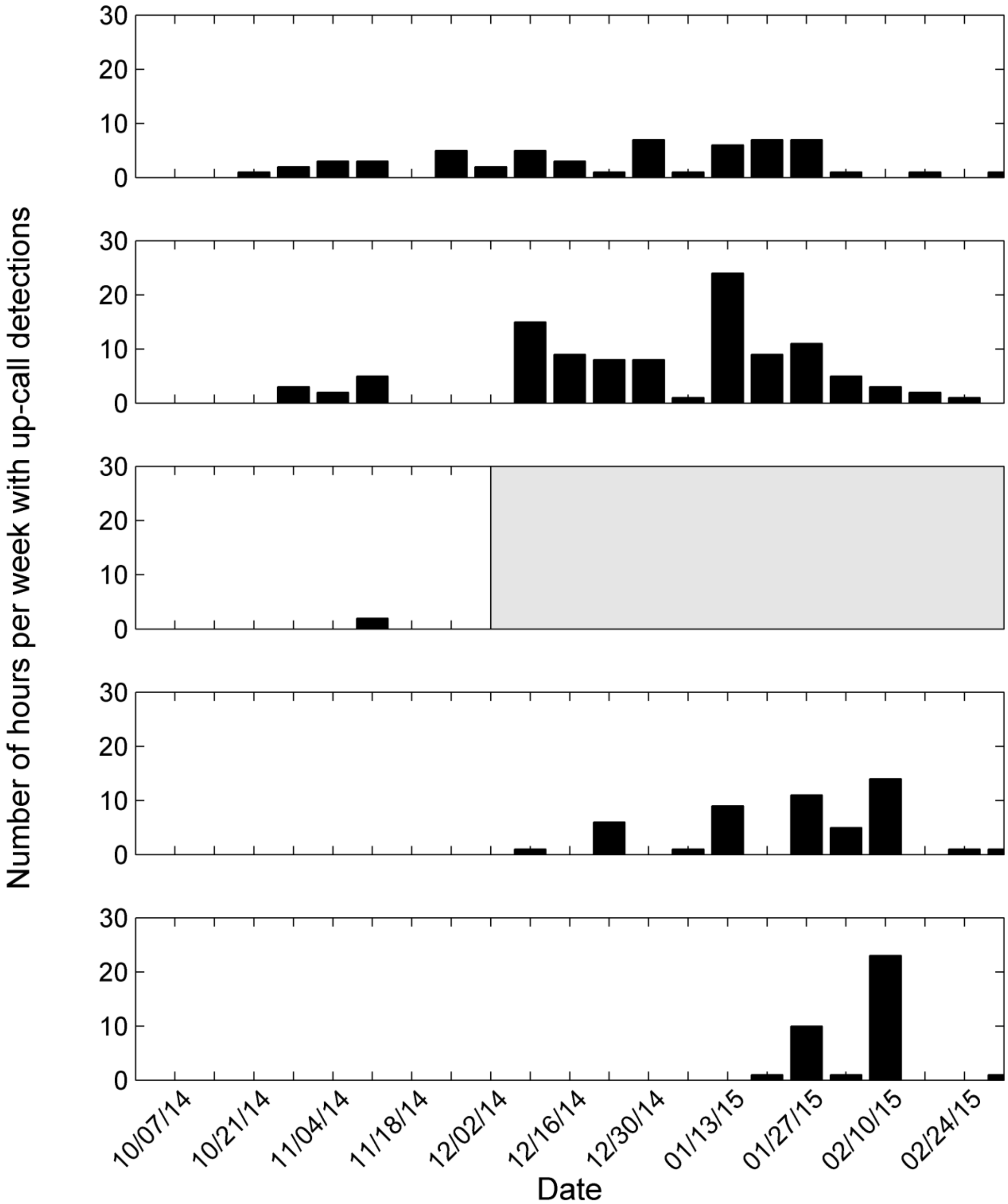


Figure 80. Weekly occurrence of unique up-call detections across MARU sites 1 (top) through 5 (bottom) between 07 October 2014 and 08 March 2015. Gray shading indicates periods of no data.

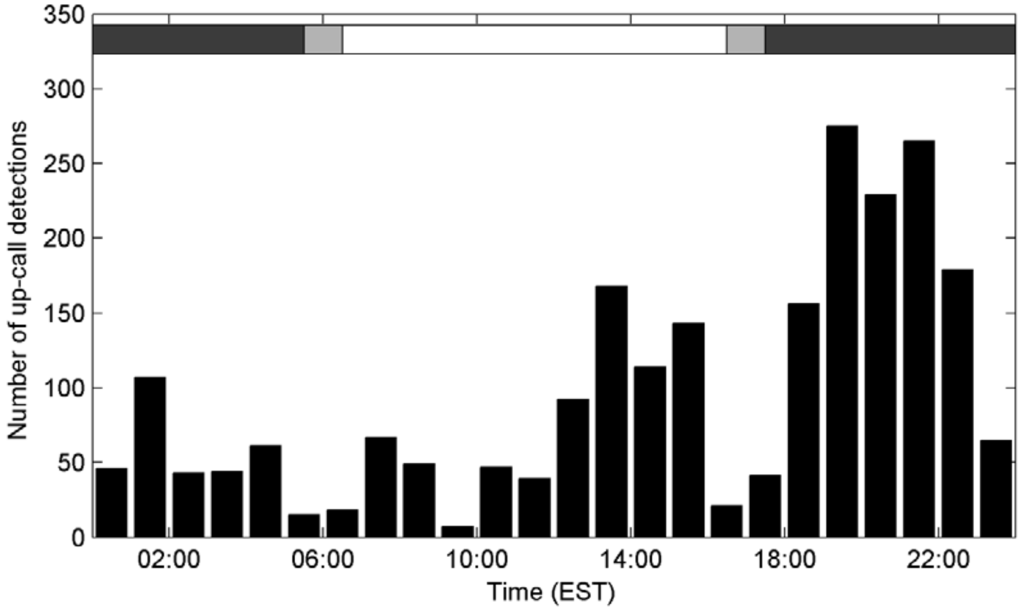


Figure 81. Diel pattern of right whale up-calls detected on all MARUs at Cape Hatteras between 07 October 2014 and 08 March 2015. Vertical bars represent the summed number of unique up-call detections in each hour of the day. The horizontal bar indicates periods of darkness (dark gray), periods of daylight (white), and periods that were either dark or light depending on the time of year (light gray).

For more information on this study, refer to the annual progress report for this project (Stanistreet et al. 2016).

2.3.6 Effect of Depth on Automated Whistle Classifiers

Passive acoustic monitoring is used extensively to collect information regarding marine mammal occurrence, distribution and behavior in areas with high naval activity, and mitigation efforts rely heavily on data obtained by seafloor recorders. However, the suitability of automated species classifiers trained using surface data from towed arrays for analyzing recordings obtained at depth is currently unknown. If classifiers perform differently on data recorded at depth, it may be necessary to re-train them to ensure accurate results. Similarly, if the behavior of animals or signal propagation affects the identification of species using echolocation clicks, this must be understood and integrated into analysis methods.

A 2-year study was initiated in 2015 to explore some of the factors that may contribute to ambiguity in acoustic identification of odontocete species using whistles and echolocation clicks. This project is a collaboration between Bio-Waves, Inc. and OSI. There are two components to this effort, *in situ* recordings of captive trained animals producing sound in San Diego Bay and recordings of wild animals in their natural habitat. As OSI is based in Hawaii, it was selected as an ideal site for the latter efforts as resources were in place, and there was a higher likelihood of encountering multiple species close to shore off the Kona coast.

Data Collection

Field acoustic recordings of odontocetes collected under a variety of scenarios—at the sea surface, at multiple depths in the water column, in different geographic locations, and under different behavioral conditions—are being examined, and the characteristics of the sounds recorded at different depths are being compared. Two types of vertical arrays were used to obtain recordings of whistles and echolocation clicks at different depths: (1) surface array of miniature Marine Autonomous Recorder System (microMARS) recorders (http://www.desertstar.com/acoustic-recorders.html) and (2) bottom array of second-generation EARs (EAR2s).

The surface microMARS array was deployed from a small (approximately 7.3-m) vessel and was composed of two vertical sub-arrays: a localization array with four broadband hydrophones spaced 10 m apart, and a line array made up of five microMARS recorders spaced 50 m apart and to a maximum depth of 250 m (**Figure 82**). The microMARS is a new type of low-cost acoustic recorder with a maximum sampling rate of 250 kHz and up to 512 gigabytes of storage space. A miniature Conductivity-Temperature-Depth probe was fixed to the bottom of the array and obtained water column profiles upon deployment and recovery. These data will be used to calculate sound-speed profiles, which will be used to investigate the effects of sound propagation on received signal properties. The microMARS line array was used to record visually detected schools of odontocetes at multiple depths. When a group of odontocetes was sighted by the observers on board the vessel, the observers spent 30 min to 1 hr observing the animals to determine their behavior, and direction and rate of travel. When the observers determined the behavioral state and movement patterns of the school, the vessel moved approximately 1 km ahead of the school and the surface array was deployed manually. Recordings were made as the school approached the boat and until it moved out of acoustic detection range.

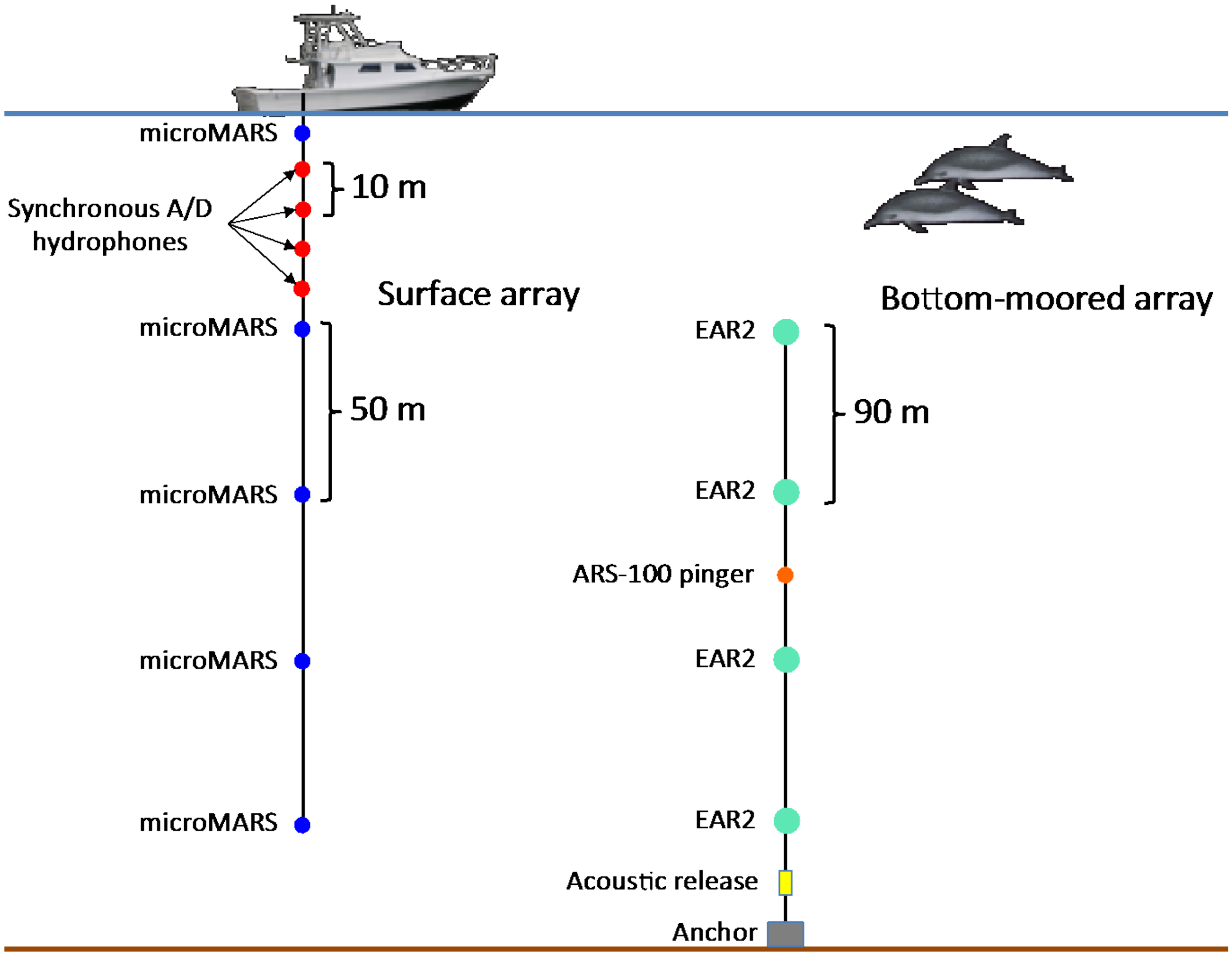


Figure 82. Schematic of the surface microMARS array and bottom-moored EAR2 array that was used for this project. Drawings and measurements are not to scale.

The bottom-moored vertical array was made up of four EAR2s spaced 90 m apart (**Figure 82**). The EAR2 is a redesigned version of the EAR and has a maximum sampling rate of 125 kHz and up to 1 terabyte of storage space and is able to sample continuously. The array also included a RJE International Acoustic Reference Source (ARS)-100 pinger, which provided a 4- to 7-kHz synchronization pulse every 30 min. This pulse was recorded on the four EAR2 recorders and will be used to time-align recordings during analysis in order to localize signaling animals and determine their range and depth. A miniature Conductivity-Temperature-Depth probe is fixed to the bottom of the moored array to allow calculation of the sound-speed profile at the deployment site at the time of deployment and the time of recovery. The EAR2 array was deployed on the sea floor at locations of known high odontocete activity at bottom depths between 500 m and 950 m for periods of 1 to 2 weeks during all field work efforts. The bottom-moored EAR2 array was left in place to record odontocete signals at night and on days when data collection using the surface array was not taking place.

A pilot field effort was conducted in the Main Hawaiian Islands, from 02 August through 12 August 2015. At the beginning of this effort, the bottom-moored EAR2 array was deployed approximately 5.6 km south of the island of Lanai, in waters 355 m deep (**Figure 83**). After deployment of the bottom-mounted EAR2 array, visual surveys were conducted off the islands of Maui and Lanai using the 7.9-m R/V *Aloha Kai* and 6.4-m R/V *Coho* (due to engine problems on the R/V *Aloha Kai*). The surface microMARS array was used to record groups of odontocetes that were encountered during these surveys. Three different microMARS hydrophones with different sensitivities and frequency ranges were tested to determine which would be best suited for the project. Two of the hydrophones had flat frequency responses up to 33 kHz and one had a flat frequency response up to 125 kHz. The configuration of microMARS hydrophones on the array was changed several times during the field testing period to compare their performance relative to one another. In addition, various strategies for deployment and recovery of the surface array were tested. Finally, the sub-array hydrophones and broadband recorder were tested using different gain levels. Based on examinations of the microMARS recordings, it was decided that the broadband hydrophones (125 kHz) with the highest sensitivity are necessary to capture the most whistles and echolocation clicks. These hydrophones were subsequently used in all microMARS during the Kona field work and will be used in all microMARS during the upcoming San Diego field work.

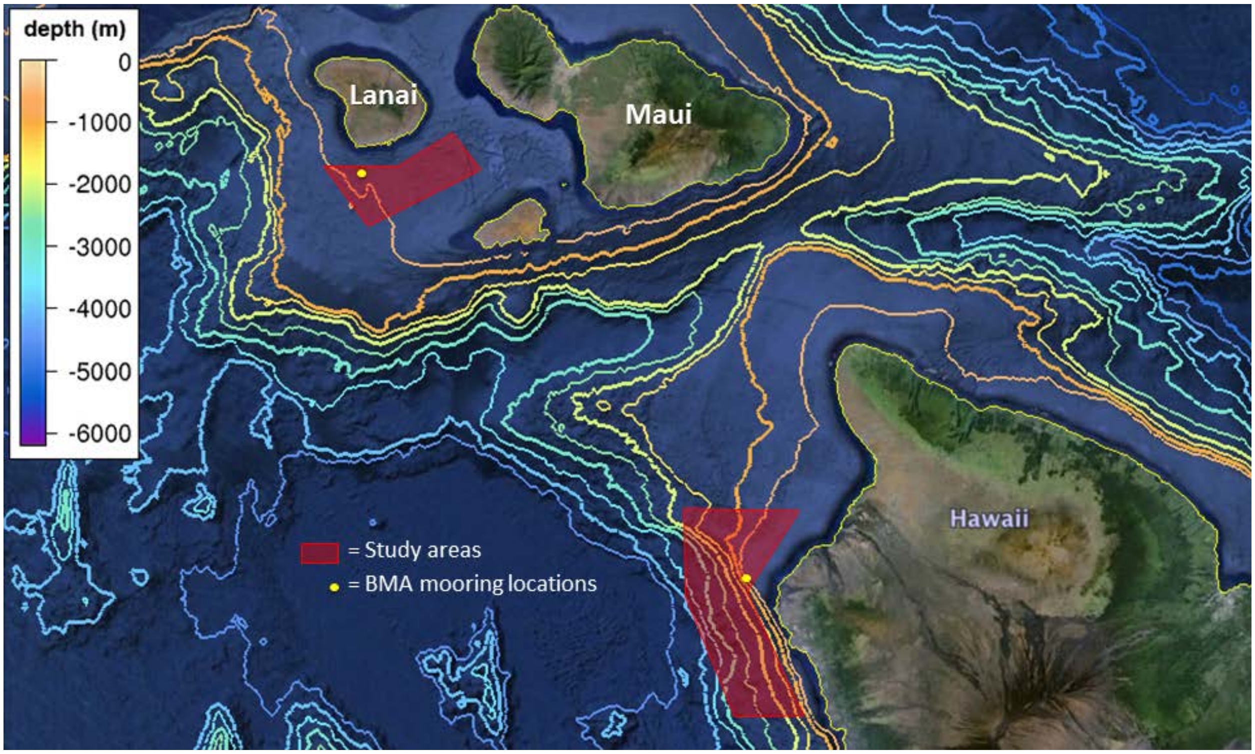


Figure 83. Lanai and Kona coast study areas, with bottom-moored EAR2 array (BMA) locations shown as yellow circles.

A field data-collection effort was conducted off the Kona (west) coast of the island of Hawaii from 02 to 14 November 2015. The bottom-moored EAR2 array was deployed for the duration of this effort, north of Kona in waters 400 m deep. Visual surveys were conducted along the Kona coast using the 7.9-m R/V *Hopena*, and the surface array of microMARS was used to record groups of odontocetes that were encountered.

A 2-week field data-collection effort is planned for spring 2016 off the coast of San Diego, California. During this effort, the bottom-moored EAR2 array will be deployed in waters approximately 400 m deep, and visual surveys will be conducted offshore of San Diego using a research vessel of similar size to that used during the Hawaii efforts. The surface microMARS array will be used to record groups of odontocetes that are encountered during these surveys.

In addition to the vessel surveys, controlled data collection will be conducted in collaboration with the U.S. Navy's Marine Mammal Program. During this effort, trained U.S. Navy dolphins will be taken into open water and stationed at a known depth, distance, and orientation from the surface and bottom-moored arrays. The dolphins will produce whistles while on station and these whistles will be recorded using both arrays.

Whistle Analysis Methodology

Initial analysis focused on data recorded during the pilot deployment of the bottom-mounted EAR2 array off the island of Lanai. Triton software (Wiggins 2007) was used to create LTSAs from recordings from all four EAR2s in the array. Analysts reviewed these LTSAs to identify delphid vocalization events, and then used Raven software to examine spectrograms of those vocalization events. Analysts then extracted time-frequency contours from the selected whistles in each event using the Real-time

Odontocete Call Classification Algorithm (ROCCA; Oswald et al. 2013) module in the acoustic data-processing software platform PAMGuard (Gillespie et al. 2008). ROCCA automatically measured 50 variables from each extracted contour. The whistle variables were used to classify whistles to species using a random-forest classifier within ROCCA. The random-forest classifier used in this analysis was a two-stage classifier trained using whistles recorded from single-species schools in the tropical Pacific Ocean. Six species were included in the model: short-finned pilot whale, false killer whale (*Pseudorca crassidens*), pantropical spotted dolphin (*Stenella attenuata*), bottlenose dolphin, rough-toothed dolphin, and spinner dolphin (*Stenella longirostris*). The first stage consisted of classifying whistles to one of two categories: 'large delphinids-*Steno'* (including false killer whales, pilot whales and rough-toothed dolphins) and '*Stenella-Tursiops*' (including spinner, spotted, and bottlenose dolphins). In stage two of the model, whistles within each category were then classified to species. Encounters were classified based on classification results summed over all whistles in the encounter. Individual whistle classifications and overall encounter classifications were compared among EAR2s for each encounter to evaluate whether observed differences in whistle structure among EAR2s affected classifier performance.

Results to Date

During the pilot field effort off the island of Lanai, 31 hr of survey effort were spent searching for and recording odontocetes over 6 days. Odontocetes were encountered and recorded with the surface microMARS array on four occasions. These encounters included two groups of pantropical spotted dolphins, one group of spinner dolphins, and one group of short-finned pilot whales. All EAR2s recorded successfully during the deployment period and the ARS-100 pinger transmitted signals every 30 min as designed. The average depth of each EAR2, based on depth-recorder readings throughout the deployment is provided in **Table 54**. The EAR2 bottom-mounted array yielded 2,063 2-min recordings, or approximately 68.7 hr of data per recorder. These recordings contain 28 delphinid encounters.

Table 54. Average depth (standard deviation in parentheses) of each EAR2 in the bottom-mounted array. No depth sensors were used for the pilot work, so depths are estimated based on the depth of deployment and the spacing between EAR2s. Depths for the Kona field effort are based on depth-recorder readings throughout the deployment.

EAR2 Number	Average Depth (m)	
	Pilot Work	Kona
EAR1	70	118 (1.2)
EAR2	160	209 (0.9)
EAR3	250	289 (0.6)
EAR4	340	389 (1.8)

During the Kona field effort, 80 hr of survey effort were spent searching for and recording odontocetes over 8 days. Odontocetes were encountered and recorded with the surface microMARS array on 14 occasions (**Table 55**). Six delphinid species were observed: pantropical spotted dolphin, short-finned pilot whale, rough-toothed dolphin, false killer whale, spinner dolphin, and pygmy killer whale (*Feresa attenuata*). The EAR2s yielded 538 2-min recordings, or approximately 18 hr of data per recorder. The average depth of each EAR2, based on depth recorder readings throughout the deployment is given in **Table 54**.

Table 55. Number of encounters per species recorded with the surface microMARS array during the Kona field effort.

Species	Number of Encounters
Pantropical spotted dolphin	7
Short-finned pilot whale	3
Rough-toothed dolphin	1
False killer whale	1
Spinner dolphin	1
Pygmy killer whale	1

Whistle Analysis

From the Lanai pilot field effort, whistles were measured and classified from 13 of the 28 encounters recorded by the bottom-mounted EAR2 array (**Table 56**). Seven of the 28 encounters did not contain enough whistles to be included in the analysis, and the remaining eight encounters are currently being analyzed. Results of statistical comparisons among EAR depths and classification results are provided in **Table 57**. One or more variables were significantly different (Kruskall-Wallis test and post-hoc Dunn's tests with Bonferonni correction, α=0.05) when compared among EARs for seven of the 13 encounters. Most of the significant differences were frequency variables; mean, median and center frequency were significantly different among EARs for six of the encounters that had significant differences (**Table 57**). Slope variables, duration, and other frequency variables were also significantly different for some of the encounters.

Table 56. Date, start time, end time for each acoustic encounter recorded on the EAR array during the pilot work off Lanai.

Encounter	Date	Start Time	End Time
1	8/4/2015	4:24:13	6:25:52
2	8/4/2015	12:52:42	13:30:04
5	8/5/2015	7:48:03	8:19:05
7	8/6/2015	3:54:55	4:13:03
9	8/6/2015	10:42:05	11:06:04
10	8/6/2015	12:43:04	13:07:04
11	8/6/2015	17:00:03	17:30:07
14	8/7/2015-8/8/2015	20:06:35	1:36:03
16	8/8/2015	10:54:04	11:48:03
19	8/9/2015	8:36:04	12:12:04
22	8/10/2015	2:55:34	7:30:04
23	8/10/2015	11:48:03	13:31:12
27	8/11/2015	17:24:59	20:54:35

Table 57. Variables that were significantly different when the same whistles were measured from recordings made at different depths. Species that encounters were classified as based on those same whistles are given for each EAR with number of whistles that each classification was based on in parentheses.

Encounter	Significant Variable	EARs	*p*	Classified as			
				EAR1	EAR2	EAR3	EAR4
1	Mean frequency	EAR1-EAR4	0.004	Spinner (*n*=5)	Bottlenose (*n*=6)	Bottlenose (*n*=7)	Bottlenose (*n*=19)
		EAR2-EAR4	0.02				
		EAR3-EAR4	0.05				
	Median frequency	EAR1-EAR4	0.01				
		EAR2-EAR4	0.01				
		EAR3-EAR4	0.04				
	End frequency	EAR1-EAR4	0.05				
	Maximum frequency	EAR1-EAR4	0.008				
		EAR2-EAR4	0.02				
		EAR3-EAR4	0.04				
	Minimum frequency	EAR1-EAR4	0.01				
	Center frequency	EAR1-EAR4	0.002				
		EAR2-EAR4	0.03				
		EAR3-EAR4	0.01				
	Mean negative slope	EAR3-EAR4	0.03				
2	None			Bottlenose (*n*=44)	Bottlenose (*n*=42)	Bottlenose (*n*=43)	Bottlenose (*n*=49)
5	Mean frequency	EAR1-EAR3	0.03	Spinner (*n*=16)	Spinner (*n*=12)	Spinner (*n*=20)	Spinner (*n*=21)
		EAR1-EAR4	0.007				
	Median frequency	EAR1-EAR3	0.03				
		EAR1-EAR4	0.008				
	Beginning frequency	EAR1-EAR3	0.03				
		EAR1-EAR4	0.01				
	Minimum frequency	EAR1-EAR3	0.008				
		EAR1-EAR4	0.02				
	Center frequency	EAR1-EAR3	0.01				
		EAR1-EAR4	0.003				
	Duration	EAR1-EAR3	0.04				
	Mean slope	EAR1-EAR4	0.01				
7	Mean frequency	EAR1-EAR3	0.04	Spinner (*n*=12)	Spinner (*n*=10)	Spotted (*n*=9)	Spotted (*n*=6)
		EAR1-EAR4	0.03				
	Median frequency	EAR1-EAR3	0.03				
		EAR1-EAR4	0.01				
	Center frequency	EAR1-EAR4	0.02				
	Mean negative slope	EAR1-EAR4	0.02				
9	none			Spinner (*n*=1)	Bottlenose (*n*=7)	Spinner (*n*=13)	Spinner (*n*=29)
10	Mean frequency	EAR2-EAR4	0.02	n/a	Spotted	Spinner	Striped

Encounter	Significant Variable	EARs	*p*	Classified as			
				EAR1	**EAR2**	**EAR3**	**EAR4**
		EAR3-EAR4	0.01	(*n*=0)	(*n*=2)	(*n*=12)	(*n*=20)
	Median frequency	EAR2-EAR4	0.02				
		EAR3-EAR4	0.01				
	Maximum frequency	EAR2-EAR4	0.02				
	Center frequency	EAR2-EAR4	0.02				
		EAR3-EAR4	0.02				
11	Mean frequency	EAR1-EAR2	0.03	Spinner (*n*=6)	Rough-toothed (*n*=14)	Spinner (*n*=27)	Spinner (*n*=13)
		EAR2-EAR3	0.004				
	Median frequency	EAR1-EAR2	0.02				
		EAR2-EAR3	0.02				
	Ending frequency	EAR1-EAR2	0.002				
	Maximum frequency	EAR2-EAR3	0.007				
	Center frequency	EAR1-EAR2	0.03				
		EAR2-EAR3	0.005				
	Duration	EAR2-EAR3	0.02				
		EAR2-EAR4	0.003				
	Percent flat	EAR1-EAR2	<0.001				
		EAR2-EAR4	0.006				
	Mean absolute slope	EAR1-EAR2	0.01				
		EAR2-EAR3	0.04				
14	None			Rough-toothed (*n*=48)	Rough-toothed (*n*=50)	Rough-toothed (*n*=49)	Rough-toothed (*n*=50)
16	None			Pilot whale (*n*=39)	Pilot whale (*n*=38)	Pilot whale (*n*=44)	Pilot whale (*n*=47)
19	Mean frequency	EAR1-EAR2	0.01	Spinner (*n*=35)	Spinner (*n*=23)	Spinner (*n*=38)	Spinner (*n*=43)
		EAR1-EAR4	0.007				
	Median frequency	EAR1-EAR2	0.01				
		EAR1-EAR4	0.008				
	Maximum frequency	EAR1-EAR2	0.02				
		EAR1-EAR4	0.04				
	Center frequency	EAR1-EAR4	0.04				
22	Minimum frequency	EAR1-EAR3	0.02	Bottlenose (*n*=43)	Bottlenose (*n*=45)	Bottlenose (*n*=48)	Bottlenose (*n*=49)
		EAR1-EAR4	0.04				
23	None			Spinner (*n*=5)	Spotted (*n*=10)	Bottlenose (*n*=12)	Bottlenose (*n*=14)
27	None			Bottlenose (*n*=34)	Spinner (*n*=40)	Spinner (*n*=40)	Bottlenose (*n*=40)

ROCCA classification results are provided in **Table 57**. For 7 of the 13 encounters (54 percent), ROCCA classified the encounter as a different species based on whistles recorded at different depths. Four of the seven encounters that were classified differently (57 percent) on different EAR2s had significant differences in whistle variables and three did not. Differences in whistle variables and classification results occurred on different EARs for different encounters. These differences are likely affected by the position of the animals relative to the EAR array.

Upcoming analyses will include localizing vocalizing animals in order to examine these relationships, as well as sound propagation analysis to investigate further causes of the observed differences and similarities among depths. The same analyses will be performed on the Kona EAR2 bottom-mounted and surface microMARS array data. These analyses will provide increased sample sizes and deeper insight to species-specific differences in the effects of depth on whistle structure, as the microMARS data have concurrent visual observations.

For more information on this study, refer to the annual progress report for this project (Oswald et al. 2016a).

2.3.7 Development of Statistical Methods for Examining Relationships Between Cetacean Vocal Behavior and Navy Sonar Signals

In an effort designed to examine marine mammal vocal behavior before, during, and after MFA sonar exercises by the U.S. Navy, acoustic recordings were made off Jacksonville, Florida (Deployment 1: September–October 2009; Deployment 2: December 2009), and in Onslow Bay, North Carolina (July 2008), using seafloor-deployed MARUs (**Figure 84**). The intent for location and timing of the MARU deployments was to target Anti-Submarine Warfare (ASW) training exercises, with the units deployed 7 to 10 days prior to the exercise and recording for at least 7 to 10 days post-exercise.

Data for JAX were initially analyzed to understand the presence/absence and species of animals within the area during an ASW exercise (Norris et al. 2012). The second stage of the study was a collaborative effort involving researchers at Cornell University, Bio-Waves, Inc., and CREEM to develop robust statistical methods that can be used to analyze vocal behavior before, during, and after MFA sonar events on a species-by-species basis when possible. MARUs were deployed with two different recording configurations. “High-frequency” (HF) MARUs recorded continuously with a 32-kHz sample rate, resulting in a nominal recording band of 0 to 16 kHz. “Low-frequency” (LF) MARUs recorded continuously with a sample rate of 2 kHz, resulting in a nominal recording band of 0 to 1 kHz. Only HF MARUs were capable of recording MFA sonar signals. Both configurations could record North Atlantic right, fin, and minke whales; sperm whales could be reliably recorded on HF MARUs and in some cases on LF MARUs.

Results from this initial analysis effort are available in Charif et al. 2015 and Oswald et al. 2015.

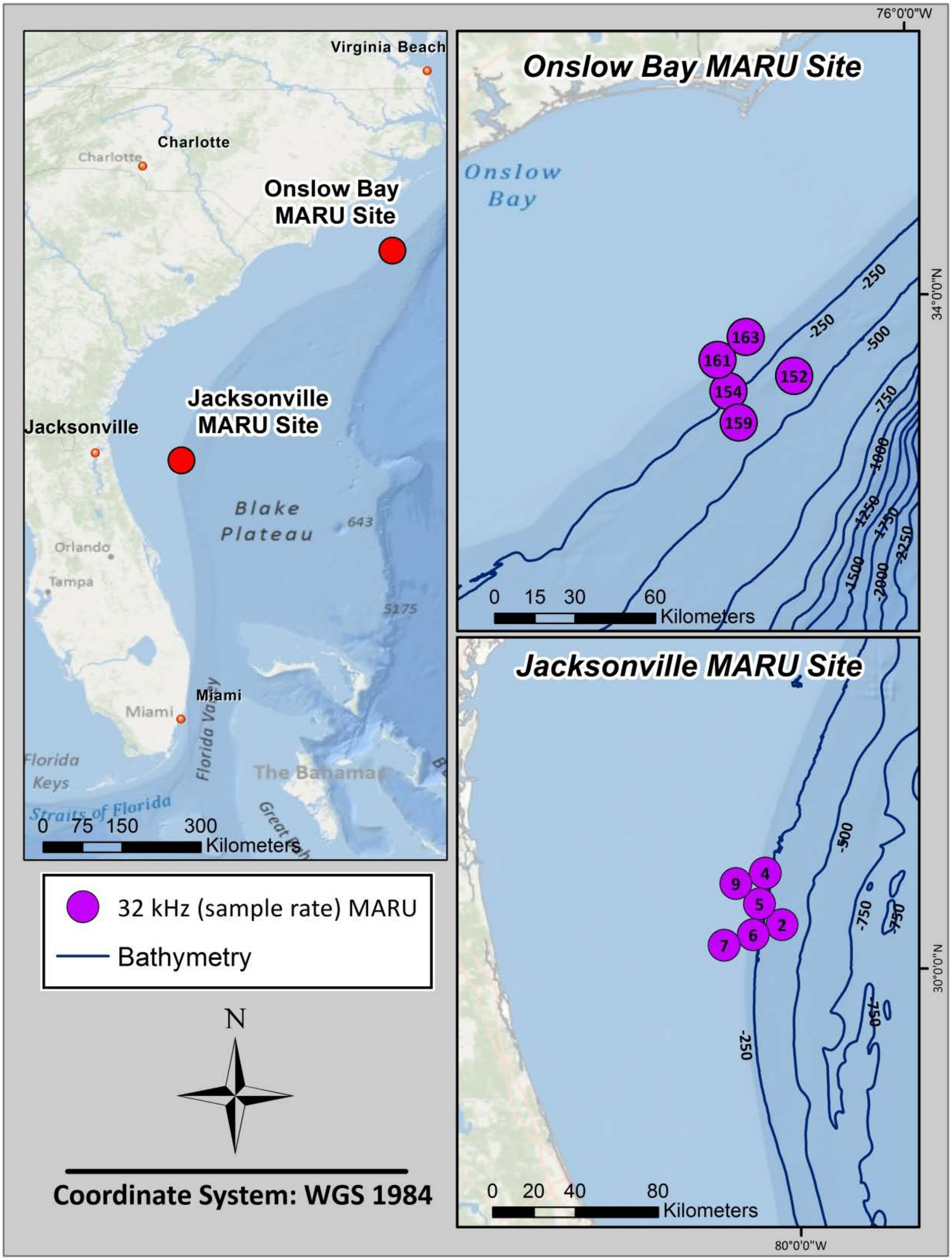


Figure 84. Map of MARUs off Jacksonville, Florida, and Onslow Bay, North Carolina.

Results of the previous analysis indicated there was low statistical power to detect effects, primarily due to the limited number of independent sonar events available in the Jacksonville and Onslow Bay datasets. As a result, additional data were included in order to continue development of robust statistical methods to evaluate species-specific differences in responses. For the current effort, increasing sample size has provided greater statistical power, which is crucial in order to develop and compare effective statistical methods.

For this follow-up work, Duke University provided recordings from four HARPs deployed between 2010 and 2012. One HARP was deployed off Cape Hatteras (deployment HAT01A), one off Jacksonville (deployment JAX05A), and two in Onslow Bay (deployments USWTR05A [also referred to as Onslow Bay 1] and USWTR06E [Onslow Bay 2]). The HARPs were deployed at varying depths ranging from 171 to 952 m, and all had a sampling rate of 200 kHz. Bio-Waves, Inc. processed data collected from these HARPs, which included reviewing and characterizing marine mammal vocalizations during the 24-hr period before sonar began, during the entire sonar event, and for a 24-hr period after the end of sonar. Metrics characterizing marine mammal vocalizations and vocalization events were provided to researchers at CREEM for statistical analysis. This analysis will increase the sample size and statistical power to detect the effects of sonar on vocal behavior. It will also allow continued development of robust statistical methods that can be used to analyze other passive acoustic datasets in order to better understand any effects of MFA sonar on marine mammal vocal behavior.

A total of 57 sonar events was identified in the entire dataset, with an overall cumulative sonar event duration of approximately 157 hr.

Minke Whales

A total of 50 minke whale encounters was logged in the dataset, with an overall duration of approximately 124 hr. The Cape Hatteras dataset contained 32 encounters with a total duration of approximately 84 hr; the Onslow Bay 1 dataset contained 18 encounters with a total duration of approximately 40 hr (**Table 58**). Minke whale vocalizations were not detected in the Jacksonville and Onslow Bay 2 datasets.

Table 58. Summary of minke whale events per site.

Site Number	Site ID	Total Number of Minke Whale Encounters Per Site	Total Duration of Minke Whale Encounters Per Site (hr:min:sec)
1	Cape Hatteras (HAT01A)	32	84:07:51
3	Onslow Bay 1 (USWTR05A)	18	40:08:31

A total of 1,213 pulse trains was identified in the sub-logging (e.g., examined at a finer scale) analysis (941 in Cape Hatteras and 272 in Onslow Bay 1; **Tables 59** and **60**). Of the pulse trains that could be identified to type, the majority were the slow-down type at each site (**Tables 59** and **60**, **Figures 85** and **86**). Speed-up type pulse trains were only identified at Cape Hatteras.

Table 59. Total numbers of minke whale pulse trains per sonar occurrence category for Cape Hatteras.

Treatment	Pulse Train Type			
	Constant	Slow-down	Speed-Up	Unidentified
24 hr Before	31	63	1	166
Between	28	23	3	249
During	11	9	-	72
24 hr After	25	95	2	163
Total	**95**	**190**	**6**	**650**

Key: hr = hour(s)

Table 60. Total numbers of minke whale pulse trains per sonar occurrence category for Onslow Bay 1.

Treatment	Pulse Train Type			
	Constant	Slow-down	Speed-Up	Unidentified
24 hr Before	0	0	0	0
Between	39	27	0	64
During	1	0	0	2
24 hr After	17	46	0	76
Total	**57**	**73**	**0**	**142**

Key: hr = hour(s)

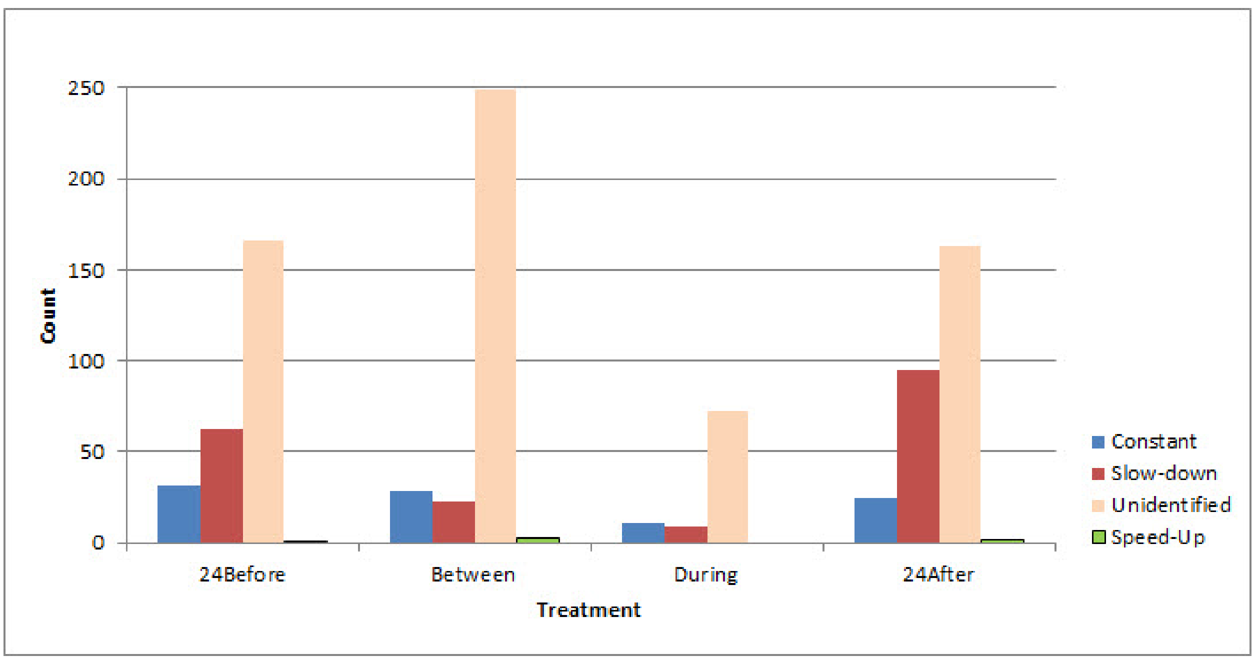


Figure 85. Summary of minke whale pulse types for Cape Hatteras for sonar occurrence categories.

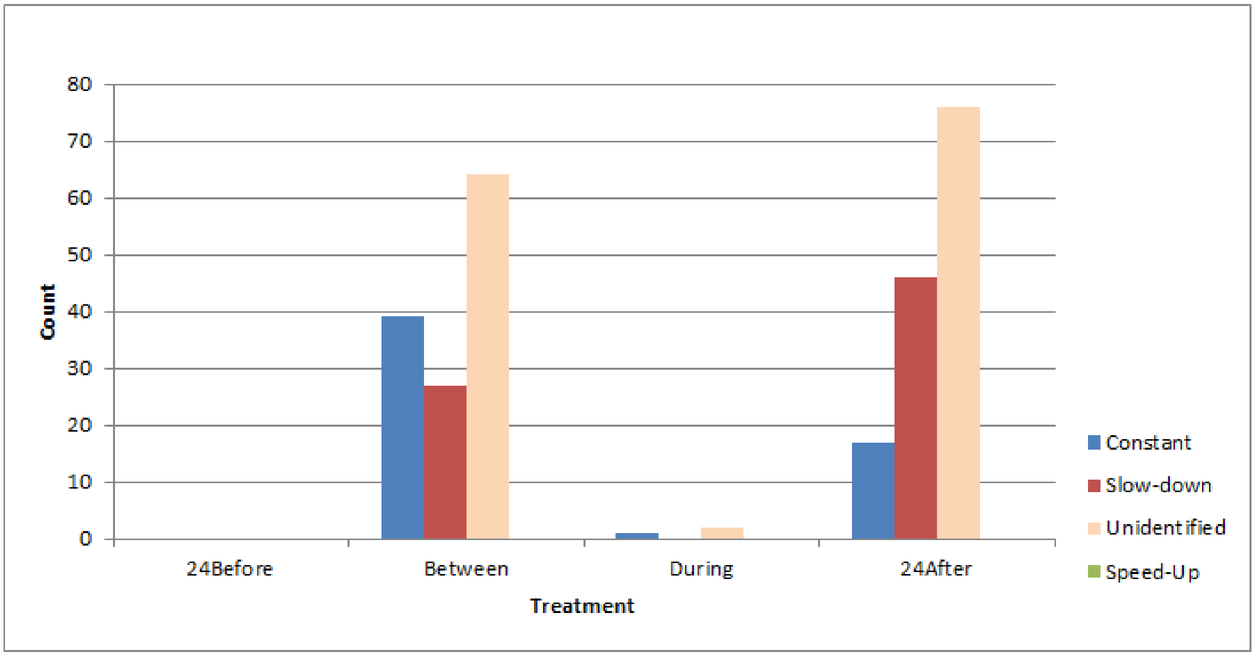


Figure 86. Summary of minke whale pulse types for Onslow Bay for sonar treatment periods.

Delphinids

A total of 88 delphinid encounters were logged in the dataset, with an overall duration of approximately 334 hr. The Jacksonville dataset contained 62 encounters, with a total duration of approximately 163 hr. The Onslow Bay 1 dataset contained 15 encounters, with a total duration of approximately 22 hr. The Onslow Bay 2 dataset contained 7 encounters, with a total duration of approximately 31 hr. The Cape Hatteras dataset contained four encounters, with a total duration of approximately 117 hr (**Table 61**).

Table 61. Summary of delphinid encounters per site.

Site Number	Site ID	Total No. of Delphinid Encounters per Site	Total No. of Delphinid Clicks per Site	Total No. of Delphinid Whistles per Site	Total Duration of Delphinid Encounters Per Site
1	Cape Hatteras (HAT01A)	4	1,249,318	881,897	117:38:14
2	Jacksonville (JAX05A)	62	852,551	26,524	162:57:43
3	Onslow Bay 1 (USWTR05A)	15	30,485	2,840	22:33:45
4	Onslow Bay 2 (USWTR06E)	7	36,493	46,838	31:20:10
	Total	**88**	**2,168,847**	**958,099**	**334:29:52**

A total of 44 delphinid events contained enough whistles to be included in the ROCCA analysis (**Figure 87)**. Most of these events (*n*=28) were recorded on the HARP deployed off Jacksonville, where the majority (61 percent) were classified as Atlantic spotted dolphins or bottlenose dolphins, and a small percentage were classified as pilot whales and striped dolphins. There were six events analyzed from the Onslow Bay 1 data and six events analyzed from the Onslow Bay 2 data. Most of the Onslow Bay events were classified as bottlenose dolphins and a small percentage were classified as pilot whales or striped dolphins. One Onslow Bay 2 event was classified as spotted dolphins. All five events analyzed from the Cape Hatteras data were classified as bottlenose dolphins.

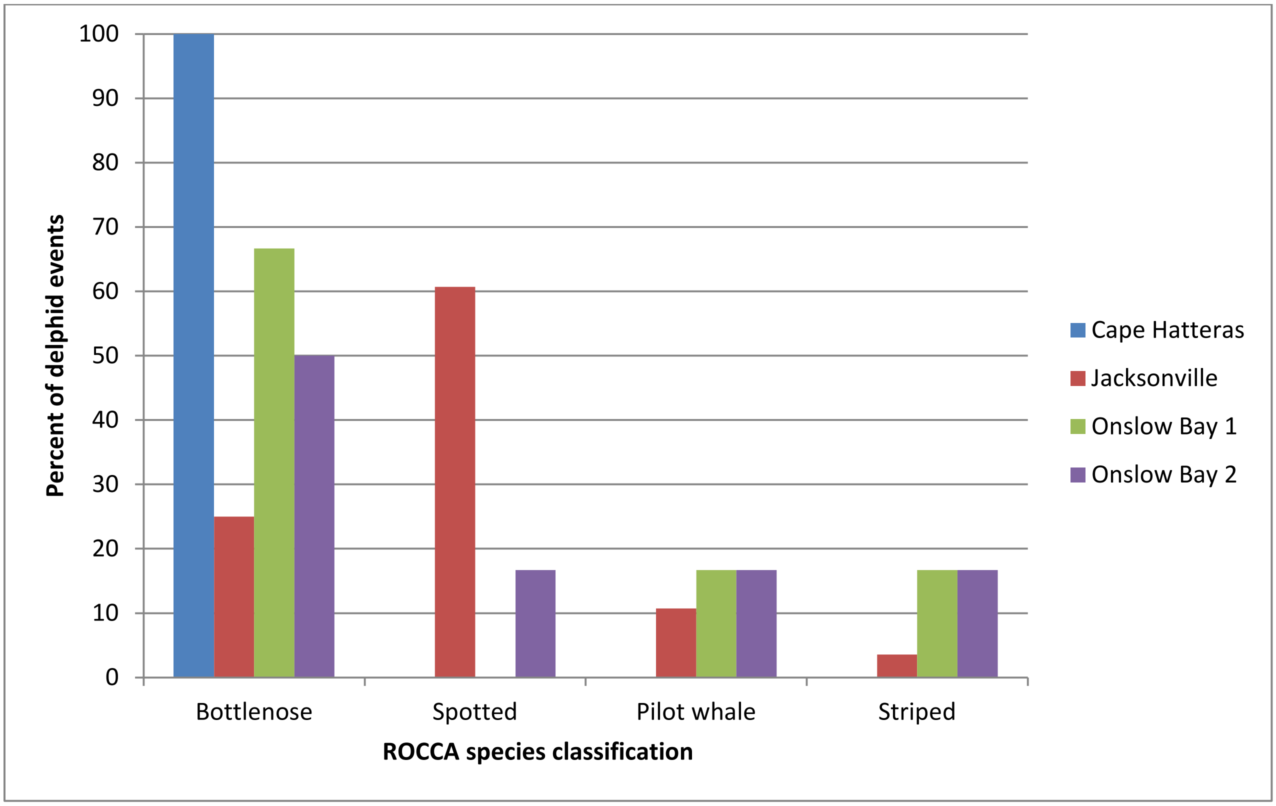


Figure 87. Percentage of delphinid acoustic events classified as each species for Cape Hatteras (*n*=5), Jacksonville (*n*=28), Onslow Bay 1 (*n*=6), and Onslow Bay 2 (*n*=6).

Beaked Whales

A total of 61 beaked whale encounters was logged in the dataset, with an overall duration of approximately 37 hr (**Table 62**). The Jacksonville dataset contained ten encounters—six Cuvier's beaked whale and four unidentified *Mesoplodon* (three probable Blainville's beaked whales and one possible Gervais' beaked whale). The Onslow Bay 1 dataset contained four beaked whale encounters—one unidentified *Mesoplodon* and three Cuvier's beaked whale. The Onslow Bay 2 dataset contained six beaked whale encounters—four unidentified *Mesoplodon* and two Sowerby's beaked whale. The Cape Hatteras dataset contained 41 beaked whale encounters, including three unidentified *Mesoplodon* (one possible Blainville's beaked whale and two possible Gervais' beaked whale) and 38 Cuvier's beaked whale.

Table 62. Summary of beaked whale encounters by site. The number of clicks is shown in parentheses next to the total number of encounters for each species group.

Site Number	Site ID	Total No. of Unidentified *Mesoplodon* Encounters per Site (Total No. Clicks)	Total Duration of Unidentified *Mesoplodon* Encounters per Site	Total No. of Cuvier's Beaked Whale Encounters per Site (Total No. Clicks)	Total Duration of Cuvier's Beaked Whale Encounters per Site	Total No. of Sowerby's Beaked Whale Encounters per Site (Total No. Clicks)	Total Duration of Sowerby's Beaked Whale Encounters per Site
1	Cape Hatteras (HAT01A)	3 (330)	0:34:02	38 (23,654)	27:10:01	-	-
2	Jacksonville (JAX05A)	4 (62)	0:52:51	6 (129)	0:21:07	-	-
3	Onslow Bay 1 (USWTR05A)	1 (35)	0:13:42	3 (110)	0:35:50	-	-
4	Onslow Bay 2 (USWTR06E)	4 (2,687)	2:00:51	-	-	2 (1,913)	5:23:16
	Total	**12 (3,114)**	**3:41:26**	**47 (23,893)**	**28:06:58**	**2 (1,913)**	**5:23:16**

Sperm Whales

A total of 49 sperm whale encounters was logged in the dataset, with an overall duration of approximately 79 hr (**Table 63**). The Cape Hatteras dataset contained 24 encounters, with a total duration of approximately 47 hr. The Onslow Bay 1 dataset contained two encounters, with a total duration of approximately 1 min. The Onslow Bay 2 dataset contained 23 encounters, with a total duration of approximately 31 hr. There were no sperm whale encounters detected at the JAX site.

Table 63. Summary of sperm whale encounters per site. The number of clicks is shown in parentheses next to the total number of encounters.

Site Number	Site ID	Total No. of Sperm Whale Encounters Per Site (Total No. Clicks)	Total Duration of Sperm Whale Encounters Per Site
1	Cape Hatteras (HAT01A)	24 (28,625)	47:41:36
3	Onslow Bay 1 (USWTR05A)	2 (43)	0:01:03
4	Onslow Bay 2 (USWTR06E)	23 (11,997)	31:18:55
	Total	**49 (40,665)**	**79:01:34**

Cetaceans and Sonar

For each site and species, encounters were plotted with sonar events overlaid with periods of darkness (i.e., nighttime) depicted with shading (**Figures 88** through **91**).

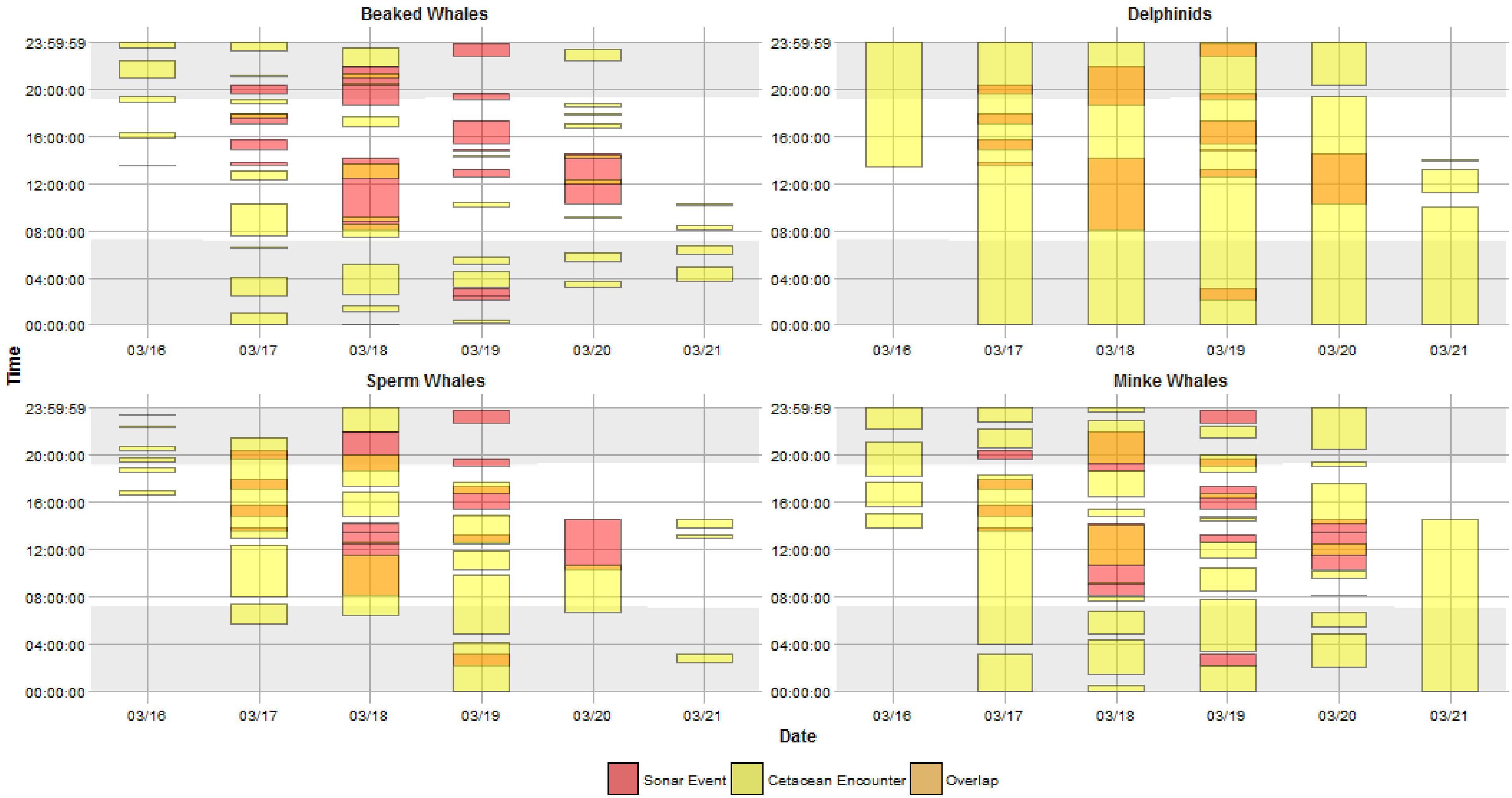


Figure 88. Sonar events (pink) and vocalization events (yellow) by species or species group for the Cape Hatteras (HAT01A) HARP deployed off Cape Hatteras, North Carolina. Time of day is plotted on the y-axis, date is plotted on the x-axis, and shading represents periods of light and darkness.

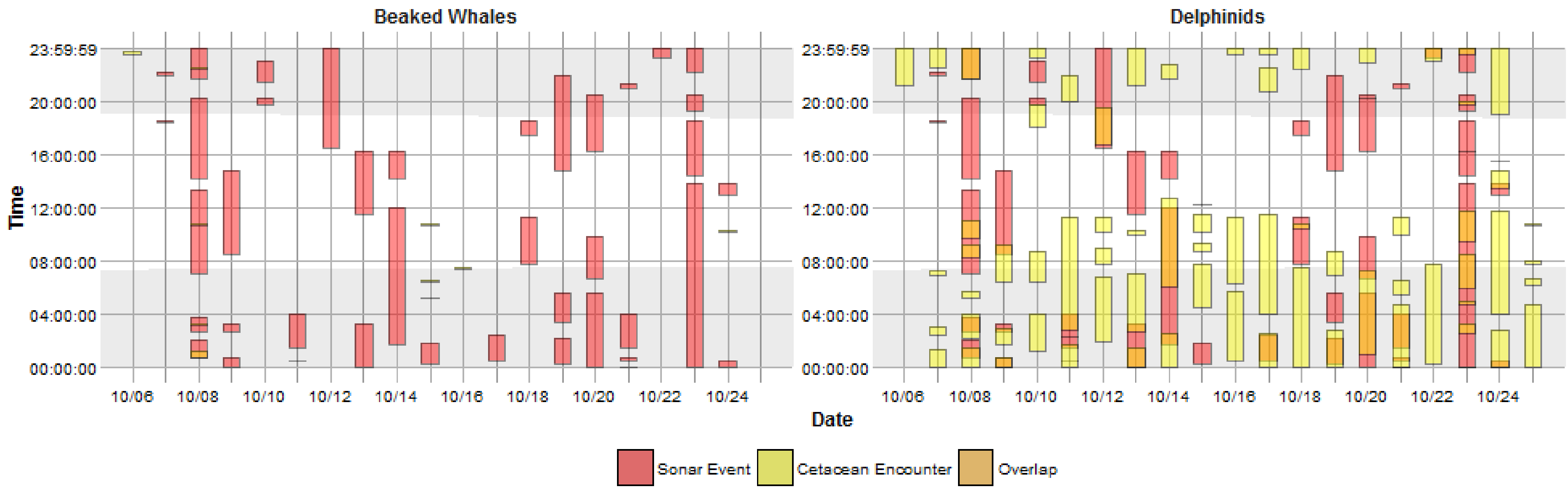


Figure 89. Sonar events (pink) and vocalization events (yellow) by species or species group for the Jacksonville (JAX05A) HARP deployed off Jacksonville, Florida. Time of day is plotted on the y-axis, date is plotted on the x-axis, and shading represents periods of light and darkness.

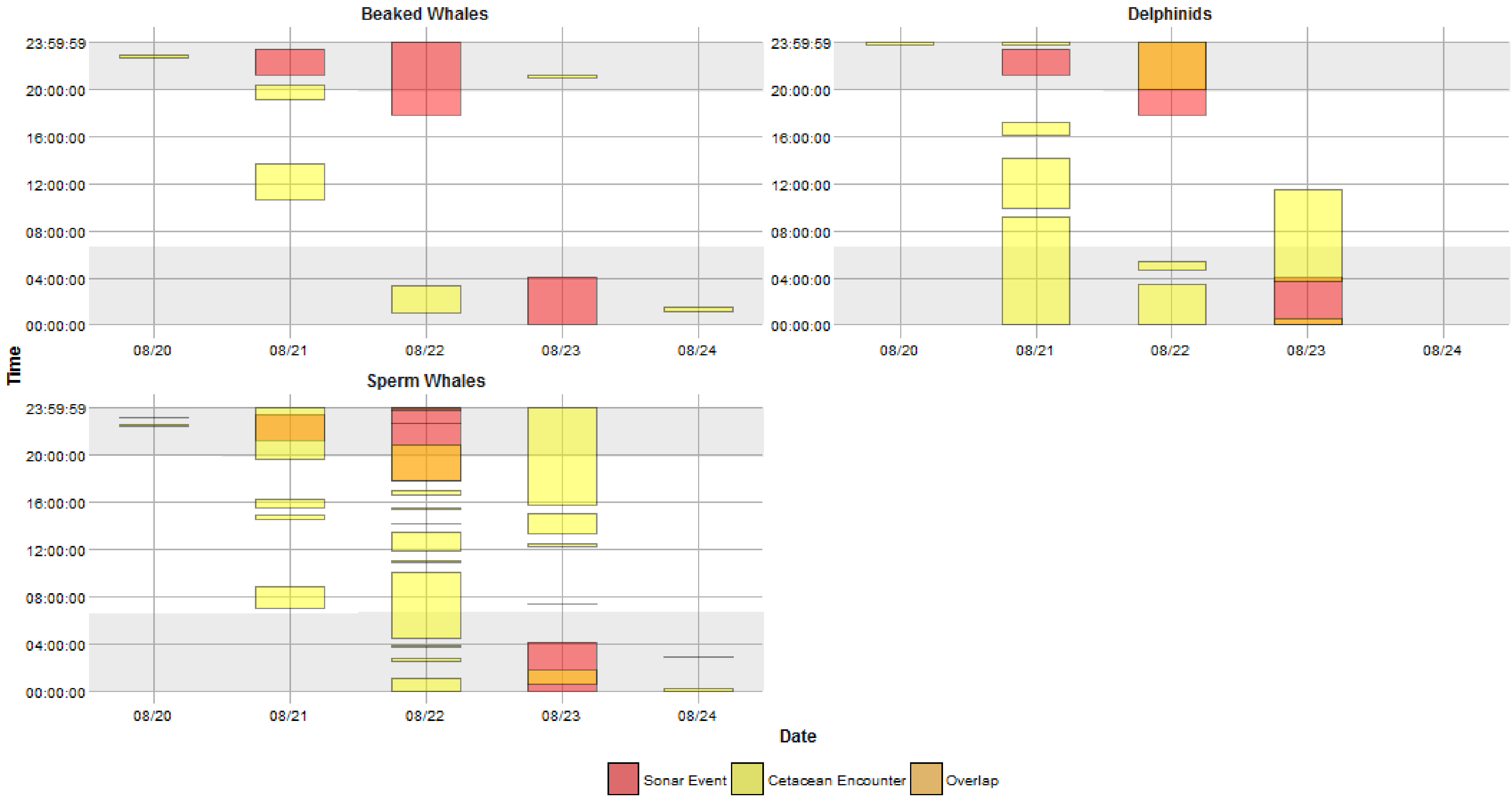


Figure 90. Sonar events (pink) and vocal encounters (yellow) by species or species group for the Onslow Bay 2 (USWTR06E) HARP deployed in Onslow Bay, North Carolina. Time of day is plotted on the y-axis, date is plotted on the x-axis, and shading represents periods of light and darkness.

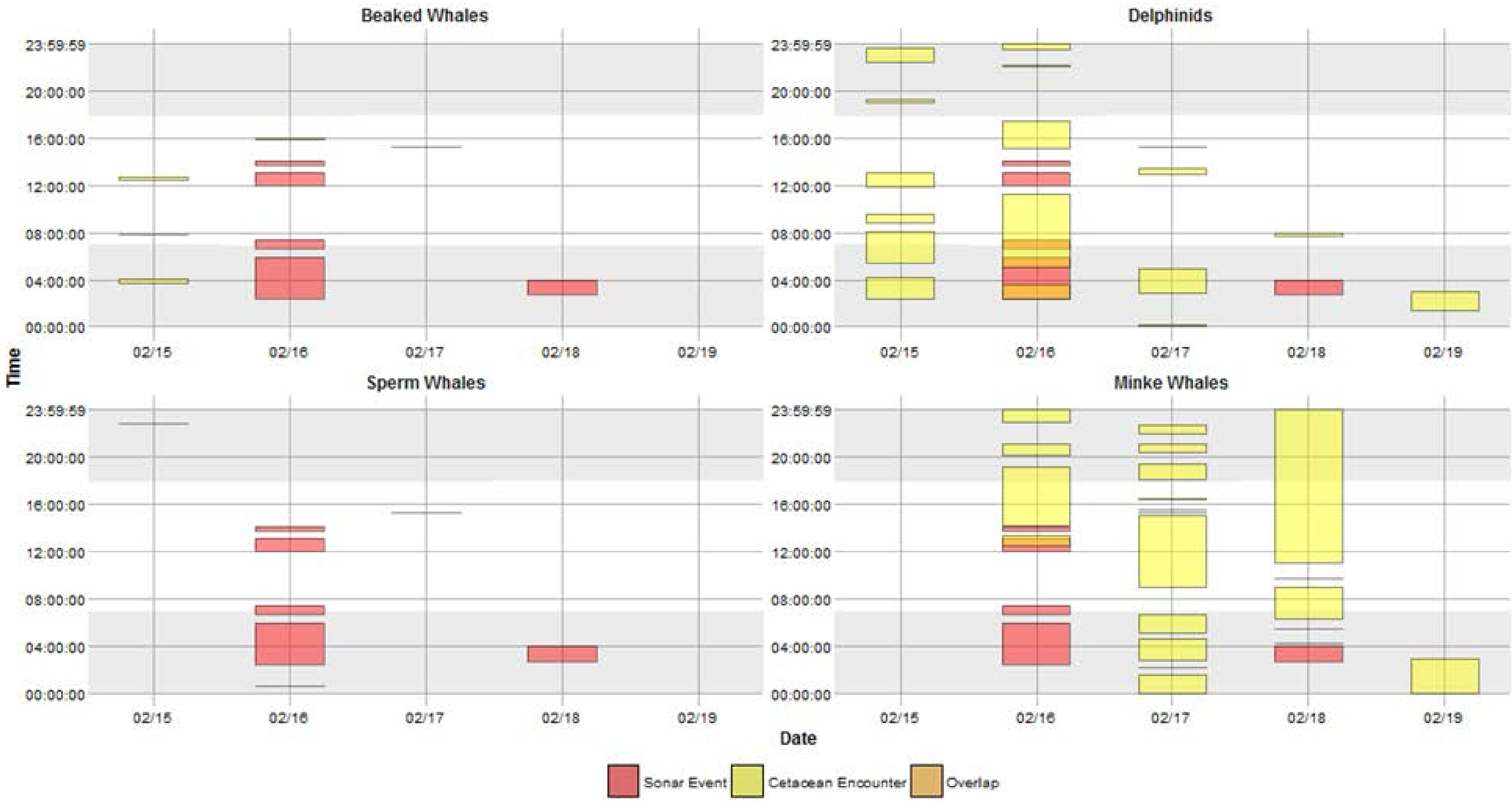


Figure 91. Sonar events (pink) and vocalization events (yellow) by species or species group for the Onslow Bay 1 (USWTR05A) HARP deployed in Onslow Bay, North Carolina. Time of day is plotted on the y-axis, date is plotted on the x-axis, and shading represents periods of light and darkness.

Statistical Modeling

Separate generalized estimating equation (GEE) statistical models were developed for minke whales, sperm whales, beaked whales (combining the *Mesoplodon* sp. and *Ziphius cavirostris* detections) and delphinids (combining all species including unidentified delphinids). Model selection is ongoing, but in all cases *Site* and *Time* were selected as significant terms in the models. In 50 percent of cases, a *Sonar* effect has been detected as a significant treatment as well, but not necessarily with a reduction of detected presences during anthropogenic sonar activity. Some preliminary results are illustrated below (**Figures 92** and **93**).

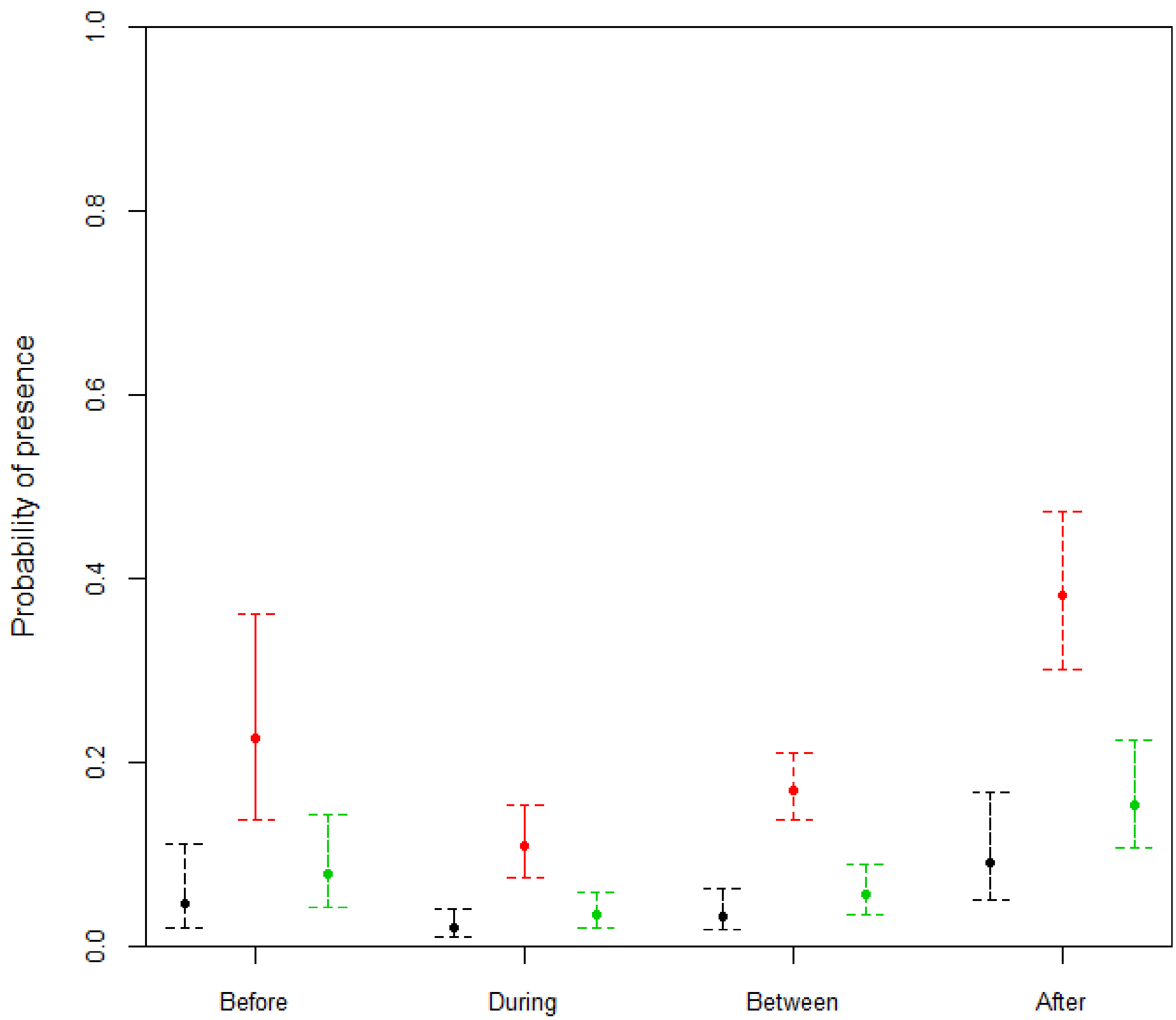


Figure 92. Probability of detected presence of minke whale pulse-trains at noon from the HARP data at the Cape Hatteras (HAT01A) site (black), the Onslow Bay 1 (USWTR05A) site (red) and the Jacksonville (JAX05A) site (green) before, during, between and after anthropogenic sonar exercises. Dashed lines indicate 95% CIs on the predictions.

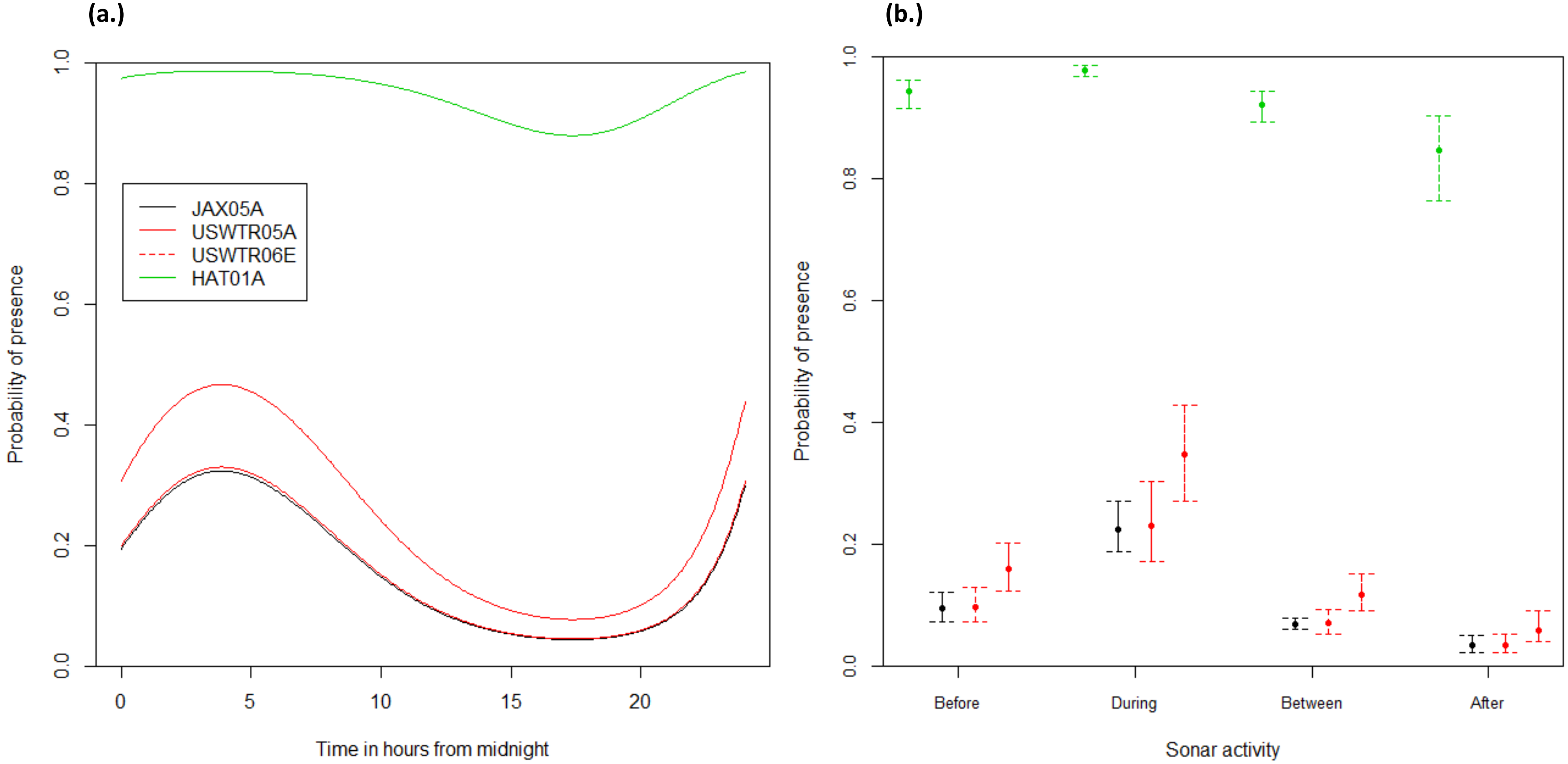


Figure 93. Estimated probability of presence of dolphin detections from the HARP data only. (a.) in relation to time (hours from midnight) at JAX05A (black), USWTR 5A and USWTR05A (both red), and HAT01A (green), assuming before any sonar exercise. (b.) Estimated probability of presence of dolphin detections at noon before, during, between and after sonar activity. Dashed lines indicate 95% CIs.

For more information on this study, refer to the annual progress report for this project (Oswald et al. 2016b).

2.3.8 Sperm Whale Response Analysis

In an effort designed to examine marine mammal vocal behavior associated with MFA sonar use, existing passive-acoustic datasets from JAX, Onslow Bay, and Cape Hatteras were analyzed to assess the presence, foraging behavior, and diel patterns of sperm whales in the coastal Atlantic Ocean off the mid-Atlantic and southeastern U.S. These acoustic recordings were made off Jacksonville, Florida (12 September–04 October 2009 and 04–26 December 2009), in Onslow Bay, North Carolina (05–27 July 2008) using MARUs, and off Cape Hatteras, North Carolina (16 November–19 December 2013) using Autonomous Multi-channel Acoustic Recorders (AMARs) (**Figure 94, Table 64**). Detailed analysis was conducted using a combination of automated and semi-automated methods to provide detailed information about the vocal behavior of sperm whales, using foraging buzzes as indicators of active prey-capture attempts.

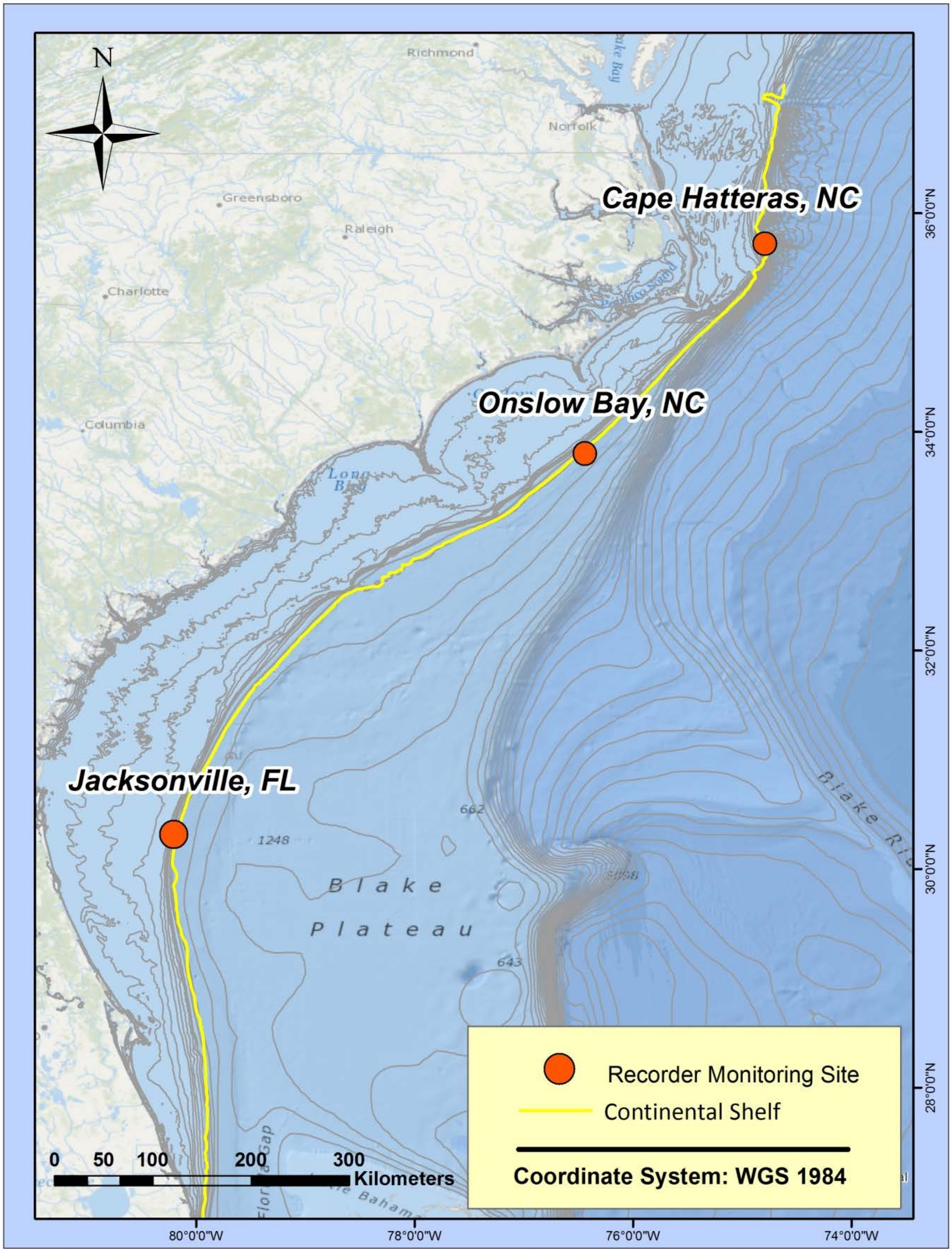


Figure 94. Passive acoustic recording locations reviewed for sperm whale vocal behavior.

Table 64. Deployment information for MARUs and AMARs used to collect the data supplied for analysis.

Location	Recorder	Latitude (N)	Longitude (W)	Water depth (m)	Deployment	Recording Start	Recording End	Recording Days
Jacksonville	2 (Site 4)	30° 21.435′	80° 09.331′	550	1	12-Sep-09	04-Oct-09	23
Jacksonville	74 (Site 5)	30° 14.505′	80° 10.879′	661	1	12-Sep-09	04-Oct-09	23
Jacksonville	96 (Site 6)	30° 07.594′	80° 12.486′	629	1	12-Sep-09	04-Oct-09	23
Jacksonville	2 (Site 4)	30° 21.357′	80° 09.170′	~600	2	04-Dec-09	26-Dec-09	23
Jacksonville	74 (Site 5)	30° 14.480′	80° 10.843′	~600	2	04-Dec-09	26-Dec-09	23
Jacksonville	96 (Site 6)	30° 07.609′	80° 12.503′	~600	2	04-Dec-09	26-Dec-09	23
Onslow Bay	PU152 (Site 1)	33˚ 43.546′	76˚ 22.132′	365	1	05-Jul-08	27-Jul-08	23
Onslow Bay	PU154 (Site 2)	33˚ 40.454′	76˚ 35.382′	236	1	05-Jul-08	27-Jul-08	23
Onslow Bay	PU159 (Site 3)	33˚ 34.164′	76˚ 33.309′	365	1	05-Jul-08	27-Jul-08	23
Cape Hatteras	A3 (Site 1)	35° 45.414′	74° 49.080′	558	1	16-Nov-13	19-Dec-13	34

Note: AMAR deployment was at Cape Hatteras; all other deployments were of MARUs.

Nine MARUs were deployed off JAX during the fall and winter, and five MARUs were deployed off Onslow Bay during the summer. The MARUs were deployed in shallow (44 to 73 m), mid-water (160 to 233 m), and deep-water sites (>300 m). Three recorders were deployed at each of the three depth ranges, for a total of nine MARUs for each of the two (fall and winter) deployment periods. Two types of MARUs were deployed: (1) units that recorded using a 32-kHz sampling rate (32-kHz recorders), and (2) units that recorded using a 2-kHz sampling rate (2-kHz recorders) (Norris et al. 2012). In Onslow Bay, each MARU sampled continuously at a high-frequency rate of 32 kHz (Norris et al. 2012).

The four AMARs were deployed off Cape Hatteras during the winter (Martin et al. 2015). The AMARs recorded continuously at 128 kHz. The AMARs were deployed in an equilateral triangle, at depths between 427 and 626 m surrounding a central unit. Since the AMARs were deployed within close proximity to each other and at similar depths, acoustic data from only one AMAR per deployment were used in the analysis.

All encounters were processed using PAMGuard, and each encounter was further processed in PAMGuard's Viewer Mode software to mark click-train and foraging-buzz events in the dataset. After identifying all click trains and foraging buzzes in an encounter, clicks were exported to ROCCA, a module in PAMGuard, which was used to obtain click counts, echolocation click measurements, and detailed time and duration information.

Diel patterns were examined in the occurrence of vocal events (for each recorder) by dividing the recordings into 3- and 1-hr time bins. The number of clicks per bin was calculated using custom Matlab code 'Bin-It Counter' to sum the number of clicks in each time bin for each day. The data violated parametric assumptions, and a Kruskal-Wallis test was used to determine if there were significant differences in the number of clicks between: (1) 3-hr bins within and among sites, (2) photo-periods within and among sites, and (3) 1-hr bins within and among sites. Dunn's tests were performed, with Bonferroni corrections for multiple comparisons, to determine how diel patterns varied within sites to assess whether there were significant differences in click counts within time bins and photoperiods among sites.

Vocal behavior varied both within and among the regions compared (**Figure 95**). Overall the highest numbers of encounters and total durations of encounters occurred during JAX deployment 1 (90 encounters, approximately 113 hr), followed by JAX deployment 2 (46 encounters, approximately 68 hr), Onslow Bay (39 encounters, approximately 50 hr), and Cape Hatteras (28 encounters, approximately 23.5 hr), respectively. Totals of 4,144 click-train events and 32 foraging-buzz events were identified.

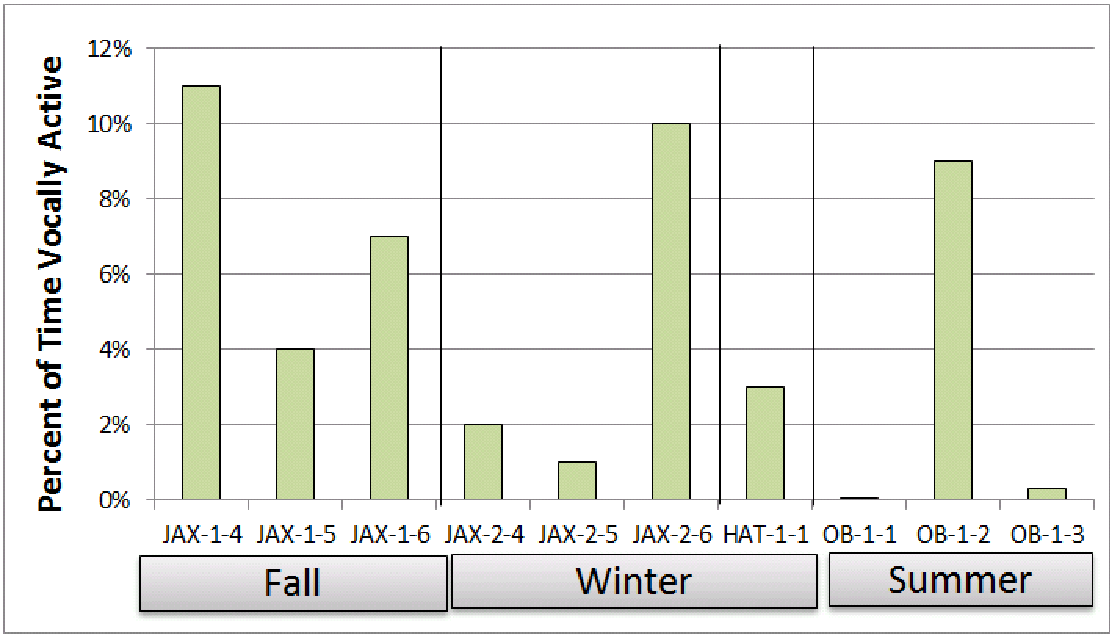


Figure 95. The percentages of total recording time (y-axis) that sperm whales were vocally active at each recording site (x-axis). The season that the recording is in is denoted beneath the x-axis.

The proportion of days with click trains and foraging buzzes present was highest overall at the JAX sites, followed by Cape Hatteras and Onslow Bay, respectively. The numbers of click trains and foraging buzzes, along with the percentages of recording days with vocal activity, varied by recording site and geographic region. Click trains were present every day of the JAX 2-6 recorder deployment, 97 percent of days at Onslow Bay site 1-2 and JAX, and 88 percent of days at JAX 1-4. Daily click-train and foraging-buzz rates varied by site and region. Onslow Bay site 1-2 had the highest occurrence of click trains per day (n = 50) but a low occurrence of foraging buzzes per day (0.04). Sperm whales were vocally active for the greatest percent of total recording time at JAX site 1-4 (11 percent), followed by JAX site 2-6 (10 percent) and Onslow Bay site 1-2 (9 percent), respectively. The highest numbers of foraging buzzes per day occurred at Cape Hatteras site 1-1 (0.91) and JAX site 2-4 (0.83).

Occurrence plots and plots of click counts in hourly bins within each geographic region suggest that there are strong diel patterns of sperm whale vocal activity in the JAX and Onslow Bay regions. There were only significant differences in click counts within light periods at Onslow Bay compared to all other sites and overall among regions. There were only significant differences within dark periods at Cape Hatteras compared to all other sites and overall among sites. Analysis to compare echolocation click measurements among regions is currently underway and will be presented in a later report.

The results of this study provide important information about the biology and behavior of sperm whales. Due to the sparse amount of data available on sperm whales in the middle to southern U.S. Atlantic coastal region, this work is important to better understand the distribution, foraging ecology, and habitat preference of sperm whales in this region.

For more information on this study, refer to the annual progress report for this project (Yack et al. 2016).

2.3.9 Development of Atlantic Odontocete Whistle Classifier

Passive acoustic monitoring is being used extensively to collect information regarding marine mammal occurrence, distribution, and behavior in naval training areas; however, it is currently not possible to identify most delphinids to species based on acoustic data alone. Efficient and accurate tools for detection and classification of sounds produced by marine mammals will significantly reduce the amount of time needed to analyze recordings made using towed hydrophone arrays or seafloor-mounted recorders.

The main goals of this study were to:

1. Refine Atlantic odontocete classifiers by adding Atlantic Marine Assessment Program for Protected Species (AMAPPS) 2013 recordings of single-species schools to the training datasets.
2. Test and ground-truth the Atlantic odontocete classifiers using whistles recorded during visually validated acoustic recordings from the SEFSC AMAPPS 2013 cruise to provide a more complete understanding of how the classifiers perform on novel data.
3. Use the Atlantic odontocete classifier to identify schools that were detected acoustically but were not sighted.

ROCCA initially contained a random-forest classifier that was developed for whistles from eight different species of delphinids occurring in the tropical Pacific Ocean (Oswald et al. 2013), but in October 2013, Bio-Waves, Inc. completed development of two additional whistle classifiers (Oswald 2013; Oswald et al. 2016c). These two classifiers each included five delphinid species (bottlenose dolphin, Atlantic spotted dolphin, striped dolphin, short-beaked common dolphin, and short-finned pilot whale) recorded in the northwestern Atlantic Ocean. The first classifier (the manual classifier) was trained and tested using whistles detected and extracted using manual methods in ROCCA. The second classifier (the automated classifier) was trained and tested using whistles detected and extracted using the fully automated 'whistle and moan detector' (WMD), a module in PAMGuard. Both the manual and the automated classifiers identify individual whistles to species. Encounters (groups of whistles produced by a single school of dolphins) are then identified based on the combined classification results for all of the whistles in each encounter.

ROCCA's Atlantic classifiers are random-forest classifiers that use a two-stage approach, where whistles are first classified to broad species categories (e.g., large delphinids, *Stenella* species) in stage one and then to species within those categories in stage two. This approach resulted in much higher correct classification scores than previous single-stage random-forest analyses. Overall, 66 percent (manual classifier) and 68 percent (automated classifier) of encounters were correctly classified using a single-stage random-forest and 86 percent (manual classifier) and 91 percent (automated classifier) of encounters were correctly classified using a two-stage approach. Because of its exceptional performance, the Atlantic classifier is an important element in the marine mammal acoustic signal-processing toolbox, therefore it is important to continue to develop and use this classifier.

During the months of July–September 2013, SEFSC collected visual and acoustic data during shipboard line-transect abundance surveys for marine mammals in the northwestern Atlantic Ocean as part of AMAPPS. These surveys covered continental shelf-edge and slope waters, from the 100-m depth contour to the edge of the EEZ, from South Carolina to the southern tip of Nova Scotia, Canada. Acoustic recordings were collected with an array of hydrophones towed approximately 300 m behind the research vessel at a depth of 8 to 12 m. Acoustic data were recorded to computer hard drives with sampling rates of 125 kHz and 500 kHz using PAMGuard software. Acoustically active schools were localized using target-motion-analysis methods and this information was used to match acoustic detections with visual detections in real-time for species identification. Bio-Waves, Inc. is using passive acoustic data collected during this cruise to test, improve, and utilize the ROCCA Atlantic classifier.

A total of 2,452 whistles from 67 encounters was measured using ROCCA's manual method from AMAPPS 2013 acoustic encounters with visual confirmation of species identity (**Table 65**). These whistles were added to the original Atlantic classifier dataset, which consisted of 174 encounters and 3,525 whistles. A total of 140,715 whistles from 69 AMAPPS encounters with visual confirmation of species identity was then measured automatically using the WMD (**Table 65**). These whistles were added to the original Atlantic classifier dataset, which consisted of 151 encounters and 41,175 whistles.

Table 65. Number of encounters and whistles measured manually and using automated methods from the AMAPPS 2013 dataset.

Species	Manual		Automated	
	Number of Encounters	Number of Whistles	Number of Encounters	Number of Whistles
Short-beaked common dolphin	3	59	NA	NA
Risso's dolphin	3	50	3	2,508
Short-finned pilot whale	2	100	NA	NA
False killer whale	1	50	NA	NA
Pantropical spotted dolphin	3	61	4	7,213
Rough-toothed dolphin	2	100	2	3,795
Striped dolphin	2	72	3	596
Clymene dolphin	2	100	2	24,783
Atlantic spotted dolphin	14	510	13	19,145
Bottlenose dolphin	35	1,350	42	82,675
Total	**67**	**2,452**	**69**	**140,715**

After testing different variables, both alone and in combination with each other, it was found that the combination of maximum frequency, absolute slope, and duration as pruning variables produced the best results—removing the greatest number of false detections, while retaining the greatest number of true detections **(Table 66)**. When applied to the automated dataset, this combination removed more than 50 percent of false detections and more than 47 percent of bad contour extractions from all species groups, while retaining a majority of good whistle extractions. All whistles manually extracted from AMAPPS 2013 encounters with visual confirmation of species identity were analyzed with the manual classifier to test the performance of this classifier with a novel dataset. A total of 56 acoustic encounters was included in this analysis. Overall, 80 percent of these encounters were classified to the correct species.

Table 66. Variables and values of those variables used to remove ('prune') false detections and bad whistle extractions from the automated data set.

Variable	Pruning Value (less than)	Pruning Value (greater than)
Maximum Frequency (Hz)	10,600	27,000
Absolute Slope Mean (Hz/sec)	9,100	82,000
Duration (sec)	0.15	2.5

Key: Hz = Hertz; sec = second(s)

The addition of the AMAPPS 2013 whistles to the Atlantic training dataset increased sample size for every species and allowed three species to be added to the classifier—Risso's dolphin, Clymene dolphin, and rough-toothed dolphin. A new random-forest classifier was trained using this larger dataset. A one-stage model and several two-stage classification models were tested. The model that produced the highest correct classification scores was a two-stage model with one species-group (rough-toothed and Risso's dolphins) and six species in stage one. In stage two, whistles in the rough-toothed-Risso's group were classified to species. When this two-stage classifier was tested, 55.4 percent of encounters were correctly classified to species (**Table 67**). For individual species, correct classification scores ranged from 3.2 percent for Risso's dolphin to 84.2 percent for pilot whales. While the correct classification score for Risso's dolphins was low, few encounters recorded from other species were misclassified as Risso's dolphins. This makes it reasonable to include this species in the classifier, as it provides the potential for Risso's dolphin encounters to be classified as such without significantly reducing correct classification scores for other species.

Table 67. Confusion matrix for the new manual Atlantic classifier, including additional species from AMAPPS 2013 data. Percent of encounters classified as each species, with standard deviation in parenthesis, is given based on 100 iterations of dividing data into training and testing datasets. Percent of encounters correctly classified are in bold on the diagonal.

Actual Species	Percent Classified as								
	Short-beaked common dolphin	Risso's dolphin	Short-finned pilot whale	Clymene dolphin	Striped dolphin	Rough-toothed dolphin	Atlantic spotted dolphin	Bottlenose dolphin	*n*
Short-beaked common dolphin	**77.6 (8.1)**	0.3 (1.9)	0 (0)	0 (0)	3.1 (5.4)	8.2 (7.4)	6.6 (6.6)	4.2 (5.8)	9
Risso's dolphin	12.4 (7.4)	**3.2 (4.7)**	22.9 (8.5)	10.9 (6.3)	19.9 (9.8)	1.8 (3.8)	14.2 (9.1)	14.4 (7.5)	12
Short-finned pilot whale	0 (0)	0.9 (2.4)	**84.2 (6.3)**	0.2 (1.2)	5.5 (3.6)	6.3 (5.8)	2.1 (3.0)	0.7 (2.2)	16
Clymene dolphin	0 (0)	3.5 (8.7)	0 (0)	**47.2 (9.3)**	21.7 (8.4)	24.5 (3.5)	0 (0)	3.0 (8.2)	4
Striped dolphin	27.3 (8.6)	2.8 (4.4)	3.7 (4.4)	5.9 (6.2)	**44.6 (10.2)**	3.1 (4.3)	8.2 (6.9)	4.2 (5.4)	13
Rough-toothed dolphin	0 (0)	0.2 (2.0)	25.8 (16.4)	4.0 (8.0)	0 (0)	**70.0 (18.1)**	0 (0)	0 (0)	5
Atlantic spotted dolphin	3.7 (2.6)	4.4 (3.2)	5.1 (2.7)	3.3 (2.7)	3.1 (2.3)	9.3 (3.7)	**61.2 (7.6)**	9.6 (4.2)	44
Bottlenose dolphin	12.6 (3.5)	3.4 (2.4)	2.8 (2.1)	9.4 (3.2)	4.7 (2.2)	3.6 (2.0)	11.0 (2.8)	**52.4 (4.7)**	73

For more information on this study, refer to the annual progress report for this project (Oswald et al. 2016c).

2.3.10 Near-Real Time Passive Acoustic Monitoring of Baleen Whales in the Gulf of Maine (Environmental Security Technology Certification Program and LMR funded)

A related project, funded by the DOD's Environmental Security Technology Certification Program and the U.S. Navy's LMR Program is underway, with the goal of evaluating near real-time detection and classification technology for eventual adoption into the U.S. Navy's Marine Species Monitoring Program. Initial fieldwork for this demonstration and validation project began in March 2015, with the objective of evaluating the performance of the digital acoustic monitoring (DMON) instrument and low-frequency detection and classification system (LFDCS), a combined hardware/software package, on three different autonomous seagoing platforms. Detections will be cross-checked between platforms and visually validated with traditional aerial, shipboard, and land-based survey methods.

The DMON/LFDCS uses dynamic programming to estimate a pitch track for any type of narrowband call. A pitch track is a compact representation of a sound (analogous to a series of notes on a page of sheet music) derived from an audio spectrogram; it consists of a time series of frequency-amplitude pairs that describe the frequency and amplitude modulation of a sound. Attributes of the pitch track (e.g., start frequency, end frequency, duration, slope of frequency variation) can be extracted and compared to the attributes of known call types using quadratic discriminant function analysis. The call library can contain hundreds of these known call types, allowing the LFDCS to efficiently detect and classify many different calls produced by numerous species. Baumgartner and Mussoline (2011) compared the performance of the LFDCS to that of several human analysts for low-frequency sei whale downsweeps and right whale upcalls, and found that the accuracy of the LFDCS was similar to that of an analyst. In addition to right whale upcalls and sei whale downsweeps, Baumgartner et al. (2013) found that the LFDCS performs quite well for fin whale 20-Hertz pulses and several types of humpback whale tonal calls. The system is programmed to look for the calls of these four species (sei, right, fin, and humpback whales) during this test.

This project involves deployment of a single wave glider (Willcox et al. 2009) during spring 2015 to conduct broad scale surveys throughout the Gulf of Maine, west of the Hague Line (i.e., within the EEZ) (**Figure 96**). The survey track is designed to sample across the southward-moving coastal current on the northern and western fringes of the Gulf of Maine using a zig-zag design, and a more conventional straight-track design throughout the central Gulf of Maine where surface currents are more quiescent. Surveying continuously at a nominal speed of 1.5 knots, the glider will complete the 2,700-km circuit in 41 days. However, the glider may be commanded to remain in areas of interest based on the near real-time whale detection information.

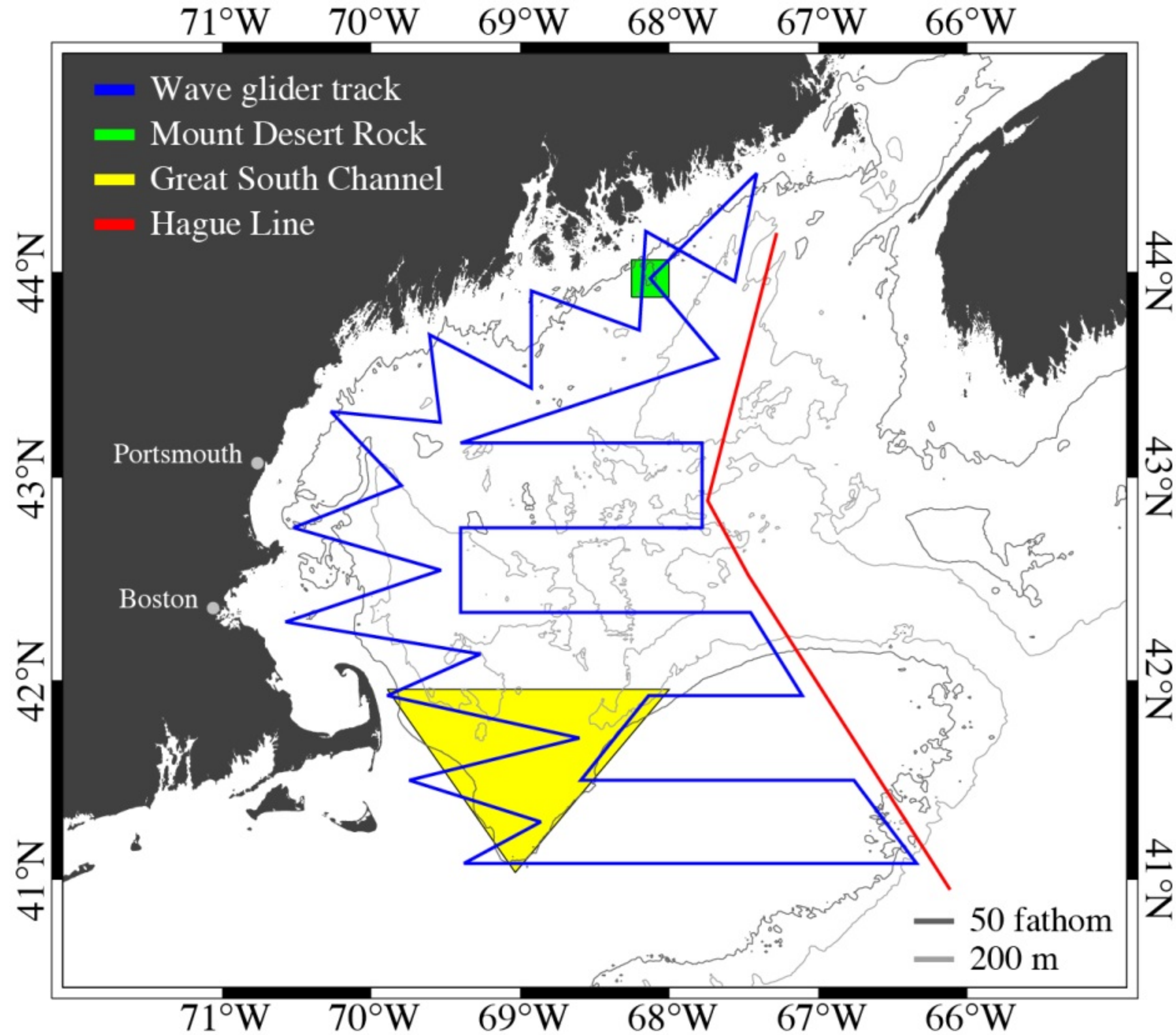


Figure 96. Map of waveglider tracks and Slocum Glider and moored buoy platform locations in the Gulf of Maine. Visual surveys will also be conducted in the Great South Channel (vessel-based) and Mount Desert Rock (shore-based) locations. Aerial surveys will cover the entire region.

To complement the large-scale survey conducted by the wave glider, smaller-scale surveys (tens of kilometers) will be conducted with a Slocum Glider in the Great South Channel (southwestern Gulf of Maine) (**Figure 96**). This region was chosen based on: (1) the ability to conduct sustained visual observations in the same area occupied by the two mobile autonomous platforms, and (2) the predictable availability of baleen whales. The Slocum Glider deployment in the Great South Channel occurred during the spring of 2015 and 2016 when right, sei, humpback, and fin whales are found in this area. These deployments coincided with the annual large whale cruise conducted by NMFS/NEFSC aboard a NOAA ship.

A moored buoy was installed in the waters immediately adjacent to Mount Desert Rock during early 2015 where fin and humpback whales are commonly encountered, and it will remain in operation for 2 years.

Each platform will be equipped with a DMON/LFDCS capable of detecting, classifying, and reporting calls produced by right, fin, humpback, and sei whales. Detection data (i.e., pitch tracks), summary classification data, and analyst-generated predicted occurrence from each platform will be reported in both graphical and tabular form on a publicly accessible web site (dcs.whoi.edu) as soon as the data are relayed to the shore-side computer.

Original deployments occurred during 2015, when a wave glider and a Slocum glider equipped with DMON/LFDCS systems were deployed in the Great South Channel. A moored buoy is also deployed to the north of Mt Desert Rock in Maine. Subsequent deployments have involved refurbishing the buoy as needed, and a second successful Slocum glider deployment during the spring of 2016. The 2016 deployment also included a Slocum glider owned and piloted by the Naval Oceanographic Office as a demonstration of the viability of the technology operating on a U.S. Navy asset. During the 2016 deployment, visual observations were conducted from the NOAA Ship *Gordon Gunter*, allowing for ground-truthing of the acoustic detections relayed by the gliders. Data analyses for these deployments are currently in progress. The wave glider will be redeployed during 2016 to complete a circuit of the Gulf of Maine.

For more information on this study, please see the project profile on the Environmental Security Technology Certification Program website (RC-201446).

2.3.11 Pile Driving Sound Source Measurement

The potential impacts from pile driving noise on marine mammals are currently a relevant topic driving a number of environmental assessments and MMPA permit applications for different parts of the U.S. Navy. However, there is uncertainty as to whether the existing data on source levels from various types and sizes of piles are applicable to the projects of concern, because most of the data were gathered on the U.S. West Coast, with significantly different bathymetry, sediments, and other environmental conditions. This project was initiated in 2012 to determine whether or not the extensive data library of source levels from pile driving collected on the U.S. West Coast (Caltrans 2012 and Washington State Department of Transportation reports) is also representative of noise levels on the U.S. East coast, and to evaluate existing noise conditions at several U.S. Navy installations on the U.S. East Coast. The project specifies six data collection efforts during pile driving projects at U.S. Navy installations on the U.S. East Coast. Six sets of measurements have been completed as of April 2016, with the project completion date set as 31 December 2016.

In May 2013, researchers conducted monitoring on two installations, measuring vibratory installation of steel sheet and H-piles at JEB-LC and impact testing of a single concrete pile at Craney Island. Underwater measurements were made at short- (approximately 10-m) and long-distance (approximately 50- to 200-m) ranges from the piles being driven at both installations. Airborne noise measurements were taken only at JEB-LC. For the steel piles at JEB-LC, the source levels for vibratory driving ranged from 115 to 121 decibels referenced to 1 micro Pascal root mean square. For the impact driving of the concrete pile, source levels averaged between 162 and 169 decibels referenced to 1 micro Pascal root mean square. For more information on this project, see Illingworth and Rodkin, Inc. (2013).

Researchers conducted similar monitoring efforts at the Philadelphia Naval Shipyard and Naval Station Norfolk in fall 2014. At the Philadelphia Naval Shipyard, monitoring included large (48-inch diameter) steel pipe piles, while monitoring at Naval Station Norfolk targeted vibratory driving of small diameter (12- to 16-inches) timber piles and impact driving of 24-inch diameter square concrete piles. For more information on these monitoring projects, please see Illingworth and Rodkin, Inc. (2015a, 2015b).

In 2015, measurements were taken at the temporary pier constructed during training for the Joint Logistics Over The Shore (JLOTS) exercise performed at JEB-LC. In September 2015, measurements of vibratory extraction of 24-inch steel pipe piles were taken. Vibratory extraction measured approximately 145 decibels referenced to 1 micro Pascal root mean square (Illingworth and Rodkin 2015c).

Analyses of how the recently collected data compare to the U.S. West Coast data points are ongoing at NAVFAC Atlantic. At the conclusion of the project, the interim reports from each monitoring event and the compared data will be published in a single comprehensive final report, which will be made available for download.

2.4 Atlantic Undersea Test and Evaluation Center

Passive acoustic methods are being combined with visual observations and satellite telemetry at the Atlantic Undersea Test and Evaluation Center (AUTEC) to document the near and long-term effect of sonar on marine mammals. A Marine Mammal Monitoring on Navy Ranges (M3R) signal processor has been installed at AUTEC as a means of developing marine mammal passive acoustic systems and applying them to long-term monitoring of cetaceans in an area of frequent sonar use.

The AUTEC acoustic range is located in a deep ocean canyon known as the Tongue Of The Ocean, which forms the southern branch of the Great Bahama Canyon among the islands of the northern Bahamas. The range consists of an array of 91 widely-spaced, bottom-mounted hydrophones that are designed to track undersea vehicles. The range is being leveraged for a multi-disciplinary study of cetaceans that combines M3R passive acoustics, expert visual on-water observers collecting individual-based photo-ID data, and the deployment of satellite tags. This work is filling key data gaps to determine the effect of sonar on cetaceans and developing techniques for long-term range monitoring.

The M3R system is being used to monitor the AUTEC hydrophones for vocalizations using real-time passive acoustic tools developed by the program. Trained at-sea visual observers are vectored to vocalizing animals isolated using the M3R system. By combining passive acoustics with visual observations, detected vocalizations are being associated with the species of origin. Significant progress has been made along these lines; however, uncertainty still remains with delphinid species vocalizations. The expert observers provide data on group composition and surface behavior and collect photo-ID data and biopsy samples for analysis. The satellite tags provide direct data on the movement and diving of animals around active sonar operations.

In 2015, field efforts were carried out during two time periods prior to the spring and fall Submarine Commander Courses. The tests were conducted under the auspice of the LMR Program and the Office of Naval Research Marine Mammal and Biology Program. The first took place during 23 April 23 to 11 May, and the second during 24 October – to 06 November. There was an additional test conducted during 10 to 23 Augusto when range activity was low and weather conditions are generally better, thus maximizing the opportunities for locating and tagging beaked whales to gather baseline data.

Vocalizing cetaceans were detected using the M3R system and a rigid-hulled inflatable boat with expert observers (D. Claridge and C. Dunn, Bahamas Marine Mammal Research Organisation) and tagger (J. Durban, NOAA or L. Hickmott, Open Ocean Consulting Ltd.) were directed to vocalizing animals. A total of 39 days were spent in the field, during which 20 days had low sea-states which allowed the team to conduct visual searches for marine mammals on the AUTEC Weapons Range with support from M3R.

During this search effort, the on-water team covered 2,070 km resulting in sightings of 10 different species seen in 30 separate groups. Sixteen groups of Blainville's beaked whales were observed including five mother-calf pairs. These data will be used to update the Blainville's beaked whale population demographic analysis and to inform critical parameters including gestational time, and time to weaning that are vitally important to the on-going Population Consequences of Disturbance (PCoD) model development.

A total of 10 ARGOS tags were deployed on beaked whales. These data are being analyzed for movement before, during, and after MFA sonar operations. Dive data from tags around sonar operations will inform foraging behavior and help document both movement and potential foraging disruption. In total, 16 tags have been deployed on Blainville's beaked whales at AUTEC. The data from the tags and visual studies are being used to inform the expanded Blainville's beaked whale PCoD model. The prototype model will be completed in 2016 will to provide insight into effect of cumulative exposure and also provide a tool to investigate various critical parameters that drive population dynamics.

Additional details on M3R progress at AUTEC and associated references can be found in Moretti et. al (2016).

SECTION 3 – DATA MANAGEMENT

The U.S. Navy's MSM Data Management Plan (DMP; HDR 2014), outlines procedures related to the collection, quality control, formatting, security, classification, governance, processing, archiving, and reporting of data acquired under the U.S. Navy's MSM program. The DMP provides the necessary framework to effectively manage all data acquired under the U.S. Navy MSM Program, from the initial step of data collection through the final step of data archival. The DMP establishes the method by which data flow through the management system and the controls applied to the data during the process. Additionally, the DMP is an important tool that promotes the fullest utilization of the data through data sharing and integration amongst U.S. Navy departments, environmental planners, and researchers. This is achieved in part via the documentation and standardization of data-collection techniques among various researchers. Procedures related to MSM data collection and data management have evolved since 2010, due to refined survey methodologies, improved technologies, and an expanded knowledge base. The DMP is a living document that reflects this evolution, and periodic revisions are driven by adaptive data management based on maturation of the program, and evolving U.S. Navy guidance on specific data-management procedures, including those outlined in the following subsections.

3.1 Data Standards Development

The U.S. Navy MSM Program requires that all acquired data be maintained for ready dissemination to U.S. Navy environmental planners, analysts, and researchers and formatted to ensure compatibility with existing marine databases. This goal is achieved in part by the application of a data standard applied to all U.S. Navy MSM datasets. A data standard involves listing all potential data elements collected under the program (e.g., species, sighting position, environmental variables, etc.), their definitions, required formats for each data element, and any notes, background information, or instructions associated with data collection or data entry for each element. Marine species data are collected under the U.S. Navy MSM Program by a variety of researchers, using multiple visual-survey platforms (vessel, aerial, shore-based), following a range of survey protocols. Standardization of the multiple data types associated with the U.S. Navy MSM Program provides a common vocabulary for data collectors and analysis, and allows large datasets to be compiled for analysis and interpretation. Standardization across all research efforts in every naval range also enables U.S. Navy data managers to ensure that these datasets comply and are compatible with any applicable Federal data standards and data-management frameworks. Examples of standards and frameworks include the multi-DOD service Spatial Data Standards for Facilities, Infrastructure, and Environment; the DOD's Environmental Information Management System (EIMS); the Navy Marine Species Density Database (NMSDD); the Navy Marine Corps Intranet data network and information transfer system; and NOAA's Protected Species Observer and Data Management Program (Baker et al. 2013).

Starting in 2013, the U.S. Navy developed a marine species data standard, applicable to visual survey data acquired under the U.S. Navy MSM Program. The standard is also capable of consolidating relevant "legacy data" collected prior to the start of the U.S. Navy MSM Program in 2010. Survey data fall into three broad categories: sightings, effort, and environmental information. Examples of sighting information include species, sighting location, number of animals, presence of calves, and behavioral information. Effort refers to the amount of time spent looking for animals, platform type, number of observers, distance traveled, and effort type (e.g., random, systematic, or transiting). Environmental conditions are also recorded, including sea state, visibility, glare, and cloud cover. The data standard specifies the required field header names for each data variable, units in which the data are expressed, and formats for each field (numeric, text, Boolean, etc.). This consistent data organization across surveys facilitates back-end data processing and analysis, and streamlines reporting and information-sharing among various researchers and stakeholders. The marine species data standard is designed primarily to accommodate visual survey data. However, in 2015 the standard was expanded to accommodate marine mammal biopsy (i.e., tissue sample) and animal tagging data collected during vessel surveys for cetaceans. **Table 68** lists examples of these attribute headers and their definitions.

Table 68. Biopsy and tagging data now collected with software updates in 2015.

Standardized Headers	Definition
BiopsyHit	Did dart hit animal attempt 1?
BiopsySample	Did dart collect full, partial, or no sample attempt 1?
BiopsyShooter	Name of shooter attempt 1
BiopsySampleLocation1	Location on animal of collected sample (below dorsal right, below dorsal left, left peduncle, right peduncle, fluke, etc.)
BiopsySampleName1	Name of stored sample
BiopsyReactionType	Reaction level of sampled individual (No reaction, Low-level reaction, Moderate reaction, Strong reaction)
BiopsyReactionEvent	Reaction event of sampled individual (shallow dive, flinch, tail slap, upwards tail sweep, banana arch, fast dive, rapid travel/acceleration, breach, etc.)
Biopsy#OthersPresent 1	# of animals surfacing with targeted biopsy individual
BiopsyOtherReactionType	Reaction level of other individuals near sampled individual during tag attempt (No reaction, Low-level reaction, Moderate reaction, Strong reaction)
BiopsyOthersReactionEvent	Reaction event of other individuals near sampled individual during tag attempt (shallow dive, flinch, tail slap, upwards tail sweep, banana arch, fast dive, rapid travel/acceleration, breach, etc.)
BiopsyAnimalFrames	Photo frames of biopsies individual
BiopsyNotes	Notes field to capture relevant biopsy information not covered by existing attributes or other information of interest
BiopsyNotes2	Notes field to capture relevant biopsy information not covered by existing attributes or other information of interest
TaggingHit	Did tag hit animal?
TaggingTagType	Type of tag used
TaggingTagNumber	Assigned tag number
TaggingShooter	Name of tag shooter
TaggingReactionType	Reaction level of tagged individual (No reaction, Low-level reaction, Moderate reaction, Strong reaction)
TaggingReactionEvent	Reaction event of tagged individual (shallow dive, flinch, tail slap, upwards tail sweep, banana arch, fast dive, rapid travel/acceleration, breach, etc.)
TaggingOtherReactionType	Reaction level of other individuals near sampled individual during tag attempt (No reaction, Low-level reaction, Moderate reaction, Strong reaction)
TaggingOthersReactionEvent	Reaction event of other individuals near sampled individual during tag attempt (shallow dive, flinch, tail slap, upwards tail sweep, banana arch, fast dive, rapid Travel/acceleration, breach, etc.)
TaggingTaggedAnimalFrames	Photo frames of tagged individual
TaggingNotes	Notes field to capture relevant tagging information not covered by existing attributes or other information of interest

3.2 Survey Data Software Platform

The U.S. Navy has identified the need to develop a survey collection platform based on the U.S. Navy's MSM Data Standards. The platform needs to streamline collection scenarios, minimize manual data management requirements, and increase the repeatability of data collection efforts. In response to this need, and in collaboration with LMR program, *fin* (no associated acronym) will be an integrated survey data collection and data management system to facilitate work conducted during MSM surveys. The final product will include a mobile platform for data collection, a web portal to set up surveys and access data products, and a server database management system.

The MSM program supports a variety of data collection scenarios and technologies. The preliminary version of the *fin* platform is to address the needs of the most common survey types: shore-based (theodolite), vessel-based, and aerial-based. All platform types will maintain consistency with the U.S. Navy's Data Standard which specifies field names, aliases, data types, units and descriptions for data that are collected in the field. Each collection scenario will use some subset of fields specified in the data standard.

HDR's *fin* survey toolkit integrates current mobile and web technologies to allow efficient real-time data collection, processing, reporting, and delivery of marine species data. This system consists of both a mobile mapping application that functions in areas without network or cellular connectivity, and a web-based interface utilized for survey setup, Quality Control (QC), team collaboration, and preliminary data processing/reporting.

The mobile application will run on the Apple iPad® platform, and will be the primary interface for the collection of field data (**Figure 97a**). The mobile application will include mapping capabilities for navigation and data collection. It will have the ability to display the data stream (e.g., sightings and effort), relevant auxiliary data (e.g., range complex boundaries, exclusion zones, PAM stations, pinnacles, etc.), and customizable basemap layers (e.g., bathymetry, ortho-imagery) (**Figure 97b)**. Users will be able to pan and zoom on the map, and control the visibility of data layers on the map. Users will have the ability to search the attributes of collected data and auxiliary data, and zoom to the search results.

Figure 97a. Example screenshot of the sighting data for the field data collection application currently in development. The Sightings View provides species, sighting, and time stamp information.

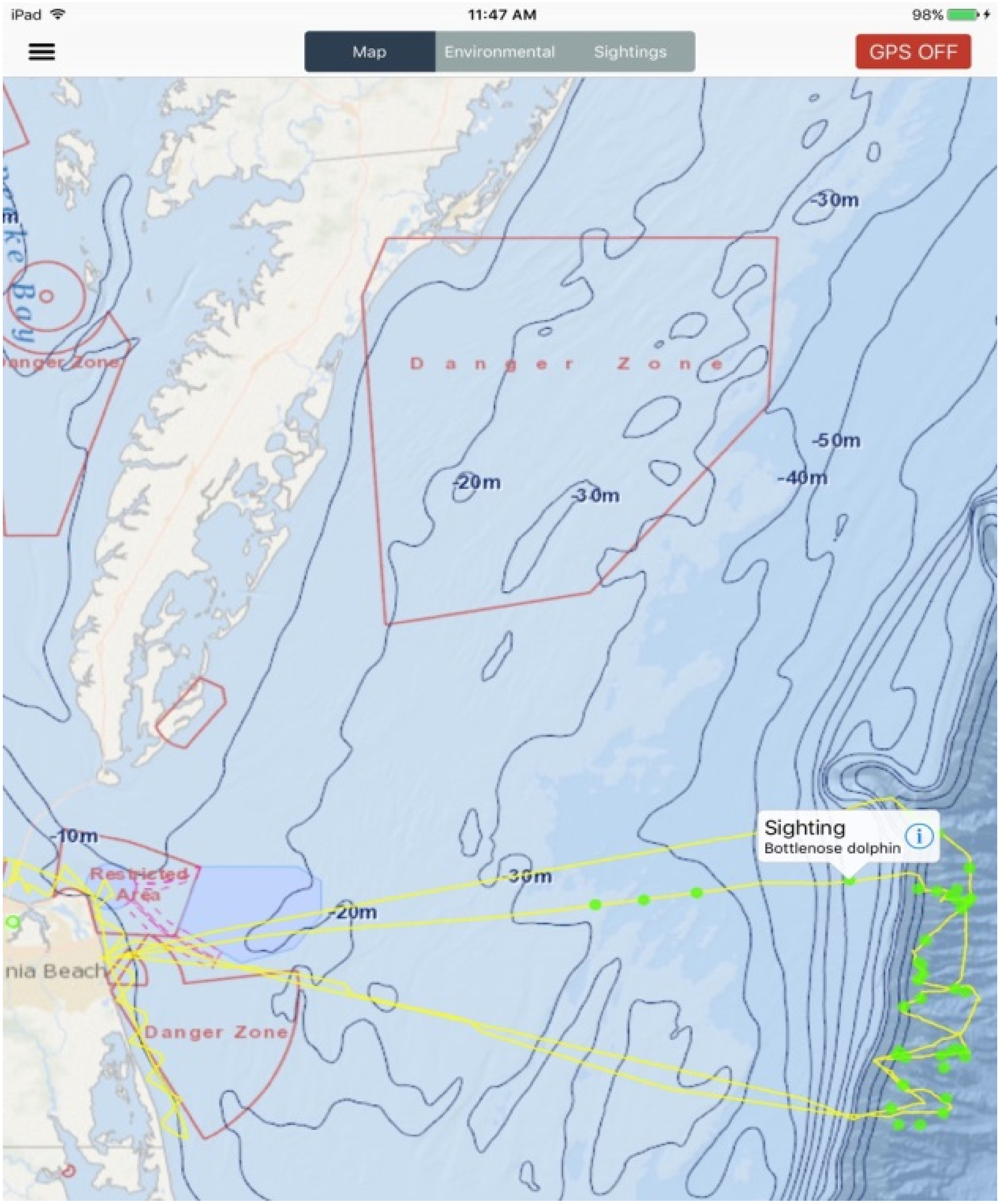


Figure 97b. Example screenshot of the mapping feature for the field data collection application currently in development. The Map View shows the platform trackline (yellow lines) and sighting locations (green dots) from vessel surveys off of Virginia Beach, Virginia. The bathymetry layer is used for reference while conducting the survey and the "hamburger" icon at the upper left allows the user to toggle between the Map View and Sightings View.

Customizable data fields will allow users to collect data relevant to each of the survey types with ancillary objects (e.g., focal-follow studies, biopsy collection, satellite tagging, etc.). All data collected will be stored on relational databases adhering to the U.S. Navy's MSM Data Standard.

Data collected with the mobile app will be synchronized to a central database server via Wi-Fi, cellular data connection, or USB. Transmitting collected data ensures that information is archived and protected, while allowing for collaborative QC review and editing through a web-based user interface. Data will also be able to backed up, editable, and managed locally when web connectivity is unavailable.

The web-based application will be the central interface for the management of marine species surveys and data. It will also allow access from any internet-connected computer, allowing field crews, biologists, and program managers from multiple locations to collaborate on active surveys.

Field crews will use the web application to verify and perform QC checks on data uploaded from the mobile application. Accessing this data via the web will not only allow field crews to verify that collected data has been successfully transmitted to the server, but also provide an opportunity to review and annotate field data from laptop computers. If internet access is unavailable, QC checks in the field can be conducted in the mobile application.

Prior to initiating a survey, the web-portal will be used to create a new survey, assign authorized users to a survey and configure survey information including species lists and equipment descriptions, etc. The web portal will also provide instructions for the loading of pre-built basemaps. These pre-built basemaps will be available for the most common survey areas. Pre-built basemaps will cover the instrumented U.S. Navy training ranges and other areas of interest. Instructions will detail the creation and loading of custom basemaps directly onto the field iPad® for surveys. The web portal will also provide instructions to load any additional feature data required for the survey including tidal data, track lines, waypoints of interest, passive acoustic mooring positions, etc.

After the survey is completed and the data is synced to a central database server, the primary access to the survey data will occur through a web-based interface. This user interface allows access to the centralized back end database, and facilitates QC review and editing. It allows a broader set of specified users (field crews, biologists, program managers, external clients) access to the data, while controlling access through the use of user accounts and permissions. Program managers will use the web application interface to monitor data collection, QC activity, and export data.

While primary data transmission will be via wireless sync to the central database server, instructions will also be provided on methods to manually backup the field data offline.

To date, a functional requirements document outlining *fin* development, specifications, user stories, and overall capabilities has been completed. This living document serves as a roadmap for the development team and provides a basis for application benchmark testing. The Geographic Information System (GIS) Data Model documentation has been finalized and has been incorporated into the base application. Programming for the web application as well as the mobile field application including the three survey platforms (e.g., aerial, vessel, and shore-based) is ongoing. Desktop and initial development testing and validation is anticipated to commence in summer 2016.

For more information, refer to the annual progress report for this project (Richlen et al. 2016b).

3.3 Data Archiving and Access

All visual-survey data collected under the U.S. Navy MSM program are provided to EIMS, a GIS-based toolset to support U.S. Navy environmental and range-sustainment programs, including environmental planning for at-sea training/testing and at-sea regulatory compliance. Data are uploaded to EIMS in the form of personal geodatabase files, containing feature classes for sightings (points) and survey tracklines (polylines). Source data from all surveys also are uploaded for archival purposes, accompanied by all relevant metadata. Marine species data maintained in this centralized location allow the U.S. Navy to track all MSM data collected in various training ranges, and also to use this information to build the NMSDD. Under U.S. Federal laws, the U.S. Navy is required to estimate the impacts of U.S. Navy-generated underwater sound on protected marine species, and to calculate the numbers of animals that may be affected by the sound generated during U.S. Navy training and testing. In order to calculate accurate "take" estimates, the U.S. Navy must consider marine species density estimates (number of animals per unit area) for all U.S. Navy training and testing ranges. The NMSDD provides the U.S. Navy with data necessary to quantify impacts of sound on protected marine species. In range complexes where density information is lacking, the NMSDD can be used to extrapolate or predict densities to calculate takes where little or no information exists.

The U.S. Navy MSM data-management team effectively disseminates data to facilitate information sharing among stakeholders, and to advance the general knowledge of marine species distribution and behavior. This information dissemination is achieved in part by the delivery of U.S. Navy MSM visual survey data to the OBIS-SEAMAP database, a spatially and temporally interactive online archive for marine mammal, sea turtle, and seabird data. Researchers worldwide contribute datasets to Duke University's Marine Geospatial Ecology and Marine Conservation Ecology Laboratories, which maintain OBIS-SEAMAP. The U.S. Navy contributes all MSM survey data to OBIS-SEAMAP to contribute to expanding the knowledge of global patterns of marine species distribution and biodiversity. Once these datasets are provided to OBIS-SEAMAP, the information is published at http://seamap.env.duke.edu/partner/NAVY. The U.S. Navy and its contractors have provided 88 datasets totaling over 33,000 records in both the Atlantic and Pacific to OBIS SEAMAP as of March 2016.

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SECTION 4 – ADAPTIVE MANAGEMENT AND STRATEGIC PLANNING PROCESS

Adaptive management is an iterative process of optimal decision-making in the face of uncertainty, with an aim to reduce uncertainty over time via system monitoring and feedback. Within the natural resource management community, adaptive management involves ongoing, real-time learning and knowledge creation, both in a substantive sense and in terms of the adaptive process itself. Adaptive management focuses on learning and adapting, through partnerships of managers, scientists, and other stakeholders. Adaptive management helps managers maintain flexibility in their decisions, knowing that uncertainties exist, and provides managers the latitude to change direction so as to improve understanding of ecological systems to achieve management objectives. Taking action to improve progress toward desired outcomes is another function of adaptive management.

AMR is a process involving NMFS, the Marine Mammal Commission (MMC), and non-governmental organizations through technical review meetings and ongoing discussions. Dynamic revisions to the compliance monitoring structure as a result of AMR include the further development of the Strategic Planning Process (DoN 2013d*)*, which is a planning tool for selection of monitoring projects, and its incorporation into the ICMP for future monitoring. Phase II monitoring addresses the ICMP top-level goals through a collection of specific regional and ocean basin studies based on scientific objectives. The AMR process and reporting requirements serves as the basis for evaluating performance and compliance.

The marine species monitoring program has evolved and improved as a result of the AMR process through changes including:

1. Recognition of the limitations of effort-based compliance metrics
2. Recasting the original generic study questions (DoN 2009b) into a revised conceptual framework
3. Shifting to monitoring projects based on scientific objectives to facilitate generation of statistically meaningful results upon which natural resources management decisions may be based
4. Focusing on priority species or areas of interest as well as best opportunities to address specific monitoring objectives in order to maximize return on investment
5. Increased transparency of the program and management standards, improved collaboration among participating researchers, and improved accessibility to data and information resulting from monitoring activities

As a result, U.S. Navy's compliance monitoring has undergone a transition with the implementation of the Strategic Planning Process under MMPA Authorizations for AFTT and Hawaii-Southern California Training and Testing (HSTT). Under this process, Intermediate Scientific Objectives serve as the basis for developing and executing new monitoring projects across the U.S. Navy's training and testing ranges (both Atlantic and Pacific). Implementation of the Strategic Planning Process involves coordination among Fleets, systems commands (SYSCOMs), CNO-N45, NMFS, and the MMC and has five primary steps:

1. **Identify overarching intermediate scientific objectives**–Through the adaptive management process, the U.S. Navy coordinates with NMFS as well as the MMC to review and revise the list of intermediate scientific objectives that are used to guide development of individual

monitoring projects. Examples include addressing information gaps in species occurrence and density, evaluating behavioral response of marine mammals to U.S. Navy training and testing activities, and developing tools and techniques for passive acoustic monitoring.

2. **Develop individual monitoring project concepts**–This step generally takes the form of soliciting input from the scientific community in terms of potential monitoring projects that address one or more of the intermediate scientific objectives. This can be accomplished through a variety of forums including professional societies, regional scientific advisory groups, and contractor support.
3. **Evaluate, prioritize, and select monitoring projects**–U.S. Navy technical experts and program managers review and evaluate all monitoring project concepts and develop a prioritized ranking. The goal of this step is to establish a suite of monitoring projects that address a cross-section of intermediate scientific objectives spread over a variety of range complexes.
4. **Execute and manage selected monitoring projects**–Individual projects are initiated through appropriate funding mechanisms and include clearly defined objectives and deliverables (e.g. data, reports, publications).
5. **Report and evaluate progress and results**–Progress on individual monitoring projects is updated through the U.S. Navy's Marine Species Monitoring Web Portal as well as annual monitoring reports submitted to NMFS. Both internal review and discussions with NMFS through the adaptive management process are used to evaluate progress toward addressing the primary objectives of the ICMP and serve to periodically recalibrate the focus on the U.S. Navy's MSM program.

These steps serve three primary purposes: 1) to facilitate the U.S. Navy in developing specific projects addressing one or more intermediate scientific objectives; 2) to establish a more structured and collaborative framework for developing, evaluating, and selecting monitoring projects across all areas where the U.S. Navy conducts training and testing activities; and 3) to maximize the opportunity for input and involvement across the research community, academia, and industry. Furthermore, this process is designed to integrate various elements including:

- Integrated Comprehensive Monitoring Program top-level goals
- Scientific Advisory Group recommendations
- Integration of regional scientific expert input
- Ongoing AMR dialog between NMFS and U.S. Navy
- Lessons learned from past and future monitoring at U.S. Navy training and testing ranges
- Leverage research and lessons learned from other U.S. Navy-funded science programs

The Strategic Planning Process will continue to shape the future of the U.S. Navy's MSM Program and serve as the primary decision-making tool for guiding investments. **Table 69** summarizes U.S. Navy monitoring projects underway in the Atlantic for 2016. Additional details on these projects as well as results, reports, and publications will be made available through the U.S. Navy's Marine Species Monitoring Web Portal as they are available.

Table 69. Summary of monitoring projects underway in the Atlantic for 2016.

Project Description	Intermediate Scientific Objectives	Status
Title: Tagging and Tracking of Endangered North Atlantic Right Whales in Florida Waters **Location**: JAX Range Complex **Objectives**: Assess movement patterns of right whales in coastal waters off Florida, rates of travel of individual whales, dive depths, rates of sound production **Methods**: Observational methods combined with short term (ca. 24 hour) non-invasive suction cup attached multi-sensor acoustic recording tags with Fastloc GPS **Performing Organizations**: Duke University, Syracuse University **Timeline**: 2014 through 2017 **Funding**: FY13 - $335K, FY14 - $390K, FY15–$505K, FY16 TBD	• Establish the baseline habitat uses and movement patterns of marine mammals where Navy training and testing activities occur • Establish the baseline vocalization behavior of marine mammals and sea turtles where Navy training and testing activities occur • Establish the baseline behavior (foraging, dive patterns, etc.) of marine mammals where Navy training and testing activities occur	**Field work - winters 2014-2017** • Technical progress report available – 2014, 2015 • 2016 field summary available
Title: Lower Chesapeake Bay Sea Turtle Tagging and Tracking **Location**: Lower Chesapeake Bay (Hampton Roads) **Objectives**: Assess occurrence and behavior of loggerhead, green, and Kemp's ridley sea turtles in the Hampton Roads region of Chesapeake Bay and coastal Atlantic Ocean **Methods**: Satellite, GPS, and acoustic transmitter tags **Performing Organizations**: Virginia Aquarium and Marine Science Center Foundation, NAVFAC Atlantic **Timeline**: 2013 through 2016 **Funding**: FY13 - $180K, FY14 - $195K, FY15 - $70K, FY16 - $128K	• Estimate the density of marine mammals and sea turtles in Navy range complexes and in specific training areas • Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to sonar and underwater explosives	**Field work summers 2013-16** • Technical progress reports available– 2013, 2014, 2015

Project Description	Intermediate Scientific Objectives	Status
Title: Assessment of Deep Diving Cetacean Behavior in Relation to Navy Training Activities **Location**: Cape Hatteras **Objectives**: Establish behavioral baseline and foraging ecology. Assess behavioral response to acoustic stimuli and Navy training activities **Methods**: Visual surveys, biopsy sampling, DTAGs, satellite tags **Performing Organizations**: Duke University, Woods Hole Oceanographic Institute, Cascadia Research Collective **Timeline**: 2013-2016 **Funding**: FY12 - $275K, FY13 - $250K, FY14 - $510K, FY15 - $520K, FY16 - $420K	• Determine what populations of marine mammals are exposed to Navy training and testing activities • Establish the baseline behavior (foraging, dive patterns, etc.) of marine mammals where Navy training and testing activities occur • Evaluate behavioral responses by marine mammals exposed to Navy training and testing activities	**Field work spring/summer 2013-15** • Technical progress reports available– 2013, 2014, 2015
Title: NAS Patuxent River Marine Species Surveys **Location**: Chesapeake Bay (NAS Patuxent River) **Objectives**: Assess occurrence, seasonality, and abundance of Tursiops in the waters new NAS PAX River **Methods**: Aerial surveys, passive acoustics **Performing Organizations**: HDR Inc **Timeline**: 2015-2017 **Funding**: $675K	• Estimate the density of marine mammals and sea turtles in Navy range complexes and in specific training areas • Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur	**Field work began April 2015** • 2015 technical progress report available
Title: Occurrence, Distribution, and Density of Marine Mammals Near Naval Station Norfolk and Virginia Beach **Location**: Hampton Roads coastal Atlantic Ocean, W-50 MINEX training range **Objectives**: Assess occurrence, seasonality, and stock structure of Tursiops in the coastal waters of Hampton Roads military installations **Methods**: Small vessel visual line transect surveys, photo ID, PAM **Performing Organizations**: HDR Inc. **Timeline**: 2012 through 2015 **Funding**: FY13 - $325K, FY14 - $340k, FY15 - $0	• Estimate the density of marine mammals and sea turtles in Navy range complexes and in specific training areas • Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur.	**Field work summers 2013-15** • Technical progress reports available– 2013, 2014, 2015 • Final project report in prep

Project Description	Intermediate Scientific Objectives	Status
Title: Bottlenose Dolphin Occurrence in Estuarine and Coastal Waters near Panama City, Florida **Location**: St. Andrew Bay and nearshore waters of Panama City, Florida **Objectives**: Determine species occurrence, and distribution, habitat use, and abundance of Tursiops in St. Andrew Bay and coastal waters adjacent to the Naval Surface Warfare Center, Panama City Division. **Methods**: Small vessel visual line transect surveys, photo ID **Performing Organizations**: NOAA Hollings Marine Laboratory **Timeline**: 2015-2016 **Funding**: FY15 - $112K	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Establish the baseline habitat uses and movement patterns of marine mammals where Navy training and testing activities occur • Estimate the density of marine mammals and sea turtles in Navy range complexes and in specific training areas.	Field work 2015 • First field season - July 2015 • Second field season – Oct 2015 • Technical report in prep
Title: Acoustic Monitoring and Evaluation of Tursiops Response to MINEX Training Activities **Location**: Hampton Roads coastal Atlantic Ocean, W-50 MINEX training range **Objectives**: Assess occurrence of *Tursiops* in the vicinity of the W-50 MINEX range. Assess vocal response of *Tursiops* to underwater explosions **Methods**: PAM **Performing Organizations**: Oceanwide Science Institute **Timeline**: 2012 through 2016 **Funding**: FY12 - $230K, FY13 - $230K, FY14 - $230K, FY15 - $135K	• Establish the baseline vocalization behavior of marine mammals where Navy training and testing activities occur • Develop analytic methods to evaluate behavioral responses based on passive acoustic monitoring techniques • Evaluate behavioral responses by marine mammals exposed to Navy training and testing activities	**Field work 2012 through 2016** • Technical progress reports available-2013, 2014, 2015 • Final report in prep

Project Description	Intermediate Scientific Objectives	Status
Title: Baseline Monitoring for Marine Mammals in the East Coast Range Complexes – **Visual surveys** **Location**: Virginia Capes, Cherry Point, and Jacksonville Range Complexes **Objectives**: Assess occurrence, habitat associations, density, and stock structure, of marine mammal and sea turtles in key areas of Navy range complexes **Methods**: Aerial and vessel visual surveys, biopsy sampling, photo-ID **Performing Organizations**: Duke University, UNC Wilmington, University of St Andrews, **Timeline**: Ongoing **Funding**: FY14 - $750K, FY15 - $1.05M, FY16 - TBD	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Estimate the density of marine mammals and sea turtles in Navy range complexes and in specific training areas • Determine what populations of marine mammals are exposed to Navy training and testing activities • Evaluate trends in distribution and abundance of populations that are regularly exposed to sonar and underwater explosives	**Ongoing** • Began in 2008 as preliminary USWTR baseline monitoring • Current focus – Norfolk Canyon, Hatteras, Jacksonville • Technical progress report series available
Title: Baseline Monitoring for Marine Mammals in the East Coast Range Complexes – **Passive acoustics** **Location**: Virginia Capes, Cherry Point, and Jacksonville Range Complexes **Objectives**: Assess occurrence, habitat associations, density, stock structure, and vocal activity of marine mammal and sea turtle in key areas of Navy range complexes **Methods**: Passive acoustic monitoring **Performing Organizations**: Duke University, Scripps Institute of Oceanography **Timeline**: Ongoing **Funding**: FY14 - $780K, FY15 - $680K, FY16 - TBD	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Establish the baseline vocalization behavior of marine mammals where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to sonar and underwater explosives	**Ongoing** • Began in 2008 as preliminary USWTR baseline monitoring • Current focus – Norfolk Canyon, Hatteras, Jacksonville • Technical progress report series available
Title: Assessment of Marine Mammal Vocal Response to Sonar **Location**: Cherry Point and Jacksonville Range Complexes **Objectives**: Develop analytic methods to evaluate the vocal response of odontocetes and mysticetes to sonar from navy training activities **Methods**: PAM **Performing Organizations**: Bio-Waves Inc, Cornell University, University of St. Andrews **Timeline**: 2014-2015 **Funding**: FY13 - $335K, FY14 - $50K,; FY15 $45K	• Determine what behaviors can most easily be assessed for potential response to Navy training and testing activities • Develop analytic methods to evaluate behavioral responses based on passive acoustic monitoring techniques • Evaluate behavioral responses by marine mammals exposed to Navy training and testing activities	**Initial methods development complete** • Final Technical reports available • Methods validation in progress Final report in prep

Project Description	Intermediate Scientific Objectives	Status
Title: Mid-Atlantic Humpback Whale Monitoring **Location**: VACAPES Range Complex **Objectives**: Assess occurrence, habitat use, and baseline behavior of humpback whales in the mid-Atlantic region **Methods**: Focal follow observational methods, photo-ID, biopsy sampling, satellite tagging **Performing Organizations**: HDR Inc. **Timeline**: 2014 through 2017 - anticipated 3 field seasons **Funding**: FY14 - $300k, FY15–260K; FY16 TBD	• Establish the baseline habitat uses and movement patterns of marine mammals where Navy training and testing activities occur • Establish the baseline behavior (foraging, dive patterns, etc.) of marine mammals where Navy training and testing activities occur	**Field work 2015-17** • First field season winter 2015 • Satellite tagging component added 2015/16 field season • Second field season winter 2015/2016Technical progress reports available – 2014, 2015
Title: VACAPES Continental Shelf Break Cetacean Study **Location**: VACAPES Range Complex **Objectives**: Assess occurrence, habitat use, and baseline behavior of cetaceans in the mid-Atlantic region **Methods**: Focal follow observational methods, photo-ID, biopsy sampling, satellite tagging **Performing Organizations**: HDR Inc. **Timeline**: 2015 through 2017 - anticipated 3 field seasons **Funding**: FY15 - $75K; FY16 TBD	• Determine what species and populations of marine mammals and sea turtles are present in Navy range complexes • Establish the baseline habitat uses and movement patterns of marine mammals where Navy training and testing activities occur • Establish the baseline behavior (foraging, dive patterns, etc.) of marine mammals where Navy training and testing activities occur	**Field work 2015-17** • Pilot project initiated 2015 • Field work summary available
Title: Haul Out Counts and Photo-Identification of Pinnipeds in Narragansett Bay, Rhode Island and Chesapeake Bay, Virginia **Location**: Chesapeake Bay and Narragansett Bay **Objectives**: Document seasonal occurrence, habitat use, and haul-out patterns of seals **Methods**: Visual surveys, photo-ID **Performing Organizations**: NAVFAC Atlantic, NUWC Newport **Timeline**: 2014 to 2016 **Funding**: FY15: $104K	• Estimate the density of marine mammals and sea turtles in Navy range complexes and in specific training areas • Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur • Evaluate trends in distribution and abundance of populations that are regularly exposed to sonar and underwater explosives	**New start winter 2014-15**

Project Description	Intermediate Scientific Objectives	Status
Title: Sound Source Measurements from Pile Driving **Location**: Navy installations along the US East Coast **Objectives**: Determine the source levels produced by impact and vibratory driving of different size and material piles during construction projects **Methods**: Source measurements and acoustic propagation modelling **Performing Organizations**: HDR Inc., Illingworth and Rodkin Inc. **Timeline**: 2012-20165 **Funding**: FY12 - $450K	• Collect data to support impact and effects analyses (e.g. sound source measurements and propagation modelling)	**Field work 2013-2016** • Reports available for measurements at JEB Little Creek, NS Norfolk, and Philadelphia Naval Shipyard • Additional measurements to be completed in 2016

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APPENDIX A

RECENT PUBLICATIONS AND PRESENTATIONS RESULTING FROM AFTT-RELATED MONITORING INVESTMENTS

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APPENDIX A: RECENT PUBLICATIONS AND PRESENTATIONS RESULTING FROM AFTT-RELATED MONITORING INVESTMENTS

Aschettino, J., D. Engelhaupt, A. Engelhaupt, J. Bell, and J. Bort Thornton. 2015. Humpback whale presence and habitat-use in high-traffic areas off Virginia. Abstracts, 21st Biennial Conference on the Biology of Marine Mammals. 13-18 December 2015. San Francisco, California.

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Publications and presentations from previous years also are available in the reading room of the U.S. Navy's Marine Species Monitoring Program website (http://www.navymarinespeciesmonitoring.us/reading-room/publications/).

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