Final Report

Operation of the Navy's Telemetry Array in the Lower Chesapeake Bay: 2013 - 2018

Cumulative Report

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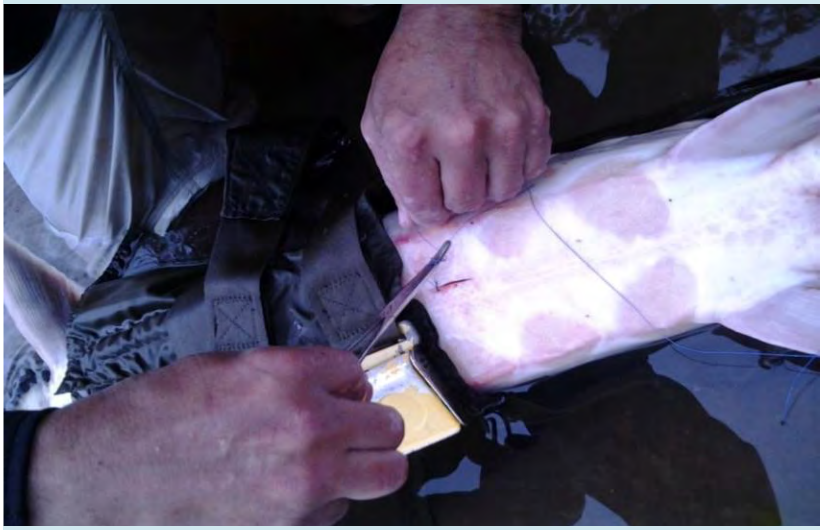

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Cover photo credit:

Chris Hager surgically implanting transmitter in Atlantic sturgeon. Photographed by Chesapeake Scientific staff, NMFS Permit 16547-01.

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Acronyms and Abbreviations

ACT	Atlantic Coastal Telemetry
BOEM	Bureau of Ocean Energy Management
cm	centimeters
CBBT	Chesapeake Bay Bridge-Tunnel
COLREGS	Collision Regulations line—dividing inland from coastal waterways and "rules of the road" as set forth in the International Regulations for the Preventing Collisions at Sea, 1972
°C	degrees Celsius
DPS	Distinct Population Segment(s)
ESA	Endangered Species Act
FL	fork length
GIS	geographic information system
kHz	kilohertz
km	kilometer(s)
m	meter(s)
mm	millimeters(s)
Navy	Department of the Navy
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NSN	Naval Station Norfolk
NOAA	National Oceanic and Atmospheric Association
NW/Ch.	Naval Weapons Station/Cheatham Annex
PIT	Passive Integrated Transponder
psu	practical salinity units
Range Sur.	Dam Neck Naval Firing Range Surrogate
RM	river mile
U.S.	United States
USFWS	United States Fish and Wildlife Service
USCG	United States Coast Guard
USGS	United States Geological Survey
VCU	Virginia Commonwealth University
VIMS	Virginia Institute of Marine Science
YOY	young-of-the-year

Executive Summary

From 2013 through 2018, HDR and Chesapeake Scientific were funded by the United States (U.S.) Department of the Navy (Navy), through U.S. Fleet Forces Command and the Commander, Navy Region Mid-Atlantic, to collect tracking data on endangered Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) within the lower Chesapeake Bay, with an emphasis on zones of military importance. The goal of the study was to use the spatial and temporal data provided through continuous long-term tracking to define occupancy and migration patterns of Atlantic sturgeon so that the Navy may conduct a more informed assessment of potential impacts of their activities on the species. The objectives of this study were to delineate migratory pathways and define periods of residency of Atlantic sturgeon. In addition, results were to be converted to and archived in a geographic information system (GIS) format. The immediate results are directly applicable to Endangered Species Act (ESA) section 7 consultations and National Environmental Policy Act (NEPA) requirements, as well as numerous other environmental policy decisions. The archived GIS data increase the value of the research project because this format allows the data to be applied to future research, the objectives of which have not yet been defined.

More than 75 VEMCO® VR2W receivers were deployed strategically in arrays to cover military zones and regions of biological significance in Virginia within the York River watershed, the Lower James River, the Elizabeth River, the mouth of the Chesapeake Bay, and nearshore Atlantic waters. These receivers remained in place for the entire six-year period. The military zones of interest monitored within these regions were: Naval Weapons Station Yorktown and Cheatham Annex zone (NW/Ch. zone, York River region); Naval Station Norfolk (NSN) and Norfolk Naval Shipyard zone (Elizabeth River zone, James River region); Joint Expeditionary Base Little Creek zone (Little Creek zone) and Joint Expeditionary Base Fort Story zone (Fort Story zone) both in the Chesapeake Bay region; and a large Range Surrogate zone just north of the Naval Firing Range off Dam Neck (Range Sur., Atlantic region). In addition to these receivers, more than 25 seasonally operational receivers were placed in the Pamunkey and Mattaponi rivers to better understand the newly discovered York River population of Atlantic sturgeon.

Atlantic sturgeon detected in the Navy arrays were originally tagged in Virginia, Maryland, Connecticut, New York, New Jersey, Delaware, North Carolina, South Carolina, and Georgia. In April 2016, one of our arrays also detected a sturgeon tagged in Maine. Sturgeon tagged in the York River system through this study were detected in the arrays of other regions as well. In winter, Atlantic sturgeon were most often detected off the coast of Virginia on the oceanic shelf. Some, mostly females, moved south along the shelf overwintering off South Carolina, Georgia, and even northern Florida. Smaller numbers of fish and detections, mostly males, were reported in Delaware and the New York Bight in the summer. Fish of varied life stages were dispersed throughout the Navy arrays. Residence by sturgeon of such diverse ages and origins within Virginia waters demonstrates the importance of the region to the species. Detections of fish in locations that were varied and distant from their original tagging location emphasize the highly migratory character of the species and the need for federal management.

For example, recent data from South Carolina suggest that many Pamunkey River females reside in nearshore waters off Folly Beach, South Carolina, during the winter. Some have been detected in the same locations over consecutive winters before returning to spawn. Males are less likely to undertake such extreme migrations and appear instead to overwinter in offshore waters near the edge of the continental shelf.

Many previous studies, especially those based on commercial fisheries data, have suggested that Atlantic sturgeon are primarily shallow water fish and do not often inhabit the continental shelf (Vladykov and Greenly 1963, Murdy et al. 1997, Stein et al. 2004, Laney et al. 2007). Such findings have resulted in the false assumption that Atlantic sturgeon are not found in deep waters. Recent expansion of acoustic monitoring approaches (2016–2018) into greater depths, supported by the Navy and Bureau of Ocean Energy Management (BOEM), is providing evidence that contradicts this belief. In fact, it provides data that prove sturgeon occupy the continental shelf more often than previously assumed (Carter Watterson, Naval Facilities Engineering Command, Atlantic, personal communication). In some cases, sturgeon have remained in deep waters off the coast of Virginia during the entire winter. Other fish demonstrate that deep corridors along the shelf are used for seasonal latitudinal migrations. Regardless of which behavior these new tracking data are recording, evidence is growing that Atlantic sturgeon frequently occupy and use waters of far greater depth than they were once believed to commonly inhabit.

The tracking of Atlantic sturgeon in Virginia provided solid spatial and temporal occupation data; enough data to delineate temporal migration patterns and define periods of residency for the species as whole. However, this study also provided critical biological data that were lacking for the Chesapeake Bay. Prior to this study, no York River stock was known to exist and very few data on the physical characteristics of preferred habitats within the Chesapeake Bay and its tributaries were available. This study's continuous efforts on tagging and tracking in the York River system provided the data necessary to better understand the species' local life history as well as to define the fundamental biological attributes of the species as a whole in Virginia.

For the past six years extensive tagging and tracking field work has occurred every summer and early fall in the York River system to further our knowledge of this previously unknown stock. These data are critical to the Navy's management decisions because the York River stock is very small and it is directly impacted by operations at NW/Ch. zone in the York River region. Despite unequal quality in recapture data between annual estimations due to highly varied inter-annual spawning behavior, overall results suggest that the system contains habitat necessary for the survival of one of the smaller, if not the smallest, reproducing stock of the species known to be in existence. The assertion that the population is very small is supported not only by our data but through genetic analysis conducted by the U.S. Geological Survey (USGS), in Leetown, West Virginia, the leading experts on the genetic composition and variability of the species.

Annual research in the York River system has provided solid evidence that spawning is occurring every fall, most likely in both the Mattaponi and Pamunkey rivers. Concurrent tagging and tracking efforts in the Mattaponi River suggest that approximately a tenth of the individuals that return to spawn in the York's system enter the Mattaponi River annually. A small percentage of male Atlantic sturgeon alternate runs between the Mattaponi and Pamunkey rivers within the same year. Females have been documented occupying an alternate river when they return to spawn a year or several years later but have not been documented in the freshwater reaches of both tributaries within the same year.

Tracking data within the bay have provided a means of examining migration patterns of returning York River adults in detail. These natives do not randomly migrate through the Chesapeake Bay on their way to the York's spawning grounds but select specific pathways and exhibit distinctly seasonal behaviors. Concurrent research in the Nanticoke River in Maryland has recorded tagged fish of York River origin (Chuck Stence, Maryland Division of Natural Resources, personal communication). In one case, the same female was attained full of eggs in freshwater in the Naticoke system and years later was captured half spawned out in the Pamunkey River. Unsurprisingly, USGS genetic research suggests that there is no distinct difference between Atlantic sturgeon obtained in the Nanticoke and those spawning in the York River system. Further research is necessary to determine whether the genetically unique reproducing population spawning in the York River is acting as a source for colonization of other stocks in the northern bay or if it is simply the only northern bay population that has been adequetely sampled.

The physical characteristics that motivate selection of various habitats during migration and spawning are not yet fully understood. However, the extended duration of this study has made it obvious that the species' behavior is in no way fixed but is temporally and spatially responsive to numerous environmental variables that expand or contract its distribution. Understanding such responses and resulting distributions is essential to the Navy's goal of avoiding negative impacts while continuing its regional missions.

The benefits of the acoustic monitoring in this project go far beyond the valuable information we have learned about Atlantic sturgeon. Due to the prudent funding of the Navy for acoustic monitoring in Virginia waters, over 5.9 million detections of nearly 3,000 individual animals belonging to 37 different species have been collected and delivered to 77 different researchers at 52 institutes and organizations. Thus, although funded by the Navy, this project contributes a tremendous value to all federally-supported grants and contracts that use acoustic tracking along the entire Atlantic coast.

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1. Introduction

The Chesapeake Bay, located in the U.S. Mid-Atlantic, borders two states (Maryland and Virginia) and is the largest (6500 sq km/2,500 square miles) and longest (314 km/195 miles) estuary in the U.S. (White 1989). The Navy has a large presence in Virginia's lower Chesapeake Bay and nearshore Atlantic waters. In order to better understand potential naval impacts on Atlantic sturgeon, receiver arrays were deployed within eight Chesapeake Bay regions: Pamunkey River, Mattaponi River, York River, Chickahominy River, mouth of the James River, Elizabeth River, lower Chesapeake Bay, and Atlantic Ocean (**Figure 1**). There are six zones of military interest that occur within these regions: the NW/Ch. zone (York River region), the NSN zone and the Elizabeth River zone (both in the James River region), the Little Creek and Fort Story zones (Chesapeake Bay region), and the Range Sur. zone (Atlantic region). Receiver arrays were strategically deployed within each of these zones to determine the temporal and spatial aspects of Atlantic sturgeon presence.

The primary objective of this project was to begin delineating spatial and temporal patterns in Atlantic sturgeon occupancy in the lower Chesapeake Bay and nearshore waters, with a focus on zones of naval interest. Numerous biological uncertainties surround Atlantic sturgeon within these regions and specifically within these military zones of interest. All zones contain military activities that could impact sturgeon and/or their habitats. Results will be directly applicable to ESA section 7, and support required analysis under NEPA and numerous other environmental policy decisions.

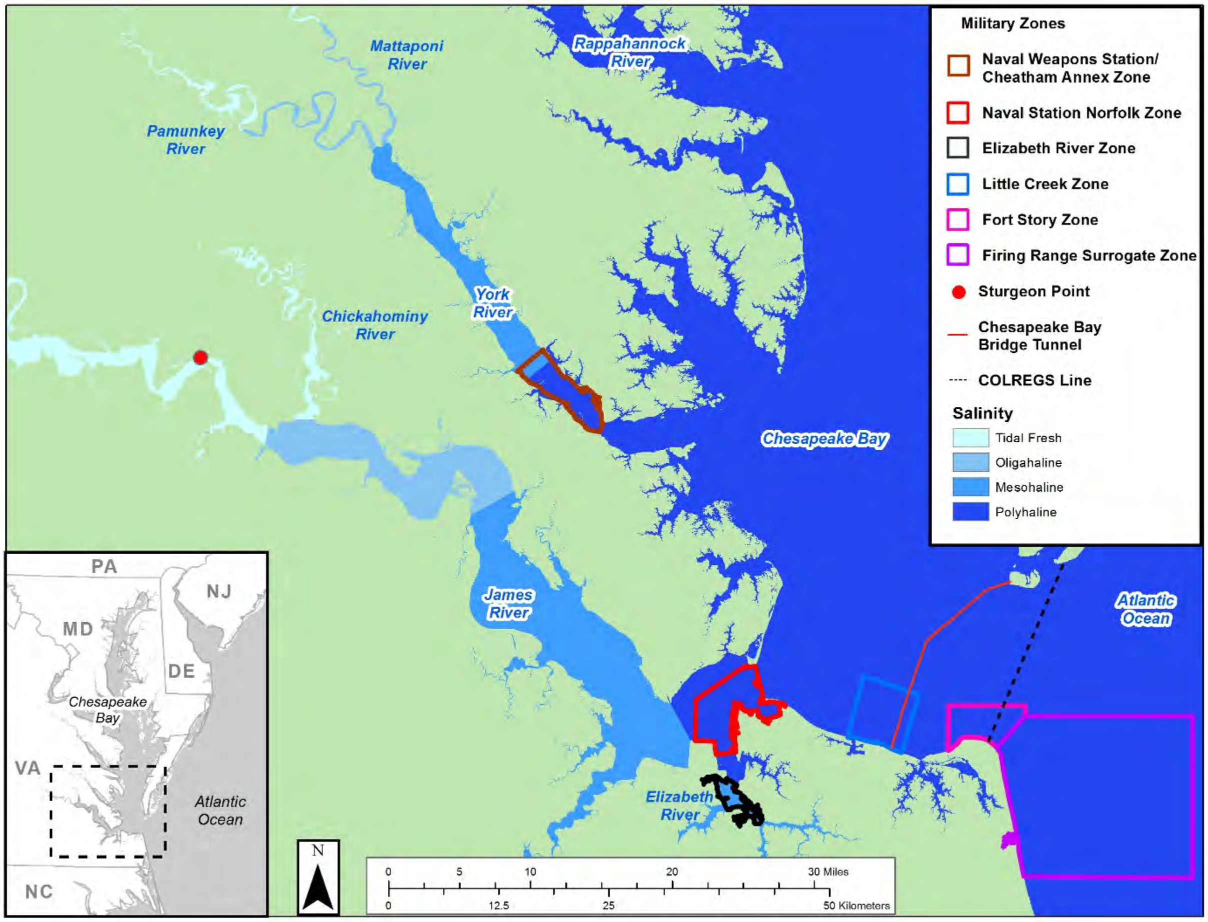

Figure 1. Geographical locations of array regions, zones of military interest within these regions, and salinity zones in rivers are presented. The varied shades of blue indicate salinity zones, the red line is the Chesapeake Bay Bridge Tunnel, the dashed line at the mouth of the Chesapeake Bay is the U.S. Coast Guard Collision Regulations (COLREGS) line, and the red filled circle marks Sturgeon Point.

In order to understand the potential impact of activities on a species of concern within a specific military zone, one must be familiar with the life history and biology of this species. The Atlantic sturgeon (**Figure 2**) was once abundant along the Atlantic coast of North America, with reproducing stocks stretching from northern Florida into Canada. Throughout the Chesapeake Bay it was an important food source for Native Americans and early colonists alike (Barbour 1986). Sturgeon were heavily fished for roe (i.e., caviar) and flesh at the end of the nineteenth century (Hildebrand and Schroeder 1928). Stocks collapsed coast-wide in the early 1900s under increased fishing pressure and concurrent habitat alterations (Hildebrand and Schroeder 1928). A complete possession moratorium, which ended the commercial fishery for sturgeon, was imposed in Virginia in 1974. A ban was extended to cover all state waters along the Atlantic coast by the Atlantic States Marine Fisheries Commission in 1998 (ASMFC 1998), and a year later all federal waters of the Atlantic Ocean were included (NMFS 1999). In order to better manage Atlantic sturgeon, the National Marine Fisheries Service (NMFS) divided remaining populations into Distinct Population Segments (DPS) based upon shared genetic composition. The Chesapeake Bay DPS was listed as endangered under the ESA on 12 February 2012

(NMFS 2012b). Four other DPS were also identified—Gulf of Maine, New York Bight, Carolina, and South Atlantic. The Gulf of Maine DPS was listed as threatened and the other three were listed as endangered (NMFS 2012a, NMFS 2012b).

Figure 2. Adult Atlantic sturgeon, Pamunkey River, anterior view. At the front of the picture, the large snout with dual spiracles (yellow arrow, openings in front of the eyes) and a single barbel (white arrow) protruding from under the snout are visible. Behind the large gill plates, the dorsal and lateral rows of scutes are evident.

1.1. Life History

The Atlantic sturgeon is anadromous, which means adults spend most of their lives in marine and estuarine waters but return to freshwater to spawn. Adults diverge in their approach to spawning, with males returning more frequently and females skipping spawning in some years; presumably in order to gain greater egg mass between spawning events. Spawning can occur from spring through early fall, with spring spawning being more common in the northeast while fall spawning occurs more frequently in the southeast. Some unique river systems may have both spring and fall spawning, although this has yet to be substantiated. Whether spring or fall, both sexes proceed upriver into freshwater where they select habitats containing appropriate substrate and physical conditions. They spawn near the bottom and fertilized eggs stick to the available benthos. After hatching, Atlantic sturgeon remain within their freshwater nursery habitats and forage for benthic prey for approximately one year (Secor et al. 2000). As they age, their range extends farther downriver (Van Den Avyle 1984). Some sub-adults, fish older than a year, may reside within their native fresh- and brackish-water nurseries for several years (Scott and Crossman 1973), while others exit into the marine environment in their second year.

Regardless of when a sub-adult transitions to the marine environment, once it does it remains a coastal transient inhabiting various coastal regions, estuaries, and rivers seasonally until maturity (Holland and Yelverton 1973). Sturgeon reach maturity between ages 7 and 12, with males maturing earlier than females (Murdy et al. 1997), and maturity is attained more quickly in southern stocks (Vladykov and Greenly 1963, Stevenson and Secor 1999).

1.2. Atlantic Sturgeon and the Coast

Little is known about how sturgeon use migrations and coastal habitats to their benefit. It has long been recognized that an overall north-south and shallow-deep coastal migration pattern is evidenced seasonally in the spring by juveniles and adults of the species alike (Holland and Yelverton 1973). Concurrent advances in genetics and tracking are just beginning to reveal links between the natal origin of fish/DPS and their migration and habitat-selection patterns. Based on tracking data of York River fish, adult sturgeon of common origin share comparable migration and occupation patterns within the bay when returning to spawn. Coastal detections of the same fish between spawning runs suggests that habitat occupation by males and females varies considerably. Males that return to spawn almost every year do not usually migrate great distances from their natal rivers. Females that do not return every year, take advantage of beneficial but distant habitats in order to maximize growth and reproductive potential. If fish of common genetic composition (DPS) preferentially occupy certain offshore locations, such locations likely contain critical habitats. If these locations are specifically selected by females between spawning events they likely provide bioenergetic advantages that increase egg production. Thus, the health/stability of these distant locations may be directly linked to a given stock's reproductive potential. It is imperative that we gain a clearer understanding of the benefits these seasonal refugia provide and identify the locations of such important coastal and/or offshore sites. The importance of such research is highlighted given society's need for fisheries resources and the current speed at which coastal and offshore habitats are being considered for energy development.

1.3. Nearshore and Coastal Migrations

In nearshore waters, bycatch (Stein et al. 2004), scientific trawl-collection (Laney et al. 2007), and tracking data (Eyler et al. 2004, Hager 2011) suggest that juveniles and adults use similar migration routes, occupy similar coastal habitats, and even intermix seasonally. Stein et al. (2004) examined federal commercial fisheries' records and found that sturgeon of varied sizes are most often caught as bycatch within a narrow range of depths (10 to 50 meters [m]) over gravel and sand. Catches are strongly associated with specific coastal features, including the mouths of bays and inlets. These findings were supported by Laney et al. (2007) who used GIS layers to describe catches obtained during Cooperative Winter Tagging cruises. Subsequent scientific cruises (Wilson Laney, U.S. Fish and Wildlife Service [USFWS], personal communication) and tracking data (Hager 2011) also identified potentially important overwintering grounds in nearshore waters off the Outer Banks of North Carolina. Tag data attested that these overwintering fish consisted of mixed ages. Tracking illustrated fish making their way north along the coast in the spring, often entering coastal bays and rivers. Although a few sturgeon have been caught in deep offshore waters, most have been captured near the coast (Vladykov and Greenly 1963).

1.4. Atlantic Sturgeon and Virginia

Historically, data documenting the spatial and temporal details of Atlantic sturgeon occupancy and migration within Virginia have been extremely limited. The knowledge obtained and shared among commercial sturgeon fishermen until the fisheries collapsed in the late 1900s was not well documented. Later attempts at scientific descriptions of local behavior, residence, and migrations were of limited success due to the apparent scarcity of the species and false assumptions that Virginia stocks mimicked behavior patterns recorded in the Hudson River, New York.

Today, two genetically dissimilar reproducing stocks of Atlantic sturgeon are known to occur in Virginia. Each is native to a river system that contains very different geological/physical attributes. One stock occurs in the York River and the other one in the James River. The York River is characterized by its relatively small watershed, short length, and naturally deep, higher-salinity waters. The James River is essentially its opposite. Its watershed, which stretches across the state, receives water from the third largest basin flowing into the Chesapeake (White 1989). It is the largest river in Virginia and its fresh waters extend far downriver from its fall line, resulting in an expansive riverine estuary. The existence of a reproducing population of Atlantic sturgeon in the York River (Hager et al. 2014) was unknown when the Navy began its investigations into sturgeon ecology. Once discovered, the York River population became a focal point of Navy research and it is thus elaborated upon and discussed in detail in subsequent sections.

The James River population has long been recognized as existing but conclusive proof of fall spawning was only recently confirmed (Balazik et al. 2012). It is known to contain a very large population of natal fish, as well as a large population of seasonal transients, in its lower estuary. The presence of so many fish in the system and the size of the system have prevented any reasonable abundance estimate from being generated.

What we know about Atlantic sturgeon in the James River must be pieced together from the efforts of various researchers. Understanding sturgeon behavior in the James River is directly applicable to our goals because the NSN and Elizabeth River zones occur at the river's mouth. Dr. Jack Musick at the Virginia Institute of Marine Science (VIMS), a component of the College of the College of William and Mary, was the leading authority on sturgeon for decades, but collection efforts had been so disappointing that very little was actually known as of 2005. Collection efforts in the late 1990s were so impoverished that Dr. Musick redirected his grant goal from field-based ecology to a research review in an effort to narrow down the habitats within the bay that might still contain the physical attributes conducive to sturgeon spawning. The result was the Bushnoe et al. (2005) publication describing potential sturgeon spawning habitat. Concurrently, Dr. Chris Hager (Virginia Sea Grant, VIMS) was working with local fishermen through a sturgeon bycatch-reduction and reward program. This effort provided the first active tracking data on sub-adult sturgeon in both the York and James River (Musick and Hager 2007). Subsequently, Hager and Musick began to collaborate with the Army Corps of Engineers. Fish were collected through Virginia Sea Grant's Fisheries Resource Grant program and tagged and tracked by Dr. Hager. Many of the sturgeon collected from 2006 to 2010 in Burwell's Bay, located in the upper mesohaline section (5-18 practical salinity units [psu]; **Figure 1**) of the James River, received acoustic tags. They were subsequently released into the first acoustic receiver array deployed in the Chesapeake Bay system to track Atlantic sturgeon. One of the major objectives of this array was to locate the spawning regions in the James River. Thus, a theoretical gate of receivers that fish could not pass without being detected was created in the oligohaline (>0.5–5 psu) region and the majority of receivers spread out through the freshwater portions of the river extending to the fall line in Richmond, VA. Specimens for tagging were selected to provide a complete size class distribution of fish captured; therefore sub-adults and adults were tagged. Tracking continued until the end of 2010. A large number of the fish tagged in the middle James River were subsequently detected in northeastern arrays during summer months, many annually. This data and the expansive number of fish tagged in the northeast that were detected in the middle James River suggest that most of the sturgeon inhabiting the middle and lower James River are not native but are transients from northeastern DPSs (Hager 2011). Detections within the James River array revealed stark differences in upriver habitat use by life stage and runs by adults into freshwater in both the late spring and late summer, with spring upriver runs being severely reduce in number in comparison to summer runs. Continued field research in the upper James River revealed that adult males running with milt were present in this large late summer/early fall run and provided increased incidence of vessel strikes in the region.

The life stage of a sturgeon dictates its habitat requirements. Although tracking of adults and sub-adults has provided very useful and unbiased estimates of habitat occupation, no study has been able to collect and acoustically tag Atlantic sturgeon young-of-the-year (YOY; juvenile fish spawned during a given year) in the Chesapeake region. Consequently, very little is known about this life stage's use of the James River or any other Chesapeake Bay tributary. Our most applicable data are derived from the tracking of small sub-adults tagged in the York and James rivers and even smaller migratory fish tagged in the Delaware River. Sub-adults (500 to 585 millimeters [mm] fork length [FL]) of Hudson River origin tagged in the York River in 2012 have been recorded migrating into the marine environment within weeks of tagging. Obviously, because they were of Hudson River origin, their presence in the York River only identifies the river's potential importance to sub-adults of varied DPSs. Similar sized sub-adults in the James (500 to 550 mm FL) tagged by the U.S. Army Corps of Engineers in 2016 remained in the upper James River for an extended period of time (Chuck Frederickson, James River Riverkeeper, James River Association, personal communication). However, because genetic data have not been examined, their behavior does not imply anything. Based on the detections of even smaller fish tagged as YOY in Delaware, small sub-adults can travel great distances to preferred non-natal habitats. Several YOY (approximately 500 mm FL) fish inhabited NSN for extended periods of time to feed and overwinter approximately 6 months after tagging. Vast differences in the observed behavior of YOY and sub-adults suggest that the age at which an individual fish leaves its natal estuary and transitions to a coastal transient life stage varies and may be related to the conditions found within the natal river.

Sub-adult telemetry data in the oligohaline and freshwater regions of the James River revealed that this life stage has far less distinct habitat occupation and migration patterns than adults (Hager 2011). Habitat use by sub-adults is much more dispersed, lacking consistency in direction without the well-defined seasonal migration patterns in adults that are driven by the need to reproduce. Wandering likely suggests that sub-adults randomly search across habitats, presumably in order to locate food. This searching behavior is interrupted by relatively short inhabitation of select habitats. Although some sub-adults of varied sizes remain within the James River's freshwater and oligohaline regions year round (**Figure 1**), most exit the zones seasonally, with greatly reduced presence in mid-summer and winter. Although tracking-based data on sub-adults above the oligohaline zone were limited, they agree with the acoustic data and bycatch records gathered from the mesohaline zone; which suggest that sub-adults congregate in deep water and exhibit sedentary behavior (through an increased number of receptions over time) during extreme temperature conditions in winter and summer (Hager 2011). These migration and residence patterns likely reflect physiological tolerances described by Niklitscheck (2001).

According to tracking data, adults make two upriver runs into freshwater in the James River: a spring run and a late summer/early fall run (Musick and Hager 2007, Hager 2011, Balazik and Musick 2015, Balazik et al. 2017). Although the fall run has been shown to be a spawning run (Balazik et al. 2012), no data confirms spring spawning in the Chesapeake Bay region. Though Balazik and Musick (2015) proposed that sturgeon undertake a spring and fall spawning run in every system in which they reproduce, no evidence of such runs was provided. In search of such evidence, Balazik et al. (2017) compared the genetic composition of sturgeon collected in the James River in the spring verses the fall. They pooled samples by collection period and found the two samples were genetically distinct. They concluded this difference proved sturgeon were spawning in both the spring and fall. The fatal flaw of this effort was that spring samples were never compared to existing genetic signatures of known baseline populations.

Based on capture and tracking data from 2007-2010, adult Atlantic sturgeon first appear in the middle James River in April when water temperatures near 17 degrees celsuis (˚C; Musick and Hager 2007, Hager 2011). Immigrating adults join sub-adults already residing in the river and they congregate in the mesohaline zone. This congregation consists of sturgeon from various DPSs (Bartron et al. 2007) including York River fish. Some adults move upriver out of the mesohaline to occupy the oligohaline zone downriver of Jamestown Island. A few of these continue upriver in late April–early May and congregate near the freshwater line near Sturgeon Point (**Figure 1**). This region contains deep, fast-moving water and was identified by Bushnoe et al. (2005) as potentially containing temporally suitable spawning conditions. Due to the extreme downriver location of the site, however, suitable spawning conditions only exist here in years with high freshwater flow (wet years). Salinity intrusion occurs during drier conditions rendering the same habitat unsuitable for spawning. Most adults that make it to Sturgeon Point in the spring remain there. One to two tagged fish per year were detected from 2007-2010 participating in short-term (less than a week) upriver runs to the confluence of the James and Appomattox rivers near Hopewell, where suitable spawning conditions and habitats occur every year. By the end of June, all adults have returned downriver below the oligohaline zone.

The fall adult run into freshwater usually starts in late July. Again fish of diverse natal origin enter the lower and middle James River. Very rarely do these fish enter freshwater regions. Upon immigration adults again appear to congregate and stage within varied salinity zones. Interestingly, initially upon mid-summer immigration adults can be found occupying slightly higher temperatures (>27º C) than sub-adults will tolerate. Presumably, being first to the spawning grounds is worth tolerating the discomfort or they simply have different physiological tolerances than sub-adults. If water temperatures remain above 27˚C for long enough in early summer, however, even adults will relocate back downriver and return upriver once temperatures decline (Hager 2011). When adults move upriver in late August they enter and remain within suitable spawning habitats until October. Patterns of movement vary annually but certain regions with suitable benthic habitats are preferred (Hager 2011). It is extremely rare for an adult to be present in the James River in the spring and also to participate in James River's fall spawning run (Hager 2011). It ws only recorded once from 2007-2010 and it did not occur in the same year.

Tracking data (2007-2010) document that adults occupy several regions in the James River where physical parameters such as salinity, bottom type, dissolved oxygen, and temperature are suitable for spawning (Bushnoe et al. 2005) in both the spring and late summer/early fall (Hager 2011). These regions include tributaries like the Chickahominy River where adults and sub-adults gather in the late summer/early fall every year from 2013-2019. Although adult males running milt have been collected in the Chickahominy River during this period, it remains unclear whether any spawning is occurring or if the river simply provides other biological advantages.

Bartron et al. (2007) conducted genetic analysis of Atlantic sturgeon collected in the James River and Chesapeake Bay. They identified most fish as belonging to northern DPSs. Tracking data resulting from adults attained supports this claim. Most adults implanted with transmitters from 2006–2010 collection efforts in the James River's mesohaline zone (Hager 2011) exited the bay in mid-spring after release and were detected in or near the Delaware River and Bay (2006–2011 tracking data from Dr. Dewayne Fox, Delaware State University, and Hal Brundage, Environmental Research and Consulting, Inc.). A few were also detected in the Hudson River and New York Bay (Musick and Hager 2007). The fact that these adults often arrived in northern rivers prior to the late spring/early summer spawning events that occur in these regions and the fact that many adults never returned to the James River in subsequent years suggests that these adults were native to northern stocks.

Numerous adults belonging to the Pamunkey River stock have been recorded occupying the lower James River below the oligohaline zone each year prior to making their spawning runs into the York River. Clearly, the James River is a very large source of fresh water, which forms an expansive and productive riverine estuary. This estuary is the closest freshwater source to the ocean in the Chesapeake Bay and it attracts Atlantic sturgeon of varied life stages and DPSs that are migrating north along the coast in the spring.

1.5. Study Area

The James River is important to Navy interests because the NSN zone extends across the mouth of the James River (**Figure 1**) and well into the Elizabeth River. In fact, the Elizabeth River intersects the James River on its southern side and forms the basin in which the NSN docks are located. The fact that the mouth of the James River attracts transient fish and supports its own reproducing population heightens the potential that activities at NSN could be negatively impacting the species. Native James River sturgeon of various life stages must repeatedly pass through the NSN zone. Young fish pass through the zone as they transition into their migratory sub-adult life stage. Transient sub-adults and adults pass through the NSN zone to congregate in the river's lower estuary. Native adults migrate past as they move upriver in the spring and/or fall, potentially to and from the spawning grounds. The NSN zone is also occupied by numerous fish of varied ages that are native to other coastal river systems. These include fish tagged in distant states like New York or Georgia, as well as fish tagged in the nearby York River system. Seasonal use of the Elizabeth River by natal and migratory fish is augmented because it intersects the James River at its mouth and it is thus also a freshwater system in close proximity to the Atlantic Ocean. This waterway may also be used to access the North Carolina sounds through the Intracoastal Waterway, although no proof of this has been found.

The Fort Story and Little Creek zones, located on the southern shore of the entrance to the Chesapeake Bay along the southern channel, are often occupied sequentially as sturgeon enter the bay or make their way into the James River. The Fort Story zone also contains several deep holes where bay and ocean waters intersect. Sturgeon gather in these holes, presumably because they offer bioenergetic advantages that other habitats do not. Because of limited deployment options and an interest in reducing interference with Dam Neck Naval Firing Range operations, a location extending from the northern border of the range and containing similar habitats was selected as a surrogate sampling area. The Range Sur. zone is located just south of the entrance to the Chesapeake Bay, and is north and inshore of deeper waters located off the North Carolina Outer Banks, where fish belonging to numerous coastal stocks have been documented overwintering (Holland and Yelverton 1973, Hager 2011, Wilson Laney, USFWS, personal communication, Rulifson et al. 2020). It is thus situated in an important corridor that is seasonally occupied by sturgeon of numerous DPSs migrating into the bay and/or north or south along the coast. It does not appear that this nearshore region serves as an overwintering ground. Sturgeon instead move farther offshore into deeper waters, some entering the joint Navy-BOEM array offshore of Virginia and others moving south into offshore holes located off the Outer Banks of North Carolina (Rulifson et al. 2020). Some adults, mostly females, have been detected several years in a row off South Carolina.

When this study began, almost nothing was known about sturgeon in the York River system. Musick and Hager (2007) had tracked fish in the river moving through the NW/Ch. zone, but it was unclear whether the York River system contained a reproducing population of sturgeon. The York River is fed by two tributaries that run nearly parallel to each other (**Figure 1**), the Pamunkey and Mattaponi rivers. Although small fish had been collected in the Pamunkey River (located upstream of the NW/Ch. zone), suggesting that a remnant spawning population may have persisted (Musick et al. 1994), NMFS had not obtained enough data to recognize a reproducing population. Our research identified a previously unknown stock of reproducing sturgeon in the York River system (Hager et al. 2014). This discovery was incredibly important to improving our understanding as to how the Navy might be impacting the species because habitat occupation/use is in large part driven by life stage. The discovery of a reproducing population in the York River implied that the NW/Ch. zone in the York could be every bit as important to sturgeon as the NSN zone, which was known to be in the direct path of a natal population's migrations. The preliminary genetic analysis that identified the York River stock as being genetically unique (Dr. Tim King, USGS, personal communication), an initial population assessment of the spawning run (Kahn et al. 2014), annual spawning abundance estimates (Kahn et al. 2019), and an unpublished assessment of the total spawning population, all resulted from data from the present study. The fact that these works suggest that this genetically unique stock is very small only increases its importance and the need for this Navy research. The NW/Ch. zone is thus of greater importance to the species than previously understood given the newly discovered presence of an additional DPS of Chesapeake origin. The piers of these installations extend out to the York River channel and their zones of influence cross it. Some required maintenance of the piers, pile driving, dredging, and vessel movements may affect both this crucial habitat and the normal use of this important migration corridor by this unique stock of Atlantic sturgeon. Understanding when and where this newly recognized spawning population of Atlantic sturgeon is present in the York River system will help the Navy minimize potential impacts on this endangered species.

1.6. Assumptions, Limitations, and Benefits of Using Tracking Data to Delineate Habitat Preference

Fish seek out habitats with physical and biological characteristics that optimize their bioenergetic budgets (Hager 2004, Niklitschek and Secor 2005). Therefore, given sufficient site-specific physical and biological data, it is possible to use historic occupancy patterns to discern habitat preference and the physical characteristics associated with preferred locations. Once the correlation between physical and biological variables and habitat occupancy are understood, one can model/estimate relative abundance in a given location. An important caveat to the application of this methodology is that the historic abundance dataset is sufficient in duration to describe the degree of temporal variability inherent to the location's physical and biological parameters. Considering temporal variability in physical and biological characteristics is especially important in some regions, like the tidal freshwater zones of a river, where conditions are highly variable seasonally and inter-annually. In some regions, anthropogenic factors such as water release from dams or dredging can quickly and dramatically alter both physical and biological conditions. Highly dynamic sites thus require a great deal more observation time to sufficiently identify natural behavior and habitat preference because the conditions motivating selectivity are in flux. Rare events like hurricanes can vastly affect the duration of suitable spawning conditions.

It is also important that specimen-collection methodology and receiver-array placement do not bias results. To minimize the chances of bias, the sub-set of fish used as specimens should be as independent of, or at least randomly collected with respect to, the behavior or habitat being studied. This is true of receiver-site selection/placement as well. If all fish sampled display a given behavior or habitat preference when collected, they do not represent an unbiased sample for assessing behavior or habitat selectivity. For example, the preference of sturgeon for sand could not be assessed if all the sampling was conducted over sand and no other benthic substrate. Receiver placement can bias data in the same manner. If most receivers are located in sandy habitats, even if no habitat preference is displayed, more detections will occur in sandy habitats. To mathematically distinguish whether habitat preferences exist or to model such preferences, it is important that method-based variability be considered.

Our array and fish collection were designed in a manner to allow resulting data to be incorporated into future habitat models. However, the objective of this project, to begin delineating spatial and temporal patterns in Atlantic sturgeon occupancy in the lower Chesapeake Bay and nearshore waters, with a focus on zones of naval interest, did not require such fine-detailed planning. Unlike predictive occupancy models, the factors motivating habitat selection do not have to be understood, weighted, or incorporated appropriately over time and space to achieve our objective. By delineating the importance of a site or zone based on occupancy alone, and operating under the assumption that this indicates preference and suitability, prioritization of these regions or zones as important to the species is justifiable without necessarily having to understand what motivates selectivity or mathematically quantify it. The fact that detections are from a highly varied sample of sturgeon (of varied ages, tagged in varied locations coastally), allows us to assume that patterns in detections represent our best approximation for actual use by the species, not a biased sub-set.

2. Materials and Methods

2.1. Telemetry Equipment

Telemetry data were gathered using VEMCO® V9, V13, and V16 sonic transmitters (VEMCO®, Bedford, Nova Scotia, Canada) operating on a frequency of 69 kilohertz (kHz). Selected transmitters were engineered for use in conjunction with a stationary array of VEMCO® VR2W receivers. Unlike a tag designed for active tracking where the researcher follows the specimen, these transmitters were not designed with short-duration transmission intervals or varied frequencies. Instead, the receivers are stationary and the tagged fish are passively detected as they move within the reception range of the receiver. This tracking approach is thus termed "passive tracking." Every tag transmits a unique identification number and the receiver records time and date. Some transmitters also carry a pressure sensor that transmits an encoded depth output to the receivers. These data help identify where within the range of the receiver a fish is located. Additionally, the data may be used to describe behavior as it relates to depth distribution.

VEMCO® transmitters (**Figure 3**) are named according to their diameter, thus a V9 is 9 mm, a V13 is 13 mm, and a V16 is 16 mm. Tags can be engineered to a limited degree to meet the criteria of a researcher, which are influenced by the morphology of the species and the tracking objectives. Transmitter size is positively correlated with battery capacity and resulting receptive distance and longevity. Thus, a V9 tag cannot be engineered to perform as a V16. Small tags have some advantages such as reduced incision size and surgical time, and they can be more safely mounted externally.

Figure 3. VEMCO® V16 (top) and V13 (below) sonic transmitters.

V9 tags have an expected life of less than one year and therefore only provide information on movements on the spawning grounds in the year of tagging. However, the surgery is so quick and incision and tag so small that less trauma is associated with the procedure. V13 tags are expected to last approximately 2 years, and V16 tags can last up to 10 years. The two most commonly used tags in this study were V13 and V16 tags (V13: 40 mm long, 11 grams; V16: 90 mm long, 32 grams; **Figure 3**). Initially, transmitters of varied sizes were selected so that fish of different sizes could be tagged effectively. Some V13 pressure-sensor tags were added to provide additional information on depth of detection, but these tags are more expensive. Consequently, some adults were implanted with smaller V13 pressure tags, although their body size would have accommodated a V16, because depth data were desired. Two V9 tags were also implanted, one in a male in 2014 and one in a female in 2015, to determine if smaller tags would be functional while considering the benefits of smaller incisions, reduced surgical time, and thus less stress to the fish. In 2014, two females bearing eggs were equipped with external V13 tags to minimize the impact of tagging. This approach was again used in 2015, when females were preferentially selected for tagging. External transmitters were attached along the midline of the dorsal fin using 400-pound monofilament that was surgically inserted under the dorsal fin, run through the external eye of the transmitter, back under the dorsal and double-crimped with brass on the opposite side. V16s were by far the most common tag implanted.

Onset temperature monitors (HOBO, Pro v2, Onset Computer Corp., Bourne, MA) that continuously recorded temperature every hour were deployed within all military zones in 2015. Several units were also deployed within the Pamunkey River during the spawning season in 2015 through 2018. These were placed at the collection site at river mile (RM) 42 to RM 58.

2.2. Determining Detection Range of Transmitters

Battery size and declining battery strength affect signal intensity and thus transmitter detection range. Detection range of marine and aquatic sonic transmitters is also influenced by environmental and biological conditions (Hager 2011, Robydek and Nunley 2012, Mathies et al. 2014). Because of the highly varied depth, topography, bottom composition, and salinity of the numerous receiver sites in this study, detection distances and effects of location needed to be rigorously assessed.

In order to provide more detailed, quantitative data, V7 and V16 tags were deployed in different aquatic environments under varied conditions. The V7 is the lowest-power 69 kHz transmitter that has been deployed within the Navy Chesapeake Bay array, and the V16 is the highest. Because power is positively correlated with detection distance, these trials gave us the requisite data to estimate average detection distances across most of the environments monitored.

During the first trial, a VEMCO® V7 transmitter tag (transmitting every 10 seconds) was deployed in Queens Lake, a local freshwater lake with similar dimensions to the upper Pamunkey River. The transmitter and receivers were deployed at a depth of approximately 1 m. The water temperature at the surface was 4.6°C and the bottom temperature was 5°C with no thermocline. Salinity was 0.2 psu and the lake was calm with winds at 8 kilometers (km) per hour. The lake was of extremely uniform depth (2.2 m) with a mud bottom. Its minimum width was 100 m and the maximum was 220 m, with inlets extending on both sides. Seven receivers were deployed at increasing distances from the transmitter. The one deployed farthest from the transmitter was picked up by fishermen and was thus eliminated from the analysis. Data were analyzed using VEMCO® distance-testing software.

For the second trial, a V16 test tag was deployed and tested in situ in the upper Pamunkey River tidal freshwater spawning grounds just prior to the spawning season in June 2015. The transmitter and receivers were deployed at a depth of approximately 1 m. The water temperature was 25.5°C and the salinity was 0.01 psu. The river was calm with winds <16 km per hour. The river section was uniform in depth (3 to 5 m) with a mud bottom and banks with trees and root systems on both sides. The test occurred in a straight section of the river that was 90 m wide at its narrowest and approximately 120 m at its widest. Initially, six receivers were deployed at increasing distances from the transmitter in a straight line. Subsequently, the transmitter was moved in its relationship to this receiver array to vary the distance between transmitter and receivers in order to better determine receptive distance under varied conditions through repetitive trials. The tag was also moved progressively farther around a bend in the river to determine whether transmissions would be refracted or reflected in a small system and result in non-line-of-sight detections. Data were again analyzed using VEMCO® distance-testing software.

As part of the third trial, an average reception range was calculated for a VEMCO® V16 in the James River within its oligohaline and mesohaline zones based on numerous field tests designed to examine the effect of aquatic noise and water depth. The Jamestown-Scotland Ferry pier was selected for shallow-water tests due to the presence of ferry noise, the extension of the pier across a range of bottom depths, and its location in the middle of the James River oligohaline zone, where many sturgeon reside for extended periods. Detections were recorded under varied environmental conditions (e.g., different wave/energy conditions, water clarity) and at different times of the year. Both receiver and transmitter were moved between depths and data were recorded at a range of known distances. Long-distance reception tests were conducted in Burwell Bay. This region is in the middle of the James River's mesohaline zone and has a depth that varies from 3 to 10 m with an irregular bottom type. Transient and native fish of varied life stages occur in this region and most sturgeon tagged in the James River have been collected here.

In the final trial, the same V16 tag was then tested within the NW/Ch. zone in the York River polyhaline region (>18 psu) in March over a sand (hard) bottom. Receivers again were deployed 1 m below the surface and trials were designed to test receptive distances under multiple tag location scenarios with regard to the eight receivers deployed. The tag was deployed in a 4 m hole within 2 m flats, on the 2 m flats, and along an 8 and 10 m channel edge adjacent to the flats. All eight receivers were deployed in a straight line across the flats.

2.3. Sturgeon Collection and Tagging

Atlantic sturgeon of numerous age classes and life stages were tagged in highly varied geographical locations. Sturgeon tagged by our team (**Figure 4**) were done so under a federal scientific collection permit (National Oceanic and Atmospheric Administration [NOAA] permit 16547-01) and in accordance with recognized protocols stated clearly in the permit (see Mohler 2003 for description of surgical protocols).

Figure 4. Implantation of a V13 transmitter in an adult Atlantic sturgeon in the Pamunkey River.

In order to address a scarcity of tracking results in the York River drainage prior to the start of our study, we targeted Atlantic sturgeon with anchored gillnets in the upper York, Pamunkey, and Mattaponi rivers during 2012 to 2018. Methods and location of collection efforts varied over time due to success rates and evolving data. In 2012 and 2013, we used small-mesh gill nets (4.6 to 6.4 cm stretched mesh) to target YOY in the upper river during the winter white perch

(*Morone americana*) fishery. We obtained two small fish (525 to 570 mm) in 2012 in the York River and these were genetically identified as belonging to the New York DPS (USGS, Tim King, personal communication).

In order to advance our goal of determing if a spawning stock of native fish existed, we deployed large-mesh nets (23 to 36 cm stretched mesh) in the lower Pamunkey River in the spring of 2013 and 2014. We attained no fish. We moved our nets upriver into the lower Pamunkey (RM 6–8, **Appendix 8.1**) in early June of 2013. Again, we caught no sturgeon. Nets were subsequently moved into the upper Pamunkey River, where we discovered spawning fish present in late summer of 2013 (Hager et al. 2014). Since that time, we have worked every late summer during 2013 to 2018 for several months (net soak hours varying from 140 to 240 hours per year) under the protocals described in Kahn and Mohead (2010). Mark recapture data has been applied to develop annual run abundance estimates as well as a total spawning population estimate.

All capture, surgical, holding, and release methods implemented by our team during this study were tested, proofed, and refined in preceding projects (Hager 2011). In this study, sturgeon were not removed from the site of capture or held after surgery, but were released immediately following an appropriate work-up, a procedure that often took less than 15 minutes. Permit protocols require that each sturgeon is tagged with USFWS T-bar and Passive Integrated Transponder (PIT) tags, supplied by USFWS Virginia Fisheries Coordinator (Albert Spells). A FL measurement was also taken because total length can vary greatly due to natural differences in species morphology and injury, and a caudal fin flesh sample was collected for genetic analysis. These samples were subsequently sent to the Leetown, West Virginia, USGS laboratory to determine the river of origin for each fish.

2.4. Telemetry Data Collection and Analysis

Receivers were placed on U.S. Coast Guard (USCG) buoys and day markers, bridge pilings, lighthouses, and private docks, with permission granted through USCG, the Office of Homeland Security, the Chesapeake Bay Bridge Tunnel (CBBT) Authority, and private landowners, respectively (**Figure 5**). Arrays were deployed to ensure coverage of all seven Chesapeake Bay regions and all six naval zones. The contract required that 70 receivers be deployed, and each checked monthly for maintenance and data collection. This number was enlarged seasonally to approximately 89 receivers in order to better describe migration and spawning behaviors in the York River system. Data were downloaded via Bluetooth® wireless, or direct cable connection if a receiver was unable to be retrieved above the waterline. The goal of maintaining 70 receivers was consistently exceeded.

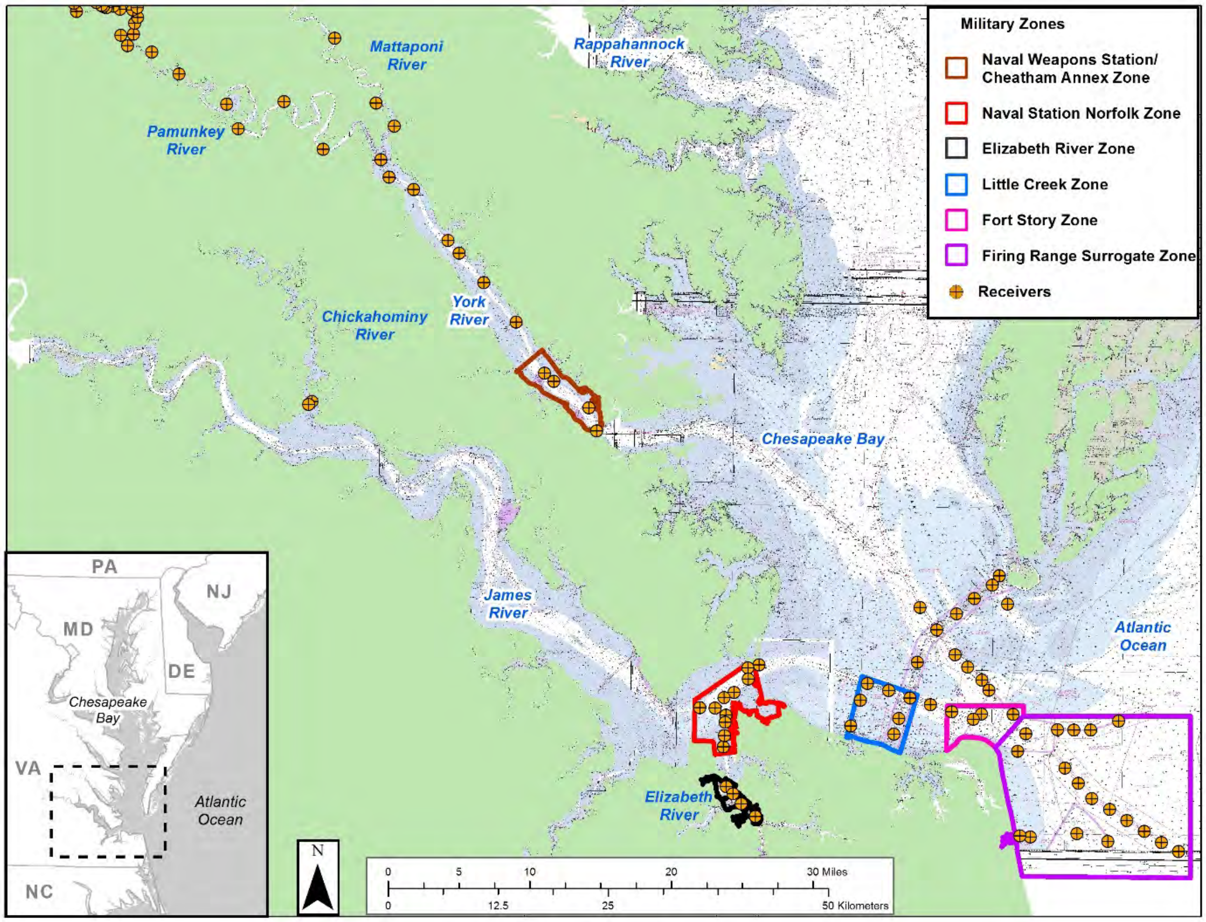

Figure 5. Map of Navy acoustic receiver locations (yellow circles with crosses). Military zones are outlined with colored polygons. Thimble Shoals Channel extends from the Fort Story zone, along the northern edge of the Little Creek zone, and ends at the mouth of the James River in the Naval Station Norfolk zone. The Baltimore Channel is marked by a line of receivers extending northwest from the Fort Story zone, and the York River Channel splits off the Baltimore Channel arriving in the Naval Weapons Station/Cheatham Annex zone.

3. Results

3.1. Transmitter Detection Distances

Through repetitive trials in a freshwater lake, the 100 percent detection distance of a V7 transmitter was determined through VEMCO® distance-testing software to be 140 m. The 50 percent range and a good approximation of the zero percent distance were determined to be 210 m and 320 m, respectively (**Figure 6**).

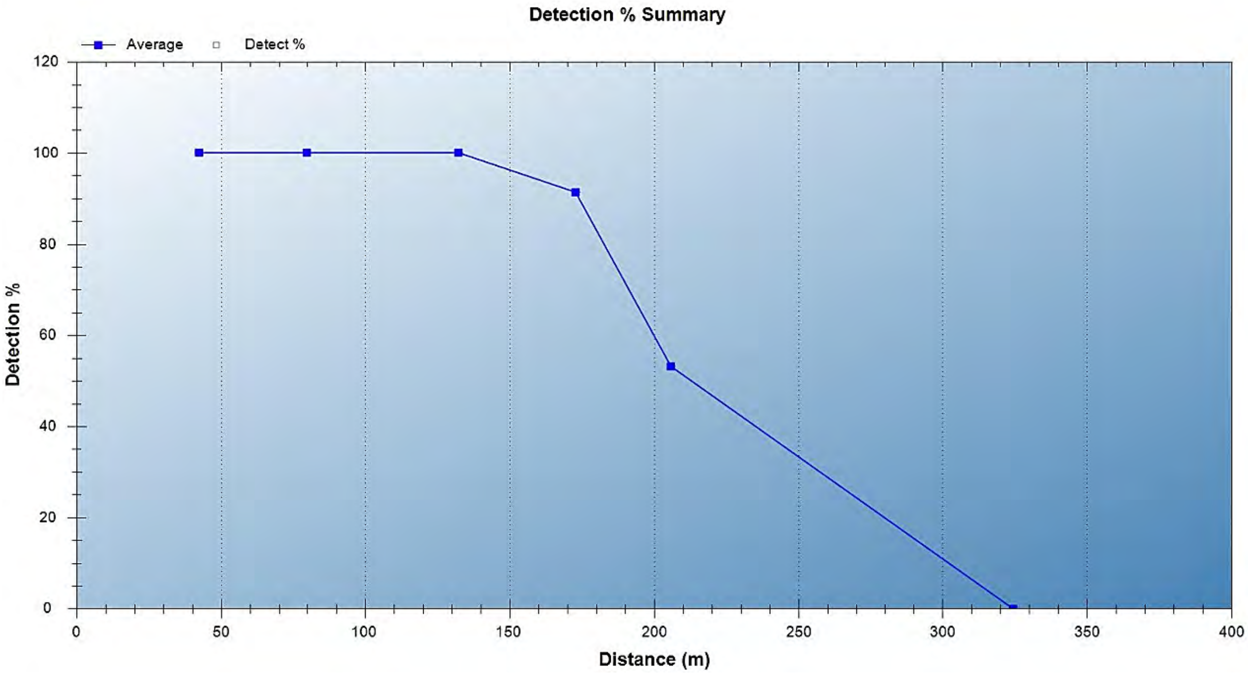

Figure 6. Percentage of detections at varied distances from a V7 transmitter in a calm lake under ideal conditions.

The results from testing the detection distance of a V16 in situ in the upper Pamunkey River were not as defined and therefore not as conclusive. They suggest that the 100 percent reception distance can be as great as 600 m, with a calculated distance of 680 m for the 50 percent rate and the zero rate at 720 m. However, receivers that were closer than 600 m did not all record 100 percent of detections (**Figure 7**). In fact, the receiver at a distance of 460 m had wide error bars because of the inconsistent percentage of transmitted signals detected. When the transmitter was relocated and the test re-run within the same stationary array, the maximum receptive distance was greatly reduced to 350 m (**Figure 8**). Detection ranges were further reduced where bends in the river did not reflect or refract transmitter signals. It is unclear whether the receiver located at 350 m in the second Pamunkey trial could have been shadowed by subaqueous objects. Another receiver located at 858 m also received no detections but this was expected because of its distance.

During trials conducted in the James River oligohaline zone at the Jamestown-Scotland Ferry pier in Jamestown, Virginia, no interference from ferry noise was evidenced. The effect of environmental noise in shallow water, however, was severe. During rough-water conditions (breaking waves of 60 to 90 centimeters [cm]) when the receiver or transmitter was positioned in shallow water (<2 m), the reception distance was reduced to 200 m. When a single receiver was deployed at varied distances from a transmitter in a deep-water (10 m) section of the James River mesohaline zone, the maximum reception distance under calm conditions was 1,300 m. In agreement with the previous distance test conducted in the James River in higher salinities, research in the York River suggested that a greater range can be achieved in calm conditions and over harder substrates (100 percent of the detections were recorded at 660 m). However, results varied substantially between receivers that were closer than 660 m, with detection percentages on some receivers recorded as low as 24.4 percent.

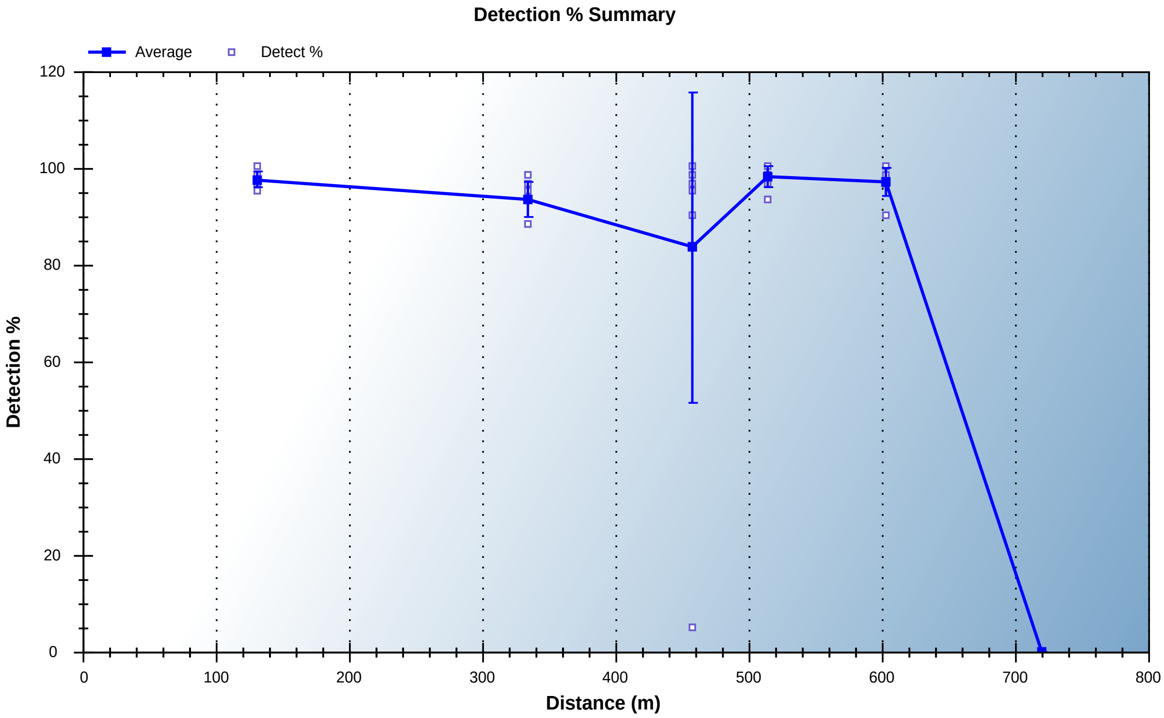

Figure 7. Detection percentages at receivers placed at varied distances from a V16 transmitter in the upper Pamunkey River. Error bars represent standard error. Large error may indicate environmental or mechanical differences in operation.

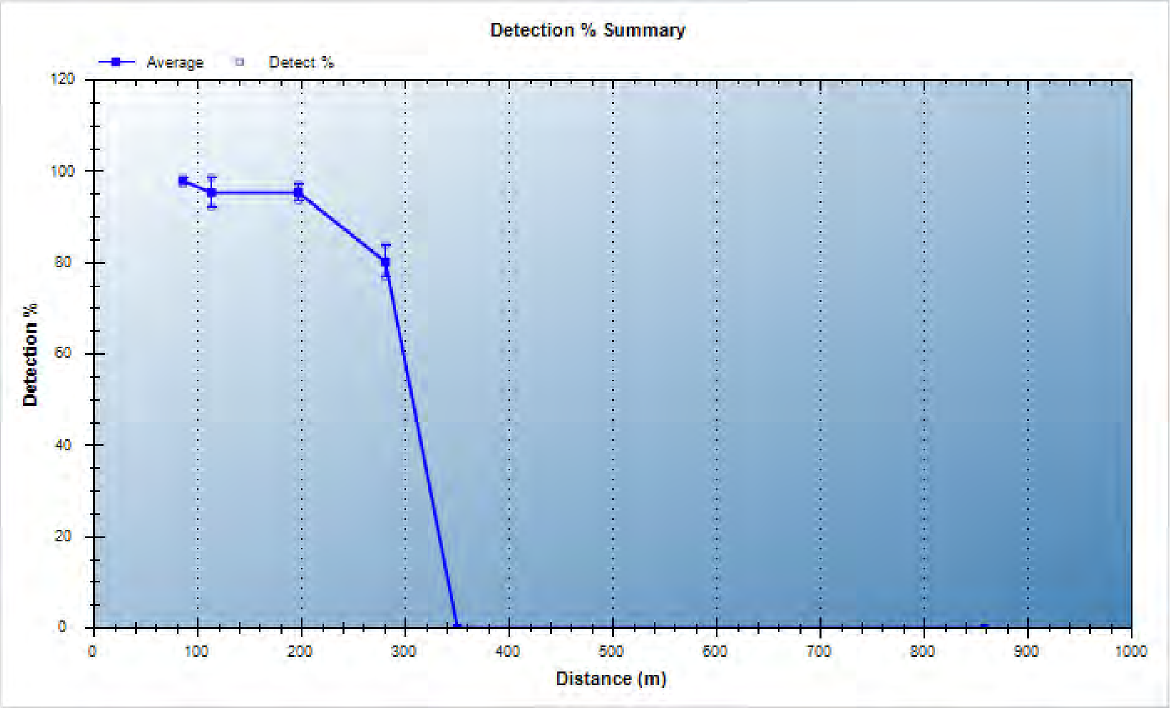

Figure 8. Detection percentages at receivers placed in different configuration than Figure 7 and at varied distances from a V16 transmitter in the upper Pamunkey River. Error bars represent standard error. Large error may indicate environmental or mechanical differences in operation.

A distance of 700 m was selected as a mean detection distance for a V16 considering its reduced performance in shallow oligohaline water and extended range under calm conditions in deeper mesohaline habitats with hard bottoms. This measurement is a conservative average between the minimum and maximum distances recorded for a V16 across a range of depths and environmental conditions. A slightly reduced average distance was selected due to the shallowness of most riverine habitats, the frequency of rough wave/energy conditions that can occur in these shallows, and the reduced performance recorded in the upper Pamunkey River. Variable detection ranges due to environmental interference factors have been documented in other studies across a range of ecosystems (Payne et al. 2010, Hager 2011, Robydek and Nunley 2012, Mathies et al. 2014). In the Gulf of Mexico, wind speed was found to have a strong impact on detection range (Robydek and Nunley 2012), whereas tidally dependent currents were the main driver of variability in detection range in the open ocean off the coast of Georgia (Mathies et al. 2014). These fluctuations in reception distance can be even more problematic when examining finer-scale movements on the order of hours (Payne et al. 2010). We fully recognize that more site-specific research must be done to better define detection distance. Site-specific research is especially import in our study because it extends across numerous ecosystems, each of which contain unique biological and physical attributes that can temporally or consistently influence detection. The use of sentinel or control tags for extended periods in multiple ecosystems would help identify any absence of data as environmentally driven rather than evidence for absence of tagged fish.

3.2. Tagging

During 2012 and 2013, we captured 18 Atlantic sturgeon from the York River watershed, with 2 recaptures. Sixteen of these fish were tagged with transmitters, including 13 adults and 3 sub-adults (**Table 1**). In 2012, two very small sub-adults were obtained in December in the York River. Both were of New York DPS origin (USGS, personal communication Tim King) and both left the Chesapeake Bay system in late winter of 2013. The other 16 fish obtained in 2013 were all collected in the upper Pamunkey at our collection site located at RM 47. Specimen collections for tag implantation continued at this site throughout the remainder of the study.

In 2014, 78 sturgeon were collected, with 21 recaptures, and 34 more transmitters were implanted. In 2015, 101 captures of sturgeon occurred; 39 of these fish had been tagged in 2013 or 2014 and some fish were recaptured more than once. Thirty new individuals were also collected, including 7 females that were fitted with transmitters. In 2016, 60 unique fish were obtained in the Pamunkey River; 37 of these had never been caught by our research team, and 23 had been captured in previous years. Nine females were tagged in the Pamunkey in 2016. In the same year, five fish were captured in the Mattaponi, two were previously captured in the Pamunkey, and one was a female carrying a tag. Four more tags were put in new fish in the Mattaponi, one of which was a female. In 2017, 84 unique fish were collected in the Pamunkey and one unique fish in the Mattaponi River. Based on PIT tags there were 58 brand new fish collected in the Pamunkey; however, some PIT tags may have failed and the number may be inflated. Of the 58 new fish, four had PIT tags. Two had been tagged in the Marshyhope by the Maryland Department of Natural Resources on 31 August 2014 and 11 September 2015, respectively, one in the James River by Virginia Commonwealth University (VCU) on 11 June 2015, and one was unknown. In 2018, 44 unique fish were obtained; 18 were new and 26 were recaptures. One of the 18 new fish was previously PIT tagged by Stony Brook University off New Jersey on 13 October 2006.

Table 1. Information on each Atlantic sturgeon tagged through this contract from November 2012 through October 2018. If a tag is listed as dead it means the tag was not working. It either failed, was shed from the fish, or the battery died. (Key: NA = not available; * = recaptures; fork lengths in bold are sub-adults)

Date Tagged/ Recaptured	PIT Tag #	T Tag #	Fork Length (mm)	Transmitter #	River	Sex
11/28/2012	None	None	525	A69-9002-13585	York	Unknown
12/2/2012	985121012611425	46350	570	A69-9002-13586	York	Unknown
8/19/2013	985121012745260	46345	1,340	A69-9001-27837	Pamunkey	Unknown
8/19/2013	985121012611330	46346	1,250	A69-9001-27842	Pamunkey	Unknown
8/20/2013	985121011606351	46349	1,290	A69-9001-27840	Pamunkey	Unknown
8/20/2013	985121012760407	46348	1,550	A69-9001-27847	Pamunkey	Male
8/22/2013	47025C7C03	None	1,330	A69-9001-27838	Pamunkey	Male
8/22/2013	985121012638136	None	1,627	A69-9001-27836	Pamunkey	Male
8/22/2013	985121012617104	None	1,345	A69-9001-27844	Pamunkey	Male
8/23/2013	900118001183738	48101	1,918	A69-9001-27845	Pamunkey	Female
8/29/2013	900118001182852	48115	1,570	A69-9001-27839	Pamunkey	Male
8/29/2013*	47025C7C03	None	1,330	A69-9001-27838	Pamunkey	Male
9/6/2013	900118001183196	48095	1,543	None	Pamunkey	Male
9/10/2013	900118001181459	48100	1,651	A69-9001-27846	Pamunkey	Male
9/13/2013	900118001201865	48114	1,524	A69-9001-27843	Pamunkey	Male
9/13/2013	900118001202200	48113	1,562	A69-9002-13589	Pamunkey	Male
9/25/2013	985161000824836	48112	1,510	A69-9002-13587	Pamunkey	Male
10/3/2013	none	48051	1,664	none	Pamunkey	Male
10/4/2013*	900118001202200	48113	1,562	A69-9002-13589	Pamunkey	Male
10/8/2013	900118001183823	48052	1,572	none	Pamunkey	Unknown
8/5/2014	900118001339357	48070	1,600	none	Pamunkey	Unknown
8/6/2014	900118001202201	50751	1,613	A69-9002-12730	Pamunkey	Male
8/6/2014	NA - malfunction	48104	1,295	A69-9002-12732	Pamunkey	Unknown
8/6/2014	900118001181160	50752	1,607	A69-9001-27841	Pamunkey	Male
8/7/2014	900118001184159	50801	1,575	A69-9002-12737	Pamunkey	Male
8/7/2014	900118001201930	50753	1,702	A69-9002-12735	Pamunkey	Male
8/11/2014	900118001181162	48069	1,657	A69-1601-7698	Pamunkey	Male
8/11/2014	900118001183583	48058	1,956	A69-1601-3779	Pamunkey	Unknown
8/11/2014	900118001342256	48068	1,537	A69-9002-12742	Pamunkey	Male
8/13/2014	900118001183957	48054	1,486	A69-9002-12746	Pamunkey	Male
8/13/2014*	985121012760407	46348	1,610	A69-9001-27847	Pamunkey	Male
8/19/2014	900118001183713	48067	1,661	none	Pamunkey	Male
8/19/2014	900118001182295	48061	2,057	A69-9002-12731	Pamunkey	Female

Date Tagged/ Recaptured	PIT Tag #	T Tag #	Fork Length (mm)	Transmitter #	River	Sex
8/19/2014	900118001182724	48066	1,461	none	Pamunkey	Unknown
8/19/2014	?	48065	1,594	none	Pamunkey	Male
8/19/2014	900118001183395	48057	2,146	none	Pamunkey	Female
8/21/2014	900118001339357	48056	1,854	A69-9002-12749	Pamunkey	Unknown
8/27/2014*	900118001183196	48055	1,543	A69-9002-12748	Pamunkey	Male
8/27/2014	989001003179718	50338	1,575	A69-9001-24476	Pamunkey	Male
9/5/2014	989001003179804	50340 & 50754	1,534	A69-9001-24479	Pamunkey	Male
9/5/2014	900118001359318	48062	1,715	A69-9002-12740	Pamunkey	Male
9/5/2014	900118001182597	48063	1,607	A69-9002-12738	Pamunkey	Male
9/5/2014*	985121012760407	46348	1,610	A69-9001-27847	Pamunkey	Male
9/5/2014	900118001184141	48064	1,724	A69-9002-12733	Pamunkey	Unknown
9/8/2014	989001003179730	50802	1,683	A69-9002-26380	Pamunkey	Male
9/8/2014	900118001201948	50803	1,934	A69-9002-12750	Pamunkey	Unknown
9/8/2014	985121026865700	50804	1,810	A69-9002-12736	Pamunkey	Female
9/8/2014	900118001202071	50805	1,581	A69-9002-12754	Pamunkey	Male
9/8/2014	900118001182788	50806	1,803	A69-9002-12752	Pamunkey	Unknown
9/8/2014*	900118001181459	50807	1,689	A69-9001-27846	Pamunkey	Male
9/9/2014*	900118001182788	50806	1,803	A69-9001-12752	Pamunkey	Unknown
9/9/2014*	900118001183713	48067	1,661	A69-9002-12745	Pamunkey	Male
9/9/2014	900118001182977	50808	1,746	A69-9002-12747	Pamunkey	Male
9/9/2014	900118001340773	50809	1,981	none	Pamunkey	Unknown
9/10/2014	900118001183504	50755	1,511	A69-9002-12739	Pamunkey	Male
9/10/2014	900118001183842	50810	1,524	A69-9002-12741	Pamunkey	Male
9/10/2014	900118001202000	50811	1,394	A69-9002-12734	Pamunkey	Male
9/12/2014	900118001182734	50757	1,880	A69-1601-3780	Pamunkey	Female
9/12/2014	900118001184316	50756	1,702	A69-9002-12751	Pamunkey	Male
9/15/2014	900118001183592	50758	2,045	A69-9002-12753	Pamunkey	Female
9/15/2014	900118001183545	50759	1,588	A69-9002-12755	Pamunkey	Male
9/15/2014*	900118001184159	50801	1,575	A69-9002-12737	Pamunkey	Male
9/17/2014	900118001184145	50812	1,695	A69-9002-12743	Pamunkey	Male
9/17/2014	900118001342234	50813	1,854	A69-9002-12758	Pamunkey	Female
9/17/2014*	900118001342256	50814	1,537	A69-9002-12742	Pamunkey	Male
9/17/2014	900118001183266	50815	1,664	A69-9002-12744	Pamunkey	Unknown
9/17/2014*	900118001183583	48058	1,956	A69-1601-3779	Pamunkey	Unknown
9/17/2014	989001003179768	50337	2,083	A69-9002-12707	Pamunkey	Unknown
9/18/2014*	900118001340773	50809	1,981	none	Pamunkey	Unknown
9/18/2014	900118001183356	50816	1,829	none	Pamunkey	Female
9/18/2014	900118001183382	50817	1,543	none	Pamunkey	Male

Date Tagged/ Recaptured	PIT Tag #	T Tag #	Fork Length (mm)	Transmitter #	River	Sex
9/18/2014	FDXA42137D5A54	50818	1,664	none	Pamunkey	Male
9/19/2014	900118001182180	50819	1,695	none	Pamunkey	Male
9/19/2014	900118001183693	50820	2,064	none	Pamunkey	Unknown
9/22/2014	900118001183749	50821	1,649	none	Pamunkey	Male
9/22/2014	900118001182680	50822	1,707	none	Pamunkey	Male
9/22/2014	989001003179728	50342	1,600	A69-9001-24481	Pamunkey	Male
9/22/2014	989001003179745	50336	1,800	A69-9001-26381	Pamunkey	Male
9/22/2014	900118001182326	50823	1,641	none	Pamunkey	Male
9/22/2014*	900118001182852	48115	1,581	A69-9001-27839	Pamunkey	Male
9/22/2014*	900118001202200	48113	~1,562	A69-9002-13589	Pamunkey	Male
9/22/2014*	900118001183504	50755	1,511	A69-9002-12739	Pamunkey	Male
9/22/2014*	900118001183545	50759	1,588	A69-9002-12755	Pamunkey	Male
9/22/2014*	900118001181551	48114	1,534	A69-9001-27843	Pamunkey	Male
9/22/2014	900118001184283	50824	1,387	none	Pamunkey	Male
9/22/2014	900118001181514	50825	1,665	none	Pamunkey	Male
9/22/2014	out of PIT tags	50826 & 50827	1,467	none	Pamunkey	Male
9/22/2014*	900118001184159	50801	1,575	A69-9002-12737	Pamunkey	Male
9/23/2014	900118001183749	50821	1,649	A69-9002-12756	Pamunkey	Male
9/23/2014	989001000099119	50828	1,575	none	Pamunkey	Unknown
9/23/2014*	900118001201930	50753	1,702	A69-9002-12735	Pamunkey	Male
9/23/2014*	900118001342256	50814	1,537	A69-9002-12742	Pamunkey	Male
9/23/2014*	900118001202071	50805	1,581	A69-9002-12754	Pamunkey	Male
9/24/2014	989001003179715	50829	1,670	none	Pamunkey	Male
9/24/2014	989001000099115	50830	~1,715	A69-9002-12757	Pamunkey	Male
9/24/2014	989001000099066	50831	1,410	none	Pamunkey	Male
9/24/2014	989001000099108	50832	1,505	none	Pamunkey	Male
9/25/2014*	900118001183356	50816	1,829	A69-9002-13588	Pamunkey	Female
8/7/2015*	900118001183823	48052	1,626	NA	Pamunkey	Unknown
8/7/2015	989001000099756	48116	1,435	NA	Pamunkey	Unknown
8/10/2015	989001000099782	50833	1,735	NA	Pamunkey	Female
8/10/2015	989001000099838	50834	1,394	NA	Pamunkey	Unknown
8/11/2015	989001000099806	50850	1,640	NA	Pamunkey	Unknown
8/12/2015	989001003179761	50849	1,565	NA	Pamunkey	Male
8/17/2015	989001000099081	50835	1,507	NA	Pamunkey	Male
8/17/2015*	900118001181551	48114	1,566	A69-9001-27843	Pamunkey	Male
8/17/2015	989001000099759	50836	1,876	NA	Pamunkey	Unknown
8/17/2015	989001000099774	50837	2,025	A69-9001-21098	Pamunkey	Female
8/17/2015	989001000099777	50838	1,950	A69-9001-21099	Pamunkey	Female

Date Tagged/ Recaptured	PIT Tag #	T Tag #	Fork Length (mm)	Transmitter #	River	Sex
8/18/2015	989001000099053	50839	1,578	NA	Pamunkey	Male
8/19/2015	989001000099128	50840	1,928	A69-9004-1178	Pamunkey	Female
8/19/2015	989001000099077	50841	1,930	NA	Pamunkey	Unknown
8/19/2015	989001000099787	50842	1,496	NA	Pamunkey	Unknown
8/20/2015	989001000099125	50761	1,510	NA	Pamunkey	Unknown
8/24/2015	989001000099067	50800	1,377	NA	Pamunkey	Male
8/25/2015	989001000099772	50843	1,634	NA	Pamunkey	Male
8/25/2015*	900118001181162	50844	1,634	DEAD TAG – 7698	Pamunkey	Male
8/25/2015	989001000099767	50845	1,876	NA	Pamunkey	Female
8/31/2015	989001000099814	50846	1,399	NA	Pamunkey	Male
8/31/2015	989001000099770	50847	1,451	NA	Pamunkey	Male
8/31/2015	989001000099794	50848	1,946	NA	Pamunkey	Female
8/31/2015	989001000099051	48150	1,691	NA	Pamunkey	Male
9/1/2015	989001000099762	48149	1,584	NA	Pamunkey	Male
9/1/2015	989001000099124	48148	1,413	NA	Pamunkey	Male
9/1/2015	989001000099761	48126	1,649	NA	Pamunkey	Unknown
9/2/2015*	900118001183356	50816	1,829	A69-9002-13588	Pamunkey	Female
9/11/2015	989001000099084	50798	1,803	NA	Pamunkey	Unknown
9/11/2015	989001000099141	50799	1,865	A69-1601-57019	Pamunkey	Female
9/14/2015	989001000099118	48117	1,577	NA	Pamunkey	Male
9/14/2015	989001000099768	48147	1,942	NA	Pamunkey	Unknown
9/14/2015*	989001000099136	50796	1,550	NA	Pamunkey	Male
9/14/2015	989001000099075	50797	1,605	NA	Pamunkey	Male
9/14/2015	989001000099044	50795	2,020	NA	Pamunkey	Unknown
9/14/2015	989001000099065	50794	1,890	A69-9002-12734	Pamunkey	Female
9/15/2015	989001000099824	48146	1,947	NA	Pamunkey	Unknown
9/15/2015	989001000099055	48145	1,750	NA	Pamunkey	Unknown
9/15/2015*	989001003179745	48144	1,660	A69-9001-26381	Pamunkey	Male
9/15/2015	989001000099760	48143	1,413	NA	Pamunkey	Male
9/15/2015*	989001000099787	50842	1,496	NA	Pamunkey	Unknown
9/15/2015*	900118001359318	48062	1,695	A69-9002-12740	Pamunkey	Male
9/15/2015*	989001000099768	48147	1,942	NA	Pamunkey	Unknown
9/15/2015*	989001000099772	50843	1,634	NA	Pamunkey	Male
9/16/2015*	900118001359318	48062	1,695	A69-9002-12740	Pamunkey	Male
9/16/2015*	900118001202071	50805	1,637	A69-9002-12754	Pamunkey	Male
9/16/2015	989001000099792	48142	1,815	NA	Pamunkey	Unknown
9/17/2015	989001000099070	50782	1,549	NA	Pamunkey	Male
9/17/2015	989001000099139	50783	1,854	NA	Pamunkey	Unknown

Date Tagged/ Recaptured	PIT Tag #	T Tag #	Fork Length (mm)	Transmitter #	River	Sex
9/17/2015	989001000099131	50781	1,930	A69-1601-7694	Pamunkey	Female
9/17/2015*	900118001183504	50780	1,511	A69-9002-12739	Pamunkey	Male
9/21/2015	989001000099804	50793	1,531	NA	Pamunkey	Male
9/21/2015*	900118001183592	50792	2,049	A69-9002-12753	Pamunkey	Female
9/21/2015	989001000099778	50971	1,427	NA	Pamunkey	Male
9/21/2015	989001000099775	50790	1,802	NA	Pamunkey	Male
9/21/2015*	989001000099767	50845	1,876	NA	Pamunkey	Female
9/21/2015	989001000099840	50789	1,549?	NA	Pamunkey	Unknown
9/22/2015	989001000099090	50788	1,540	NA	Pamunkey	Male
9/22/2015*	989001003179745	48144	1,660	A69-9001-26381	Pamunkey	Male
9/22/2015	989001000099064	50787	2,225	A69-9004-1177	Pamunkey	Female
9/22/2015*	900118001184316	50786	1,702	A69-9002-12751	Pamunkey	Male
9/22/2015	989001000099074	50785	1,570	NA	Pamunkey	Male
9/22/2015	989001000099130	50784	1,565	NA	Pamunkey	Unknown
9/22/2015*	900118001182977	48141	1,705	NA	Pamunkey	Male
9/22/2015*	989001003179730	50802	1,686	A69-9001-26380	Pamunkey	Male
9/22/2015*	900118001183196	48055	1,560	A69-9002-12748	Pamunkey	Male
9/22/2015*	989001000099777	50838	1,950	A69-9001-21099	Pamunkey	Female
9/22/2015*	900118001183592	50792	2,049	A69-9002-12753	Pamunkey	Female
9/22/2015*	985161000824836	48112	1,495	DEAD TAG – 13587	Pamunkey	Male
9/22/2015*	989001000099819	48140	1,580	NA	Pamunkey	Male
9/22/2015	989001000099098	48139	1,475	NA	Pamunkey	Unknown
9/23/2015	989001000099054	48138	1,525	NA	Pamunkey	Male
9/23/2015*	989001000099759	50836	1,876	NA	Pamunkey	Unknown
9/23/2015	989001000099112	48137	1,533	NA	Pamunkey	Male
9/23/2015	989001000099140	48136	1,860	NA	Pamunkey	Unknown
9/25/2015*	989001000099814	50846	1,399	NA	Pamunkey	Male
9/25/2015*	900118001202200	50779	1,626	DEAD TAG – 13589	Pamunkey	Male
9/25/2015	989001000099072	50778	1,918	NA	Pamunkey	Female
9/25/2015	989001000099105	50777	1,568	NA	Pamunkey	Unknown
9/28/2015	989001000099765	48135	1,632	NA	Pamunkey	Male
9/28/2015*	989001000099792	48142	1,815	NA	Pamunkey	Unknown
9/28/2015	989001000099817	48134	1,536	NA	Pamunkey	Male
9/28/2015*	900118001202000	48133	1,429	A69-9002-12759	Pamunkey	Male
9/28/2015*	989001000099070	50782	1,549	NA	Pamunkey	Male
9/28/2015	989001000099750	48132	1,444	NA	Pamunkey	Male
9/28/2015*	989001003179761	50849	1,565	NA	Pamunkey	Male

Date Tagged/ Recaptured	PIT Tag #	T Tag #	Fork Length (mm)	Transmitter #	River	Sex
9/28/2015	989001000099785	48131	1,546	NA	Pamunkey	Male
9/29/2015*	900118001202071	50805	1,637	A69-9002-12754	Pamunkey	Male
9/29/2015*	900118001183504	50780	1,511	A69-9002-12739	Pamunkey	Male
9/29/2015	989001000099811	48130	?	NA	Pamunkey	Male
9/29/2015*	900118001202200	50779	1,626	NA	Pamunkey	Unknown
9/29/2015	989001000099129	48129	1,387	NA	Pamunkey	Male
9/29/2015*	989001000099760	48143	1,413	NA	Pamunkey	Male
9/29/2015	989001000099123	48128	1,587?	NA	Pamunkey	Male
9/29/2015	989001000099784	50776	2,115	NA	Pamunkey	Female
9/30/2015*	989001000099074	50785	1,570	NA	Pamunkey	Male
9/30/2015*	989001000099141	50799	1,626	A69-1601-57019	Pamunkey	Female
9/30/2015	989001000099823	50775	?	NA	Pamunkey	Male
10/5/2015*	989001000099772	50843	1,634	NA	Pamunkey	Male
10/5/2015*	900118001183196	48055	1,560	A69-9002-12748	Pamunkey	Male
10/5/2015	989001000099116	50774	1,560	NA	Pamunkey	Male
8/3/2016	NA	51151	1,690	NA	Pamunkey	Unknown
8/8/2016	989001000099086	51152	1,557	NA	Pamunkey	Unknown
8/29/2016	424E7A4E02	51153	1,431	NA	Pamunkey	Male
8/29/2016	989001000098593	51154	1,465	NA	Pamunkey	Unknown
8/30/2016	989001000098586	51155	1,613	NA	Pamunkey	Male
8/31/2016	989001000098595	51156	1,647	NA	Pamunkey	Male
9/6/2016	989001000098585	51157	1,468	NA	Pamunkey	Unknown
9/6/2016	989001000098581	51158	2,045	A69-9001-17228	Pamunkey	Female
9/6/2016	989001000098591	51159	1,921	A69-9001-17227	Pamunkey	Female
9/6/2016	989001000098578	51160	1,609	A69-9001-17229	Pamunkey	Female
9/6/2016*	900118001201930	50753	1,698	A69-9002-12735	Pamunkey	Male
9/7/2016	989001000098600	51161	1,534	NA	Pamunkey	Male
9/7/2016*	900118001181160	50752	1,523	A69-9001-27841	Pamunkey	Male
9/7/2016	989001000098609	51162	1,538	NA	Pamunkey	Male
9/7/2016	989001000098606	51163	1,915	A69-9001-17224	Pamunkey	Female
9/7/2016*	900118001202071	50805	1,534	A69-9002-12754	Pamunkey	Male
9/7/2016	989001000098604	51164	1,357	NA	Pamunkey	Male
9/7/2016*	900118001183196	51165	1,484	A69-9002-12748	Pamunkey	Male
9/7/2016	989001000098576	51166	1,468	NA	Pamunkey	Male
9/7/2016*	989001000099787	50842	1,484	NA	Pamunkey	Unknown
9/7/2016*	900118001183545	51167	1,596	A69-9002-12755	Pamunkey	Male
9/7/2016	989001000098584	51168	1,368	NA	Pamunkey	Male
9/8/2016*	900118001181551	48114	1,526	A69-9001-27843	Pamunkey	Male

Date Tagged/ Recaptured	PIT Tag #	T Tag #	Fork Length (mm)	Transmitter #	River	Sex
9/8/2016	989001000098588	51169	1,424	NA	Pamunkey	Male
9/8/2016	989001000098613	51170	1,416	NA	Pamunkey	Male
9/8/2016	989001000098599	51171	1,414	NA	Pamunkey	Male
9/8/2016	989001000098582	51173	2,045	A69-9001-17225	Pamunkey	Female
9/8/2016	989001000098611	51174	1,426	NA	Pamunkey	Unknown
9/14/2016	989001000098616	51175	1,386	NA	Pamunkey	Unknown
9/14/2016*	989001000098599	51171	1,414	NA	Pamunkey	Unknown
9/14/2016*	900118001359318	48062	1,660	A69-9002-12740	Pamunkey	Male
9/14/2016	989001000098612	51176	2,105	A69-9001-17226	Pamunkey	Female
9/15/2016*	900118001181551	48114	1,526	A69-9001-27843	Pamunkey	Male
9/16/2016*	900118001202201	50751	?	A69-9002-12730	Pamunkey	Male
9/19/2016*	989001000098606	51163	1,915	A69-9001-17224	Pamunkey	Female
9/19/2016	989001000099771	51177	1,538	NA	Pamunkey	Male
9/21/2016	989001000098583	51178	1,770	A69-9001-17223	Pamunkey	Female
9/21/2016*	900118001183693	51179	2,115	A69-9001-17222	Pamunkey	Female
9/21/2016*	900118001201930	50753	1,698	A69-9002-12735	Pamunkey	Male
9/21/2016*	989001000098600	51180	1,534	NA	Pamunkey	Male
9/21/2016	989001000098577	51181	1,545	NA	Pamunkey	Male
9/21/2016*	989001000099136	51182	1,570	NA	Pamunkey	Male
9/21/2016*	989001000099814	51183	1,404	NA	Pamunkey	Male
9/22/2016	989001000098587	51184	1,930	A69-9001-17221	Pamunkey	Female
9/22/2016	989001000098615	51185	1,465	NA	Pamunkey	Unknown
9/22/2016	989001000098608	51186	1,694	NA	Pamunkey	Male
9/22/2016*	900118001342234	51187	1,958	A69-9002-12758	Pamunkey	Female
9/22/2016	989001000098607	51188	1,678	NA	Pamunkey	Male
9/26/2016*	900118001182724	51189	1,355	NA	Pamunkey	Male
9/26/2016*	900118001182288	51190	1,589	NA	Pamunkey	Male
9/26/2016*	989001000099761	51191	1,446	NA	Pamunkey	Male
9/26/2016	989001000098598	51192	1,574	NA	Pamunkey	Male
9/26/2016*	989001003179745	51193	1,674	A69-9001-26381	Pamunkey	Male
9/27/2016	989001000098601	51194	NA	NA	Pamunkey	Male
9/28/2016*	989001000098606	51163	1,915	A69-9001-17224	Pamunkey	Female
9/28/2016	989001000098641	50771	1,588	NA	Pamunkey	Unknown
9/28/2016*	989001000099817	NA	1,549	NA	Pamunkey	Unknown
9/28/2016*	900118001181162	NA	1,588	DEAD TAG – 7698	Pamunkey	Male
9/28/2016*	989001000099116	50774	NA	NA	Pamunkey	Male
9/28/2016	989001000098567	50770	1,613	NA	Pamunkey	Male
9/28/2016	989001000098620	NA	1,441	NA	Pamunkey	Male

Date Tagged/ Recaptured	PIT Tag #	T Tag #	Fork Length (mm)	Transmitter #	River	Sex
9/28/2016*	989001000099090	NA	1,651	NA	Pamunkey	Male
10/3/2016*	989001000099105	50777	1,552	NA	Pamunkey	Male
10/3/2016	989001000099758	51195	1,415	NA	Pamunkey	Male
10/5/2016*	989001003179745	51193	NA	NA	Pamunkey	Male
10/5/2016	989001000098579	51196	1,376	NA	Pamunkey	Male
10/5/2016*	989001000099130	51197	1,570	NA	Pamunkey	Male
10/5/2016*	900118001359318	48062	NA	NA	Pamunkey	Male
9/8/2016*	985121026865700	51200	1,669	A69-9002-12736	Mattaponi	Female
9/19/2016	989001000099754	51199	1,845	A69-9001-17230	Mattaponi	Female
9/21/2016	989001000098637	51198	1,557	A69-9001-17231	Mattaponi	Male
9/26/2016	900118001181383	50773	NA	A69-9001-17232	Mattaponi	Male
10/4/2016	989001000098551	none	1,486	A69-9001-17233	Mattaponi	Male
8/15/2017	989001000099088	none	1,499	NA	Pamunkey	Male
8/15/2017	989001000098632	none	1,740	NA	Pamunkey	Male
8/18/2017	989001000099049	none	1,671	A69-9001-17234	Pamunkey	Female
8/22/2017*	989001000098595	53551	1,715	NA	Pamunkey	Male
8/22/2017	989001000099833	53552	1,477	NA	Pamunkey	Unknown
8/28/2017	985121014190406	50763	1,402	NA	Pamunkey	Male
8/28/2017*	989001000099067	50764	1,417	NA	Pamunkey	Male
8/28/2017	989001000099085	50765	1,488	NA	Pamunkey	Male
8/28/2017	989001000099815	50766	1,982	A69-9001-17235	Pamunkey	Female
8/28/2017*	989001003179728	50767	1,630	A69-9001-24481	Pamunkey	Male
8/28/2017	989001000098597	50768	1,460	NA	Pamunkey	Male
8/28/2017*	989001000099088	50769	1,495	NA	Pamunkey	Male
8/29/2017*	989001000099066	50831	1,474	NA	Pamunkey	Male
8/29/2017	989001000099801	53553	1,616	NA	Pamunkey	Male
8/29/2017*	989001000099782	53554	1,850	A69-9001-17220	Pamunkey	Female
8/29/2017	989001000099810	53555	2,130	A69-9001-17218	Pamunkey	Female
8/29/2017*	900118001181383	53556	1,553	A69-9001-17232	Pamunkey	Male
8/29/2017*	989001000099075	50797	1,639	NA	Pamunkey	Male
8/29/2017	989001000099813	53557	1,466	NA	Pamunkey	Unknown
8/30/2017*	900118001181551	48114	1,569	A69-9001-27843	Pamunkey	Male
8/30/2017*	985121012760407	53563	1,561	A69-9001-27847	Pamunkey	Male
8/30/2017	989001000098605	53558	1,366	NA	Pamunkey	Male
8/30/2017*	985161000824836	53559	1,498	DEAD TAG - 13587	Pamunkey	Male
8/30/2017	989001000099828	53560	1,408	NA	Pamunkey	Unknown
8/30/2017	989001000099752	53565	1,415	NA	Pamunkey	Male
8/31/2017*	989001003179745	51193	1,635	A69-9001-26381	Pamunkey	Male

Date Tagged/ Recaptured	PIT Tag #	T Tag #	Fork Length (mm)	Transmitter #	River	Sex
8/31/2017	989001000099834	53566	1,993	A69-9001-17219	Pamunkey	Female
8/31/2017*	900118001181162	53567	1,606	DEAD TAG - 7698	Pamunkey	Male
8/31/2017*	989001000099823	53568	1,570	NA	Pamunkey	Male
8/31/2017	989001000099797	53569	1,372	NA	Pamunkey	Male
8/31/2017	989001000099788	53570	1,542	NA	Pamunkey	Male
8/31/2017	989001000098594	53571	1,598	A69-9001-17236	Pamunkey	Female
9/5/2017*	989001000099085	50765	1,488	NA	Pamunkey	Male
9/5/2017*	989001000099804	50793	1,500	NA	Pamunkey	Male
9/5/2017*	989001003179730	53572	1,680	A69-9001-26380	Pamunkey	Male
9/5/2017*	989001000099767	53573	1,890	A69-9001-17237	Pamunkey	Female
9/5/2017	989001000098590	53574	1,417	NA	Pamunkey	Unknown
9/5/2017	989001000099809	53575	1,661	NA	Pamunkey	Unknown
9/5/2017	985161000857643	53576	1,481	NA	Pamunkey	Male
9/5/2017	989001000099062	53577	1,376	NA	Pamunkey	Male
9/6/2017*	989001000099064	53501	2,270	DEAD TAG-1177/17245	Pamunkey	Female
9/6/2017	989001000098552	53502	1,469	NA	Pamunkey	Unknown
9/6/2017*	989001000099833	53552	1,477	NA	Pamunkey	Unknown
9/6/2017*	989001000099074	53578	1,581	NA	Pamunkey	Male
9/7/2017*	989001000099782	53554	1,850	A69-9001-17220	Pamunkey	Female
9/7/2017	989001000099746	53579	1,486	NA	Pamunkey	Male
9/7/2017	989001000098580	53580	1,589	NA	Pamunkey	Male
9/7/2017	989001000099058	53581	1,509	NA	Pamunkey	Unknown
9/8/2017*	989001000099767	53573	1,890	A69-9001-17237	Pamunkey	Female
9/8/2017	989001000099079	53582	1,984	A69-9001-17238	Pamunkey	Female
9/11/2017*	989001000098594	53571	1,598	A69-9001-17236	Pamunkey	Female
9/11/2017*	900118001202000	53583	1,413	A69-9001-12759	Pamunkey	Male
9/11/2017*	900118001201930	53584	1,764	DEAD TAG – 12735	Pamunkey	Male
9/12/2017*	989001003179728	50767	1,630	A69-9001-24481	Pamunkey	Male
9/12/2017	989001000099822	53585	1,443	NA	Pamunkey	Male
9/12/2017*	900118001183196	53586	1,535	A69-9002-12748	Pamunkey	Male
9/12/2017	989001000099786	53587	1,544	NA	Pamunkey	Male
9/12/2017	989001000099104	53588	1,930	A69-9001-17246	Pamunkey	Female
9/12/2017	989001000099800	53589	1,550	NA	Pamunkey	Male
9/12/2017	989001000099089	53590	1,729	A69-9001-17247	Pamunkey	Female
9/13/2017*	989001000098597	50768	1,460	NA	Pamunkey	Male
9/13/2017*	985121012760407	53563	1,561	A69-9001-27847	Pamunkey	Male
9/13/2017*	989001000099053	53591	1,527	NA	Pamunkey	Male

Date Tagged/ Recaptured	PIT Tag #	T Tag #	Fork Length (mm)	Transmitter #	River	Sex
9/13/2017	985161001135040	53592	1,468	NA	Pamunkey	Male
9/13/2017	989001000098602	53593	1,401	NA	Pamunkey	Unknown
9/13/2017	989001000098614	53594	1,894	A69-9001-17239	Pamunkey	Female
9/13/2017	989001000099048	53595	1,494	NA	Pamunkey	Male
9/13/2017	989001000098483	53596	1,563	NA	Pamunkey	Male
9/13/2017	989001000098486	53598	1,407	NA	Pamunkey	Male
9/13/2017	985121014190595	53599	1,370	NA	Pamunkey	Male
9/14/2017*	989001003179804	50754	1,530	A69-900-24479	Pamunkey	Male
9/14/2017*	989001000098620	53526	1,470	NA	Pamunkey	Male
9/14/2017*	989001000098595	53551	1,715	NA	Pamunkey	Male
9/14/2017*	900118001182326	53600	1,630	NA	Pamunkey	Male
9/14/2017*	900118001183356	NA	1,873	DEAD TAG – 13588/ 17240	Pamunkey	Female
9/18/2017*	989001000098632	53522	1,740	NA	Pamunkey	Male
9/19/2017	989001000098526	53523	2,189	A69-9001-17241	Pamunkey	Female
9/25/2017*	989001000099104	53588	1,930	A69-9001-17246	Pamunkey	Female
9/26/2017*	989001000099772	53524	1,608	NA	Pamunkey	Male
9/26/2017	989001000098468	53525	1,498	NA	Pamunkey	Unknown
9/27/2017	989001000098447	53527	1,457	NA	Pamunkey	Unknown
9/27/2017	989001000098536	53528	1,896	NA	Pamunkey	Female
9/28/2017*	989001000099811	53529	1,427	NA	Pamunkey	Male
9/28/2017	989001000098541	53530	1,539	NA	Pamunkey	Unknown
9/28/2017*	989001000099814	53531	1,372	NA	Pamunkey	Male
9/28/2017	989001000098537	53532	1,504	NA	Pamunkey	Male
10/2/2017	989001000098493	53533	1,563	NA	Pamunkey	Male
10/2/2017*	985161000824836	53559	1,498	DEAD TAG - 13587	Pamunkey	Male
10/2/2017*	985161001135040	53592	1,468	NA	Pamunkey	Male
10/2/2017*	900118001202201	50751	1,676	A69-9002-12730	Pamunkey	Male
10/3/2017	989001002746059	53535	1,422	NA	Pamunkey	Male
10/3/2017	989001000098500	53536	2,301	NA	Pamunkey	Female
10/3/2017*	900118001182326	53600	1,630	NA	Pamunkey	Male
10/3/2017	989001000098446	53537	1,585	NA	Pamunkey	Male
10/4/2017*	989001000099804	50793	1,500	NA	Pamunkey	Male
10/4/2017*	900118001181383	53538	1,553	A69-9001-17232	Pamunkey	Male
10/4/2017	985151014383235	53539	1,471	NA	Pamunkey	Male
10/4/2017	989001000098454	53540	1,423	NA	Pamunkey	Male
10/4/2017*	985121012760407	53563	1,561	A69-9001-27847	Pamunkey	Male
10/4/2017*	989001003179730	53572	1,680	A69-9001-26380	Pamunkey	Male

Date Tagged/ Recaptured	PIT Tag #	T Tag #	Fork Length (mm)	Transmitter #	River	Sex
10/10/2017*	989001000099786	53587	1,544	NA	Pamunkey	Male
10/10/2017	989001000098519	53541	2,060	A69-9001-17243	Pamunkey	Female
10/16/2017	989001000098510	53542	1,535	NA	Pamunkey	Male
10/16/2017*	989001000098474	50779	1,590	DEAD TAG – 13589/17250	Pamunkey	Male
10/16/2017*	989001000098597	50768	1,460	NA	Pamunkey	Male
9/25/2017	989001000098631	NA	1,575	NA	Mattaponi	Unknown
7/30/2018	989001000098391	53543	1,560	NA	Pamunkey	Unknown
7/31/2018	989001000098440	53544	1,436	NA	Pamunkey	Male
8/7/2018	989001000098382	53545	1,588	A69-9001-17244	Pamunkey	Female
8/7/2018*	989001000098591	51159	1,913	A69-9001-17227	Pamunkey	Female
8/27/2018	989001000098407	53546	1,468	NA	Pamunkey	Male
8/27/2018	989001000098377	53547	1,605	NA	Pamunkey	Male
8/27/2018*	900118001183957	53548	1,534	A69-9002-12746	Pamunkey	Male
8/29/2018	989001000098506	53550	1,630	NA	Pamunkey	Male
8/29/2018*	989001003179761	50849	1,629	NA	Pamunkey	Male
9/5/2018*	989001000098602	54051	1,439	NA	Pamunkey	Male
9/11/2018*	900118001202090	48051	1,665	NA	Pamunkey	Male
9/11/2018*	989001000099055	54100	1,755	A69-9001-17242	Pamunkey	Unknown
9/11/2018*	900118001183504	54099	1,515	A69-9002-12739	Pamunkey	Male
9/12/2018*	985121012760407	54052	1.596	A69-9001-27847	Pamunkey	Male
9/12/2018*	900118001183713	54053	1,633	DEAD TAG - 12745	Pamunkey	Male
9/12/2018*	900118001202201	50751	1,629	A69-9002-12730	Pamunkey	Male
9/12/2018*	900118001183545	54054	1,640	DEAD TAG - 12755	Pamunkey	Male
9/12/2018*	989001000099085	50765	1,542	NA	Pamunkey	Male
9/12/2018	989001000098507	54055	1,476	NA	Pamunkey	Male
9/12/2018*	989001000099778	54056	1,461	NA	Pamunkey	Male
9/13/2018*	900118001183196	54057	1,529	A69-9002-12748	Pamunkey	Male
9/13/2018	989001000098364	54058	1,425	NA	Pamunkey	Male
9/13/2018*	989001000099136	51182	1,597	NA	Pamunkey	Male
9/13/2018*	989001003179730	54059	1,713	A69-9001-26380	Pamunkey	Male
9/17/2018*	989001000099058	53581	1,530	NA	Pamunkey	Male
9/17/2018*	985161001135040	54060	1,463	A69-9001-26350	Pamunkey	Male
9/17/2018	989001000098540	54061	1,900	A69-9001-17248	Pamunkey	Female
9/17/2018	989001000098450	54062	2,051	A69-9001-17249	Pamunkey	Female
9/18/2018*	989001000099822	53585	1,500	NA	Pamunkey	Male
9/18/2018*	989001000099075	50797	1,677	NA	Pamunkey	Male

Date Tagged/ Recaptured	PIT Tag #	T Tag #	Fork Length (mm)	Transmitter #	River	Sex
9/18/2018*	989001000099777	54063	1,915	A69-9001-21099	Pamunkey	Female
9/18/2018*	989001000099800	53589	1,579	NA	Pamunkey	Male
9/24/2018*	989001003179761	50849	1,629	NA	Pamunkey	Male
9/24/2018*	989001000099058	53581	1,530	NA	Pamunkey	Male
9/24/2018	989001000098466	54064	1,502	NA	Pamunkey	Male
9/24/2018*	989001000099822	53585	1,500	NA	Pamunkey	Male
9/25/2018	989001000098470	54065	1,555	NA	Pamunkey	Male
9/26/2018	989001000098376	54066	1,627	NA	Pamunkey	Unknown
9/26/2018*	985121012760407	54052	1.596	A69-9001-27847	Pamunkey	Male
9/26/2018	989001000098482	54067	1,375	NA	Pamunkey	Male
9/26/2018	989001000098538	54068	1,440	NA	Pamunkey	Male
10/1/2018*	900118001183196	54057	1,529	A69-9002-12748	Pamunkey	Male
10/1/2018	989001000098532	54069	1,695	A69-9001-17251	Pamunkey	Unknown
10/1/2018*	989001000099116	50774	1,531	NA	Pamunkey	Male
10/2/2018*	989001000099804	50793	1,605	NA	Pamunkey	Male
10/2/2018*	900118001183196	54057	1,529	A69-9002-12748	Pamunkey	Male
10/3/2018*	989001000098595	54070	1,688	A69-9001-27836	Pamunkey	Male
10/3/2018	989001003179724	54071	1,705	A69-9002-12740	Pamunkey	Male
10/9/2018	985161001135589	54072	1,993	A69-9001-17252	Pamunkey	Female

The sex of an Atlantic sturgeon cannot be visually identified externally. Rather, sex can be determined by internal examination or the external expression of gametes. In early 2013, the presence of many adult fish in the Pamunkey River during suitable water temperatures (18–20°C) suggested that spawning could be occurring. Spawning activity was confirmed on 23 August 2013, when a nearly spent female still expelling residual eggs was collected (Hager et al. 2014). Eggs were collected and preserved for analysis. Between 2013 and 2014, five of the adults collected were confirmed to be females, 41 fish were identified as male due to the emission of milt (i.e., seminal fluid), and the rest were unknown. Of the 77 newly collected fish in 2015, 11 were female, 37 were male, and 29 were of unknown gender. In 2016, of the 37 new fish obtained in the Pamunkey, 9 were confirmed females that received sonic transmitters, 18 were males, and 9 were of unknown gender. In the Mattaponi, two of the five fish were females, one previously tagged in the Pamunkey (12736) and one was new (17230). Three Mattaponi River males also received tags. In 2017, 15 females and one male were tagged in the Pamunkey River including three re-tags: female 13588 (old tag) is now 17240 (new tag), female 1177 (external) is now 17246, and male 13589 is now 17250. Female fish were tagged in both 2016 and 2017 in an effort to balance the sex ratio of tagged fish in the system to a 50/50 ratio, to aid in the delineation of spawning habitats, and to examine sexual differences in behavior. In 2018, 4 females and 2 large but sexually unidentified fish were tagged. As of the end of 2018, taking into account failed and/or rejected tags, we have 26 operating tags in males, 30 tags in females, and 10 in fish of unknown sex.

Mattaponi River netting began in July of 2016. It first occurred in deep holes in the upper river (RM 30–35) but was moved downriver in mid-August to a few miles below the Walkerton Bridge near RM 25 due to a lack of success upriver (**Appendix 8.1**). Five fish were captured in the Mattaponi River between the beginning of September and the first week of October. The first fish was not captured until 8 September 2016. Its capture was especially important because it was a ripe female (12736) carrying late-stage eggs, which had been tagged in the Pamunkey River in 2014. It did not return to spawn in the Pamunkey in 2016, but occupied the Mattaponi exclusively, presumably to spawn. The other four fish collected had not been captured previously, and these included a second late-stage, egg-bearing female that was also only detected in the Mattaponi River during the 2016 spawning season. We fished much farther upriver in the Mattaponi River in 2017 to increase our chances of obtaining a partially spawned-out female to prove that spawning is occurring in the Mattaponi, but managed to capture only a single fish.

3.3. Array Coverage

Receiver locations were mapped in terms of RM, bay mile, or offshore distance from the Collision Regulations (COLREGS) line to increase the applicability of telemetry data with regard to consultations with state and federal managers who use these mile markers as delineations when discussing management alternatives. Mile delineation maps are found in **Appendix 8.1**. Receiver coverage within military zones based on our 0.7 km mean detection range (for a V16 tag) is presented in **Table 2**. Maps denoting estimated receiver reception coverage within each zone of military interest are in **Appendix 8.2**.

Table 2. Estimated receiver coverage in military zones of interest. Perimeters, areas, and percentage of aquatic area covered by the receiver array (0.7 km estimated reception range) are presented.

Military Zone	Perimeter (m)	Water Area (m^2)	Receiver Coverage (m^2)	Percent Coverage (%)
Naval Weapons/Cheatham Annex	37,644.2	31,716,399.0	5,235,329.1	16.5
Naval Station Norfolk	66,777.0	48,066,219.8	14,828,030.6	30.8
Elizabeth River	46,684.3	10,249,604.0	4,995,695.0	48.7
Little Creek	27,492.8	44,061,016.4	9,996,580.8	22.7
Fort Story	26,26.4	31,414,453.6	7,066,425.8	22.5
Dam Neck Naval Firing Range Surrogate	84,761.2	375,837,361.0	27,436,899.9	7.3

[α]Coverage excludes RA Outside in Range Sur., which was removed in August 2017 and B3 in Fort Story removed in Feb of 2013.

Because of loss and breakage, every receiver site did not contain an operational receiver during every day of every month of the study (**Appendix 9.1**). Gaps in receiver operation could have resulted in missed detections. The likelihood of missed detections was positively correlated with the amount of time a receiver was not functional, and receiver malfunction and loss were positively correlated with the amount of wave energy to which the receiver was exposed. Within the first year we stopped monitoring at several sites that experienced high loss rates and/or were in proximity to other receivers. Therefore, 11N (Chesapeake Region), NH5 (NSN), B3 (Fort Story), NCA (Atlantic Region), and CB15 (Range Sur.) have not been monitored since 2013 (**Appendix 8.1**). The RA outside buoy located in the Range Sur. zone was removed in 2017 and has not been put back on site since.

The largest gaps in receiver coverage because of receiver failure or loss occurred in the Atlantic Ocean in the Range Sur. zone, followed by the Chesapeake Bay region and then Fort Story at the mouth of the Chesapeake Bay. Losses in other military zones were minimal or non-existent. The occurrence of data gaps within military zones of interest may result in an underestimation of sturgeon occupation because of reduced receiver function. **Appendix Table 9.1** lists receiver site, region, and military zone, if applicable, and describes monitoring by month. Because of limited space, it does not include every time a receiver site was maintained.

During array operation in 2013, we faced many receiver deployment challenges. Receiver losses (30) increased with distance from shore across all years but the loss rate was significantly reduced in subsequent years and was virtually insignificant in 2017. Losses when they occurred were because of vessel and dredge interactions but most often were related to extreme equipment stress during unusually large storms. Twelve losses occurred during a single storm event in March 2013, when waves remained large (2 to 6 m) for 3 weeks. Faulty equipment (e.g., shackles) and potentially direct removal by unknown persons also played a role in 2013. In one instance, a site on the CBBT needed to be moved to perform bridge maintenance. We relocated to a buoy nearby to save the location as a monitored site.

Loss and breakage of receivers were greatly reduced in 2014. Receivers in high-energy areas were wrapped in neoprene jackets and secured within 10-cm diameter conduit pipes with custom U-bolts. These were then attached with two separate stainless steel cables with 2,200-kilogram breaking strength, on cables extending from the top and underside of each buoy. Although this method was much more successful, we continued to improve our ability to retain receivers in 2015 by switching to stainless steel crimps from copper. However, despite the thickness or type of cable, some losses still occurred. Our largest loss of receivers in 2014 occurred when six buoys and associated receivers were removed by USCG during replacement after storm damage. Some of these were recovered, but not all. Largest losses in data in 2015 were due to damage and wear sustained during a late-season hurricane on 1 October. Losses in 2016 were again reduced (n = 2). One loss on the CBBT (CBBT3; **Appendix 8.1**) was most likely due to the cable friction against a concrete pilling during a hurricane and another receiver on a day marker in the York River was struck by a Navy vessel and the day marker not retrievable. In August 2017, USCG removed 10 of our receivers. All sites were in the ocean except B9. Receivers were replaced within a week of removal at all sites except B9. Conversations between the USN and USCG resulting from USCG removal of USN equipment in August of 2017 have occurred that should address this issue in the future. The only receiver loss in 2017 occurred at a public fishing pier (Chick Bridge; **Appendix 8.1**) in the Chickahominy River where the stainless cable securing the device had clearly been cut with wire clippers. In 2018, one receiver was lost when the USCG replaced buoy 36 located in the Elizabeth River with a new buoy. The gear was never recovered from the USCG.

3.4. Transmitter Detection Overview

A total of 1,225 individual Atlantic sturgeon were detected within the receiver array from December 2012 to December 2018. Data on the number of detections at each receiver are presented in the appropriate regional and military zone sections below. Thirty-five other species with sonic tags were also recorded (**Appendix Table 9.2)**; these represent the efforts of 77 researchers from 52 different organizations (**Appendix Table 9.3**). The greatest number of sturgeon detected from December 2012 to December 2018 were tagged north of Chesapeake Bay (n = 694), followed by those tagged within the bay and its tributaries (n = 470), then those tagged in waters south of Chesapeake Bay (n = 62).

GIS maps denoting the total number of detections by month, year, and interannual totals are presented in the appendices (**Appendices 8.3–8.9**). Maps of each region are included, with integral military zones. If a map is not included for a given month, it is due to a lack of detections, not because a receiver within the array was not in place. Detection maps/layers also can be combined in the future with layers describing other concurrent parameters such as bottom composition, temperature, salinity, and dissolved oxygen—factors known to affect Atlantic sturgeon distribution (Niklitschek and Secor 2005). Thus, layers provide a means of combining data to build models that describe which habitats are preferred and concurrent physical attributes of selected habitats. Bathymetry images are used as backgrounds for total detections from 2013-2018 (**Appendices 8.3–8.9**). Pamunkey River detection maps are plotted on habitat delineation maps to identify the exact location of spawning (**Appendix 8.3**).

Habitat research was provided by the NOAA Chesapeake Bay Office, which used side-scan sonar images (600 kHz) to delineate habitat types, determine composition, and then model habitat distribution (Bruce and McGowan 2017). This effort provides an example of how temporal detection layers can be combined with habitat or depth layers to identify the characteristics of specific high-occupancy locations within regions and zones to advance our knowledge as to which habitats are preferred and critical to the species.

The interannual trends in detections were relatively stable in most zones, with a couple of exceptions (**Figure 9**). The annual average number of detections per receiver in the Fort Story zone of Atlantic sturgeon increased by an order of magnitude in 2016 after three years of relative consistency. It decreased an order of magnitude in 2017 but remained three times as high as its pre-2016 peak. In 2018, the average number of detections per receiver in the Fort Story zone returned to nearly the level recorded in 2016 (approximately 20,000). This zone is occupied by transients and native fish alike but native occupancy in late summer produces differences between years. Additionally, varied ecological conditions result in large differences in occupation of this site annually. The average number of detections per receiver at the NW/Ch. zone more than doubled in 2016, after having increased an order of magnitude in 2014. This zone experienced increased detections in 2017 and 2018 as well. This continual increase in the average number of detections is due to detections of returning fish and our continual tagging upriver each fall. In 2016, the average number of detections per receiver in NSN declined for the first time and was approximately half that recorded in 2015. This trend has continued through 2017 and 2018. This decline in the average number of detections within the NSN zone may a result of VIMS discontinuing its spring tagging efforts in the middle James River in 2016. The fact that fish are not returning to the James River annually may suggest that either sub-adults characterized by their wandering behavior were selected for tagging or that adults selected were not of James River origin or both. The average number of detections within Little Creek was nearly constant in 2015–2018. This contrasts the dynamic differences recorded between 2013 and 2014. The Range Sur. zone showed a steady increase in the average number of detections per receiver annually until 2017, when the average number of detections was roughly half what was recorded in 2016. In 2018, the average number of detections in this zone increased to approximately what was recorded in 2015 but it did not quite return to the level recorded in 2014. Receptions in this offshore zone are the combined result of fish tagged in the bay and fish tagged in other regions. Numerous factors could be driving the relatively small shifts in average detection volume which have always remained within the same order of magnitude. The average number of detections in the small Elizabeth River zone has consistently been low. Increased tag detection volume and years with largest average detections per receiver correlate with the VIMS/VCU tagging efforts in the middle James River in 2014–2016. This zone has had the smallest average number of detections per fish recorded in every year but 2015 when adult fish of James River tagging origin were recorded occupying this zone and substantially contributing to average detection volume.

The numbers of individual Atlantic sturgeon detected within each military zone varied substantially (**Figure 10**). The largest numbers of individual sturgeon detected each year were in the Range Sur. zone. The second largest numbers were detected in the Fort Story zone; followed closely by the Little Creek and NSN zones, where nearly identical numbers of fish were detected each year until 2016. From 2016 through 2018, fewer fish have been entering or transiting through NSN. Again, this likely reflects alterations in tagging practices by VIMS and VCU in the James, upriver of NSN. The annual number of sturgeon detected within the NW/Ch. zone clearly reflects our large increase in tagging effort in 2014, the steady return of males, selective tagging of females during 2016–2018, and to a lesser degree females beginning to return. The Elizabeth River zone recorded its highest number of fish in 2015 (n = 29). In 2016, adult James River fish occupied the zone for a substantial period of time. James River adults did not show up in 2017 or 2018.

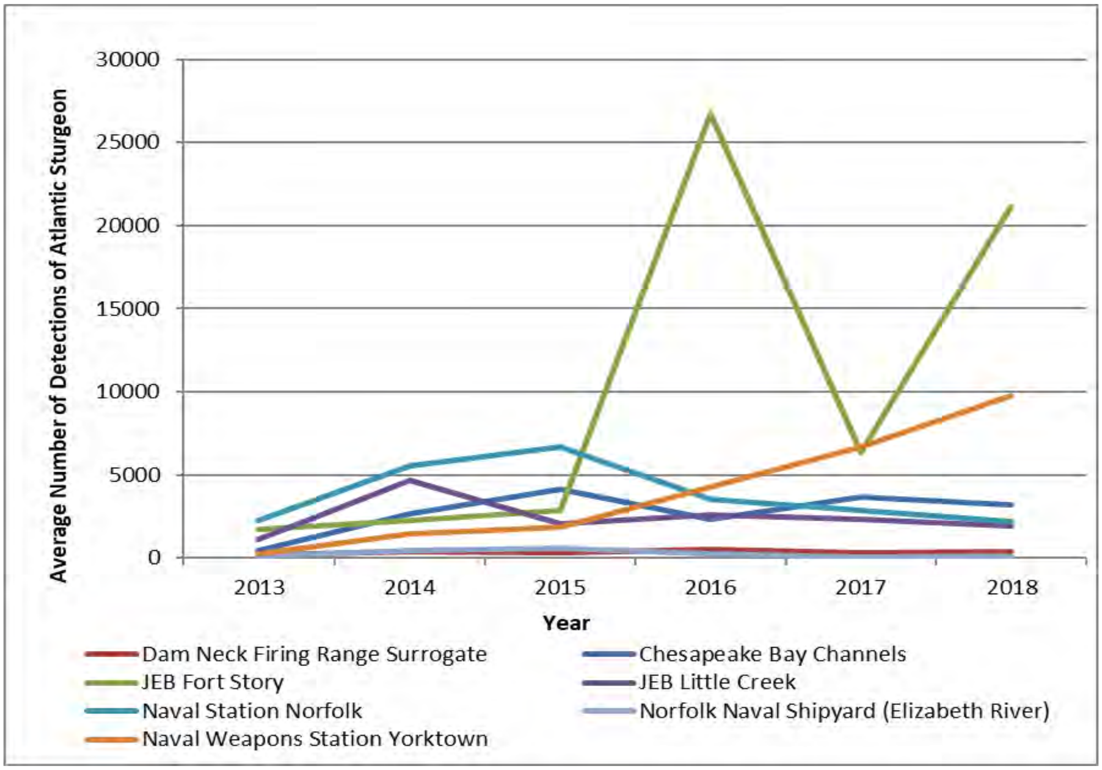

Figure 9. Average number of detections per receiver within each zone from 2013 to 2018.

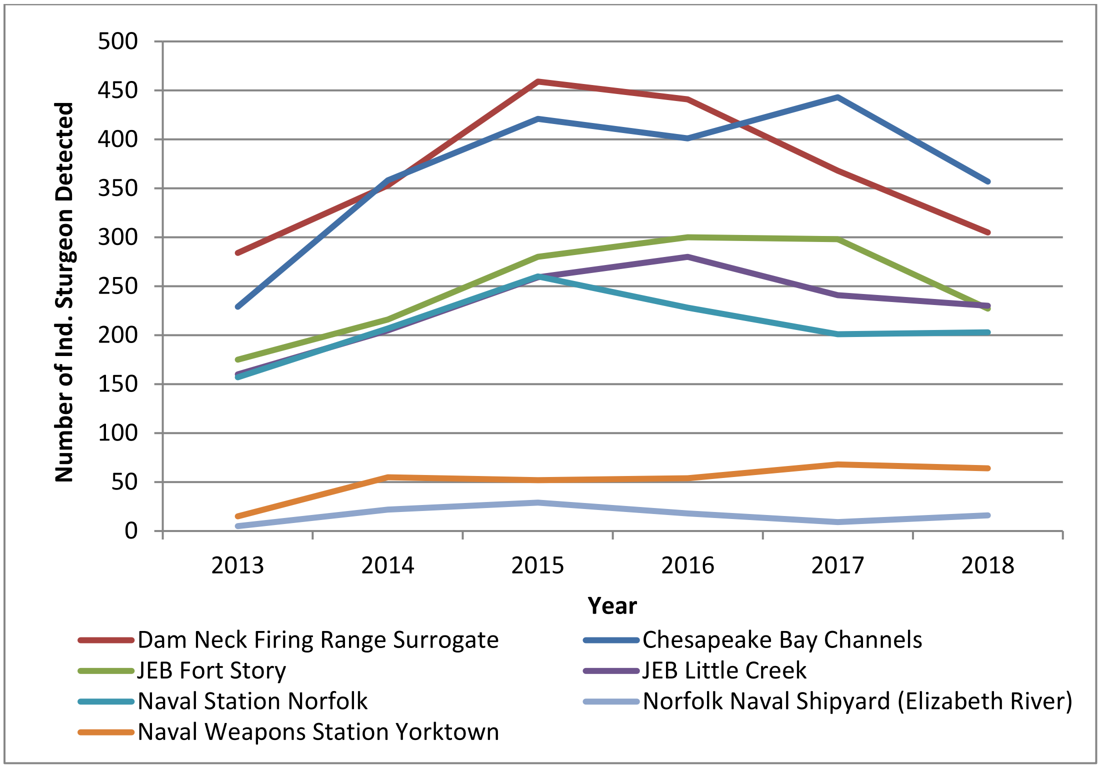

Figure 10. The number of individual Atlantic sturgeon detected in each zone from 2013 to 2018. The number of fish detected in Little Creek from 2013 to 2015 was nearly identical to those of NSN and thus its purple line is not visible below the teal line until 2016.

3.5. Results by Region and Military Zone

3.5.1. Pamunkey River Region

There were no telemetry results from the Pamunkey River and little within the York River watershed prior to our tagging of adult Atlantic sturgeon in late summer 2013. From 2013 through 2018, we have continued to conduct a mark-recapture study and to tag adults. Concurrently, we have expanded our receiver array coverage greatly in the Pamunkey River and to a lesser degree in the York River in order to improve data on fish behavior. When additional receiver sites were added within regions of interests in the Pamunkey, original receiver sites were maintained so that consistent inter-annual coverage was achieved. Maintaining consistent receiver locations is critical to understanding inter-annual alterations in behavior because riverine use is motivated by varying environmental conditions that result in different spatial and temporal distribution patterns. This detail is crucial if long-term, standardized tracking data sets are to be obtained that can be used to develop meaningful statistics and mathematical models.

Large numbers of males were tagged in 2013 and 2014, some with 6-year and some with 10-year duration tags. Since 2015, females have been selectively tagged in an attempt to balance the sex ratio of tagged fish. We are currently close to a 50/50 sex ratio with 26 active tags in males, 30 in females, and 10 in fish of unidentified sex. The capture and tracking of a significant number of both sexes is very important to estimating the actual population size and determining behavior because it was discovered to be sexually divergent. It is impossible to determine the adult population size or examine sex-based differences in behavior unless enough of each sex are collected during mark-recapture efforts and a reasonable percentage of each are implanted with transmitters.

Based upon mark-recapture collections from 2013 to 2018, our most recent population analysis estimates the total adult population for the York River system at 325 fish (95 percent confidence interval = 226 – 423, Kahn 2019). We have inserted PIT tags and taken genetic samples from 239. The number of fish tagged is within the confidence interval because the estimate includes all six years of tag-recapture data and not all years are equal in sample value. Subsequent tracking and recaptures have determined that males and females do not return at the same spawning intervals. Males return to the Pamunkey on average every 1.31 years and females return every 2.29 years. We are confident that our methods can accurately determine return rates because we have calculated the actual population size and know that the number of fish of both sexes tagged represents a significant portion of the existing fish.

By far the largest number of Atlantic sturgeon detected in Pamunkey River were tagged in the Pamunkey (**Table 3**). At first this may not seem worth noting; however, as detection data in following sections will attest, often fish of vastly different tagging origins and DPS significantly contribute to detection data. As has been the case since the beginning of our research, few fish tagged in other systems enter the York River system and even fewer enter its freshwater tributaries. A meaningful exception to this are 3 adult males tagged in the Nanticoke system in Maryland. Given that few fish have been tagged in this small Eastern Shore system, they appear to have an extremely high occurrence in the York River system's spawning regions during the late summer/fall spawning period in following years. One adult (26350), tagged in

Marshyhope Creek, Maryland, in 2014 actively used the Pamunkey River spawning grounds in 2015, 2017, and 2018 and was in the Mattaponi in 2016. In 2016 and 2018, another Maryland fish (27547) tagged in 2014 ran the Pamunkey, and one tagged in 2015 (26354) did the same in 2017 and 2018. In 2017, a number of fish of James River genetic origin were captured in the Pamunkey River in late September/early October but none were carrying transmitters. One was a large female, but she was not actively spawning. She was, however, captured in association with other males, several of James River origin.

Table 3. Tagging origins of Atlantic sturgeon detected within the Pamunkey River from 2013 to 2018. The tagging location of VIMS fish is generalized to the Chesapeake Bay region. They are separated in the table as that institution does not share the exact tagging location.

Year	Pamunkey	Mattaponi	Maryland	James	VIMS	Total
2013	13	0	0	0	1	14
2014	43	0	0	0	11	54
2015	33	0	1	1	16	51
2016	33	0	1	0	12	46
2017	43	1	2	0	10	56
2018	41	2	3	0	10	54

In 2014, researchers with the Virginia Institute of Marine Science conducted tagging operations targeting adults in the Pamunkey River directly upriver of our site, thus we know the life stage, tagging origin, and even stock identity of the ten adults tagged in that year. Starting in 2015 and extending through 2017, VIMS began to tag sub-adults in the Pamunkey, Mattaponi, and upper York rivers. In addition, they had been tagging a large number of sub-adults in the James River in 2014 and 2015. Fish tagged by VIMS are presented in a separate column because the DPS, life stage and even tagging origin of these fish becomes unclear in 2015.

The only sub-adults tagged through this study were two small fish tagged in the upper York River in December of 2012. Both were later determined to be of Hudson River, New York origin (Tim King, USGS, personal communication). These fish left the York River shortly after tagging and did not return over the 1.5-year period of tag duration. Both were detected off Virginia Beach in the ocean, on the Eastern Shore, and in the bay several months after tagging. One has not returned to the bay since 2013 and the other resided seasonally in the James River within the NSN zone. We assisted VIMS in 2015 and 2016 with their sub-adult collections in the Pamunkey River by providing real-time information on the location of our numerous adult fish. They used these adult fish to locate sub-adults associated with adult congregations. VIMS subsequently tagged ten sub-adults: nine in the lower Pamunkey and one in the lower Mattaponi. Without genetic analysis, there is no way to know if these VIMS sub-adults are native York River fish, or are simply highly mobile sub-adults from other systems exemplifying the transient behavior for which they are known (Bain 1997, Savoy and Pacileo 2003). For example, sub-adults (n = 2) tagged in the James River have moved into the Pamunkey and those tagged in the Pamunkey have left the river to reside for extended amounts of time in the James. Sub-adults tagged downriver in the York have moved up into the Pamunkey in the spring (mid-March) and remained through November. One sub-adult tagged in the James River moved into the Pamunkey and remained for several months. Based upon subsequent detections (2012–

2018), sub-adults tagged in the Pamunkey River are highly mobile, and exemplify the behavior of sub-adults tagged in other Virginia waters (Hager 2011, Eyler et al. 2004). One behavioral tendency that appears consistent for sub-adults is their preference for occupying the oligohaline and higher salinity zones (below RM 23) versus returning to pure freshwater regions.

Adults are in the Pamunkey River from April through November (**Figure 11**), with seasonal abundance in the oligohaline portion of the river (receiver site Glenns at RM 23 and below; **Appendix 8.1**) highest in late spring and mid-fall (**Table 4**). This coincides with the period during which adult fish are adjusting to alterations in salinity during their late spring/early summer immigration and fall emigration. September is the peak of the spawning season with consistently the largest numbers of fish detected in the upper river (**Table 4**), the largest numbers of days/month that fish are detected, and the largest numbers of detections (**Figure 11**).

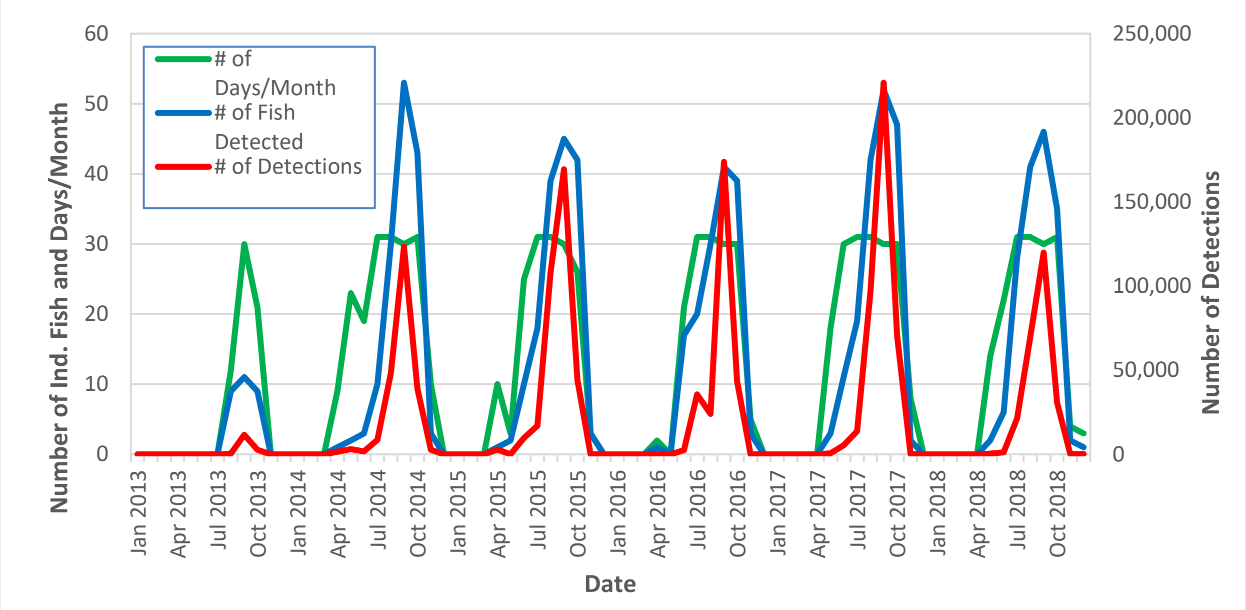

Figure 11. Atlantic sturgeon occurrence based on receiver detections in the Pamunkey River region, 2013 to 2018.

Table 4. Numbers of detections by month in the Pamunkey River region, December 2012–December 2018, by year. Receiver sites are listed in descending order by RM. Asterisks indicates a receiver site that is seasonal and only contained a receiver from early summer to late fall/early winter. Note: NA signifies a period when the receiver was not deployed. River miles and receiver site names can be referenced on Appendix 8.1.

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Dec. 2012	Jan. 2013	Feb. 2013	Mar. 2013	Apr. 2013	May 2013	June 2013	Jul. 2013	Aug. 2013	Sep. 2013	Oct. 2013	Nov. 2013	Dec. 2013	Total
Pamunkey River	55	Pam. 360	None	0	0	0	0	0	0	0	0	0	3,580	1801	0	0	**5,381**
Pamunkey River	49	Pam. Upper William *	None	NA	NA	NA	NA	NA	NA	0	0	64	1,405	28	NA	NA	**1,497**
Pamunkey River	47	Pam. Williams	None	0	0	0	0	0	0	0	0	250	2,310	129	0	0	**2,689**
Pamunkey River	43	Pam. Brick wall *	None	NA	NA	NA	NA	NA	NA	0	0	0	1554	465	NA	NA	**2,019**
Pamunkey River	30	Pam. Res.	None	0	0	0	0	0	0	0	0	17	757	179	0	0	**953**
Pamunkey River	18	Pam. Soffin	None	0	0	0	0	0	0	0	0	50	213	143	0	0	**406**
Pamunkey River	6	Pam. John	None	0	0	0	0	0	0	0	0	0	3,580	1,801	0	0	**5,381**
Sum 2013				**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**381**	**9,910**	**2,351**	**0**	**0**	**12,642**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2014	Feb. 2014	Mar. 2014	Apr. 2014	May 2014	June 2014	June 2014	Aug. 2014	Sep. 2014	Oct. 2014	Nov. 2014	Dec. 2014	Total
Pamunkey River	55	Pam. 360	None	0	0	0	0	0	0	0	2,379	2,720	71	0	0	**5,170**
Pamunkey River	51	Pam. Top $ *	None	NA	NA	NA	NA	NA	NA	NA	1,362	3,865	361	NA	NA	**5,588**
Pamunkey River	50	Pam. Top 1 *	None	NA	NA	NA	NA	NA	0	40	broken	3,124	1,604	NA	NA	**4,768**
Pamunkey River	50	Pam. Rootball *	None	NA	NA	NA	NA	NA	NA	NA	1,719	5,784	1,255	NA	NA	**8,758**
Pamunkey River	50	Pam. Hickory Tree *	None	NA	NA	NA	NA	NA	0	22	1,942	6,169	846	NA	NA	**8,979**
Pamunkey River	49	Pam. H2O *	None	NA	NA	NA	NA	NA	0	17	1,316	4,717	614	NA	NA	**6,664**
Pamunkey River	49	Pam. Upper William *	None	NA	NA	NA	NA	NA	0	4,606	2,074	8,323	1,147	NA	NA	**16,150**
Pamunkey River	49	Pam. L. Up William *	None	NA	NA	NA	NA	NA	0	129	53,340	9,235	1,238	NA	NA	**63,942**
Pamunkey River	48	Pam. Fos. Cliff *	None	NA	NA	NA	NA	NA	0	655	2,391	6,195	1,158	NA	NA	**10,399**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2014	Feb. 2014	Mar. 2014	Apr. 2014	May 2014	June 2014	June 2014	Aug. 2014	Sep. 2014	Oct. 2014	Nov. 2014	Dec. 2014	Total
Pamunkey River	47	Pam. Williams	None	0	0	0	0	0	0	485	4,363	7,777	1,575	0	0	**14,200**
Pamunkey River	46	Pam. William Lower *	None	NA	NA	NA	NA	NA	0	1,634	5,349	11,587	2,659	NA	NA	**21,229**
Pamunkey River	46	Pam. L. L. William *	None	NA	NA	NA	NA	NA	0	NA	NA	7,447	1,360	NA	NA	**8,807**
Pamunkey River	44	Pam. Poles *	None	NA	NA	NA	NA	NA	NA	NA	NA	17,235	4,900	NA	NA	**22,135**
Pamunkey River	43	Pam. Brick wall *	None	NA	NA	NA	NA	NA	0	35	7,128	12,834	1,735	NA	NA	**21,732**
Pamunkey River	30	Pam. Res.	None	0	0	0	0	0	763	201	3,571	7,035	1,693	0	0	**13,263**
Pamunkey River	18	Pam. Soffin	None	0	0	0	0	0	99	427	1,471	6,169	5,922	60	0	**14,148**
Pamunkey River	6	Pam. John	None	0	0	0	1,677	3,168	950	430	7,846	3,125	10,895	2,656	0	**30,747**
Sum 2014				**0**	**0**	**0**	**1,677**	**3,168**	**1,812**	**8,681**	**96,251**	**123,341**	**39,033**	**2,716**	**0**	**276,679**
Total 2013–2014				**0**	**0**	**0**	**1,677**	**3,168**	**1,812**	**8,681**	**96,632**	**133,251**	**41,384**	**2,716**	**0**	**289,321**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2015	Feb. 2015	Mar. 2015	Apr. 2015	May 2015	June 2015	Jul. 2015	Aug. 2015	Sep. 2015	Oct. 2015	Nov. 2015	Dec. 2015	Total
Pamunkey River	55	Pam. 360	None	0	0	0	0	0	0	11	878	5,652	1707	0	0	**8,248**
Pamunkey River	51	Pam. Top $ *	None	NA	NA	NA	NA	NA	0	71	780	3,017	418	NA	NA	**4,286**
Pamunkey River	50	Pam. Top 1 *	None	NA	NA	NA	NA	NA	0	91	3,140	4,168	678	NA	NA	**8,077**
Pamunkey River	50	Pam. Rootball *	None	NA	NA	NA	NA	NA	0	86	2,304	3,612	710	NA	NA	**6,712**
Pamunkey River	50	Pam. Hickory Tree *	None	NA	NA	NA	NA	NA	0	499	3,407	5,590	797	NA	NA	**10,293**
Pamunkey River	49	Pam. H2O *	None	NA	NA	NA	NA	NA	0	413	2,790	3,935	684	NA	NA	**7,822**
Pamunkey River	49	Pam. Upper William *	None	NA	NA	NA	NA	NA	76	4,173	14,858	5,736	848	NA	NA	**25,691**
Pamunkey River	49	Pam. L. Up William *	None	NA	NA	NA	NA	NA	1,300	1,521	4,430	5,778	1,032	NA	NA	**14,061**
Pamunkey River	45	Pam. Fos. Cliff *	None	NA	NA	NA	NA	NA	472	214	1,795	5,112	893	NA	NA	**8,486**
Pamunkey River	45	Pam. Williams	None	0	0	0	0	0	1,168	387	2,398	7,315	976	0	0	**12,244**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2015	Feb. 2015	Mar. 2015	Apr. 2015	May 2015	June 2015	Jul. 2015	Aug. 2015	Sep. 2015	Oct. 2015	Nov. 2015	Dec. 2015	Total
Pamunkey River	47	Pam. William Lower *	None	NA	NA	NA	NA	NA	316	84	3,361	7,394	1,347	NA	NA	**12,502**
Pamunkey River	46	Pam. L. L. William *	None	NA	NA	NA	NA	NA	34	43	3,141	6,473	583	NA	NA	**10,274**
Pamunkey River	44	Pam. 4.5 *	None	NA	NA	NA	NA	NA	16	165	21,070	25,301	3,781	NA	NA	**50,333**
Pamunkey River	44	Pam. Poles *	None	NA	NA	NA	NA	NA	16	25	23,832	27,803	3,467	NA	NA	**55,143**
Pamunkey River	43	Pam. Brick wall *	None	NA	NA	NA	NA	NA	44	14	3,931	15,980	2,034	NA	NA	**22,003**
Pamunkey River	41	Pam. BBW *	None	NA	NA	NA	NA	NA	42	38	2,645	19,389	1,472	NA	NA	**23,586**
Pamunkey River	30	Pam. Res.	None	0	0	0	0	0	612	786	8,428	8,268	2,418	0	0	**20,512**
Pamunkey River	18	Pam. Soffin	None	0	0	0	0	25	213	1,294	1,569	3,177	4,849	60	0	**11,187**
Pamunkey River	6	Pam. John	None	0	0	0	2,866	36	5,442	7,032	3,135	5,668	15,567	29	0	**39,775**
Sum 2015				**0**	**0**	**0**	**2,866**	**61**	**9,751**	**16,947**	**107,892**	**169,368**	**44,261**	**89**	**0**	**351,235**
Total 2013–2015				**0**	**0**	**0**	**4,543**	**3,229**	**11,563**	**25,628**	**204,524**	**302,619**	**85,645**	**2,805**	**0**	**640,556**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	June 2016	Jul. 2016	Aug. 2016	Sep. 2016	Oct. 2016	Nov. 2016	Dec. 2016	Total
Pamunkey River	60	Pam. 2nd Trestle *	None	NA	NA	NA	NA	NA	0	0	563	2,537	1,624	NA	NA	**4,724**
Pamunkey River	58	Pam. 27 *	None	NA	NA	NA	NA	NA	0	5	737	3,043	1,402	NA	NA	**5,187**
Pamunkey River	57	Pam. Spring Trib. *	None	NA	NA	NA	NA	NA	0	5	500	4,101	1,177	NA	NA	**5,783**
Pamunkey River	53	Pam. Power Lines *	None	NA	NA	NA	NA	NA	16	61	232	3,470	862	NA	NA	**4,641**
Pamunkey River	53	Pam. Shady Hole *	None	NA	NA	NA	NA	NA	9	99	135	1,545	637	NA	NA	**2,425**
Pamunkey River	55	Pam. 360	None	0	0	0	0	0	0	2	18	543	288	0	0	**851**
Pamunkey River	51	Pam. Top $ *	None	NA	NA	NA	NA	NA	5	61	106	3,710	582	NA	NA	**4,464**
Pamunkey River	50	Pam. Top 1 *	None	NA	NA	NA	NA	NA	7	203	299	3,382	363	NA	NA	**4,254**
Pamunkey River	50	Pam. Rootball *	None	NA	NA	NA	NA	NA	10	60	178	2,679	260	NA	NA	**3,187**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	June 2016	Jul. 2016	Aug. 2016	Sep. 2016	Oct. 2016	Nov. 2016	Dec. 2016	Total
Pamunkey River	50	Pam. Hickory Tree *	None	NA	NA	NA	NA	NA	12	744	623	3,643	289	NA	NA	**5,311**
Pamunkey River	49	Pam. H2O *	None	NA	NA	NA	NA	NA	11	861	275	3,144	567	NA	NA	**4,858**
Pamunkey River	49	Pam. Upper William *	None	NA	NA	NA	NA	NA	17	9,342	331	2,922	436	NA	NA	**13,048**
Pamunkey River	49	Pam. L. Up William *	None	NA	NA	NA	NA	NA	14	4,676	480	3,990	616	NA	NA	**9,776**
Pamunkey River	48	Pam. Fos. Cliff *	None	NA	NA	NA	NA	NA	5	82	146	3,238	748	NA	NA	**4,219**
Pamunkey River	47	Pam. Williams	None	0	0	0	0	0	11	115	246	4,674	960	0	0	**6,006**
Pamunkey River	46	Pam. William Lower *	None	NA	NA	NA	NA	NA	10	153	586	8,359	1,246	NA	NA	**10,354**
Pamunkey River	46	Pam. L. L. William *	None	NA	NA	NA	NA	NA	15	22	638	4,736	722	NA	NA	**6,133**
Pamunkey River	45	Pam. 4.5 *	None	NA	NA	NA	NA	NA	40	113	2,783	19,144	2,706	NA	NA	**24,786**
Pamunkey River	44	Pam. Poles *	None	NA	NA	NA	NA	NA	70	78	2,390	22,327	4,056	NA	NA	**28,921**
Pamunkey River	43	Pam. Boathouse *	None	NA	NA	NA	NA	NA	NA	NA	509	8,137	2,301	NA	NA	**10,947**
Pamunkey River	43	Pam. Brick wall *	None	NA	NA	NA	NA	NA	33	74	2,983	17,163	2,465	NA	NA	**22,718**
Pamunkey River	42	Pam. BBW *	None	NA	NA	NA	NA	NA	18	81	771	8,508	2,417	NA	NA	**11,795**
Pamunkey River	40	Pam. Leaning Hickory *	None	NA	NA	NA	NA	NA	NA	NA	20	7,763	2,351	0	NA	**10,134**
Pamunkey River	36	Pam. Duck Blind *	None	NA	NA	NA	NA	NA	NA	NA	238	1,953	496	0	NA	**2,687**
Pamunkey River	30	Pam. Res.	None	0	0	0	0	0	299	268	3,087	5,759	3,096	37	0	**12,546**
Pamunkey River	23	Pam. Glenns *	None	NA	NA	NA	NA	NA	NA	NA	419	18,011	4,333	28	0	**22,791**
Pamunkey River	18	Pam. Soffin	None	0	0	0	0	0	149	952	1,408	1,851	1,270	10	0	**5,640**
Pamunkey River	6	Pam. John	None	0	0	0	52	0	1,787	17,608	3,270	3,511	5,096	54	0	**31,378**
Sum 2016				**0**	**0**	**0**	**52**	**0**	**2,538**	**35,665**	**23,971**	**173,843**	**43,366**	**129**	**0**	**279,564**
Total 2013–2016				**0**	**0**	**0**	**4,595**	**3,229**	**14,101**	**61,293**	**228,495**	**476,462**	**129,011**	**2,934**	**0**	**920,120**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2017	Feb. 2017	Mar. 2017	Apr. 2017	May 2017	Jun. 2017	Jul. 2017	Aug. 2017	Sep. 2017	Oct. 2017	Nov. 2017	Dec. 2017	Total
Pamunkey River	60	Pam. 2nd Trestle *	None	NA	NA	NA	NA	NA	0	0	118	815	245	0	NA	**1,178**
Pamunkey River	58	Pam. 27 *	None	NA	NA	NA	NA	NA	0	0	1,482	6,555	356	0	NA	**8,393**
Pamunkey River	57	Pam. Spring Trib. *	None	NA	NA	NA	NA	NA	0	0	1,801	3,729	659	0	NA	**6,189**
Pamunkey River	53	Pam. Power Lines *	None	NA	NA	NA	NA	NA	0	0	753	5,182	1,097	0	NA	**7,032**
Pamunkey River	53	Pam. Shady Hole *	None	NA	NA	NA	NA	NA	0	0	584	2,910	733	0	NA	**4,227**
Pamunkey River	55	Pam. 360	None	0	0	0	0	0	0	0	117	384	32	0	0	**533**
Pamunkey River	51	Pam. Top $ *	None	NA	NA	NA	NA	NA	0	0	585	4,403	784	0	NA	**5,772**
Pamunkey River	50	Pam. Top 1 *	None	NA	NA	NA	NA	NA	0	24	851	6,982	2,434	0	NA	**10,291**
Pamunkey River	50	Pam. Rootball *	None	NA	NA	NA	NA	NA	0	14	864	5,726	1,723	0	NA	**8,327**
Pamunkey River	50	Pam. Hickory Tree *	None	NA	NA	NA	NA	NA	0	55	1,633	11,193	1,929	0	NA	**14,810**
Pamunkey River	49	Pam. H2O	None	NA	NA	NA	NA	NA	0	67	1,329	9,153	3,251	0	NA	**13,800**
Pamunkey River	49	Pam. Upper William *	None	NA	NA	NA	NA	NA	0	4,989	8,645	12,303	13,951	0	NA	**39,888**
Pamunkey River	49	Pam. L. Up William *	None	NA	NA	NA	NA	NA	0	851	3,081	9,601	5,483	0	NA	**19,016**
Pamunkey River	48	Pam. Fos. Cliff *	None	NA	NA	NA	NA	NA	0	113	1,877	5,591	1,135	0	NA	**8,716**
Pamunkey River	47	Pam. Williams	None	0	0	0	0	0	0	289	3,718	4,166	1,141	0	0	**9,314**
Pamunkey River	46	Pam. William Lower *	None	NA	NA	NA	NA	NA	0	491	6,304	9,222	2,073	0	NA	**18,090**
Pamunkey River	46	Pam. L. L. William *	None	NA	NA	NA	NA	NA	0	61	3,375	5,650	943	0	NA	**10,029**
Pamunkey River	45	Pam. 4.5 *	None	NA	NA	NA	NA	NA	0	24	8,621	19,177	2,510	0	NA	**30,332**
Pamunkey River	44	Pam. Poles *	None	NA	NA	NA	NA	NA	0	30	10,308	25,178	3,447	0	NA	**38,963**
Pamunkey River	43	Pam. Boathouse *	None	NA	NA	NA	NA	NA	0	15	4,110	14,559	2,766	0	NA	**21,450**
Pamunkey River	43	Pam. Brick wall *	None	NA	NA	NA	NA	NA	0	26	6,694	13,167	4,042	0	NA	**23,929**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2017	Feb. 2017	Mar. 2017	Apr. 2017	May 2017	Jun. 2017	Jul. 2017	Aug. 2017	Sep. 2017	Oct. 2017	Nov. 2017	Dec. 2017	Total
Pamunkey River	42	Pam. BBW *	None	NA	NA	NA	NA	NA	0	30	8,056	13,934	3,296	0	NA	**25,316**
Pamunkey River	40	Pam. Leaning Hickory *	None	NA	NA	NA	NA	NA	0	25	4,972	11,991	3,349	0	NA	**20,337**
Pamunkey River	36	Pam. Duck Blind *	None	NA	NA	NA	NA	NA	0	10	899	2,543	652	0	NA	**4,104**
Pamunkey River	30	Pam. Res.	None	0	0	0	0	171	52	367	5,410	4,589	1,792	0	0	**12,381**
Pamunkey River	23	Pam. Glenns *	None	NA	NA	NA	NA	NA	430	635	5,914	6,401	1,075	0	NA	**14,455**
Pamunkey River	18	Pam. Soffin	None	0	0	0	0	262	213	1,183	3,601	2,289	7,550	141	0	**15,239**
Pamunkey River	6	Pam. John	None	0	0	0	0	183	4,677	4,522	1,377	3,459	2,255	18	0	**16,491**
Sum 2017				**0**	**0**	**0**	**0**	**616**	**5,372**	**13,821**	**97,079**	**220,852**	**70,703**	**159**	**0**	**408,602**
Total 2013–2017				**0**	**0**	**0**	**4,595**	**3,845**	**19,473**	**75,114**	**325,574**	**697,314**	**199,714**	**3,093**	**0**	**1,328,722**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2018	Feb. 2018	Mar. 2018	Apr. 2018	May 18	Jun. 2018	Jul. 2018	Aug. 2018	Sep. 2018	Oct. 2018	Nov. 2018	Dec. 2018	Total
Pamunkey River	60	Pam. 2nd Trestle *	None	NA	NA	NA	NA	NA	0	60	1,050	2,521	1,013	0	NA	**4,644**
Pamunkey River		Pam. 31 *	None	NA	NA	NA	NA	NA	0	28	333	639	221	0	NA	**1,221**
Pamunkey River	58	Pam. 27 *	None	NA	NA	NA	NA	NA	0	85	839	2,192	1,097	0	NA	**4,213**
Pamunkey River	57	Pam. Spring Trib. *	None	NA	NA	NA	NA	NA	0	144	1,745	2,665	1,110	0	NA	**5,664**
Pamunkey River	53	Pam. Power Lines *	None	NA	NA	NA	NA	NA	0	89	432	3,264	1,331	0	NA	**5,116**
Pamunkey River	53	Pam. Shady Hole *	None	NA	NA	NA	NA	NA	0	40	272	1,072	457	0	NA	**1,841**
Pamunkey River	55	Pam. 360	None	0	0	0	0	0	0	21	43	195	102	0	0	**361**
Pamunkey River	51	Pam. Top $ *	None	NA	NA	NA	NA	NA	0	618	428	1,869	539	0	NA	**3,454**
Pamunkey River	50	Pam. Top 1 *	None	NA	NA	NA	NA	NA	0	125	575	2,418	791	0	NA	**3,909**
Pamunkey River	50	Pam. Rootball *	None	NA	NA	NA	NA	NA	0	102	566	1,906	613	0	NA	**3,187**
Pamunkey River	50	Pam. Hickory Tree *	None	NA	NA	NA	NA	NA	0	165	633	2,641	689	0	NA	**4,128**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2018	Feb. 2018	Mar. 2018	Apr. 2018	May 18	Jun. 2018	Jul. 2018	Aug. 2018	Sep. 2018	Oct. 2018	Nov. 2018	Dec. 2018	Total
Pamunkey River	49	Pam. H2O *	None	NA	NA	NA	NA	NA	0	157	549	2,031	671	0	NA	**3,408**
Pamunkey River	49	Pam. Upper William *	None	NA	NA	NA	NA	NA	0	5,983	791	1,847	227	0	NA	**8,848**
Pamunkey River	49	Pam. L. Up William *	None	NA	NA	NA	NA	NA	9	717	1,069	2,369	564	0	NA	**4,728**
Pamunkey River	48	Pam. Fos. Cliff *	None	NA	NA	NA	NA	NA	13	126	956	2,177	1,042	0	NA	**4,314**
Pamunkey River	47	Pam. Williams	None	0	0	0	0	0	27	194	1,735	5,668	1,345	0	0	**8,969**
Pamunkey River	46	Pam. William Lower *	None	NA	NA	NA	NA	NA	9	851	1,718	5,504	1,470	0	NA	**9,552**
Pamunkey River	46	Pam. L. L. William *	None	NA	NA	NA	NA	NA	16	382	1,096	3,715	869	0	NA	**6,078**
Pamunkey River	45	Pam 4.5 *	None	NA	NA	NA	NA	NA	22	684	3,295	8,536	810	0	NA	**13,347**
Pamunkey River	44	Pam. Poles *	None	NA	NA	NA	NA	NA	63	1,539	5,654	0	0	0	NA	**7,256**
Pamunkey River	43	Pam. Boathouse *	None	NA	NA	NA	NA	NA	3	622	6,757	12,412	1,207	0	NA	**21,001**
Pamunkey River	43	Pam. Brick wall *	None	NA	NA	NA	NA	NA	12	1,127	10,914	15,818	2,017	0	NA	**29,888**
Pamunkey River	42	Pam. BBW *	None	NA	NA	NA	NA	NA	11	935	5,992	13,729	2,365	0	NA	**23,032**
Pamunkey River	40	Pam. Leaning Hickory *	None	NA	NA	NA	NA	NA	13	931	7,200	14,894	2,446	0	0	**25,484**
Pamunkey River	36	Pam. Duck Blind *	None	NA	NA	NA	NA	NA	11	254	1,709	2,706	910	0	NA	**5,590**
Pamunkey River	30	Pam. Res.	None	0	0	0	0	208	344	1,378	5,466	4,697	1,212	0	0	**13,305**
Pamunkey River	23	Pam. Glenns *	None	NA	NA	NA	NA	NA	43	609	6,768	6,730	2,645	25	NA	**16,820**
Pamunkey River	18	Pam. Soffin	None	0	0	0	0	240	174	141	2,312	2,932	1,903	5	0	**7,707**
Pamunkey River	6	Pam. John	None	0	0	0	0	55	478	3,985	2,331	2,061	1,978	126	198	**11,212**
Sum 2018				**0**	**0**	**0**	**0**	**503**	**1,248**	**22,092**	**73,228**	**129,208**	**31,644**	**156**	**198**	**258,277**
Total 2013–2018				**0**	**0**	**0**	**4,595**	**4,348**	**20,721**	**97,206**	**398,802**	**826,522**	**231,358**	**3,249**	**198**	**1,586,999**

3.5.1.1. Spawning Behavior

Based on netting and tracking data, adults of both sexes can occupy the Pamunkey spawning grounds from early August through the end of October. Upon arrival adult Atlantic sturgeon generally congregate near the oligohaline freshwater interface prior to committing to freshwater inhabitation. The first fish to arrive in fresh waters exhibit reduced movements which may be due to higher water temperatures.

Behavior and habitat selection during spawning is sexually divergent. Though the sex of the first adult sturgeon to arrive varies annually, males consistently arrive prior to suitable spawning conditions and once males enter freshwater they rarely descend back downriver to higher salinities. As the season progresses males begin to move rapidly up and down the river, patrolling large, overlapping ranges or territories that encompass numerous potential spawning sites. In some cases, such sites may be 20 river miles apart. Males presumably become highly mobile and engage in these rapid movements between diverse spawning grounds in order to locate receptive females. While males arrive in mass prior to suitable spawning conditions, female arrivals are more dispersed as if timed by a personal clock. Distinct differences in female behavior upon arrival appear to be correlated with the suitablity of the enviromental conditions within the spawning grounds with respect to spawning. Females that arrive prior to optimal conditions generally make an initial upriver run that may have two apexes and then return downriver to reside or stage in lower freshwater regions and/or the upriver extent of the oligohaline zone (**Figure 1**). In rare cases, some females descend all the way back downriver into the middle oligohaline before returning upriver to freshwater. But in a given year, if females arrive later in the season when conditions in the freshwater regions are or have already been condusive to spawning, then they rarely drop back out of freshwater once they enter it. Once commited to fresh water, females make several upriver runs with apexes culminating in various suitable habitats with the last most often being the farthest upstream. It is very rare that a female will not return downriver at all but will go straight to the upriver spawning grounds and remain there for the duration of her residence but it has happened when conditons make extreme upriver spawning habitats preferred.

Females most often quickly exit the system's spawning grounds after their last farthest upriver run. However, in some cases, this rapid descent downriver from their apex run is followed by several lesser upriver runs prior exiting the system. These lesser runs often culminate in locations that the same female visited on minor upriver runs prior to her apex run. Often these downriver suitable spawning locations are where other females either showed occupation preferences as well or culminated their apex runs.

In a very few cases, a female has been captured twice in a season—once prior to spawning and once during or post-spawning. Except for these rare cases, it is difficult to determine exactly when spawning occurred unless the fish is actively expelling eggs upon capture. Most often females exit the spawning grounds quickly after a definitive run upriver. However, a few females have occupied the spawning grounds and detection patterns suggest that spawning may not have occurred at all. In other cases females have actually been recaptured late in the season still filled with eggs. Females that exhibit these detection patterns, including those that have been recaptured, always return and exhibit normal spawning runs the following year. The fact that these fish do not return the year after making these normal runs, or sometimes even for consecutive years following, supports the assertion that successful spawning occurred on return.

In 2014, the only tracking data on female fish were the result of three females carrying tags implanted in 2014. Recent tagging may have affected spawning behavior (**Figure 12**) but these are the best available data on females for 2014. Tracks of these fish in 2014 suggested that spawning was occurring in mid-September between RM 43 and 48 when water temperatures were between 20 and 23.5°C (**Table 4; Appendix 8.1**). In 2015, the number of females tagged was expanded (n = 8), as was our knowledge of other spawning ground locations. Females 13588 and 12753 tagged in 2014 both returned to spawn in 2015. 12753 primarily occupied the river section between RM 43 and 47, a region similar to that which she occupied in 2014 (**Appendix 8.1**). Only one female tagged in 2015 remained below RM 48 throughout the spawning season (**Figure 13**); most culminated runs much farther upriver than recorded in 2014, with numerous runs terminated between RM 50 and 55 (**Appendix 8.1**). Three individual runs extended even farther upriver, with apexes between RM 57 and 60. Residency in this section was short for two out of three females, but unusually extended (19 August–12 September 2015) for the first one to arrive (21098). Run times for the other two females spawning in the RM 57–60 region overlapped temporally and spatially. Returning female 13588 was one of these two. Males (n = 5) were already on the upriver grounds when 13588 arrived (13 September 2015) and two tagged males remained when the second female (12734) arrived (16 September 2015). Following their 2- to 3-day occupation of this upriver region, both females quickly dropped downriver into the oligohaline zone of the Pamunkey where they remained for several weeks prior to proceeding down into the York River.

In 2016, we added five more stations extending to RM 60 (**Table 4**) in the upper Pamunkey River to improve upriver tracking capabilities after female (21098) made a run in 2015 and resided above the last upriver receiver site (RM 55) for the duration of her spawning season (**Appendix 8.1**). Additionally, we tagged nine new females in 2016 and two tagged in 2014 returned—12758 for the first time and 12753 for the third consecutive year. In 2016, female 12753 made runs between RM 43 and 47 as she had in the prior two years. These runs, as well as others, support the hypothesis that numerous spawning grounds are located between RM 43 and 60, with runs most often culminating in the RM 43–48 and 51–58 regions (**Figure 14; Appendix 8.1**). The fact this female returned three years in a row suggests that some females likely spawn every year or can at a least spawn in consecutive years. Two of the females tagged in 2016 were not detected leaving the river. In fact, detections ceased below the Reservation receiver site (PAM Res; **Appendix 8.1**). These females were tagged on the same day and detections from both ceased within hours of each other. It is unclear what happened to these fish and/or tags but poaching is suspected.

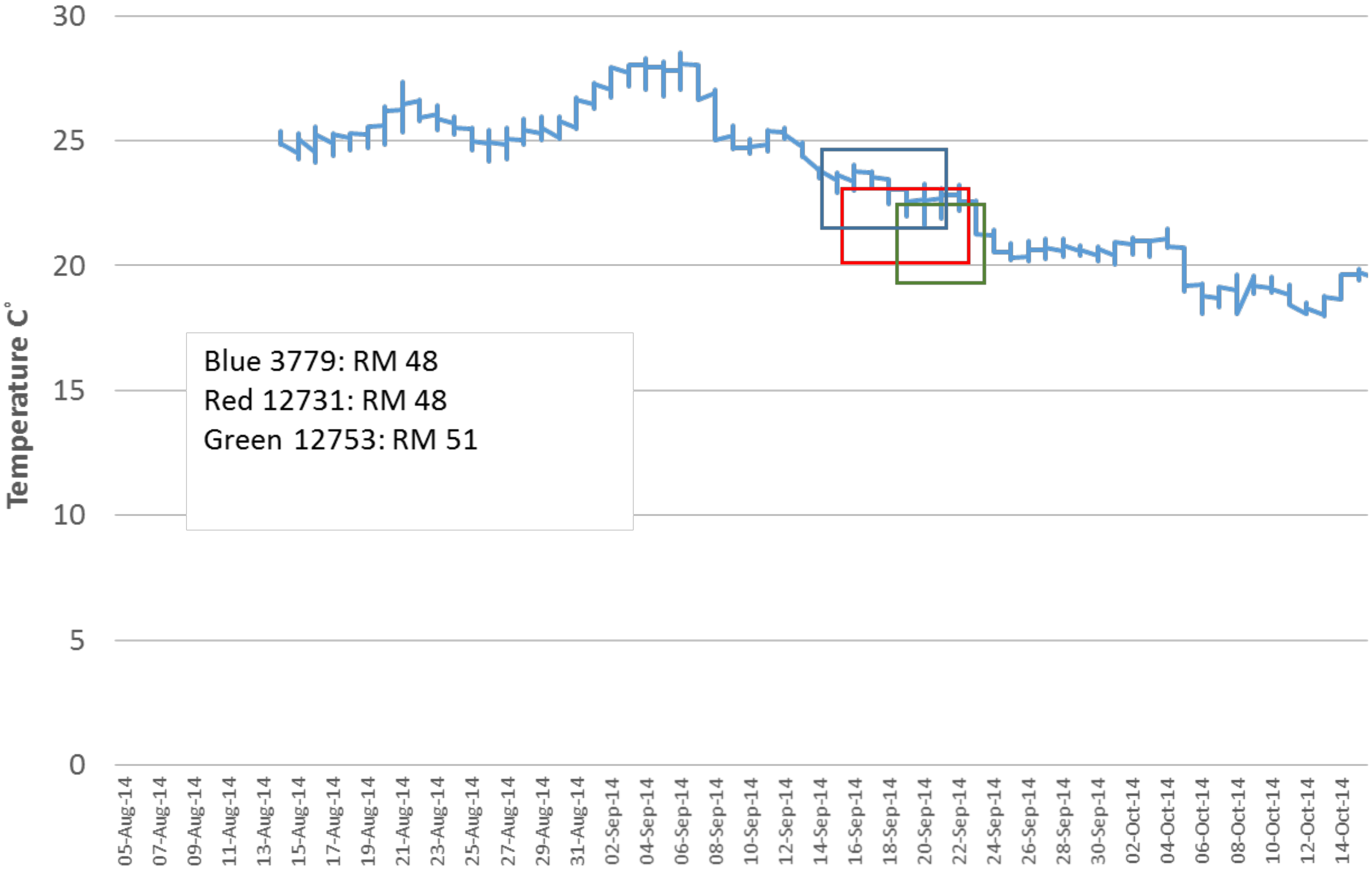

Figure 12. Female Atlantic sturgeon spawning runs vs. temperature in the Pamunkey River from 14 to 24 September 2014. Each colored box shows the timing of an individual female's upriver run—left side = ascending, right = descending. The upriver extents of each spawning run are shown by the RMs in the key.

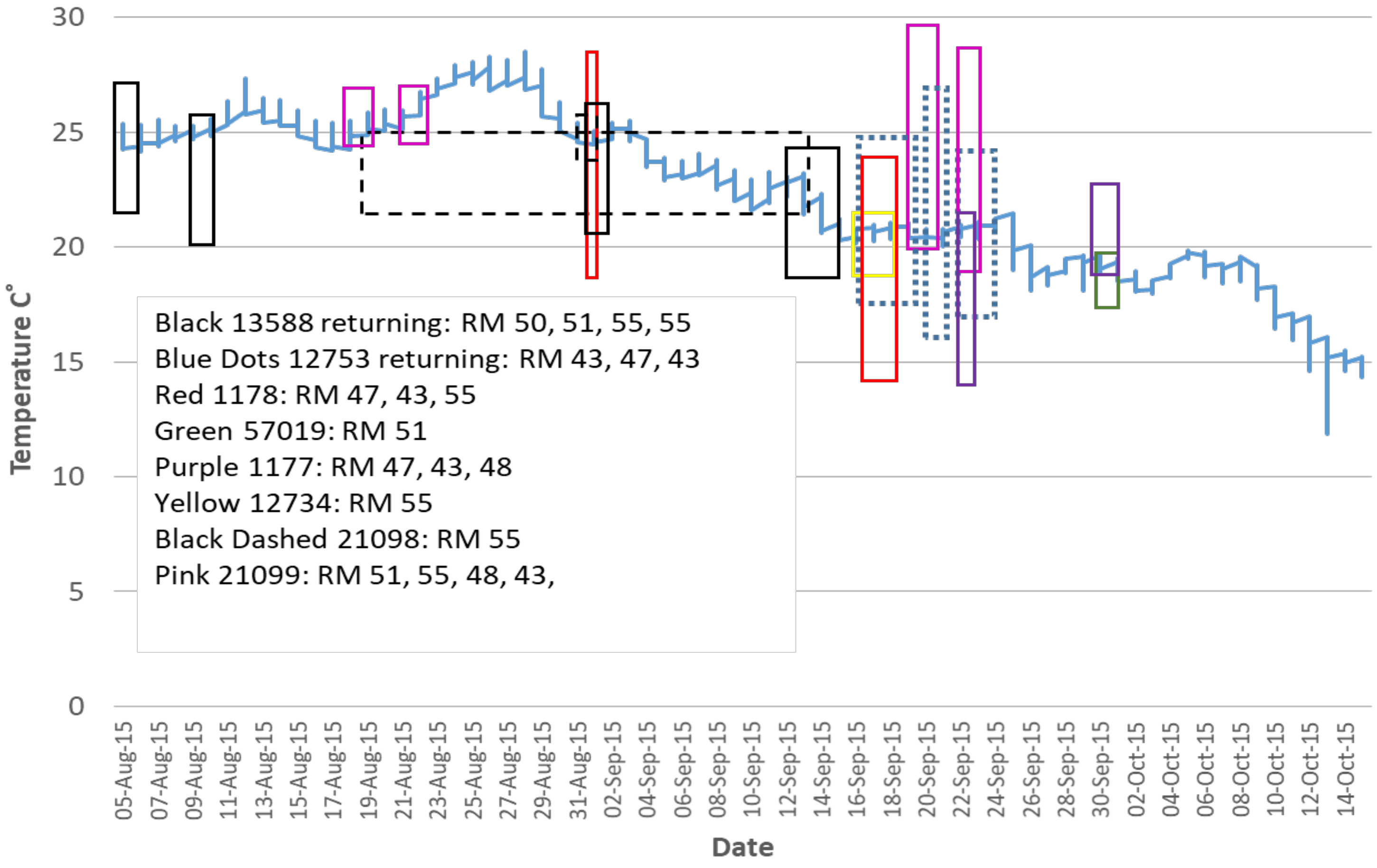

Figure 13. Female Atlantic sturgeon spawning runs vs. temperature in the Pamunkey River from 5 August to 1 October 2015. 13588 and 12753 tagged in 2014 returned to spawn. Each colored box shows the timing of an individual female's upriver run—left side = ascending, right = descending. If more than one box appears, that female made more than one definitive upriver run. The upriver extents of each spawning run are shown by the RMs in the key.

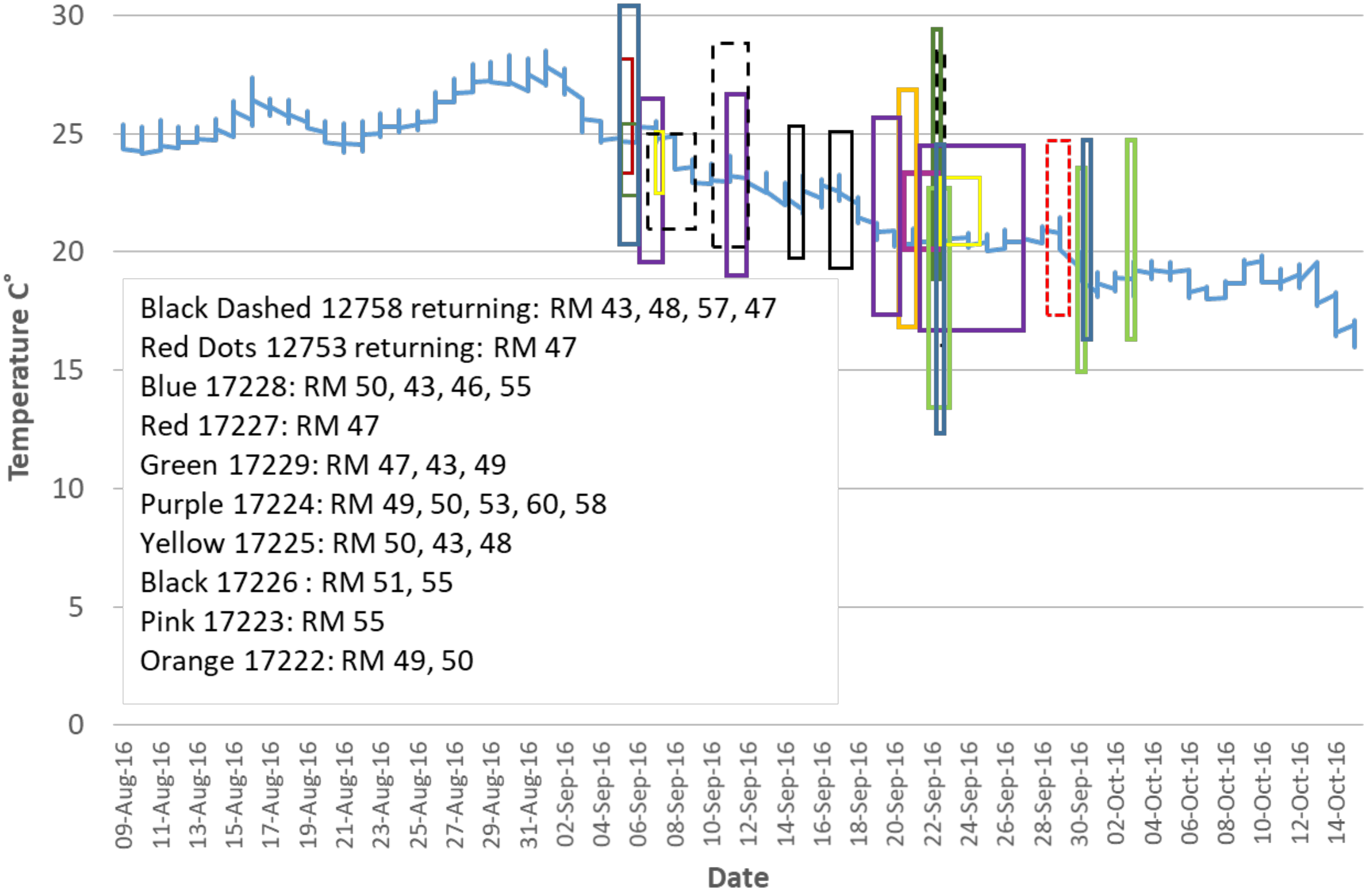

Figure 14. Female Atlantic sturgeon spawning runs vs. temperature in the Pamunkey River from 5 September to 2 October 2016. Females 12758 and 12753 tagged in 2014 returned to spawn. Each colored box shows the timing of an individual female's upriver run—left side = ascending, right = descending. If more than one box appears, that female made more than one definitive upriver run. The upriver extents of each spawning run are shown by the RMs in the key.

In 2017, female 21098, tagged in 2015, returned to the Pamunkey. Female 12734, also tagged in 2015, returned to the Mattaponi River. The fact that 12734 never entered the Pamunkey in 2017 but engaged in typical upriver spawning runs in the Mattaponi, where she concurrently inhabited many suitable spawning sites with numerous tagged males, supports the assertion that fall spawning is occurring in the Mattaponi River. Female 21098 is the fish that remained above the last receiver in the Pamunkey array (RM 55; **Appendix 8.1**) in 2015. Although the timing of her immigration and emigration in 2017 was similar to that which occurred in 2015, her occupancy pattern was dramatically different. Instead of making an extreme upriver run of long duration, she appears to have used spawning grounds farther downriver. She made two significant upriver runs onto these suitable habitats, one culminating at RM 43 and the second at RM 48 (**Figure 15**). She made these runs in mid- and late August. After the second and farthest upriver run she exited the freshwater portion of the river and resided within the oligohaline zone for several weeks before exiting the river. Thirteen new females were also tagged in 2017 not including 13588 and 1177, which were retagged due to the expiration of the batteries in their previous tags. Five females made only downriver runs after tagging which may suggest that they did not spawn in 2017. Conversely, because these fish did not return in 2018 this may suggest that they spawned in 2017 in sites located below RM 47 (the tagging location; **Appendix 8.1**). Detections of the other 8 of the 13 newly tagged fish supports the hypothesis that spawning was occurring in downriver locations in 2017, a behavior not prevalent since 2014. VIMS established two receiver sites far upriver in the Pamunkey in 2017; one approximately at RM 75 and another at approximately RM 95. These were added in order to establish an upriver boundary to the region considered potential Atlantic sturgeon spawning grounds. Two males visited the RM 75 site in 2017 and no fish were detected at RM 95.

In 2018, we added another upriver station at RM 64 (Pam 31) to compliment the upriver sites added by VIMS in 2017. The Pam 31 site was the farthest upriver that we could travel to by boat at the time. There were 10 returning females in 2018; none of these were tagged in 2017. Since returning females provide by far the best data on natural behavior and spawning habitat selection only returning fish were graphed in 2018 (**Figure 16**). All spawning runs occurred when water temperatures were between 21.5 and 25.5º C, the same temperature range in which we obtained actively spawning females. Female runs in 2018 culminated farther upriver than usual between RM 43 and RM 95. Female 17224, which occupied our farthest upriver site (Pam 30) during her last spawning run in 2016, was the only female to visit the VIMS station at RM 95. Nineteen other fish were recorded at this exteme upriver site; 16 were male and three were of unknown sex.

Examining detection data from the farthest upriver sites monitored provides greater insight into how unusual this extreme upriver migration was. Data were only examined from 2014 through 2018 to include fish only in years after tagging in order to eliminate the potential that tagging in the same year may affect the distance of subsequent spawning runs. It is also assumed that recapture in the same year of tracking did not affect upriver run distance. The Pam 360 site at river mile 55 was the farthest upriver receiver deployed throughout the study and thus provides the only continuous data. The percent of tags detected at the Pam 360 (RM 55) out of the total number of tags in the river in a given year varied considerably over time. In 2014, 89 percent were present, 38 percent in 2015, 79 percent in 2016, 75 percent in 2017 and 85 percent in

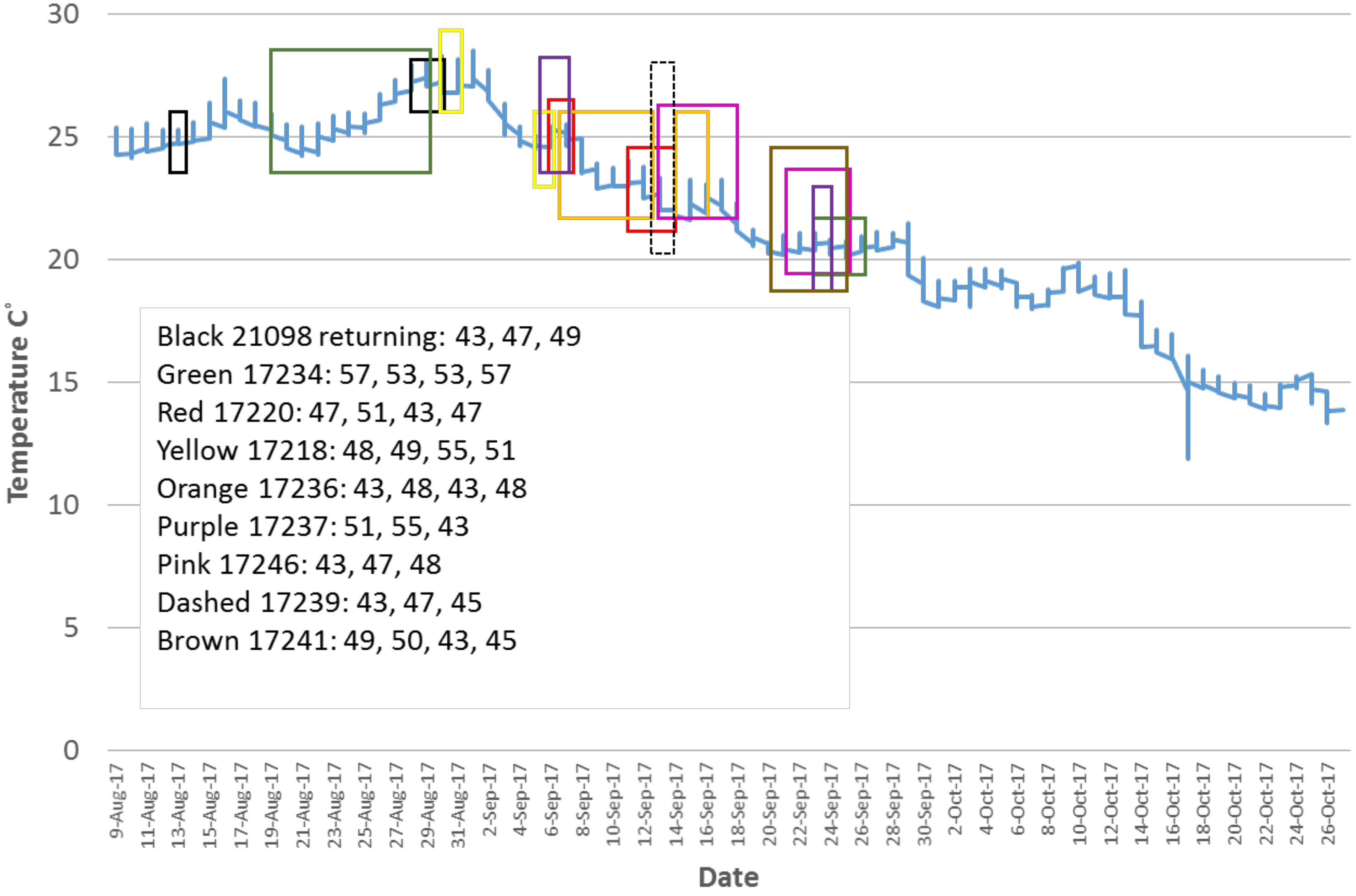

Figure 15. Female Atlantic sturgeon spawning runs vs. temperature in the Pamunkey River from 12 August to 10 October 2017. Female 21098 tagged in 2015 returned to spawn. Each colored box shows the timing of an individual female's upriver run—left side = ascending, right = descending. If more than one box appears, that female made more than one definitive upriver run. The upriver extents of each spawning run are shown by the RMs in the key.

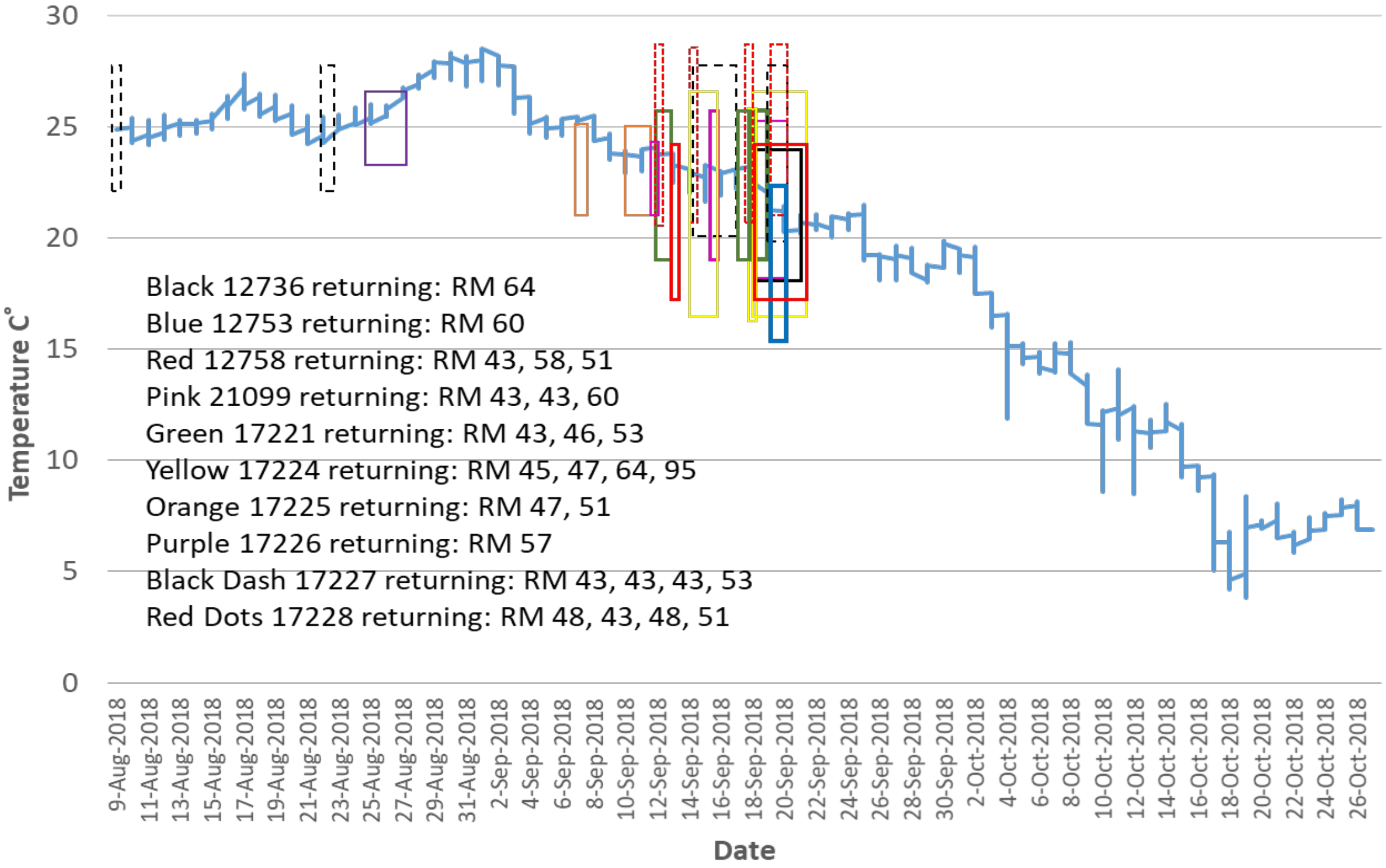

Figure 16. Female Atlantic sturgeon spawning runs vs. temperature in the Pamunkey River from 9 August to 22 September in 2018. Each colored box shows the timing of an individual female's upriver run—left side = ascending, right = descending. If more than one box appears, that female made more than one definitive upriver run. The upriver extents of each spawning run are shown by the RMs in the key.

2018. The receiver at the second trestle (60 RM) site was deployed in 2016. The percentage of fish detected at the second trestle was 75 percent in 2016, 63 percent in 2017 and 79 percent in 2018. Although the extreme upriver sites placed by VIMS did not exist prior to 2017, no fish were detected this far upriver in 2017. However, in 2018, 56 percent of returning fish were detected at VIMS extreme upriver sites.

The temperatures at which Atlantic sturgeon spawn have been well documented and appear to vary by natal system. Bain et al. (2000) and Scott and Crossman (1973) determined that coastal Atlantic sturgeon spawn between 13 and 26°C based on all the research done across various spawning populations. All Pamunkey River females made upriver runs when temperatures at the collection site within the middle section of spawning grounds were between 19 and 27°C in every year (**Figures 12, 13, 14, 15, and 16**) but it should be noted that water temperatures on the upriver spawning grounds are generally at least a degree cooler than at the collection site (**Appendix 8.3**). Graphic comparison between annual female spawning runs versus river temperature indicates that periods of increased spawning activity coincide with the 21.5˚C to 25.5˚C range of water temperatures at which we captured females in mid-spawn (i.e., half full and/or expelling eggs).

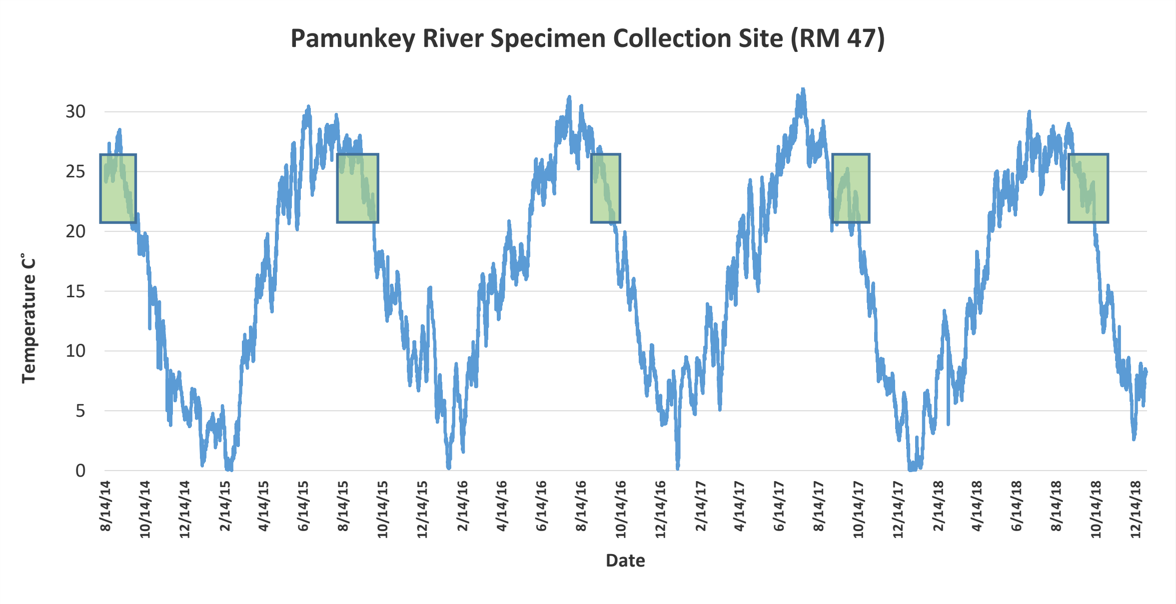

Figure 17. Water temperatures recorded from 2014 to 2018 within the lower spawning grounds (RM 47; Appendix 8.1) at the Pamunkey River specimen collection site. The green-shaded areas denote suitable spawning temperatures determined by the range of temperatures (21.5 to 25.5°C) at which egg bearing females were collected. The figure indicates that the temporal extent of suitable spawning temperatures varies annually.

From 2013 through 2018, we obtained 11 females that were in mid-spawn and/or were actively extruding eggs when water temperatures were between 21.5 and 25.5°C. **Figure 17** above clearly shows that the period over which these suitable temperatures persist varies annualy. If the species spawning is as closely tied to temperature as larval development has been shown to be (Smith et al. 1980, Mohler 2003) climate change could drastically effect the suitability of habitats for Atlantic sturgeon propogation as well as the amount of time for larval growth and thus survival.

Inter-annual differences in the length of the spawning season were evidenced by the timing of female runs in 2015–2018. In 2015, females made runs from 5 August to 1 October at which time hurricane-associated flooding forced fish out of the upper Pamunkey River. The summer of 2016 was hot and female runs started later, occurring from 5 September to 2 October. Upriver runs were of short duration and the apexes of female runs were less dispersed spatially. In contrast, 2017 was a mild summer followed by a cool fall, and runs occurred over an elongated period of time (12 August to 25 September) in comparison to those in 2016. Female runs were extended spatially as well in 2017. Runs in 2018 occurred over a similar time frame as 2017 (9 August to 22 September) but a larger percentage of fish runs culminated farther upriver.

Inter-annually, alterations in summer water temperatures and flow rates appear to affect not only the duration of spawning but the spatial extent across which suitable spawning conditions occur. Similar inter-annual alterations in spawning habitat selection that appeared to be tied to water temperature were also evidenced in the James River (Hager 2011). In cooler summers, favorable spawning conditions can occur as early as late August and extend into October (**Figure 15**). In 2015, 2017, and 2018, two peaks in spawning activity are evident: one in mid- to late August and one in mid- to late September. In 2015, female upriver runs occurred across a greater diversity of spawning sites/RMs and over a longer period of time (**Figure 13**). In 2017, no late-season storms occurred, and summer and fall were mild (**Figure 15**). Consequently, suitable spawning conditions were expanded. Females made numerous runs with apexes in August, and two more in September. The locations of peak female runs were well dispersed across numerous spawning habitats. Specimen-collection data showed that both sexes remained in the spawning grounds well into late October. In fact, an egg-bearing female was collected on 10 October, later in the season than had ever been recorded (**Table 1**). 2018 was an extremely wet year and numerous releases from Lake Anna occurred, resulting in higher water levels and faster current conditions in upriver habitats than had been previously recorded during the spawning season. Fish traveled farther upriver than previously recorded (**Figure 16**), thus the extent of spawning grounds was expanded due to increased river flow and water levels. Presumably, these attributes made more habitats available and suitable. 2016 was the warmest year of the six. Fish began the late spring/early summer by immigrating into the Pamunkey River system as normal. But as temperatures continued to climb, most dropped out of the system and subsequently spent an extended period of time in the lower York. Some exited the system altogether, returning to the bay. One female moved into the mouth of the James River and did not move up the York River again until water temperatures declined later in the summer. August runs were completely curtailed (**Figure 14**). Consequently, although runs were extended into the early fall, the temporal extent of runs was shortened (5 September to 2 October). When fish ascended to cooler upper-river spawning grounds (RM 50–60; **Appendix 8.1**) they did so more rapidly and did not undertake as many extreme upriver downriver runs during the spawning period.

Extreme meteorological events such as northeasters and/or hurricanes can deliver torrential rains that alter the timing and extent of the spawning season. Such an event ended the spawning season on 1 October 2015 and caused extensive flooding. Short-term flooding dispersed fish and resulted in mass, rapid emigration downriver. In 2015, several adults that were unable to make it downriver quickly enough were washed into flooded agricultural fields and stranded in low-lying ditches and ponds when flood waters receded. 2018 was an extremely wet year, but flash flooding did not occur. Instead, greater-than-average rainfall in both spring and summer increased flow rates and water levels in a more consistent manner. Large releases of water from Lake Anna maintained greater flow rates throughout the spawning season; a period generally characterized by low rainfall and concurrent increases in water withdrawal by the numerous large water pumps located throughout the river. Interestingly, most Atlantic sturgeon responded to these conditions by ascending the river to spawning grounds located much farther upriver than we had previously recorded being used.

3.5.1.2. Female Behavior Comparisons: Inter-annual versus Post-tagging

We have tagged adults during their spawning runs in the Pamunkey River since 2013 (**Table 1**). Due to the extreme mobility of males, it is difficult to examine their behavior to determine if tagging has had any impact. Numerous females have dropped out of the spawning grounds descending as far as the middle oligohaline zone after tagging. It was feared that this behavior was related to tagging and could negatively impact spawning effort in the tagging year. However, until numerous females with tags are tracked in years following the tagging procedure, one cannot discern what behavior patterns are normal.

Fifteen females have been detected returning to the Pamunkey River spawning grounds following tagging, some returning numerous times, and two have returned to the Mattaponi River in years after tagging. Therefore it is possible for us to compare detection results between years to determine if tagging has been altering female behavior and/or residence longevity during the year of tagging. This approach is important because numerous researchers have suggested that tagging and holding time can affect behavior (Winter 1983, Sutton and Benson 2003, Musick and Hager 2007) and successful spawning is critical to species recovery.

Female 13588 was full of eggs when tagged on 25 September 2014, relatively late in the spawing season. Tagging occurred several days after a large downriver run of fish was recorded, and she did not make a subsequent upriver run in 2014 nor did she descend far down river after tagging. Instead, she spent three days after tagging in a freshwater region only slightly downriver of the tagging site, a site that was heavily used by females during subsequent spawning seasons.13588 returned in 2015, providing our first series of detections without potential tagging bias. She entered the bay early in 2015, transited the mouth from the east to the west, and resided in the NSN zone for several weeks in early summer before entering the York River. She entered the Pamunkey River spawning grounds in early August and made three runs into freshwater prior to being captured full of eggs on 2 September 2015, on her third downriver run of the year. At this time, she was not expressing eggs but temperatures at the capture site (**Figure 17**) were not yet optimal for spawning. After capture without holding or tagging, she continued downriver but never left freshwater. She occupied the lower river spawning grounds (RM 43) that she had selected in 2014 until making her farthest (above RM 55) and final upriver run in mid-September (**Appendix 8.1**). She exited the York River in mid-October, skipping all bay receivers until detected offshore during the third week of November. 13588 thus offers no detection evidence that tagging altered her behavior.

Atlantic sturgeon 12753 has returned three times (2015, 2016, and 2018) since she was tagged in 2014. She thus offers numerous behavioral comparisons. After receiving her tag on 15 September 2014 she proceeded downriver but again never left freshwater. Interestingly, she stopped at the same region (RM 43) preferred by 13588 in 2014 (**Appendix 8.1**). She made two definitive runs upriver following tagging, one of short duration that ended at the collection site (RM 47) four days after tagging and her last of several days duration which extended to RM 51. She left the river after this run. In 2015, she made her first upriver run to RM 47 on 19 September, followed by another on 20 September. She was recaptured on 21 September still gravid. Upon release she made a short run upriver to RM 48 and then descended downriver to RM 43 again. She made her final run of 2015 back to RM 47 the next day and began her exit the following. When 12753 returned in 2016 she was not recaptured but her behavior pattern and regional preferences (RM 43-48) mimic those exhibited in 2014 and 2015. 12753 was not recaptured in 2018 either, and here early occupation pattern exhibits a similar regional preference for the lower freshwater sites. Like other spawners in 2018, she demonstrated her farthest upriver run to date, culminating near RM 60. Sturgeon 12753 thus offers no evidence that tagging significantly altered behavior or time spent on freshwater spawning gounds.

Fish 12736 was tagged on 8 September 2014 and returned in 2016 and 2018. After tagging in 2014, she descended from RM 47 to RM 43 (**Appendix 8.1**) a day later, where both females previously discussed (13588 and 12753) resided for a considerable amount of time in 2014. She remained in this region, although not always onsite, through the third week in September when other females were making upriver runs (**Figure 12**). The fact that she did not return until 2016 may suggest she successfully spawned in 2014 in this region. In early March 2016, she was detected on the eastern side of the bay and was in the York River by late June. 12736 arrived before most male sturgeon and made runs up and down the York River from mid-June until mid-July. A pattern similar to 13588 immigration in 2015. The York River was unusually warm late into mid-summer of 2016. As temperatures continued to rise in late July, 12736 demonstrated unprecedented behavior by ceasing upriver progress while in the middle York River and returning to the lower bay where she resided in the Baltimore Channel into late August. In early September, she crossed the bay and entered the James River but in contrast to the more extended early summer residence of 13588 in the NSN zone the year before, 12736 occupied the zone for less than a day compared to weeks. Fish 12736 ascended the York the following day and entered the Mattaponi. She ascended to the Mattaponi potential spawning reaches in early September and remained there, making what resembled spawning runs in the Mattaponi from 6 to 29 September. Once she entered the Mattaponi's freshwater regions she did not exit them until her runs were over. In 2018, 12736 like 12753 showed a similar preference for lower river sites that during a normal year would have been oligohaline. 12736 like 12753 also made a definitive spawning run much farther upriver than usual in 2018. She rapidly ascended the river from RM 43 on 16 September to above our last station in RM 64 (**Appendix 8.1**). She remained undetected, presumably above RM 64, from 19 to 22 September, when she was detected returning downriver. She exited the freshwater Pamunkey less than 24 hours later. 12736 was not captured in 2016 or 2018. Though its behavior patterns mimic those seen by other fish, including occupation of certain regions and shifts in habitat use motivated by temperature and salinity alterations, this female also offers no evidence that tagging altered behavior or habitat selection.

Female 12758 was tagged on 17 September 2014 and returned in 2016 and 2018. In 2014, after tagging she descended down river but remained within freshwater until October. When she entered the bay in 2016 she did so undetected and was recorded in the York River in late June.

Unlike many fish that staged in the lower York or left the river (like 12736) during the heat of summer (July), 12758 only spent a week transitioning between the York River salinity zones in June and rapidly entered the lower Pamunkey's oligohaline zone in early July. She apparently found suitable refuge in the Pamunkey River because she remained in the oligohaline and freshwater regions of the river until early September, when she moved onto the spawning grounds. During the next three days, she made two runs into known lower (RM 43) and mid-river (RM 48) spawning sites followed by a run into the farthest upriver receiver sites (RM 58–60; **Appendix 8.1**). She remained within this upriver section from 10 through 12 September before a rapid descent to the RM 36 region near the freshwater interface. Four days later, she made two more runs back into lower river spawning grounds (RM 43) on consecutive days followed by another descent to RM 36. On her next upriver run on 22 September, she was recaptured by our crew. Instead of descending back to her favored RM 36, she remained within the lower river spawning grounds and made another minor run to RM 43-47 on 23 September, after which she begin her downriver emigration. In the York River, her emigration was uncharacteristically short and marked by no lower York River detections. In 2018, 12758 spent 8 days within the spawning grounds from 13 to 21 September. Her run in 2018, like other females in the same year, was very short in duration and extended much farther upriver than is typical. She was not recaptured in 2018, but as in 2016, after ascending to RM 43 twice in she dropped back much farther downriver than normal into the same RM 36 section she had retreated to in 2016. Two days later she moved back upriver into the RM 43 region again. She remained here for two days before undertaking her farthest upriver run to RM 57. Her residence on these far upriver grounds was less than a day. She began her downriver run on 20 September, making it to RM 49 before returning upriver to RM 51 for several hours. This was followed by an exit to the river's lowest freshwater station (Pam Res., RM 30; **Appendix 8.1**) in the next 9 hours. 12758 went downriver after tagging in 2014 but remained within freshwaters unitl October. She consistently made extreme downriver runs and showed preference for these regions whether she was captured in a year or not. Thus, she offers no data suggesting that tagging influenced her behavior or prefference for lower river habitats since her detections suggests this behavior is typical for this fish.

Female 21098 was tagged on 17 August 2015. Following tagging, she immediately ascended to our farthest upriver receiver site in 2015 located at RM 55 (Pam 360; **Appendix 8.1**). She remained above this receiver or between it and RM 51 from 21 August until 13 September, at which point she rapidly exited the spawning grounds. She returned in 2017 and entered the bay in April, remaining in the mouth of the bay, primarily the Baltimore Channel, until late June. She spent a week transitioning between the York poly- and mesohaline zones and arrived at the oligohaline interface four days later (4 August). She made a run to RM 42 from RM 18 in the oligohaline zone in early August and another from the same extreme downriver location to RM 43 in mid-August. She returned to the oligohaline zone and made a final run to RM 48 in late August (**Appendix 8.1**). She was recaptured on this run on 28 August 2017. She did not return to the oligohaline on release but remained in the lower-river spawning region (RM 43) for several days before slowly exiting the Pamunkey over the next month, spending considerable time in the oligohaline and upper mesohaline zones before rapidly exiting the York in three days. 21098 did not retreat downriver when tagged initially in 2015 nor did she retreat downriver in 2017 when retagged.

Female 12734, tagged in the Pamunkey on 14 September 2015, ascended upriver immediately after tagging. She was located above our farthest upriver station (RM 55) or between it and our second farthest (RM 51) from 15 through 18 September. She returned in 2017 and holds the record as the earliest adult female detected running the York River (Y wat; **Appendix 8.1**) in late April. She exited the middle York River undetected and was detecteed twice again at the Y wat station in mid-May and early June. Again she dropped back downriver and was not detected again until mid-August when she rapidly ascended the York, arriving at the mouth of the Mattaponi the same day (10 August). She moved upriver to the oligohaline interface in the Mattaponi River over the next five days and resided in this region for a week, making numerous runs into the lower freshwater reaches. She made four upriver runs between 29 August and 5 September 2017 into RM 30–35, which contain suitable spawning conditions, and spent considerable time in the RM 35 (Mike's Branch) and RM 33 (Jensen) sites on each run, where suitable hard bottom is located (**Appendix 8.1**). After her last run on 6 September, she exited the river on 10 September. She remained in the York River for an extremely long duration (10 September to 11 December), spending a considerable time (11 to 25 October) at and near RM 7 (Y Wat), and uncharacteristically even moved back upriver to RM 25 (Y20) in the upper mesohaline as late as 8 November. When she left the river on 11 December, she moved rapidly into and out of the bay being picked up on TS5, TS7, and BOEM 9 (in Atlantic Ocean 15 miles south of the mouth of the bay) all in the same day (13 December).

The theory that tagging and/or handling somehow alters the behavior of spawning adult female Altlantic sturgeon is not supported by our detection data. Individual sturgeon consistently show similar behavior through habitat selection and/or exhibit behaviors and habitat selections that are typical of other females in the same year. Leading us to to believe that behaviors witnessed after tagging are more motivated by environmental parameters or personal prefence than stress due to handling and/or surgery.

3.5.1.3. Return Rates

Nine of the 13 adults tagged in 2013 returned in 2014, but because one tag failed after several days, the true return rate was 75 percent. In 2015, 11 of the 12 adult males tagged in 2013 returned. Although two of the V13 tags implanted in 2013 had stopped working, we positively identified these fish on recapture because of PIT tags. Of the 34 adults tagged in 2014, 18 returned in 2015, including one female. Our total return for the 2013 and 2014 fish in 2015 was therefore 29 out of 46 possible fish. In 2016, 9 of the 10 active 2013 tags, 14 of the 30 active 2014 tags, and none of the 7 female fish tagged in 2015 returned. In 2017, all 10 active tags from 2013 and a female with dead tag 13589 returned. She was retagged with tag 17250. Nineteen of the 30 active 2014 tags, two of the 7 females tagged in 2015 returned, and 3 of the five fish collected in the Mattaponi in 2016 returned in 2017. All three immigrated into the Mattaponi and all were males. In 2018, 11 of the 12 active tags from 2013 returned. One tag (27843) died while within the array and thus its movements were not included in migration analysis because the fish's emigration could not be detected. Eighteen of the 34 fish tagged in 2014 returned in 2018. Again, one 2015 tag (12754) stopped working while in the array so this fish was also excluded from the 2018 portion of migration analysis. Only one of the 7 females tagged in 2015 returned in 2018 (21099). All 7 of the females with working tags that left the Pamunkey River in 2016 returned in 2018, and two of the three males tagged in the Mattaponi in 2016 joined them. No female fish tagged in 2017 returned in 2018, but the only male

(13589/17250) retagged in 2017 did. Based on our current data and including the year of capture in calculations, males return on average every 1.14 years with a range of 1–2 years, and females return every 1.65 years with a range of 1–2 years. However, because this result was calculated before we knew fish were returning to potentially spawn in other bay tributaries, the true return rate may be even more frequent because these fish were not included in the formula.

3.5.1.4. Migration Paths

To determine if patterns were discernable, the detection sequences of 136 adult Atlantic sturgeon were examined during immigration and emigration in years following their tagging (**Table 5**) from 2014 to 2018. All fish tracked were collected in the Pamunkey or Mattaponi rivers while on spawing runs from 2013 to 2016. Although most fish returned to the York River system, all fish carrying tags that migrated up bay to the Rappahannock River and Maryland rivers were included. Numerous other Atlantic sturgeon, predominantly females, implanted with transmitters temporarily occupied the mouth of the bay, including the Baltimore and Thimble Shoals channels, in the spring and fall as well, but these were excluded from analysis (**Table 5**) because they did not make runs into tributaries.

Based upon the past six years of data, 72 percent of immigrating Pamunkey River adults used the Baltimore Channel (**Figure 5; Appendix 8.1**) during their immigration run to the spawning grounds; 47 percent used it exclusively. Thirty-six percent of the adults were detected in the Thimble Shoals Channel (**Figure 5; Appendix 8.1**) with 10 percent of individuals using it exclusively. The cumulative number of detections recorded in the Baltimore Channel (26,842) originating from adult fish collected while spawning in the Pamunkey was more than an order of magnitude larger than that recorded in the Thimble Shoals (2,095). Comparisons between the total numbers of detections of adult sturgeon exclusively using each channel also reveal an order of magnitude difference between Baltimore Channel (5,298) and Thimble Shoals Channel (109). Twenty-six percent of immigrating adults were detected in both the Baltimore and Thimble Shoals Channels and 7 percent used unknown pathways into the Chesapeake Bay.

If we look at detections from a regional perspective, we find that 49 percent immigrated into the bay on the eastern side only, whereas 11 percent used the western side exclusively. As was the case when examining channel data alone, a considerable percentage of fish resided within the mouth of the bay upon immigration for long enough and were mobile enough to be detected on both the eastern and western sides of the bay. The percentage of fish that occupied both the western and eastern side of the bay during immigration varied from 22 to 44 percent. In a small number of cases, this lateral movement at the mouth of the bay resulted in Pamunkey River fish entering the mouth of the James River for short periods of time during early summer immigration.

Table 5. The immigration and emigration pathways and genetic orgin of adult Atlantic sturgeon tagged in the Pamunkey River from 2013 to 2018. Tag numbers of females are followed by F, males by M, and unknown by ?. Receiver station location is followed by the numerical month of detections and the number of detections (underlined) in parenthesis. When bolded river names appear, it indicates a fish immigrated into a river other than the Pamunkey River. In some cases this immigration was prior to entering the Pamunkey. Not applicable (NA) indicates the fish did not undertake a spawning run or that it occurred in the year of tagging. Unknown indicates migration occurred but the fish was not detected. Abbreviations for receiver locations are: TS=Thimble Shoals Channel; B=Baltimore Channel; CBBT=Chesapeake Bay Bridge Tunnel, and E=Eastern Shore. Gray shading alternates for easier interpretation. For geographical locations see Appendix 8.1 and 8.2.

Tag number & Genetic Origin	2014 immigration	2014 emigration	2015 immigration	2015 emigration	2016 immigration	2016 emigration	2017 immigration	2017 emigration	2018 immigration	2018 emigration
Tagged in 2013										
9001-27836M York	B(5-6, 95), CBBT3 (6,3), TS(4,6, 69)	CBBT2 (10, 23), B(10, 48)	B(7, 17)	B(10, 2)	B(4-6, 56)	E(10,1)	B(4,6, 14), CBBT2(4, 14), E(4, 2)	B(10, 24)	B(6,48)	NA
9001-27837? York	NA	NA	B(4-5, 7) CBBT3(4-5, 12), TS(4, 5)	unknown	B(6, 1), TS(6,16)	B(10,8), TS(10,10)	B(3,2), CBBT2(3,1), CBBT3(5,1), TS(4, 22)	CBBT7(10,6)	**Mattaponi River 8, Pamunkey 9-10:** B(4,6,7,48), CBBT4(7,7), TS(7,225)	B(10,8)
9001-27838M York	NA	NA	E(4,3), CBBT4(4,11), CBBT5(4,23), CBBT7(4,1), TS(4,1)	unknown	B(5-6, 802) CBBT3(6,1)	unknown	**Mattaponi River (7-10)**	unknown	E(4,1), CBBT3(6,2), TS(6,10), CBBT2(7,2)	CBBT3(11,8)
9001-27839M York	B(6,14), TS(6,8)	unknown	**Rappahannock River (4), Pamunkey River (6-10):** TS(4, 8)	unknown	unknown	CBBT2(11,30)	CBBT4(4,63), CBBT5(4,75)	B(11,1)	TS(4,1), CBBT2(4,3), B(4,3)	E(11,1)

Tag number & Genetic Origin	2014 immigration	2014 emigration	2015 immigration	2015 emigration	2016 immigration	2016 emigration	2017 immigration	2017 emigration	2018 immigration	2018 emigration
Tagged in 2013 (continued)										
9001-27840? York	NA	NA	B(4,2)	unknown	NA	NA	**Rappahannock River(6), Pamunkey River (7-10):** B(3,4), TS(6,105)	unknown	CBBT2(4,4), B(4,3), CBBT3(4,2), TS(6,5), B(7,66)	unknown
9001-27842? York	B(5-6,17), CBBT3(5,3)	B(11,21)	**Rappahannock River(8-10):** B(4,8) CBBT3(5,6)	**Rappahannock River(8-10):** TS(10,74), CBBT3(10,7) B(11,78)	TS(4,30)	CBBT3(10,3)	unknown	B(10,6)	B(6,36)	unknown
9001-27843M York	B(4-5,6)	B(10,24) E(11,5)	CBBT3(4,9), TS(4,7)	B(11,12)	CBBT4(3,6)	CBBT3(11,8), TS(11,3)	B(3,5-6, 82), CBBT2(5,1), CBBT5(6,5), E(6,1), TS(5-6,51)	TS(11,2)	NA	NA
9001-27844M York	B(4,21)	B(10,33)	B(4,5)	B(10,27)	B(4-5,14), CBBT2(4,41), CBBT3(5,6), CBBT7(4,18)	B(10-11,39), CBBT3(10,2), TS(11,32)	B(4,13)	B(10,21) E(11,10)	unknown	B(11,7), CBBT3(11,3)
9001-27846M York	B(6-7,100), E(4,7), CBBT2(4,7)	B(11,56)	B(4,5-6,88), TS(6,18), CBBT3(5-6,21), CBBT4(6,4)	B(11,8)	**Mattaponi River(7-10):** B(4,1), CBBT3 (4,7)	B(11,3)	B(6,86)	unknown	B(6,288)	B(11,7)
9001-27847M York	unknown	unknown	CBBT3(4,1)	E(10,1)	B(4,6,11), CBBT3(6,4)	CBBT7(11,6), B(11,4), E(11,1)	CBBT3(5,20)	unknown	TS(6,6), CBBT3(6,8), B(6,14)	CBBT7(12,1), E(12,1)
9002-13587M York	unknown	unknown	dead tag	dead tag	dead tag	dead tag	dead tag	dead tag	dead tag	dead tag
9002-13589/17250M York	B(6-8, 31)	unknown	dead tag	dead tag	dead tag	dead tag	retagged in 2017	NA	TS(4,6), B(6-7,625)	B(12,16), TS(12,15)

Tag number & Genetic Origin	2014 immigration	2014 emigration	2015 immigration	2015 emigration	2016 immigration	2016 emigration	2017 immigration	2017 emigration	2018 immigration	2018 emigration
Tagged in 2014										
1601-7698M York	NA	NA	dead tag	dead tag	dead tag	dead tag	dead tag	dead tag	dead tag	dead tag
9001-27841M York	NA	NA	CBBT2(4, 10), E(4-5,8), B(6-7, 38)	CBBT1(9,4)	B(6,33), CBBT2(6,15), CBBT3(6,13)	unknown	B(5-6,26), CBBT2(6,1)	E(10,1), CBBT7(10,1)	CBBT2(4,19), B(5-7,64)	unknown
9002-13588/17240F York	NA	NA	CBBT5(3,8)	B(12,32)	**Nanticoke MD(9/23-10/7):** B(6,4), TS(8,4)	unknown	retagged in 2017	NA	James River mid 9-mid 10: (no fresh)	NA
9002-12730M York	NA	NA	NA	NA	CBBT4(4,4)	B(12,31)	CBBT4(4,13)	B(12,4)	TS(4,26)	TS(11,38)
9002-12732? York	NA	**NA**	**Nanticoke River MD (5-6) Pamunkey River (9)**: unknown	B(11,19)	**Mattaponi (9) Pamunkey rivers (9-10):** B(4-6,104), CBBT2(5,11), TS(6,20)	unknown	**Rappahannock (8), Pamunkey rivers (9-10)**: E(4,1), CBBT7(4,2)	unknown	**Mattaponi River (9-10):** B(4,21), CBBT3(4,3), B(5-6,67)	B(11,11)
9002-12733? York	NA	NA	NA	NA	**Mattaponi River (8-10):** B(4,1), CBBT3(4,11)	E(11,4)	NA	NA	NA	NA
9002-12736F York	NA	NA	NA	NA	**Mattaponi River(9):** B(4,8,180)	B(11,79), TS(11,23)	NA	NA	B(4,5), B(6-7,127)	B(11,56)
9002-12737M York	NA	NA	E(4,8)	E (10,16)	CBBT4(4,3), TS(4,5)	unknown	TS(3,3)	CBBT7(10-11,17)	NA	NA

Tag number & Genetic Origin	2014 immigration	2014 emigration	2015 immigration	2015 emigration	2016 immigration	2016 emigration	2017 immigration	2017 emigration	2018 immigration	2018 emigration
Tagged in 2014 (continued)										
9002-12738M James	NA	NA	NA	NA	**James River** (into fresh,9):B(6,16) CBBT4(5-6,105), CBBT5(5-8,815), TS(3,6-8,360)	TS(11,17), B(12,9)	**Pamunkey** (Jons,9) then **James rivers** (below fresh,9):B(6,25) CBBT5(8,5) TS(2,6-8,711)	CBBT2(11,7) E(11,17)	NA	NA
9002-12739M Albemarle, N.C.	NA	NA	TS(6,30), B(6-7,9), CBBT3(6,1)	TS(10,68)	**Piankatank(9) and Rappahannock Rivers (9-10)**: B(4-8,56),E(5,4), CBBT2(5,9), CBBT3(5-6,14) TS(5-6,8,26), CBBT4(8,4)	B(10,41)	E(4,17), B(6,8,48) CBBT1&2(4,25) CBBT3(7-8,39), CBBT5(7,1), TS(5-8,112)	unknown	B(7,80), CBBT3(7,11), TS(7,12), B(8,20), TS(8,8), CBBT3(8,7), TS(8,60)	B(10,3)
9002-12740M York	NA	NA	B(6,2)	unknown	B(4,6,16)	unknown	B(4,6,16) CBBT2(4,107)	unknown	B(4,8), CBBT3(5,8), B(6,67)	unknown
9002-12741M York	NA	NA	TS(4,9), B(5,9), E (5,9), CBBT1(5,3), CBBT7(5,4)	unknown	CBBT2(4,87)	CBBT7(11,18), E(11,3)	CBBT7(5,3), E(5,4)	E(10,1)	CBBT2(4,18), B(4,16), CBBT1(4,7)	unknown
9002-12742M York	NA	NA	E(5,3)	unknown	CBBT2(4,75)	E(11,1)	B(4,12), CBBT3(4,30)	B(11,235), CBBT3(11,1), CBBT2(12,10), CBBT7(12,6), E(12,2)	E(5,2)	unknown

Tag number & Genetic Origin	2014 immigration	2014 emigration	2015 immigration	2015 emigration	2016 immigration	2016 emigration	2017 immigration	2017 emigration	2018 immigration	2018 emigration
Tagged in 2014 (continued)										
9002-12743M York	NA	NA	**Pocomoke MD (8-9):** B(6,9) CBBT3(6,8)	unknown	**Rappahannock River(9-10)**: CBBT2(4,4), B(4,6,2)	CBBT7(11,4) CBBT2(12,10)	**Mattaponi River (8-10)**:B(4,6,42), CBBT2(3-4,17), CBBT3(3,4), CBBT7(4,2)	CBBT3(11,1)	E(4,9), CBBT7(4,3), B(6-7,87)	unknown
9002-12744? York	NA	NA	**Rappahannock (end 8) Nanticoke & Marshyhope rivers MD(9)**: B(5-8, 9999), TS(6,8,64)	CBBT2(10,4), B(10,59)	**Mattaponi River(8-10)**: CBBT2(5,38), B (6-8,2516), TS(7-8,71)	CBBT3(10,6), CBBT7(10,3), B(10,1), E(10,3)	NA	NA	**Mattaponi River (9-10):** CBBT2(5,70), B(5-6,977), TS(6,6), B(7,263), TS(7,3), B(8,2)	unknown
9002-12745M York	NA	NA	CBBT1(5,2)	B(11,84)	NA	NA	NA	NA	tag dead on recapture 9/12/18	NA
9002-12746M York	NA	NA	TS(4,8,44), B(6,8,9)	B(11,51)	NA	NA	CBBBT3(3,7) CBBT4(3,6) TS(3,1)	TS(11,20)	TS(4,2)	CBBT7(11,3)
9002-12747M York	NA	NA	B(4-6,19) CBBT1(4,2) CBBT2(4,27) CBBT3(4,13)	E(10,6)	B(4-7,90)	B(10,12)	**Mattaponi River (8-10)**: B(4-6,81), CBBT7(4,1), TS(6,131)	B(10,25) CBBT2(10,1)	CBBT2(4,52)	unknown
9002-12748M Mixture	NA	NA	CBBT3(4,12), B(6-7,52)	unknown	CBBT1 (3,1), CBBT2(3,5,18), CBBT3(3,3), B(5-6,45), TS(3,5,25) E(3,3)	CBBT3(10, 10)	CBBT2(3,11), B(3-4,6,21)	CBBT7(10-11,6), E(11,1)	TS(4,16), CBBT4(4,10), LC(4,21), B(5,41)	unknown
9002-12749? York	NA	NA	NA	NA	NA	NA	B(5,2), CBBT2(5,22)	B(10,13)	NA	NA

Tag number & Genetic Origin	2014 immigration	2014 emigration	2015 immigration	2015 emigration	2016 immigration	2016 emigration	2017 immigration	2017 emigration	2018 immigration	2018 emigration
Tagged in 2014 (continued)										
9002-12750? York	NA	NA	NA	NA	B(7,7), CBBT3(7,12)	CBBT2(10,4), CBBT7(10,6), B(10,7), E(10,2)	NA	NA	NA	NA
9002-12751M York	NA	NA	E(5,2), B(6-7,173), TS(7,22)	B(11,32)	B(6-7,74)	B(11,44)	NA	NA	NA	NA
9002-12752? York	NA	NA	NA	NA	NA	NA	**Mattaponi River (8-10)**: CBBT3(3-4,29),TS(3,4)	CBBT3(10,6)	NA	NA
9002-12753F York	NA	NA	E(4,1), B(6-8,232), CBBT1(4,7), CBBT2(4,38), CBBT3(4,9)	E(10,1)	E(4-5,4), B(5,7-8,31)	CBBT7(10,1), B(11,37)	NA	NA	E(4,3), b(5-7,2741), CBBT3(6,28), TS(6,2)	unknown
9002-12754M York	NA	NA	B(5-6,181)	CBBT3(12,4)	B(6,23)	B(12,3)	E(4,3), CBBT3(5,6), B(6-7,32)	unknown	NA	NA
9002-12755M York	NA	NA	NA	NA	NA	NA	NA	NA	tag dead on recapture 9/12/18	NA
9002-12756M York	NA	NA	B(5-7,95), CBBT7(4,1), TS(7,370)	B(10,5)	NA	NA	CBBT2(4,4), B(5,7,44), CBBT3(7,30), TS(7,8)	TS(11,13)	NA	NA
9002-12757M York	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9002-12758F York	NA	NA	NA	NA	unknown	B(11,40)	NA	NA	TS(4,3), CBBT3(4,16), B(5-6,231), TS(6,2)	B(10,4)

Tag number & Genetic Origin	2014 immigration	2014 emigration	2015 immigration	2015 emigration	2016 immigration	2016 emigration	2017 immigration	2017 emigration	2018 immigration	2018 emigration
Tagged in 2014 (continued)										
9001-12759M York	NA	NA	CBBT2(4,5), B(6-8,68)	unknown	B(8,15)	unknown	unknown	E(10,2)	**Mattaponi River (8-10):** B(4,2), CBBT1(4,3), B(6,81)	unknown
Tagged in 2015										
9001-21098F York	NA	NA	NA	NA	NA	NA	E(4,3), CBBT2(4,47) B(4,6,127) CBBT3(4,6,82), CBBT7(4,1)	retagged 8/28/17; unknown	NA	NA
9001-21099F York	NA	NA	NA	NA	NA	NA	NA	NA	CBBT2(5,9), CBBT1(5,5), CBBT3(6,18), B(6,18)	B(10,2), CBBT2(10,1)
1601-57019F York	NA	NA	NA	Tag life expired	NA	NA	NA	NA	NA	NA
9002-12734F York	NA	NA	NA	NA	NA	NA	**Rappahannock River (4), Mattaponi River(8-9)**: CBBT4(3,12), TS1(3,1)	TS(12,2)	NA	NA
9004-1177/17245F York	NA	NA	NA	Tag life expired	NA	NA	retagged in 2017	NA	NA	NA
9004-1178F York	NA	NA	NA	Tag life expired	NA	NA	NA	NA	NA	NA

Tag number & Genetic Origin	2014 immigration	2014 emigration	2015 immigration	2015 emigration	2016 immigration	2016 emigration	2017 immigration	2017 emigration	2018 immigration	2018 emigration
Tagged in Mattaponi in 2016										
9001-17230F York	NA	NA	NA	NA	NA	Tag lost in Mattaponi	NA	NA	NA	NA
9001-17231M York	NA	NA	NA	NA	NA	NA	**Mattaponi River (9)**: CBBT3(5,31), B(5-6,173)	TS(10-11,66), CBBT4(10,3), CBBT5(10,250), B(11,16), CBBT3(11,11)	**James FRiver (10):** no fresh	unknown
9001-17232M York	NA	NA	NA	NA	NA	NA	**Pamunkey River (7-10)**: unknown	B(11,27)	**Pamunkey River:** CBBT2(4,12)	unknown
9001-17233M not available	NA	NA	NA	NA	NA	NA	**Mattaponi River (7-10)**: B(4,19)	TS(11,45), E(11,13), B(11,18)	**Pamunkey River:** B(4,4), CBBT3(4,106)	B(12,2), CBBT2(12,18)
Tagged in Pamunkey in 2016										
9001-17221F York	NA	NA	NA	NA	NA	NA	NA	NA	CBBT3(4,11), B(4,28), CBBT2(4,13)	B(10,109)
9001-17222F York	NA	NA	NA	NA	NA	reject/poaching at res?	NA	NA	NA	NA
9001-17223F York	NA	NA	NA	NA	NA	reject/poaching at res?	NA	NA	NA	NA
9001-17224F York	NA	NA	NA	NA	NA	NA	NA	NA	CBBT2(5,2), B(5-7,700)	E(10,2)
9001-17225F York	NA	NA	NA	NA	NA	NA	NA	NA	B(4,27), B(6,47), TS(7,13)	unknown

Tag number & Genetic Origin	2014 immigration	2014 emigration	2015 immigration	2015 emigration	2016 immigration	2016 emigration	2017 immigration	2017 emigration	2018 immigration	2018 emigration
Tagged in 2016 (continued)										
9001-17226F York	NA	NA	NA	NA	NA	NA	NA	NA	E(6,6), B(6,269), CBBT3(6,4), TS(6,2), TS(7,3), B(7,1)	B(10,52)
9001-17227F York	NA	NA	NA	NA	NA	NA	NA	NA	TS(4,11), CBBT2(6,7)	**mouth of James** (11,26), CBBT5(11,7)
9001-17228F York	NA	NA	NA	NA	NA	NA	NA	NA	E(4,3), CBBT7(4,2), B(6-7,2251), TS(6-7,30), LC2(7,3), CBBT4(8,2), CBBT5(8,4), LC2(8,24)	B(10,12)
9001-17229F York	NA	NA	NA	NA	NA	NA	NA	NA	**Mattaponi River (9-10):** CBBT4(5,7), LC1(5,3), B(6,9), B(9,5)	LC2(10,2), CBBT5(11,2)
Tagged in 2017										
9001-17218F York	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9001-17219F York	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9001-17220F York	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Tag number & Genetic Origin	2014 immigration	2014 emigration	2015 immigration	2015 emigration	2016 immigration	2016 emigration	2017 immigration	2017 emigration	2018 immigration	2018 emigration
Tagged in 2017 (Continued)										
9001-17234F York	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9001-17236F York	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9001-17237F York	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9001-17238F Albemarle, N.C.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9001-17239F York	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9001-17241F York	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9001-17243F York	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9001-17246F York	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9001-17247F York	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Differences in 2014–2018 detection data during migration periods suggest that adult Atlantic sturgeon of a given reproducing stock behave differently during immigration and emigration with regard to migration pathways and duration of residence in the lower bay. During immigration, 72 percent of Pamunkey River adults were detected in the Baltimore Channel. Only 36 percent were detected in this channel during emigration. If fish were opting to use the Thimble Shoals Channel as an alternative route, a reduction in the use of the Baltimore Channel would be easily explainable. However, fewer fish were detected exiting through the Thimble Shoals (12 percent) than were detected during immigration (36 percent) as well. Total detections within the Baltimore Channel during emigration remained one order of magnitude larger during emigration (1,639 vs. 473) as did comparison between detections recorded from adults that exclusively occupied each channel (1,377 vs. 146).

A regional perspective suggests that, although fish may not be occupying the deep water channels as frequently during emigration, they are still exiting the bay predominantly on the eastern side (52 percent) versus the western side (7 percent), and that fish immigrating and emigrating through the eastern side of the bay are roughly equal (49 percent vs. 52 percent). The increased number of fish detected exclusively in the Baltimore Channel during migrations (n = 113) compared to the Thimble Shoals (n = 20) supports this assertion. The consistently larger number of fish that escape detection during emigration is also remarkable. Only 9 immigrating fish (7 percent) escaped detection versus 43 emigrating fish (32 percent). Over six years 32 percent of immigrating fish resided within the mouth of the bay long enough during immigration to be detected on both the eastern and western sides of the bay. Such lateral movements were only detected 6 percent of the time during emigration. In addition, no emigrating fish entered the mouths of any other bay or tributary or entered the bay and returned upriver as many fish where repeatedly recorded doing during immigration.

Migratory Pamunkey River fish were present in the lower Chesapeake Bay array from March to early September, with new fish arriving from March through July. Most immigration into the lower bay occurs in June, which is the time when a few Pamunkey adults have resided within the lower James River, where the short polyhaline zone of the river and the NSN zone are located. Most Pamunkey adults enter the York River mouth or polyhaline zone from late May through early August and move upriver to the freshwater tributaries in late summer/early fall. In a small number of cases, adults of both sexes moved rapidly into the lower oligohaline section of the Pamunkey, arriving as early as the end of May. Most often, however, adults linger in the York River mesohaline zone. From here they make repetitive runs upriver into lower-salinity waters with each run extending farther upriver. Often they reside in the upper mesohaline and lower oligohaline zone prior to taking up residence in tidal freshwater for the spawning season. Regardless of immigration approach, no adults have been detected residing in the Pamunkey freshwater spawning grounds until late June.

Once males reach freshwater they reside within it for the spawning season. Females make initial runs onto the spawning grounds but often drop back off these grounds to reside in the lower freshwater reaches or even the upper oligohaline zone of the river. After a series of upriver runs culminating in river stretches known to contain suitable spawning habitats, females exit the spawning regions. Often, these runs culminate with the farthest upriver run by females, but some make a few shorter runs over suitable substrate following this apex run. Final runs are followed by a rapid exit to higher salinity waters downriver regardless of their extent. Females may exit the spawning reaches from late August until late October. Males have been observed leaving the Pamunkey as early as the last week of September but most remain into mid- to late October.

Emigration appears to be motivated by cooling water temperatures in the upper Pamunkey River. However, severe flooding in early October due to late-season hurricanes can quickly end suitable spawning conditions and result in rapid downriver movements. Residence within the York River during emigration can be as short as a week or as long as two months. Emigrating adult males and any females that remain into the latest period of spawning usually pass the Coleman Bridge receiver near the mouth of the York River (upper polyhaline zone; **Appendix 8.1**) in October but can exit as early as the end of September. A very few have been recorded remaining until early December. Because of mild fall temperatures, adults remained on the spawning grounds into late October 2017. Consequently, some did not leave the Pamunkey oligohaline region until early November and the lower river (upper polyhaline) where the NW/Ch. zone is located until late November/early December. The within-river emigration period can be similar to immigration in that it is characterized by a series of up- and down-river movements and extended periods of time spent resting/staging in the lower mesohaline and upper polyhaline zones; or it can be extremely rapid and last less than a week. Generally, female fish exit the river, entering the bay, more quickly than males. Most often emigration is a continuation of their downriver run following their last spawning effort. Thus, the timing of each fish's emigration run is primarily dependent upon their completion of their individual spawning effort. In contrast, males remain on the spawning grounds as long as an opportunity to spawn exists. Very few males have been detected emigrating into the bay as early as late September. Most arrive in middle October or November. In rare cases, when females remain on the spawning grounds late into the spawning season, they exit the York River system much more slowly than is typical. It is unclear why female emigration behavior varies in this pattern.

3.5.2. Mattaponi River Region

The Mattaponi and Pamunkey rivers converge to form the York River at West Point (**Figure 1**). Therefore, it is logical that the most common tagging origin of fish detected in the Mattaponi is the Pamunkey River (**Table 6**). Four adults were obtained in 2016 Mattaponi tagging efforts and all but a large female who appears to have lost her tag in 2016 during potential spawning activities returned to the Mattaponi in 2017. A fish worth noting again is 26350, tagged in the Nanticoke system on the Maryland Eastern Shore. This fish has made spawning runs in either the Pamunkey or Mattaponi rivers every year since being tagged in 2014 and to date is the only fish tagged in another system to run in both of these York River tributaries.

Table 6. Tagging origin of Atlantic sturgeon detected within the Mattaponi River annually from 2013 to 2018. VIMS fish are again presented as a separate column in the table below due to a lack of important specimen and tagging information crucial to interpreting detection relevance.

Year	Pamunkey	Mattaponi	Maryland	James	VIMS	Northeast	Total
2013	0	0	0	0	0	0	0
2014	0	0	0	0	1	0	1
2015	6	0	0	0	2	0	8
2016	7	4	1	0	5	1	18
2017	9	3	0	0	2	0	14
2018	5	0	1	0	1	1	8

Adults are present from April through late October in the Mattaponi River (**Figure 18, Table 7**). In early years of monitoring, most Pamunkey River fish did not enter the Mattaponi freshwater regions but only entered the lower oligohaline section of the river near West Point. Adults that will subsequently ascend one of these tributaries often barely enter into the lower oligohaline section of the other tributary, and it is not uncommon for some of these fish to re-enter that tributary during emigration; although residence is generally more extended during immigration. Recent data indicate that a subset of fish, males and females tagged in the Pamunkey and/or Mattaponi rivers, freely alternates between these systems, periodically spending the entire spawning season in either. While some males have done so, it is uncommon for a fish to enter freshwater zones of both rivers in a single year.

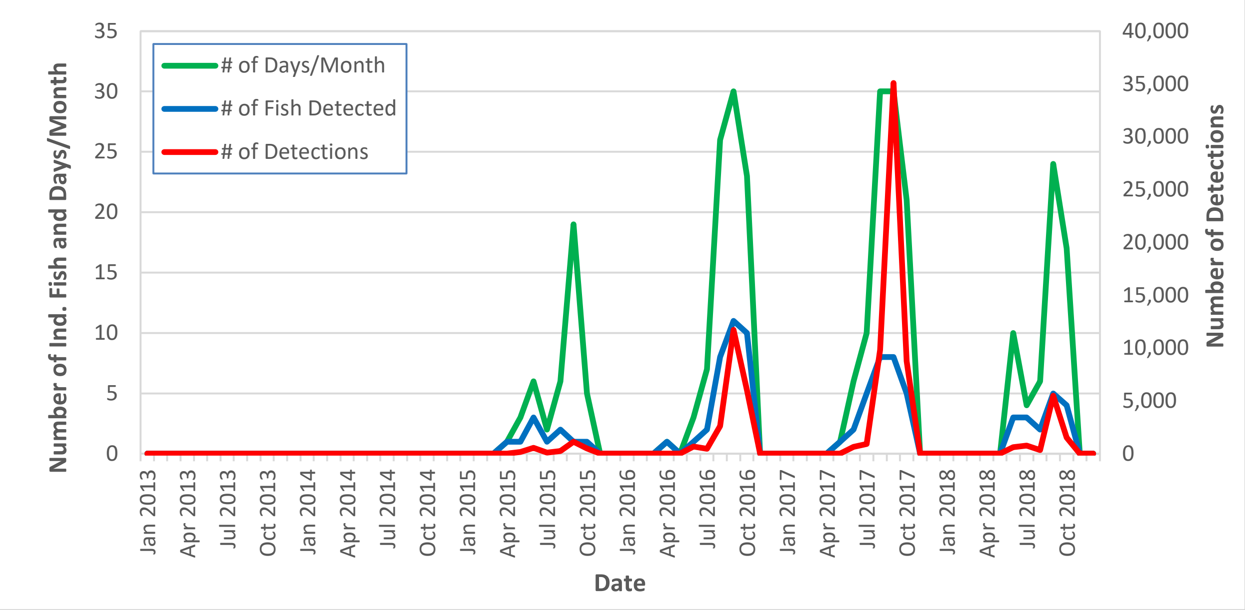

Figure 18. Atlantic sturgeon occurrence based on receiver detections in the Mattaponi River region from 2013 to 2018.

The limited detection information from sub-adults suggests they were present in the Mattaponi and Pamunkey from March to May. They leave during the heat of summer and may return in the fall. They occupied both lower RM, preferentially residing near or in the oligohaline zone (**Figure 1**).

Table 7. Number of detections by month in the Mattaponi River region, July 2016–November 2018. Receiver sites are listed in descending order by RM. NA signifies a period when the receiver was not deployed. River miles and receiver site names can be referenced on Appendix 8.1.

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May. 2016	June 2016	July 2016	Aug. 2016	Sep. 2016	Oct. 2016	Nov. 2016	Dec. 2016	Total
Mattaponi River	39	Walls	None	NA	NA	NA	NA	NA	NA	0	0	46	102	0	NA	**148**
Mattaponi River	35	Mike's Branch	None	NA	NA	NA	NA	NA	NA	0	0	126	129	0	NA	**255**
Mattaponi River	30	Above Whitehall	None	NA	NA	NA	NA	NA	NA	0	0	1,920	168	0	NA	**2,088**
Mattaponi River	24	White Oak Landing	None	NA	NA	NA	NA	NA	NA	0	0	256	1,286	0	NA	**1,542**
Sum 2016				**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2,348**	**1,685**	**0**	**0**	**4,033**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2017	Feb. 2017	Mar. 2017	Apr. 2017	May 2017	Jun. 2017	Jul. 2017	Aug. 2017	Sep. 2017	Oct. 2017	Nov. 2017	Dec. 2017	Total
Mattaponi River	39	Walls	None	NA	NA	NA	NA	NA	NA	0	0	10	68	0	NA	**78**
Mattaponi River	35	Mike's Branch	None	NA	NA	NA	NA	NA	NA	0	112	559	39	0	NA	**710**
Mattaponi River	30	Above Whitehall	None	NA	NA	NA	NA	NA	NA	0	1,687	6,842	3,849	0	NA	**12,378**
Mattaponi River	24	White Oak Landing	None	NA	NA	NA	NA	NA	NA	0	912	1,259	164	0	NA	**2,335**
Sum 2017				**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2,711**	**8,670**	**4,120**	**0**	**0**	**15,501**
Total 2016-2017				**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2,711**	**11,018**	**5,805**	**0**	**0**	**19,534**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2018	Feb. 2018	Mar. 2018	Apr. 2018	May 2018	Jun. 2018	Jul. 2018	Aug. 2018	Sep. 2018	Oct. 2018	Nov. 2018	Dec. 2018	Total
Mattaponi River	39	Walls	None	NA	NA	NA	NA	NA	NA	0	0	161	19	0	NA	**180**
Mattaponi River	35	Mike's Branch	None	NA	NA	NA	NA	NA	NA	0	0	310	18	0	NA	**328**
Mattaponi River	30	Above Whitehall	None	NA	NA	NA	NA	NA	NA	0	0	35	11	0	NA	**46**
Mattaponi River	24	White Oak Landing	None	NA	NA	NA	NA	NA	NA	0	345	2,984	802	0	NA	**4,141**
Sum 2018				**0**	**0**	**0**	**0**	**0**	**0**	**0**	**345**	**3,490**	**850**	**0**	**0**	**4,685**
Total 2016-2018				**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3,056**	**14,508**	**6,655**	**0**	**0**	**24,219**

VIMS has monitored the Mattaponi River since 2013, but until 2016 very few Atlantic sturgeon detection data were recorded within freshwater reaches. In 2013, four fish tagged in the Pamunkey in that same year entered the lower brackish mouth of the Mattaponi River near West Point when emigrating. None of the six returning 2013 fish, nor any of the 34 newly tagged fish from 2014, were detected in the Mattaponi River in 2014. Chesapeake Scientific began to monitor several freshwater stations in the Mattaponi River in 2015 in preparation for a tagging effort in 2016. Although 29 tagged fish ran the Pamunkey in 2015, only six of these entered the lower Mattaponi and only one VIMS fish (12707) was detected in fresh water.

Of the 11 adults implanted with Navy tags detected in the Mattaponi in 2016, four were tagged in the Mattaponi that same year. Two confirmed females were present, one (12736) was a returning fish tagged in the Pamunkey in 2014 and the other (17230) was newly tagged in 2016. Both were carrying late-stage eggs and neither entered the Pamunkey River spawning grounds during their York River system occupation that year. Female 17230 was a large female full of well-developed eggs that was captured on 19 September 2016. A V16 transmitter was inserted into her egg mass, as is the normal practice. However, it appears that because of her size and the late developmental stage of her eggs, she expelled the tag during or after subsequent spawning. This hypothesized method of loss is supported by her normal behavior during weeks preceding loss, her detection pattern immediately before loss, the characteristics of the habitat in which the tag is now located, and concurrent occupation of this site by another female (12736) and numerous male fish.

Male fish 26350 tagged in the Nanticoke River in Maryland also ran the Mattaponi in 2016. It remained in the Mattaponi the entire spawning season and made numerous upriver runs in late September into suitable spawning reaches. The same fish resided in the Pamunkey River spawning grounds during the entire 2015 and 2017 seasons, therefore, considerable data suggest that this fish is of York River origin and was tagged while transiting through the Nanticoke. In 2016, the first fish of Northeast tagging origin (23393) was recorded entering the Pamunkey or Mattaponi rivers. It never entered freshwater and was in the lower Mattaponi River for less than 7 hours before descending and exiting the York River.

In 2017, 12 of our tagged adults entered the Mattaponi River (**Table 7**) and eight ascended above the oligohaline interface into what could be considered suitable spawning habitats. Seven of these fish were males. One (12734) was a female tagged in 2015 who spent the winter of 2016 off the Georgia coast. Instead of returning to spawn in the Pamunkey in 2016, as her 2015 track suggests she did in that year, she spent the entire 2016 spawning season in the Mattaponi. Although her residence was not as late in the season nor as extended in duration as other females in 2016, her simultaneous occupation of potential spawning habitats with five males, repetitive upriver runs, and early (6 September) and rapid downriver emigration following an upriver run all suggest that spawning occurred.

In 2017, the only female detected (12734, tagged in 2015) made four upriver runs between 29 August and 5 September between RM 30 and 35 (**Appendix 8.1**), which contain suitable spawning conditions and habitats. She spent considerable time with males in the Mike's Branch (RM 35) and Jensen (RM 33) sites on each run. After her last run on 6 September she exited the river on 10 September.

A single tagged female ran the Mattaponi River in 2018; she was accompanied by four tagged males. Female 17229 was tagged in early September 2016 and entered the Mattaponi River in mid-September in 2018. She made five upriver runs with the first four runs (15, 21, 24, and 27 Sep.) culminating near Walkerton (RM 28; **Appendix 8.1**). This area is well within the Mattaponi's freshwater reaches and does contain some hard bottom with sufficient flow. Her last run occurred on 2 October and it was her farthest upriver with an apex at RM 30 (above Whitehall). Also of interest was the large number of detections recorded at McDevitt (RM 20) where she was often simultaneously recorded with multiple tagged males. Concurrent occupation of this site by both sexes was regularly recorded during the spawning season and supports the assertion that this may be an important Mattaponi River spawning location.

There are numerous occupation and behavior patterns that lead us to believe that spawning is occurring in the Mattaponi River though we have no solid evidence, such as a half spawned out female. Tag 17230, placed in an extremely gravid female in 2016, stopped moving a few weeks after implantation while within the receptive distance of the McDevitt receiver station (**Appendix 8.1**) located in the Mattaponi (RM 20), where a narrow, deep river bend contains hard sediments and substantial current. Prior to the tag becoming stationary, detections were not slow moving or sedentary, which would suggest injury or impending death, nor was it passively moving with the tidal cycle as a floating carcass would. Both tagged females present in 2016 demonstrated a similar affinity for the site where the tag was found. Their occupation of the site overlapped with that of six males. In fact, the only detected male that did not co-occupy the site with these females was tagged on 4 October 2016 and exited the river several days after tagging. If female 17230 had died, it is highly unlikely that the carcass would have gone unnoticed. Large fish like sturgeon decay rapidly in warm water, and the carcass floats and lets off a strong scent, thus drawing attention from boaters and vultures. Other VIMS researchers transiting the detection zone tagging sub-adults likely would have noticed the carcass.

In addition to the potential spawning habitat at the McDevitt receiver site (**Appendix 8.1**) there are several other sites that contain fast current and gravel substrate in freshwater located farther upriver that appear promising as potential spawning sites. The VIMS female (12707) that may have spawned in the Mattaponi in 2015 made two runs to Aylett near RM 37. In 2016, female 12736, tagged in the Pamunkey in 2014, not only simultaneously occupied McDevitt in late September with female 17230 but also made a quick run upriver to the suitable spawning site located at RM 33 (Jensen, **Appendix 8.1**) just below the Route 360 bridge. The only tagged female detected in 2017 preferred the river section between RM 30 and RM 33, and this was also the farthest upriver region selected by the only female to run in 2018.

One of the four males tagged in 2016 was detected with five other males making runs to above Matt Walls at RM 37 (**Appendix 8.1**) and two males terminated their 2016 runs even farther upriver near RM 47. Although these male runs were concurrent with Pamunkey River spawning efforts in late September through early October, no females with tags were detected. As has been previously recorded, males made runs in 2018 that again reached much farther upriver (RM 35) than females were detected. This repetitive movement pattern may be due to males often travel great distances searching for females, thus their runs may not indicate actual spawning efforts.

Our limited detection data from 2016 suggests that adults arrive and aggregate in potential spawning grounds in the lower Mattaponi River (RM 20) later than they do in the Pamunkey (**Figure 18, Table 7**) and that adults remain later into the fall (**Table 4**), emigrating out of the Mattaponi in mid- to late October versus late September to early October in the Pamunkey. Water temperatures generally decrease as fish move upriver unless altered by anthropogenic inputs. Temperatures in the upper rivers are often several degrees cooler than those found in the mid-river sections. While the Pamunkey is spring-fed by many tributaries, the Mattaponi is much shorter and straighter with a midsection dominated by extensively vegetated, expansive marshes resting on shallow flats composed of very dark sediments. Based on 2016 data, the Mattaponi is a few degrees warmer than the Pamunkey in similar river sections with optimal spawning temperatures occurring several weeks later (**Figure 19**).

Congregations over suitable spawning substrates in 2016 in the Mattaponi occurred several weeks later than most culminating female runs in the Pamunkey, but corresponded with similar spawning temperatures recorded in the Pamunkey. The summer of 2017 was not as warm as 2016 and the spawning season in the Pamunkey was of much longer duration. The apex runs of the sole female present (12734) in the Mattaponi in 2017 also occurred much earlier than similar runs in 2016. In fact, the timing of the upriver runs of the 2017 female (12734) temporally overlapped with numerous apex runs of females in the Pamunkey River in 2017. The extent of male site co-occupancy also differed in 2017. In 2016, females spent considerable time with males in the lower Mattaponi near the oligohaline interface (RM 20; **Appendix 8.1**). In 2017, 12734 did not dwell for long within this lower river region but resided predominantly in the upper river where she made typical repetitive upriver runs culminating near RM 35. Although one of the females made a run into this section in late September 2016, she did not remain in the upper river as 12734 did in 2017, nor did she make repetitive runs resembling those detected in the Pamunkey since 2014. In 2018, the only tagged female made repetitive runs to RM 30 and spent most of her time near RM 20. Both of these Mattaponi regions have been consistently occupied by females and males during late September early October.

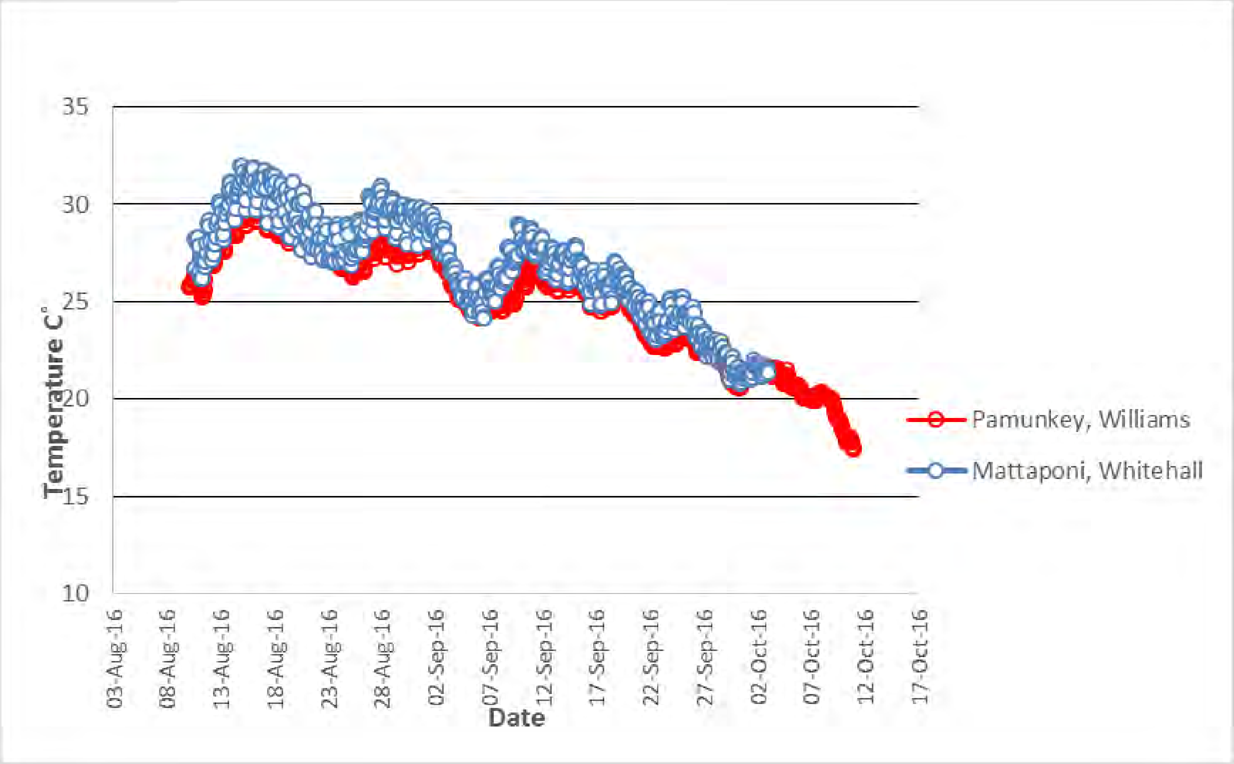

Figure 19. Comparison of water temperatures from receiver stations at similar RMs on the Pamunkey and Mattaponi rivers during the fall spawning season in 2016.

The tracking data from 2017 and 2018 did not mimic patterns recorded in 2016. Limited data suggest that 2016 was so warm that it may have resulted in abnormal occupation patterns. This assertion is supported by the abnormal alterations in spawning behavior observed in the Pamunkey as well. Unfortunately, our temperature gauges in the upper Mattaponi failed in 2017 and were not deployed in 2018 so it is not possible to determine what the exact temperatures were during these runs, but it stands to reason that the milder water temperatures recorded at numerous stations in the Pamunkey also occurred in the Mattaponi.

It seems highly likely that spawning is occurring in the Mattaponi River for the following reasons: the concurrent timing of the culminating runs of ripe females, the overlapping presence of males and females over suitable substrates in appropriate water temperatures in every year, the fact that all females have remained solely within the Mattaponi River during the entire fall spawning period, and the fact that no females have returned the next year to spawn after residing in the Mattaponi for the spawning season. However, eggs and/or a partly spawned-out female have not yet been observed. Only more data will elicit what is considered normal behavior and the influence of water temperature variability on river occupation patterns.

3.5.3. York River Region (Naval Weapons Station Yorktown/Cheatham Annex Zone)

There are 11 stations in the York River region and four of these are located within the NW/Ch. Zone (**Appendix 8.2**). Due to the narrowness of the river and placement of the receivers within these zones, this array creates an effective gate for the river—so that there is very little chance that tagged fish can pass through without being detected. This zone has been consistently monitored since 2012 by four receivers that cover 17 percent of its area (**Table 2**), despite the Page's Rock Lighthouse receiver having to be moved to Y6 in the middle of 2015 (**Appendix 8.2**). Therefore, the zone's data are intrinsically tied to subsequent river occupation and can be used to describe river occupation patterns.

Based on reception data from 2007 to 2010 at the York River Bridge (Hager, unpublished) and Navy data since 2012, the York River system experiences little use by transient fish from other systems (**Table 8**). Although researchers in the Northeast region have tagged more Atlantic sturgeon than in any other region, only six Northeast fish have been detected in NW/Ch. zone: one in 2013, three in 2014, one in 2016, one in 2017, and two in 2018 (**Table 8**). None of these fish have come into the river more than once and none have moved into the spawning grounds. Only one fish of Northeast tagging origin has ever entered the Pamunkey or Mattaponi rivers (**Tables 6, 7**). All of the Northeast fish entering the York were collected and tagged in the ocean off the coast of Delaware (**Table 8**) where numerous genetically distinct stocks of Atlantic sturgeon mix (Wirgin et al. 2014). Therefore, fish tagged in this location may be natives of any number of DPSs/stocks including the York or James rivers.

Three different adult fish tagged in the James River by VCU have entered the lower York River. One each year from 2013 to 2015. None have come into the York River past the Y WAT station more than once. One entered the Pamunkey's freshwater region for less than a day and then progressed rapidly downriver and out of the system. In 2017, numerous males and a single female whose genetics matched the James River were collected in the Pamunkey River during the spawning season but none had transmitters. This is the second time that fish bearing James River genetics have been sampled in the Pamunkey River. The only time prior was the capture of single adult male (**Table 6**). This fish was telemetry tagged when obtained in the Pamunkey River and has since not returned to the Pamunkey but has been detected returning exclusively to the James River since tagging.

Twenty-five Atlantic sturgeon carrying VIMS tags have been detected in the York River Military zone, but because of inconsistent tagging approaches, these fish are of mixed life stages. In addition, they were collected from numerous locations including the Pamunkey and Mattaponi rivers. Others were tagged in the lower James River where fish originating from various DPSs are prevalent. Detections of VIMS sturgeon are thus of limited ecological value unless sample-specific data on age and genetic origin are known. We know that most VIMS sturgeon detected in the York River for the first time after 2015 were sub-adults tagged in the Pamunkey and Mattaponi systems and that those detected prior to 2015 were adults tagged in the Pamunkey.

Table 8. Tagging origin of Atlantic sturgeon detected within the Naval Weapons Station Yorktown/Cheatham Annex zone annually from 2013 to 2018.

Year	Northeast	Chesapeake Bay	Southeast	Total Detected
2013	1	14	0	15
2014	3	56	0	59
2015	0	52	0	52
2016	1	54	0	55
2017	1	67	0	68
2018	2	63	0	65

Almost nothing is known about YOY Atlantic sturgeon in the York River system. Because reproduction is likely occurring in both the Pamunkey and Mattaponi rivers, life history dictates that native YOY should be present year-round within both tributaries in fresh- and brackish-water nursery areas for several years following hatching (Scott and Crossman 1973, Secor et al. 2000). All fish produced in these tributaries must pass through the NW/Ch zone when they emigrate out of their native system into the bay for the first time. Very little is known about how sub-adults use the York River up to the point they leave their native estuary or whether they return during their sub-adult lives. Three small (525 to 575 mm FL) sub-adults (genetically identified by Tim King, USGS) were tagged as a part of this study, two in December 2012 and one in February 2015. The first two were later identified as being part of the New York Bight DPS. They left the York River in the same month they were tagged. Nothing is known about the third fish because its tags failed to function.

VIMS researchers have tagged 12 sub-adults obtained in the York River: two in spring 2014 and 10 in 2015. The two tagged in 2014 entered the Pamunkey for the summer and emigrated in mid-fall. One has yet to return and the other spent most of 2014 and 2015 in the James River watershed. Detections of the tagged VIMS sub-adults suggest that this life stage spends most of its time in the Pamunkey and Mattaponi oligohaline zone far upriver of the NW/Ch. zone (**Figure 1**). Most migrated through the zone from mid-April to May and again in mid-October to December. However, these dates are based upon a limited number of known sub-adults. This life stage is known for being highly transient, which makes predicting behavior, motivation, and locational preferences more difficult. To complicate interpretation further, the genetic origins of these sub-adults tagged by VIMS have not been established. Consequently, observed behavior may not represent habitat preference of native fish but habitat use by wandering sub-adults originating in other systems. The 2016 recapture of an adult male, tagged as a sub-adult by Chris Hager in 2007 in the lower York River below the military zone, suggests that native sub-adults reside in the lower river, but detection data to date are not sufficiently robust to define spatial and temporal aspects of such residence. It is also worth noting that numerous fish of James River origin have been documented using the mouth of the York River where submerged aquatic vegetation is prevalent (Musick and Hager 2007).

In 2014, the detection of nine returning adults tagged in 2013 suggested that residence within the NW/Ch. zone during immigration began in June and ended in mid-August. Since 2014, the number of adults tagged in the Pamunkey River has grown from 15 to 85 and our understanding of zone use has expanded accordingly. Adults are now known to occupy the NW/Ch. zone upon immigration from late May until early September. Immigration usually occurs in two waves within the zone. The first occurs in June but can stretch into July depending on the year. A second wave of immigrants arrives in August. Adult sturgeon appear to slow their upriver immigration while within the deep, fast currents at the narrowest point of the river, under the Coleman Bridge zone in Yorktown where the Y WAT receiver is located within NW/Ch. (**Appendix 8.2**). The number of detections per fish within the zone is negatively correlated with arrival time, meaning that fish that arrive early spend more time in the zone than those arriving late (**Table 9**, **Figure 20**). The length of occupation by individual fish at this location during immigration is usually days, not weeks. Usually fish belonging to the first aggregation have moved upriver out of the naval zone by the time the second aggregation arrives in August. In 2016, an increased number of fish occupied the location for an extended period of time prior to spawning. In fact, many fish that had previously passed through the zone in late spring actually returned downriver during the heat of mid-summer and took up residence below the bridge prior to moving back upriver to spawn. Detection frequency indicated an extent of sedentary behavior during immigration that had previously not been noted (**Table 9**). In 2017, fewer fish were in the site during June but even more detections resulted. We know from tracks in 2016 that fish continued downriver and into the bay and even into other tributaries. In 2017, these fish were not forced out of the river and remained in the Y WAT receiver's range, resulting in a large number of detections. In July of 2017, detections per fish were much lower than in 2016 because fish moved upriver in a typical fashion instead of remaining as they had in 2016. Adult sturgeon arriving in August do not linger in the lower river naval zone but move more rapidly upriver. This is clearly seen in **Figure 20** in all years but 2018. In 2018, fish held up in the bay and did not arrive in large numbers in the lower York River until late June and July. They also lingered longer in the zone, which is illustrated by the large number of detections (3,611) that were recorded from what was a normal number of fish (n = 17) for August.

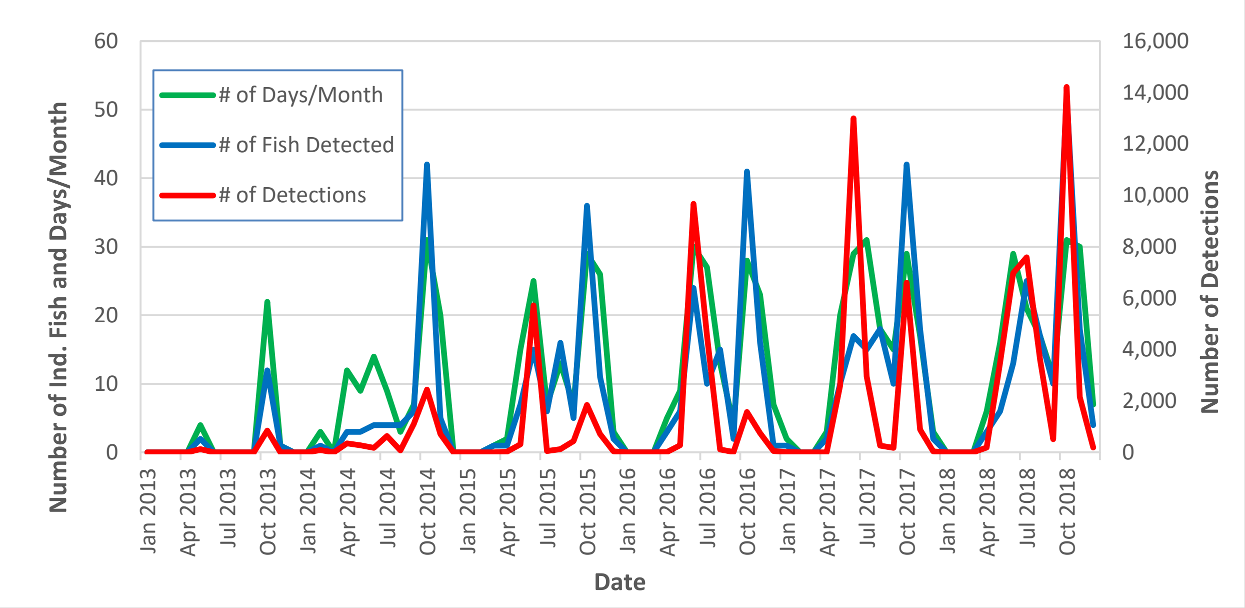

Figure 20. Atlantic sturgeon occurrence based on receiver detections in the Naval Weapons Station Yorktown/Cheatham Annex zone from 2013 to 2018.

In 2015, 2016, and 2017, most detections were recorded during immigration. In 2013, 2014, and 2018 the reverse was true. This result makes perfect sense in 2013 and 2014 when a large number of tags were being implanted upriver during the late summer and thus more tagged fish were leaving the river than could have entered. The large number of receptions during emigration in 2018 was not due to a larger number of fish being tagged during the spawning season but due to salinity shifts that occurred in the river due to excessive rains. Fish that would have normally encountered higher salinities farther upriver and slowed their emigration in order to allow for the physiological adjustments associated with osmoregulation descended much farther downriver into the military zone before encountering such salinities in 2018, stalling their emigration. Our past six years of data suggest that inter-annual alterations in water temperature (2016) and salinity (2018) during emigration and immigration can significantly alter the duration of the zone's occupation by migrating adults.

Table 9. Number of detections by month in the York River region, December 2012–December 2018. Receiver sites are listed in descending order by RM. Note that the Pages Rock Light was removed in 2015 and this station was replaced with York 6. York 6 was subsequently struck by a Navy vessel in September of 2016 and was not on site for several weeks. Therefore, the number of detections recorded at this station (1) is likely unrealistically low. River miles and receiver site names can be referenced on Appendix 8.1.

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Dec. 2012	Jan. 2013	Feb. 2013	Mar. 2013	Apr. 2013	May 2013	Jun. 2013	Jul. 2013	Aug. 2013	Sep. 2013	Oct. 2013	Nov. 2013	Dec. 2013	Total
York River	31	Y29 NOAA	None	0	0	0	0	0	0	0	0	0	99	271	0	0	**370**
York River	29	Y BELL NOAA	None	48	0	0	0	0	0	0	0	0	123	206	0	0	**377**
York River	25	Y20 NOAA	None	0	0	0	0	0	0	0	0	0	117	216	2	0	**335**
York River	23	Y18 NOAA	None	20	0	0	0	0	0	0	0	0	46	565	0	0	**631**
York River	17	Y12	None	0	0	0	0	0	13	0	0	0	0	1,675	104	0	**1,792**
York River	14	Y PAGE	NW/Ch.	7	0	0	0	0	9	0	0	0	0	223	1	0	**240**
York River	13	Y8	NW/Ch.	17	0	0	0	0	85	0	0	0	0	362	3	0	**467**
York River	9	Y2	NW/Ch.	0	0	0	0	0	1	0	0	0	0	99	0	0	**100**
York River	7	Y WAT	NW/Ch.	0	0	0	0	0	32	0	0	0	0	161	0	0	**193**
Sum 2013				**92**	**0**	**0**	**0**	**0**	**140**	**0**	**0**	**0**	**385**	**3,778**	**110**	**0**	**4,505**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2014	Feb. 2014	Mar. 2014	Apr. 2014	May 2014	Jun. 2014	Jul. 2014	Aug. 2014	Sep. 2014	Oct. 2014	Nov. 2014	Dec. 2014	Total
York River	31	Y29 NOAA	None	0	87	0	293	122	113	91	13	1,099	1,844	39	0	**3,701**
York River	29	Y BELL NOAA	None	0	48	0	281	62	17	68	6	559	2,649	80	0	**3,770**
York River	25	Y20 NOAA	None	0	159	0	125	48	32	108	3	388	2,149	33	0	**3,045**
York River	23	Y18 NOAA	None	0	72	0	81	38	29	44	8	388	1,871	55	0	**2,586**
York River	17	Y12	None	0	26	0	30	117	66	15	2	990	5,709	83	0	**7,038**
York River	14	Y PAGE	NW/Ch.	0	6	0	46	29	5	3	0	10	277	75	0	**451**
York River	13	Y8	NW/Ch.	0	21	0	144	224	104	215	37	906	1,163	386	0	**3,200**
York River	9	Y2	NW/Ch.	0	8	0	110	10	21	4	0	22	164	206	0	**545**
York River	7	Y WAT	NW/Ch.	0	56	0	51	11	49	418	37	172	845	53	0	**1,692**
Sum 2014				**0**	**483**	**0**	**1,161**	**661**	**436**	**966**	**106**	**4,534**	**16,671**	**1,010**	**0**	**26,028**
Total 2013-2014				**0**	**483**	**0**	**1,161**	**801**	**436**	**966**	**106**	**4,919**	**20,449**	**1,120**	**202**	**30,643**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2015	Feb. 2015	Mar. 2015	Apr. 2015	May 2015	Jun. 2015	Jul. 2015	Aug. 2015	Sep. 2015	Oct. 2015	Nov. 2015	Dec. 2015	Total
York River	33	Y 35	None	0	0	0	140	147	299	489	803	85	873	41	0	**2,867**
York River	31	Y29 NOAA	None	0	0	0	211	150	521	537	1,109	129	1,004	33	0	**3,690**
York River	29	Y BELL NOAA	None	0	0	8	88	43	141	270	1,361	172	1,341	48	0	**3,460**
York River	25	Y20 NOAA	None	0	0	30	57	241	529	503	471	99	1,113	159	0	**3,202**
York River	23	Y18 NOAA	None	0	0	40	127	322	463	660	163	103	1,582	189	0	**3,635**
York River	21	Y 16	None	0	0	14	15	46	375	41	107	143	3,849	1,362	4	**5,906**
York River	17	Y 12	None	0	0	27	30	85	401	351	105	107	1,445	1,377	33	**3,910**
York River	14/12	Y PAGE/Y 6	NW/Ch.	0	0	6	15	58	316	422	23	28	462	134	8	**1,443**
York River	13	Y 8	NW/Ch.	0	0	0	6	148	169	23	18	9	462	356	15	**1,079**
York River	9	Y 2	NW/Ch.	0	0	0	4	28	59	3	17	10	191	68	2	**376**
York River	7	Y WAT	NW/Ch.	0	0	3	2	81	5,179	21	76	396	738	162	15	**6,640**
Sum 2015				**0**	**0**	**128**	**695**	**1,349**	**8,452**	**2,898**	**4,253**	**1,281**	**13,060**	**3,929**	**77**	**36,208**
Total 2013-2015				**0**	**483**	**128**	**1,856**	**2,150**	**8,888**	**3,864**	**4,359**	**6,200**	**33,509**	**5,049**	**279**	**66,851**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	Jun. 2016	Jul. 2016	Aug. 2016	Sep. 2016	Oct. 2016	Nov. 2016	Dec. 2016	Total
York River	32	Y 35	None	0	0	0	80	379	615	405	410	497	857	73	0	**3,316**
York River	31	Y29 NOAA	None	0	0	0	26	147	1,068	396	642	261	1,527	68	0	**4,135**
York River	29	Y BELL NOAA	None	0	0	0	15	115	723	577	749	195	1,227	69	0	**3,670**
York River	25	Y20 NOAA	None	0	0	0	15	45	561	790	1,974	218	1,013	210	0	**3,839**
York River	23	Y18 NOAA	None	0	0	0	65	134	812	925	495	257	3,206	119	0	**6,013**
York River	20	Y 16	None	0	0	0	8	45	388	290	61	66	1,771	2,216	0	**4,845**
York River	17	Y 12	None	0	0	0	14	52	911	288	66	7	6,035	1,836	0	**9,209**
York River	12	Y 6	NW/Ch.	0	0	0	7	118	295	62	18	1	50	46	0	**597**
York River	13	Y 8	NW/Ch.	0	0	0	5	60	528	345	13	18	343	455	1	**1,767**
York River	9	Y 2	NW/Ch.	0	0	0	4	36	352	161	62	1	322	113	1	**1,051**
York River	7	Y WAT	NW/Ch.	0	0	0	6	68	8,498	3,982	19	2	861	188	1	**13,624**
Sum 2016				**0**	**0**	**0**	**245**	**1,199**	**14,751**	**8,221**	**4,509**	**1,523**	**17,212**	**5,393**	**3**	**52,066**
Total 2013-2016				**0**	**483**	**128**	**2,101**	**3,349**	**23,639**	**12,085**	**8,868**	**7,723**	**50,721**	**10,442**	**282**	**118,917**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2017	Feb. 2017	Mar. 2017	Apr. 2017	May 2017	Jun. 2017	Jul. 2017	Aug. 2017	Sep. 2017	Oct. 2017	Nov. 2017	Dec. 2017	Total
York River	32	Y 35	None	0	0	0	0	53	276	434	420	783	1,122	23	58	**3,169**
York River	31	Y29 NOAA	None	0	0	0	0	95	411	898	391	522	1,452	5	44	**3,818**
York River	29	Y BELL NOAA	None	0	0	0	0	119	282	1,142	671	560	2,567	43	27	**5,411**
York River	25	Y20 NOAA	None	0	0	0	0	84	490	951	230	112	1,971	286	26	**4,150**
York River	23	Y18 NOAA	None	0	0	0	0	190	1,115	1,050	178	146	1,609	677	39	**5,004**
York River	20	Y 16	None	0	0	0	0	78	560	401	60	65	1,730	1,298	17	**4,209**
York River	17	Y 12	None	0	0	0	13	123	992	476	186	233	4,988	609	17	**7,637**
York River	12	Y 6	NW/Ch.	8	0	0	1	58	84	66	22	7	129	96	5	**476**
York River	13	Y 8	NW/Ch.	0	0	0	5	162	354	408	162	115	1,429	360	13	**3,008**
York River	9	Y 2	NW/Ch.	2	0	0	1	64	152	266	27	12	141	64	4	**733**
York River	7	Y WAT	NW/Ch.	11	0	0	1	2,317	12,415	2,219	59	50	4,913	373	25	**22,383**
Sum 2017				**21**	**0**	**0**	**21**	**3343**	**17131**	**8311**	**2406**	**2605**	**22051**	**3834**	**275**	**59998**
Total 2013-2017				**21**	**483**	**128**	**2,122**	**6,692**	**40,770**	**20,396**	**11,274**	**10,328**	**72,772**	**14,276**	**557**	**178,915**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2018	Feb. 2018	Mar. 2018	Apr. 2018	May 2018	Jun. 2017	Jul. 2018	Aug. 2018	Sep. 2018	Oct. 2018	Nov. 2018	Dec. 2018	Total
York River	32	Y 35	None	0	0	0	33	183	610	1,347	1,834	368	767	105	11	**5,258**
York River	31	Y29 NOAA	None	0	0	0	80	212	1,245	3,077	3,177	806	1,141	3	26	**9,767**
York River	29	Y BELL NOAA	None	0	0	0	32	45	839	2,183	3,579	1,153	836	2	16	**8,685**
York River	25	Y20 NOAA	None	0	0	0	109	64	874	1,441	1,989	1,251	770	26	0	**6,524**
York River	23	Y18 NOAA	None	0	0	0	244	100	1,338	2,009	2,526	2,652	3,853	271	6	**12,999**
York River	20	Y 16	None	0	0	0	49	26	582	264	733	970	571	57	15	**3,267**
York River	17	Y 12	None	0	0	0	39	100	519	377	14	0	1,640	498	8	**3,195**
York River	12	Y 6	NW/Ch.	0	0	0	45	26	63	33	38	26	885	639	48	**1,803**
York River	13	Y 8	NW/Ch.	0	0	0	51	59	387	0	147	319	4,415	407	22	**5,807**
York River	9	Y 2	NW/Ch.	0	0	0	16	27	80	54	33	68	632	555	96	**1,561**
York River	7	Y WAT	NW/Ch.	0	0	0	75	3,377	6,450	7,501	3,393	108	8,285	555	22	**29,766**
Sum 2018				**0**	**0**	**0**	**773**	**4,219**	**12,987**	**18,286**	**17,463**	**7,721**	**23,795**	**3,118**	**270**	**88,632**
Total 2013-2018				**21**	**483**	**128**	**2,895**	**10,911**	**53,757**	**38,682**	**28,737**	**18,049**	**96,567**	**17,394**	**827**	**267,547**

Note: NW/Ch. is an abbreviation for Naval Weapons/Cheatham Annex.

Emigration of native adults starts in late September and peaks in October, a few fish have remained into December (**Table 9**). Maps of monthly detections are found in **Appendix 8.5**. Maps and associated tables do not reflect the series of up- and downriver movements that most fish undertake during immigration and emigration because these movements occur over a shorter period of time than a monthly scale can convey. Military zone maps (**Appendix 8.5**) do reflect, however, the extended periods of time spent by immigrating adults in the lower mesohaline (RM 18–35) and emigrating adults in the upper polyhaline (RM 12–18) stretches during the early summer and early fall, respectively. This pattern was severely altered in 2018. The 2018 NW/Ch. zone maps clearly illustrate a large increase in the number of detections in July during immigration and in October during emigration. These increases were due to fish shifting downriver in response to decreased salinity in comparison to a normal year. Fish were slower to immigrate, and shifted their occupancy patterns farther downriver. This shift in occupancy supports the assertion that the species alters its location during immigration and emigration in order to adjust to physiological stresses associated with varying salinities.

3.5.4. Chickahominy River Region

The Chickahominy River is a tributary of the James River and was originally monitored through a separate U.S. Navy blueback herring (*Alosa aestivalis*) study (N62470-09-D-2003, task order 194220-001). Atlantic sturgeon have historically occupied the Chickahominy River, and it is not unusual for fishermen to encounter Atlantic sturgeon of varied sizes at the river's mouth (Hager 2011). It appears that adult and sub-adult occupation of this region is ongoing and historically normal. Maps of detections are found in **Appendix 8.6**. The majority (n = 200, 85 percent) of sturgeon detected in this region from 2013 to 2018 (**Table 10**) were tagged in the James River by VCU or VIMS in Burwell Bay in the middle of the mesohaline zone. There were 30 fish over the six years that were detected in the Chickahominy River of Northeast tagging origin but there were only 20 unique individuals over the six years. Of these 20, all but one was tagged off the coast of Delaware, the majority in the ocean and therefore may belong to any DPS including the James River. The only fish tagged in the Northeast that was not tagged off Delaware was tagged in Connecticut. It was detected in October of 2015 and 2016 and May of 2018. One fish tagged in North Carolina was also detected in July and September of 2013.

Table 10. Tagging origin of Atlantic sturgeon detected within the Chickahominy River annually from 2013 to 2018.

Year	Northeast	Southeast	VCU	VIMS	Total Detected
2013	4	1	17	0	22
2014	10	0	23	7	40
2015	4	0	14	13	31
2016	6	0	30	12	48
2017	4	0	23	6	33
2018	2	0	19	5	26

Sturgeon were detected in the Chickahominy from June to October in 2013, April to December in 2014, May to November in 2015, March to December in 2016, April to May and again from August to November in 2017, and March until October in 2018. Sturgeon numbers were greatest during August to October in all years. Sturgeon numbers peaked in September from 2013 through 2018 at 13, 21, 16, 25, 18, and 11, respectively (**Figure 21**). The largest number of fish recorded in the river (n = 25) occurred in September 2016 during the warmest year of the six recorded. In 2018, the wettest year on record, only 8 fish occupied the mouth of the Chickahominy River in September, which is roughly half the average number (mean = 18.6) recorded in this location over the previous five years.

The August–October period when most fish are detected in the mouth of the Chickahominy River corresponds to the fall spawning season in the upper James River, and many adults occupy the Chickahominy during this entire season. Although sturgeon numbers consistently have been largest in September across years, 2016 and 2017 data suggest that fish are immigrating into the system in two waves—one in spring and one in late summer, a pattern that appears in most tributaries. This pattern is less obvious in 2014 and 2015 when VCU and VIMS were placing tags in sub-adult sturgeon downriver of the Chickahominy in the James River's mesohaline. These are also the years when the most sedentary behavior was demonstrated by a small number of fish during mid-summer, presumably these fish were newly tagged sub-adults.

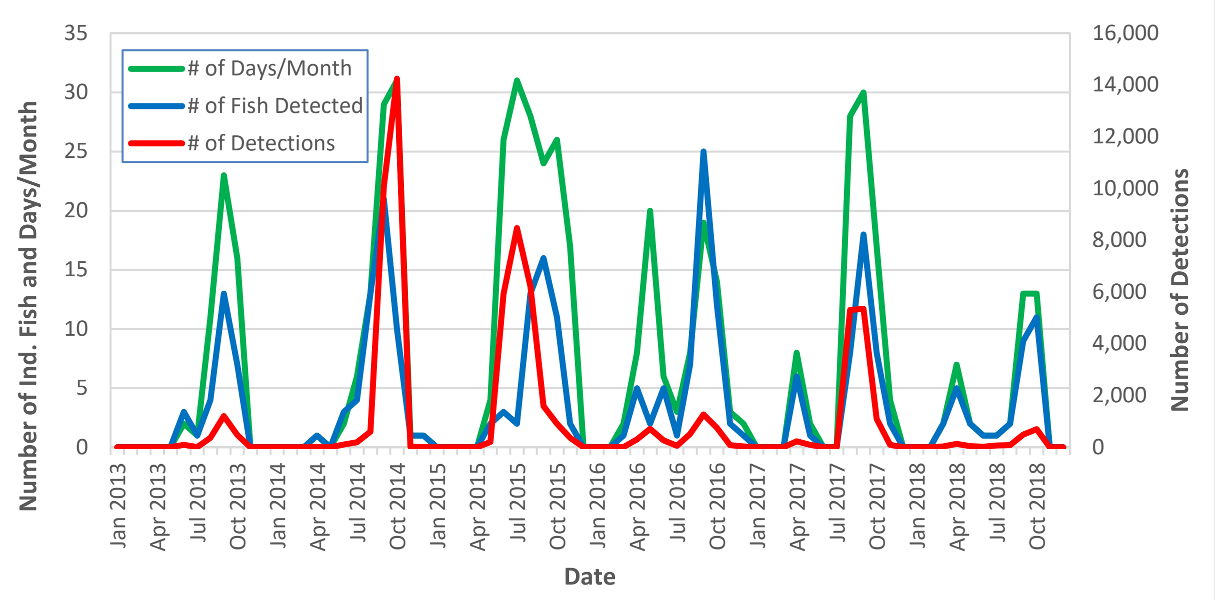

Figure 21. Atlantic sturgeon occurrence based on receiver detections at the mouth of the Chickahominy River from 2013 to 2018.

Increased abundances of sturgeon in the spring and late summer are evident at the mouth of the Chickahominy during all six years. In 2013, 2016, 2017, and 2018 these peaks are more distinct than in 2014 or 2015 when sub-adult fish were being tagged downriver in late spring. In 2013, a lack of sequential detections of any sturgeon over any significant period of time (weeks) suggested that extended residence times were not common in the Chickahominy. It may also suggest that sturgeon occupying the region simply were not carrying tags. Numerous sub-adult sturgeon newly tagged by VIMS and VCU in 2014 (30/40, 75 percent) were detected for extended periods of time in the Chickahominy River following tagging. Many remained for weeks in the Chickahominy River. The average number of detections per fish tagged by VIMS and VCU in 2014 was 812. It was 91 for the 10 fish detected that had been tagged in the Northeast. It should be noted that one VIMS fish contributed 13,158 detections in October of

2014 (**Table 11**). In 2015, although the total number of fish detected in the Chickahominy was 31 versus the 40 detected in 2014, the number of days with detections increased. In 2015, 87 percent (27/31) of the fish detected in the Chickahominy River's mouth were tagged by VCU and VIMS. The average number of detections per fish for VIMS and VCU fish was 867. The average number of detections per fish for fish tagged in Northeast was 64. Some residence times of VCU and VIMS fish extended over several months. There were no major outliers with a very large number of detections as there had been in 2014. Instead a much larger number of fish tagged in the lower James River illustrated sedentary behavior through a large number of detections. Again, downriver tagging in 2014 and 2015 targetted sub-adults and thus increased residence durations are most likely due to sturgeon of this life stage.

In 2016, tagging in the lower James River stopped. Immigration patterns from 2016 through 2018 were similar with spring and late summer apexes. From 2016 through 2018 only one fish exhibited sedentary behavior for any length of time. This fish was tagged by VIMS and it resulted in 7,006 detections from August through October in 2017. Detection distribution during this time showed a preference for the eastern side of the river. No fish tagged in the Northeast illustrated such behavior. The largest sub-adult and adult abundances were detected in the extremely warm year of 2016. Detections occurred in short sequences with no individual residence persisting for over a week without intermittent movements between and/or away from receivers. The smallest number of sturgeon present, number of days with sturgeon present, and number of detections occurred in the very wet year of 2018.

Adults appear in the Chickahominy River in early spring (May). This wave of fish exits the river by mid-June. Significant numbers of adults are not are detected again until August, with peak annual abundance occurring in late September, concurrent with James River spawning (Balazik et al. 2012). Most adults detected at the mouth of the Chickahominy River were tagged in the James River. Bushnoe et al. (2005) mentioned that water-quality conditions in the Chickahominy River were favorable to spawning but since no hard-bottom habitats were recognized, Bushnoe et al. did not specifically address the suitability of the river. According to behavior evidenced by adult fish of York River origin, it is highly unusual for an adult, let alone a group of adults, to stop their spawning run once in fresh water. The fact that adults spend the entire fall spawning period in the lower Chickahominy River, and a few have even repeated this behavior over the years, suggests that limited spawning may occur in this river. This hypothesis is supported but in no way confirmed by the tagging of an adult male running milt in September 2018. The fact that most fish of Northeast tagging origin are repeat visitors may suggest that these fish were not of Northeast origin at all but were actually Chesapeake fish that were tagged while in the ocean off Delaware. Conversely, if genetics show that these fish are of Northeast origin, then their repeated presence suggests not only that the freshwater tributaries in the Chesapeake Bay are far more important to the species as a whole than previously realized but that the presence of adult fish within freshwater tributaries during a given season does not denote spawning.

Table 11. Number of detections by month in the Chickahominy River region, December 2012–December 2018. Receiver sites are listed in descending order by RM. River miles and receiver site names can be referenced on Appendix 8.1.

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Dec. 2012	Jan. 2013	Feb. 2013	Mar. 2013	Apr. 2013	May 2013	Jun. 2013	Jul. 2013	Aug. 2013	Sep. 2013	Oct. 2013	Nov. 2013	Dec. 2013	Total
Chickahominy River	24	Chick. Dam	None	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Chickahominy River	23	Chick. nest tree 1	None	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Chickahominy River	22	Chick. nest tree 2	None	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Chickahominy River	16	Chick. Ronnies	None	0	0	0	0	0	0	0	0	93	482	241	0	0	**816**
Chickahominy River	3	Chick. Bridge	None	0	0	0	0	0	0	95	2	277	729	236	0	0	**1,339**
Sum 2013				**0**	**0**	**0**	**0**	**0**	**0**	**95**	**2**	**370**	**1,211**	**477**	**0**	**0**	**2,155**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2014	Feb. 2014	Mar. 2014	Apr. 2014	May 2014	Jun. 2014	Jul. 2014	Aug. 2014	Sep. 2014	Oct. 2014	Nov. 2014	Dec. 2014	Total
Chickahominy River	3	Chick. Bridge	None	0	0	0	13	0	109	191	589	9,699	14,131	14	11	**24,757**
Chickahominy River	3	Chick. W. bank Bridge	None	0	0	0	0	0	1	2	8	386	110	4	2	**513**
Sum 2014				**0**	**0**	**0**	**13**	**0**	**110**	**193**	**597**	**10,085**	**14,241**	**18**	**13**	**25,270**
Total 2013-2014				**0**	**0**	**0**	**13**	**0**	**205**	**195**	**967**	**11,296**	**14,718**	**18**	**13**	**27,425**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2015	Feb. 2015	Mar. 2015	Apr. 2015	May 2015	Jun. 2015	Jul. 2015	Aug. 2015	Sep. 2015	Oct. 2015	Nov. 2015	Dec. 2015	Total
Chickahominy River	3	Chick. Bridge	None	0	0	0	0	190	4,850	8,149	5,868	1,464	851	359	0	**21,731**
Chickahominy River	3	Chick. W. bank Bridge	None	0	0	0	211	11	1,078	327	351	123	62	7	0	**2,170**
Sum 2015				**0**	**0**	**0**	**211**	**201**	**5,928**	**8,476**	**6,219**	**1,587**	**913**	**366**	**0**	**23,901**
Total 2013-2015				**0**	**0**	**0**	**224**	**201**	**6,133**	**8,671**	**7,186**	**12,883**	**15,631**	**384**	**13**	**51,326**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	Jun. 2016	Jul. 2016	Aug. 2016	Sep. 2016	Oct. 2016	Nov. 2016	Dec. 2016	Total
Chickahominy River	3	Chick. Bridge	None	0	0	0	249	406	224	39	424	1,095	555	68	30	**3,090**
Chickahominy River	3	Chick. W. bank Bridge	None	0	0	6	53	308	48	13	85	174	193	19	0	**899**
Sum 2016				**0**	**0**	**6**	**302**	**714**	**272**	**52**	**509**	**1269**	**748**	**87**	**30**	**3,989**
Total 2013-2016				**0**	**0**	**6**	**526**	**915**	**6,405**	**8,723**	**7,695**	**14,152**	**16,379**	**471**	**43**	**55,315**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2017	Feb. 2017	Mar. 2017	Apr. 2017	May 2017	Jun. 2017	Jul. 2017	Aug. 2017	Sep. 2017	Oct. 2017	Nov. 2017	Dec. 2017	Total
Chickahominy River	3	Chick. Bridge	None	0	0	0	135	24	0	0	3,550	4,064	852	79	0	**8,704**
Chickahominy River	3	Chick. W. bank Bridge	None	0	0	0	95	74	0	0	1,762	1,277	244	21	0	**3,473**
Sum 2017				**0**	**0**	**0**	**230**	**98**	**0**	**0**	**5,312**	**5,341**	**1,096**	**100**	**0**	**12,177**
Total 2013-2017				**0**	**0**	**6**	**756**	**1,013**	**6,405**	**8,723**	**13,007**	**19,493**	**17,475**	**571**	**43**	**67,492**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2018	Feb. 2018	Mar. 2018	Apr. 2018	May 2018	Jun. 2018	Jul. 2018	Aug. 2018	Sep. 2018	Oct. 2018	Nov. 2018	Dec. 2018	Total
Chickahominy River	3	Chick. Bridge	None	0	0	17	93	31	14	42	79	321	558	0	0	**1,155**
Chickahominy River	3	Chick. W. bank Bridge	None	0	0	15	37	19	9	28	6	170	139	0	0	**423**
Sum 2018				**0**	**0**	**32**	**130**	**50**	**23**	**70**	**85**	**491**	**697**	**0**	**0**	**1,578**
Total 2013-2018				**0**	**0**	**38**	**886**	**1,063**	**6,428**	**8,793**	**13,092**	**19,984**	**18,172**	**571**	**43**	**69,070**

3.5.5. James River Region

3.5.5.1. Naval Station Norfolk

NSN was monitored by 12 receivers that covered 31 percent of the total area of the region (**Table 2; Appendix 8.2**). The number of Atlantic sturgeon detected within the NSN zone increased each year from 2013 to 2015 (150, 205, 258, respectively) as did the number of detections while upriver tagging was occurring in the middle James River. These trends reversed in 2016 and continued their downward trajectory in 2017, with 222 and 201, respectively (**Table 12**). The detected abundance increased slightly to 203 in 2018. Detection number was more uniformly correlated with the number of sturgeon present than it had been in 2014 and 2015.

It is worth noting that 2016 was the first year since 2014 that sub-adult sturgeon were not being tagged upriver of this zone in the spring by VIMS researchers. Therefore, detection data from 2016, 2017, and 2018 may reflect more natural occupation patterns as expressed through relatively standard correlations between the number of sturgeon and total detection number. Clearly there were fewer unnaturally sedentary fish during 2016 through 2018. However, it is also worth noting that more fish of foreign tagging origin were detected in the military zone from 2013 through 2015 than from 2016 through 2018. In fact, some of these sturgeon of foreign tagging origin significantly contributed to total detection number in 2014, as they also demonstrated sedentary behavior in the zone during this year though to a lesser degree than newly tagged sub-adults attained in the James River. In 2015, newly tagged sub-adult sturgeon clearly exhibited sedentary behavior while transient fish were not present. Some sub-adults tagged in 2014 also exhibited extended occupancy in 2015 however, which may suggest the region's environment and not the effect of tagging may be motivating resulting extended residence.

Sturgeon occupied the zone year-round in all years. Sub-adults and adults were present in all years, although the exact number of each life stage is unknown due to a lack of data disclosure. Numerous factors highlight the importance of the zone to the species. These include: large numbers of individual fish, year-round presence, occurrence of varied life stages (**Figure 22**), consistently high numbers of days each month with detections, and extensive occupation by fish tagged in other regions (**Table 12**).

Table 12. Tagging origin of Atlantic sturgeon detected within the Naval Station Norfolk zone annually from 2013 to 2018.

Year	Northeast	Chesapeake Bay	Southeast	Total Detected
2013	34	111	5	150
2014	43	153	9	205
2015	47	205	6	258
2016	21	197	4	222
2017	16	185	0	201
2018	22	179	2	203

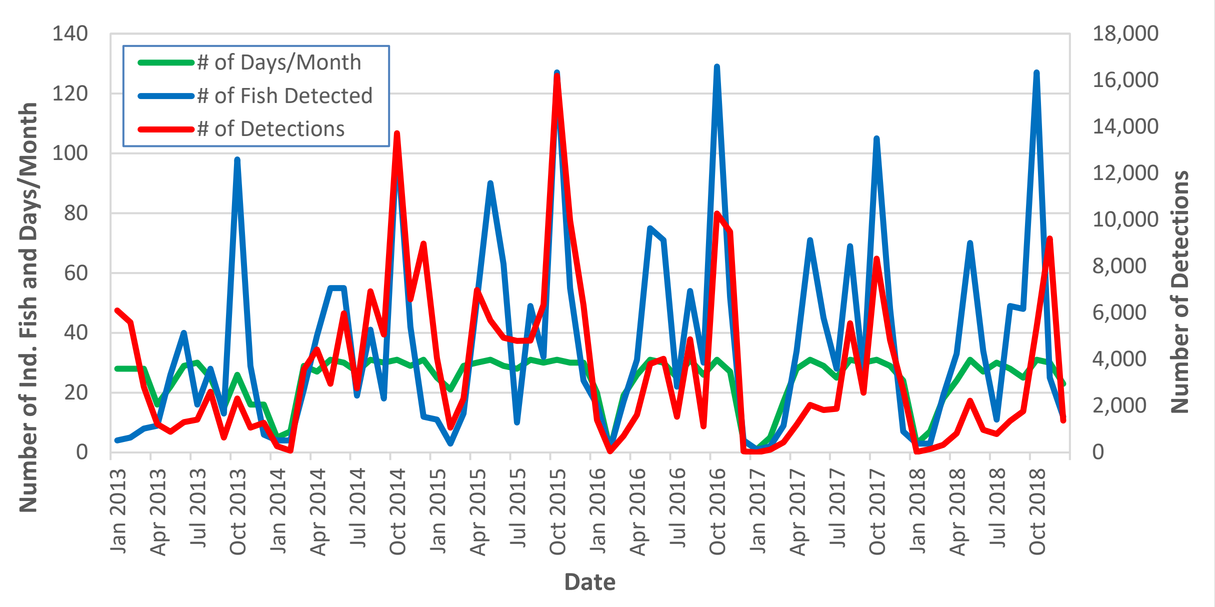

Figure 22. Atlantic sturgeon occurrence based on receiver detections in the Naval Station Norfolk zone from 2013 to 2018.

Available size-range data for fish detected in the NSN zone indicate that the zone provides native and transient sub-adults with feeding habitats (Matt Fisher, VIMS, personal communication), and is temporarily occupied by numerous adults. In contrast to the extended occupancy exhibited by some sub-adult fish, adults generally pass through the zone and do not linger.

Consistently large detection numbers suggest that the zone is heavily occupied annually, with 27,605 in 2013, 63,478 in 2014, 75,783 in 2015 , 39,934 in 2016, 31,751 in 2017, and 24,767 in 2018 (**Table 13**). An unusually high number of detections for the winter occurred in January (6,098) and February (5,596) of 2013, with most detections attributed to five sedentary sub-adults of Northeast tagging origin and most detections occurring in the James River's main channel at NN2 followed by NN5 (**Appendix 8.7**). In 2015 there was another unusually large number of detections (4,056) in January. This time, the increase was due to 11 fish with only three of Northeast tagging origin and the rest (n = 9) of James River tagging origin. In that year, the winter aggregation was again concentrated around NN5 but it also shifted its location slightly with more detections occurring in the Elizabeth River channel at NH8. February recorded the lowest values for all three parameters over the six years, followed by March.

Migrations are clearly evident by the number of fish detected in the spring, late summer, and fall in all years (**Figure 22**). In 2013, 2016, and 2017 migration peaks are most pronounced. Two immigration apexes generally occur; one in the spring (May-June) and one in August. In 2018, although a peak in abundance is evidenced in August, a peak in detection volume is not. This suggests that fish were present but were rapidly passing through the zone. Peaks in detection volume are not as obvious in 2014 or 2015 due to more downriver movement by, and extended residence times of, a few newly tagged sub-adults from the James River (Burwell Bay). April and May of each year illustrate similar patterns indicative of spring immigration into the river by adults and sub-adults, as well as increased activity levels of both. Some adults leave the James

River, exiting through the zone in June, and a few adults from the York system have entered the lower James at this time. Residence by adult females of Pamunkey River origin (13588 and 12758), who resided within the NSN zone in 2015 and 2016 during immigration, does not appear to be typical York River female behavior. This assertion is based on the large number of females that returned to spawn in the York River system in 2018 that did not enter the James River. Native adults migrate upriver through the zone in August, making their way to the spawning grounds. Emigration is evidenced each year in October, with a large number of fish passing through the zone annually.

Increased detection numbers in 2014 and 2015 (**Figure 22**) were in large part due to the extended residence times of a sub-set of sturgeon (6/111 in 2014 and 8/133 in 2015). In 2014, these fish were from varied tagging locations (three from Virginia, two from North Carolina, one from South Carolina) and of different age classes (two adults, two sub-adults, one unknown). Although in 2014 VIMS sub-adult fish tagged in the James River were detected, they did not significantly contribute to detection numbers until November (4,817 detections). Interestingly, some of these evidenced longer residence durations for the region with a few remaining as late as January of 2015. In 2015, except for a returning fish of unknown age from North Carolina, all fish that exhibited extended residence times were sub-adults tagged in the James River in 2014 or 2015 by VIMS. The October emigration period has recorded the largest number of fish every year, a trend that is due in some part, at least in 2014 and 2015, to annual upriver tagging efforts by VCU in late summer.

Table 13. Number of detections by month in the Naval Station Norfolk and Elizabeth River zones, December 2012–December 2018. Receiver sites are listed in descending order by RM. It should be noted that one of the sites (N14) which is within the NSN zone, actually occurs within the mouth of the Elizabeth River and is thus listed at the bottom of the table because sites are listed in descending river order. NA signifies a period when the receiver was not deployed. The NA that occurred at NN Danger was due to a computer failure. River miles and receiver site names can be referenced on Appendix 8.2.

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Dec. 2012	Jan. 2013	Feb. 2013	Mar. 2013	Apr. 2013	May 2013	Jun. 2013	Jul. 2013	Aug. 2013	Sep. 2013	Oct. 2013	Nov. 2013	Dec. 2013	Total
James River	5	NN8	Naval Station Norfolk	134	13	3	222	18	60	71	60	157	33	520	126	15	**1,432**
James River	5	NH10	Naval Station Norfolk	17	9	52	57	7	21	70	93	40	28	44	55	0	**493**
James River	5	NH12	Naval Station Norfolk	0	0	149	0	0	25	22	96	21	19	20	14	0	**366**
James River	5	NH14	Naval Station Norfolk	0	0	170	0	0	23	24	54	14	6	18	0	40	**349**
James River	4	NH8	Naval Station Norfolk	603	732	140	767	128	74	98	161	105	110	67	126	10	**3,121**
James River	4	NN5	Naval Station Norfolk	2,140	1,585	277	1,363	766	32	53	66	56	4	326	84	26	**6,778**
James River	3	NH5	Naval Station Norfolk	74	277	308	102	13	68	142	26	0	0	0	0	0	**1,010**
James River	3	NN2	Naval Station Norfolk	303	3,482	4,497	248	121	37	51	60	41	42	320	155	36	**9,393**
James River	2	NN 3ER NOAA SP	Naval Station Norfolk	0	0	0	0	25	130	161	93	189	128	83	79	61	**949**
James River	1	NN 1ER FWS	Naval Station Norfolk	0	0	0	0	7	197	181	250	239	142	203	90	47	**1,356**
James River	1	NN DANGER FWS	Naval Station Norfolk	0	0	0	0	28	75	185	201	245	64	155	110	60	**1,123**
James River	1	NN R22 NOAA SP	Naval Station Norfolk	0	0	0	0	134	153	248	286	1,507	70	565	211	978	**4,152**
Elizabeth River	7	NH36	Elizabeth River	0	0	0	0	0	1	65	0	0	0	0	0	0	**66**
Elizabeth River	6	NH32	Elizabeth River	0	0	0	0	0	71	53	38	0	0	17	0	0	**179**
Elizabeth River	5	NH29	Elizabeth River	0	0	0	0	0	6	3	11	0	0	16	0	0	**36**
Elizabeth River	4	APMI	Elizabeth River	0	0	0	0	0	5	15	17	14	0	22	0	0	**73**
Sum 2013				**3,271**	**6,098**	**5,596**	**2,759**	**1,247**	**978**	**1,442**	**1,512**	**2,628**	**646**	**2,376**	**1,050**	**1,273**	**30,876**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2014	Feb. 2014	Mar. 2014	Apr. 2014	May 2014	Jun. 2014	Jul. 2014	Aug. 2014	Sep. 2014	Oct. 2014	Nov. 2014	Dec. 2014	Total
James River	5	NN8	Naval Station Norfolk	30	0	202	128	354	556	69	140	67	756	270	44	**2,616**
James River	5	NH10	Naval Station Norfolk	0	0	158	461	113	318	86	394	117	38	122	218	**2,025**
James River	5	NH12	Naval Station Norfolk	0	0	239	352	141	360	50	225	101	49	41	0	**1,558**
James River	5	NH14	Naval Station Norfolk	0	0	150	135	179	263	51	125	43	51	0	0	**997**
James River	4	NH8	Naval Station Norfolk	0	0	238	454	170	310	149	453	369	773	696	1,858	**5,470**
James River	4	NN5	Naval Station Norfolk	105	0	497	324	451	767	99	140	110	9,001	3,968	4,349	**19,811**
James River	3	NH5	Naval Station Norfolk	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**0**
James River	3	NN2	Naval Station Norfolk	7	19	397	529	112	616	113	555	297	549	810	1,961	**5,965**
James River	2	NN 3ER NOAA SP	Naval Station Norfolk	6	0	423	816	215	521	174	640	275	223	194	208	**3,695**
James River	1	NN 1ER FWS	Naval Station Norfolk	6	22	499	223	329	534	232	712	744	549	201	89	**4,140**
James River	1	NN DANGER FWS	Naval Station Norfolk	16	9	465	566	473	865	336	1,240	2,286	1,219	76	72	**7,623**
James River	1	NN R22 NOAA SP	Naval Station Norfolk	105	25	307	442	416	889	1,406	2,312	656	802	200	176	**7,736**
Elizabeth River	7	NH36	Elizabeth River	0	0	0	63	0	0	0	114	81	0	0	0	**258**
Elizabeth River	6	NH32	Elizabeth River	0	0	19	40	0	0	0	202	146	0	0	0	**407**
Elizabeth River	5	NH29	Elizabeth River	0	0	3	17	0	42	0	197	60	20	0	0	**339**
Elizabeth River	4	APMI	Elizabeth River	0	0	325	26	112	155	0	175	14	31	0	0	**838**
Sum 2014				**275**	**75**	**3922**	**4576**	**3065**	**6196**	**2765**	**7624**	**5366**	**14061**	**6578**	**8975**	**63,478**
Total 2013-2014				**6,373**	**5,671**	**6,681**	**5,823**	**4,043**	**7,638**	**4,277**	**10,252**	**6,012**	**16,437**	**7,628**	**10,248**	**91,083**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2015	Feb. 2015	Mar. 2015	Apr. 2015	May 2015	Jun. 2015	Jul. 2015	Aug. 2015	Sep. 2015	Oct. 2015	Nov. 2015	Dec. 2015	Total
James River	5	NN8	Naval Station Norfolk	229	127	143	377	550	511	74	180	830	2,987	1,548	82	**7,638**
James River	5	NH10	Naval Station Norfolk	149	96	33	229	173	306	89	199	76	53	656	600	**2,659**
James River	5	NH12	Naval Station Norfolk	1	0	60	249	233	336	85	254	171	94	884	1,645	**4,012**
James River	5	NH14	Naval Station Norfolk	15	0	195	144	446	412	64	160	151	121	438	719	**2,865**
James River	4	NH8	Naval Station Norfolk	802	76	136	874	400	489	107	241	199	74	701	513	**4,612**
James River	4	NN5	Naval Station Norfolk	2,187	14	1,050	2,628	650	420	60	358	2,663	8,045	3,046	1,497	**22,618**
James River	3	NN2	Naval Station Norfolk	335	596	396	455	386	635	1,147	370	932	3,323	1,493	603	**10,671**
James River	2	NN 3ER NOAA SP	Naval Station Norfolk	60	32	115	202	479	395	334	862	770	227	289	301	**4,066**
James River	1	NN 1ER FWS	Naval Station Norfolk	82	51	80	313	530	549	457	823	265	327	264	158	**3,899**
James River	1	NN DANGER FWS	Naval Station Norfolk	48	17	45	745	833	390	460	93	4	366	286	83	**3,370**
James River	1	NN R22 NOAA SP	Naval Station Norfolk	148	61	70	765	996	495	1,917	1,265	289	574	367	125	**7,072**
Elizabeth River	7	NH36	Elizabeth River	0	0	0	0	43	116	30	22	10	0	0	0	**221**
Elizabeth River	6	NH32	Elizabeth River	0	0	0	0	117	63	43	25	51	0	62	10	**371**
Elizabeth River	5	NH29	Elizabeth River	43	0	0	0	88	223	130	37	162	0	67	86	**836**
Elizabeth River	4	APMI	Elizabeth River	194	0	0	54	146	164	65	34	59	31	44	82	**873**
Sum 2015				**4,293**	**1,070**	**2,323**	**7,035**	**6,070**	**5,504**	**5,062**	**4,923**	**6,632**	**16,222**	**10,145**	**6,504**	**75,783**
Total 2013-2015				**10,666**	**6,741**	**9,004**	**12,858**	**10,113**	**13,142**	**9,339**	**15,175**	**12,644**	**32,659**	**17,773**	**16,752**	**166,866**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	Jun. 2016	Jul. 2016	Aug. 2016	Sep. 2016	Oct. 2016	Nov. 2016	Dec. 2016	Total
James River	5	NN8	Naval Station Norfolk	53	0	66	112	458	631	396	143	140	1,113	540	2	**3,654**
James River	5	NH10	Naval Station Norfolk	111	0	52	163	127	147	50	165	73	72	42	0	**1,002**
James River	5	NH12	Naval Station Norfolk	124	0	67	119	263	360	228	179	87	132	37	0	**1,596**
James River	5	NH14	Naval Station Norfolk	58	0	26	168	143	145	81	134	121	13	0	0	**889**
James River	4	NH8	Naval Station Norfolk	239	0	27	173	182	252	183	215	58	188	81	0	**1,598**
James River	4	NN5	Naval Station Norfolk	510	0	105	86	274	398	108	152	315	6,184	1356	0	**9,488**
James River	3	NN2	Naval Station Norfolk	46	0	30	120	298	401	94	360	67	881	234	6	**2,537**
James River	2	NN 3ER NOAA SP	Naval Station Norfolk	81	0	37	112	382	347	97	1,468	95	448	167	1	**3,235**
James River	1	NN 1ER FWS	Naval Station Norfolk	80	0	35	136	485	526	66	488	76	328	258	25	**2,503**
James River	1	NN DANGER FWS	Naval Station Norfolk	52	50	86	202	514	320	48	242	43	248	218	0	**2,023**
James River	1	NN R22 NOAA SP	Naval Station Norfolk	47	8	184	231	662	493	187	1,317	56	662	6,549	2	**10,398**
Elizabeth River	7	NH36	Elizabeth River	0	0	0	0	0	4	0	0	93	0	0	0	**97**
Elizabeth River	6	NH32	Elizabeth River	0	0	9	0	0	92	4	34	85	0	0	0	**224**
Elizabeth River	5	NH29	Elizabeth River	0	0	163	0	0	59	30	70	109	0	0	0	**431**
Elizabeth River	4	APMI	Elizabeth River	0	0	74	6	0	66	10	25	78	0	0	0	**259**
Sum 2016				**1,401**	**58**	**961**	**1,628**	**3,788**	**4,241**	**1,582**	**4,992**	**1,496**	**10,269**	**9,482**	**36**	**39,934**
Total 2013-2016				**12,067**	**6,799**	**9,965**	**14,486**	**13,901**	**17,383**	**10,921**	**20,167**	**14,140**	**42,928**	**27,255**	**16,788**	**206,800**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2017	Feb. 2017	Mar. 2017	Apr. 2017	May 2017	Jun. 2017	Jul. 2017	Aug. 2017	Sep. 2017	Oct. 2017	Nov. 2017	Dec. 2017	Total
James River	5	NN8	Naval Station Norfolk	0	18	56	102	294	262	157	176	320	1,408	381	10	**3,184**
James River	5	NH10	Naval Station Norfolk	0	0	11	74	99	30	103	62	25	29	14	18	**465**
James River	5	NH12	Naval Station Norfolk	0	0	14	204	82	110	19	43	21	2	24	1	**520**
James River	5	NH14	Naval Station Norfolk	0	0	0	90	97	39	33	18	33	1	16	0	**327**
James River	4	NH8	Naval Station Norfolk	0	0	31	43	119	86	164	148	107	66	22	15	**801**
James River	4	NN5	Naval Station Norfolk	1	10	31	75	240	340	227	177	430	4,723	3,595	2,430	**12,279**
James River	3	NN2	Naval Station Norfolk	0	12	34	82	188	148	405	363	946	1,449	258	163	**4,048**
James River	2	NN 3ER NOAA SP	Naval Station Norfolk	1	46	45	60	238	187	194	313	159	55	97	25	**1,420**
James River	1	NN 1ER FWS	Naval Station Norfolk	0	2	87	122	228	353	253	212	189	174	187	19	**1,826**
James River	1	NN DANGER FWS	Naval Station Norfolk	0	17	15	87	130	87	62	72	51	111	79	0	**711**
James River	1	NN R22 NOAA SP	Naval Station Norfolk	0	17	117	248	325	181	261	3,964	294	316	147	1	**5,871**
Elizabeth River	7	NH36	Elizabeth River	0	0	0	0	0	0	0	13	7	0	0	0	**20**
Elizabeth River	6	NH32	Elizabeth River	0	0	0	0	0	0	0	20	37	0	15	0	**72**
Elizabeth River	5	NH29	Elizabeth River	0	0	0	26	0	0	1	1	28	0	12	0	**68**
Elizabeth River	4	APMI	Elizabeth River	0	0	0	79	0	0	8	3	29	0	20	0	**139**
Sum 2017				**2**	**122**	**441**	**1,292**	**2,040**	**1,823**	**1,887**	**5,585**	**2,676**	**8,334**	**4,867**	**2,682**	**31,751**
Total 2013-2017				**12,069**	**6,921**	**10,406**	**15,778**	**15,941**	**19,206**	**12,808**	**25,752**	**16,816**	**51,262**	**32,122**	**19,470**	**238,551**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2018	Feb. 2018	Mar. 2018	Apr. 2018	May-18	Jun. 2018	Jul. 2018	Aug. 2018	Sep. 2018	Oct. 2018	Nov. 2018	Dec. 2018	Total
James River	5	NN8	Naval Station Norfolk	0	34	19	119	335	119	18	149	274	1,618	1,599	18	**4,302**
James River	5	NH10	Naval Station Norfolk	8	0	1	6	75	29	3	129	149	214	104	142	**860**
James River	5	NH12	Naval Station Norfolk	0	0	0	17	103	69	15	73	157	213	17	44	**708**
James River	5	NH14	Naval Station Norfolk	0	0	0	0	48	79	6	39	215	51	0	3	**441**
James River	4	NH8	Naval Station Norfolk	3	2	0	24	64	56	21	162	250	151	862	56	**1,651**
James River	4	NN5	Naval Station Norfolk	0	15	5	118	339	67	17	55	102	1,335	2,201	92	**4,346**
James River	3	NN2	Naval Station Norfolk	2	27	157	67	210	62	39	44	123	635	1,523	346	**3,235**
James River	2	NN 3ER NOAA SP	Naval Station Norfolk	4	44	13	43	97	76	126	164	227	258	128	108	**1,288**
James River	1	NN 1ER FWS	Naval Station Norfolk	1	13	38	116	296	101	41	145	78	321	20	0	**1,170**
James River	1	NN DANGER FWS	Naval Station Norfolk	1	0	31	63	194	40	18	67	77	415	133	7	**1,046**
James River	1	NN R22 NOAA SP	Naval Station Norfolk	1	11	67	253	469	277	484	327	117	184	2,615	549	**5,354**
Elizabeth River	7	NH36	Elizabeth River	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Elizabeth River	6	NH32	Elizabeth River	0	0	0	0	0	5	0	0	77	1	0	0	**83**
Elizabeth River	5	NH29	Elizabeth River	0	0	0	0	0	7	0	0	89	60	0	0	**156**
Elizabeth River	4	APMI	Elizabeth River	0	0	0	0	0	10	0	6	102	9	0	0	**127**
Sum 2018				**20**	**146**	**331**	**826**	**2,230**	**997**	**788**	**1,360**	**2,037**	**5,465**	**9,202**	**1,365**	**24,767**
Total 2013-2018				**12,089**	**7,067**	**10,737**	**16,604**	**18,171**	**20,203**	**13,596**	**27,112**	**18,853**	**56,727**	**41,324**	**20,835**	**263,318**

3.5.5.2. Elizabeth River

In 2013, five Atlantic sturgeon were recorded as occupying the Elizabeth River zone (354 detections): three tagged in Delaware, one in North Carolina, and one in the James River, Virginia (**Table 14**). The zone was occupied from late May to August. The month with the greatest number of detections was June (**Table 13**) and these were from a single fish tagged in North Carolina. In 2014, 20 sturgeon were recorded (1,842 detections). Nine, nearly half the fish, were tagged in the James River (two were sub-adults with short residence periods), 10 fish were tagged in Delaware, and one was again from North Carolina. Fish were within the zone from March to June and from August to October in 2014. The largest numbers of fish and detections occurred in August due to 10 fish—six adults tagged in the James River and four from the Northeast. In 2015, 29 different sturgeon were detected (2,271 detections). Nineteen fish were tagged in the James, seven of which were sub-adults. Nine were of Delaware tagging origin and unknown age, but because large-mesh nets are used in the ocean to collect fish, most, if not all, were adults. One fish of unknown age was from North Carolina. Fish occupied the zone in January and April–December in 2015. The largest number of detections occurred in June and the largest number of fish occurred in September. In 2016, sturgeon were present in March–April and June–September. Fish from North Carolina were not detected, but five sturgeon were tagged in the Northeast and 13 were tagged in the James River. The largest numbers of detections and fish occurred in September due to the presence of adult fish from Delaware (n = 3) and the James River (n = 5). The second largest number of detections occurred due to two sub-adults in March. In 2017, only 9 tagged fish occupied the Elizabeth River; 8 tagged in the Chesapeake and one tagged in the Northeast. The largest number of detections occurred in April and was due to one sedentary sub-adult tagged in the James River. In 2018, 16 fish were detected in the Elizabeth River. The four detected during immigration, three in June and one in August were tagged in the James River by VCU. In September there were 10 different sturgeon present, all were tagged by VIMS or VCU. October recorded four fish and this time one female (13588/17240) tagged in the Pamunkey River joined three fish of James River tagging origin. Female 13588 is a highly mobile, wandering female that was discussed fully in the previous Pamunkey River section. The largest numbers of fish in all years but 2013 and 2014 occurred in September. The largest number of detections (n = 688) in a single month occurred in August of 2014 when fish moved through this zone earlier than usual. The numbers of detections and days per month detected reflect the characteristically short durations of adult residence during these periods (**Figure 23**).

Table 14. Tagging origin of Atlantic sturgeon detected within the Elizabeth River zone annually from 2013 to 2018.

Year	Northeast	Chesapeake Bay	Southeast	Total Detected
2013	3	1	1	5
2014	10	9	1	20
2015	9	19	1	29
2016	5	13	0	18
2017	1	8	0	9
2018	0	16	0	16

Although few sub-adults were detected in the winter and early spring, their sedentary behavior accounted for numerous detections in January, March, November, and December. Peak periods of detections across years for all sturgeon were June and August–September. June detections were from adult and sub-adult fish (n = 19) tagged in highly varied locations. August (n = 24) and September (n = 32) fish were almost equally split between adults tagged in the James and adults tagged offshore in Delaware waters in all years but 2018, when they were all of Chesapeake tagging origin. The June period corresponds with adult outward migration from the James River as well as coastal migrations up the coast. The August–September period corresponds to native James River fish immigrating into the freshwater reaches of the river to spawn. We are not suggesting that these adults visiting the Elizabeth River are there to spawn but that they are following the freshwater source to determine if it is the correct path to the spawning grounds. This would also explain why such a comparatively large number of fish entered the river in 2018. York River adults have been documented demonstrating similar behavior in numerous other freshwater tributaries (**Table 5**) prior to correctly selecting their natal spawning locations.

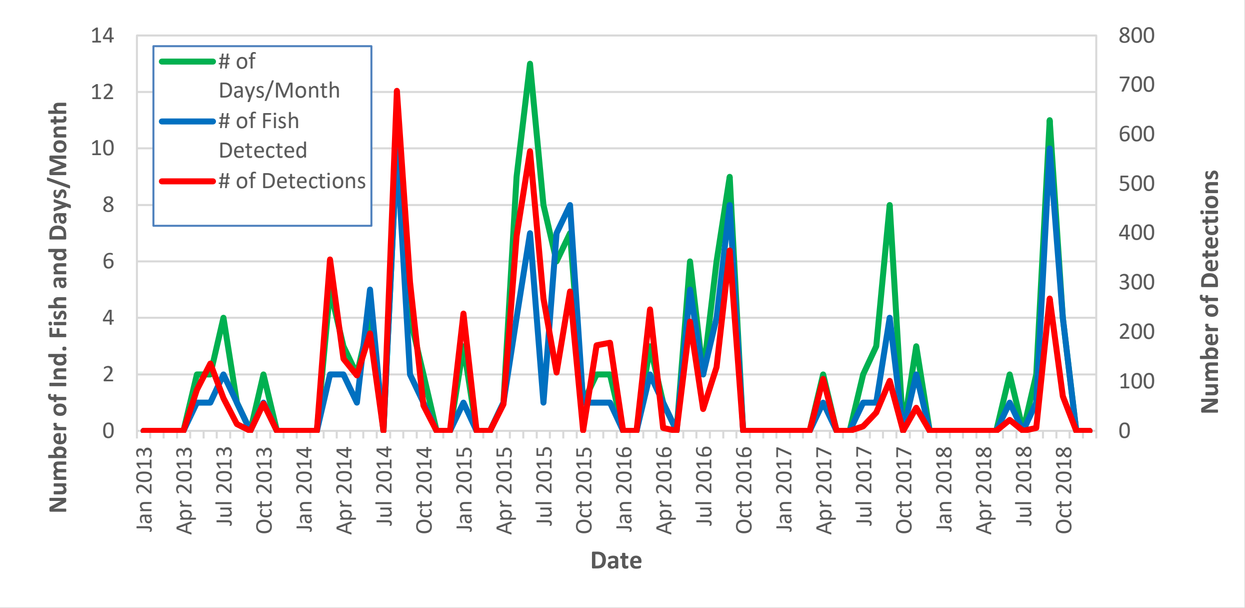

Figure 23. Atlantic sturgeon occurrence based on receiver detections in the Elizabeth River zone from 2013 to 2018.

No fish have gone upriver past the last Elizabeth River station (NH36) without returning to the Norfolk zone; therefore, there is no evidence that the Elizabeth River is being used as a passage into North Carolina waters through the inland waterway. Maps indicating detections by month are presented for both the NSN and Elizabeth River zones in **Appendix 8.7**.

3.5.6. Lower Chesapeake Region (Little Creek and Fort Story Zones)

The receivers that characterize the lower Chesapeake region form an irregular gate across the mouth of the Chesapeake Bay, extending up both the Baltimore and Thimble Shoals channels (**Appendix 8.2**). These channels ultimately lead to all of the tributaries in the bay. The southernmost channel, the Thimble Shoals Channel, passes between the first and second CBBT islands and terminates in Hampton Roads where the NSN zone is located (**Figure 5**).

The Thimble Shoals Channel leads to and receives water from the James River alone. It conveys a massive outflow of fresh water, originating from the western portion of Virginia, into and along the southern shore of the lower bay, where its water quality attributes influence Atlantic sturgeon occupation patterns in both the Little Creek and Fort Story zones. Detections within the Little Creek and Fort Story zones are referred to here but are described more fully in their own sections that follow.

The Baltimore Channel joins the Thimble Shoals Channel in the deep holes located off Fort Story, where the Chesapeake Bay joins the Atlantic Ocean and where the 2C Henry receiver is located (**Appendix 8.2**). The Baltimore Channel extends through the middle of the bay passing north between the third and fourth islands on the CBBT. The Baltimore Channel leads to every tributary in the bay except the James River. The York River channel, which ends in the NW/Ch. zone, splits off the Baltimore Channel at York Spit about 8 km north of the CBBT.

The channels and holes within the region provide sturgeon and other species with migration corridors and deepwater refugia. The degree to which these channels are occupied by sturgeon in the late spring and early summer appears to be highly variable inter-annually. Detection data clearly identify fish of various tagging origins exhibiting sedentary behavior within the channels and holes at the mouth of the bay during inshore immigration each spring and early to mid-summer, but preferred locations shift between years. Thirteen of these receivers are not located within any military zone but surround these zones (**Appendix 8.1**).

The geographical positions of both the Little Creek and Fort Story zones in the middle of the range of the Atlantic sturgeon and their location at the mouth of the largest estuary in North America increase their use by and importance to the species. The zones experience constant occupation by numerous life stages of various DPSs. Increases in the number of sturgeon and detection numbers of various life stages throughout the lower Chesapeake region in the spring, summer, and fall demonstrate sturgeon migrating through the mouth of the bay and clearly mark the importance of the region as a resting, staging, and feeding area, as well as a migration corridor for both transient and native sturgeon (**Figure 24**, **Table 15**).

Table 15. Tagging origin of Atlantic sturgeon detected within the Chesapeake Bay region annually from 2013 to 2018.

Year	Northeast	Chesapeake Bay	Southeast	Total Detected
2013	131	126	15	272
2014	176	196	14	386
2015	187	264	12	463
2016	121	310	9	440
2017	118	315	2	435
2018	82	289	10	381

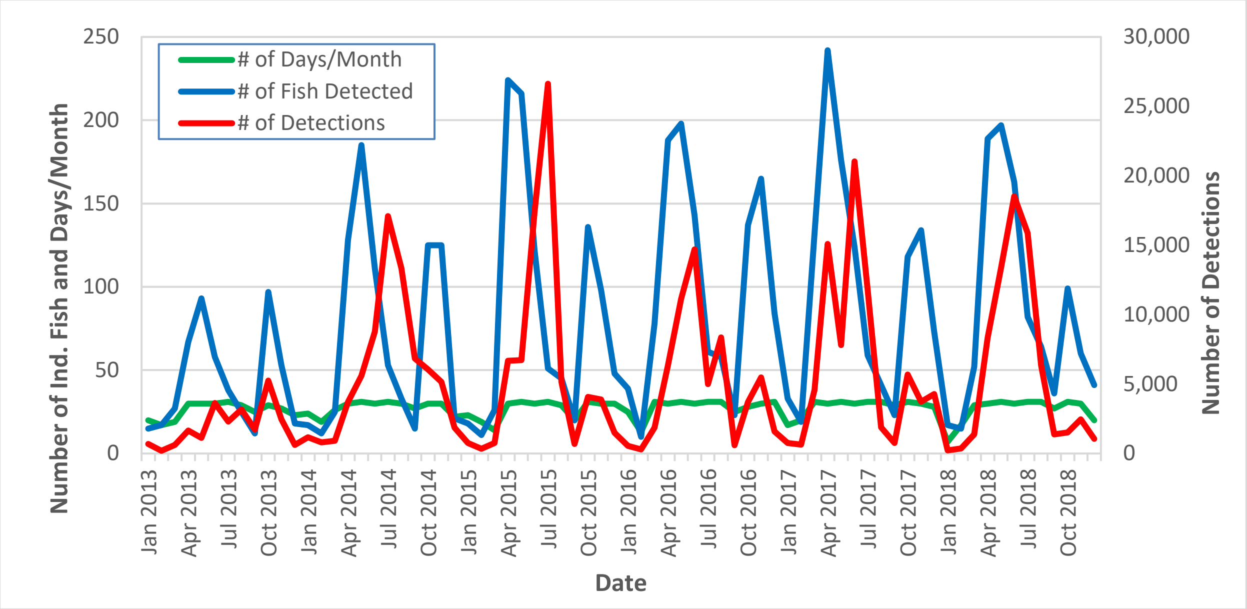

Figure 24. Atlantic sturgeon occurrence based on receiver detections occurring at the mouth of the Chesapeake Bay from 2013 to 2018.

The total number of fish detected in the region that were tagged in the Chesapeake Bay illustrates an increasing trend from 2013 to 2017. This is in part due to increased tagging efforts by VIMS, VCU, and the Navy and reflects increasing rates of return over time for adult fish. The slight decline in fish of native tagging origin in 2018 also corresponds to decreased tagging efforts. The number of fish of Northeast tagging origin, most of which were tagged off the coast of Delaware, has remained reasonably constant over time. While the number of fish of Northeast tagging origin declined slightly in 2018, the number of fish of Southeast tagging origin experienced a slight resurgence from its steady decline from 2013 to 2017 (**Table 15**).

3.5.6.1. Eastern Chesapeake Bay Region and Baltimore Channel

There are 13 receivers located outside military zones at the mouth of the Chesapeake Bay (**Figure 5**). Six of these occur within the Baltimore Channel (B5, B7, B9, B11, B13, and B15), two are along the eastern shore (LS and 10N), three are on the eastern section of the CBBT (CBBT1, CBBT2, and CBBT7), one is in the middle section (CBBT3), and one is located between Little Creek and Fort Story zones in the Thimble Shoals Channel (TS5; **Appendix 8.1**). Atlantic sturgeon detected at these locations were primarily of Chesapeake Bay origin (**Table 16**), with this trend increasing in recent years due to augmentation of within-bay tagging efforts. There were also large numbers of fish detected from the Northeast, as many of these fish visit the mouth of the bay when they move inshore in the spring prior to their migration north. A few of these, and a larger percentage of fish from Southeast origin, remain in the mouth during the entire summer. In some cases, their sedentary behavior during this period significantly increased the total number of annual detections.

Table 16. Tagging origin of Atlantic sturgeon detected within the Eastern Chesapeake Bay Region/Baltimore Channel, excluding those in Little Creek and Fort Story, annually from 2013 to 2018.

Year	Northeast	Chesapeake Bay	Southeast	Total Detected
2013	111	106	13	230
2014	173	185	10	368
2015	171	250	8	429
2016	111	278	7	396
2017	102	312	3	417
2018	73	279	10	362

Annual detection totals within the stations of this region were 8,010 in 2013, 32,782 in 2014, 49,959 in 2015, 30,374 in 2016, 48,007 in 2017, and 38,956 in 2018. During every year the stations within the Baltimore Channel recorded the majority of annual detections, with the percentage of detections ranging from 65 to 81 percent. Receiver B9 had the largest number of detections (n = 68,403) followed by B15 (38,732) and B11 (23,653). When data from the Baltimore Channel were less dominant a larger percentage of detections were recorded at the TS5 and CBBT2 receivers (**Appendix 8.1**). Inter-annual variability between detection numbers at specific sites within the region was linked more closely to individual fish behavior rather than fish numbers. In July 2014, an unusually large number (n = 2,408) of detections occurred at the TS5 receiver. Forty-nine percent of these detections (n = 1186) were due to a single fish (20471) tagged in Delaware. In June of 2017, 20471 returned to the Thimble Shoals Channel and resided at TS3 within the Fort Story zone for an extended period of time. During its residence it was detected 1,049 times which was 66 percent of the total number of detections for the month at TS3 (**Table 21**).

Large increases in the number of detections in 2014 within the Chesapeake Bay region (**Figure 25**) were primarily due to increased detections in June and July in the B9 site and June through August at the B15 site. In June, two fish tagged in Northeast locations exhibited sedentary behavior in the B9 site; these fish were responsible for 64 percent or 923 of the 1,435 detections recorded. In July 2014, there were only 14 fish detected in the B9 site versus the 24 detected in June (**Table 17**). Although the two sedentary fish present in June were no longer present in July, three others of Northeast tagging origin replaced them. These three contributed to an even greater proportion (3,254/4,608 = 70 percent) of the increased number of detections in July. A significant number of detections (1,190/4,608 = 26 percent) also resulted from three slow-moving fish of James River tagging origin. There were 70 Atlantic sturgeon detected in the B15 site in June, 32 in July, and 15 in August. Of the 70 detected in June, 52 were of Chesapeake tagging origin and 16 of Northeast origin. Most fish were moving through the channel and did not overwhelmingly contribute to the total (n = 2,279). In July, although the number of fish was less than half that present in June, the average number of detections per fish increased from 33 to 50 indicating that fish were less active (**Table 17**). In August, 2,088 detections were recorded from only 15 sturgeon. Six fish demonstrated sedentary behavior, three of Northeast tagging origin and three from the James River.

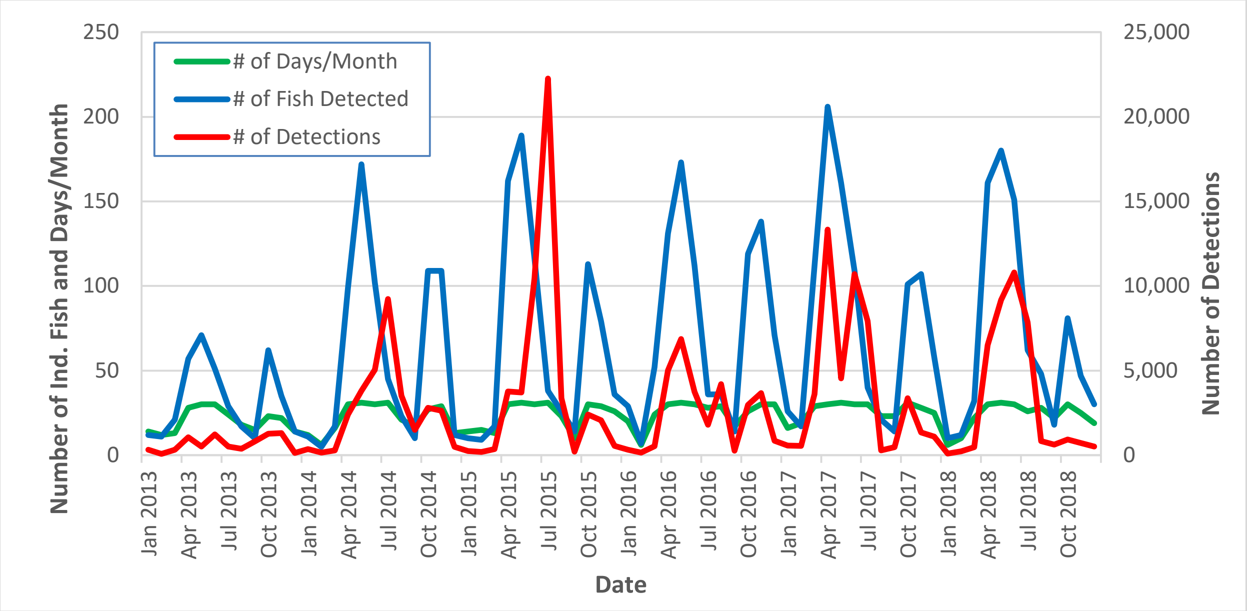

Figure 25. Atlantic sturgeon occurrence based on receiver detections occurring at the mouth of the Chesapeake Bay from 2013 to 2018 excluding Little Creek and Fort Story zones.

In 2015, a huge number of detections was recorded at the B9 site (**Table 17**; **Appendix 8.1**) in July (n = 20,922), but the number of detections from June to August was also larger. An increased number was also recorded at B11 and TS5 during June but these numbers were an order of magnitude lower than that recorded at B9. Of the 6,504 detections generated by the 36 tagged fish present near B9 in June, 2,186 (34 percent) were due to a single fish of Northeast origin. Another 1,354 detections were due to a native York River fish (21 percent). The other 28 fish of Chesapeake tagging origin present contributed additional 2,747 detections (42 percent). Despite the fact that only 11 fish were left at B9 in July, an extremely large number of detections (n = 20,922) was recorded. Four of the 11 fish, three of Chesapeake tagging origin (n = 14,092) and one of Northeast origin (n = 5,798), contributed thousands of detections, thus exhibiting the most sedentary behavior recorded in this region to date. In August, only four fish remained at the site but a single female of York River origin that was detected (n = 6,683) in July was detected 1,491 more times (1,491/2,722 = 56 percent).

In 2016, the receiver at the B11 site (**Table 17**; **Appendix 8.1**) just up the channel from the B9 site recorded 25 fish and a greater detection number (n = 987) than was typical in April. Sixty-six percent of detections were from two fish tagged in the James River. There were 14 fish of Chesapeake tagging origin present. In May, 49 fish were present—34 of Chesapeake tagging origin. Of the 2,750 detections, 1,661 (60 percent) were from two fish, one from the York River and one tagged in Connecticut. In June, the number of fish at B11 dropped to 26 and then to 10 by July. June recorded a reasonably normal number of fish at B9 (n = 27) but only one fish from the Northeast (20446) exhibited any sort of site fidelity with 52 percent (621/1,196) of the total detections. In July, the number of fish at B9 dropped to a record low of six fish. A single York River female (1177) accounted for 73 percent of detections and a fish from the Delaware (20446) contributed another 25 percent of detections. In August, although the number of fish detected was higher (n = 12), only 299 detections were recorded, a large percentage (38 percent) from one Pamunkey adult (1177). Interestingly, although the number of fish detected at B15 decreased from 17 in July to 14 in August, the number of detections increased drastically from 238 to 2,594. Again, a single fish of Pamunkey origin (12744) demonstrated extreme site fidelity, accounting for 2,323 detections (90 percent).

CBBT2 experienced an exceptionally large total number of detections (n = 5,950) in 2016 (**Table 17**; **Appendix 8.1**). In this case, the total number of detections was more evenly dispersed over time, with large numbers occurring during April–May as well as November. Increased April (n = 2,663) and May (n = 1,854) detections were due to numerous fish, n = 44 and 45, respectively. Only seven of these fish were detected in both months. The largest numbers of fish detected at CBBT2 (n = 15 James River, n = 4 York River, and n = 7 unknown) and largest number of detections (n = 1,111) were due to Atlantic sturgeon of Chesapeake tagging origin. In May 2016, the percentage of sturgeon of Chesapeake tagging origin (n = 24 James River, n = 5 York River, and n = 1 unknown) increased from 59 to 67 percent, but fewer fish of Northeast tagging origin accounted for the majority of detections (n = 848 vs. 1,006). The bulk of these detections (n = 862) were due to the sedentary behavior of four fish. In November 2016 the number of detections at CBBT2 was again unusually high (n = 1,132). This increase in detection number was due to the presence of 17 fish; 11 of Chesapeake Bay tagging origin. Two fish from the James River contributed 71 percent of the monthly receptions (809/1,132 detections).

In 2017, numerous Atlantic sturgeon entered the region in early spring (April), spreading throughout the Baltimore Channel and occupying sites between B7 and B15 (**Appendix 8.1**). In 2017 sturgeon (n = 73) demonstrated a preference for B13 in April (**Table 17**). Fish (n = 41) began to show at B9 in April as well, but detection numbers peaked as usual in June and July. The site was heavily occupied in June 2017 with 44 fish present. This number dropped to 12 in July but typical sedentary behavior demonstrated by three fish during this warm period resulted in an increased number of detections from 4,421 to 5,825. By August 2017, only two fish, which were not of Pamunkey stock, remained at B9. All immigrating Pamunkey River sturgeon had already moved up-channel of B9 and even into the York River by this time. Neither of these two remaining fish demonstrated sedentary behavior.

In 2018, B15, B11, and B9 were all heavily occupied again (**Table 17**; **Appendix 8.1**). In this year detections at B15 were most numerous (n = 18,049) and the period during which they were greatest was May –July. There were 127, 121, and 44 individual Atlantic sturgeon within the B15 reception distance in April, May, and June, respectively. The average number of detections per fish increased from 33 to 63 and was 98 in August. The number of detections at B9 was second largest (n = 5,417) with a largest number of detections occurring in April and May. In April, 26 fish were detected and in May the number increased to 34. The average number of detections per fish increased from 45 to 59 from April to May. One fish of Northeast tagging origin was responsible for 1,281 detections at B11 in May or 63 percent of the month's detections. The third largest number of detections occurred at B11 and its largest number of detections (n = 2,134) occurred in July. Again a single native York River fish was responsible for a large portion (90 percent) of total detections.

Closer examination of 2014–2018 data suggests that sedentary behavior is repeated to varied degrees annually, with detections most often occurring in the Baltimore Channel in the B9 through B15 sites (**Table 17**; **Appendix 8.1**) during late spring and early summer and again in the fall due to fish migrations. Large inter-annual differences in the numbers of detections in the region are often linked to the behavior of individuals through site-specific habitat selection rather than to fish numbers. This is supported by numerous observations in various locations where the detection number is dramatically increased due to the sedentary behavior of a small number of fish. This being said, sedentary behavior, indicated by consistent increases in the average number of detections per fish, is positively correlated with increasing water temperatures.

Figure 25 illustrates some of the annual variation in the temporal and spatial aspects of occupation within the Baltimore Channel sites. Normal immigration patterns in the spring and early summer marked by peaks in numbers and detections in mid-summer are evident in 2014, 2015, and 2017. By late summer fish have moved upriver towards spawning grounds. In 2016, a second peak in August due to a few Pamunkey fish exemplifying extreme sedentary behavior suggests that immigrating fish did not move upriver, but remained or returned to the mouth of the bay where they waited to immigrate. Tracking data in Little Creek and Fort Story in the following sections will support this assertion.

Table 17. Number of detections by month in the lower Chesapeake Bay, which do not occur within the Little Creek or Fort Story military zones, December 2012–December 2018. Receiver sites are listed in descending order by RM. NA signifies a period when the receiver was not deployed. River miles and receiver site names can be referenced on Appendix 8.2.

Geographic Region	Miles from COLREGS	Receiver Site Name	Military Interest Zone	Dec. 2012	Jan. 2013	Feb. 2013	Mar. 2013	Apr. 2013	May 2013	Jun. 2013	Jul. 2013	Aug. 2013	Sep. 2013	Oct. 2013	Nov. 2013	Dec. 2013	Total
Chesapeake Bay	10	B15	None	5	38	5	1	26	67	227	130	105	514	375	689	0	**2,182**
Chesapeake Bay	8	B13	None	204	12	0	42	54	59	44	17	85	180	144	46	17	**904**
Chesapeake Bay	8	CBBT1	None	0	1	14	0	7	12	0	0	0	0	0	0	0	**34**
Chesapeake Bay	8	CBBT2	None	0	24	0	62	69	44	5	2	0	0	43	11	9	**269**
Chesapeake Bay	8	CBBT7	None	0	0	0	8	47	38	13	0	0	0	90	48	18	**262**
Chesapeake Bay	8	LS	None	4	6	4	22	53	28	2	0	0	0	27	10	0	**156**
Chesapeake Bay	7	CBBT3	None	0	84	7	28	39	0	0	8	35	10	56	40	4	**311**
Chesapeake Bay	6	10N	None	17	37	0	36	38	105	27	9	0	0	57	11	24	**361**
Chesapeake Bay	5	B11	None	20	0	4	0	53	29	677	212	72	48	151	106	6	**1,378**
Chesapeake Bay	4	B9	None	5	33	18	29	409	32	46	24	20	7	147	98	1	**869**
Chesapeake Bay	4	TS5	None	35	33	13	59	124	72	102	50	42	29	0	0	33	**592**
Chesapeake Bay	3	B7	None	12	15	0	0	27	18	75	45	12	11	94	195	22	**526**
Chesapeake Bay	2	B5	None	2	4	0	33	165	32	18	14	16	15	102	65	4	**470**
Sum 2013				**304**	**287**	**65**	**320**	**1,111**	**536**	**1,236**	**511**	**387**	**814**	**1,286**	**1,319**	**138**	**8,314**

Geographic Region	Miles from COLREGS	Receiver Site Name	Military Interest Zone	Jan. 2014	Feb. 2014	Mar. 2014	Apr. 2014	May 2014	Jun. 2014	Jul. 2014	Aug. 2014	Sep. 2014	Oct. 2014	Nov. 2014	Dec. 2014	Total
Chesapeake Bay	10	B15	None	23	0	6	82	767	2,279	1,585	2,088	4	157	184	0	**7,815**
Chesapeake Bay	8	B13	None	126	13	1	90	122	142	0	46	44	101	153	133	**923**
Chesapeake Bay	8	CBBT1	None	16	0	4	37	184	2	0	0	5	4	17	0	**349**
Chesapeake Bay	8	CBBT2	None	0	0	9	315	816	60	12	11	2	261	119	0	**1,667**
Chesapeake Bay	8	CBBT7	None	4	11	2	258	747	35	0	4	1	276	84	1	**1,037**
Chesapeake Bay	8	LS	None	0	0	0	119	212	68	3	6	3	91	20	8	**504**
Chesapeake Bay	7	CBBT3	None	3	0	67	233	210	100	78	24	0	294	325	53	**1,441**
Chesapeake Bay	6	10N	None	14	11	25	435	420	59	0	0	1	134	39	7	**1,051**
Chesapeake Bay	5	B11	None	27	5	46	79	103	239	464	149	146	196	224	25	**1,698**
Chesapeake Bay	4	B9	None	66	11	26	528	140	1,435	4,608	584	750	446	1,070	210	**9,074**
Chesapeake Bay	4	TS5	None	41	88	53	101	143	543	2,391	615	322	560	144	22	**5,029**
Chesapeake Bay	3	B7	None	26	8	0	156	63	96	93	4	166	172	163	17	**907**
Chesapeake Bay	2	B5	None	17	11	49	91	89	63	0	0	54	200	116	23	**654**
Sum 2014				**363**	**158**	**288**	**2,524**	**4,016**	**5,121**	**9,234**	**3,531**	**1,498**	**2,892**	**2,658**	**499**	**32,149**
Total 2013-2014				**650**	**223**	**608**	**3,635**	**4,552**	**6,357**	**9,745**	**3,918**	**2,312**	**4,178**	**3,977**	**637**	**40,463**

Geographic Region	Miles from COLREGS	Receiver Site Name	Military Interest Zone	Jan. 2015	Feb. 2015	Mar. 2015	Apr. 2015	May 2015	Jun. 2015	Jul. 2015	Aug. 2015	Sep. 2015	Oct. 2015	Nov. 2015	Dec. 2015	Total
Chesapeake Bay	10	B15	None	3	31	17	75	561	998	336	213	27	233	276	58	**2,782**
Chesapeake Bay	8	B13	None	79	0	12	81	606	357	63	13	2	90	89	29	**1,403**
Chesapeake Bay	8	CBBT1	None	2	5	1	54	29	1	0	0	4	11	0	9	**111**
Chesapeake Bay	8	CBBT2	None	46	5	2	414	281	55	0	0	11	28	0	31	**872**
Chesapeake Bay	8	CBBT7	None	1	25	68	350	338	4	0	0	6	0	77	31	**899**
Chesapeake Bay	8	LS	None	3	1	36	181	113	40	1	0	2	5	5	0	**387**
Chesapeake Bay	7	CBBT3	None	9	22	151	1,017	1,077	392	26	5	0	394	102	84	**3,266**
Chesapeake Bay	6	10N	None	19	25	17	982	285	35	0	0	13	161	18	20	**1,545**
Chesapeake Bay	5	B11	None	12	6	37	105	190	766	300	70	42	419	260	90	**2,265**
Chesapeake Bay	4	B9	None	25	13	21	335	178	6,504	20,922	2,722	5	608	687	84	**32,067**
Chesapeake Bay	4	TS5	None	30	1	17	115	38	722	495	126	48	245	330	23	**2,142**
Chesapeake Bay	3	B7	None	6	5	0	177	61	413	75	207	4	88	113	47	**1,188**
Chesapeake Bay	2	B5	None	12	56	21	57	58	231	52	12	38	116	111	29	**738**
Sum 2015				**247**	**195**	**400**	**3,943**	**3,815**	**10,518**	**22,270**	**3,368**	**202**	**2,398**	**2,068**	**535**	**49,665**
Total 2013-2015				**897**	**418**	**1,008**	**7,578**	**8,367**	**16,875**	**32,015**	**7,286**	**2,514**	**6,576**	**6,045**	**1,172**	**90,128**

Geographic Region	Miles from COLREGS	Receiver Site Name	Military Interest Zone	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	Jun. 2016	Jul. 2016	Aug. 2016	Sep. 2016	Oct. 2016	Nov. 2016	Dec. 2016	Total
Chesapeake Bay	10	B15	None	39	1	8	75	285	566	238	2,594	20	246	207	94	**4,254**
Chesapeake Bay	8	B13	None	40	0	50	249	329	244	32	29	6	18	156	225	**1,352**
Chesapeake Bay	8	CBBT1	None	4	0	5	16	16	1	0	2	0	3	6	1	**54**
Chesapeake Bay	8	CBBT2	None	3	2	69	2,663	1,854	61	5	6	40	97	1,132	18	**5,950**
Chesapeake Bay	8	CBBT7	None	17	9	39	117	204	23	0	14	29	166	104	23	**741**
Chesapeake Bay	8	LS	None	2	0	0	42	73	12	0	10	11	32	26	14	**222**
Chesapeake Bay	7	CBBT3	None	56	89	149	210	401	215	20	2	0	308	220	115	**0**
Chesapeake Bay	6	10N	None	1	0	23	103	107	25	2	5	44	159	87	28	**563**
Chesapeake Bay	5	B11	None	40	16	54	987	2,745	635	199	226	33	838	588	42	**6,393**
Chesapeake Bay	4	B9	None	73	10	26	245	408	1,196	1,130	299	20	801	557	57	**4,743**
Chesapeake Bay	4	TS5	None	14	7	42	198	176	596	83	951	38	41	239	23	**2,391**
Chesapeake Bay	3	B7	None	20	10	29	83	91	61	70	29	7	33	166	124	**699**
Chesapeake Bay	2	B5	None	16	13	45	69	240	112	21	33	19	122	153	79	**896**
Sum 2016				**325**	**157**	**539**	**5,057**	**6,929**	**3,747**	**1,800**	**4,200**	**267**	**2,864**	**3,641**	**843**	**28,258**
Total 2013-2016				**1,222**	**575**	**1,547**	**12,635**	**15,296**	**20,622**	**33,815**	**11,486**	**2,781**	**9,440**	**9,686**	**2,015**	**118,386**

Geographic Region	Miles from COLREGS	Receiver Site Name	Military Interest Zone	Jan. 2017	Feb. 2017	Mar. 2017	Apr. 2017	May 2017	Jun. 2017	Jul. 2017	Aug. 2017	Sep. 2017	Oct. 2017	Nov. 2017	Dec. 2017	Total
Chesapeake Bay	10	B15	None	14	7	160	875	532	1,250	268	52	44	655	193	75	**4,125**
Chesapeake Bay	8	B13	None	330	383	2199	4359	620	114	53	3	10	358	239	108	**1,322**
Chesapeake Bay	8	CBBT1	None	0	0	36	38	19	4	0	0	1	3	19	4	**124**
Chesapeake Bay	8	CBBT2	None	11	25	148	707	270	44	18	1	8	514	109	56	**1,898**
Chesapeake Bay	8	CBBT7	None	0	9	62	186	171	25	0	7	19	278	97	10	**860**
Chesapeake Bay	8	LS	None	0	9	27	33	44	1	0	1	0	37	49	9	**210**
Chesapeake Bay	7	CBBT3	None	68	25	406	1,868	531	600	150	33	22	345	188	73	**4,309**
Chesapeake Bay	6	10N	None	0	13	63	260	102	24	0	2	22	147	147	37	**817**
Chesapeake Bay	5	B11	None	6	11	106	1,173	792	3,535	948	55	246	288	20	51	**7,231**
Chesapeake Bay	4	B9	None	33	28	202	3,059	1,209	4,421	5,825	44	46	286	85	79	**15,317**
Chesapeake Bay	4	TS5	None	61	0	65	79	82	239	413	79	29	448	114	525	**2,115**
Chesapeake Bay	3	B7	None	31	42	90	583	37	229	162	0	11	10	41	48	**1,263**
Chesapeake Bay	2	B5	None	5	9	79	154	177	212	85	6	21	33	90	34	**877**
Sum 2017				**559**	**561**	**3,643**	**13,374**	**4,586**	**10,698**	**7,922**	**283**	**479**	**3,402**	**1,391**	**1,109**	**40,468**
Total 2013-2017				**1,781**	**1,136**	**5,190**	**26,009**	**19,882**	**31,320**	**41,737**	**11,769**	**3,260**	**12,842**	**11,077**	**3,124**	**158,854**

Geographic Region	Miles from COLREGS	Receiver Site Name	Military Interest Zone	Jan. 2018	Feb. 2018	Mar. 2018	Apr. 2018	May 2018	Jun. 2018	Jul. 2018	Aug. 2018	Sep. 2018	Oct. 2018	Nov. 2018	Dec. 2018	Total
Chesapeake Bay	10	B15	None	0	37	37	986	4,238	7,662	4,312	48	422	127	95	85	**18,049**
Chesapeake Bay	8	B13	None	2	24	45	303	529	332	158	49	15	28	54	27	**1,566**
Chesapeake Bay	8	CBBT1	None	0	0	12	23	74	7	0	2	0	11	2	1	**132**
Chesapeake Bay	8	CBBT2	None	0	27	25	638	336	54	15	1	0	28	3	41	**1,168**
Chesapeake Bay	8	CBBT7	None	0	0	25	114	269	10	0	5	0	20	62	52	**557**
Chesapeake Bay	8	LS	None	0	1	0	90	74	13	0	0	0	8	8	15	**209**
Chesapeake Bay	7	CBBT3	None	65	61	118	1,991	313	227	23	101	4	43	18	12	**2,976**
Chesapeake Bay	6	10N	None	0	3	5	113	133	14	0	0	0	42	52	31	**393**
Chesapeake Bay	5	B11	None	4	13	26	614	867	619	2,132	86	74	152	28	21	**4,636**
Chesapeake Bay	4	B9	None	14	16	43	1,159	2,013	778	569	99	37	359	272	58	**5,417**
Chesapeake Bay	4	TS5	None	13	18	53	72	226	823	579	373	27	35	27	28	**2,274**
Chesapeake Bay	3	B7	None	1	6	55	413	68	77	52	37	43	35	15	29	**831**
Chesapeake Bay	2	B5	None	1	15	27	76	115	200	18	27	4	48	98	119	**748**
Sum 2018				**100**	**221**	**471**	**6,592**	**9,255**	**10,816**	**7,858**	**828**	**626**	**936**	**734**	**519**	**38,956**
Total 2013-2018				**1,881**	**1,357**	**5,661**	**32,601**	**29,137**	**42,136**	**49,595**	**12,597**	**3,886**	**13,778**	**11,811**	**3,643**	**197,810**

3.5.6.2. Little Creek Zone

Little Creek is monitored by seven receivers that cover 23 percent of its area (**Table 2; Appendix 8.2**). Due to the location of the zone at the inshore end of the Thimble Shoals Channel and directly southeast of the mouth of the James River (NSN), it receives a large volume of freshwater from the James as its flow turns to the right upon entering the bay due to the Coriolis effect. The benthos of this zone is characterized by extensive sandy shallows with minor holes, and the Thimble Shoals Channel forms the northern border of the zone.

In 2013, 2014, 2015, 2016, 2017, and 2018 there were 153, 202, 257, 275, 235, and 230 individual sturgeon recorded in the Little Creek zone, respectively (**Table 18**) and the resulting numbers of detections from the fish were 7,626, 32,514, 14,497, 18,085, 16,112, and 13,253 respectively (**Table 19**). Across all years, most fish detected in the zone were of Chesapeake Bay tagging origin (**Table 18**). Many of these fish, detected during immigration, were subsequently recorded entering the NSN zone. Consistent peaks in fish number and short-duration detection series suggest two periods of immigration: one in spring (April–May) and another in late summer (August). One emigration period is evident, occurring in October through November (**Figure 26**). When outlier, transient fish are removed a clear pattern of increasing abundance is evident during the spring, and sedentary behavior by some adult fish is demonstrated in June of each year. Unlike the unusually reduced numbers of detections and fish recorded in the Baltimore Channel in the very warm year of 2016 (**Figure 25**), detection values in the Thimble Shoals Channel during late spring and early summer appear to be consistent with the annual occupation patterns evident in other years (**Figure 26**), this is likely due to the fact that the Thimble Shoals Channel receives freshwater from the James River while the Baltimore Channel is higher salinity due to its location on the eastern side of the bay.

Table 18. Tagging origin of Atlantic sturgeon detected within the Little Creek zone annually from 2013 to 2018.

Year	Northeast	Chesapeake Bay	Southeast	Total Detected
2013	62	83	8	153
2014	78	113	11	202
2015	79	169	9	257
2016	56	212	7	275
2017	45	189	1	235
2018	41	186	3	230

Based on Virginia fish alone, sub-adults can be found in this military zone during any time of year but are far more numerous from March to June, with peak presence occurring May through June. Adults are most numerous in June and to a lesser degree in August. Adults again exit through the zone in October and November but are not present in December through March. In 2014 and 2015, when tagging was occurring in the middle and upper James River, fall detection data were augmented in all zones and regions downriver of the tagging site, including Little Creek.

Individual Atlantic sturgeon preferentially occupied the CBBT5 site (**Appendix 8.2**) and to a lesser degree the CBBT4 site in spring and early summer (April–June). The CBBT5 site was consistent with respect to its increased detection volume in comparison to the CBBT4 site. Although fewer fish inhabit these shallow sites than the deeper ones located in the Thimble

Shoals Channel along the edge of the Little Creek zone, detection volume due to a few individual fish resulted in consistently high annual detections at CBBT5 (1,045 to 6,725). In all years but 2016 and 2018, June detections were an order of magnitude higher than any other month (**Table 19**). In 2016, both May and June were an order of magnitude higher than other months. In 2018, detection volume was greatly reduced at the CBBT4 and CBBT5 sites, however CBBT5's largest detection number occurred in May and was more than double that recorded at CBBT4 (**Appendix 8.2**).

Large numbers of Atlantic sturgeon have passed through the TS9–TS11 receiver sites (**Appendix 8.2**) in the Thimble Shoals Channel along the northern edge of the zone during immigration and emigration each year. Detection volume within the Little Creek zone is primarily due to the Thimble Shoals Channel sites. The CBBT sites have detection volumes that correspond to fish availability—a relationship that suggests that fish occupy the sites more out of convenience than due to a strong selectivity for the conditions found there. Annual peaks in abundance during both immigration and emigration periods (**Figure 26**) are clearly evident. Peak detection volume, however, does not always correlate with migrations and can be drastically influenced by the sedentary behavior of a few fish.

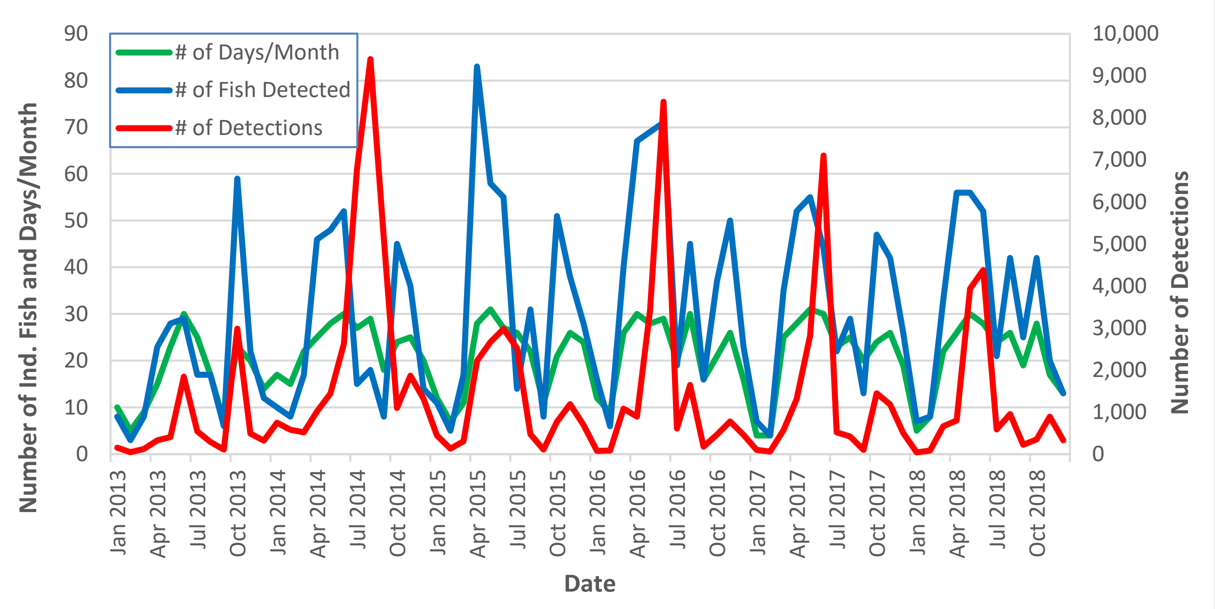

Figure 26. Atlantic sturgeon occurrence based on receiver detections in the Little Creek zone from 2013 to 2018.

In some years (2013, 2016, and 2017), detection volume corresponds well with the number of fish present through early summer, suggesting typical occupation and migration patterns. These patterns are similar to those recorded in the Baltimore Channel in the same year. In 2014, detection volume in late summer (July–September) was significantly increased by a few sedentary fish of Southeast tagging origin that took up residence at TS9 (**Table 19**; **Appendix 8.2**). Of the 20,401 detections recorded during this period, 20,083 (98 percent) were due to a single fish of unknown age of Georgia tagging origin (45354). During the same period in 2015, a larger number of sub-adult and adult fish of various tagging origins were detected including a few of Southeast tagging origin, but detection volume (1,977) was an order of magnitude lower than that recorded in 2014. July was the month with largest detection volume at TS9 (1,812), and a single VIMS fish that is a suspected sub-adult (26381) was responsible for 50 percent of the monthly detections. In 2013, 2016, and 2017 numerous fish of varied ages and tagging origins were detected within the Thimble Shoals Channel, some of Southeast tagging origin in 2013 and 2016, but none demonstrated such strong site fidelity as the individual in 2014. If we consider the reduced number of fish carrying tags in 2013, the extremely reduced number of detections recorded in the Little Creek Zone is an outlier. By far the largest number of detections occurred in TS11 in May and June. These were due to 25 fish in May and 32 in June. Twenty-one of the 25 fish present in May were tagged in the James River, and four were of Northeast origin. Twenty-four of the 32 present in June were of the James River origin, five were York River fish, and three were tagged in the Northeast.

Table 19. Number of detections by month in the Little Creek military zone, December 2012–December 2018. Receiver sites are listed in descending order by RM. River miles and receiver site names can be referenced on Appendix 8.1.

Geographic Region	Miles from COLREGS	Receiver Site Name	Military Interest Zone	Dec. 2012	Jan. 2013	Feb. 2013	Mar. 2013	Apr. 2013	May 2013	Jun. 2013	Jul. 2013	Aug. 2013	Sep. 2013	Oct. 2013	Nov. 2013	Dec. 2013	Total
Chesapeake Bay	7	LC1	Little Creek	18	4	5	5	55	2	7	0	0	11	13	4	33	**157**
Chesapeake Bay	7	TS11	Little Creek	2	29	2	14	58	47	113	74	112	5	1,558	126	55	**2,195**
Chesapeake Bay	6	LC2	Little Creek	0	50	8	1	6	37	31	19	29	23	1	17	47	**269**
Chesapeake Bay	6	TS9	Little Creek	36	3	0	3	44	40	115	29	36	6	1,195	248	118	**1,873**
Chesapeake Bay	5	TS7	Little Creek	8	57	4	81	87	44	121	126	50	44	219	69	51	**961**
Chesapeake Bay	4	CBBT4	Little Creek	0	9	16	4	17	4	37	66	14	5	2	19	0	**193**
Chesapeake Bay	3	CBBT5	Little Creek	0	0	9	7	69	230	1,423	228	46	13	0	2	15	**2,042**
Sum 2013				**64**	**152**	**44**	**115**	**336**	**404**	**1,847**	**542**	**287**	**107**	**2,988**	**485**	**319**	**7,690**

Geographic Region	Miles from COLREGS	Receiver Site Name	Military	Jan. 2014	Feb. 2014	Mar. 2014	Apr. 2014	May 2014	Jun. 2014	Jul. 2014	Aug. 2014	Sep. 2014	Oct. 2014	Nov. 2014	Dec. 2014	Total
Chesapeake Bay	7	LC1	Little Creek	4	5	58	61	60	18	1	4	19	214	23	30	**497**
Chesapeake Bay	7	TS11	Little Creek	615	306	270	108	555	436	163	114	162	258	834	802	**4,623**
Chesapeake Bay	6	LC2	Little Creek	13	1	14	79	46	65	16	24	25	81	109	0	**473**
Chesapeake Bay	6	TS9	Little Creek	73	40	70	76	176	527	6,371	9,124	4,819	304	639	343	**22,562**
Chesapeake Bay	5	TS7	Little Creek	21	83	69	155	164	284	166	89	43	192	146	50	**1,462**
Chesapeake Bay	4	CBBT4	Little Creek	4	144	5	178	91	52	24	5	2	27	79	56	**667**
Chesapeake Bay	3	CBBT5	Little Creek	16	1	33	358	345	1,240	39	42	53	23	39	41	**2,230**
Sum 2014				**746**	**580**	**519**	**1,015**	**1,437**	**2,622**	**6,780**	**9,489**	**5,123**	**1,099**	**1,869**	**1,322**	**32,601**
Total 2013-2014				**898**	**624**	**634**	**1,351**	**1,841**	**4,469**	**7,322**	**9,776**	**5,230**	**4,087**	**2,354**	**1,705**	**40,291**

Geographic Region	Miles from COLREGS	Receiver Site Name	Military Interest Zone	Jan. 2015	Feb. 2015	Mar. 2015	Apr. 2015	May 2015	Jun. 2015	Jul. 2015	Aug. 2015	Sep. 2015	Oct. 2015	Nov. 2015	Dec. 2015	Total
Chesapeake Bay	7	LC1	Little Creek	50	0	68	363	245	70	0	24	4	15	33	104	**976**
Chesapeake Bay	7	TS11	Little Creek	221	8	18	163	208	333	538	83	33	385	249	146	**2,385**
Chesapeake Bay	6	LC2	Little Creek	12	74	0	319	278	584	11	50	24	8	57	77	**1,494**
Chesapeake Bay	6	TS9	Little Creek	55	5	36	135	688	536	1,812	146	19	136	537	56	**4,161**
Chesapeake Bay	5	TS7	Little Creek	48	28	58	227	192	258	116	89	11	223	265	80	**1,595**
Chesapeake Bay	4	CBBT4	Little Creek	37	6	78	445	257	154	25	21	9	3	13	53	**1,101**
Chesapeake Bay	3	CBBT5	Little Creek	18	13	48	562	796	1,044	21	61	6	1	37	178	**2,785**
Sum 2015				**441**	**134**	**306**	**2,214**	**2,664**	**2,979**	**2,523**	**474**	**106**	**771**	**1,191**	**694**	**14,497**
Total 2013-2015				**1,339**	**758**	**940**	**3,565**	**4,505**	**7,448**	**9,845**	**10,163**	**5,336**	**4,858**	**3,545**	**2,399**	**54,701**

Geographic Region	Miles from COLREGS	Receiver Site Name	Military Interest Zone	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	Jun. 2016	Jul. 2016	Aug. 2016	Sep. 2016	Oct. 2016	Nov. 2016	Dec. 2016	Total
Chesapeake Bay	7	LC1	Little Creek	4	0	85	73	64	115	11	24	0	1	67	0	**444**
Chesapeake Bay	7	TS11	Little Creek	22	10	58	113	106	1,004	274	149	5	113	200	65	**2,119**
Chesapeake Bay	6	LC2	Little Creek	0	0	84	20	150	93	29	52	10	29	36	4	**507**
Chesapeake Bay	6	TS9	Little Creek	14	10	21	106	1,039	4,907	89	499	43	207	169	63	**7,167**
Chesapeake Bay	5	TS7	Little Creek	26	5	202	181	246	283	78	754	90	66	285	34	**2,250**
Chesapeake Bay	4	CBBT4	Little Creek	10	13	130	155	176	241	68	80	25	13	19	33	**963**
Chesapeake Bay	3	CBBT5	Little Creek	2	50	502	247	1,651	1,743	61	87	6	29	0	257	**4,635**
Sum 2016				**78**	**88**	**1,082**	**895**	**3,432**	**8,386**	**610**	**1,645**	**179**	**458**	**776**	**456**	**18,085**
Total 2013-2016				**1,417**	**846**	**2,022**	**4,460**	**7,937**	**15,834**	**10,455**	**11,808**	**5,515**	**5,316**	**4,321**	**2,855**	**72,786**

Geographic Region	Miles from COLREGS	Receiver Site Name	Military Interest Zone	Jan. 2017	Feb. 2017	Mar. 2017	Apr. 2017	May 2017	Jun. 2017	Jul. 2017	Aug. 2017	Sep. 2017	Oct. 2017	Nov. 2017	Dec. 2017	Total
Chesapeake Bay	7	LC1	Little Creek	0	5	59	84	58	93	23	11	14	**536**	**536**	**536**	**536**
Chesapeake Bay	7	TS11	Little Creek	27	8	55	70	90	59	16	36	0	**1,361**	**1,361**	**1,361**	**1,361**
Chesapeake Bay	6	LC2	Little Creek	2	0	8	32	626	34	8	59	21	**902**	**902**	**902**	**902**
Chesapeake Bay	6	TS9	Little Creek	19	8	48	68	92	137	168	92	25	**1,709**	**1,709**	**1,709**	**1,709**
Chesapeake Bay	5	TS7	Little Creek	51	0	105	153	108	256	193	93	0	**1,282**	**1,282**	**1,282**	**1,282**
Chesapeake Bay	4	CBBT4	Little Creek	0	38	176	290	1,070	1,824	54	33	15	**3,597**	**3,597**	**3,597**	**3,597**
Chesapeake Bay	3	CBBT5	Little Creek	0	0	124	617	771	4,701	58	97	28	**6,725**	**6,725**	**6,725**	**6,725**
Sum 2017				**99**	**59**	**575**	**1,314**	**2,815**	**7,104**	**520**	**421**	**103**	**1,449**	**1,184**	**469**	**16,112**
Total 2013-2017				**1,516**	**905**	**2,597**	**5,774**	**10,752**	**22,938**	**10,975**	**12,229**	**5,618**	**6,765**	**5,505**	**3,324**	**88,898**

Geographic Region	Miles from COLREGS	Receiver Site Name	Military Interest Zone	Jan. 2018	Feb. 2018	Mar. 2018	Apr. 2018	May 2018	Jun. 2018	Jul. 2018	Aug. 2018	Sep. 2018	Oct. 2018	Nov. 2018	Dec. 2018	Total
Chesapeake Bay	7	LC1	Little Creek	0	0	14	63	296	40	6	8	8	2	4	5	**446**
Chesapeake Bay	7	TS11	Little Creek	10	0	14	23	2,418	3,495	128	120	43	107	137	18	**6,513**
Chesapeake Bay	6	LC2	Little Creek	0	3	36	9	22	2	37	56	35	16	8	19	**243**
Chesapeake Bay	6	TS9	Little Creek	2	13	68	85	329	424	265	413	40	101	680	201	**2,621**
Chesapeake Bay	5	TS7	Little Creek	30	39	123	353	179	289	104	206	34	95	57	51	**1,560**
Chesapeake Bay	4	CBBT4	Little Creek	0	3	173	179	209	81	35	108	21	7	0	9	**825**
Chesapeake Bay	3	CBBT5	Little Creek	0	29	235	90	486	51	16	44	40	24	7	23	**1,045**
Sum 2018				**42**	**87**	**663**	**802**	**3,939**	**4,382**	**591**	**955**	**221**	**352**	**893**	**326**	**13,253**
Total 2013-2018				**1,558**	**992**	**3,260**	**6,576**	**14,691**	**27,320**	**11,566**	**13,184**	**5,839**	**7,117**	**6,398**	**3,650**	**102,151**

3.5.6.3. Fort Story Military Zone

The Fort Story zone was originaly monitored by five receivers that cover 24.7 percent of its area. B3 was removed two months into the six year study resulting in 22.5 percent coverage there after (**Table 2; Appendix 8.2**). One ocean receiver (2C off Cape Henry, defined as such because it is east of the COLREGS line) is contained within the Fort Story zone (**Appendix 8.2**). This zone north of Cape Henry is characterized by extreme currents that sweep through the deepest hole at the mouth of the bay, a hole that forms the beginning of both the Thimble Shoals and Baltimore channels (**Figure 5**). The largest numbers of Atlantic sturgeon within this zone occur concurrently with seasonal coastal and in-bay immigration in the spring and emigration in the fall. The high numbers of individuals detected, combined with the reduced numbers of detections during these periods in all years except 2016 and 2018, are indicative of highly mobile behavior, in this case suggesting migration (**Figure 27**).

Annual totals of 167, 213, 277, 281, 293, and 227 fish (**Table 20**) and 8,631, 9,106, 11,576, 106,813, 25,402, and 84,633 annual detections were recorded in 2013, 2014, 2015, 2016, 2017, and 2018, respectively, within the Fort Story zone (**Table 21**). Detection volume and the number of fish detected were not well correlated; indicating that behavior of fish within the zone varies over time. In January and February fish numbers were reduced in every year, as were the numbers of detections resulting from these fish. Fish numbers begin to increase in March and peak in June. A spike in fish number in April (n = 616) with a reduced number of associated average number of detections per fish (n = 15) denotes coastal migrations. The largest number of fish occurred in June (n = 798) but many of these fish were also migrating through as the relatively low average number of detections per fish (n = 50) indicates. The largest numbers of detections occurred in May through September (**Table 21, Figure 27**) and these trends are heavily influenced by detection volume at the 2C site. The degree to which fish remained within this specific habitat was highly variable annually.

Although the numbers of fish in the Little Creek and Fort Story zones were similar in 2014 (204 vs. 214), the number of detections within Little Creek (35,514) dwarfed that recorded within the Fort Story zone (9,106). As discussed previously, this vast difference in detection volume in Little Creek in 2014 was due to the few sedentary fish of Southeast origin that resided at the TS9 station (**Appendix 8.2**) in July and joined other adults who were within the site from July to September. In 2015, the numbers of fish (257 vs. 277) and annual detection totals (14,497 vs. 11,576) were similar in both zones. In 2017, the Baltimore Channel again contained numerous fish and prolific detections in April–August when adult fish moved out of the site to spawning grounds. The 2C Henry site (**Appendix 8.2**) that had contained many sedentary fish in May–August, with a peak in the late summer of 2016, contained nearly the same number of fish in 2017, but only a few exhibited any site fidelity and this was only evident in August.

The large total number of detections at the 2C Henry site are primarily due to very high detections in 2016 and 2018. In these years fish indicated extreme site fidelity at 2C Henry but the period during which this sedentary behavior occurred shifted between years. In July of 2016 the 2C Henry site recorded 39,600 detections, this is more than half the total number of 76,217 detections recorded during this month from 2013 through 2018 (**Table 21**). The average number of detections per fish at the 2C Henry site during July from 2013 through 2018 was 156. In July of 2016, it was 921. The average number of detections per fish was high in May (n = 299), June (n = 325), August (n = 326), and September (n = 288) in 2016 but not near the number in July. Thirty-one of the 43 fish present were of Chesapeake Bay tagging origin. Although these fish were detected 27,371 times, the 12 other fish present—most of Northeast tagging origin—also demonstrated extreme site fidelity, illustrated by an their average detection rate per fish of 1,019. In 2018, site fidelity was demonstrated through higher-than-average detection rates in July (n = 332), August (n = 512), and September (n = 630), but the highest average detection rate per fish occurred in September not July. There were only 22 fish detected and 19 of these were tagged in the Chesapeake Bay. Three of these were native to the York River system and none of them made spawning runs in 2018.

Because reasonable life-stage data exist for fish tagged in Virginia, they are the best data to determine life-stage-specific habitat-use patterns. Applying this approach revealed that sub-adults can be found in the Fort Story zone year-round but do not usually stay for any length of time. One sub-adult demonstrated site fidelity from May to September in 2015, and five demonstrated site fidelity in 2016.

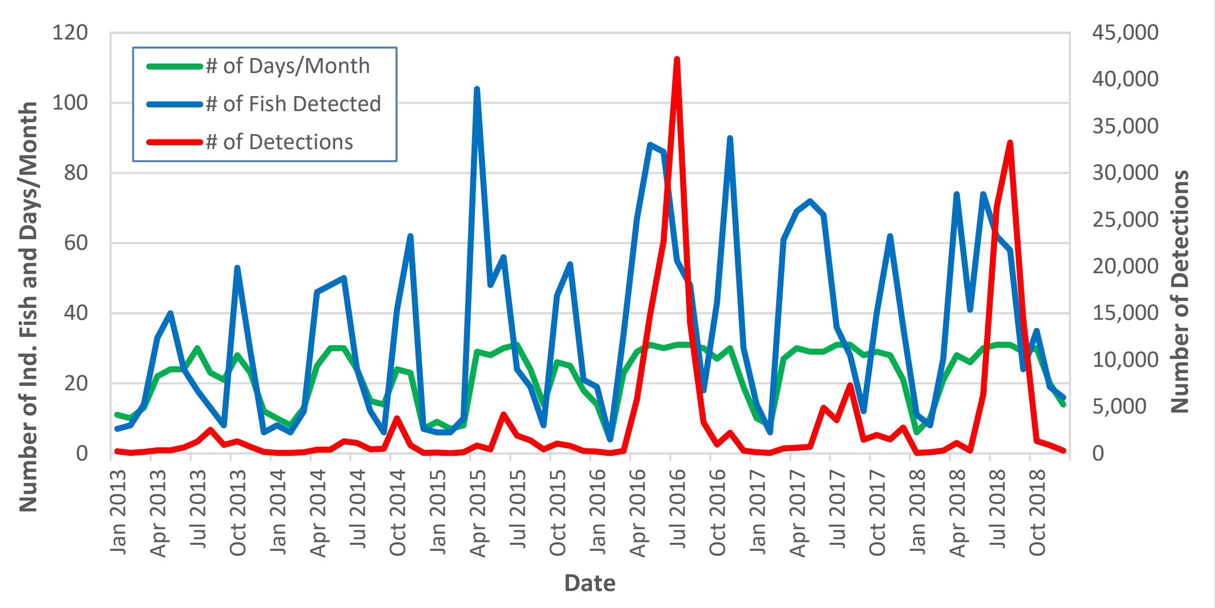

Figure 27. Atlantic sturgeon occurrence based on receiver detections in the Fort Story zone from 2013 to 2018.

Table 20. Tagging origin of Atlantic sturgeon detected within the Fort Story zone annually from 2013 to 2018.

Year	Northeast	Chesapeake Bay	Southeast	Total Detected
2013	76	79	12	167
2014	91	109	13	213
2015	121	149	7	277
2016	78	198	5	281
2017	81	210	2	293
2018	39	182	6	227

Table 21. Number of detections by month in the Fort Story military zone, December 2012–December 2018. Receiver sites are listed in descending order by RM. River miles and receiver site names can be referenced on Appendix 8.1. NA signifies a period when the receiver was not deployed. B3 was removed in January of 2013.

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Dec. 2012	Jan. 2013	Feb. 2013	Mar. 2013	Apr. 2013	May 2013	Jun. 2013	Jul. 2013	Aug. 2013	Sep. 2013	Oct. 2013	Nov. 2013	Dec. 2013	Total
Chesapeake Bay	2	TS3	Fort Story	41	103	43	60	111	47	60	60	92	23	336	363	17	**1,356**
Chesapeake Bay	1	2CH CAPE HENRY	Fort Story	0	10	18	63	56	62	68	49	52	82	169	130	56	**815**
Chesapeake Bay	1	TS1	Fort Story	8	55	15	42	93	92	436	1,137	2,361	702	500	176	88	**5,705**
Chesapeake Bay	1	B3	Fort Story	27	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**52**
Atlantic Ocean	2	2C CAPE HENRY	Fort Story	17	7	0	8	80	136	66	0	19	115	303	45	0	**796**
Sum 2013				**93**	**200**	**76**	**173**	**340**	**337**	**630**	**1,246**	**2,524**	**922**	**1,308**	**714**	**161**	**8,724**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2014	Feb. 2014	Mar. 2014	Apr. 2014	May 2014	Jun. 2014	Jul. 2014	Aug. 2014	Sep. 2014	Oct. 2014	Nov. 2014	Dec. 2014	Total
Chesapeake Bay	2	TS3	Fort Story	13	15	40	134	129	370	650	213	6	391	215	47	**2,223**
Chesapeake Bay	1	2CH CAPE HENRY	Fort Story	9	15	26	61	119	309	82	165	125	371	202	1	**1,485**
Chesapeake Bay	1	TS1	Fort Story	48	40	35	86	111	416	343	43	82	1,390	240	7	**2,841**
Chesapeake Bay	1	B3	Fort Story	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Atlantic Ocean	2	2C CAPE HENRY	Fort Story	0	0	13	118	60	207	59	1	277	1,607	215	0	**2,557**
Sum 2014				**70**	**70**	**114**	**399**	**419**	**1,302**	**1,134**	**422**	**490**	**3,759**	**872**	**55**	**9,106**
Total 2013-2014				**270**	**146**	**287**	**739**	**756**	**1,932**	**2,380**	**2,946**	**1,412**	**5,067**	**1,586**	**309**	**17,830**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2015	Feb. 2015	Mar. 2015	Apr. 2015	May 2015	Jun. 2015	Jul. 2015	Aug. 2015	Sep. 2015	Oct. 2015	Nov. 2015	Dec. 2015	Total
Chesapeake Bay	2	TS3	Fort Story	44	3	32	133	131	2,118	265	301	20	529	210	123	**3,909**
Chesapeake Bay	1	2CH CAPE HENRY	Fort Story	13	8	34	195	98	769	925	662	196	171	154	55	**3,280**
Chesapeake Bay	1	TS1	Fort Story	4	4	26	366	123	1,037	645	341	163	204	263	81	**3,257**
Atlantic Ocean	2	2C CAPE HENRY	Fort Story	22	8	39	152	94	246	71	79	49	159	194	17	**1,130**
Sum 2015				**83**	**23**	**131**	**846**	**446**	**4,170**	**1,906**	**1,383**	**428**	**1,063**	**821**	**276**	**11,576**
Total 2013-2015				**353**	**169**	**418**	**1,585**	**1,202**	**6,102**	**4,286**	**4,329**	**1,840**	**6,130**	**2,407**	**585**	**29,406**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	Jun. 2016	Jul. 2016	Aug. 2016	Sep. 2016	Oct. 2016	Nov. 2016	Dec. 2016	Total
Chesapeake Bay	2	TS3	Fort Story	66	24	74	95	196	1,101	791	954	36	96	609	80	**4,122**
Chesapeake Bay	1	2CH CAPE HENRY	Fort Story	41	0	72	106	272	634	636	484	39	64	135	94	**2,577**
Chesapeake Bay	1	TS1	Fort Story	35	16	88	234	357	827	1,168	1,095	71	99	290	94	**4,374**
Atlantic Ocean	2	2C CAPE HENRY	Fort Story	46	3	28	5,369	14,048	20,141	39,600	11,422	3,170	686	1,201	26	**95,740**
Sum 2016				**188**	**43**	**262**	**5,804**	**14,873**	**22,703**	**42,195**	**13,955**	**3,316**	**945**	**2,235**	**294**	**106,813**
Total 2013-2016				**541**	**212**	**680**	**7,389**	**16,075**	**28,805**	**46,481**	**18,284**	**5,156**	**7,075**	**4,642**	**879**	**136,219**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2017	Feb. 2017	Mar. 2017	Apr. 2017	May 2017	Jun. 2017	Jul. 2017	Aug. 2017	Sep. 2017	Oct. 2017	Nov. 2017	Dec. 2017	Total
Chesapeake Bay	2	TS3	Fort Story	44	3	68	100	154	1,599	1,121	183	54	575	906	2,378	**7,185**
Chesapeake Bay	1	2CH CAPE HENRY	Fort Story	16	12	194	147	100	558	960	408	21	57	59	62	**2,594**
Chesapeake Bay	1	TS1	Fort Story	30	18	123	197	200	1,086	1,265	590	106	244	231	233	**4,323**
Atlantic Ocean	2	2C CAPE HENRY	Fort Story	30	21	140	150	259	1,641	211	6,095	1,289	1,094	293	77	**11,300**
Sum 2017				**120**	**54**	**525**	**594**	**713**	**4,884**	**3,557**	**7,276**	**1,470**	**1,970**	**1,489**	**2,750**	**25,402**
Total 2013-2017				**661**	**266**	**1,205**	**7,983**	**16,788**	**33,689**	**50,038**	**25,560**	**6,626**	**9,045**	**6,131**	**3,629**	**161,621**

Geographic Region	River mile	Receiver Site Name	Military Interest Zone	Jan. 2018	Feb. 2018	Mar. 2018	Apr. 2018	May 2018	Jun. 2018	Jul. 2018	Aug. 2018	Sep. 2018	Oct. 2018	Nov. 2018	Dec. 2018	Total
Chesapeake Bay	2	TS3	Fort Story	28	22	60	467	84	0	3,879	1,915	179	58	714	52	**7,458**
Chesapeake Bay	1	2CH CAPE HENRY	Fort Story	5	2	86	340	65	736	929	563	40	20	36	30	**2,852**
Chesapeake Bay	1	TS1	Fort Story	43	36	86	237	109	2,594	2,614	2,102	311	159	99	143	**8,533**
Atlantic Ocean	2	2C CAPE HENRY	Fort Story	1	59	53	81	27	2,953	18,925	28,679	13,850	1,105	28	59	**65,820**
Sum 2018				**77**	**119**	**285**	**1,125**	**285**	**6,283**	**26,347**	**33,259**	**14,380**	**1,342**	**877**	**284**	**84,663**
Total 2013-2018				**738**	**359**	**1,477**	**9,124**	**16,931**	**39,876**	**76,217**	**58,807**	**20,923**	**9,798**	**6,796**	**3,868**	**244,914**

3.5.7. Atlantic Region (Dam Neck Naval Firing Range Surrogate Zone)

Twenty receivers were originally distributed in the nearshore Atlantic region, 19 of which occurred within the Range Sur. zone (**Appendix 8.2**). In July of 2017, RA out was removed and this reduced the area coverage to 7.3 percent (**Table 2**). Since such a small area total was being monitored by RA out and the station was not extremely large in its number of receptions from 2013 through July 2017, the receiver's removal had little impact on the data. The array within this zone detected 272 individual sturgeon in 2013, 347 in 2014, 456 in 2015, 424 in 2016, 365 in 2017, and 308 in 2018 (**Table 22**). This zone consistently recorded the largest number of fish because its coastal location at the mouth of the bay detects Atlantic sturgeon migrating north in the spring and south in the fall, as well as fish that subsequently entered the Chesapeake Bay and its tributaries. Fish detected were originally tagged in the Northeast, Chesapeake Bay, and Southeast. Although the number from each region shifted over time, consistently large numbers of fish of Northeast tagging origin indicate how important the zone is to migratory fish (**Table 22**). Sturgeon were detected 4,118, 6,833, 5,634, 10,201, 5,280, and 6,182 times in each year from 2013 to 2018, respectively (**Table 23**). Although sturgeon were not detected in every month of every year within the Range Sur. zone (no fish were detected in August 2013, with only one in September 2013), trends in the numbers of detections were consistent between years. Coastal migrations in this nearshore region and Range Sur. zone were extremely well defined, generally extending from March to May and October to January, with consistent peaks in April and November (**Figure 28**). The average number of detections per fish during these periods indicate short-term duration within sites indicative of migratory fish.

Table 22. Tagging origin of Atlantic sturgeon detected within the Range Sur. zone annually from 2013 to 2018.

Year	Northeast	Chesapeake Bay	Southeast	Total Detected
2013	189	69	14	272
2014	200	126	21	347
2015	263	171	22	456
2016	191	224	9	424
2017	130	230	5	365
2018	94	194	20	308

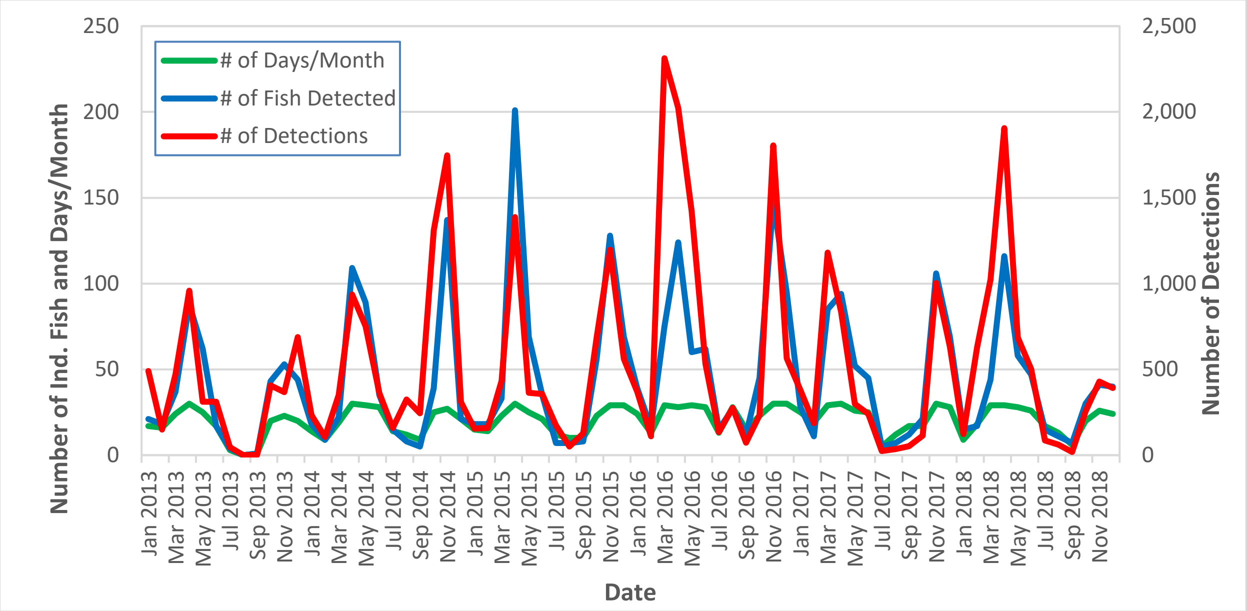

Figure 28. Atlantic sturgeon occurrence based on receiver detections in the Dam Neck Naval Firing Range Surrogate zone from 2013 to 2018.

Detection variables were consistent across years with minor exceptions in March–May of 2016 (**Table 23**). Closer examination of individual receiver stations indicate variability was due to receptions at the RI1 site (**Table 23**; **Appendix 8.9**) in March and April. The increased volume of detections at this site during this period was due to a congregation of sub-adults, all tagged by VIMS, that stayed close to the coast during migration. Fourteen of these fish were present in March contributing to 917 of the 1,004 monthly detections (91 percent). Five of these fish remained into April when they were joined by nine new sub-adults also tagged by VIMS. They contributed to 1,846 out of 1,923 total detections or 96 percent of the detections. The other site that experienced higher than usual detection volume in 2016 was NCD in May. This increased number of detections was due to two adult fish, one of Delaware tagging origin and one of James River tagging origin that contributed to 97 percent of the monthly detections (992/1,023).

Table 23. Number of detections by month in the Atlantic region, December 2012–December 2018. Receiver sites are listed in descending order by distance offshore from the COLREGS line. River miles and receiver site names can be referenced on Appendix 8.1. NA signifies a period when the receiver was not deployed.

Geographic Region	Miles from COLREGS	Receiver Site Name	Military Interest Zone	Dec. 2012	Jan. 2013	Feb. 2013	Mar. 2013	Apr. 2013	May 2013	Jun. 2013	Jul. 2013	Aug. 2013	Sep. 2013	Oct. 2013	Nov. 2013	Dec. 2013	Total
Atlantic	11	NCA	None	0	1	0	0	71	34	1	NA	NA	NA	107	107	107	**107**
Atlantic	14	CB	Range Sur.	26	78	12	51	95	2	0	0	0	0	332	332	332	**332**
Atlantic	13	CB1	Range Sur.	0	52	13	11	28	5	0	0	0	0	311	311	311	**311**
Atlantic	11	CB3	Range Sur.	8	22	9	47	11	9	1	0	0	0	238	238	238	**238**
Atlantic	10	CB5	Range Sur.	0	12	0	30	44	18	0	0	0	0	104	104	104	**104**
Atlantic	10	NCB	Range Sur.	0	0	1	0	46	3	4	0	0	2	56	56	56	**56**
Atlantic	9	CB7	Range Sur.	10	0	0	0	22	21	0	21	0	0	169	169	169	**169**
Atlantic	9	RA OUT	Range Sur.	1	25	10	22	27	1	3	0	0	0	145	145	145	**145**
Atlantic	8	CB9	Range Sur.	13	0	1	16	19	8	10	8	0	0	127	127	127	**127**
Atlantic	8	NCC	Range Sur.	15	5	9	7	23	35	0	0	0	0	108	108	108	**108**
Atlantic	7	CB11	Range Sur.	0	0	42	23	52	35	5	0	0	0	482	482	482	**482**
Atlantic	7	RA	Range Sur.	17	11	10	55	44	11	2	0	0	0	190	190	190	**190**
Atlantic	6	CB13	Range Sur.	0	0	0	19	29	41	13	0	0	0	170	170	170	**170**
Atlantic	6	NCD	Range Sur.	5	1	12	12	38	26	6	0	0	0	243	243	243	**243**
Atlantic	5	NCE	Range Sur.	16	13	0	10	21	8	0	0	0	0	68	68	68	**68**
Atlantic	5	CB15	Range Sur.	2	60	0	0	0	0	0	0	0	0	62	62	62	**62**
Atlantic	3	CH	Range Sur.	5	31	9	39	56	10	248	0	0	0	398	398	398	**398**
Atlantic	3	RI2	Range Sur.	16	0	0	28	68	3	1	0	0	0	144	144	144	**144**
Atlantic	3	RI1	Range Sur.	13	78	11	59	214	17	8	4	0	0	463	463	463	**463**
Atlantic	2	CH1	Range Sur.	9	15	10	43	54	21	9	14	0	0	357	357	357	**357**
Sum 2013				**156**	**404**	**149**	**472**	**962**	**308**	**311**	**47**	**0**	**2**	**406**	**368**	**689**	**4,274**

Geographic Region	Miles from COLREGS	Receiver Site Name	Military Interest Zone	Jan. 2014	Feb. 2014	Mar. 2014	Apr. 2014	May 2014	Jun. 2014	Jul. 2014	Aug. 2014	Sep. 2014	Oct. 2014	Nov. 2014	Dec. 2014	Total
Atlantic	11	NCA	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Atlantic	14	CB	Range Sur.	54	0	0	0	54	0	0	0	0	7	137	31	**283**
Atlantic	13	CB1	Range Sur.	0	0	0	2	41	0	0	0	0	1	36	23	**103**
Atlantic	11	CB3	Range Sur.	0	1	0	26	17	0	0	0	0	0	56	9	**109**
Atlantic	10	CB5	Range Sur.	0	17	0	0	0	1	0	0	0	5	90	15	**128**
Atlantic	10	NCB	Range Sur.	0	0	11	35	11	0	0	0	0	2	48	9	**116**
Atlantic	9	CB7	Range Sur.	0	10	0	49	18	0	1	0	0	18	41	2	**139**
Atlantic	9	RA OUT	Range Sur.	0	1	27	26	16	0	0	0	0	22	183	24	**299**
Atlantic	8	CB9	Range Sur.	0	0	26	3	11	0	1	0	0	8	63	8	**120**
Atlantic	8	NCC	Range Sur.	7	0	7	50	30	16	0	0	0	24	90	16	**240**
Atlantic	7	CB11	Range Sur.	44	23	0	0	0	0	0	0	0	117	184	9	**377**
Atlantic	7	RA	Range Sur.	38	0	1	20	5	20	0	0	1	264	62	27	**438**
Atlantic	6	CB13	Range Sur.	36	3	66	28	48	18	0	2	7	95	248	17	**568**
Atlantic	6	NCD	Range Sur.	0	0	0	90	26	19	0	0	0	16	44	13	**208**
Atlantic	5	NCE	Range Sur.	0	0	20	68	22	26	3	0	2	76	105	17	**339**
Atlantic	5	CB15	Range Sur.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Atlantic	3	CH	Range Sur.	0	2	36	106	127	172	136	287	232	535	191	10	**1,834**
Atlantic	3	RI2	Range Sur.	6	8	71	86	40	6	0	5	0	4	40	2	**268**
Atlantic	3	RI1	Range Sur.	35	3	60	208	166	43	0	12	2	17	77	57	**680**
Atlantic	2	CH1	Range Sur.	14	39	25	139	120	41	17	18	0	98	53	20	**584**
Sum 2014				**234**	**107**	**350**	**936**	**752**	**362**	**158**	**324**	**244**	**1,309**	**1,748**	**309**	**6,833**
Total 2013-2014				**638**	**256**	**822**	**1,898**	**1,060**	**673**	**205**	**324**	**246**	**1,715**	**2,116**	**998**	**10,951**

Geographic Region	Miles from COLREGS	Receiver Site Name	Military Interest Zone	Jan. 2015	Feb. 2015	Mar. 2015	Apr. 2015	May 2015	Jun. 2015	Jul. 2015	Aug. 2015	Sep. 2015	Oct. 2015	Nov. 2015	Dec. 2015	Total
Atlantic	14	CB	Range Sur.	14	4	34	59	8	0	0	0	0	30	64	80	**293**
Atlantic	13	CB1	Range Sur.	0	1	12	21	6	0	0	0	0	8	44	14	**106**
Atlantic	11	CB3	Range Sur.	10	18	0	24	13	0	0	0	0	17	39	15	**136**
Atlantic	10	CB5	Range Sur.	9	14	0	18	29	0	0	0	0	17	53	13	**153**
Atlantic	10	NCB	Range Sur.	4	4	7	12	16	2	0	0	0	39	54	17	**155**
Atlantic	9	CB7	Range Sur.	5	28	32	23	16	0	0	0	5	24	100	26	**259**
Atlantic	9	RA OUT	Range Sur.	16	12	21	51	32	0	0	0	0	6	50	79	**267**
Atlantic	8	CB9	Range Sur.	0	21	6	40	11	0	0	0	0	2	31	9	**120**
Atlantic	8	NCC	Range Sur.	7	5	44	77	33	16	2	0	1	21	41	32	**279**
Atlantic	7	CB11	Range Sur.	8	7	53	55	15	12	0	0	0	62	152	29	**393**
Atlantic	7	RA	Range Sur.	6	3	19	27	7	3	0	5	0	8	27	8	**113**
Atlantic	6	CB13	Range Sur.	1	0	1	74	9	15	118	17	28	221	220	58	**762**
Atlantic	6	NCD	Range Sur.	0	0	15	50	17	11	0	0	1	15	46	17	**172**
Atlantic	5	NCE	Range Sur.	0	0	29	97	29	29	4	0	3	12	53	16	**272**
Atlantic	3	CH	Range Sur.	7	33	23	133	21	113	36	24	29	136	114	5	**674**
Atlantic	3	RI2	Range Sur.	36	3	32	83	16	8	0	1	0	0	12	35	**226**
Atlantic	3	RI1	Range Sur.	0	0	82	339	54	28	0	0	0	63	44	75	**685**
Atlantic	2	CH1	Range Sur.	31	5	22	204	32	119	3	4	59	4	53	33	**569**
Sum 2015				**154**	**158**	**432**	**1,387**	**364**	**356**	**163**	**51**	**126**	**685**	**1,197**	**561**	**5,634**
Total 2013-2015				**792**	**414**	**1,254**	**3,285**	**1,424**	**1,029**	**368**	**375**	**372**	**2,400**	**3,313**	**1,559**	**16,585**

Geographic Region	Miles from COLREGS	Receiver Site Name	Military Interest Zone	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	Jun. 2016	Jul. 2016	Aug. 2016	Sep. 2016	Oct. 2016	Nov. 2016	Dec. 2016	Total
Atlantic	14	CB	Range Sur.	0	4	6	7	3	0	0	0	0	0	114	72	**206**
Atlantic	13	CB1	Range Sur.	7	8	10	30	9	0	0	0	0	0	123	80	**267**
Atlantic	11	CB3	Range Sur.	5	0	16	18	0	2	5	0	0	47	55	8	**156**
Atlantic	10	CB5	Range Sur.	0	0	5	3	0	2	16	0	0	6	93	32	**157**
Atlantic	10	NCB	Range Sur.	15	1	0	22	8	21	0	0	0	7	20	10	**104**
Atlantic	9	CB7	Range Sur.	21	4	7	12	8	2	0	3	3	11	27	17	**115**
Atlantic	9	RA OUT	Range Sur.	7	18	0	31	37	13	0	0	1	0	65	47	**219**
Atlantic	8	CB9	Range Sur.	16	3	0	0	5	7	18	4	2	7	65	39	**166**
Atlantic	8	NCC	Range Sur.	22	0	27	7	19	24	0	1	1	15	87	24	**227**
Atlantic	7	CB11	Range Sur.	9	3	19	24	14	236	0	5	2	12	64	27	**415**
Atlantic	7	RA	Range Sur.	8	3	22	23	9	4	0	2	5	2	50	6	**134**
Atlantic	6	CB13	Range Sur.	10	0	32	35	64	35	7	9	11	11	99	42	**355**
Atlantic	6	NCD	Range Sur.	21	2	21	24	1,023	30	9	2	6	20	102	34	**1,294**
Atlantic	5	NCE	Range Sur.	66	1	0	138	41	54	37	7	3	16	80	28	**471**
Atlantic	3	CH	Range Sur.	94	3	16	516	71	140	37	180	9	55	143	26	**1,290**
Atlantic	3	RI2	Range Sur.	5	24	117	69	29	19	0	7	5	3	15	37	**330**
Atlantic	3	RI1	Range Sur.	58	30	1,923	1,004	46	16	0	25	8	21	93	38	**3,262**
Atlantic	2	CH1	Range Sur.	5	6	92	60	43	167	23	40	18	20	499	60	**1,033**
Sum 2016				**369**	**110**	**2,313**	**2,023**	**1,429**	**772**	**152**	**285**	**74**	**253**	**1,794**	**627**	**10,201**
Total 2013-2016				**1,161**	**524**	**3,567**	**5,308**	**2,853**	**1,801**	**520**	**660**	**446**	**2,653**	**5,107**	**2,186**	**26,786**

Geographic Region	Miles from COLREGS	Receiver Site Name	Military Interest Zone	Jan. 2017	Feb. 2017	Mar. 2017	Apr. 2017	May 2017	Jun. 2017	Jul. 2017	Aug. 2017	Sep. 2017	Oct. 2017	Nov. 2017	Dec. 2017	Total
Atlantic	14	CB	Range Sur.	25	4	18	10	2	0	0	0	0	0	9	0	**68**
Atlantic	13	CB1	Range Sur.	30	5	27	23	0	0	0	0	0	0	10	40	**135**
Atlantic	11	CB3	Range Sur.	0	5	6	9	7	0	0	0	0	2	84	35	**148**
Atlantic	10	CB5	Range Sur.	3	0	15	9	2	0	0	0	5	5	90	102	**231**
Atlantic	10	NCB	Range Sur.	0	8	3	9	2	8	0	0	0	13	64	27	**134**
Atlantic	9	CB7	Range Sur.	25	0	12	11	0	0	0	0	0	5	14	5	**72**
Atlantic	9	RA OUT	Range Sur.	35	0	26	16	14	5	0	NA	NA	NA	NA	NA	**96**
Atlantic	8	CB9	Range Sur.	16	1	35	23	18	1	0	0	0	10	73	54	**231**
Atlantic	8	NCC	Range Sur.	10	9	67	30	21	3	0	0	0	12	84	43	**279**
Atlantic	7	CB11	Range Sur.	5	0	41	15	10	3	0	0	6	14	105	43	**242**
Atlantic	7	RA	Range Sur.	30	0	4	0	0	0	0	0	4	3	124	59	**224**
Atlantic	6	CB13	Range Sur.	8	0	98	21	35	8	0	3	4	27	58	55	**317**
Atlantic	6	NCD	Range Sur.	0	0	459	38	58	14	0	5	0	14	130	121	**839**
Atlantic	5	NCE	Range Sur.	8	0	19	27	26	15	0	4	6	5	75	38	**223**
Atlantic	3	CH	Range Sur.	13	25	84	34	95	138	7	19	4	7	90	35	**551**
Atlantic	3	RI2	Range Sur.	44	7	53	31	3	6	0	0	4	3	4	1	**156**
Atlantic	3	RI1	Range Sur.	110	99	185	142	15	13	0	0	5	1	31	1	**602**
Atlantic	2	CH1	Range Sur.	38	25	97	425	18	30	18	4	15	3	32	27	**732**
Sum 2017				**400**	**188**	**1,249**	**873**	**326**	**244**	**25**	**35**	**53**	**124**	**1,077**	**686**	**5,280**
Total 2013-2017				**1,561**	**712**	**4,816**	**6,181**	**3,179**	**2,045**	**545**	**695**	**499**	**2,777**	**6,184**	**2,872**	**32,066**

Geographic Region	Miles from COLREGS	Receiver Site Name	Military Interest Zone	Jan. 2018	Feb. 2018	Mar. 2018	Apr. 2018	May 2018	Jun. 2018	Jul. 2018	Aug. 2018	Sep. 2018	Oct. 2018	Nov. 2018	Dec. 2018	Total
Atlantic	14	CB	Range Sur.	0	0	13	42	10	0	0	0	0	7	30	52	**154**
Atlantic	13	CB1	Range Sur.	6	0	0	0	26	0	0	0	3	2	134	22	**193**
Atlantic	11	CB3	Range Sur.	0	38	26	28	4	0	0	0	0	5	10	40	**151**
Atlantic	10	CB5	Range Sur.	35	19	18	20	28	6	0	0	1	6	64	24	**221**
Atlantic	10	NCB	Range Sur.	0	32	1	34	9	6	0	0	0	0	4	12	**98**
Atlantic	9	CB7	Range Sur.	17	3	13	26	3	4	0	0	6	9	16	23	**120**
Atlantic	9	RA OUT	Range Sur.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Atlantic	8	CB9	Range Sur.	0	16	1	4	4	3	8	0	0	7	25	2	**70**
Atlantic	8	NCC	Range Sur.	0	1	64	401	130	7	0	0	0	7	5	0	**615**
Atlantic	7	CB11	Range Sur.	24	73	3	31	179	17	0	0	0	92	23	78	**520**
Atlantic	7	RA	Range Sur.	26	4	15	36	15	11	0	0	0	36	0	1	**144**
Atlantic	6	CB13	Range Sur.	1	23	3	10	9	32	1	3	0	10	10	18	**120**
Atlantic	6	NCD	Range Sur.	0	291	432	487	66	27	1	0	0	31	15	0	**1,350**
Atlantic	5	NCE	Range Sur.	1	64	12	75	28	149	27	25	1	5	9	3	**399**
Atlantic	3	CH	Range Sur.	2	27	1	93	48	85	52	23	6	31	101	69	**538**
Atlantic	3	RI2	Range Sur.	0	9	4	27	8	2	0	0	0	0	2	41	**93**
Atlantic	3	RI1	Range Sur.	8	22	389	561	57	13	0	0	0	13	0	5	**1,068**
Atlantic	2	CH1	Range Sur.	4	23	30	35	66	142	5	10	1	2	6	4	**328**
Sum 2018				**124**	**645**	**1,025**	**1,910**	**690**	**504**	**94**	**61**	**18**	**263**	**454**	**394**	**6,182**
Total 2013-2018				**1,685**	**1,357**	**5,841**	**8,091**	**3,869**	**2,549**	**639**	**756**	**517**	**3,040**	**6,638**	**3,266**	**38,248**

4. Discussion

The Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*, is a wide-ranging, highly mobile, anadromous species and therefore subjected to diverse environmental variables, as well as a host of anthropogenic pressures. Inherent characteristics such as a long lifespan and skipping spawning events emphasize the necessity of long-term studies, particularly in ecologically important habitats, such as the Chesapeake Bay. Improving our understanding of how Atlantic sturgeon respond to varying environmental conditions and other pressures allows us to more efficiently manage this endangered species. Our long-term study examined the spatial and temporal distribution patterns of telemetry-tagged Atlantic sturgeon within the Chesapeake Bay and nearshore waters for six years to clarify the importance of the bay to regional Chesapeake Bay stocks as well as other DPSs of the species. Its focus on zones of military interests not only delineated the species presence in these zones, but also was able to provide a framework to form correlations between inter-annual variability in environmental conditions and the species' distribution patterns. Our project was also able to estimate abundance of the York River adult Atlantic sturgeon population, define their return spawning rate, and identify sex-based differences in behavior through the discovery of a genetically unique stock reproducing in the York River system and a subsequent combined mark-recapture and acoustic-tracking effort. Continuous tracking over the years during the spawning season allowed us to identify the preferred spawning conditions of the York River stock and where such conditions occurred. Shifting locations of these preferred habitats identified behavioral responses to varied environmental conditions. Long-term tagging and tracking also allowed us to assess post-surgical behaviors of adult fish and compare the behavior of individuals over subsequent years to identify potential differences.

4.1. The Chesapeake Bay and Atlantic Sturgeon

Passive acoustic telemetry has grown in popularity for researchers tracking animal movement. Technological advances have reduced the size of transmitters while increasing their longevity. VEMCO® produces the best-known acoustic tagging equipment for aquatic use, and most researchers use their 69 kHz transmitters. The best data available on operational VEMCO® tags along the U.S. Atlantic coast are found in the Atlantic Cooperative Tagging (ACT) Network (www.theactnetwork.com). The quantitative comparisons that follow were calculated based upon annual estimates generated from the ACT Network database in December of 2012, 2013, 2014, 2015, and 2016. In 2017, funding for the ACT Network was discontinued. It is therefore not possible to accurately predict how many tagged Atlantic sturgeon there were in 2017 or 2018 and thus not possible to calculate the percentage we detected within our array in these years. However, our previous estimates calculate annual increases in the number of species carrying tags, and specifically Atlantic sturgeon, from 2012 until 2017 and thus still have value for those periods.

As of December 2012, there were 1,243 Atlantic sturgeon carrying tags, and by the end of 2013 there were 1,392. We detected 387 of those from December 2012 to January 2014, which is approximately 28 percent of tagged Atlantic sturgeon that were detected in 2013. The total number of active Atlantic sturgeon tags was projected to drop to 967 in 2014, due to estimated tag expiration. In order to ensure ample numbers of Atlantic sturgeon to track in the coming years, we and other researchers increased our tagging efforts and as of December of 2014, there were an estimated 1,571 active Atlantic sturgeon tags. We recorded 505 sturgeon in 2014 or approximately 32 percent of tagged Atlantic sturgeon. In 2015, 640 Atlantic sturgeon were detected, which represented approximately 37 percent of the operational transmitters. In January of 2017, there were an estimated 1,403 active Atlantic sturgeon tags and we detected 579, or 41 percent of the tagged Atlantic Coast population. Although we are unsure of the total percentage of Atlantic sturgeon carrying transmitters that we detected, we detected 1,223 sturgeon from 2013 until 2018.

Based upon these high levels of detection alone, habitats within the lower Chesapeake Bay estuary and nearshore waters appear to be extremely important to the species. When considering that many of the tags reported in the ACT Network were implanted in juvenile fish in regions far north or south of the Chesapeake Bay, habitat use and detection rates in our array are even more impressive because these fish have not yet matured enough to undertake ocean migrations and therefore could not be detected in our array.

Aside from the large amount of telemetry data, several attributes of the Atlantic sturgeon detected emphasize the relevance of the Chesapeake Bay to the sustainability of the species. First, there are at least two genetically unique stocks of Atlantic sturgeon reproducing in the bay (Tim King, USGS, personal communication) and the temporal and spatial elements of detections as well as newly obtained genetic analysis of samples from Maryland may suggest more. Second, most Atlantic sturgeon detected within the Chesapeake Bay arrays do not originate from these native Chesapeake Bay stocks based on tagging origin (**Appendix Table 9.3**). This assertion is supported by a previous genetic examination of a subset of fish randomly collected from locations throughout the bay (Bartron et al. 2007). Third, the Atlantic sturgeon detected represent a highly varied age structure, demonstrating that the bay supports the species throughout varied life stages. Fourth, there are numerous examples of aggregations of and extended occupation by sub-adult and adult Atlantic sturgeon within the Chesapeake Bay and its tributaries. Therefore, not only do bay tributaries support multiple reproducing populations of native Atlantic sturgeon through the provision of spawning and nursery grounds, but the Chesapeake Bay region also sustains varied life-stages of non-native stocks as well.

All but one of the Atlantic sturgeon detected in this study were captured and tagged in regions where local DPSs are listed as "endangered" under the ESA. The one exception was a fish tagged in Maine, where the DPS is listed as "threatened." Only 62 of the 1,223 (5 percent) Atlantic sturgeon detected within the array were tagged south of Virginia. Because so few Atlantic sturgeon from south of Virginia were recorded using Virginia waters, the percentage of sturgeon detected originating within the NOAA Northeast Region is actually larger than the 29 to 41 percent we predicted based on the active tags listed in ACT. However, many of the fish tagged in the Northeast are being collected in the ocean off the coast of Delaware and New York, where Atlantic sturgeon from varied DPSs are known to congregate (Greene et al. 2009, Hager 2011, Wirgin et al. 2014). Only future genetic analysis of each specimen will provide the data necessary to determine how DPS origin affects habitat occupation in the Chesapeake Bay.

4.2. Behavioral Responses of Atlantic Sturgeon to Varied Environmental Conditions

Habitat selection is due in large part to an individual animal's attempt to optimize its bioenergetic budget and thus grow, maintain health, and successfully reproduce. When faced with disadvantageous environmental conditions an animal is cued by its physiological tolerances/thresholds to seek out more beneficial habitats. In some cases the stressful attribute can be minimized by alteration in behavior or relocation to nearby micro-environments that are less stressful. If behavioral alterations or relocation to different micro-environments are not sufficient, the individual must move to more advantageous conditions because excessive stress can lead to death if not abated.

Every adult of an anadromous species must adjust to the extreme differences in salinity they encounter as upriver migration to spawn is undertaken. Numerous species of adult anadromous fish must stage their movements between varied salinities in order to allow for osmotic adjustment (Black 1957). Salinity alterations are in no way the only environmental variables that significantly affect a species' bioenergetic budget. Environmental factors such as temperature, dissolved oxygen, and even riverine flow rate also influence the energetic budget of an Atlantic sturgeon, as does the behavior of the individual. Therefore, a fish can improve its physiological condition and ability to deal with one stressor by selecting habitats and behaviors that benefit its energy budget in other ways (Hager 2004).

Niklitschek and Secor (2005) suggested that temperature and dissolved oxygen were primary motivators for Atlantic sturgeon habitat selection, and when thresholds are reached fish relocate. Dissolved oxygen within our array system has not been recorded low enough that Atlantic sturgeon would face severe stress, however, the 27°C mark representing a physiological threshold that motivates sub-adult sturgeon to relocate (Niklitschek and Secor 2005) is commonly exceeded in the summer throughout many Chesapeake Bay locations. Both life stages appeared to avoid such warm temperatures when possible and exhibited sedentary behavior during short warm-water periods when temperature was at or near 27°C (Hager 2011). When temperature remained at or exceeded 27ºC, sub-adults in the James River left the region, thus adhering to the findings of Niklitschek and Secor (2005). Adults did not strictly adhere to this threshold. Hager (2011) in 2007 to 2010 documented several adults that remained within brackish waters that slightly exceeded 27˚C, remaining near or even within downriver spawning locations prior to the spawn. This same behavior was documented in the present study in York River adults from 2013 to 2018. It is important to note that when adults chose to remain in such warm waters, they selected habitats with reduced salinity, increased flow, and/or higher dissolved oxygen. These factors are important to Atlantic sturgeon physiology (Niklitscheck 2001) and osmoregulation (Black 1957), helping to offset stress resulting from elevated temperatures.

However, even adults exhibited tolerance thresholds. In most years, those that reached the spawning grounds could withstand the heat of summer by relocating within the cooler, freshwaters of the upper rivers. However, in 2016 this relocation to beneficial micro-environments was not sufficient and adult Atlantic sturgeon that were well upriver retreated back downriver into deep waters located in higher salinity zones or in extreme cases left the York River system—returning to cooler bay waters or even the fresher, faster-moving water in holes located at the mouth of the James River. When conditions are extreme, adults are also motivated to decrease physiological stress through large-scale relocation in order to prevent overburdening physiological trauma.

Some adults in the James River divert their upriver migrations to reside in freshwater tributaries leading into the James during the heat of summer. The Chickahominy River is the largest freshwater tributary entering the middle James River, located at approximately RM 34 (**Appendix 8.1**) above NSN near the upriver boundary that defines the James River oligohaline zone (**Figure 1**). The freshwater flow out of the Chickahominy River can be so large that it defines the James River freshwater delineation line. Chickahominy River detections document Atlantic sturgeon of varied ages preferentially occupying habitats with physical attributes that resemble those required for spawning, such as reduced salinity, increased flow, and higher dissolved oxygen. The fact that adults and sub-adults of varied DPS origin (based on location of transmitter implantation) return to and intermix in this location during the heat of summer every year supports the assertion that Atlantic sturgeon seek out specific locations at times due to their physiological benefits alone (Collins et al. 2000b, Musick and Hager 2007, Hager 2011). It also suggests that the belief that adult Atlantic sturgeon occur in freshwater only to spawn (Balazik et al. 2012) is inaccurate.

Interestingly, during the late summer when sub-adult and adult fish gather in the mouth of the Chickahominy River, it is often the same temperature as the surrounding James River. However, it is fresher in comparison and much higher in dissolved oxygen (VECOS 2016). In addition, and in common with the Y WAT site in the NW/Ch. zone in the York River (**Appendix 8.1**), its velocity is much greater due to tidal and downriver flows. Late summer/early fall residence in the Rappahannock River and Maryland tributaries of the Chesapeake Bay may be based on the presence of similarly beneficial physiological conditions, because no spawning has been confirmed in either location. These apparent refuge sites contain mixed age classes and physical attributes commonly recognized as motivating habitat selection by Atlantic sturgeon (Niklitscheck 2001), but not all the conditions necessary for spawning, suggesting that sturgeon of all ages preferentially occupy regions solely because they are beneficial to their bioenergetic budget.

Interestingly, many adults that choose to enter the Chickahominy River never continued upriver reaching what Bushnoe et al. (2005) described as suitable James River spawning grounds. It is therefore alternatively possible that spawning may be occurring somewhere in the Chickahominy River. It is also possible that Atlantic sturgeon are somehow being prevented from traveling up the James River due to some temporarily but not yet determined physiochemical blockage (e.g., warm water and/or lower dissolved oxygen) and are thus forced to take temporary shelter annually in the Chickahominy River. However, if this were occurring it would still support the assertion that the river provides critical refuge and does not explain why adults would remain in the Chickahominy River after such a theoretical mid-summer blockage would abate.

It is unclear if fish of varied ages and/or genetic origin have similar physiologically derived thresholds with regards to environmental tolerances. The physiology experiments of Niklitschek and Secor (2010) that established our best physiological threshold data for Atlantic sturgeon were conducted on sub-adult fish of Northeast origin. Thus the dissolved oxygen, temperature, and salinity thresholds they developed apply well to the sub-adults of the examined northern population, but may not be applicable to older fish or fish of southern origin that have evolved to prosper in warmer southern climates. A family of fish that possesses evolutionary diversification due to its polygenic nature (Gómez et al. 2009) and has proliferated since the Paleozoic era (Murdy et al. 1997) has demonstrated its ability to adapt and evolve. It is only logical that each DPS would have adapted to its native environmental attributes. More research should be done to identify if physiological tolerances are life-stage and/or genotypically dependent.

4.3. Atlantic Sturgeon in Military Zones

Detection data suggest that occupation characteristics of Atlantic sturgeon within military zones of naval interest vary substantially, even on an individual basis. In numerous cases over the past six years, total detection volume at a single site during a given period was significantly increased by the sedentary behavior of an individual Atlantic sturgeon, or several, often of the same tagging origin. Thus, to determine if the detections of a single individual indicate a meaningful trend or are an anomaly, the characteristics of each tagged fish must be considered in order to understand how and/or if its behavior relates to that of other fish. This complication again highlights the importance of knowing the age and genetic origin/DPS of each fish in order to understand the motivation of a given behavior and the importance of detections with regards to characterizing occupation patterns as a species.

The numbers of individual Atlantic sturgeon detected within military zones were inversely correlated with distance from the ocean. Thus, more Atlantic sturgeon were detected in the ocean than in any other zone and as one approached the James River passing through the Fort Story, Little Creek, and NSN zones, the number of fish detected gradually declined (**Figure 10**). This correlation holds for all zones except the NW/Ch. zone in the York River. Here our tagging efforts, combined with the narrowness of the river, increased detection volume (**Figure 9**). The general trend exemplified in other zones where Atlantic sturgeon abundance increases with salinity reflects the species migratory behavior as well as its anadromous life history, in which more age classes of sturgeon are located in coastal waters. Most Atlantic sturgeon with transmitters were tagged in locations outside of the Chesapeake Bay region, further augmenting the likelihood of sturgeon detection in higher-salinity waters and coastal zones, especially during seasonal migrations.

Abundance in the lower Chesapeake Bay region is second only to that found in the ocean. This finding is unsurprising because this region is in proximity to the ocean and the species is known to be a highly mobile, coastal transient during most of its life phases. Fort Story and Little Creek military zones, located in the lower bay, recorded numerous Atlantic sturgeon of varied life stages belonging to various stocks, both native and non–native. Transient sub-adults tagged within multiple DPSs entered the Chesapeake Bay to take advantage of the food and environmental resources it provides. Native adults enter to undertake spawning runs. Adults from other DPS populations inhabit the bay, indulging in migratory breaks prior to proceeding to more northern climes. In some cases, these transient adults and even native adults that are not participating in spawning remain in the lower bay for some time. The few adults that resided in the mouth of the bay all summer were predominantly of Southeast tagging origin. Native adult females that were not participating in the spawning of that year and adults of Northeast origin were only present in the spring and early summer. Sub-adult and wandering adult males tended to move into the tributaries at this time. In years when adults slowed their immigration into local tributaries (2016 and 2018), some adults remained in the bay for a significant part of the summer, exhibiting sedentary behavior during the high water temperatures. These fish often substantially contributed to detection volume within the Fort Story and Little Creek military zones.

The James River is the largest freshwater river in Virginia. It has a tremendously large watershed and often contributes a high volume of freshwater into the lower Chesapeake Bay. In fact, the immense size of the James River forms its own estuary. It thus provides any fish that enters the lower bay with a rapidly accessible region of increased productivity and reduced salinity. The Little Creek and Fort Story zones are in proximity to the James River mouth. The NSN zone is located where the James River meets the bay in a region historically referred to as the Hampton Roads. Therefore, the water flowing through all three of these zones originates in the James River and contains its water quality attributes, which include decreased salinity and increased dissolved oxygen. It is natural that the numerous Atlantic sturgeon immigrating inshore in the spring, sub-adults to feed and adults to spawn, would be drawn to this highly productive river and its beneficial physiological attributes. Therefore, Atlantic sturgeon were often sequentially detected moving through the Fort Story and Little Creek zones as they immigrated up-current into the mouth of the James River where the NSN zone is located.

Most Atlantic sturgeon spend the winter in the ocean and therefore must slow their upriver migrations upon entering lower salinities to allow for physiological adjustments related to osmoregulation. This reaction is followed by either an extended holding period in this salinity and sequential runs into increasingly fresher water or an eventual reversing of upriver progress. Fish that reverse progress may drop back into the bay and move north to other Chesapeake Bay tributaries. Or, when examining detection data from transient adults from other northern systems, they exit the bay and move north to natal rivers. A few adults will remain in the bay as we have already discussed. The reason for and the extent of varied upriver movement between years and even between different fish in the same year is unclear. Detection data from 2016 and 2018 support our assertion that such behavior is linked to environmental conditions and the genetic origin of the fish. The location of the NSN zone in the polyhaline zone of the James River significantly augments the number of fish and detections (**Figure 1**). The Elizabeth River zone is in proximity to and directly upstream from the NSN zone, thus any fish diverted into the Elizabeth River zone also passes through the NSN zone at least twice because there is no evidence that Atlantic sturgeon are using the Intracoastal Waterway.

The York River is geographically disconnected from the other military zones and has unique environmental attributes. Located farther north, the York watershed is hydrologically different from the James River. Its watershed and resulting flow is minute in comparison and thus its freshwater input and freshwater-related chemical signature within the Chesapeake Bay is consequently vastly reduced. The York River channel is connected to the Baltimore Channel in the middle of the bay, whereas Thimble Shoals Channel leads to the James River (**Figure 5**). These physical properties appear to largely separate the spawning migrations of York River Atlantic sturgeon from the more southern military zones. Instead of immigrating along the southern shore of the Chesapeake Bay around Cape Henry and through numerous military zones, the York River adult population predominantly enters along the eastern shore, travels up the Baltimore Channel, and then into the York River Channel. The geographical separation, increased salinity, and unique physical characteristics of the York River watershed are also likely the reasons that few transient fish are attracted to the York River (**Table 8**). This stands in stark contrast to the highly varied tagging origin of fish detected farther south in the Fort Story, Little Creek, and NSN zones (**Table 12**, **Table 18**, **Table 20**).

The NW/Ch. zone has recorded a steadily increasing number of individual Atlantic sturgeon since 2013 and in the average number of detections since 2015 (**Figure 20**). These trends are in large part due to our increased tagging efforts following our discovery of a reproducing population of native Atlantic sturgeon in the York River (Hager et al. 2014). Our selection of fish that receive tags since 2015 is equally influential with regards to variance in detection data in this zone. In early years of research, we tagged every adult in good health that we collected. Consequently, predominantly males were tagged because their highly mobile behavior on the spawning grounds makes them more susceptible to gillnet gear, unlike the more sedentary females. Males also exhibit a high rate of annual return and thus significantly contribute to increasing annual rates of the number of Atlantic sturgeon detected. Since 2016, we have only selected females for tagging. Females do not exhibit nearly as high a rate of return as males. In fact, after six years we are only now getting enough migration data on females to examine if sexually divergent migration patterns or approaches exist. Significant increases in the average number of female detections have only occurred in the past year (2018) when 10 tagged females tagged in 2015 and 2016 returned.

The summer of 2016 was unusually warm compared to the other five years observed (**Figure 17, Appendices 8.3**, **8.5**, **8.7**, **8.8**, **8.9**) and 2018 was unusually wet. In both years habitat-occupation patterns, especially at the mouth of the bay where the Fort Story and Little Creek zones are located, varied significantly from that exemplified in the other four years. The numbers of individual Atlantic sturgeon and the average numbers of detections per station in these zones in these years marks unique differences in spatial and temporal aspects of occupation. Although we do not fully understand the details of correlations between environmental attributes like temperature and salinity and habitat selection, such attributes are likely important motivating factors.

Given six years of detection data, similarities in summer behavior patterns and their correlation to water temperature are becoming inescapable. Long-term data indicate that various locations within Virginia waters contain aggregations of Atlantic sturgeon that demonstrate similar sedentary behavior during the warmest-water periods. Atlantic sturgeon are known to prefer deeper habitats (Moser and Ross 1995, Savoy and Pacileo 2003) and the use of thermal and salinity refuges have been documented in other systems (Moser and Ross 1995). The summer of 2016 was significantly warmer than any of the other five years monitored (**Appendices 8.3**, **8.5**, **8.7**, **8.8**, **8.9**). This extreme year improved our understanding of how Atlantic sturgeon respond to increased temperatures and helped clarify that this factor was the primary environmental attribute motivating analogous behaviors observed in numerous other sites during the heat of summer over the other five years.

Tracking data suggest that a habitat does not necessarily have to be cooler to provide bioenergetic advantages that decrease stress during warm-water conditions. James River tracking data from 2007 to 2011 suggested that sub-adults within the James River watershed preferentially occupied waters that were fresher and contained higher flow rates, higher dissolved oxygen concentrations, and/or preferred temperatures (Hager 2011). Navy efforts have built upon this research, and the combined tracking data now suggest that relocation and sedentary behavior in response to heat is not age-, stock-, or river-specific, but is evidenced throughout the Chesapeake Bay and its tributaries by fish of varied DPS in specific locations that contain similar attributes. Habitat selection seems to be motivated not only by waterbody characteristics, but for native adults it can be influenced by proximity to intended spawning locations.

The Coleman Bridge receiver site (Y WAT; **Appendix 8.2**) located within the NW/Ch. zone is annually occupied by numerous immigrating adults prior to upriver migration. Although this site has increased fish occupation in June and July every year, in 2016 the number of fish and length of residence time increased significantly (**Figure 20, Table 9**). Temperatures were so high in the lower York in early summer 2016 that one returning Pamunkey female exited the York River altogether and dropped all the way back to the fresher NSN zone, where she resided for several weeks before resuming her spawning run up the York. Other York River fish also exited but most remained sedentary for an extended period at the Coleman Bridge. It appears this site was preferentially selected by adult Atlantic sturgeon not only because it is convenient to their spawning run destination, but because it also contains unique physical characteristics that are bioenergetically beneficial. These attributes increased detections in the location every year but made the site exceptionally attractive during the extreme heat of 2016.

The Coleman Bridge crosses the York River at its narrowest point. The river is abnormally deep (30 to 33 m) at this location and contains both fast- and slow-moving currents in proximity to one another. The slower currents are due to eddies created by bridge abutments, submerged cables, and the rapid expansion in river width after it passes through the strait. Fast currents increase flow across the gills thus decreasing the amount of energy necessary to obtain oxygen and allowing the fish to osmoregulate more efficiently with less energy expense. Eddies formed by anthropogenic alterations result in regions that minimize required swim speed and thus save energy by allowing fish to escape currents. We suggest these factors increase occupancy each year but that these bioenergetic advantages were the prime motivator for Atlantic sturgeon selecting the Y WAT site in 2016.

While the unique habitats of the York River are critical to its native fish, the consistently larger number of detections resulting from fish of highly varied tagging origins (**Table 12**) that occur 12 months of the year every year speak to the importance of the NSN zone to the entire species. Before discussing the geological and biological factors that make this region preferred, it is important to recognize that the reception data from the NSN zone are augmented slightly by the construct of our experimental approach and that of other researchers. The zone has slightly better reception coverage than other zones (**Table 2**) and this may slightly bolster its ability to detect fish. The zone has lower receiver coverage than the Elizabeth River, but its coverage is 6 percent greater than that which occurs in Fort Story zone and is 8 percent higher than the Little Creek zone. Detection volume within the zone was also augmented to some degree in 2014 and 2015 by tagging efforts conducted in the middle James River by VIMS. In addition, VCU continues to tag a few adults annually. All fish tagged upriver must exit through the NSN at some time because the zone forms a gate across the river mouth. Nevertheless, slightly increased coverage and tagging efforts do not completely explain the consistent preferential occupation exemplified by the species within the zone.

Though increases in the number of Atlantic sturgeon detected in 2014 and 2015 (**Figure 10**) in the NSN zone did, to a very limited extent, reflect tagging of sub-adult sturgeon by VIMS and VCU in the middle James River in the same years, the fact that sturgeon of other tagging origins exhibited similar occupation pattens in 2014 and sub-adults tagged in the James River in 2014 returned to the zone for an extended period in 2015 suggests that other attributes of the zone are motivating extended occupancy.

Tracking data illustrates consistent occupancy of the NSN zone by varied life stages of Atlantic sturgeon and suggest that the zone is important to Atlantic sturgeon due to its unique location and beneficial environment. This region, historically referred to as Hampton Roads, contains a naturally deep, low-salinity harbor with easy access to several deep-water channels located within a short distance from the ocean. Therefore, from a geological and biological perspective, the consistently large number of Atlantic sturgeon of highly varied tagging origins (**Table 12**) and life stages recorded within the NSN zone is logical. The zone literally extends across the James River mouth and forms a gate through which all sturgeon transient or native must pass in order to take advantage of the largest river in Virginia and its highly productive river estuary.

The James River historically contained a large population of Atlantic sturgeon (Hildebrand and Schroeder 1928, Barbour 1986) and until research performed under this contract proved otherwise, it was believed to support the only remaining reproducing population of Atlantic sturgeon in the Chesapeake Bay. Every native James River sub-adult Atlantic sturgeon passes through the NSN zone and some may use it as a nursery. Every returning James River adult must also pass through the zone at least twice in order to spawn. In addition, every sturgeon that enters the lower bay from the south passes through waters that flow out of the James River. The anadromous nature of the species implies that freshwater is essential to its life history, and many of the sturgeon migrating past and immigrating into the lower bay sense this freshwater signal and follow it to its source. Physical traits in the lower estuary of the river where the zone is located result in a diverse benthic infauna indicated by the high availability of bivalves (Mann et al. 2005). This productive benthic community likely increases the appeal of the zone to Atlantic sturgeon due to its prolific food resources. Therefore, many of the same physical characteristics that make this location an exceptional port result in its selection and active use by both native and transient Atlantic sturgeon.

Varied patterns in the detection characteristics within the NSN zone suggest that Atlantic sturgeon of different tagging origins and life stages occupied the zone in dissimilar ways. Most fish detected resided within the zone for short durations, with this pattern most pronounced during seasonal migration periods. Although many adults and sub-adults that are detected in the zone continue up the James River, an equally large number are transients that enter the zone but do not reside there and instead head to more northern tributaries, outside the Chesapeake Bay, where some adults ultimately contribute to the spawning efforts of other DPSs. These transient adults most commonly pass through the zone in the spring and early summer and do not return in the fall (Hager 2011). Some sub-adults pass through the zone quickly while others have been detected occupying it for over a month. Several young sub-adults from Delaware were recorded occupying the zone extensively in the winters of 2012 and 2013 (**Table 13**). This, and the frequent occupation of the zone by numerous other sub-adults, may suggest that the zone serves as an important feeding ground for various DPSs. However, because some of the sub-adults with the longest residence times in 2014 and 2015 also recently underwent surgery it is unclear whether this caused their sedentary behavior. The fact that many long sub-adult residence periods also coincided with warm summer water temperatures further complicates interpretation of what motivates such behaviors. Improved data on the genetic origin and age structure of detected sturgeon would significantly help to parse the data into more meaningful biological subsets and help identify potential connections between occupation patterns and life stage and/or DPS origin. Over time, with more fish-specific data and fewer local tag implantations, the motivation for extended occupation will become clearer.

The vastly lower detection volume per receiver and number of fish recorded (**Figure 23**) in the Elizabeth River reflects its reduced occupation. This hypothesis is supported by the fact that many fish are detected within the NSN zone and few enter the closely associated Elizabeth River. Some of the largest influxes of fish to enter the Elizabeth River were adults entering the river in the spring and early summer. These adults, previously tagged in the upper James, were presumably attempting to return to the James River to spawn in 2014 and 2015. They may have been drawn to the Elizabeth River because it was the closest source of freshwater or simply been confused. Adult fish did not enter the Elizabeth River in 2016. Why adults enter the Elizabeth River in one year and not in the next is unknown.

Large annual variations in number and temporal nature of detections within the Little Creek zone suggest inconsistent occupation patterns. Detections in this zone are again due to adults and sub-adults of highly varied tagging origins (**Table 18**). In early summer (June) of 2013 and 2014 concurrent increases in the number of fish, detection volume, and days with detections suggested that the zone was serving as a staging area for adults, where fish would sometimes reside for extended periods prior to entering the James River (**Figure 26**). This assumption seemed logical due to its geographic position south of the James River mouth. In 2015, fish availability peaked much earlier in April, and the 2013 and 2014 patterns of concurrent increases in all three detection parameters in early summer did not occur. Detection parameters instead indicated that fish were not holding in the area but were passing through to stage elsewhere.

Differences in annual detection values indicating varied occupation patterns also occurred during late summer within the Little Creek zone. In 2014, a reduced number of fish of southern tagging origin occupied the Thimble Shoals Channel sites (TS9 and TS11; **Appendix 8.1**) on the northern border of the zone for an extended period during the heat of summer. These fish demonstrated sedentary behavior and vastly increased the number of detections in channel sites within the zone. Atlantic sturgeon did not demonstrate similar behavior in the Little Creek zone in 2013 or 2015, but were more transient. In 2016, the Thimble Shoals Channel experienced normal spring and early summer occupation but larger numbers of fish and detections than usual in the heat of August (**Table 19**).

Fish demonstrated a consistent preference for the Baltimore Channel during both 2014 and 2015, with the most detections shifting downstream from B15 towards B9 in 2015 (**Table 17**). In 2016, fish did not exemplify much sedentary behavior in the Baltimore Channel. Instead, in late summer they increased occupation within the fresher Thimble Shoals Channel to some degree but demonstrated extreme site fidelity within the deep hole located at the 2C Henry buoy off Fort Story (**Appendix 8.8**). They were also found to a lesser degree within the closely associated CH receiver site in the Range Sur. zone. In 2017, occupation patterns within the Baltimore Channel, Thimble Shoals Channel, and Fort Story zone were similar to what had been recorded prior to 2016. Summer temperatures in 2017 were not as extreme. Detections did not reveal fish dropping out of the rivers after late-spring immigration as some had in 2016, but instead they continued to advance, after a short pause in normal staging areas, into the spawning grounds. Early arrival and cool summer temperatures on the Pamunkey and Mattaponi spawning grounds resulted in more numerous upriver runs over a more extended period than had been recorded in previous years (**Figure 15**). In the extremely wet year of 2018, adult fish did not move up the tributaries until later than usual. This meant that fish were available for detection at the mouth of the bay in the Fort Story and Little Creek zones for an increased period of time as they crossed the bay repetitively, as if unable to pick up on their natal river location. Again, a group of Atlantic sturgeon increased detection numbers at the 2C Henry site in the Fort Story zone due to their sedentary behavior in August and September. Interestingly, many of these fish did not make spawning runs in 2018 but remained at this station throughout the spawning period. This result provides further data supporting our assertion that alterations in environmental conditions, especially temperature and salinity, directly impact migration patterns in the mouth of the Chesapeake Bay as well as subsequent spawning behavior.

Detections in the Range Sur. zone continue to demonstrate the largest number of fish with the greatest diversity in tagging origin (**Table 22**). Detection patterns are consistent annually and indicate dispersed migrations seasonally. This expansive zone is located just north of overwintering habitats for numerous Atlantic sturgeon populations off the North Carolina Outer Banks (Hager 2011; Wilson Laney, USFWS, personal communication), South Carolina, and Georgia. Many of the tagged fish detected migrating up the coast through the Range Sur. Zone entered the Chesapeake Bay and zones of military importance, further supporting our earlier assertion that Virginia estuaries provide the species with crucial habitats.

Peaks in spring and fall detections within the Range Sur. zone are approximately a month earlier and a month later, respectively, than those recorded in other zones located near the mouths of the York and James rivers. Slight shifts in the timing of such migrations annually affirm that migrations are motivated by alterations in water temperatures (Smith 1985). During the heat of summer through early fall (July–September), fewer Atlantic sturgeon are usually detected in nearshore ocean waters (**Table 23**).

Many fish also leave the lower bay in summer/early fall and enter rivers in preparation for upstream spawning runs. Those remaining in the lower bay in mid-summer often enter deeper habitats and become more sedentary, presumably due to the physiological stress caused by heat, near or slightly exceeding 27°C (Niklitscheck 2001). These behaviors are evidenced in the offshore array to varied degrees each year but only in stations located at the mouth of the bay that are in proximity to the Fort Story zone. In the warm summer of 2016, the number of fish at the mouth of the bay increased atypically from July to August, driven by detections at the CH buoy (**Table 23; Appendix 8.8**). This is an interesting deviation linked to the same physical factors that motivated the drastic increases in detection and fish number recorded at the 2C Henry buoy within the neighboring Fort Story zone. A closer examination of all August data reveals that almost all of the data for this month (**Table 23**) each year are recorded at the CH site. An examination of the maps (**Appendix 8.1**) reveals that the CH and 2C Henry site at Fort Story, which received the majority of detections in late summer of 2016, are next to each other within the same deep-water channel. In fact, of the 25 Atlantic sturgeon detected in the two sites, ten were detected at both. This suggests that common water-quality attributes and a combination of biological factors are likely motivating habitat selection within this geographic region. It is also interesting that all available data suggest that the fish at the 2C Henry and CH sites during July and August were adults.

The physical characteristics of many receiver sites within the Chesapeake region array, Little Creek, and the Fort Story zones are similar. They all occur at the mouth of the bay and are thus geographically linked (**Figure 1, Figure 5**) and all contain channels: the Baltimore Channel to the north in the Chesapeake region and the Thimble Shoal Channel extending through the Little Creek and Fort Story zones. The southernmost channel, Thimble Shoals, leads into the James River through the NSN zone and thus links this zone to those that occur down-channel. During a given period, the same water body with common physical attributes can extend throughout all three zones. Therefore, it is no surprise that fish freely pass between these similar areas of interest and often demonstrate comparable behaviors within them. In 2013 and 2014, the physical characteristics of the lower bay motivated fish to congregate within the Thimble Shoals Channel (TS11, TS9) and Baltimore Channel (B9 and B15) in the heat of summer (**Appendix 8.8**). The numbers of detections at Thimble Shoals Channel sites within the Little Creek zone during the summer months of 2015 were drastically reduced in comparison with 2014 (17,370 vs. 3,699) despite a slight increase in the number of fish present (August; **Table 19**). NSN detections suggest that fish moved farther up the James River channel and staged in the NSN zone in 2015 instead of the Thimble Shoals during this time. Similar detection reductions were not recorded in the corresponding Baltimore Channel in 2015, where York River fish stage prior to proceeding up the connecting York River Channel. In fact, while the number of fish within the Baltimore Channel (B9) was slightly less in mid-summer (July) of 2015 (n = 10) than in 2014 (n = 15), the number of detections increased substantially from 4,608 to 20,913 (**Table 17**). In 2016, warm water temperatures motivated fish to remain in cooler waters nearer the ocean within the Fort Story zone and a closely associated receiver site in the Range Sur. zone. Adult fish, which in previous years had staged in either the Thimble Shoals or Baltimore channels in the mid-bay at this time of year, resided in the 2C Henry (**Table 21**) and CH (**Table 23**) receiver sites where they adopted typical staging/sedentary behavior prior to immigration and cooler ocean waters reduced temperatures during each tidal cycle (**Figure 29**).

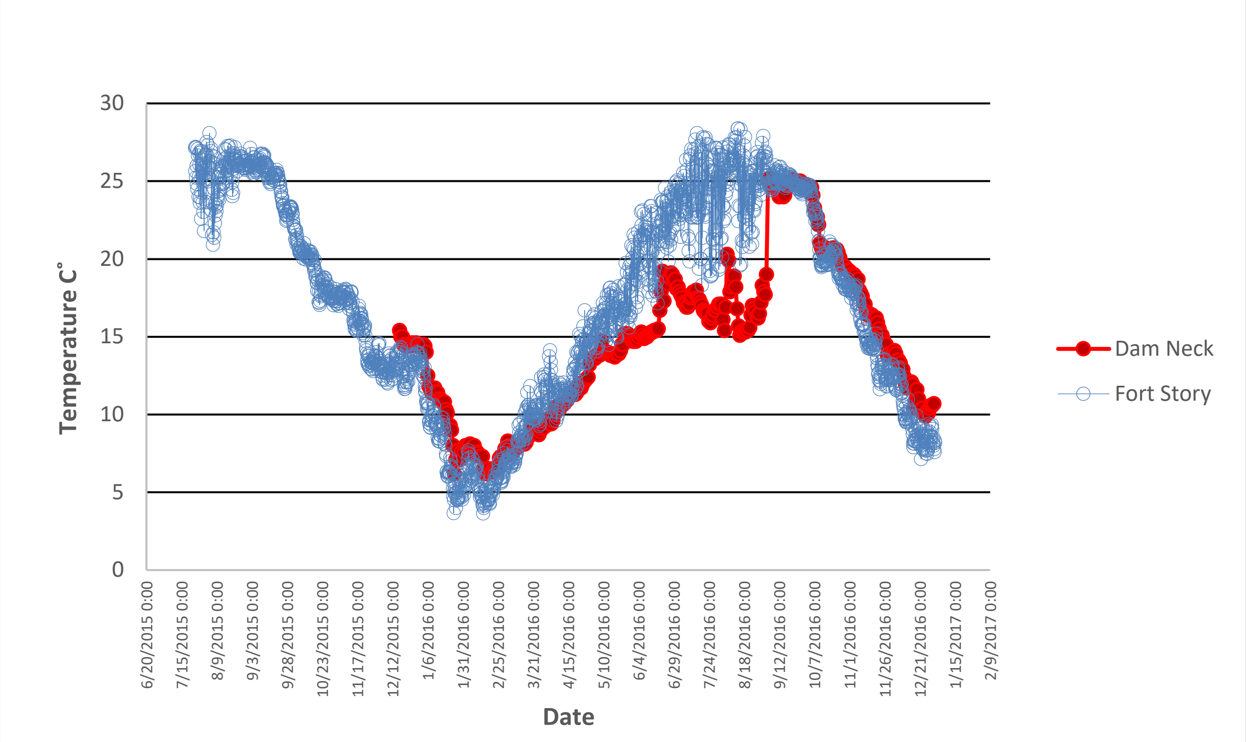

Figure 29. Comparison of water temperatures in the Fort Story and Range Sur. zones, July 2015–January 2017. The actual degree to which bottom temperatures cooled within the lower portion of the Fort Story zone was masked to some degree because the temperature gauge is located in the top 4 m and does not sufficiently reflect the cooler waters occurring at depth where the fish were located.

Refuge from elevated summer water temperatures appears to be a consistent motivator for habitat selection. However, the exact habitat selected varies substantially as does the degree to which sedentary behavior persists. Preferred mid-summer habitats throughout the Chesapeake Bay fluctuate annually because of variations in environmental attributes; the preferred locations share common physical attributes. Although the mouth of the Chickahominy River, the Baltimore and Thimble Shoals channels, the narrows of the York River, and the deep holes off Fort Story are all highly varied in their physical characteristics, adults and sub-adults aggregate and demonstrate sedentary behavior in all of these locations during warm-water conditions. In normal years, both the Thimble Shoals and Baltimore channels are preferentially occupied by Atlantic sturgeon in mid-summer when waters temperatures peak, suggesting that these sites usually provide some metabolic and migration advantages. Fish did not remain in the Baltimore Channel in the extremely warm water temperatures in the summer of 2016, but continued to use the fresher waters in the Thimble Shoals Channel and preferentially occupied the cooler, deep hole near the 2C Henry station in the Fort Story zone. A similar shift to the 2C Henry site indicated by a large number of detections was recorded in the wet year of 2018 when salinities in the bay plummeted. The degree to which this hole at the mouth of the bay and/or other sites are occupied appears to be related to various interacting water quality parameters. The same interacting factors that create the incredible productivity of estuaries, further highlights how dependent the species is upon estuary health.

4.4. York River Atlantic Sturgeon Population

Prior to our Pamunkey and Mattaponi River tagging efforts, almost nothing was known about Atlantic sturgeon in the York River system. In fact, previous York River monitoring efforts suggested that the York River was rarely occupied by sturgeon (Hager 2011). Our York River system research targeted adults within the spawning grounds, and Navy-funded research in 2013 proved that a natal, reproducing population of Atlantic sturgeon exists in the Pamunkey River and that spawning is occurring each fall (Hager et al. 2014). This discovery was pivotal and enabled subsequent years of sampling, tagging, and tracking that are now providing long-term data critical to understanding and protecting this genetically unique stock of Atlantic sturgeon. It is now evident that our previous perception of lack of use by the species was due to a deficiency of data on fish of York natal origin. While our original assertion that few transient fish from other systems use the York River is still holding true, we now know that the York River system contains a stock of highly mobile fish which use the York and other Chesapeake Bay waters in unique ways.

The York River system, made up of the Pamunkey and Mattaponi rivers, is the second most southerly tributary to the Chesapeake Bay, just north of the James River. Genetic results (Tim King, USGS, personal communication) conclude that the Pamunkey population is genetically unique and not closely related to the James River stock, as was once hypothesized. Not only is the York River Atlantic sturgeon population genetically unique but preliminary analysis suggests that the population is extremely small, which emphasizes its vulnerability. Our estimated total adult population of 325 (95 percent confidence interval = 226 – 423) for the entire York River system likely represents the smallest reproducing population of Atlantic sturgeon in existence (Kahn 2019). Although there are no direct comparisons of adult population estimates, the York River population is small compared to others along the coast. Assuming some relative comparability between Atlantic sturgeon effective population estimates along the coast and census abundance (Frankham 1995), the York River population is smaller than all other populations except the Connecticut River population (Waldman et al. 2018, Savoy et al. 2017). Upon listing Atlantic sturgeon under the Endangered Species Act in 2012, the National Marine Fisheries Service (2012a, b) assumed the abundance of every population in the United States except for the Hudson River to be smaller than 300 individuals. Our super-population abundance estimate, therefore, suggests that all other Atlantic sturgeon populations are likely larger than roughly 300 individuals. The fact that the York River adult population is so small could have enormous consequences for how the stock and its critical habitats in both rivers are managed.

We have been fortunate in that our mark-recapture efforts used to calculate our population estimation have spanned over a more extended time period than any other Atlantic sturgeon researchers. Six years of repetitive mark-recapture sampling in the same system combined with the smaller population inherent to the system has allowed us to achieve abnormally high recapture rates. These data were then used to estimate within-year annual spawning abundances (Kahn et al. 2019). Through combining all six years of mark recapture data with comparisons of tag returns and monitoring the number of new captures versus recaptures we have been able to calculate the total adult population contributing to the spawning effort in the York River system. No other researchers have been able to conduct such a directed and extensive field study and produce a comparable estimate.

There are four other published population estimates: the Hudson River (New York), the Altamaha River (Georgia), the Saint John River (New Brunswick, Canada), and a genetically-based estimate for the Connecticut River. Each used a very different approach from ours to create a population estimate. In short, limited funding resulted in forced approximation of many important variables that we were able to calculate due to our expanded research opportunity. The Hudson River estimate (Kahnle et al. 2007) suggests that at least 870 adults, based on fisheries-dependent data from the 1980s and 1990s, make up the population. The abundance estimates in the Altamaha River were most similar to our approach (Peterson et al. 2008). They applied a modified Schnabel, closed-population, mark-recapture estimate of abundance of two annual spawning runs. These suggest an annual spring abundance of 143 to 667 in 2004 and 216 to 787 in 2005 (both 95 percent confidence intervals). The data from each run were not combined to estimate the total adult population; two years is simply not sufficient data to validate such an approach. In addition, further research in the system discovered that a small proportion of adults congregate in the spring and join a larger proportion that enters and spawns in the fall (Ingram and Peterson 2016). Therefore, while the work does provide a valid estimate of the number of adults staging in the river in the spring in order to spawn in the fall, it is not a complete assessment of the number of spawning Atlantic sturgeon in those years. Dadswell et al. (2017) estimated that the Saint John River population ranged from 18,179 to 20,789 and used both open- and closed-population models. They also assumed no birth or death and constant annual return of both sexes. Needless to say, both approaches cannot be appropriate and thus one estimate cannot be used to verify the other. Thus, both are highly questionable. Finally, Savoy et al. (2017) used genetic variation to estimate the effective population in the Connecticut River. Based on that analysis, data suggest that the population in this river may be small. However, because this conclusion is only based on a reduced number of samples from juvenile fish collected from a single cohort during a single spawning season, their effective population estimate is not representative of the true effective population size (Waldman et al. 2018). The overarching theme inherent to these comparative studies is that to accurately estimate Atlantic sturgeon populations multiple years of data are required and this research must be directed at attaining data to achieve this goal alone. Only then can meaningful benchmarks be obtained to improve management.

4.5. Attributes of York River Spawning Population

Atlantic sturgeon range from New Brunswick, Canada to Florida, U.S. thus individuals of the same species experience a wide spectrum of environmental variables. Many misconceptions about Atlantic sturgeon have been based on the assumption that, because the species was well studied in the Hudson River (Murdy et al. 1997), it was well understood coastally. By choosing to use a DPS framework for listing in 2012, NMFS acknowledged that the genetic composition of stocks is important and should be considered in conservation decisions. Genetic composition of a particular region is inherited over time because it is selected for due to the conditions previous generations have endured and the most fit have survived, subsequently producing a unique genetic sequence that is best suited to given environmental conditions.

Since 2012, Atlantic sturgeon research has advanced considerably. It has begun to describe the unique life histories of a York River population that in 2012 was wholly undiscovered. We are only beginning to understand how these previously unrecognized populations have adapted to the unique challenges presented in their native regions. It has become apparent that this species is highly adaptable to different conditions. Atlantic sturgeon DPSs are genetically unique, partly due to selection pressures resulting in adaptations specific to their regions of origin (Damon-Randall et al. 2010). These adaptations have resulted in varied behaviors, life-history patterns, and even physical attributes. What has become painfully clear is if, as we once presumed, the species as a whole were to adhere to the same environmental requirements to reproduce as the fish in the New York Bight DPS, there would be no Atlantic sturgeon except within the range of the New York Bight DPS. Atlantic sturgeon reproduce and even thrive in regions that are different from the conditions that formed the genetically unique New York Bight DPS and thus each DPS should be monitored for particular environmental adaptations rather than applying those of one stock to the whole species.

In 2016, data were collected that strongly suggest that individuals contributing to the Pamunkey stock are also reproducing in the Mattaponi River. This hypothesis is supported by a plethora of data from both rivers. First, two females, one tagged in the Pamunkey in 2014, were caught full of roe in the Mattaponi in late summer of 2016. Another female tagged in the Pamunkey in 2014 returned to exclusively occupy the Mattaponi in 2017. Second, active adult males were detected transiting between suitable spawning grounds in both rivers in 2016 and 2017. Third, adult males tagged in the Mattaponi in 2016 returned to it exclusively in 2017. Fourth, adult fish of both sexes in spawning condition were detected aggregating over suitable spawning habitats in both rivers concurrently in 2016 and 2017. Finally, females tagged in both rivers have returned to remain in the Mattaponi exclusively during the entire spawning season and have not returned the following year to spawn. Thus, these native York River females either spawned in the Mattaponi or came into the fresh waters of the system and subsequently skipped spawning in the system that year as well as following years. Although we have seen females that apparently fail to spawn or at least fail to spawn fully in a given year, we have never seen one fail to return the next year to complete spawning. These data not only suggest that spawning is occurring in the Mattaponi, but that a single genetically unique but homogeneous York River stock exists. We are confident that our original mathematical model estimate still represents the entire population because this model uses five years to calculate the estimate and fish freely move between each system within this time scale.

Genetic analysis of fish collected in the Pamunkey and Mattaponi rivers show that no genetic differences exist between fish collected in these rivers and that in fact related fish enter both systems during the fall spawning season. This suggests that there is a York River system stock not a Pamunkey River stock. In addition, three fish that were tagged in the Nanticoke in Maryland have been found to be of Pamunkey genetic structure and have not returned to Maryland since tagging. Other fish genetically examined from the Maryland collection efforts have also shown they share a great deal of genetic structure in common with the York River fish. This may suggest that there is a northern bay population segment that has not yet been studied thoroughly enough to be identified, a stock that could include undiscovered reproducing populations in various northern tributaries including the large Potomac and Susquehanna rivers.

Interesting differences in male and female behavior once on the spawning grounds have been documented in the York River system. In agreement with the findings of others, our initial tracking data suggested that most male adults arrive on the spawning grounds prior to females. When Fox et al. (2000) asserted that males arrived first, they asserted this was because males had a greater tolerance for lower spring water temperatures. In our case, an earlier arrival in the warm waters occurring in mid-summer would suggest the opposite. Others have also found that males remain on the spawning grounds throughout the spawning season (Smith 1986, Hager 2011). Although our recent data continue to support that males remain for the entire spawning season, tracks of females on return immigration runs suggest that females arrive just as early as males but some females continue to arrive long after the last male is on the spawning grounds. Two out of three females returning to spawn prior to 2018 immigrated before the majority of males. In 2018, when ten tagged females returned most arrived in conjunction with males, thus our current data assert that significant sex-based differences in immigration timing may not exist, at least in the York River system.

Once Atlantic sturgeon immigrate into the freshwater region of the Pamunkey River, male and female behavior patterns vary considerably. Males stage within lower freshwater spawning grounds at the start of the season but begin to rapidly move between suitable spawning locations that are often many river miles apart, presumably looking for females as the season progresses. Males are thus much more mobile once on the spawning grounds than females and consequently more susceptible to intercept gear like gillnets. Females enter the spawning grounds upon arrival but often descend back downriver and take up residence near or in the oligohaline section of the river, where they reside until they are ready to re-ascend. These lower freshwater and upper oligohaline staging areas may be within the range of a few males, but most often are located below the range of searching males. Females appear to be preferentially selecting this downriver habitat, thus isolating themselves from male attention until they are ready to spawn. Smith (1986) suggested that the last spawning effort of a female is marked by a rapid ascension upriver followed by an equally quick exit downriver. In most cases, tracking data and the spawned-out state of females captured on this exiting run support his assertion. We have, however, witnessed several females that are very gravid late in the year. Most often these fish return the next year. It is unclear at this point if these females failed to spawn, spawned only partially, or completed their spawn below their last collection point.

Perceived differences between sexes with regard to the timing of immigration by other researchers may have been due to varied gear susceptibility between sexes, which we have recorded, and/or simply a lack of long-term tracking data on females. Conversely, latitudinal differences in the timing of male immigration may exist in other locations. Water temperatures vary the temporal component of spawning and could feasibly shorten the spawning window in northern climes to the extent that males must arrive early to increase their chances of reproducing, thus this behavior could be naturally selected for under certain circumstances.

Based on 2013 to 2018 data, males return to the Pamunkey on average every 1.31 years and females return every 2.29 years. Scott and Crossman (1973) suggested that some females return every year, in concurrence with our findings. Such frequent returns contrast with the findings of more northern researchers who have found that adult Atlantic sturgeon do not return every year (Van Eenennam et al. 1996, Caron et al. 2002), but is in agreement with other southern researchers. Smith (1985) indicates that males spawn every 1 to 5 years, and several other researchers have documented repetitive returns by males in southern rivers (Fox et al. 2000, Collins et al. 2000a). Maximum Atlantic sturgeon size is positively correlated with latitude, while growth rate is negatively correlated with latitude (Smith 1985, Collins et al. 1996, Stevenson and Secor 1999). Atlantic sturgeon mature at different rates along the coast, with southern populations reaching maturity more rapidly (Vladykov and Greenly 1963, Stevenson and Secor 1999). It seems perfectly suitable that a southern fish that does not grow as large or live as long would adopt a more rapid reproductive cycle to improve its chances of contributing to the genetic composition of the next generation.

The pattern of anadromy varies with latitude for shortnose sturgeon, *Acipenser brevirostrum*, a closely related species, and this pattern likely reflects bioenergetic adaptations to latitudinal differences in thermal and foraging habitat suitability (Kynard 1997). Similar latitudinal correlations between spawning populations have not yet been conducted for Atlantic sturgeon but comparisons between published works describing biological attributes of various spawning populations illustrate considerable variability in numerous parameters. Our findings support the hypothesis that the reproductive rate of Atlantic sturgeon varies with latitude. Increasing genetic exchange through augmenting individual rates of return promotes genetic diversification through natural selection more quickly. Resulting genetic differences due to such selection are reflected through the varied behaviors and life histories demonstrated by southern Atlantic sturgeon that often do not agree with literature published on northern stocks. Consequently, although many of our findings are not in the majority with regard to the behavior documented in northern stocks, they likely exemplify the genetic flexibility of Atlantic sturgeon.

Several important factors must be considered to understand the significance of a return rate estimate. Fish presence in favorable habitat does not substantiate spawning, even if it is a male running with milt, a spawned out female, or an egg carrying female. It is possible that returning females like those recorded within the Pamunkey River spawning grounds on consecutive years did not spawn in both years. Numerous males visit various river systems containing suitable spawning conditions where no spawning is believed to occur. We captured a male running milt in the Chickahominy River in 2018, but this likely has nothing to do with spawning in that river. It is also important to note that our return rate calculations are only based on Pamunkey River detections. If a fish returned to any other system, like the Mattaponi, this return was not included in our calculation. Therefore, the true return rate we calculated would be more frequent if all returns to any system in which spawning is occurring were included. Both are significant with respect to spawning thus the implications of these details are biologically important.

Some presume that because Atlantic sturgeon spawn in the late spring in the Hudson River, New York, they must also spawn in the spring in the mid-Atlantic, including Virginia (ASMFC 2009, Balazik and Musick 2015, Balazik et al. 2017). Others have suggested that perhaps two spawning seasons occur (Hager 2011, Balazik and Musick 2015) in the James River. Hager's assertion (2011) was based on numerous ripe males found in the upper river in the fall in 2008 and tracking data showing that some fish were making what appeared to be spring spawning runs into the upper James River (Musick and Hager 2007). From 2012-2014 a large amount of time was spent looking for spawning adults in the York system and no adults were captured. In addition, no spring detections of any native or transient adults have ever been evidenced in the York system. Despite this, published evidence to the contrary, Balazik and Musick (2015) continued to advance the theory that spring and fall spawning occurs not just in the mid-Atlantic but throughout the species range.

Balazik et al. (2017) supported their assertion of the existence of spring spawn in the James River by demonstrating that the genetic composition of fish collected in the James River in the spring (presumably collected at Sturgeon Point) is different than that attained from fall spawning fish (presumably collected near Hopewell). However, Balazik et al. (2017) is fatally flawed in several ways. First, spring spawning has never been observed in the James River, therefore the genetic composition of a theoretical population cannot be identified. In fact, Balazik et al. (2012) offers some of the best data that no spring spawn exists. During this research Balazik et al. (2012) ran gill-nets from April to June in the upper James River over suitable spawning habitat for three years and failed to collect a single Atlantic sturgeon. In the fall, they caught 106 males and tagged 40 in the same location. None of these tagged fish ever returned in the spring. Second, the collection locations of the two groups of fish were not identified. This point is critical because the James River, especially the lower sections, is well documented as containing a mixed stock of Atlantic sturgeon from many DPSs (Bartron 2007). Third, the genetic samples from fish collected in these unknown locations were not compared to genetics of other known DPSs to ensure they were not from one or a combination of other known stocks. Fourth, of the 31 adults tagged in the middle James River in the spring of 2006 through 2010, only three ever made spring runs up the James River into suitable spawning grounds (Bushnoe et al. 2005) during the five subsequent years of tracking. Most moved north and never returned to spawn in the James River in spring or fall (Musick and Hager 2007, Hager 2011). Unlike the theoretical spring spawning event, there is actual evidence of fall spawning occurring in the James River. Although Balazik et al. (2012) claimed that a post-spawn female captured in the fall of 2011 was empirical evidence that spawning was occurring, concrete data proving fall spawning was not collected until 2014 when several YOY were entrained in an intake screen of the Dominion Power plant near Richmond, Virginia.

Not only does evidence suggest that no dual spawning exists in the Chesapeake Bay but no evidence exists to substantiate that Atlantic sturgeon conduct dual spawning coast wide. No historic records of a spring Atlantic sturgeon fishery in the bay have ever been cited, although mid-summer sturgeon fisheries and even historic fishing techniques are prevalent in the literature. Captain John Smith specifically mentioned based on his observations from 1607 to 1609 that large fish/adults were not available in the James River until summer (Barbour 1986). During the peak of the Atlantic sturgeon fishery (1890–1900), sturgeon were taken during July and August by men of the Pamunkey and Mattaponi tribes using bush nets, a type of blocking gear (Speck 1928). More recently, data collected on sturgeon bycatch based on observer and fisherman reports funded through the Fisheries Resource Grant Program's 2005 to 2010 reward program provided no evidence to substantiate a spring spawning run in the York River. There simply are no data, recent or historic, that suggest that dual annual spawning migrations have ever occurred in the James or York rivers watersheds, although fall spawning has been confirmed in both (Balazik et al. 2012, Hager et al. 2014). Even in Georgia, what was once thought to be a spring spawn is now recognized as a spring immigration followed by a fall spawn (Ingram and Peterson 2016). Additionally, no fall spawning occurs in the Hudson. Therefore, data from the most thoroughly studied Atlantic sturgeon DPS in existence does not support the hypothesis of more than one annual spawning event.

4.6. Behavioral Responses of Spawning York River Population to Varied Environmental Conditions

In 2016, the NOAA Chesapeake Bay Office created GIS maps (Bruce and McGowen 2017) that complement Navy tracking research in the Pamunkey River spawning grounds through the provision of habitat layers that delineate and describe benthic habitats. NOAA maps show the locations of numerous areas within the river's receiver array that contain hard-bottom habitats such as cobble/rock and sand/pebbles, which provide suitable spawning substrates. Such habitats most often occur on the outside bends of the river near elevated riverbanks, where higher flow velocities move smaller/lighter sediments downriver, resulting in suitable clean, large-particulate spawning substrate. In all years, our telemetry data has indicated that females have terminated their spawning efforts after residing within river segments containing identified spawning sites.

Our long-term mark-recapture efforts in the Pamunkey River have resulted in extremely high recapture rates which have allowed us to precisely calculate the adult population of the system. Extensive specimen collection efforts have also allowed us to telemetry tag a large proportion (20 percent) of this adult population and achieve a nearly equal ratio of adult male and female fish. Concurrent long-term tracking and an expansive array in the Pamunkey, Mattaponi, and York rivers and the lower bay have provided sufficient data to examine behavior of the population and its responses to changing environmental variables at a much more detailed level than has previously been possible. Through tracking data we can determine not only when and where Atlantic sturgeon are in a given year but can compare how these locations and behaviors vary over time and draw correlations between habitat selection and environmental variables. Through cross referencing GIS habitat maps and detection data over time, correlations between spawning aggregation locations and physical attributes like temperature and river levels have been established. Telemetry allows us to observe fish behavior, which is used to determine how fish respond under varied environmental conditions. Thus, we can establish through observation which habitats spawning adults prefer under certain physical conditions and in turn determine how such environmental attributes influence behavior and ultimately spawning habitat selection.

Annual data collection efforts within the Pamunkey River have recorded interesting inter-annual alterations in the attributes of fall spawning related to water temperature. Mohler (2003) witnessed Atlantic sturgeon spawning in aquaculture facilities between 20 and 21°C. This range is nearly identical to the 19 to 22°C range in which adult fish were detected making rapid upriver runs in the James River to known fall spawning grounds in repetitive springs from 2008 to 2011 (Hager 2011). Increased activity and repetitive upriver runs have been documented in the Pamunkey River within a similar temperature range of 19 to 26°C, with spawning runs marked by larger gillnet catches and indicated by tracks of females undertaking their terminal runs for the season. Females have been netted in mid-spawn and post-spawn condition in temperatures ranging from 21.5 to 25.5°C, confirming that spawning is occurring within this range.

Because the duration of this preferred temperature range varies annually in the Pamunkey River (**Figure 17**), the suitability of the river as spawning habitat also fluctuates over time and space.

Temporal alterations in temperature determine when and where spawning can occur and thus expand or contract the duration of the spawning season directly influencing behavior and altering occupation patterns. In cooler years like 2015 and 2017 (**Figure 13 and 15**), two separate and distinguishable runs are evident in the Pamunkey River one in late summer and one in early fall. In warmer years like 2016 (**Figure 14**), a single spawning run of shorter duration occurs in early fall. Similar temporal alterations in behavior linked to environmental factors were noticed in the James River during tracking in its spawning grounds in 2007 to 2010 (Hager 2011) and have been documented in other systems as well (Smith 1986).

In 2018, detection data demonstrated how important river level and/or flow rate are to the selection of spawning habitats. Due to excessive rains the river was much higher and faster than usual. The dam at Lake Anna continued to release water during the spawning season, which is an uncommon occurrence during this normally dry time of year. In addition, the numerous (n > 20) large pumps run by local farmers irrigating their fields were silent. Spawning fish responded to the increase flow by moving much farther upriver (RM 95; **Appendix 8.3**) than they had ever previously been recorded. It is unclear if they did so because they normally are restricted from these locations due to water levels, if excessive flows in the extreme upper river cleared fine sediment exposing suitable larger particulate spawning substrate, or if some yet to be determined factor such as increased flow rates due to dam release motivated such an alteration in spawning habitat use.

Tagging efforts in the York River system have provided important biological information on the adult population size, return rate of spawning fish, spawning temperatures and sites, and differential sex-based behavior on the spawning grounds. Continued monitoring in the York River and lower bay has allowed us to identify the temporal and spatial characteristics of annual migrations and the environmental factors that motivate alterations in them. Such cause-and-effect data are critical to the Navy goal of reduced negative impact on the endangered species through avoidance because Atlantic sturgeon occupation of certain regions/zones is greatly influenced by annual alterations in environmental factors.

Substantial differences in detection and Atlantic sturgeon distribution patterns during immigration and emigration suggest that behavior during these migration phases varies significantly. Robust detection data are collected during immigration but emigration data are greatly reduced in volume. It is unclear if the cause of this difference is biological variations in behavior or in part a technological or methodological artifact. Extreme variation in the ability of a receiver to detect a fish may be the result of differences in the detectability of transmitters seasonally (Mathies et al. 2014). Environmental conditions may exist in the fall that make detection more difficult, although this explanation seems less likely for several reasons. Similar seasonal variability in the volume of detections of other fishes is not recorded. Because the lower Chesapeake Bay where the Chesapeake region array is located is shallow and well-mixed and thus not prone to the thermoclines, it is highly unlikely that vastly different ranges in transmitter detectability occurred seasonally. Range tests suggest that transmitters located in shallow water have a decreased detection range than those in deeper regions. If adults are using shallower pathways along the shore to aid in fall emigration speeds, such routes are numerous and not well covered by receiver range. The combination of these factors would result in poorer detection data resembling the data recorded in this study.

Differences in seasonal detection variables are most likely due to alterations in seasonal Atlantic sturgeon behavior. Atlantic sturgeon are known to prefer deeper habitats (Moser and Ross 1995, Savoy and Pacileo 2003). The species has evolved to be an effective bottom feeder, and numerous researchers have remarked on the uneven distributions of catches in gillnets, with the majority occurring in the lower portion of the water column (Musick and Hager 2007, Levesque et al. 2015). Historic differences in catch rates in bottom fishing gillnets upon immigration versus emigration in the Delaware River were so apparent that Hovey (1884) specifically noted it: “How they get out of the river without being caught is a mystery. All that the fishermen know about it is, that one day they are busy catching fish and the next all their nets are empty.” Significant seasonal differences in the depth distributions of adults were recorded in the James River based upon pressure/depth sensor data that suggest that the average depth of adults is shallower in the fall than it is in the spring (Musick and Hager 2007). Levesque et al. (2015) suggested that differences in the distribution of sub-adults within the water column may be due to migration phase. The attributes of fluid dynamics offer a simple explanation for observed differences in seasonal depth distributions. Due to the combination of net downriver movement of water and friction between the water and the bottom, water at the surface or in the shallows moves more quickly downriver than water at the bottom. It is therefore more efficient to move upriver by staying near the bottom on outgoing tides and take advantage of upriver movement during incoming tides. For a feeding sub-adult attempting to move upriver, staying near the bottom on both tides is bioenergetically beneficial because it minimizes downriver movement in the slower outgoing currents near the bottom and net upriver motion is accomplished on the incoming tide while feeding can occur continuously. It is possible that if the fish is traveling downriver to rapidly exit the river, it simply selects water that is exiting most quickly, which would be located near the surface. Because the majority of sub-adults entangled in gill nets in the spring were caught in the lower half of the nets when most fish are moving upriver, and most were found in the upper half of the gear in the fall when fish were emigrating out of the rivers, net interaction patterns suggest that Atlantic sturgeon are selecting the most advantageous position in the water column for migration.

Based on detections of native Pamunkey adults during spawning migrations in years following tagging, adults reside or stage within the lower Chesapeake Bay during immigration more often and for a longer length of time than during emigration. Atlantic sturgeon tend to congregate and often move back and forth across the mouth of the bay during spring and early summer. This behavior may reflect physiological adjustment and/or an effort to identify the chemical signal of their natal river. Consecutive up- and downriver runs within the York River during immigration and emigration suggest that physiological adjustments occur within the rivers during both migration phases. The repetitive runs made by adults that traverse salinity zones and result in gradual relocations up- or downriver into fresher or saltier conditions according to the direction of movement/season are perhaps the most revealing behavior exemplifying the need of the species to osmotically regulate during spawning migrations. The fact that immigrating and emigrating fish in the wet year of 2018 shifted their normal York River staging locations between these repetitive runs downriver in response to shifts in the river's normal salinity zones (**Figure 1**) during both immigration and emigration supports the assertion that Atlantic sturgeon like other anadromous fish must osmotically adjust to alteration in salinity during migrations (Black 1957). Osmotic regulation provides a logical, bioenergetically based explanation for many of the observed differences in occupation patterns within a given system on a smaller scale and variations in the temporal and spatial aspects of migration on a larger scale.

4.7. Post-Surgical Behavior of Natal York River Adult Sturgeon

It was once presumed that all Atlantic sturgeon were significantly stressed by surgical tagging and that this stress often severely affected behavior. It now appears that the effect of surgery can be highly varied and influenced by numerous environmental, biological, and handling-related factors. The importance of the genetic origin and life stage of each specimen and having numerous years of tracking data in order to properly interpret individual behaviors cannot be overemphasized. With insufficient data, it is easy to make unwarranted assumptions, advance incorrect hypotheses, and potentially suggest false conclusions.

Although it has been suggested that Atlantic sturgeon naturally adjust their behavior to maximize their energy budgets and reduce environmental stress, the degree to which behavior is altered by surgery and holding, and whether varied life stages are impacted differently is still not well understood. To better understand the impacts of surgery and holding, post-surgical holding experiments were conducted in 2007 and 2008 in the James River to: test the effectiveness of surgical procedures, ensure that procedures were not negatively affecting Atlantic sturgeon, and determine if behavior after release was altered. In 2007, sub-adult and adult Atlantic sturgeon were held for varied amounts of time after surgery. Upon release, most remained near their release site for a significant amount of time, with the resting period positively correlating with holding time (Hager 2011).

However, some adult fish left the system after release leading to concern that adults may be abandoning spawning runs due to surgery. In 2008, fish were not held but were released at the capture site immediately following surgery. Fish did not immediately exit the river and thus we assumed shorter holding times resulted in less-altered behavior. However, because the natal origin of these fish is unknown, behavior that is considered "normal" is only speculation. Because we assumed adults collected in the James River in the spring were native fish there to spawn, their departure after tagging was misinterpreted as abandonment of spawning runs due to tagging stress. Subsequent years of tracking revealed that a large percentage of these fish entered the lower James River each year yet never migrated upriver. They did, however, make annual migrations north, as far as New York. Many resided every summer in waters off Delaware and in Delaware Bay (Hager 2011). These tracking data strongly support the genetic findings of Bartron et al. (2007) that most fish found in the lower James River belong to non-native DPSs. Therefore, their exiting the river was likely due to normal outward migrations to northern regions and not an effect of surgical stress.

VIMS and VCU tagged fish in the Burwell Bay area of the James River (mesohaline zone) in 2014 and 2015. Most of the fish implanted with tags in Burwell Bay by VIMS and VCU were sub-adults. It is unclear if this life stage exhibits the same post-surgical response as adults. Subsequent tracking of these sub-adults may suggest that the effect of tagging is influenced by the life stage of the fish and/or size relative to the tag. The tag weight/body mass and the incision length/fish size ratios are far larger for sub-adults implanted with like-sized V16 transmitters than they are for adults, and this likely prolongs recovery time. Some of the tagged sub-adults descended into the higher-salinity zone (polyhaline zone; **Figure 1**) and resided within the NSN zone for extended periods in both years. Others ascended the river and entered the Chickahominy River, where they exhibited similar sedentary behavior. The fact that sub-adults did not exhibit this behavior in other years when tagging of sub-adults was not occurring in the middle river is suspicious but may be coincidental.

Not all sub-adults implanted in the same year exhibit this behavior, therefore other factors may have contributed that cannot be discerned from detection data. The electro-narcosis method of anesthesia being used by VIMS and VCU may have varied, resulting in more long-term effects on fish of smaller body size. The amperage may have been unsteady or too high. There are numerous ways sub-adults could have been handled differently before, during, and after surgery that might have resulted in varied degrees of stress and thus post-release behavior. Only tracking sub-adults under intentionally varied handling and surgical techniques and during similar environmental conditions would help determine if resulting sedentary behaviors were connected to tagging.

Often the misconceptions of altered behavior after surgery are due to a lack of long-term tracking data and/or poor assumptions. Male Atlantic sturgeon have never appeared to alter their behavior due to interactions or tagging. Detections of post-release ripe females in the Pamunkey River initially led us to believe that many females were prompted to descend downriver and take up residence following tagging, a behavior again presumed to result from stress. Because females were captured on the spawning grounds and released immediately following surgery, it was logical to assume that tagging stress could have motivated them to re-enter the oligohaline zone downriver. However, several initial factors suggested that this behavior was not due to tagging stress. First, the behavior was sexually divergent, in that males did not exhibit the same downriver movements. Second, females were less likely to exhibit this response when caught later in the season or in a more advanced spawning stage. It was not until females (n = 15) returned in years after tagging that tracking data could be reliably compared. Upon their return, the majority of females made initial runs of short duration onto the spawning grounds where males were waiting. They then descended downriver to reside below the spawning grounds, often entering the oligohaline zone. They remained downriver, as the newly tagged fish had, for short periods of time before resuming repetitive sequential runs of different distances back into upriver spawning grounds. Returning females tagged in years prior (n = 15) often exemplified the same habitat occupation patterns as newly tagged females in the same year, which suggests that such behavior is normal and unrelated to tagging stress.

Females may travel downriver to regions below the spawning grounds occupied by awaiting males in order to escape the unwanted, premature, and aggressive attention of competing males if eggs are not mature. Physical or chemical interactions with males during this initial foray may also stimulate females in some way that prepares them for the subsequent spawning event. Female behavior appears to be unmodified by tagging or recapture in that site selection during residency, longevity of residence, and duration and extent of spawning runs of individual female's are similar across years. Temperature graphs that identify spawning site selection as well as residence times suggest that spawning site selection and residence times are instead predominantly influenced by annual temperature, flow variability on the spawning grounds, and potentially individual female preference for certain regions (**Figures 12, 13, 14, 15, 16, and 17**).

4.8. Conclusions

Estuaries have long been recognized as extremely important to Atlantic sturgeon. Their value for growth, nursery areas, and thermal and salinity refuges has been extensively documented (Dovel and Berggren 1983, Moser and Ross 1995) as have migrations between coastal estuaries (Welsh et al. 2002, Savoy and Pacileo 2003), illustrating the importance of native and coastal estuaries alike. Deep channels at the mouths of estuaries have already been recognized by the Atlantic States Marine Fisheries Commission (Greene et al. 2009) as habitats of particular concern due to their provision of critical migration corridors and high levels of anthropogenic alteration. Inter-annual variations in the location of pre-spawning adult sturgeon congregations and their concurrent sedentary behavior in the heat of summer prior to spawning runs suggest that the mouths of rivers and estuaries are not only essential routes to spawning grounds but provide critical thermal refuges in late summer prior to subsequent runs as well.

Spatially diverse tracking data are necessary to determine the transient locations of such preferred habitats and migration routes, and these datasets must be of sufficient duration to characterize the temporal nature of the physical factors that motivate behavior/habitat selection. Sequential detections within a given year illustrate the power of the array to describe the temporal and spatial attributes of a given migration. Long-term data sets that include concurrent measurements of physical parameters are required to construct meaningful correlations between migrations, staging areas, and refuges over time that include the numerous factors that alter behavior. Through tracking, time-tested mathematically based correlations between behavioral response and environmental variables can be created based on repetitive observations of a species' responses to varied environmental conditions alone. These can be incorporated into predictive models capable of describing temporal and spatial distributions based on a given combination of environmental conditions and historic responses.

Given current data, we already have the ability to estimate the adult population within the NW/Ch. zone temporally, based upon our York River adult population estimate, temporal and spatial patterns evidenced in historic data, and recent detection data at stations downstream. Correlations between detection parameters in sequential zones are beginning to suggest that such data can be used to predict the relative abundance of fish present in other zones as well.

Clearly, advances in technology have greatly improved our ability to assess animal behavior and provided a means of directly monitoring their temporal and spatial patterns of distribution. Although the assessment capabilities are extensive, such advancements should not be viewed as definitive. Transmitters only assess presence/absence and the value of these data is greatly influenced by the array design and the percentage of the available population that is tagged. In addition, detection-distance trials suggest that additional trials are necessary to understand why detection distances vary so extremely and non-linearly. Tests must include different strength tags in varied salinities over numerous benthic and environmental conditions to be more accurate and precise about true detection distances. With so many biological and physical variables influencing detectability, determining a detection distance will always be an approximation based on repetitive in situ tests. Testing for longer periods of time over more highly varied conditions may also help to resolve many of the difficulties in determining the average detectability, according to VEMCO® engineers.

The array and associated tagging research is young compared to the biological behaviors it is trying to describe. The current dataset, although impressive, is far too limited to predict all of its future applications. In its six short years it has greatly advanced what we know about Atlantic sturgeon within the bay and coastal areas. We have discovered new populations and estimated their abundance. We have found spawning occurring in additional rivers and redefined the boundaries of critical habitats. We are now on the cusp of understanding what motivates habitat selection in critical locations and are thus closer to being able to predict spatial and temporal distribution patterns. We look forward to what the future of Atlantic sturgeon research will teach us and to sharing this knowledge in order to improve our nation's ability to protect its natural resources.

5. Deployment Challenges

Our first-generation offshore receiver deployment method was designed to improve upon the approach used by another Atlantic Coast researcher (Dewayne Fox, Delaware State University) and our earlier method that we had used successfully in local rivers since 2006. Our original offshore approach doubled the size and breaking strength of our attachment cables, but this was not sufficient to hold receivers on Chesapeake Bay or offshore buoys, where heavy traffic, narrow channels, and severe storms occur. Generation Two deployment methodology was developed to address chafing issues on pilings, which became apparent after 6 months of deployment (June 2013) on the CBBT. A Generation Three buoy attachment method was developed in August 2013 and deployed in September 2013 to address losses on buoys in the ocean. This attachment method placed the receiver directly below the buoy and out of the way of vessel impact. Although no receivers were lost using this approach, receivers failed because of suspected vibration and buoy impact.

Because receivers were still failing due to water leaks, battery disconnections, and/or clocks rattling off the internal motherboard, our Generation Four approach padded the Generation Three attachment. This greatly reduced leakage, but clocks still detached despite little detectable movement between receiver and buoy. VEMCO® recognized this clock detachment as a problem and altered the battery attachment design in response. To further reduce stress on the receivers, we have begun to re-suspend ocean receivers. In high-energy environments, we now attach padded and encased receivers to two 6 m long, 8 mm diameter, stainless steel cables each with breaking strength of 2,200 kilograms. One cable attaches the receiver to the bottom of the buoy and one to the top. These cables are attached with custom stainless-steel U-bolts to the receiver and buoy. In combination with VEMCO®'s new battery attachment methods, this approach has worked well. However, no matter the deployment method, some breakage and loss will occur, especially in offshore environments.

6. Acknowledgements

We would like to thank David MacDuffee and Laura Busch at U.S. Fleet Forces Command and David Noble and Jessica Bassi at Commander, Navy Region Mid-Atlantic for funding the work. We are enormously thankful for the opportunity to help the Navy better manage our nation's marine resources. We would also like to thank the numerous researchers who allowed us to use their fish tags in this study. We also want to recognize the Chesapeake Bay Bridge-Tunnel Authority, USCG, USFWS, and NOAA for essential help. Private landowners played an essential role through donating the use of their facilities and their time: Jonathan Lenthal, William Tyler, and Steve Soffin in particular. We would like to extend our gratitude to now-deceased Tim King (USGS) for his invaluable expertise in genetics research. His jovial character and constant guidance made a vital contribution to this study. We will miss him greatly. We also want to thank Carter Watterson (U.S. Navy) and Jason Kahn (West Virginia University and NOAA), as well as Ramsey Noble, Jay Russo, Craig Marcuson, Tracy Massey, Kirk Moore, and Noelle Mathies of my crew for their tireless efforts that enabled this research, as well as, April Deacy and Desiree Nuckols of the Pamunkey Indian Tribe. Atlantic sturgeon research was conducted under a federal collection permit managed by Albert Spells (USFWS, NOAA permit 16547-01) and Jason Kahn (NMFS, NOAA permit 19642), as well as annual permits issued by the Virginia Department of Game and Inland Fisheries and Virginia Marine Resources.

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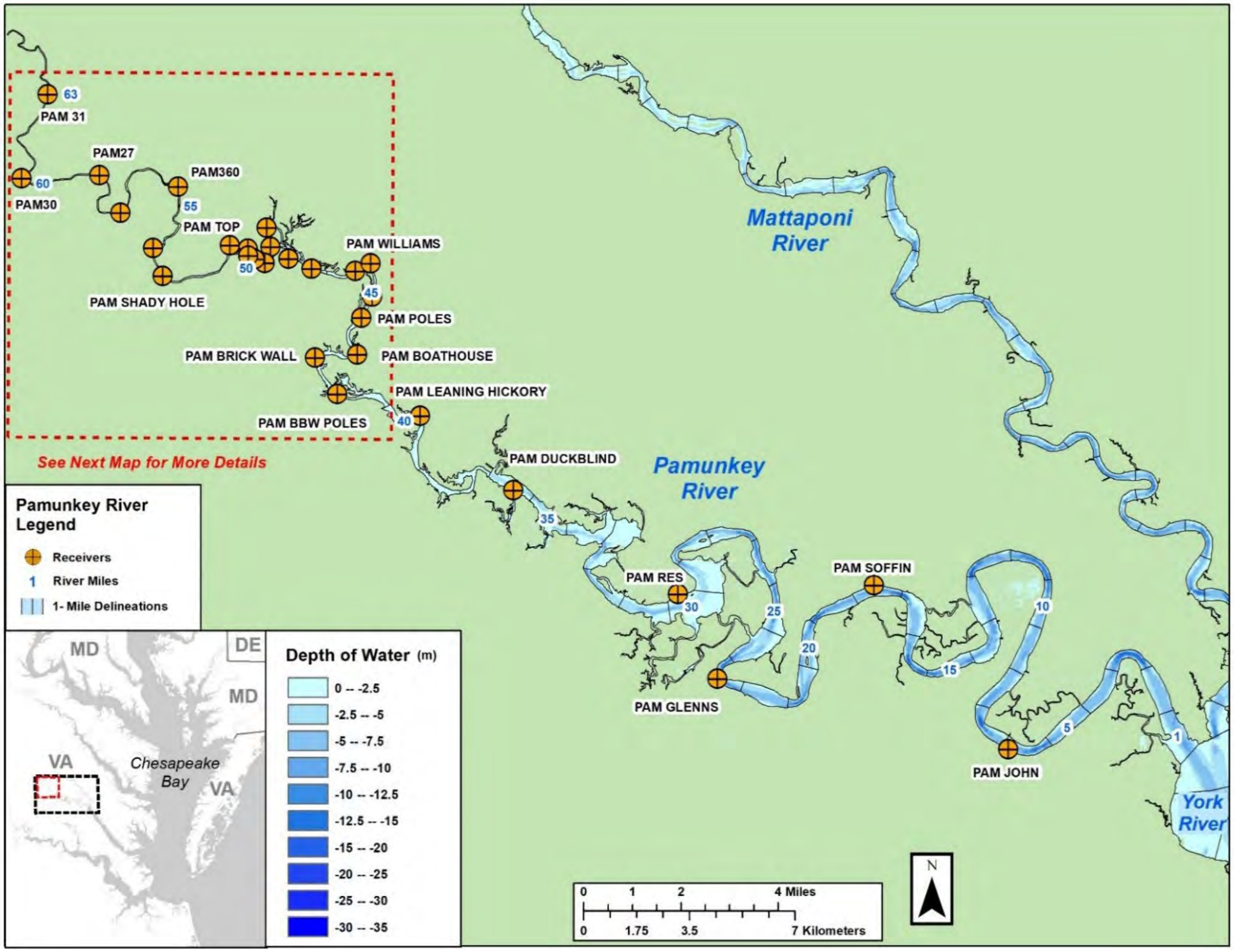
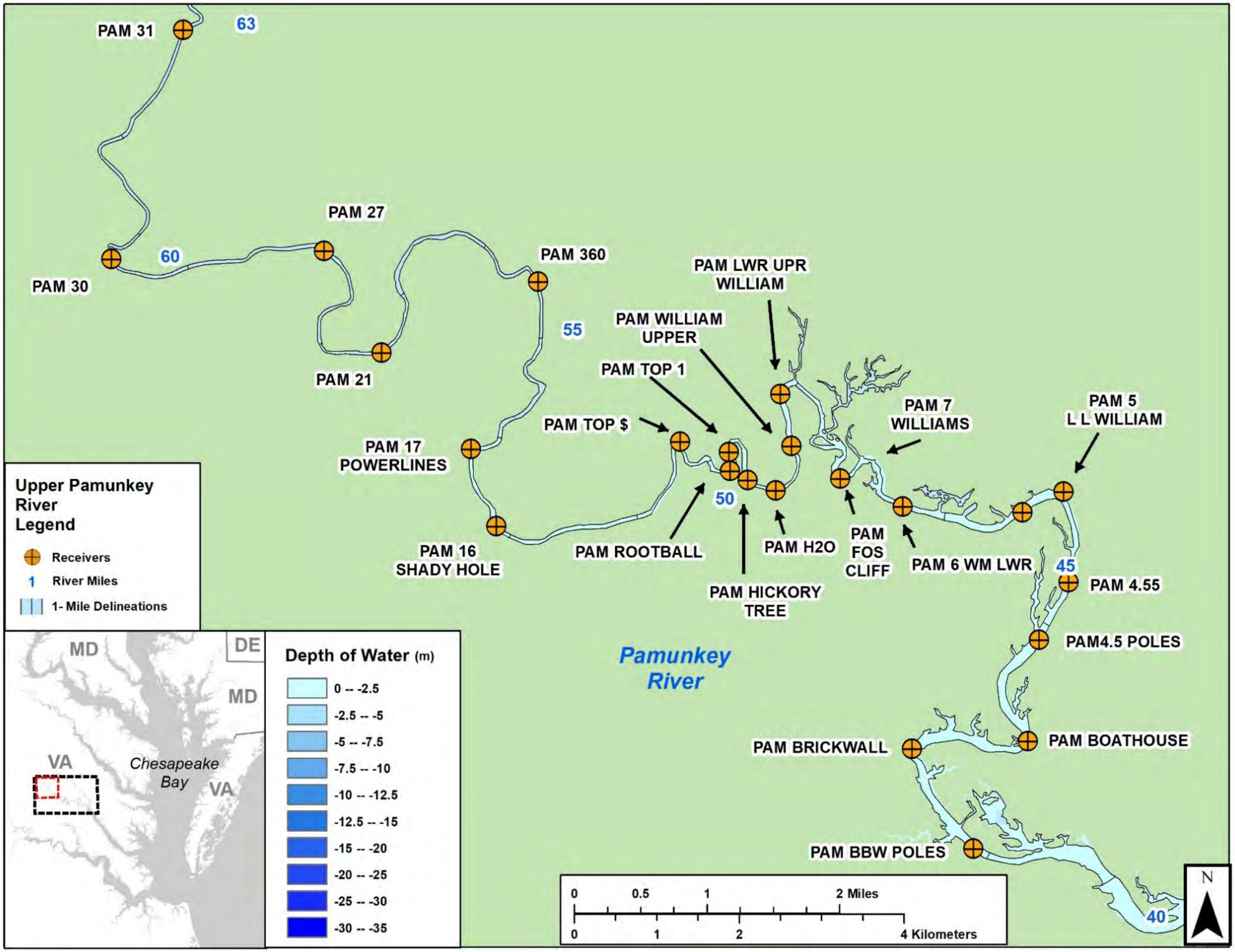
8. Map Appendices

8.1. Appendix 8.1: Receiver Locations and RM Designations for Each Study Region

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63
PAM 30
60
PAM 27
PAM 21
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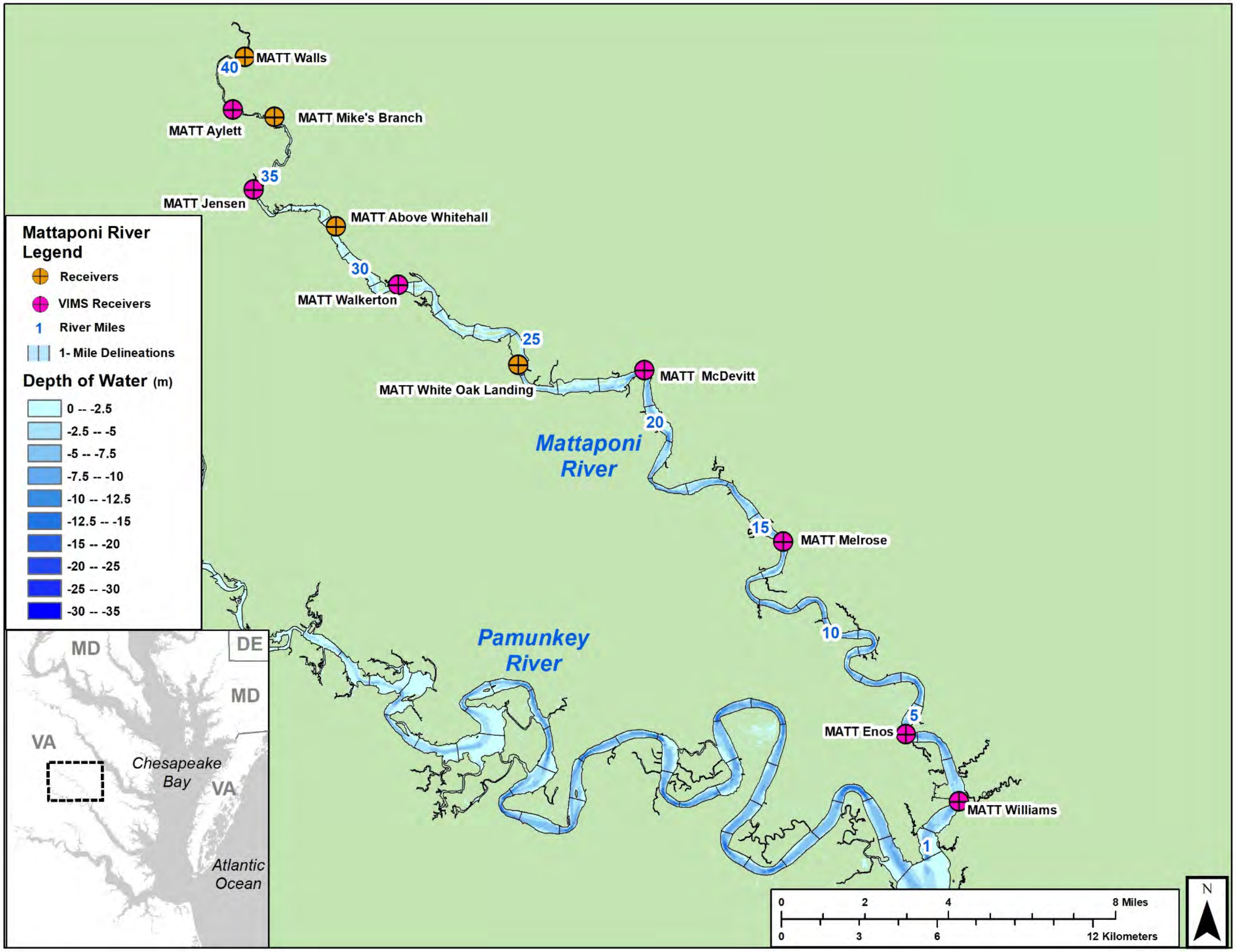
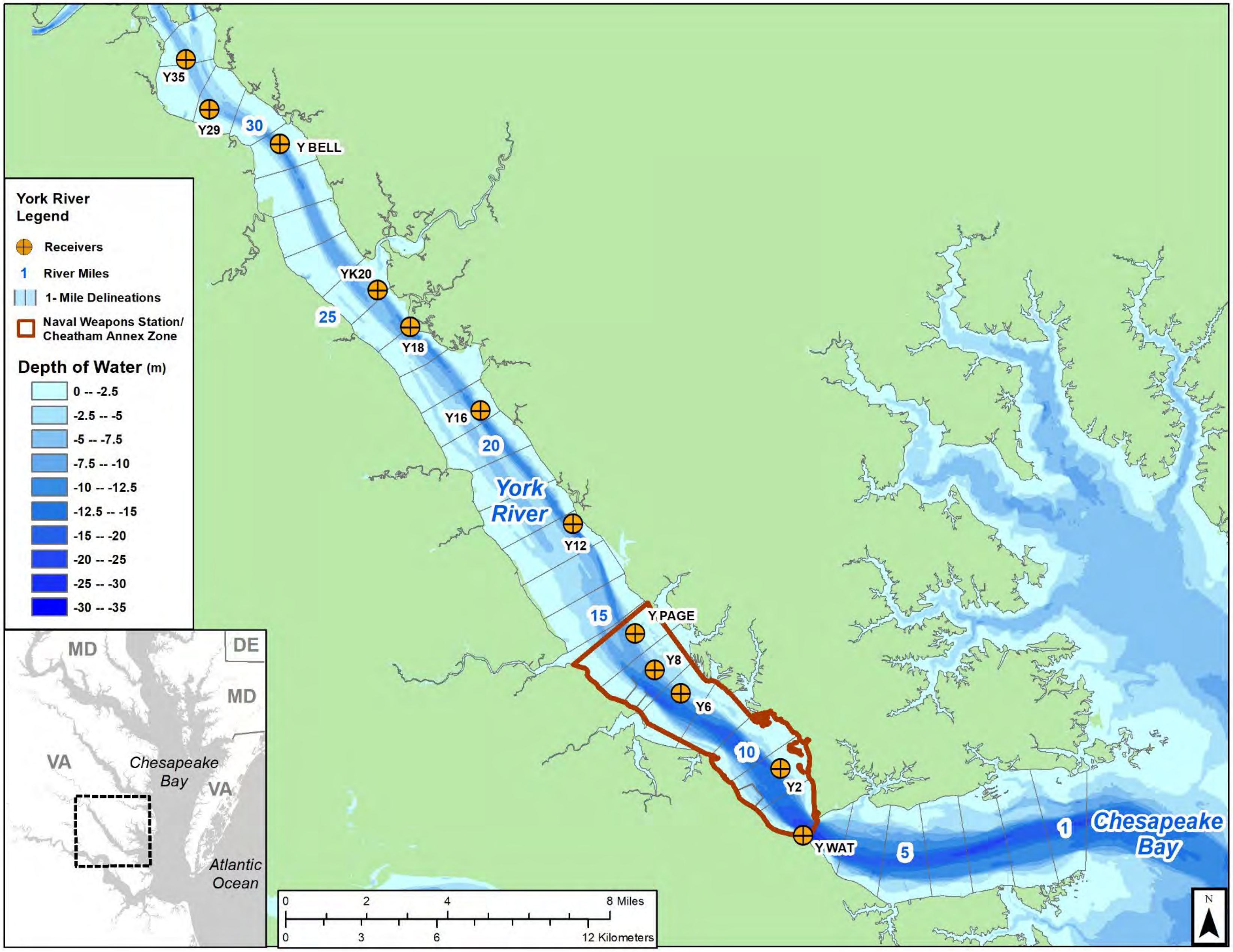
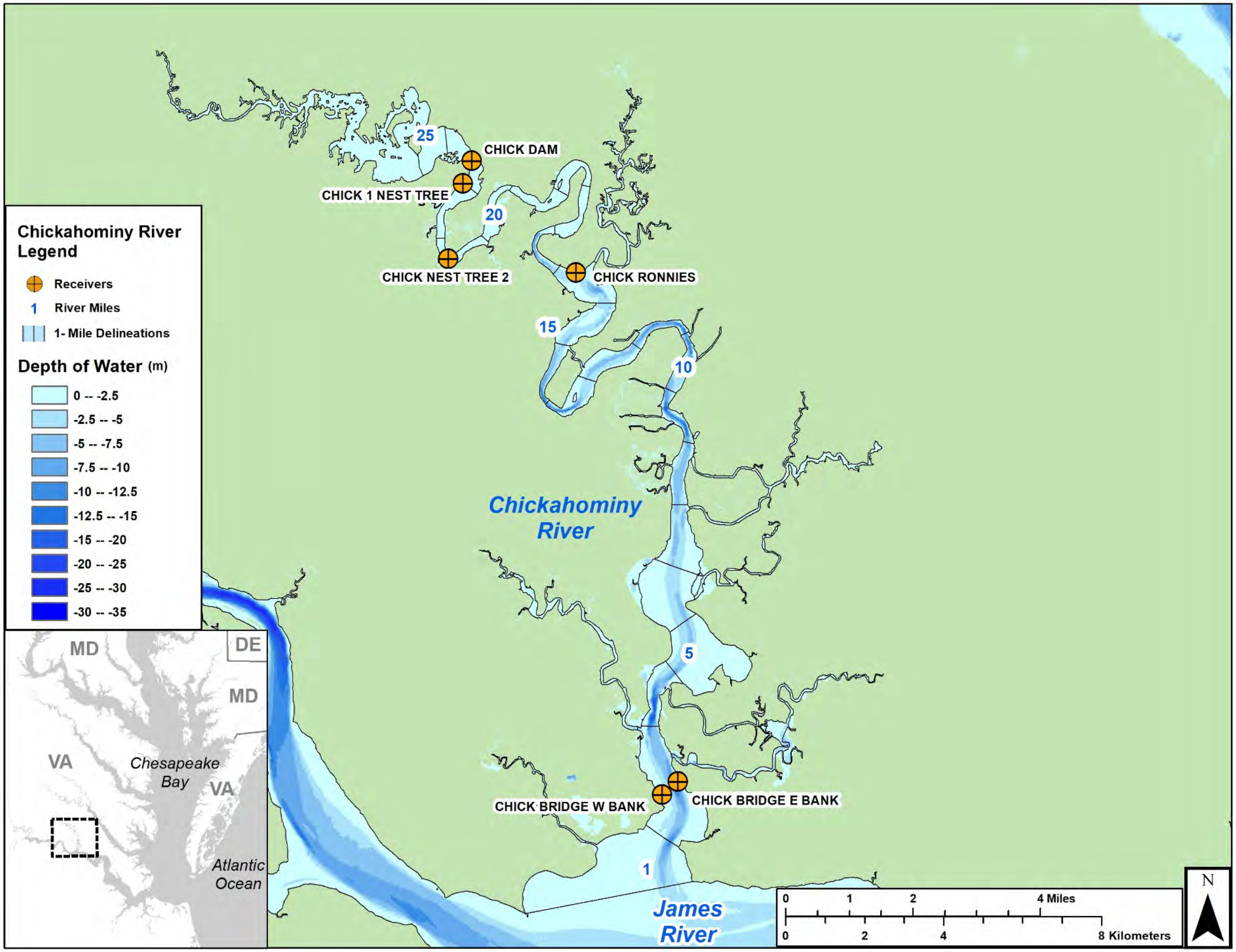
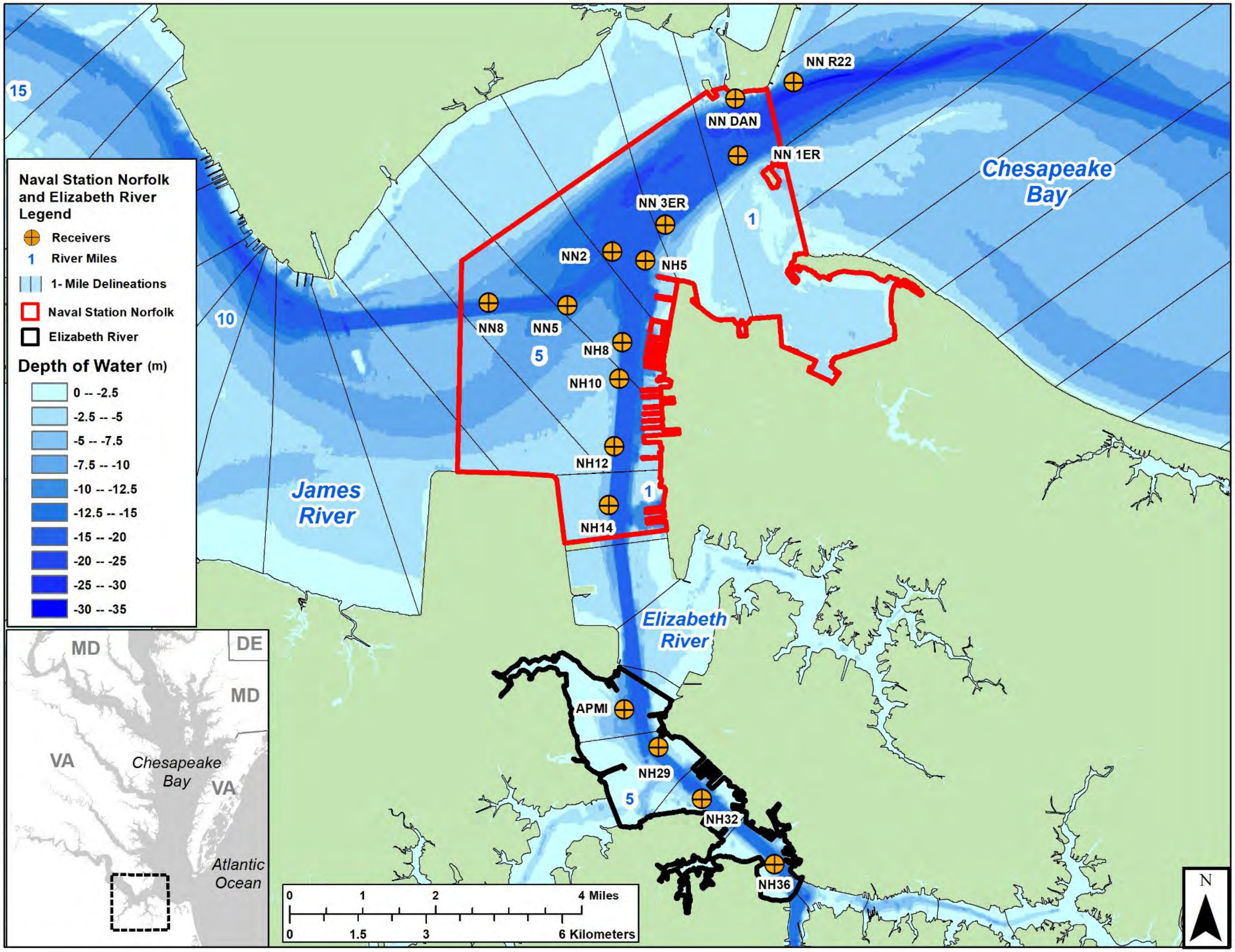
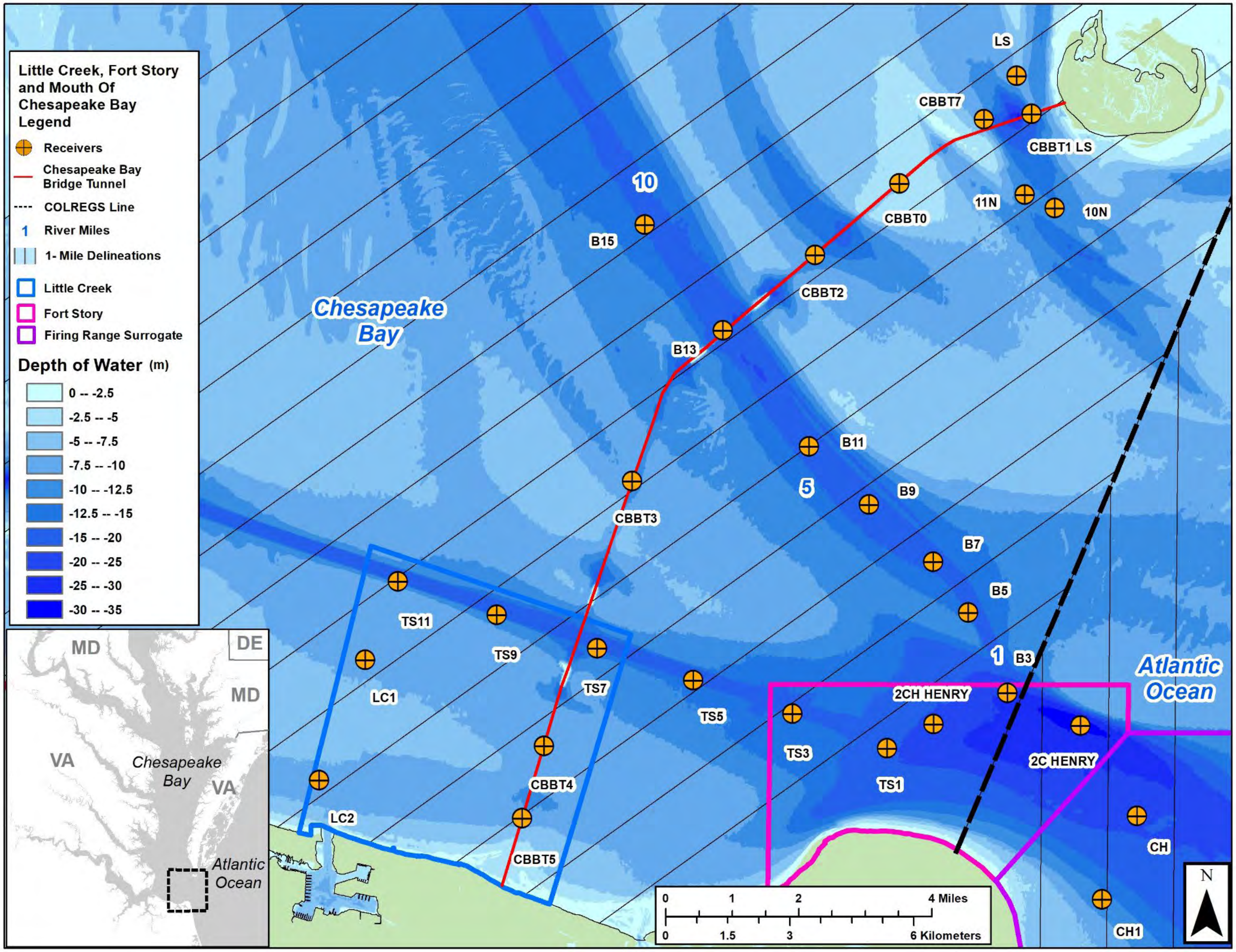
55
PAM LWR UPR WILLIAM
PAM WILLIAM UPPER
PAM TOP 1
PAM TOP $
PAM 17 POWERLINES
PAM 16 SHADY HOLE
PAM ROOTBALL
50
PAM HICKORY TREE
PAM H2O
PAM FOS CLIFF
PAM 7 WILLIAMS
PAM 6 WM LWR
PAM 5 L L WILLIAM
45
PAM 4.55
PAM4.5 POLES
PAM BOATHOUSE
PAM BRICKWALL
PAM BBW POLES
40
Pamunkey River
Upper Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Depth of Water (m)
0 -- -2.5
-2.5 -- -5
-5 -- -7.5
-7.5 -- -10
-10 -- -12.5
-12.5 -- -15
-15 -- -20
-20 -- -25
-25 -- -30
-30 -- -35
0 0.5 1 2 Miles
0 1 2 4 Kilometers
N


MATT Walls
40
MATT Aylett
MATT Mike's Branch
35
MATT Jensen
MATT Above Whitehall
30
MATT Walkerton
25
MATT White Oak Landing
MATT McDevitt
20
Mattaponi River
15
MATT Melrose
10
5
MATT Enos
MATT Williams
1
Pamunkey River
Mattaponi River Legend
Receivers
VIMS Receivers
1 River Miles
1- Mile Delineations
Depth of Water (m)
0 -- -2.5
-2.5 -- -5
-5 -- -7.5
-7.5 -- -10
-10 -- -12.5
-12.5 -- -15
-15 -- -20
-20 -- -25
-25 -- -30
-30 -- -35
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N

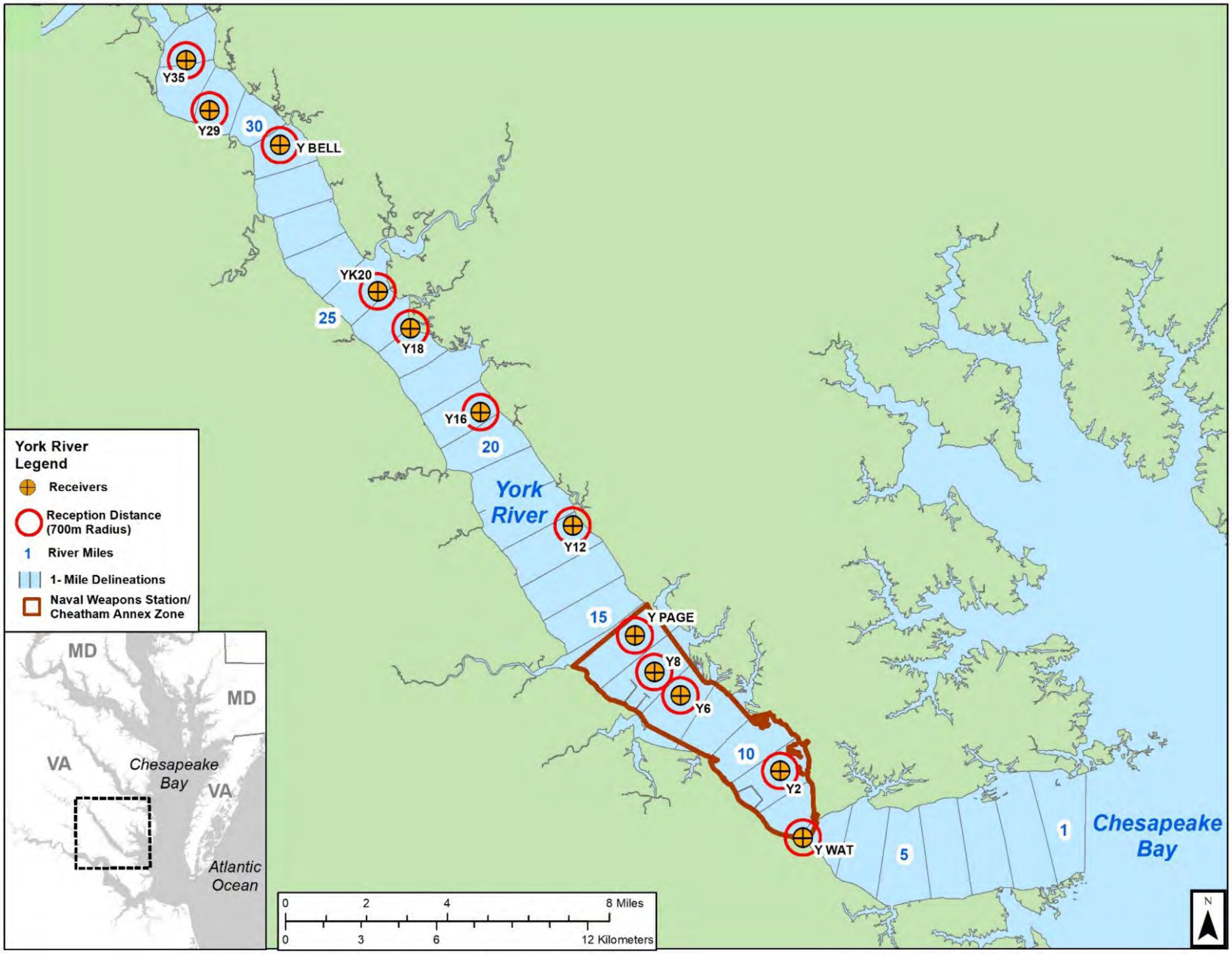

York River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Depth of Water (m)
0 -- -2.5
-2.5 -- -5
-5 -- -7.5
-7.5 -- -10
-10 -- -12.5
-12.5 -- -15
-15 -- -20
-20 -- -25
-25 -- -30
-30 -- -35
Y35
Y29
30
Y BELL
YK20
25
Y18
Y16
20
York River
Y12
15
Y PAGE
Y8
Y6
10
Y2
Y WAT
5
1
Chesapeake Bay
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N

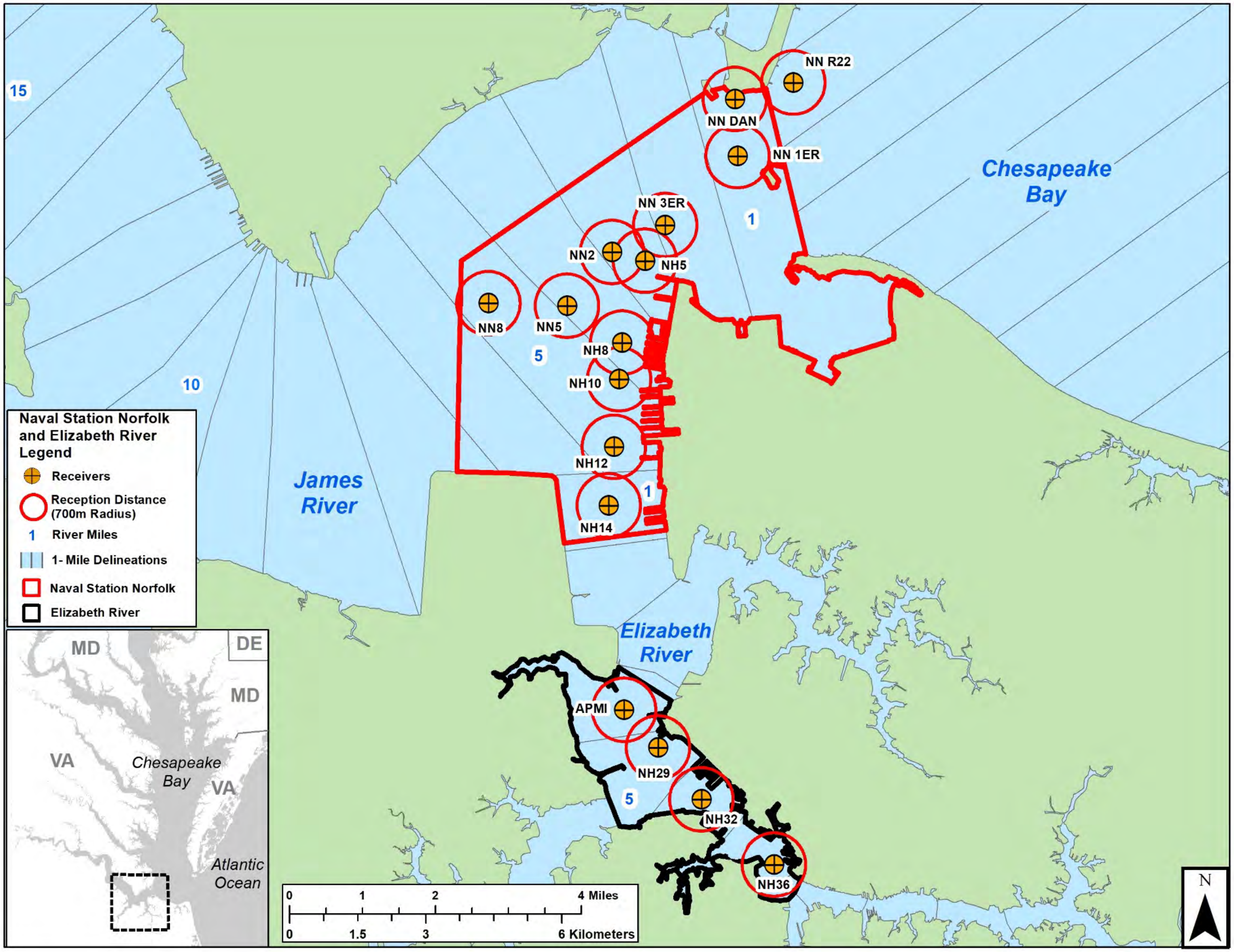

Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Depth of Water (m)
0 -- -2.5
-2.5 -- -5
-5 -- -7.5
-7.5 -- -10
-10 -- -12.5
-12.5 -- -15
-15 -- -20
-20 -- -25
-25 -- -30
-30 -- -35
CHICK DAM
CHICK 1 NEST TREE
CHICK NEST TREE 2
CHICK RONNIES
CHICK BRIDGE W BANK
CHICK BRIDGE E BANK
25
20
15
10
5
1
Chickahominy River
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 1 2 4 Miles
0 2 4 8 Kilometers
N


Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Depth of Water (m)
0 -- -2.5
-2.5 -- -5
-5 -- -7.5
-7.5 -- -10
-10 -- -12.5
-12.5 -- -15
-15 -- -20
-20 -- -25
-25 -- -30
-30 -- -35
15
10
5
1
1
5
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

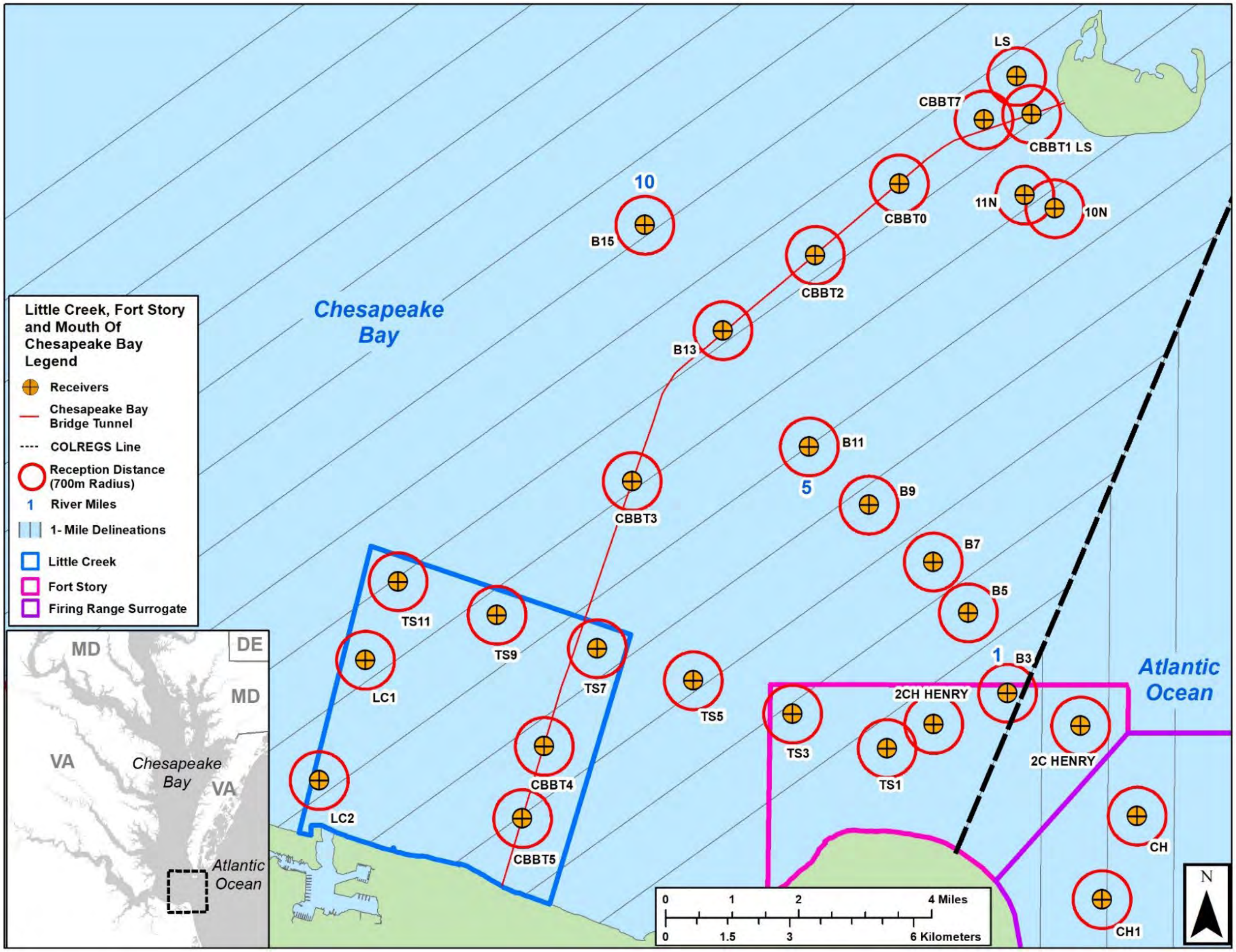

Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Depth of Water (m)
0 -- -2.5
-2.5 -- -5
-5 -- -7.5
-7.5 -- -10
-10 -- -12.5
-12.5 -- -15
-15 -- -20
-20 -- -25
-25 -- -30
-30 -- -35
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Chesapeake Bay
Atlantic Ocean
10
5
1
LS
CBBT7
CBBT1 LS
CBBT0
11N
10N
B15
CBBT2
B13
B11
B9
B7
B5
B3
CBBT3
TS11
TS9
TS7
TS5
TS3
TS1
LC1
LC2
CBBT4
CBBT5
2CH HENRY
2C HENRY
CH
CH1
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

8.2. Appendix 8.2: Receiver Locations and Receptive Distances within Zones



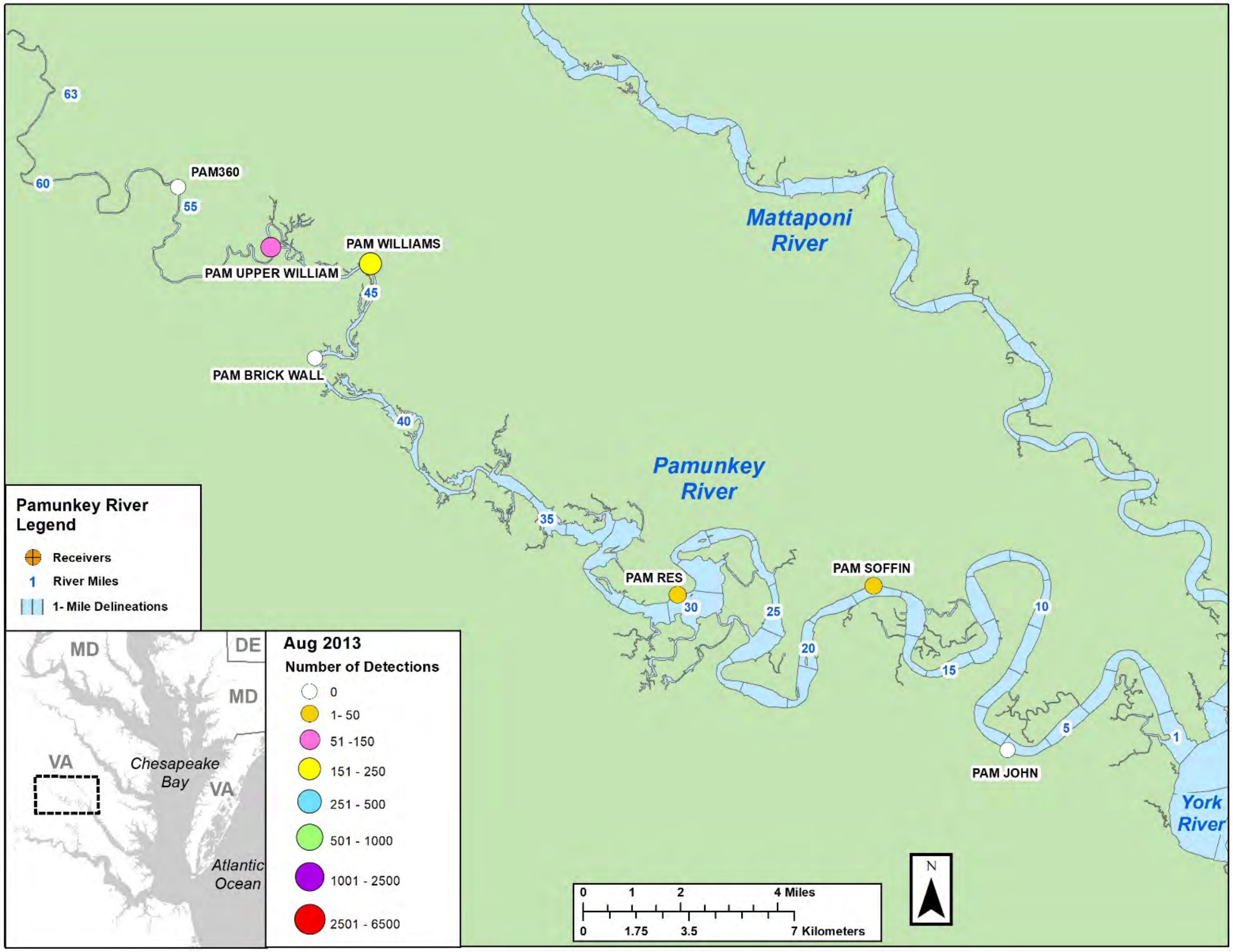

15
10
5
1
5
1
1
5
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
Naval Station Norfolk and Elizabeth River Legend
Receivers
Reception Distance (700m Radius)
River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
1
2
4 Miles
0
1.5
3
6 Kilometers
N

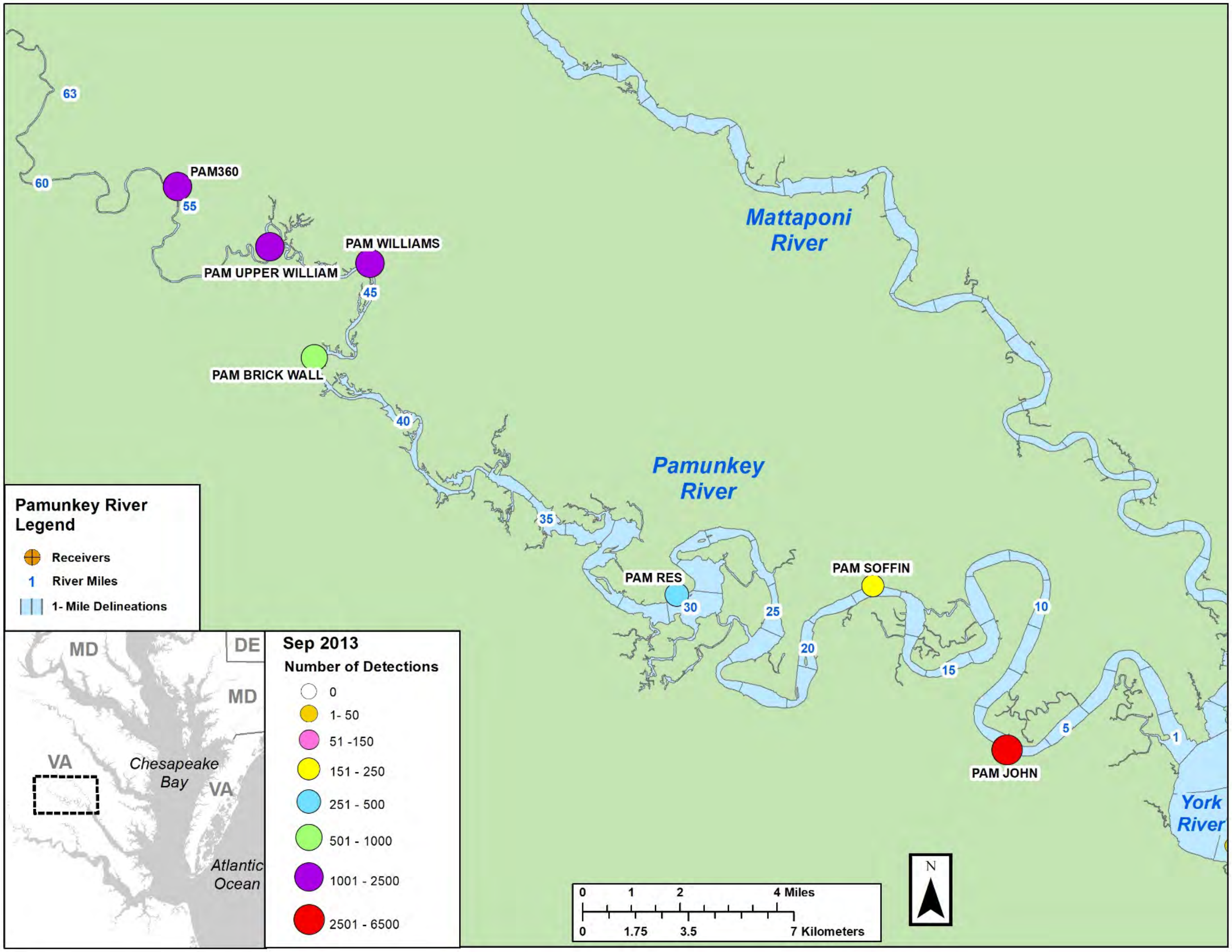
On this map one can see the CBBT0 station that was moved to LS when the section of the CBBT that it was hanging on had to be repaired.

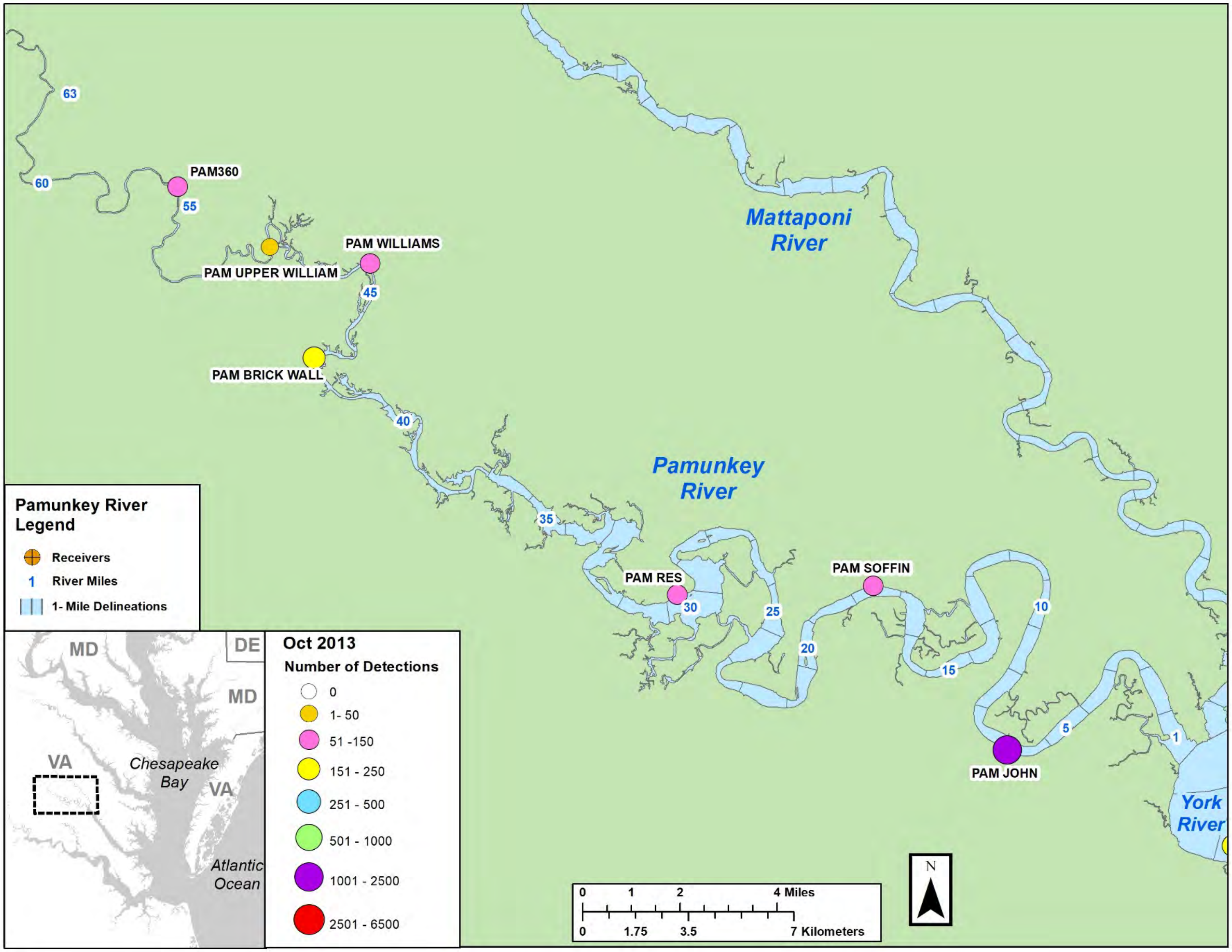


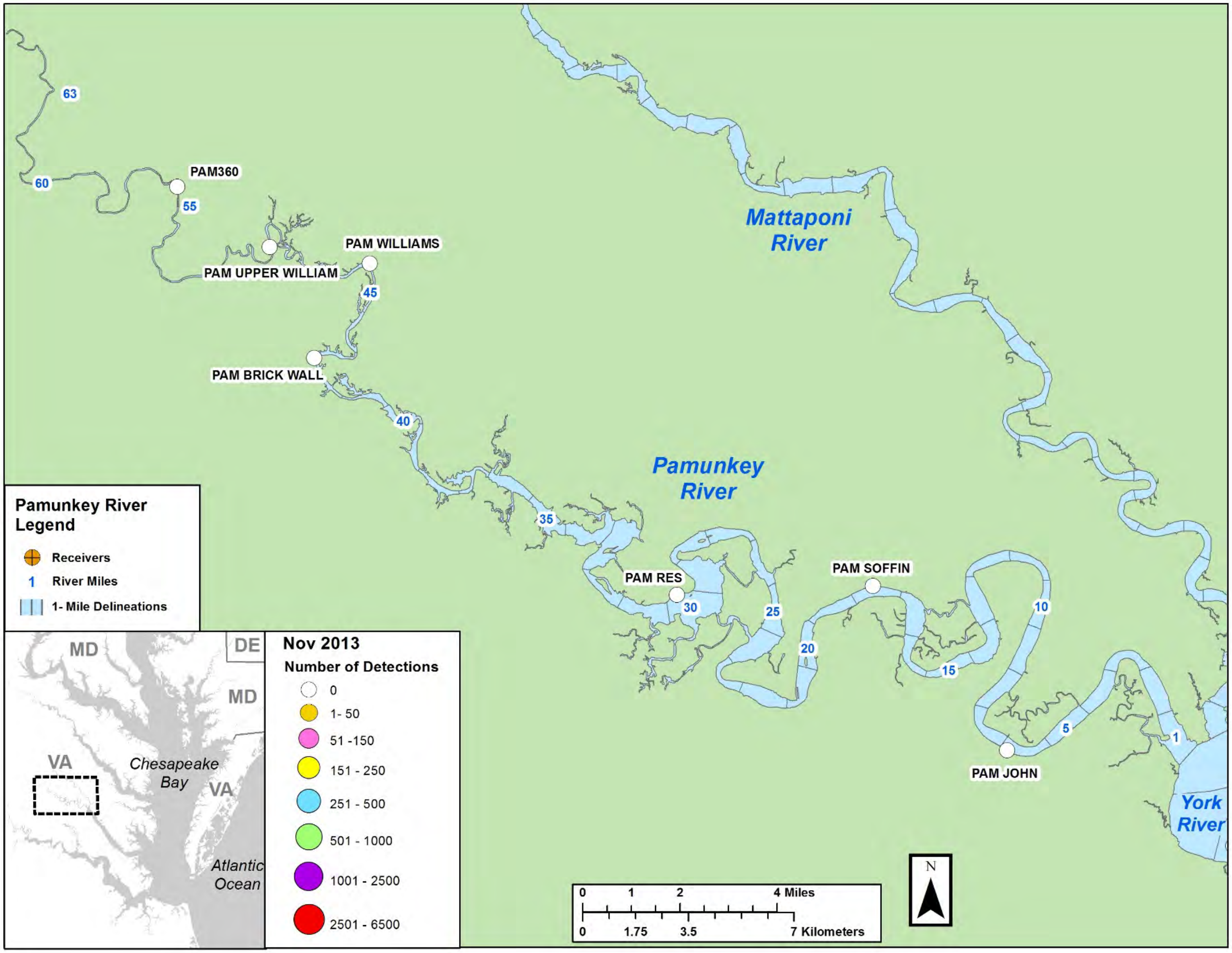
8.3. Appendix 8.3: Detections of Sonic-tagged Atlantic Sturgeon in the Pamunkey River Region, by Month, Year, and Overall

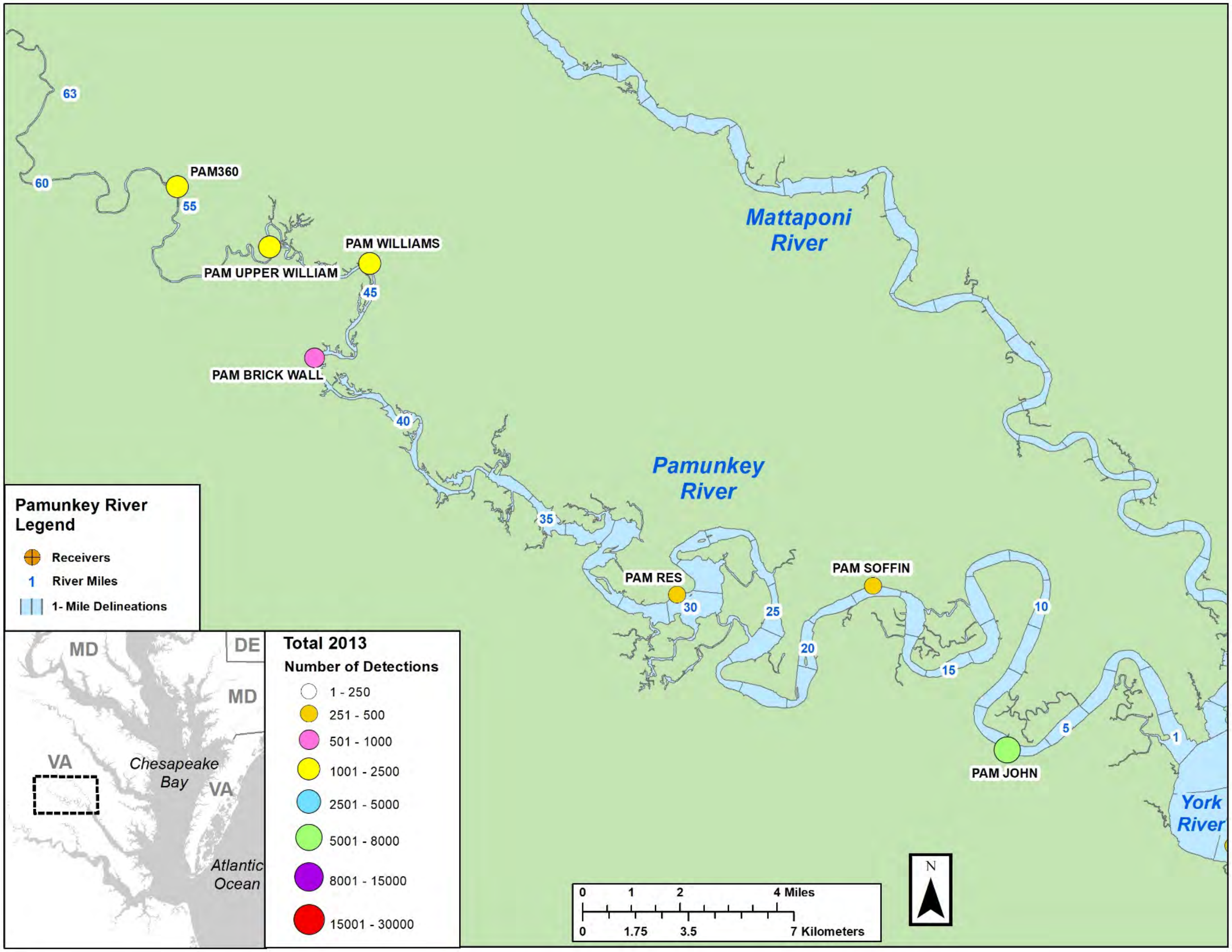
If a map does not appear for a given month it is because no detections were recorded during the period. If two maps appear for the same month and region, the second map contains a modified scale to more adequately represent the differences among the sites.

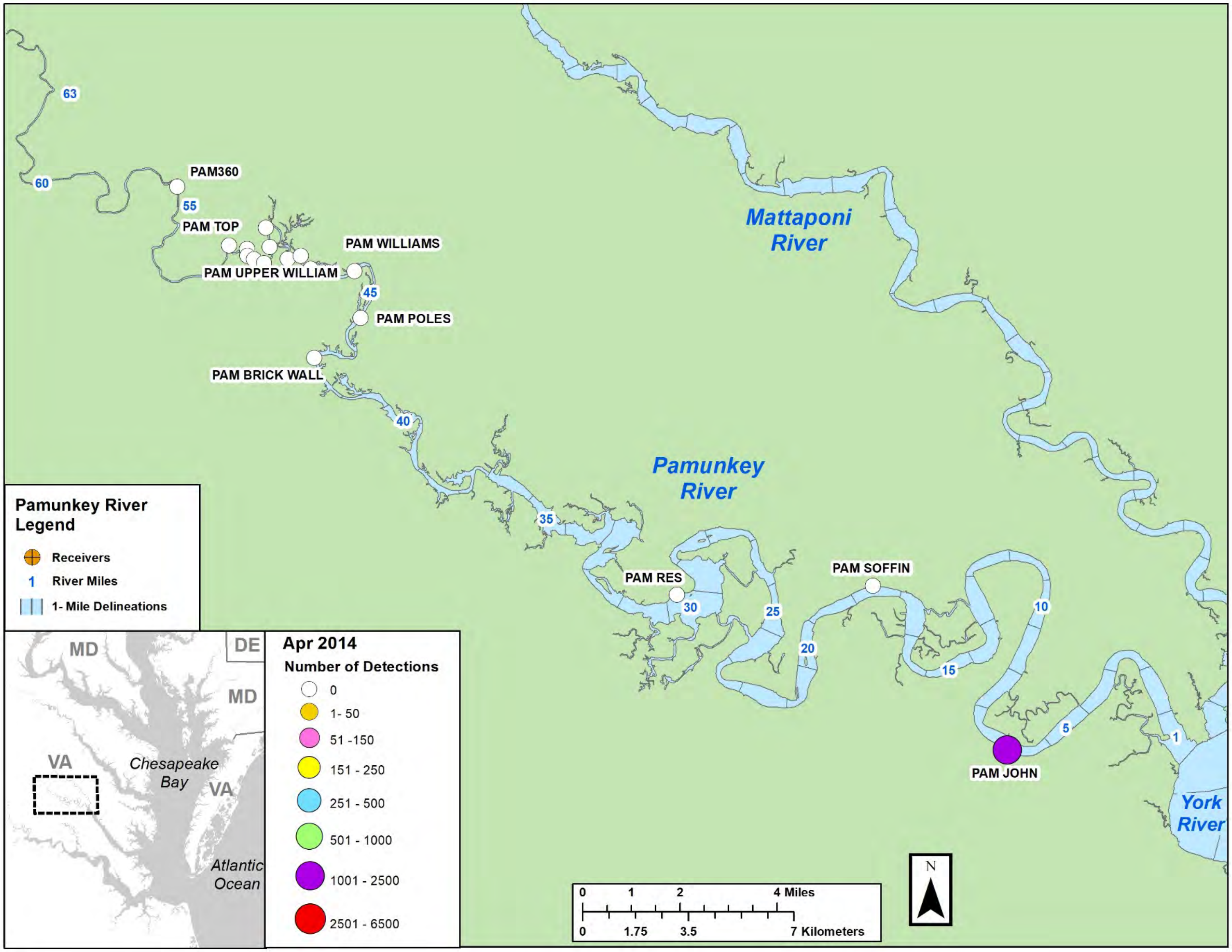


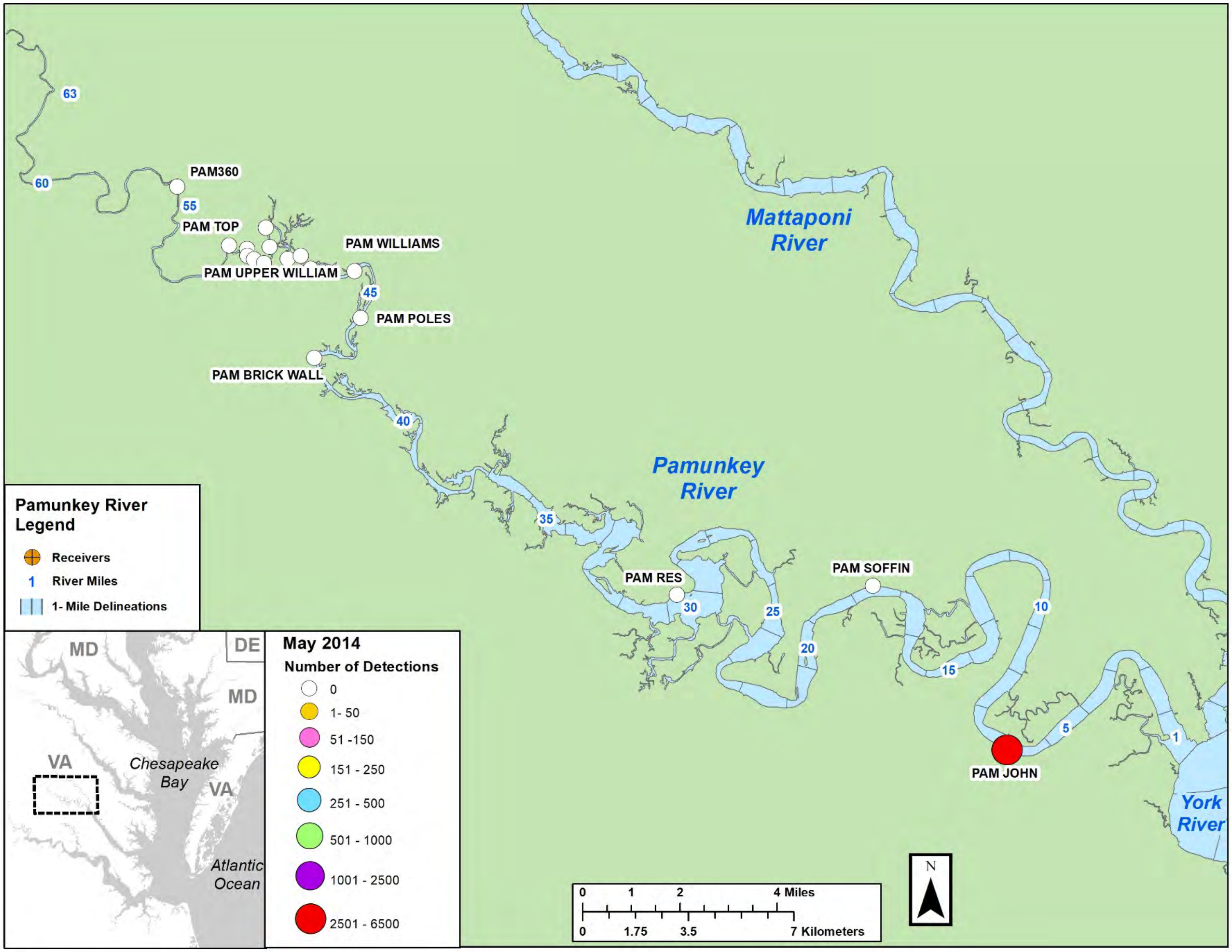

63
60
55
PAM360
PAM WILLIAMS
PAM UPPER WILLIAM
45
PAM BRICK WALL
40
Mattaponi River
Pamunkey River
35
PAM RES
30
25
PAM SOFFIN
20
15
10
5
1
PAM JOHN
York River
Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Sep 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 1 2 4 Miles
0 1.75 3.5 7 Kilometers
N


63
60
55
45
40
35
30
25
20
15
10
5
1
PAM360
PAM UPPER WILLIAM
PAM WILLIAMS
PAM BRICK WALL
PAM RES
PAM SOFFIN
PAM JOHN
Mattaponi River
Pamunkey River
York River
Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Oct 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 1 2 4 Miles
0 1.75 3.5 7 Kilometers
N


63
60
55
45
40
35
30
25
20
15
10
5
1
PAM360
PAM WILLIAMS
PAM UPPER WILLIAM
PAM BRICK WALL
PAM RES
PAM SOFFIN
PAM JOHN
Mattaponi River
Pamunkey River
York River
Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
VA
Chesapeake Bay
Atlantic Ocean
Nov 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 1 2 4 Miles
0 1.75 3.5 7 Kilometers
N


63
60
55
PAM360
PAM UPPER WILLIAM
PAM WILLIAMS
45
PAM BRICK WALL
40
35
Mattaponi River
Pamunkey River
PAM RES
30
25
20
PAM SOFFIN
15
10
5
1
PAM JOHN
York River
Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Total 2013
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
0 1 2 4 Miles
0 1.75 3.5 7 Kilometers
N


63
60
55
45
40
35
30
25
20
15
10
5
1
PAM360
PAM TOP
PAM WILLIAMS
PAM UPPER WILLIAM
PAM POLES
PAM BRICK WALL
PAM RES
PAM SOFFIN
PAM JOHN
Mattaponi River
Pamunkey River
York River
Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Apr 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 1 2 4 Miles
0 1.75 3.5 7 Kilometers
N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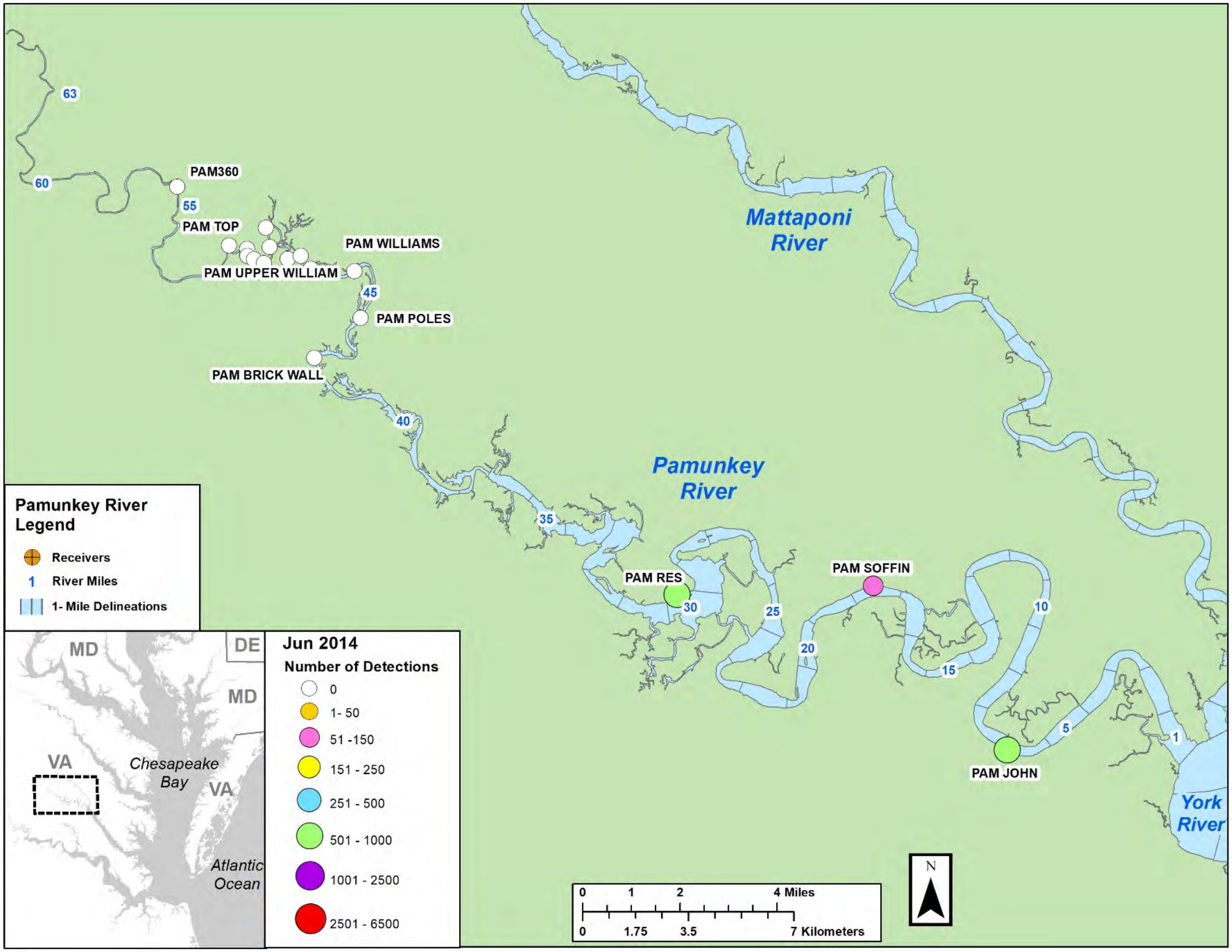
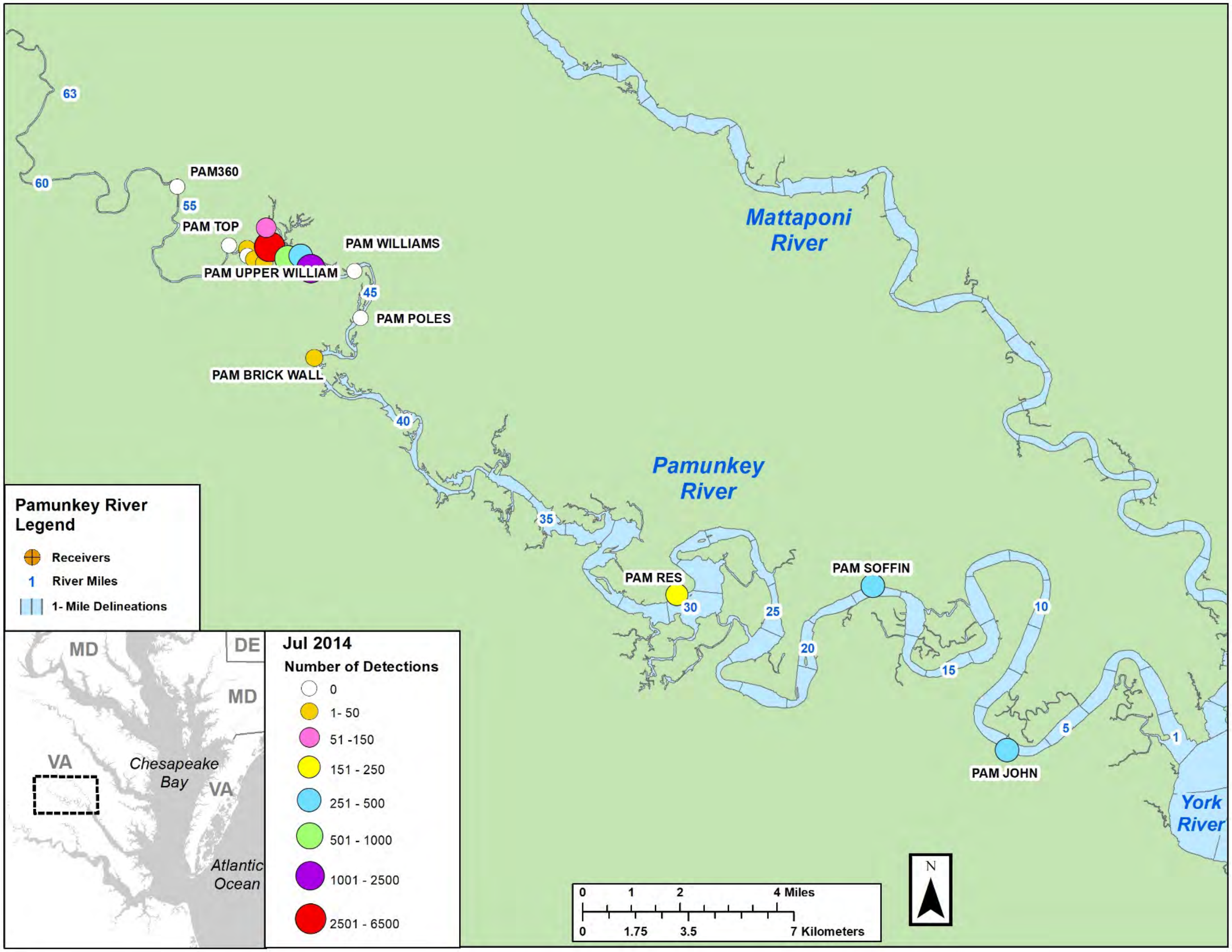
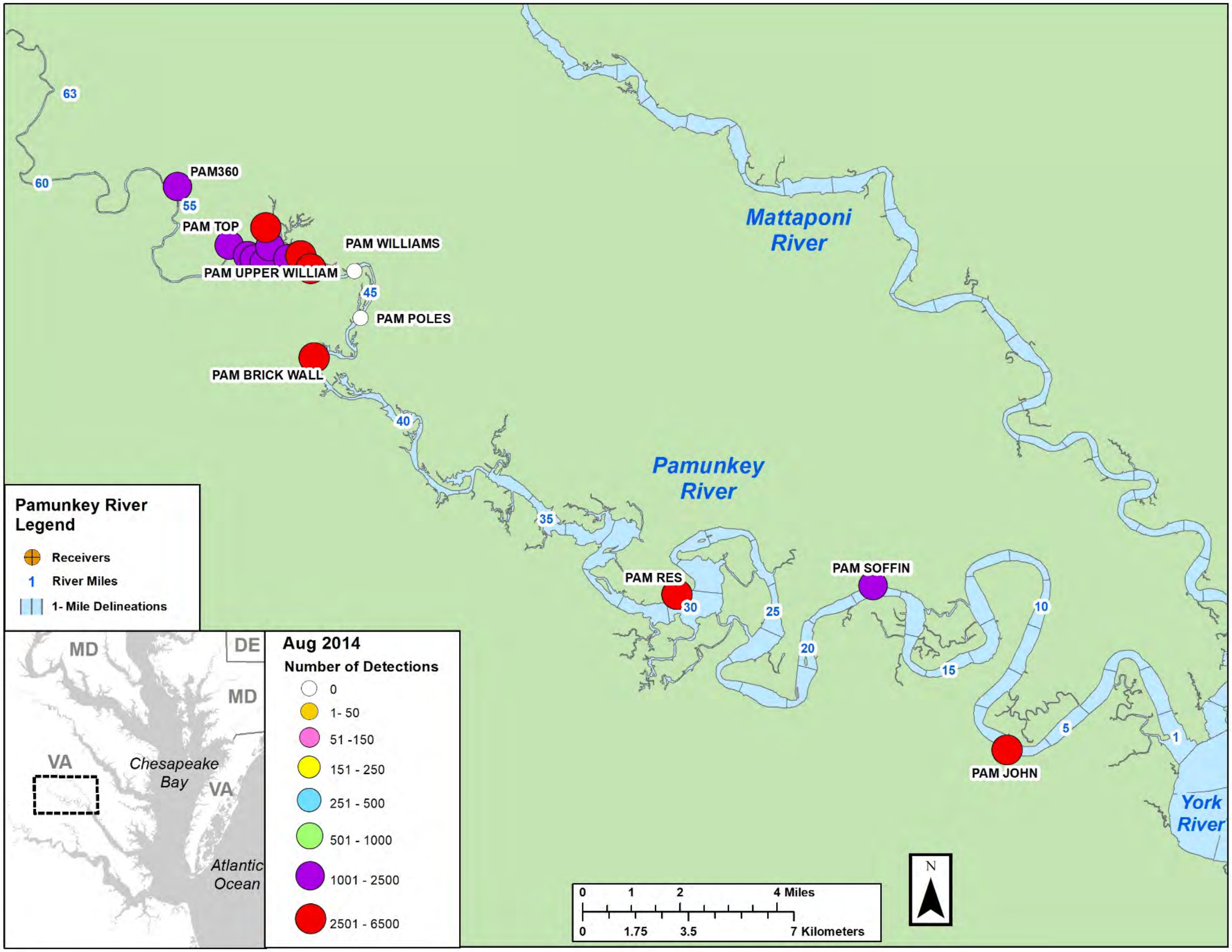
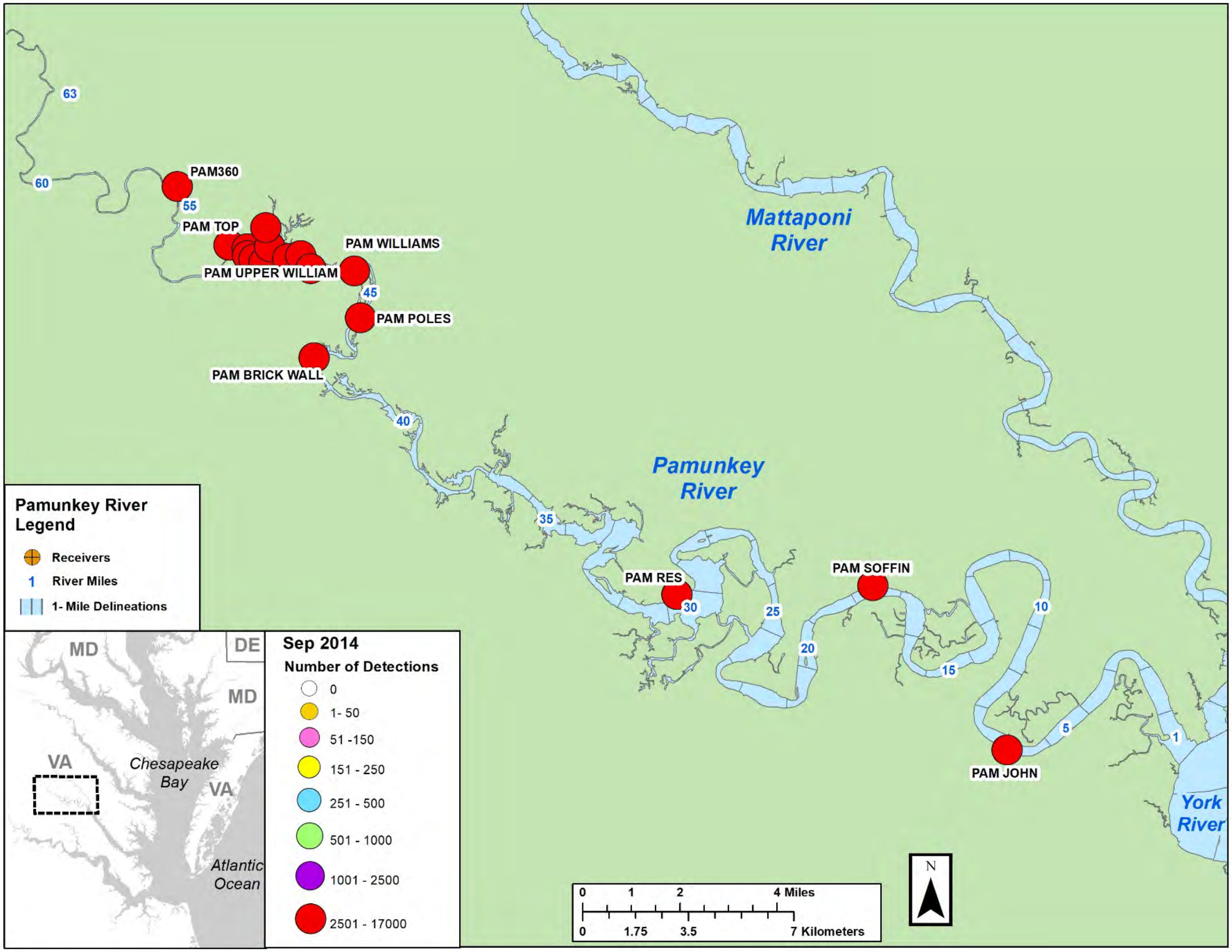
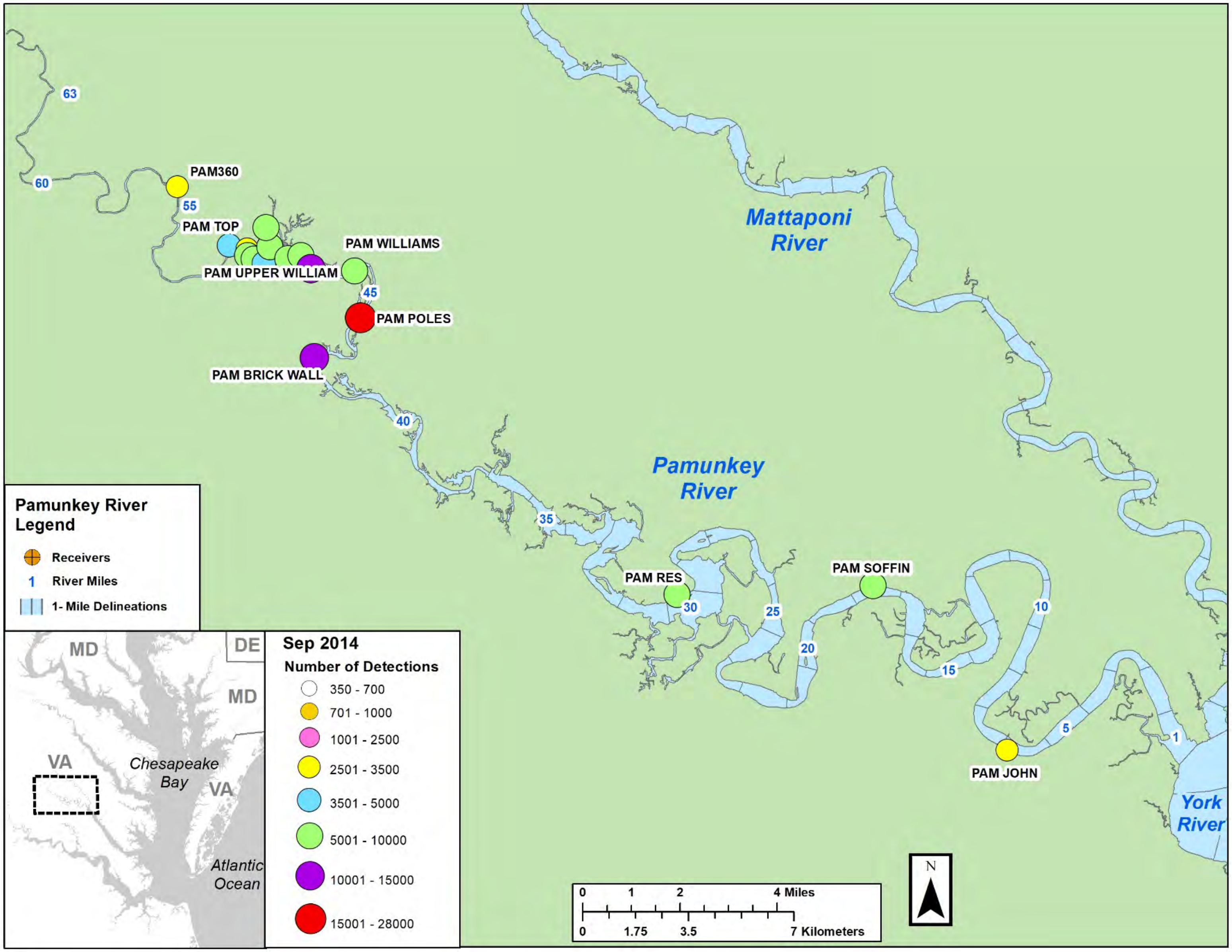
60
55
45
40
35
30
25
20
15
10
5
1
PAM360
PAM TOP
PAM WILLIAMS
PAM UPPER WILLIAM
PAM POLES
PAM BRICK WALL
PAM RES
PAM SOFFIN
PAM JOHN
Mattaponi River
Pamunkey River
York River
Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
May 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0
1
2
4 Miles
0
1.75
3.5
7 Kilometers
N


63
60
55
45
40
35
30
25
20
15
10
5
1
PAM360
PAM TOP
PAM WILLIAMS
PAM UPPER WILLIAM
PAM POLES
PAM BRICK WALL
PAM RES
PAM SOFFIN
PAM JOHN
Mattaponi River
Pamunkey River
York River
Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Jun 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 1 2 4 Miles
0 1.75 3.5 7 Kilometers
N


Mattaponi River
Pamunkey River
York River
63
60
55
45
40
35
30
25
20
15
10
5
1
PAM360
PAM TOP
PAM UPPER WILLIAM
PAM WILLIAMS
PAM POLES
PAM BRICK WALL
PAM RES
PAM SOFFIN
PAM JOHN
Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Jul 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 1 2 4 Miles
0 1.75 3.5 7 Kilometers
N


Mattaponi River
Pamunkey River
York River
63
60
55
45
40
35
30
25
20
15
10
5
1
PAM360
PAM TOP
PAM WILLIAMS
PAM UPPER WILLIAM
PAM POLES
PAM BRICK WALL
PAM RES
PAM SOFFIN
PAM JOHN
Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Aug 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 1 2 4 Miles
0 1.75 3.5 7 Kilometers
N


63
60
55
PAM360
PAM TOP
PAM WILLIAMS
PAM UPPER WILLIAM
45
PAM POLES
PAM BRICK WALL
40
Mattaponi River
Pamunkey River
35
PAM RES
30
25
20
PAM SOFFIN
15
10
5
1
PAM JOHN
York River
Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Sep 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 17000
0 1 2 4 Miles
0 1.75 3.5 7 Kilometers
N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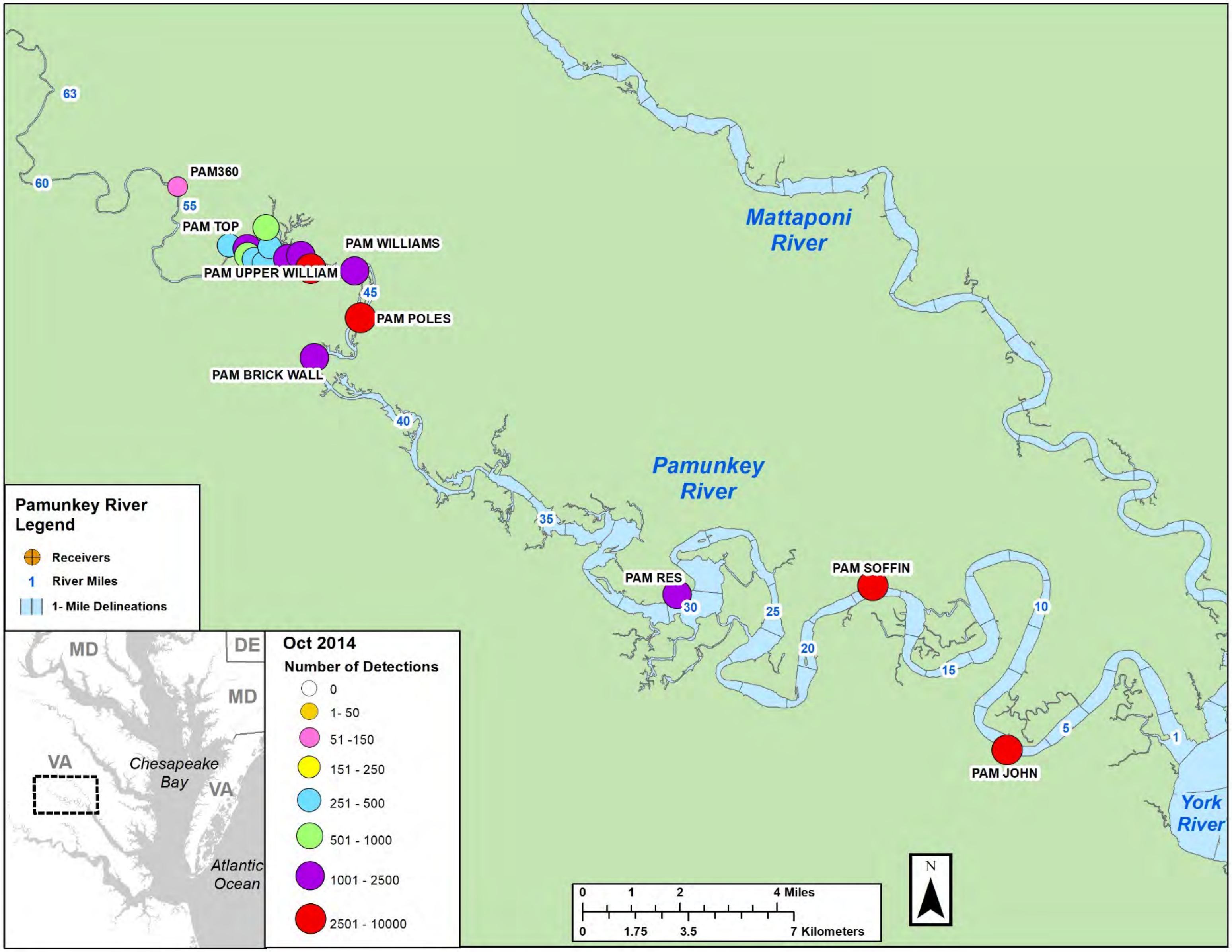
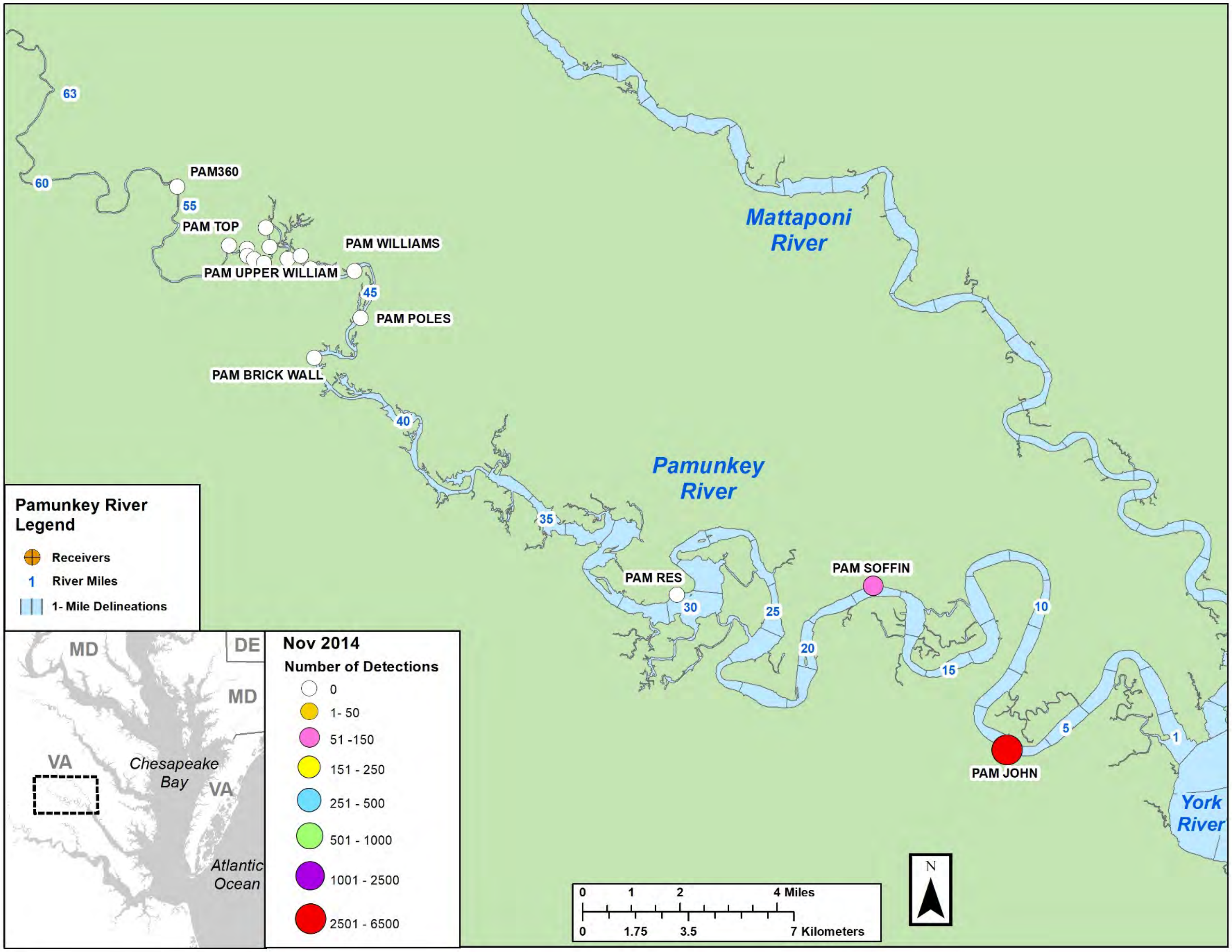
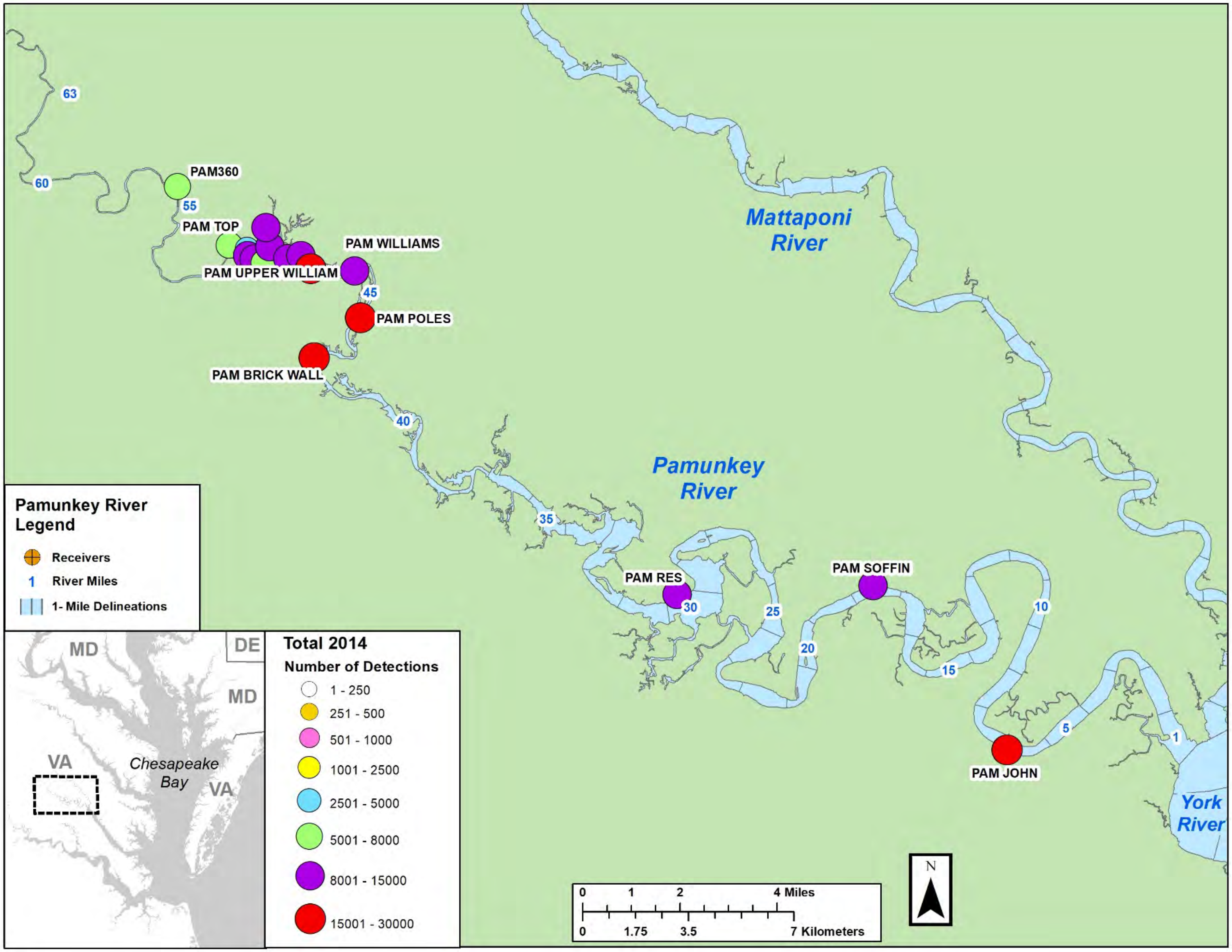
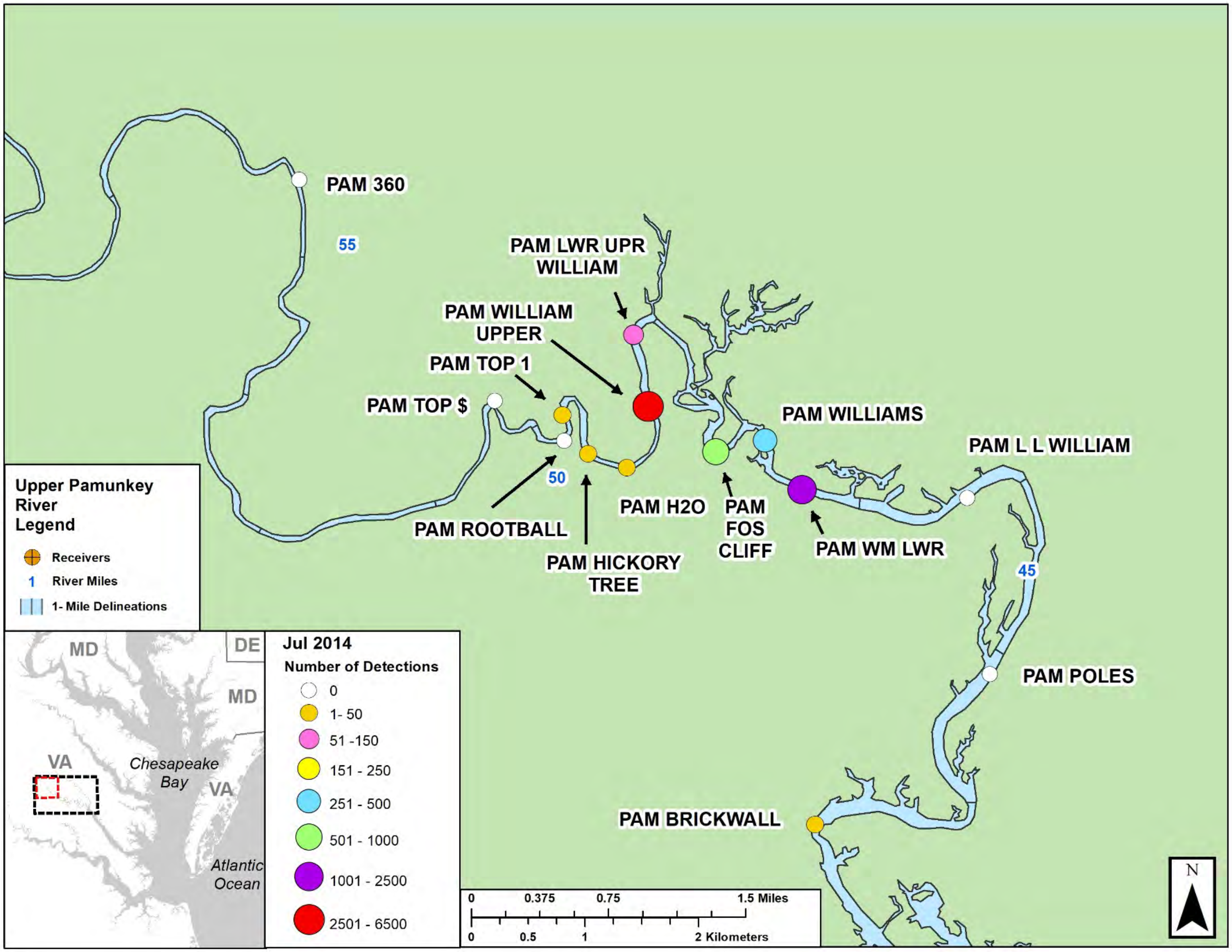
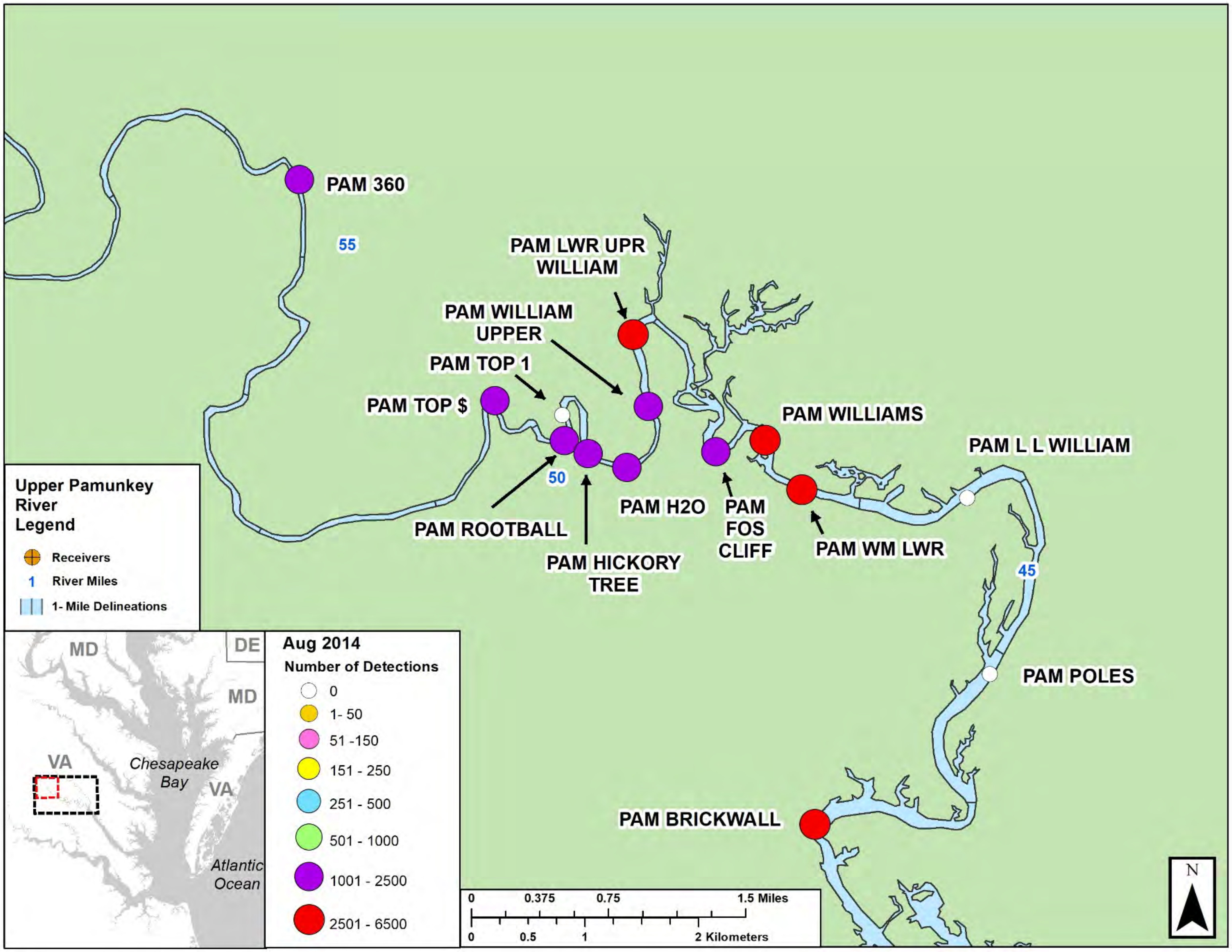
60
55
45
40
35
30
25
20
15
10
5
1
PAM360
PAM TOP
PAM WILLIAMS
PAM UPPER WILLIAM
PAM POLES
PAM BRICK WALL
PAM RES
PAM SOFFIN
PAM JOHN
Mattaponi River
Pamunkey River
York River
Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Sep 2014
Number of Detections
350 - 700
701 - 1000
1001 - 2500
2501 - 3500
3501 - 5000
5001 - 10000
10001 - 15000
15001 - 28000
0 1 2 4 Miles
0 1.75 3.5 7 Kilometers
N

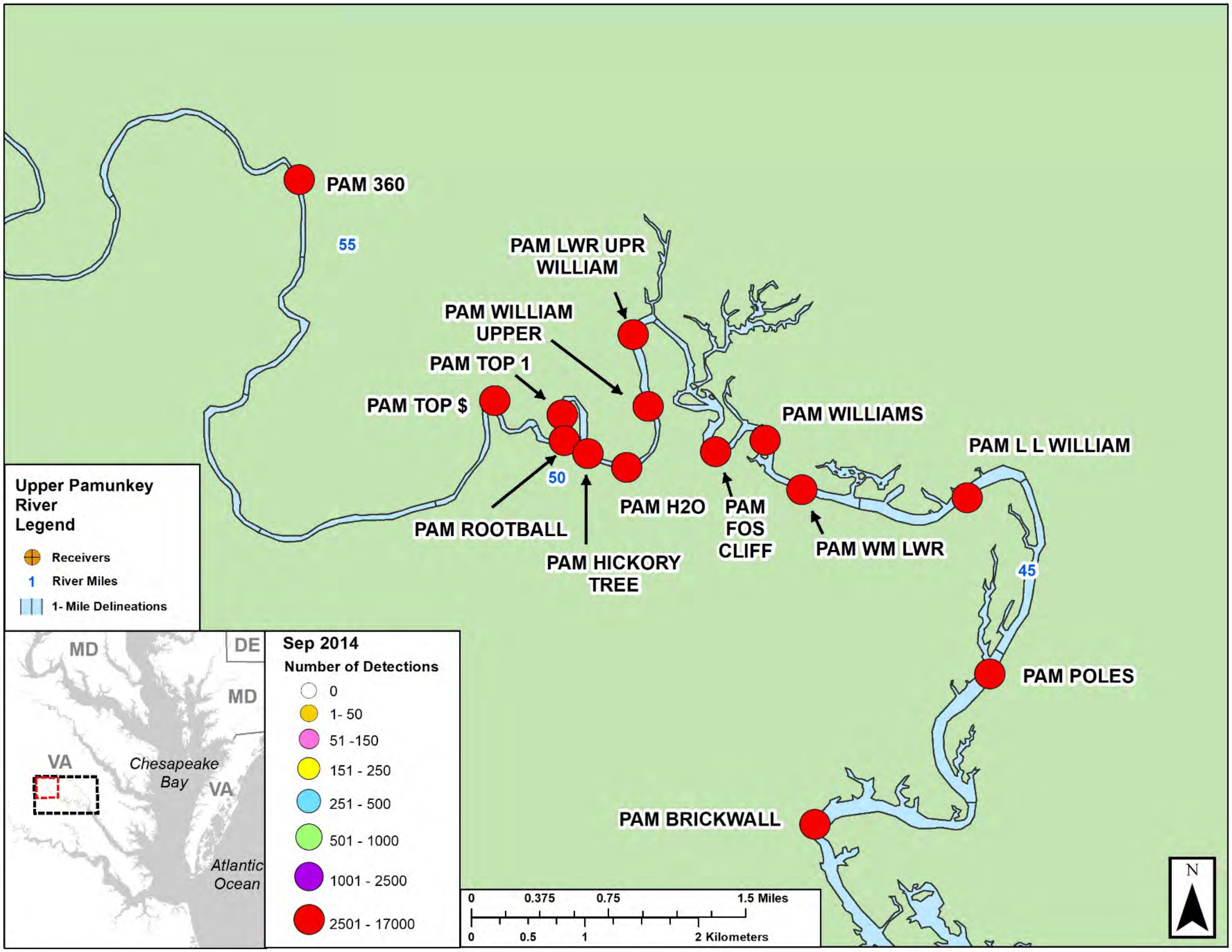

63
60
55
45
40
35
30
25
20
15
10
5
1
PAM360
PAM TOP
PAM UPPER WILLIAM
PAM WILLIAMS
PAM POLES
PAM BRICK WALL
PAM RES
PAM SOFFIN
PAM JOHN
Mattaponi River
Pamunkey River
York River
Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Oct 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 10000
0 1 2 4 Miles
0 1.75 3.5 7 Kilometers
N

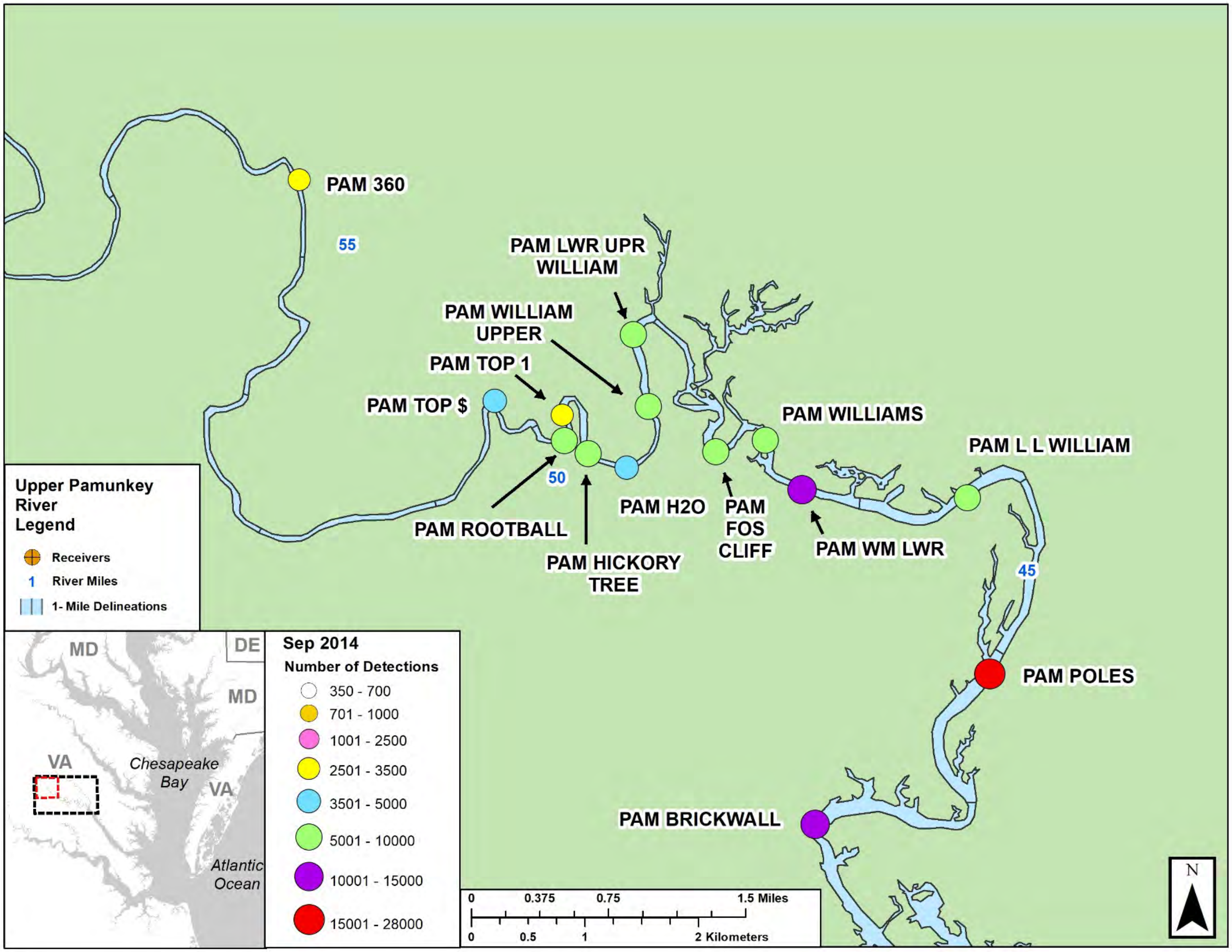

63
60
55
45
40
35
30
25
20
15
10
5
1
PAM360
PAM TOP
PAM WILLIAMS
PAM UPPER WILLIAM
PAM POLES
PAM BRICK WALL
PAM RES
PAM SOFFIN
PAM JOHN
Mattaponi River
Pamunkey River
York River
Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Nov 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 1 2 4 Miles
0 1.75 3.5 7 Kilometers
N

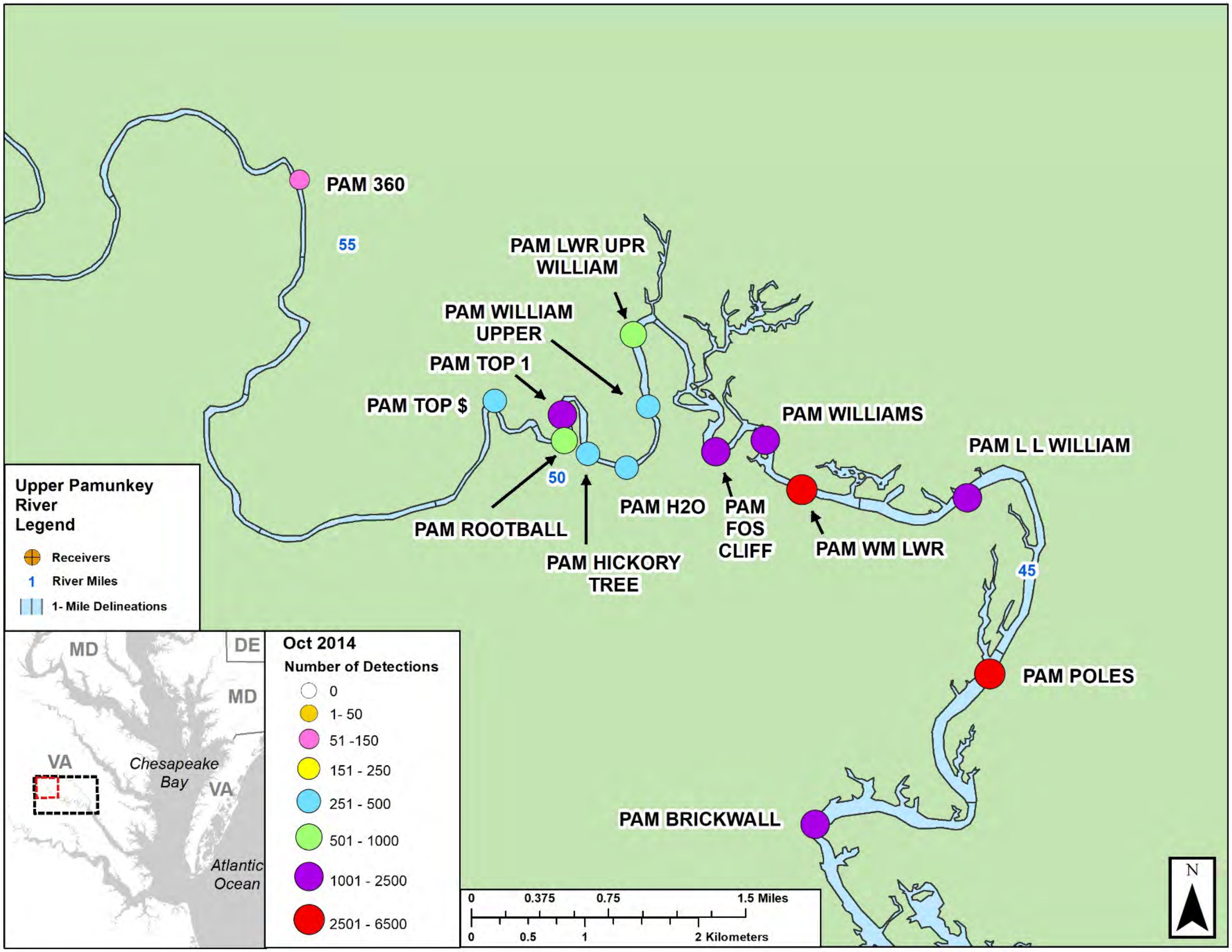

63
60
55
45
40
35
30
25
20
15
10
5
1
PAM360
PAM TOP
PAM UPPER WILLIAM
PAM WILLIAMS
PAM POLES
PAM BRICK WALL
PAM RES
PAM SOFFIN
PAM JOHN
Mattaponi River
Pamunkey River
York River
Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Total 2014
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
0 1 2 4 Miles
0 1.75 3.5 7 Kilometers
N

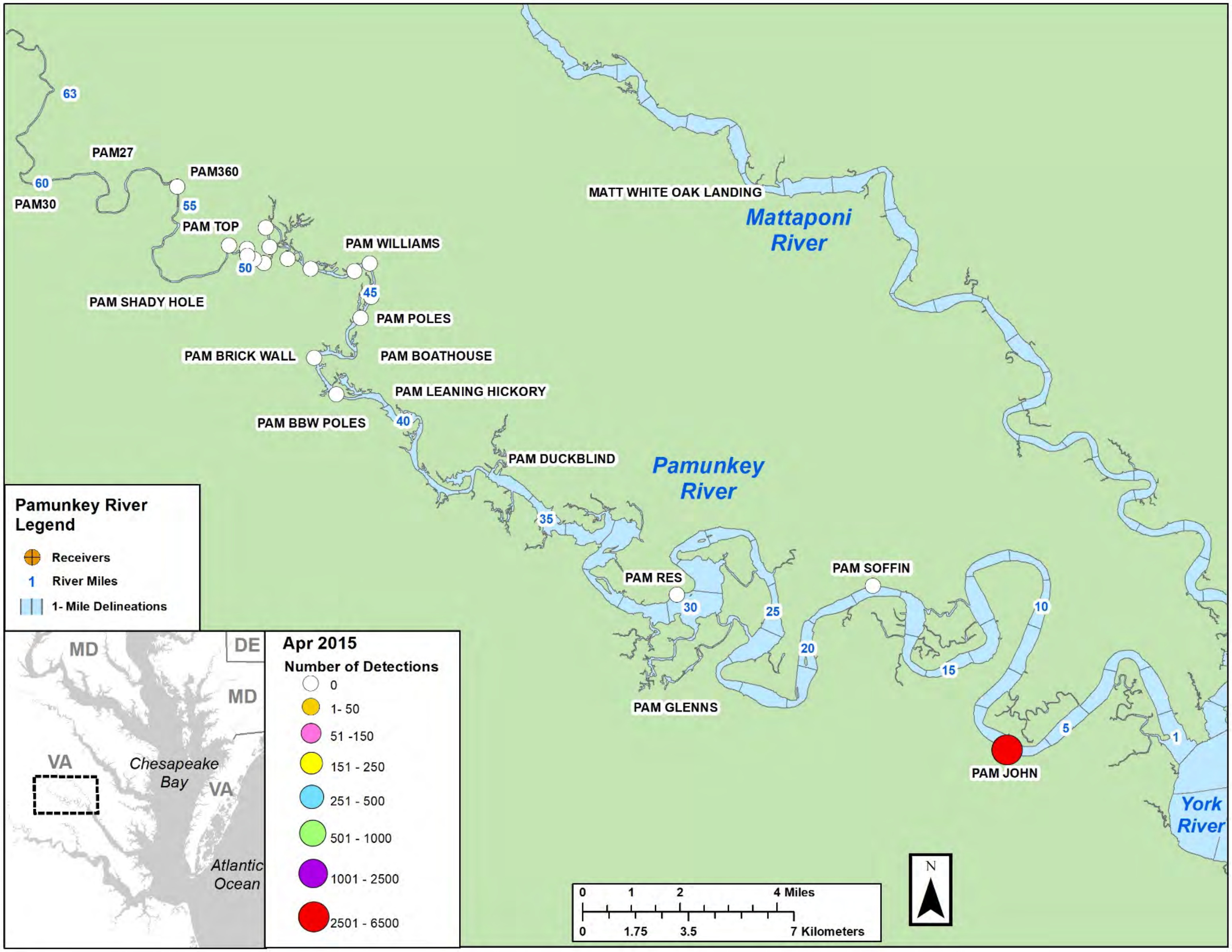

PAM 360
55
PAM LWR UPR WILLIAM
PAM WILLIAM UPPER
PAM TOP 1
PAM TOP $
PAM WILLIAMS
PAM L L WILLIAM
50
PAM H2O
PAM FOS CLIFF
PAM ROOTBALL
PAM HICKORY TREE
PAM WM LWR
45
PAM POLES
PAM BRICKWALL
Upper Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Jul 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0
0.375
0.75
1.5 Miles
0
0.5
1
2 Kilometers
N


PAM 360
55
PAM LWR UPR WILLIAM
PAM WILLIAM UPPER
PAM TOP 1
PAM TOP $
PAM WILLIAMS
PAM L L WILLIAM
50
PAM ROOTBALL
PAM H2O
PAM FOS CLIFF
PAM WM LWR
PAM HICKORY TREE
45
PAM POLES
PAM BRICKWALL
Upper Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Aug 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.375 0.75 1.5 Miles
0 0.5 1 2 Kilometers
N


PAM 360
55
PAM LWR UPR WILLIAM
PAM WILLIAM UPPER
PAM TOP 1
PAM TOP $
PAM WILLIAMS
PAM L L WILLIAM
50
PAM ROOTBALL
PAM HICKORY TREE
PAM H2O
PAM FOS CLIFF
PAM WM LWR
45
PAM POLES
PAM BRICKWALL
Upper Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Sep 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 17000
0 0.375 0.75 1.5 Miles
0 0.5 1 2 Kilometers
N


PAM 360
55
PAM LWR UPR WILLIAM
PAM WILLIAM UPPER
PAM TOP 1
PAM TOP $
PAM WILLIAMS
PAM L L WILLIAM
50
PAM ROOTBALL
PAM HICKORY TREE
PAM H2O
PAM FOS CLIFF
PAM WM LWR
45
PAM POLES
PAM BRICKWALL
Upper Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Sep 2014
Number of Detections
350 - 700
701 - 1000
1001 - 2500
2501 - 3500
3501 - 5000
5001 - 10000
10001 - 15000
15001 - 28000
0
0.375
0.75
1.5 Miles
0
0.5
1
2 Kilometers
N


PAM 360
55
PAM LWR UPR WILLIAM
PAM WILLIAM UPPER
PAM TOP 1
PAM TOP $
PAM WILLIAMS
PAM L L WILLIAM
50
PAM H2O
PAM FOS CLIFF
PAM ROOTBALL
PAM HICKORY TREE
PAM WM LWR
45
PAM POLES
PAM BRICKWALL
Upper Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Oct 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.375 0.75 1.5 Miles
0 0.5 1 2 Kilometers
N


63
PAM27
60
PAM30
PAM360
55
PAM TOP
50
PAM WILLIAMS
PAM SHADY HOLE
45
PAM POLES
PAM BRICK WALL
PAM BOATHOUSE
PAM LEANING HICKORY
PAM BBW POLES
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PAM DUCKBLIND
MATT WHITE OAK LANDING
Mattaponi River
Pamunkey River
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PAM RES
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York River
Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
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MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Apr 2015
Number of Detections
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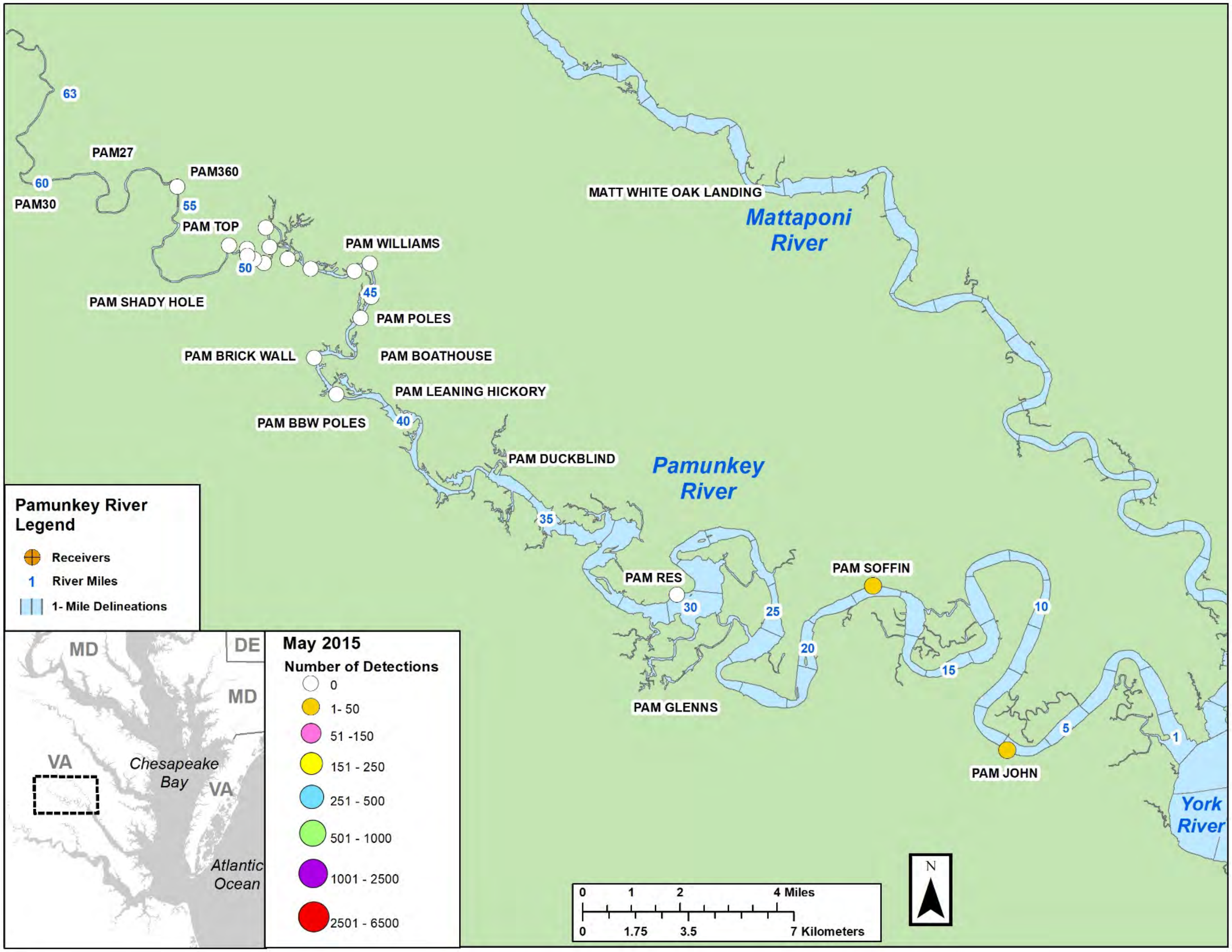
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Pamunkey River Legend
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Chesapeake Bay
VA
Atlantic Ocean
May 2015
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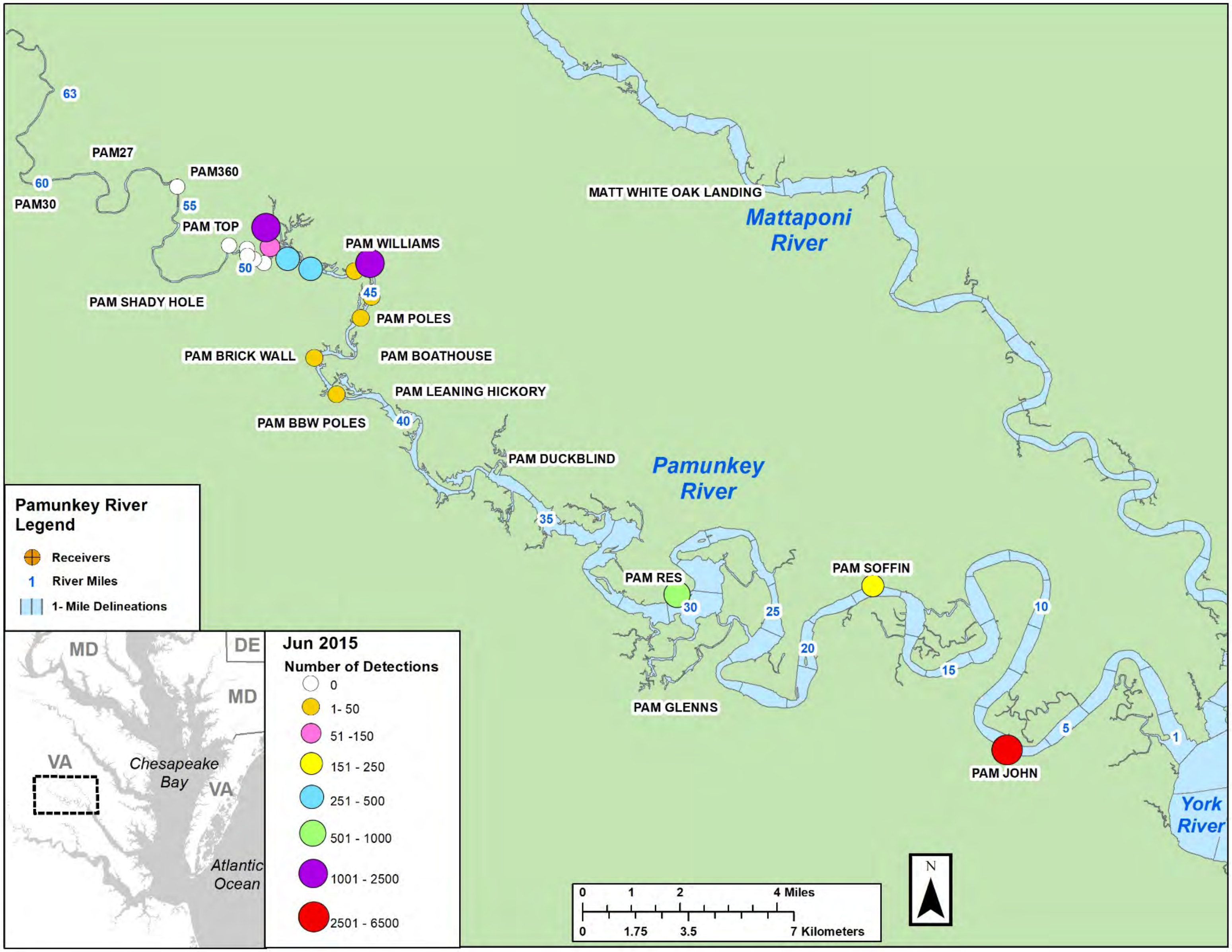
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York River
Pamunkey River Legend
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River Miles
1- Mile Delineations
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Chesapeake Bay
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Atlantic Ocean
Jun 2015
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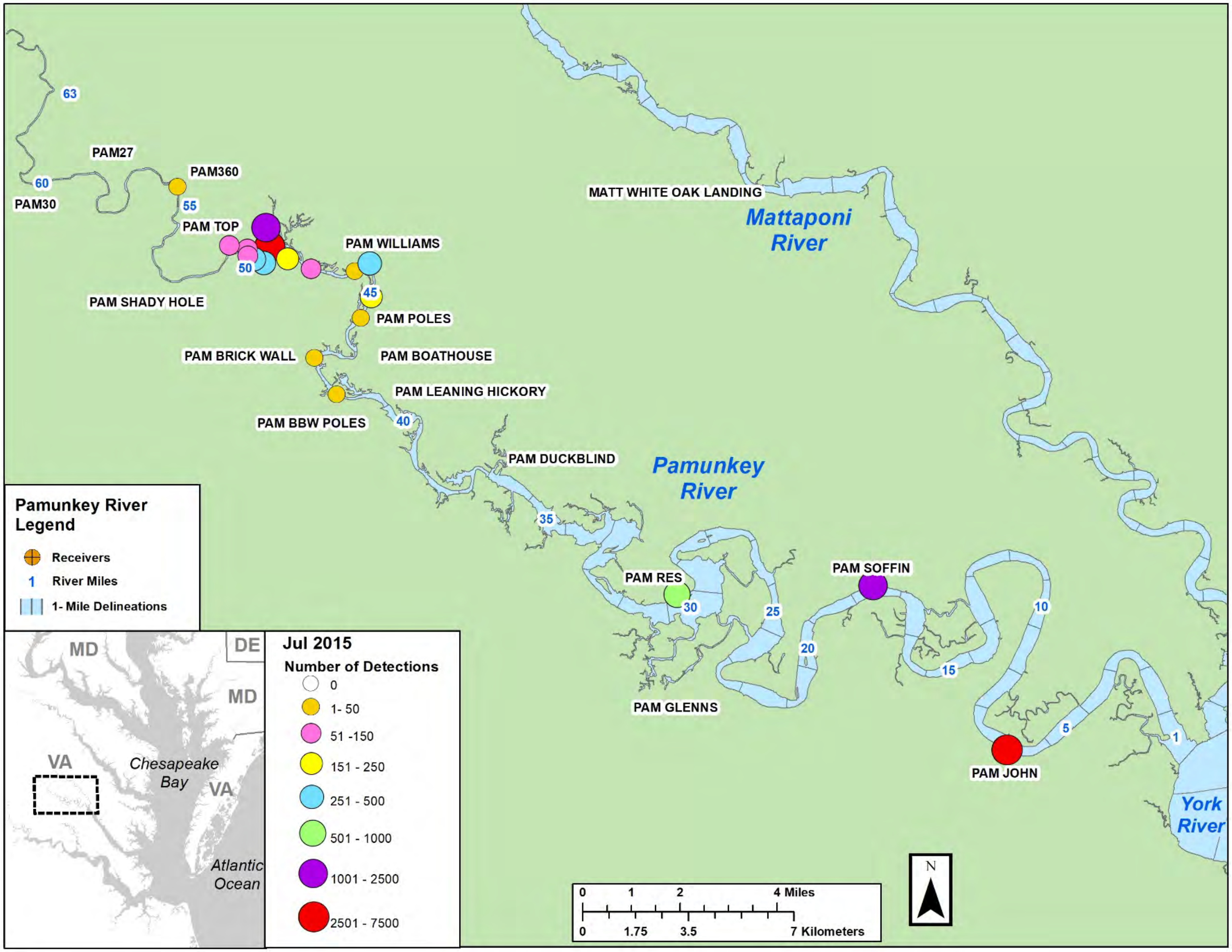
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Atlantic Ocean
Jul 2015
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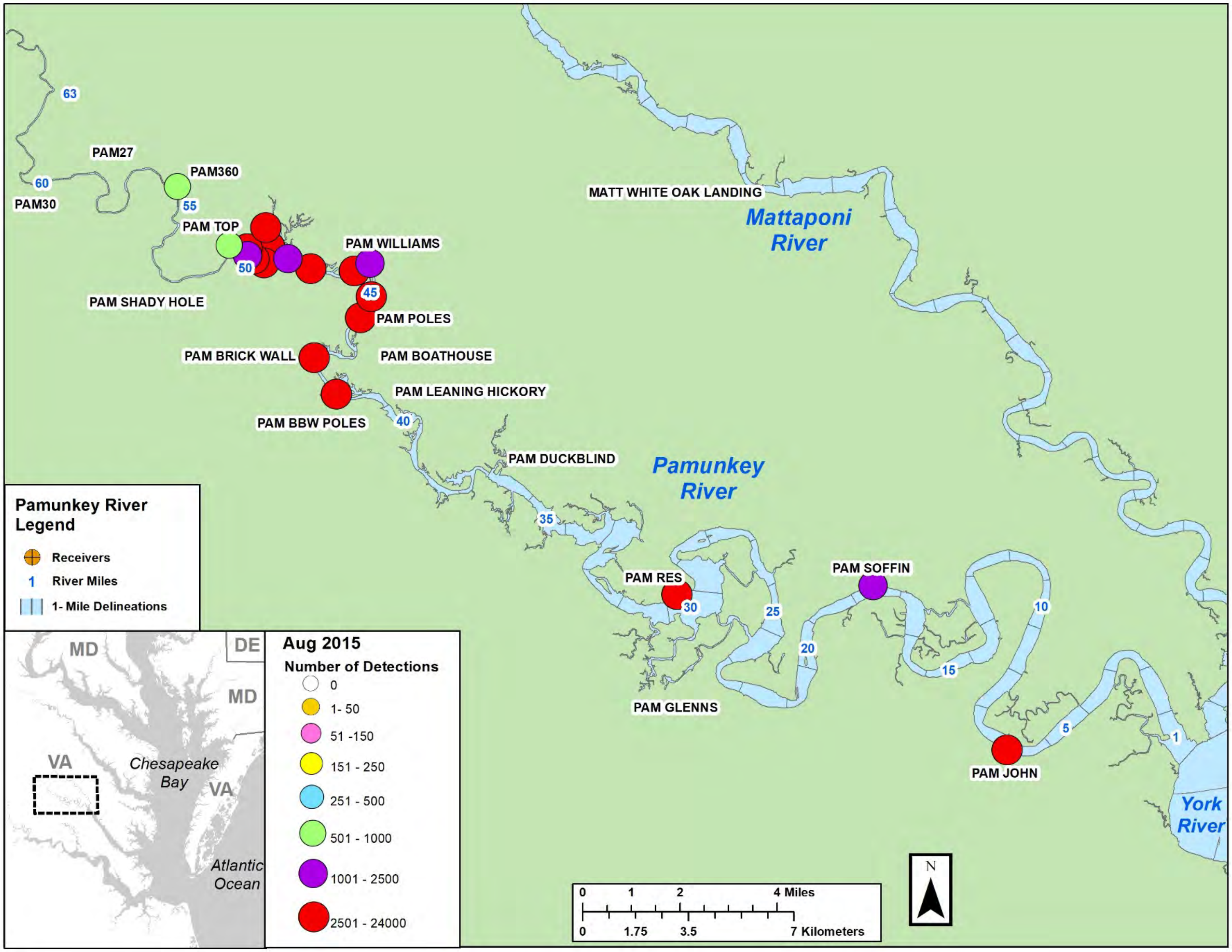
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River Miles
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Atlantic Ocean
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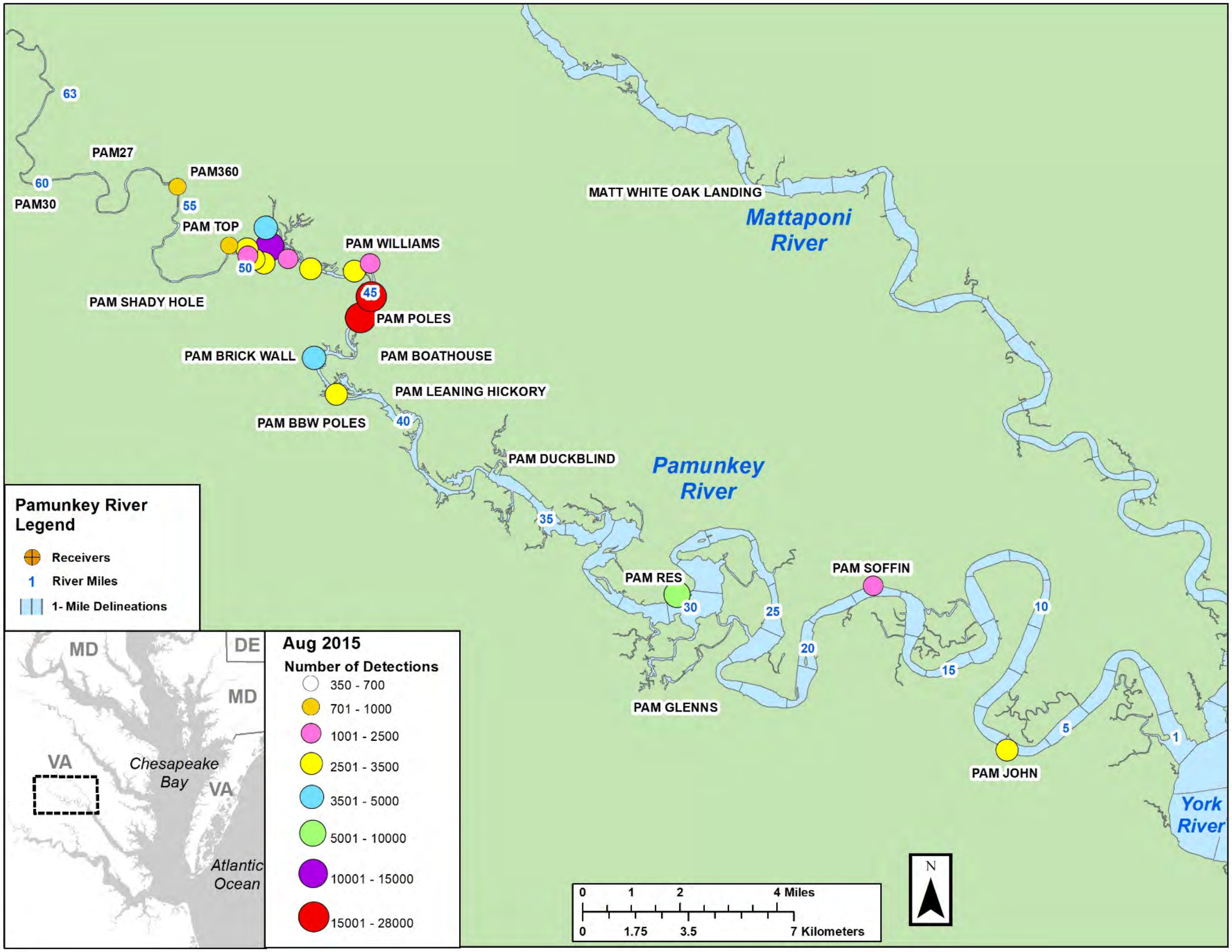
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Atlantic Ocean
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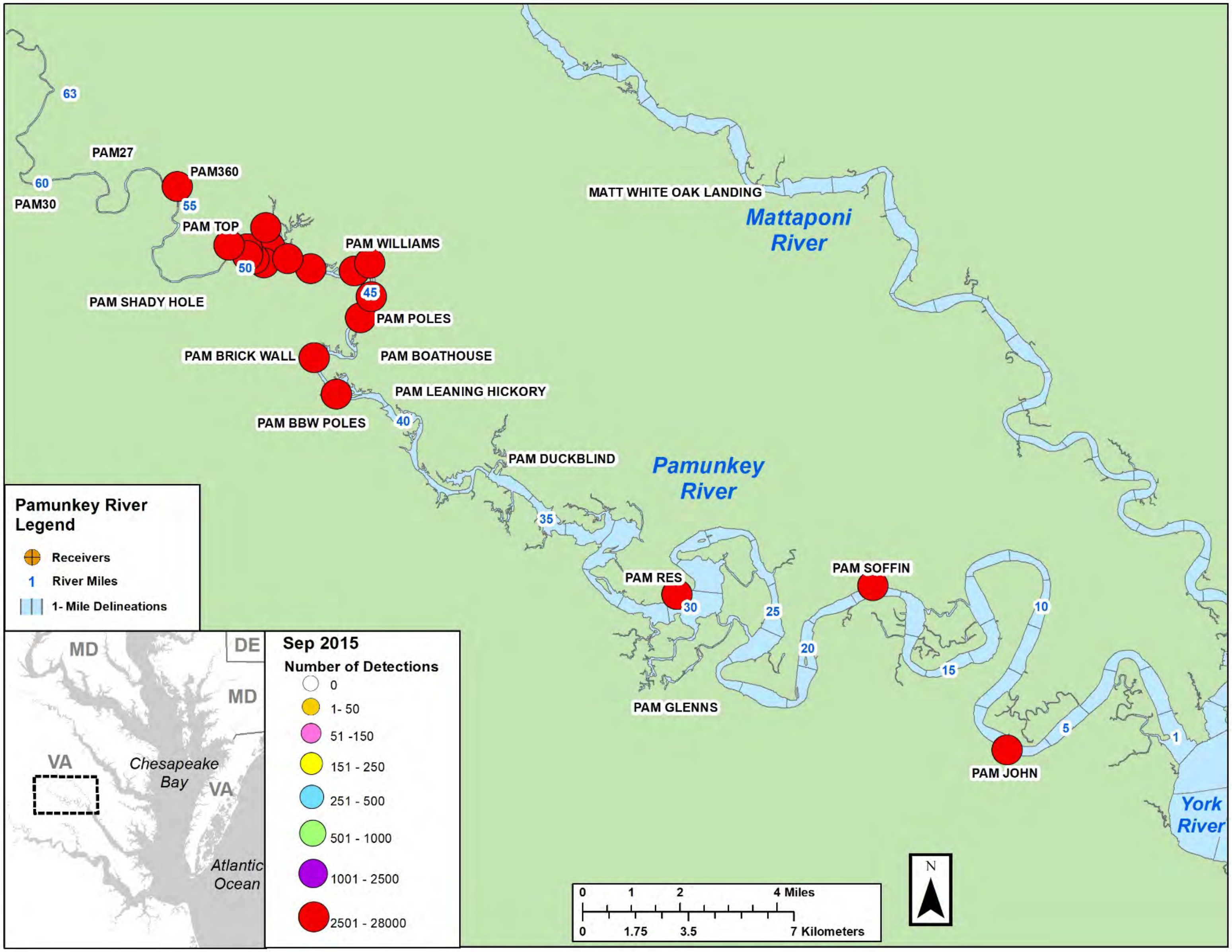
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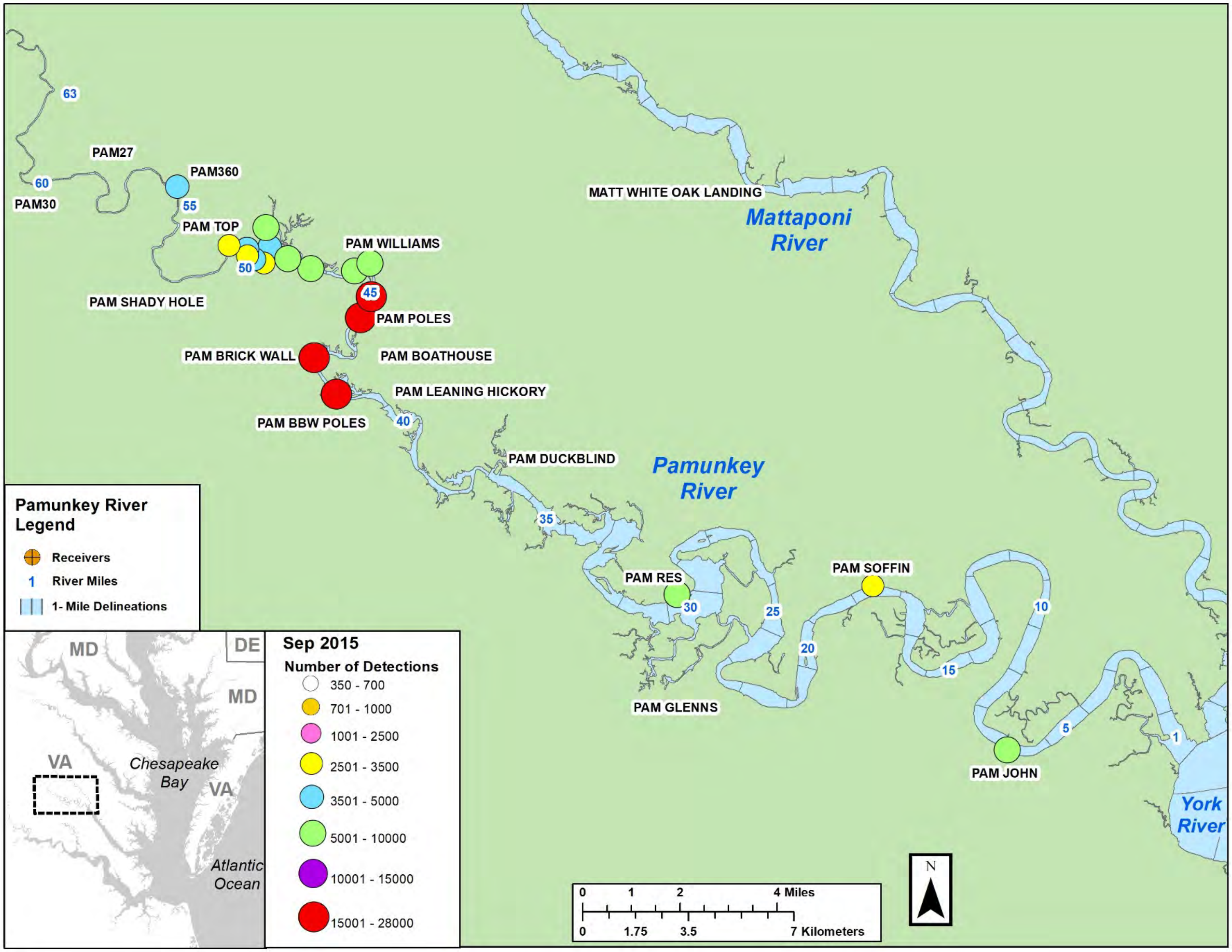
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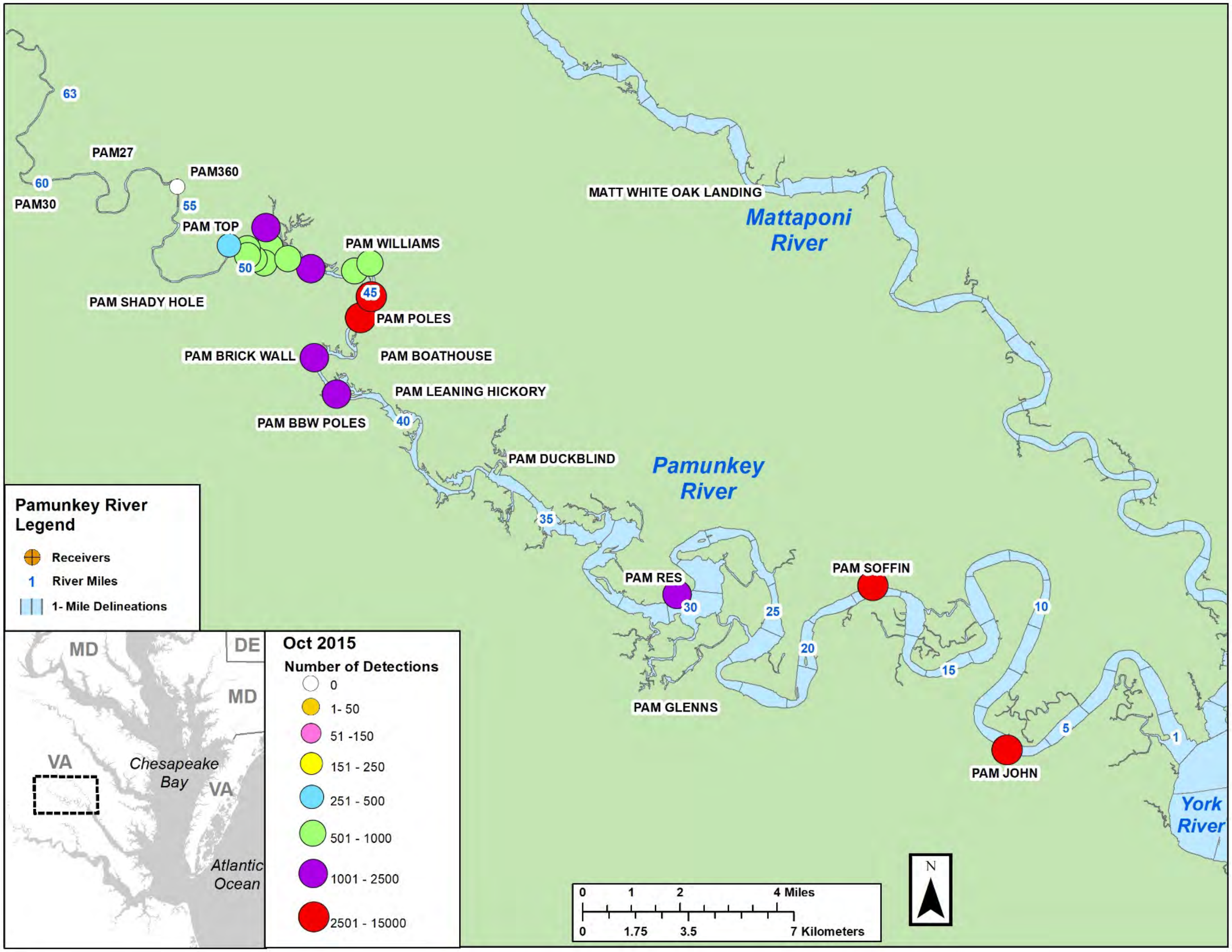
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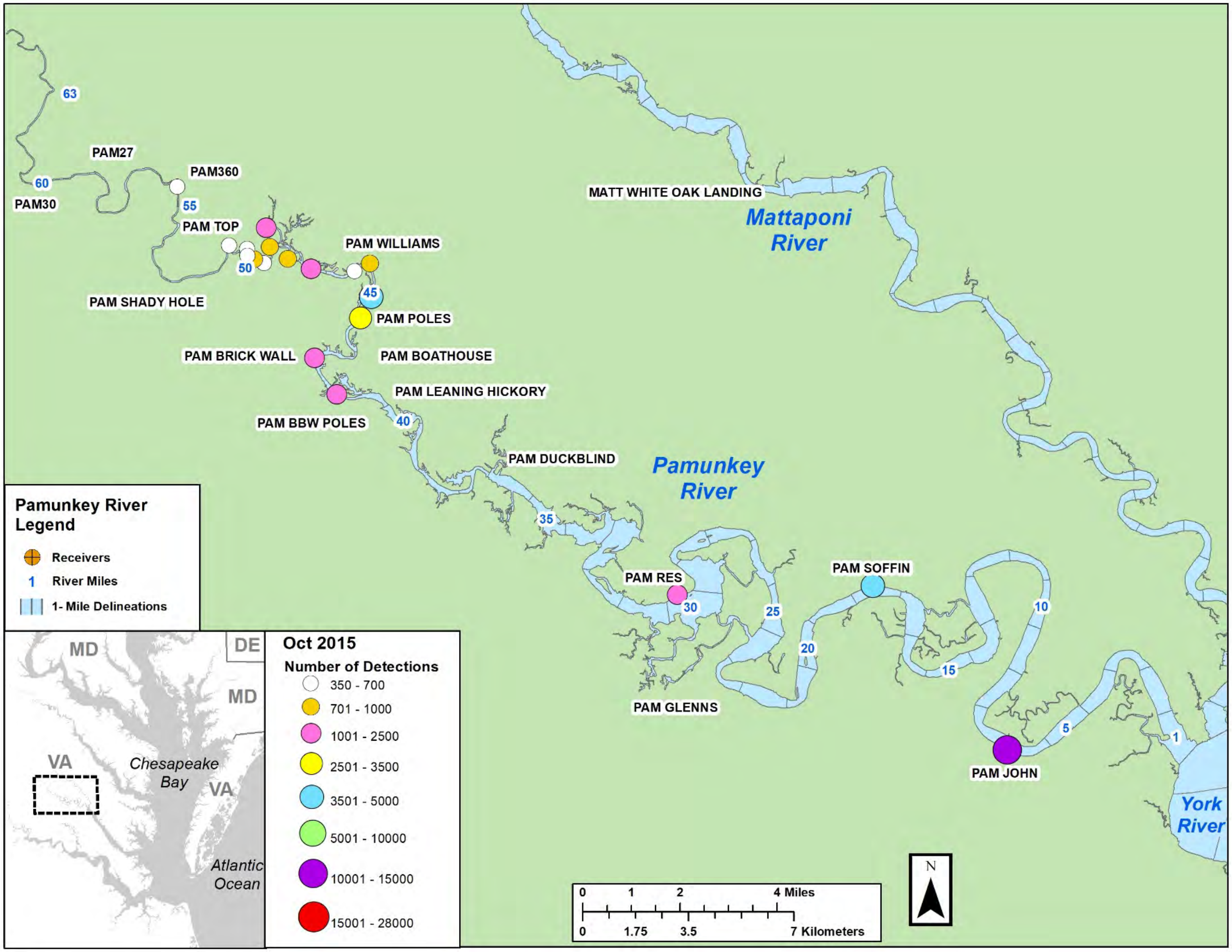
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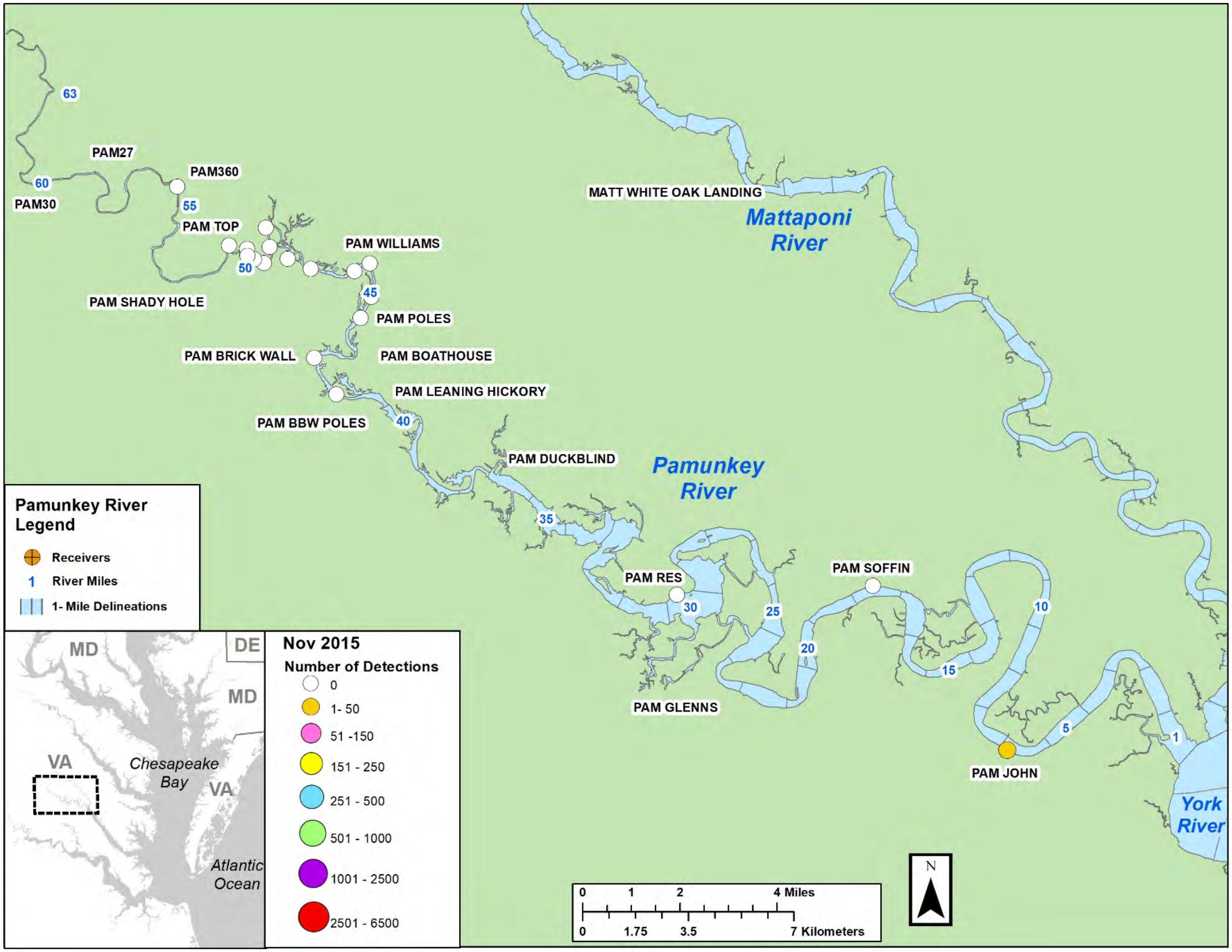
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VA
Atlantic Ocean
Nov 2015
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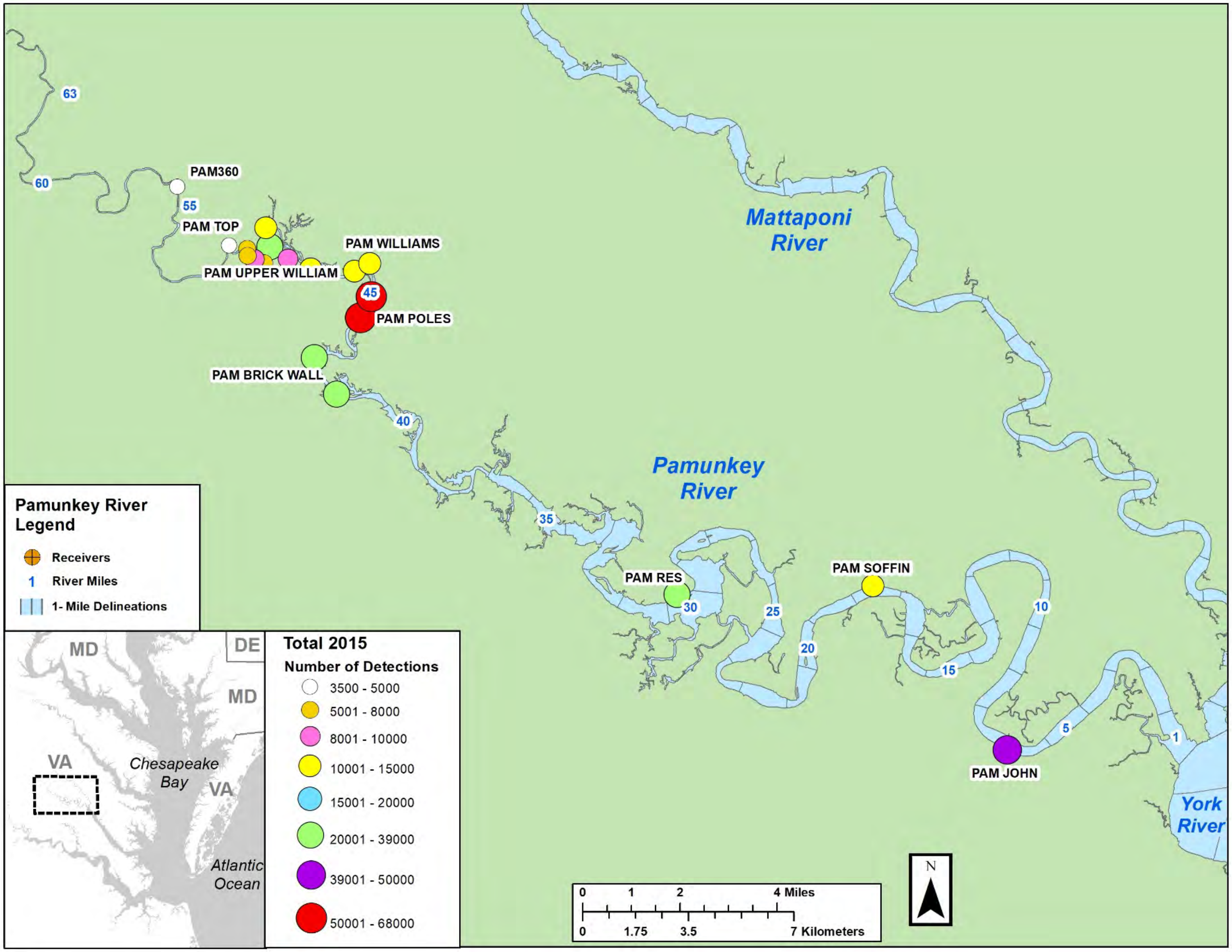
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1- Mile Delineations
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VA
Atlantic Ocean
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Number of Detections
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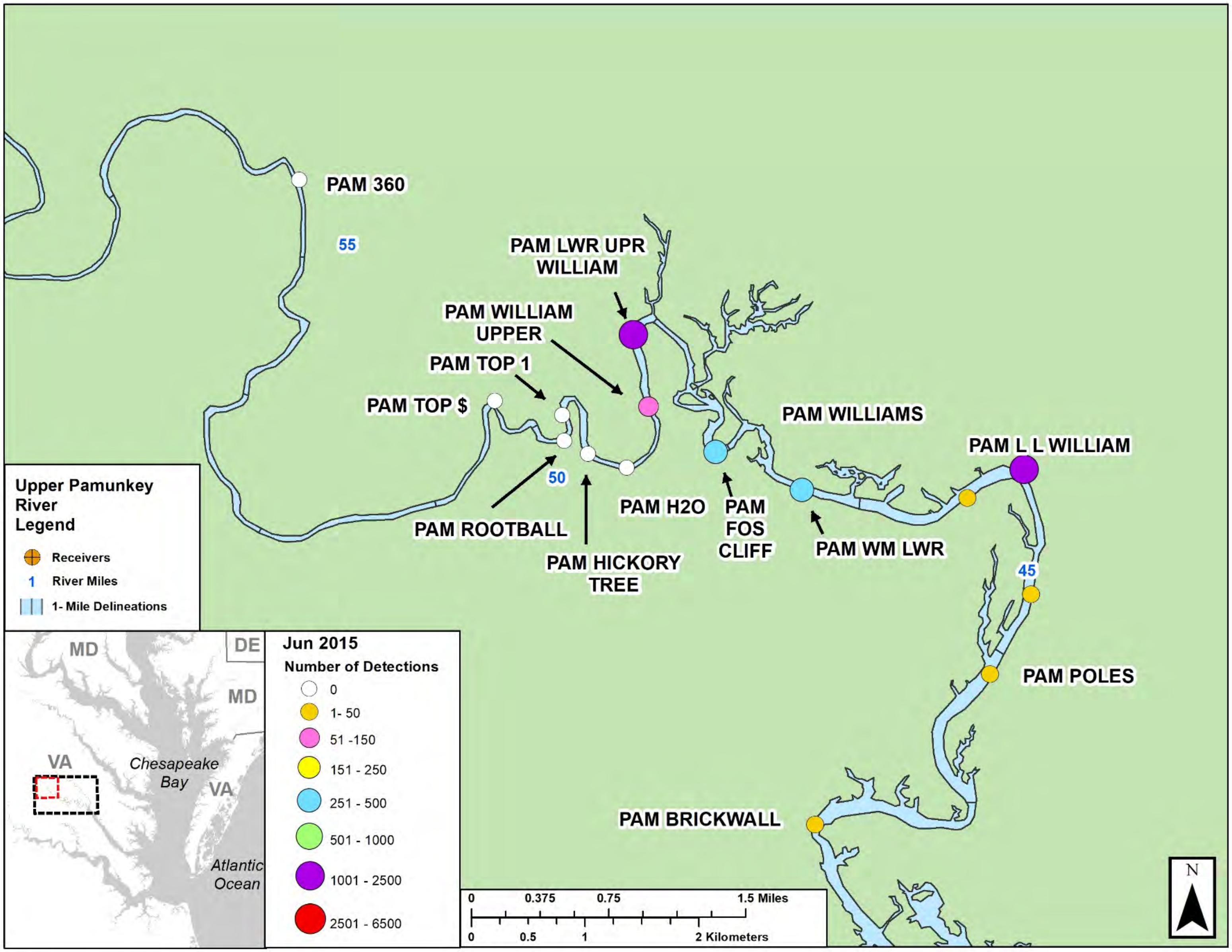
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Upper Pamunkey River Legend
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1- Mile Delineations
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Chesapeake Bay
VA
Atlantic Ocean
Jun 2015
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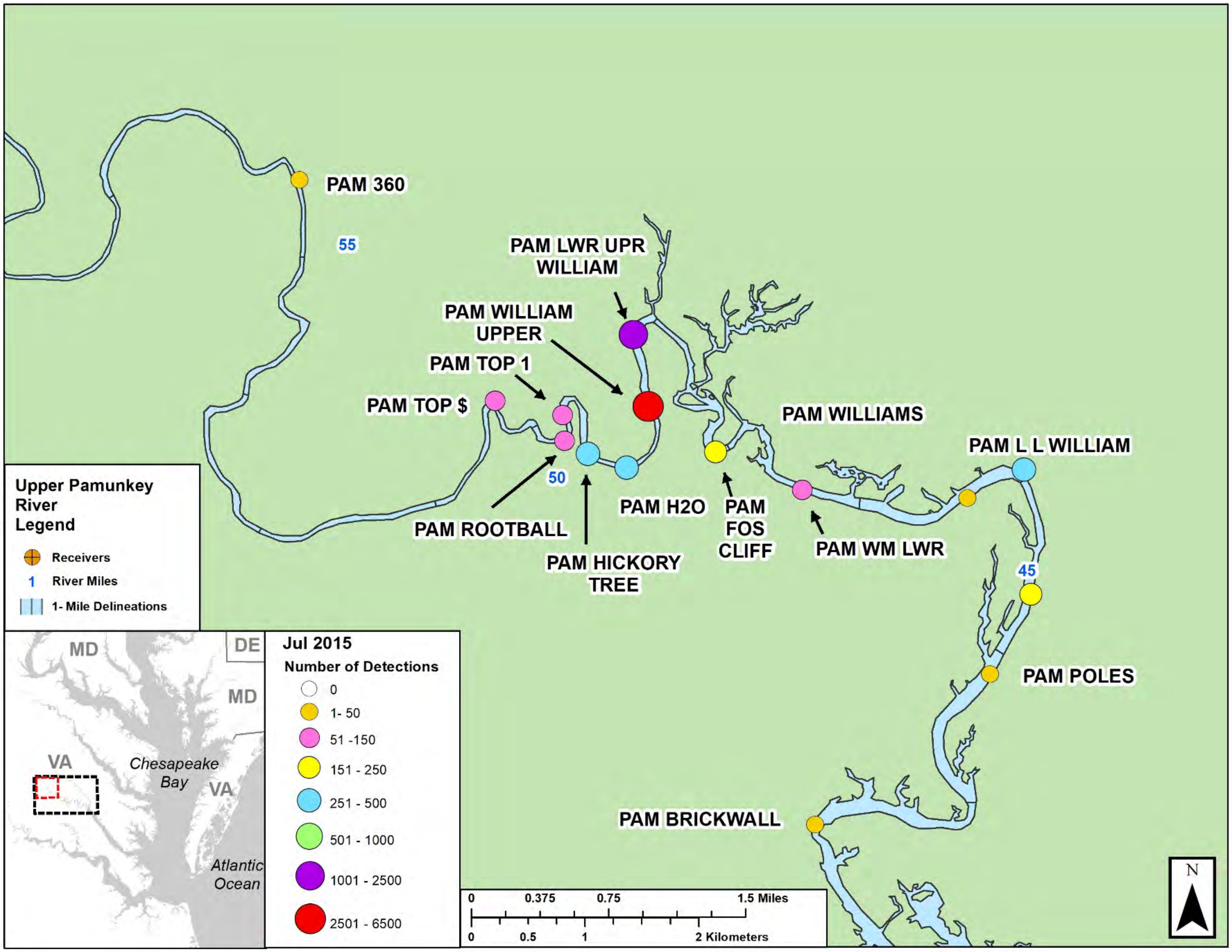
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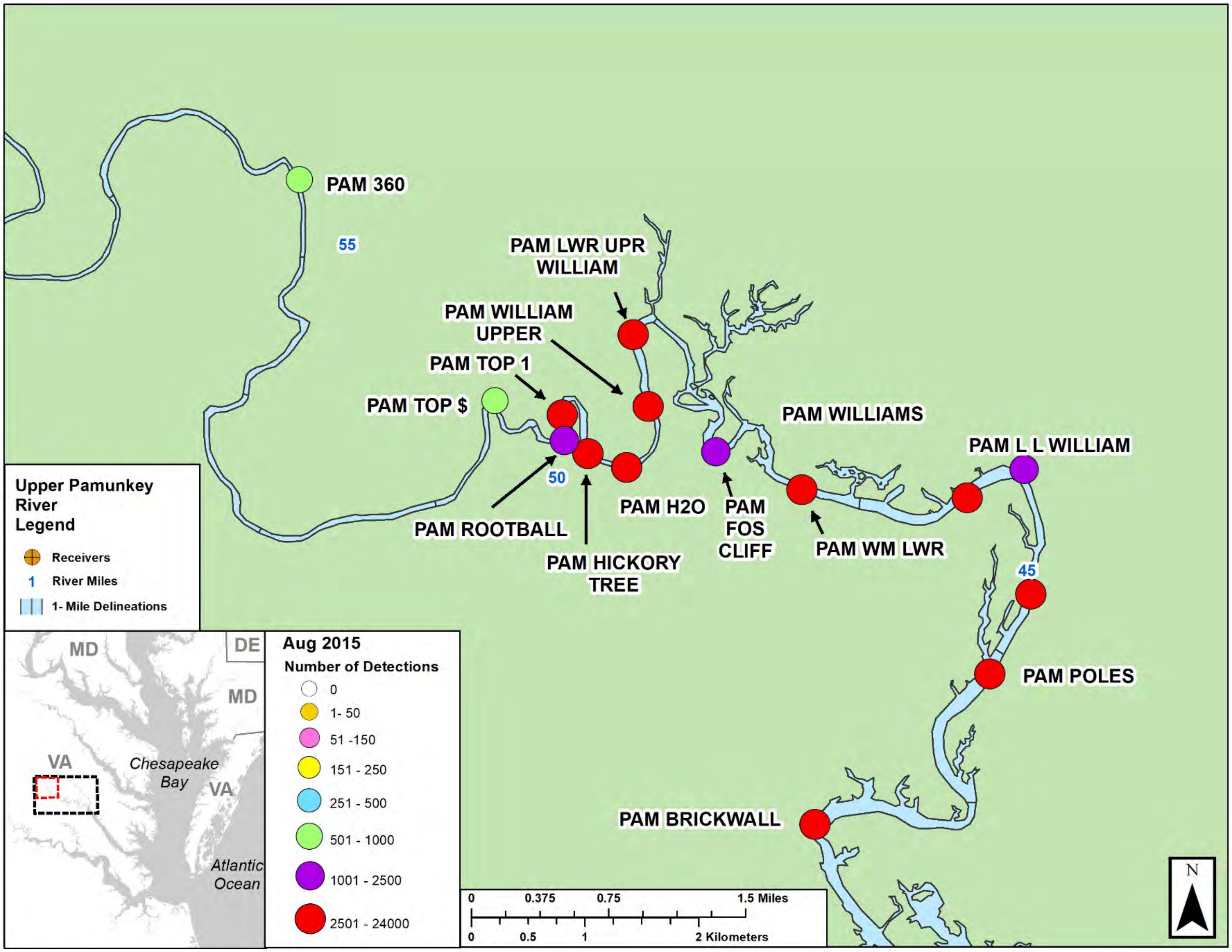
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Upper Pamunkey River Legend
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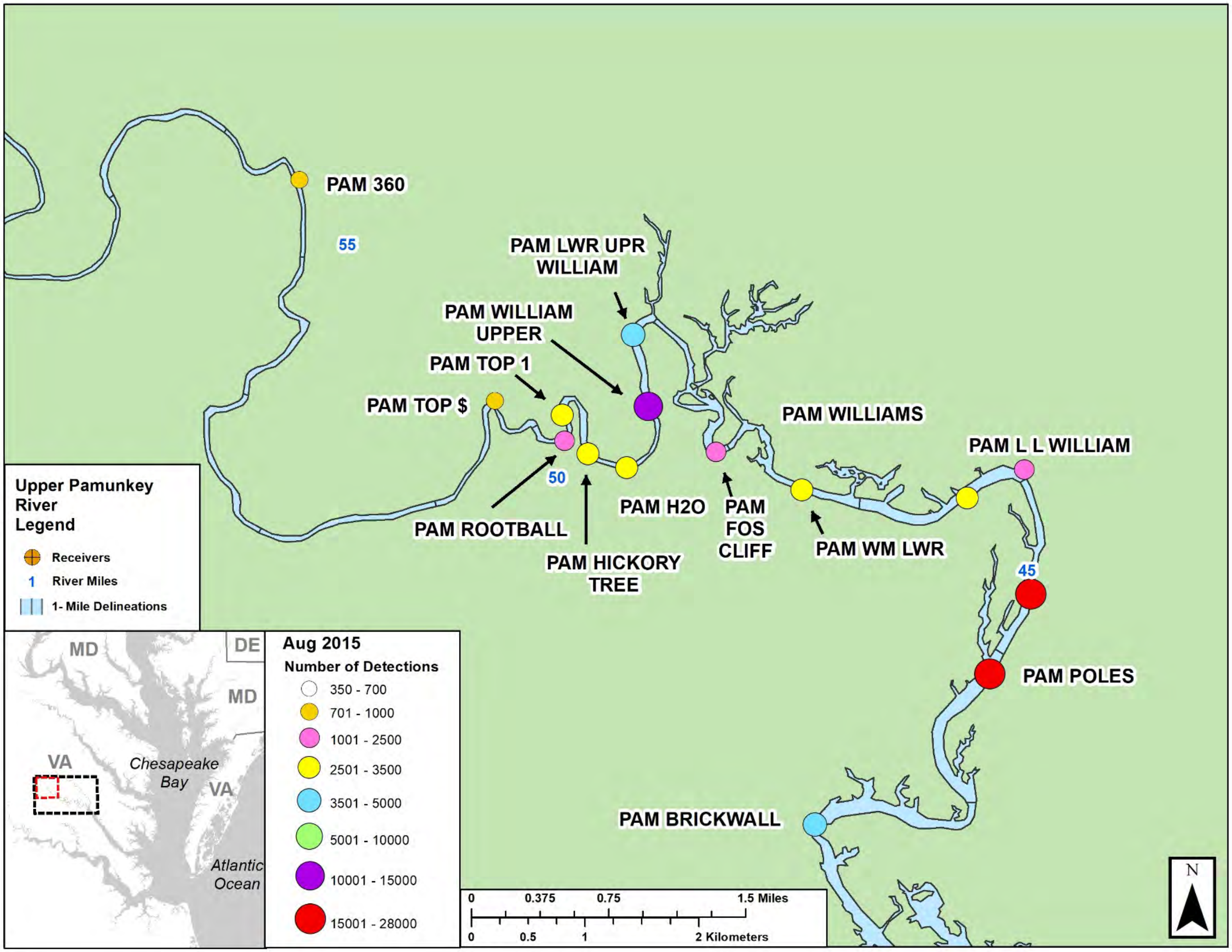
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Upper Pamunkey River Legend
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Aug 2015
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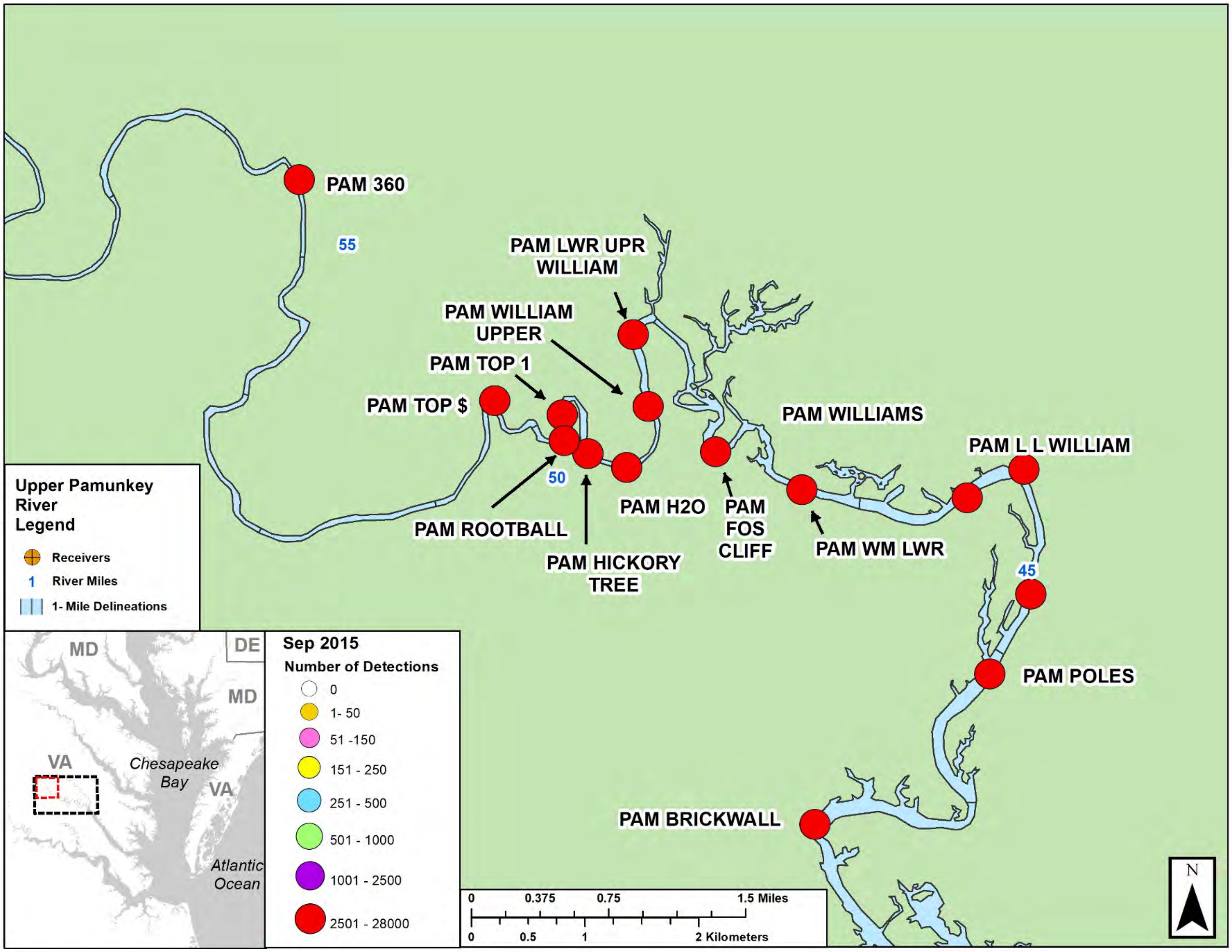
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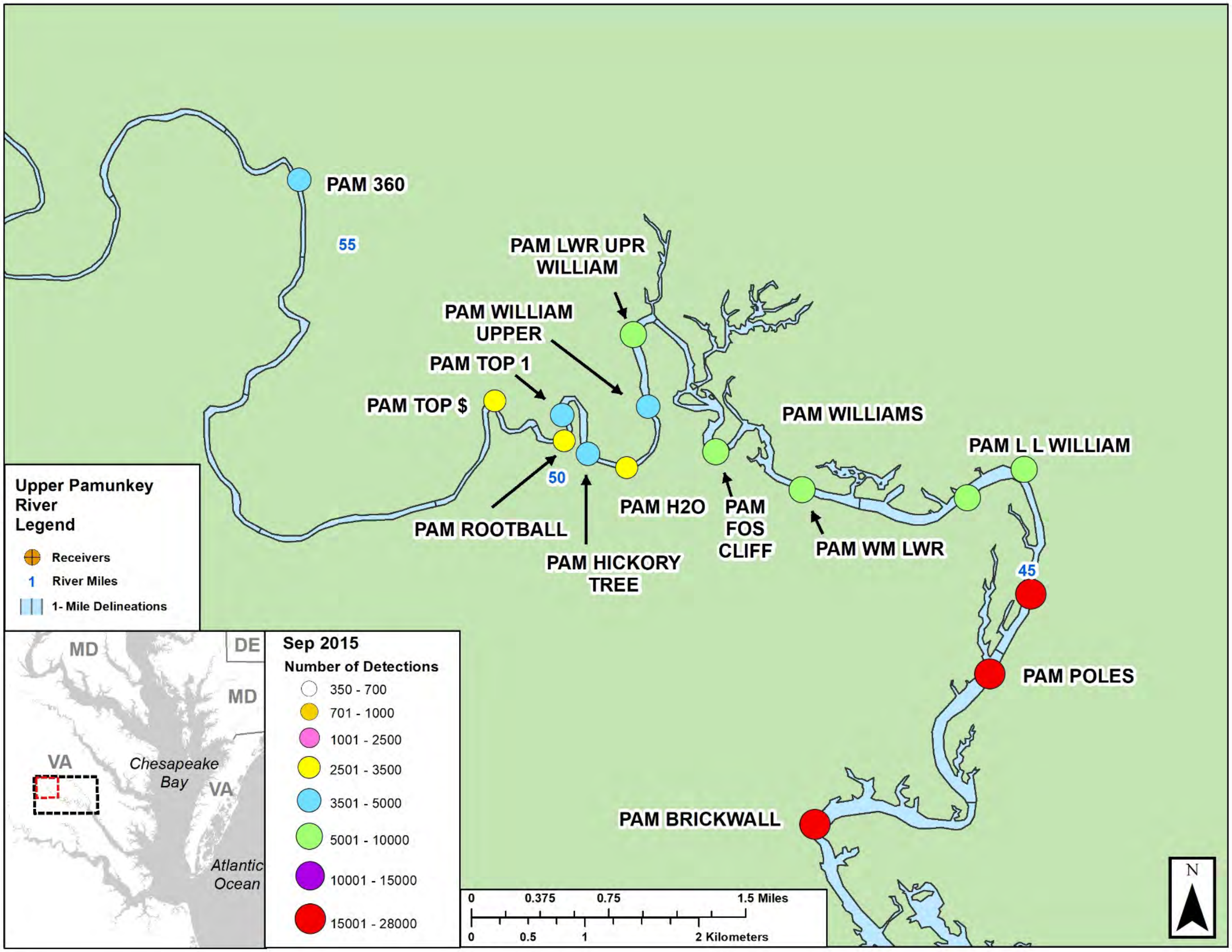
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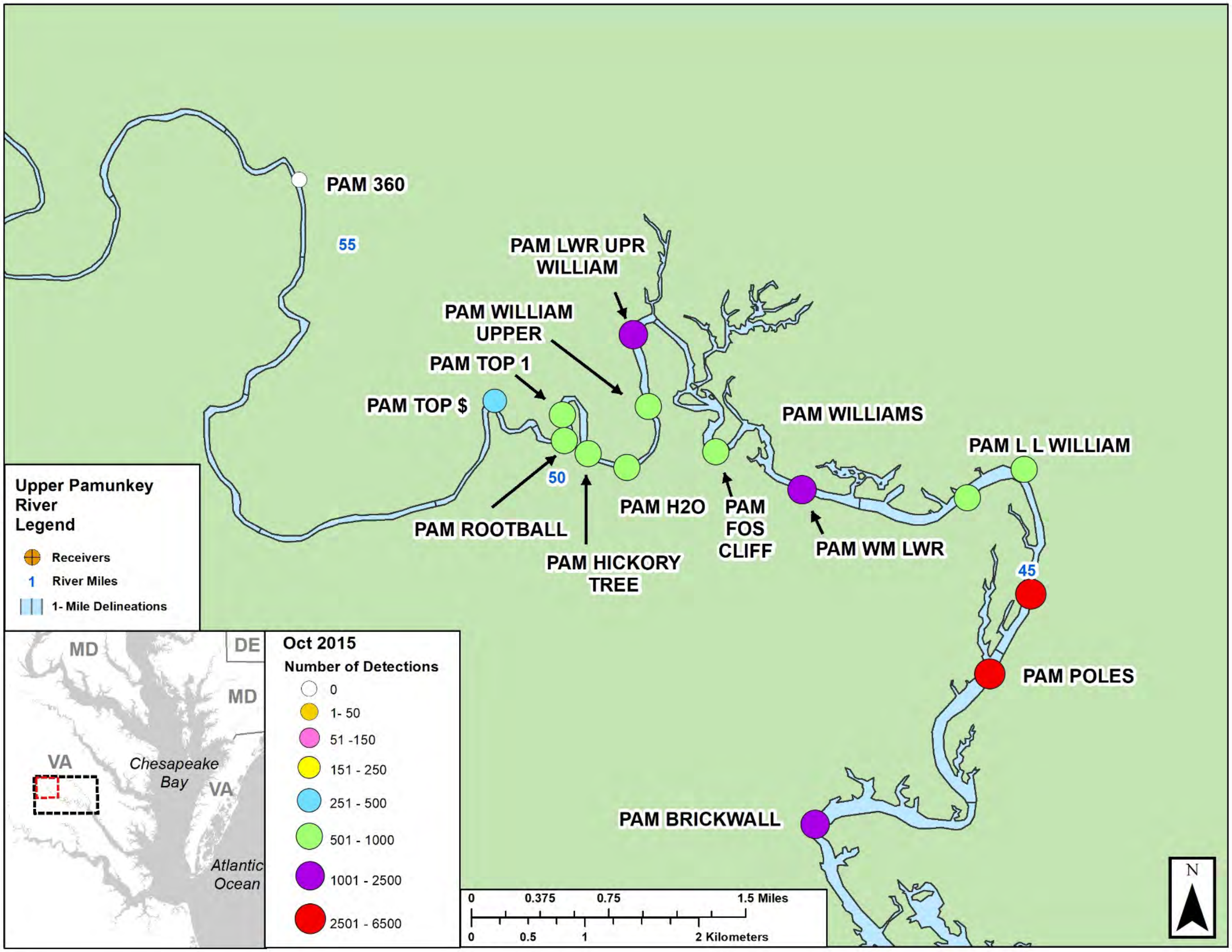
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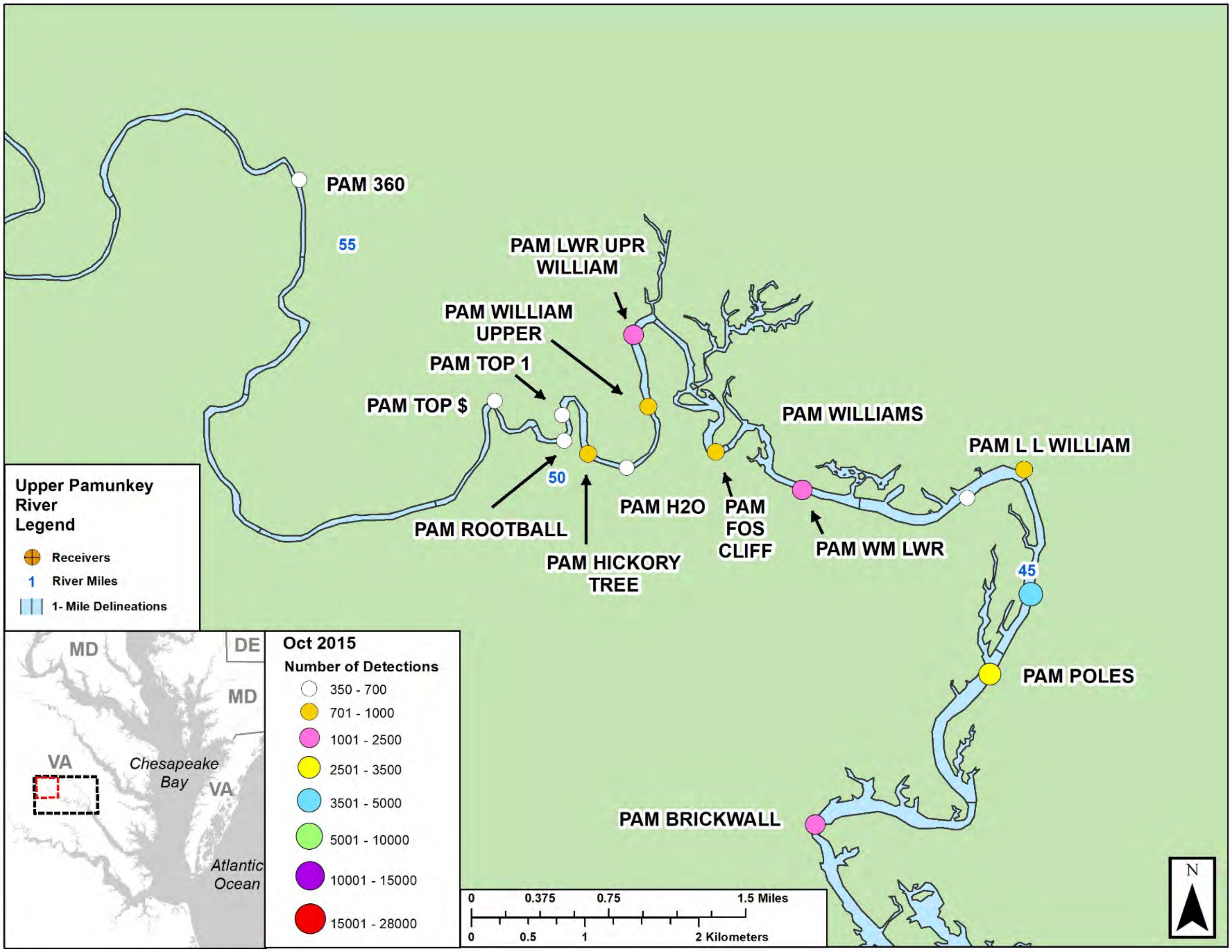
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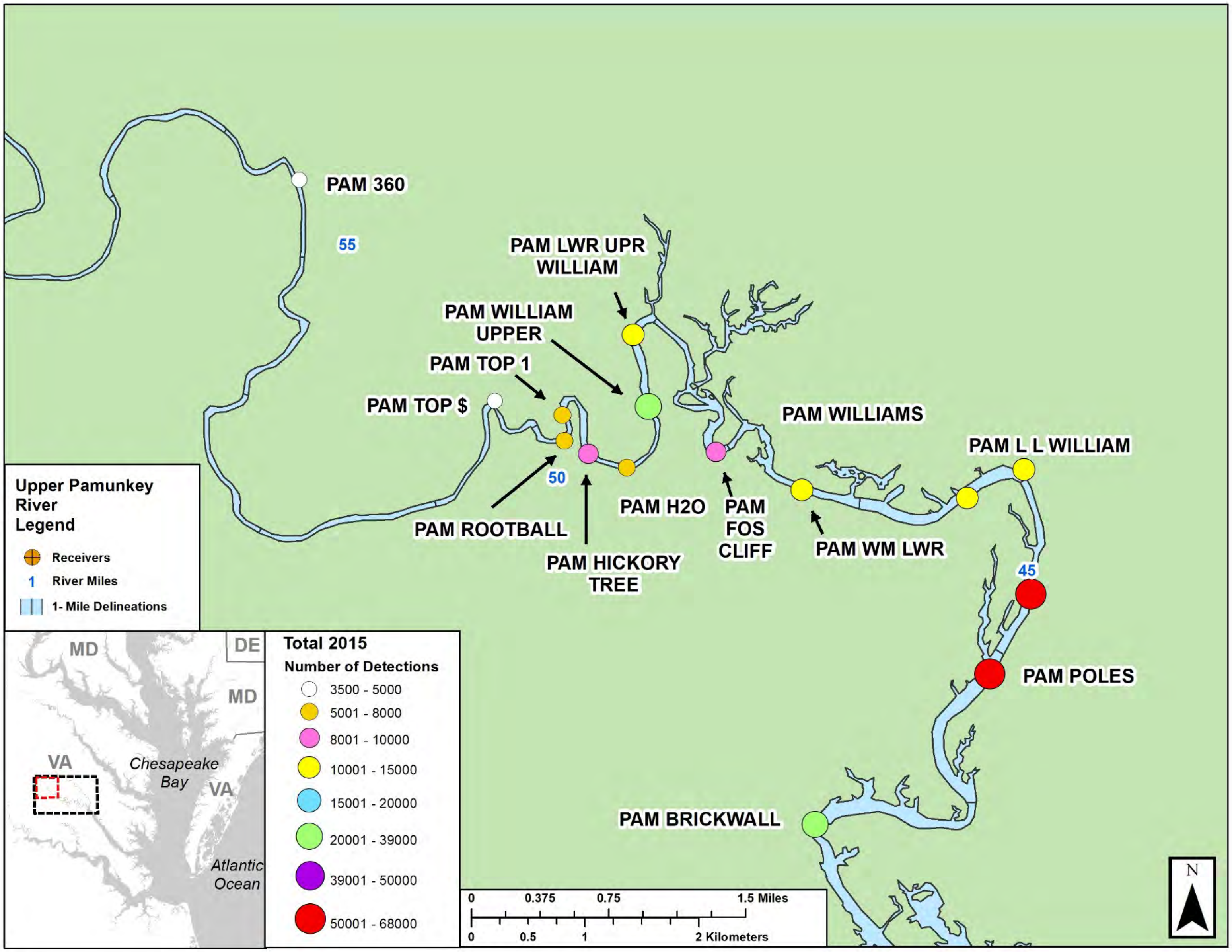
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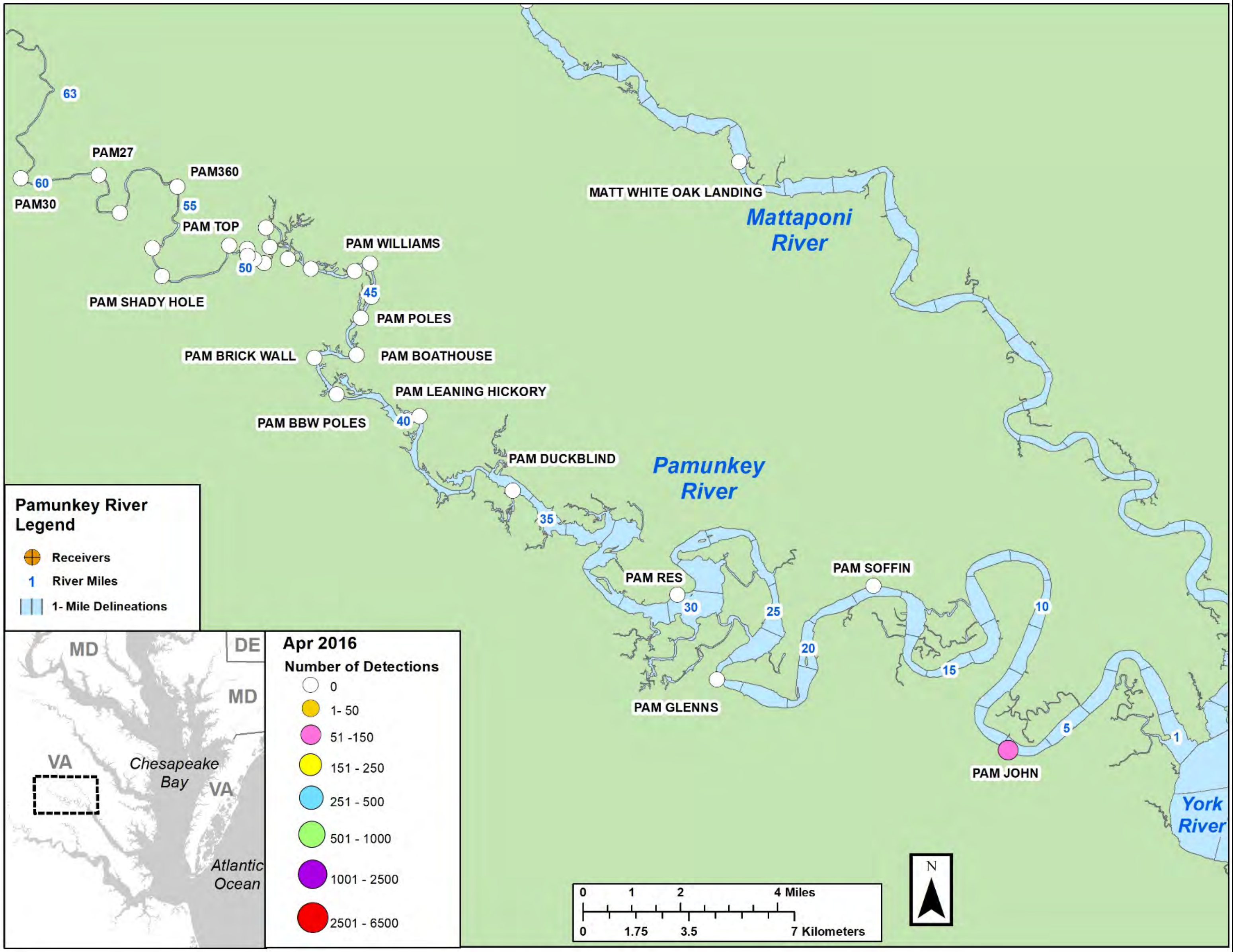
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PAM BBW POLES
PAM DUCKBLIND
MATT WHITE OAK LANDING
Mattaponi River
Pamunkey River
PAM RES
PAM SOFFIN
PAM GLENNS
PAM JOHN
York River
Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Apr 2016
Number of Detections
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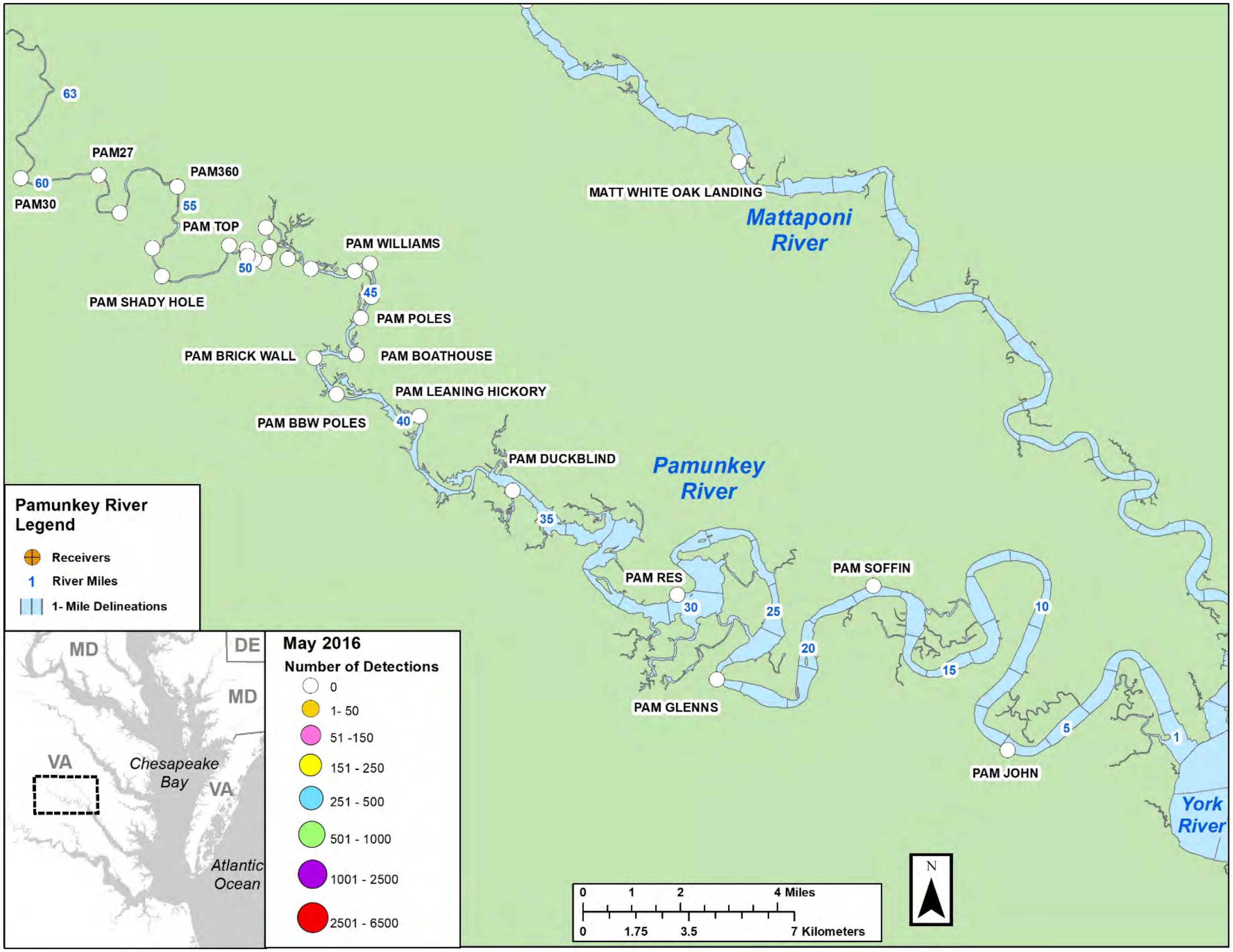
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PAM BBW POLES
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PAM DUCKBLIND
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Mattaponi River
Pamunkey River
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PAM GLENNS
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York River
Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
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MD
VA
Chesapeake Bay
VA
Atlantic Ocean
May 2016
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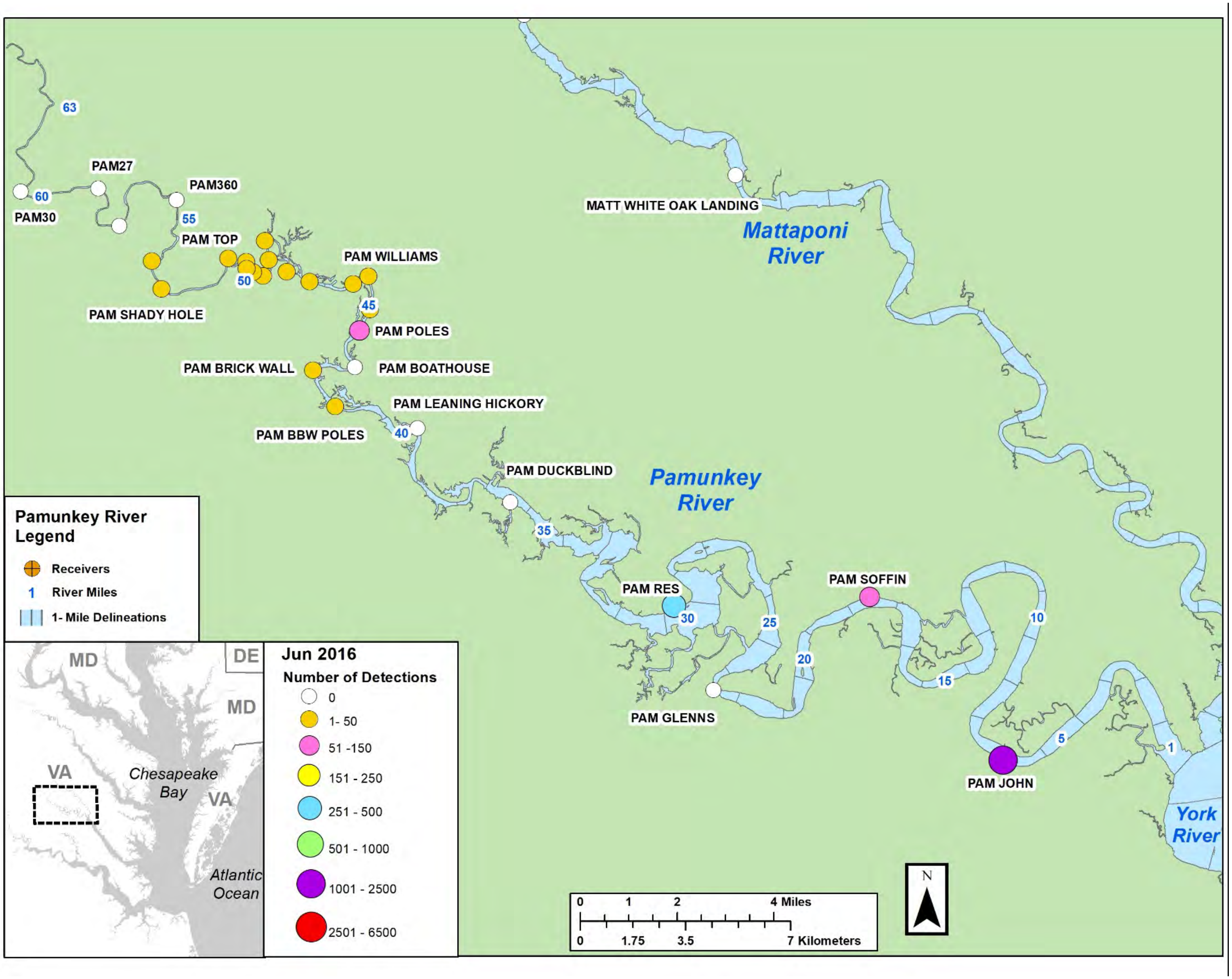
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PAM JOHN
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Pamunkey River Legend
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River Miles
1- Mile Delineations
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DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Jun 2016
Number of Detections
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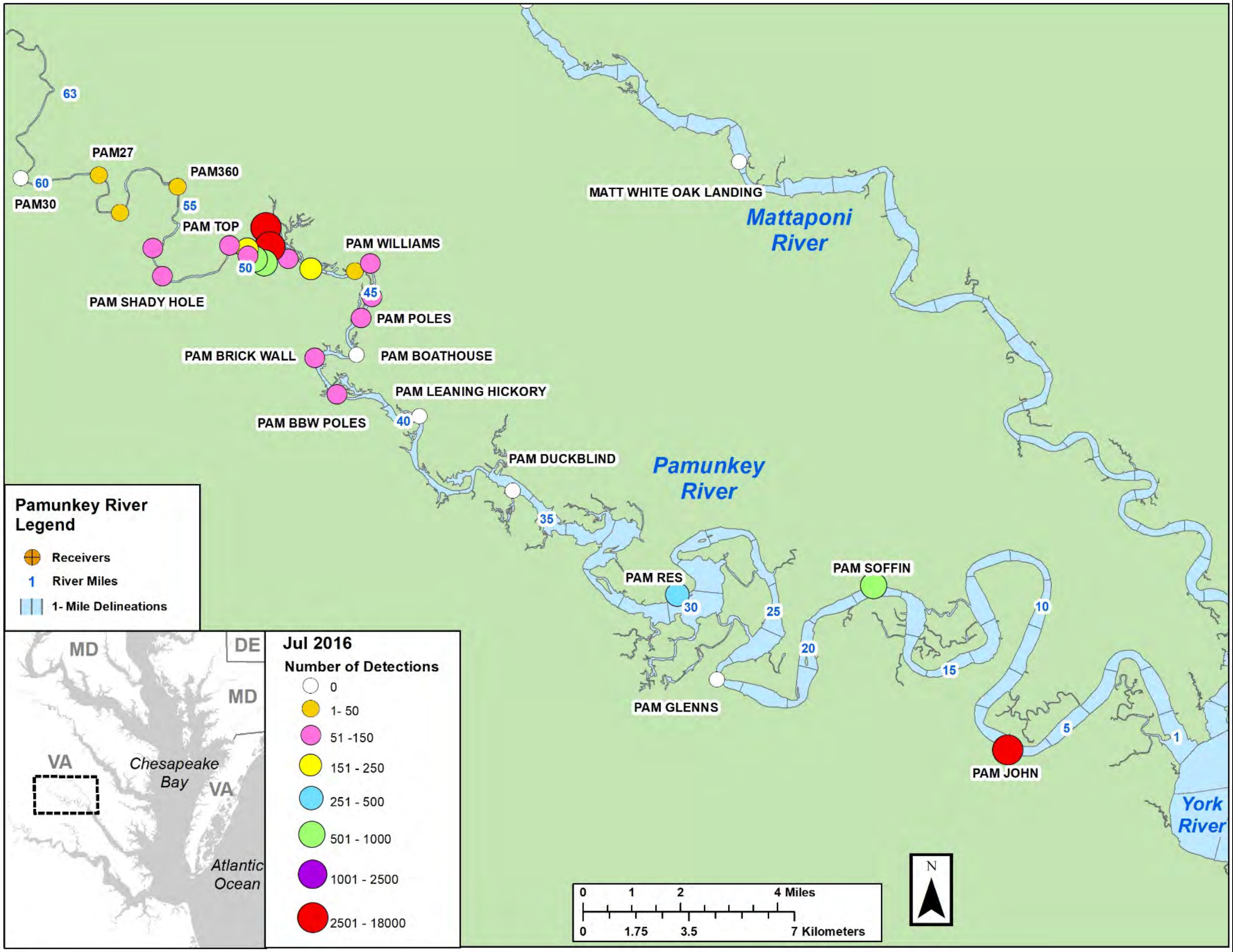
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1- Mile Delineations
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Chesapeake Bay
VA
Atlantic Ocean
Jul 2016
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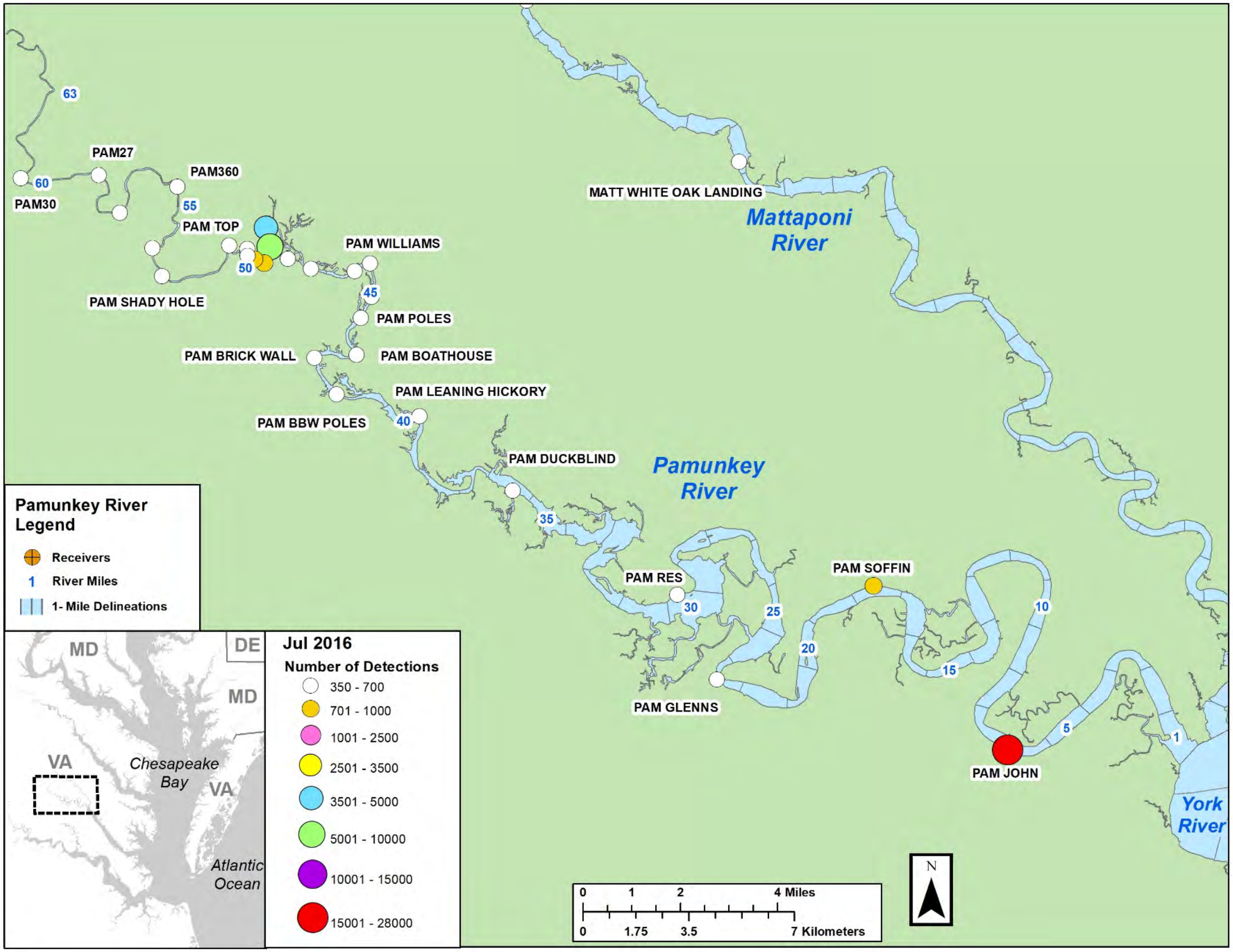
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York River
Pamunkey River Legend
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1- Mile Delineations
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MD
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Chesapeake Bay
VA
Atlantic Ocean
Jul 2016
Number of Detections
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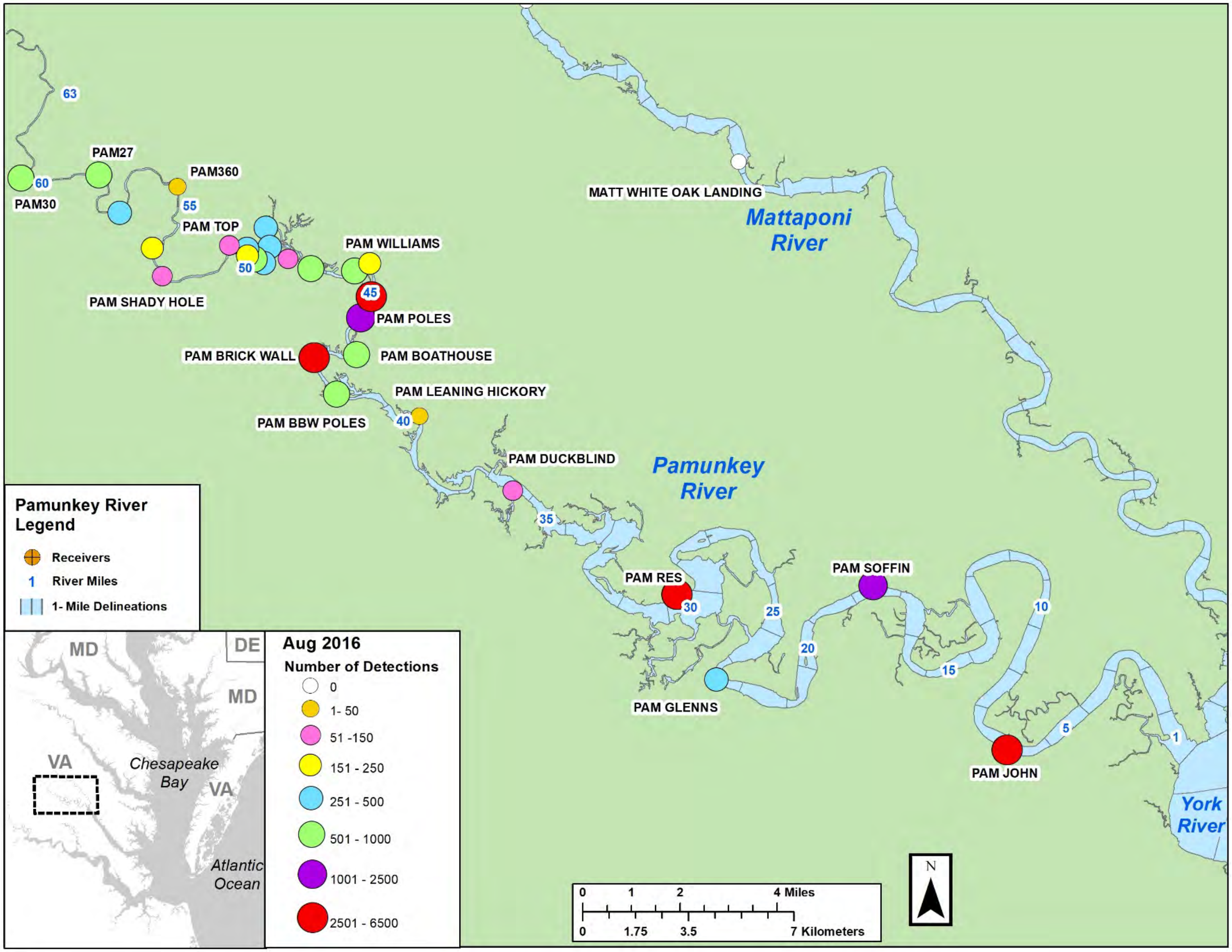
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Pamunkey River Legend
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River Miles
1- Mile Delineations
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Chesapeake Bay
VA
Atlantic Ocean
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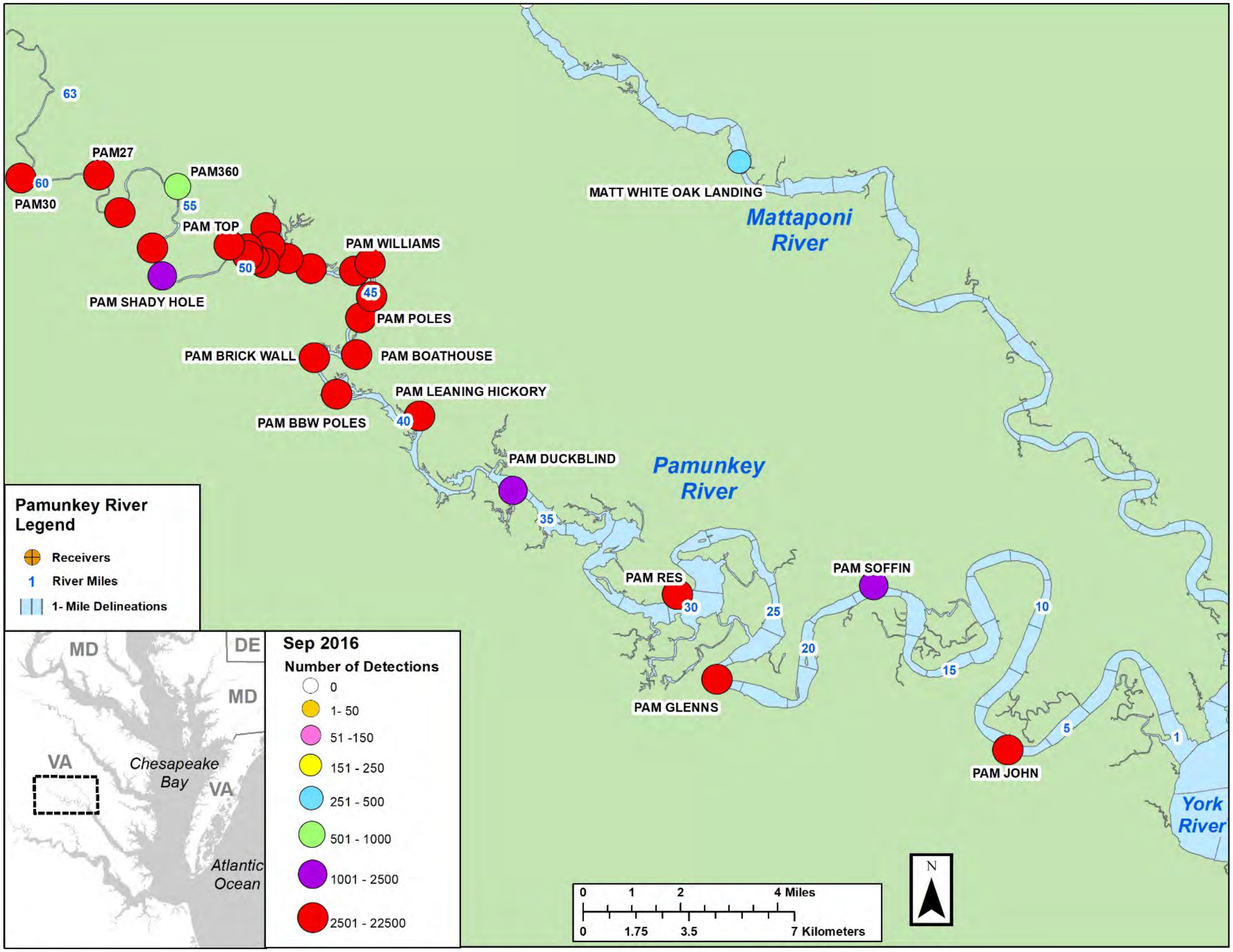

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Mattaponi River
Pamunkey River
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York River
Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
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MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Sep 2016
Number of Detections
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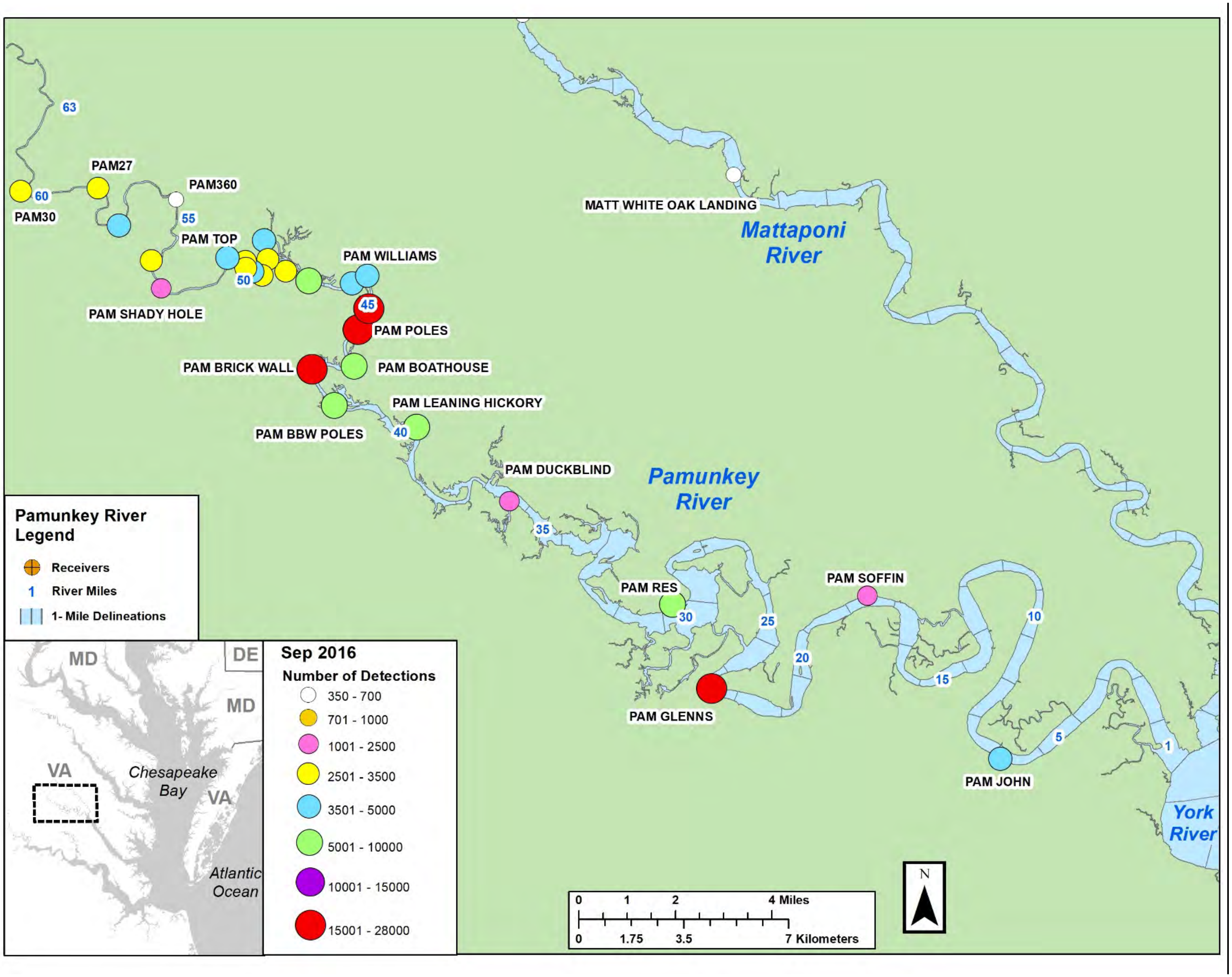
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Atlantic Ocean
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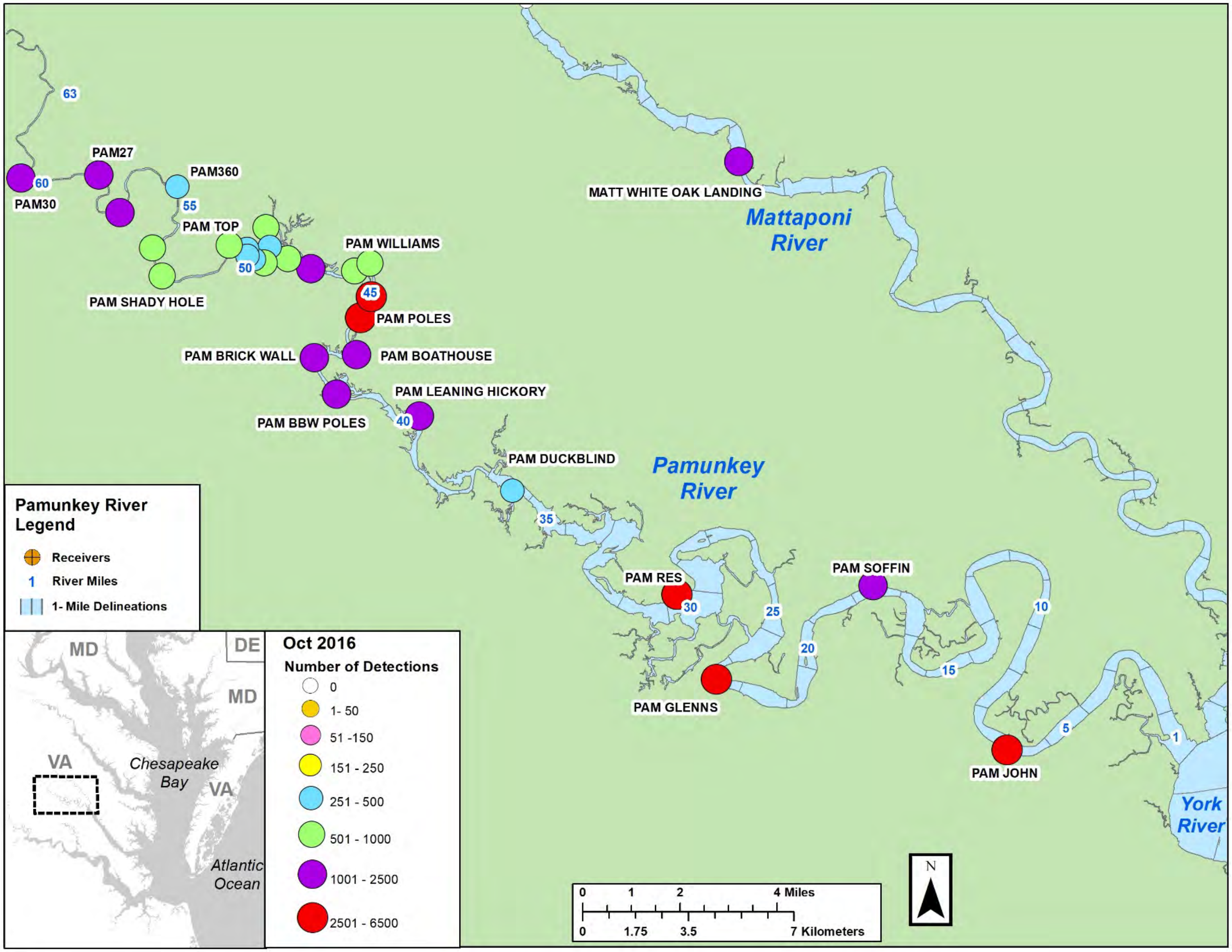
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York River
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Receivers
1 River Miles
1- Mile Delineations
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Chesapeake Bay
VA
Atlantic Ocean
Oct 2016
Number of Detections
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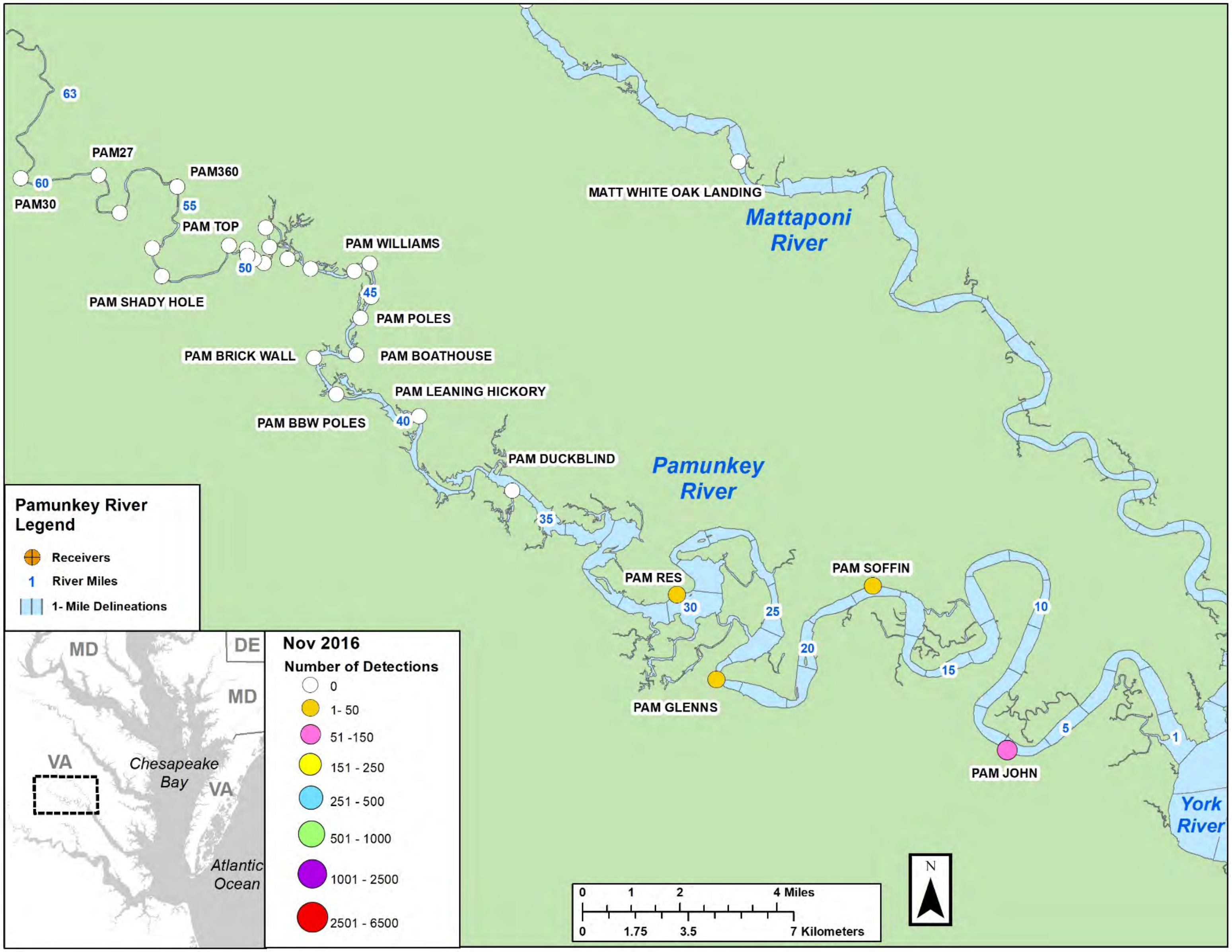
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Pamunkey River Legend
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1 River Miles
1- Mile Delineations
MD
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VA
Chesapeake Bay
VA
Atlantic Ocean
Nov 2016
Number of Detections
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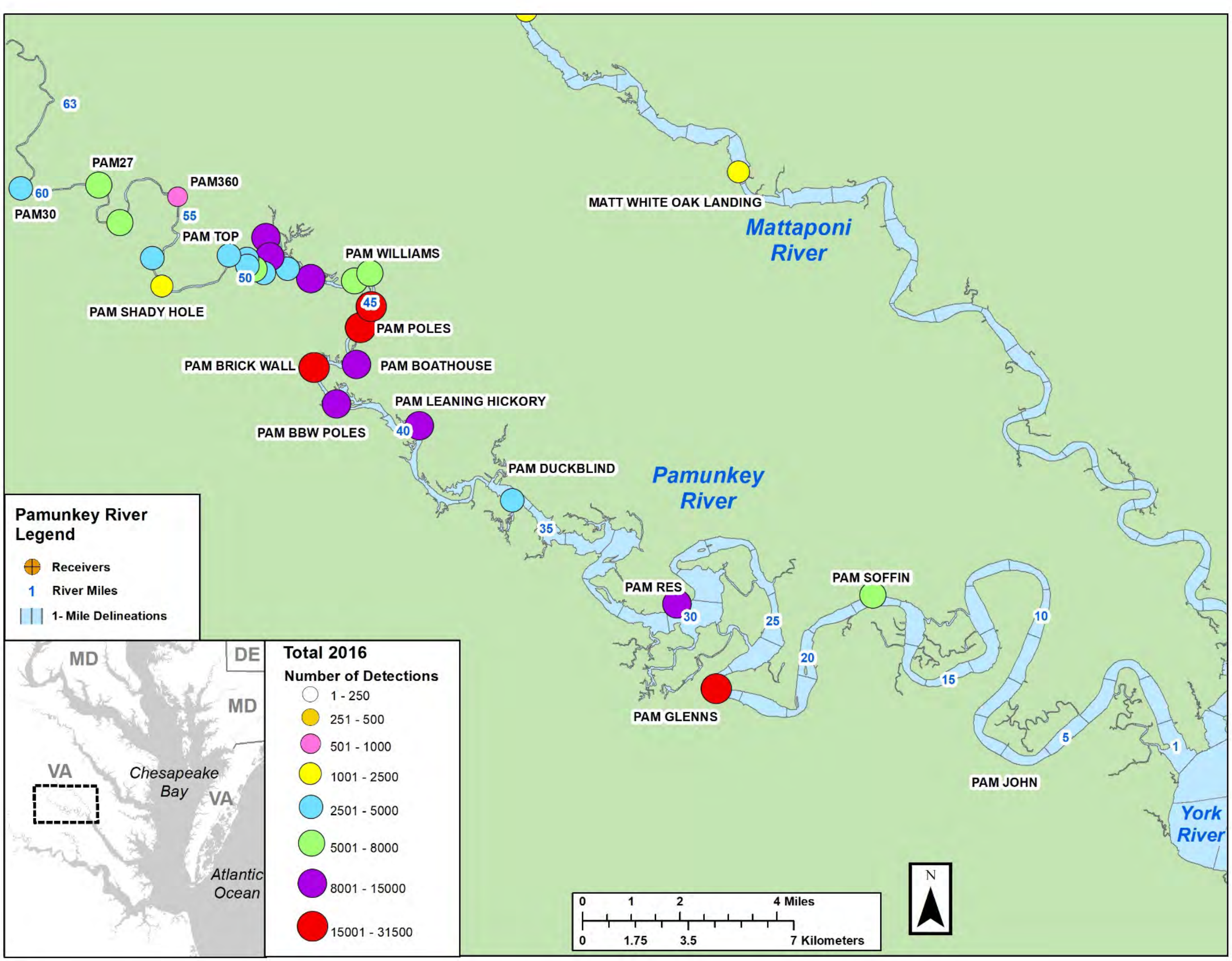
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Mattaponi River
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PAM SOFFIN
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York River
Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Total 2016
Number of Detections
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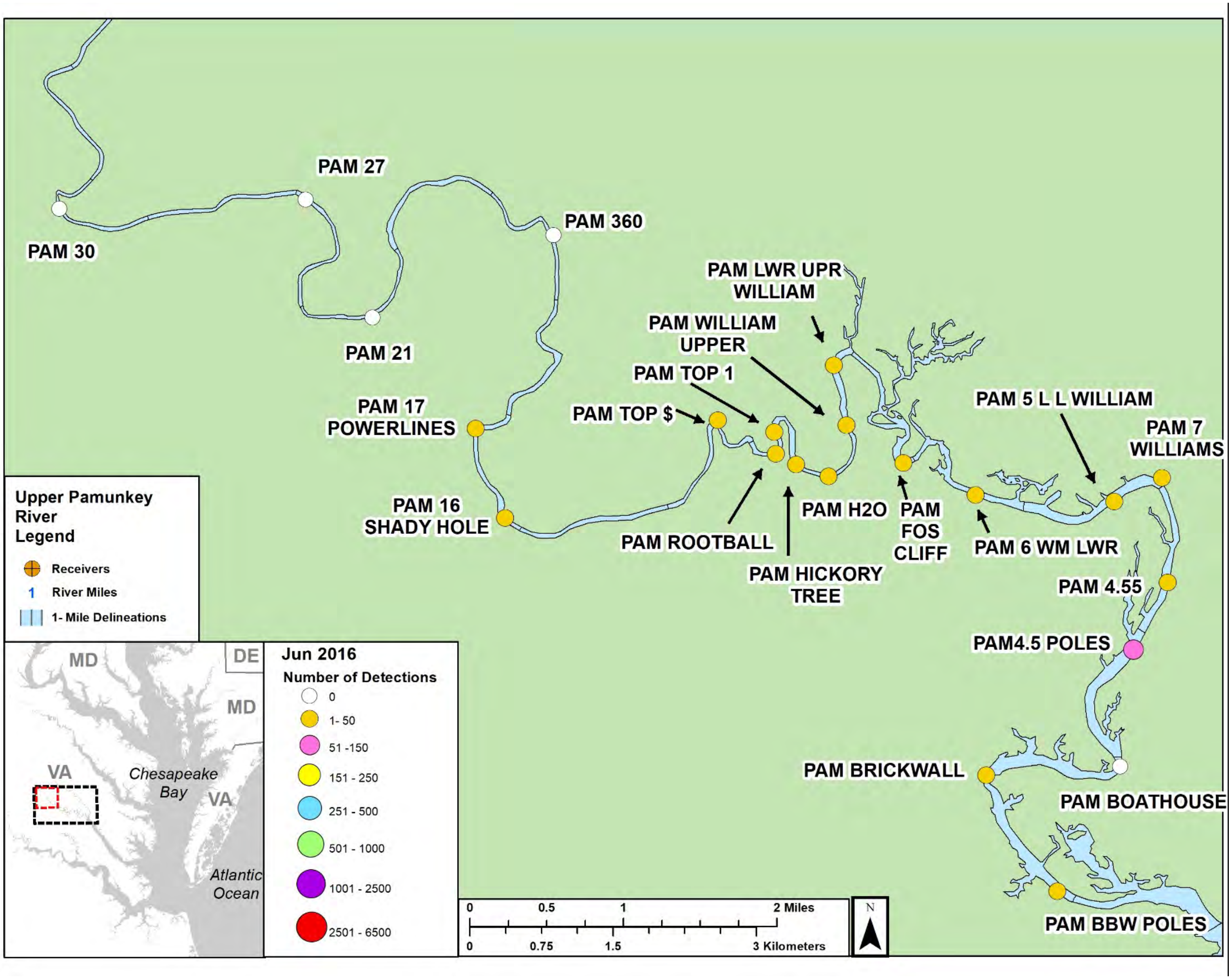
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PAM ROOTBALL
PAM HICKORY TREE
PAM H2O
PAM FOS CLIFF
PAM 6 WM LWR
PAM 5 L L WILLIAM
PAM 7 WILLIAMS
PAM 4.55
PAM4.5 POLES
PAM BRICKWALL
PAM BOATHOUSE
PAM BBW POLES
Upper Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Jun 2016
Number of Detections
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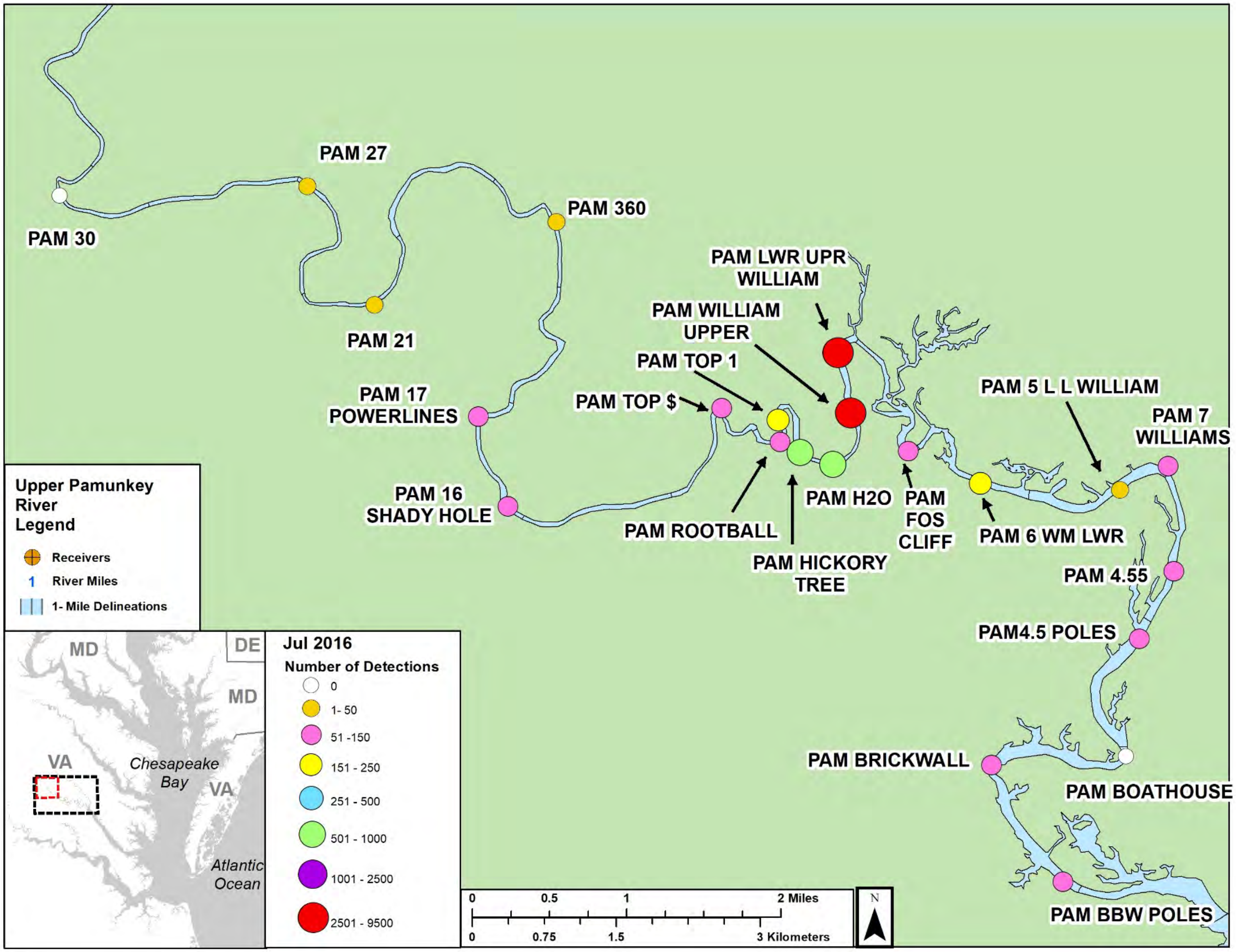
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PAM H2O
PAM FOS CLIFF
PAM 6 WM LWR
PAM 5 L L WILLIAM
PAM 7 WILLIAMS
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PAM4.5 POLES
PAM BRICKWALL
PAM BOATHOUSE
PAM BBW POLES
Upper Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
MD
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MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Jul 2016
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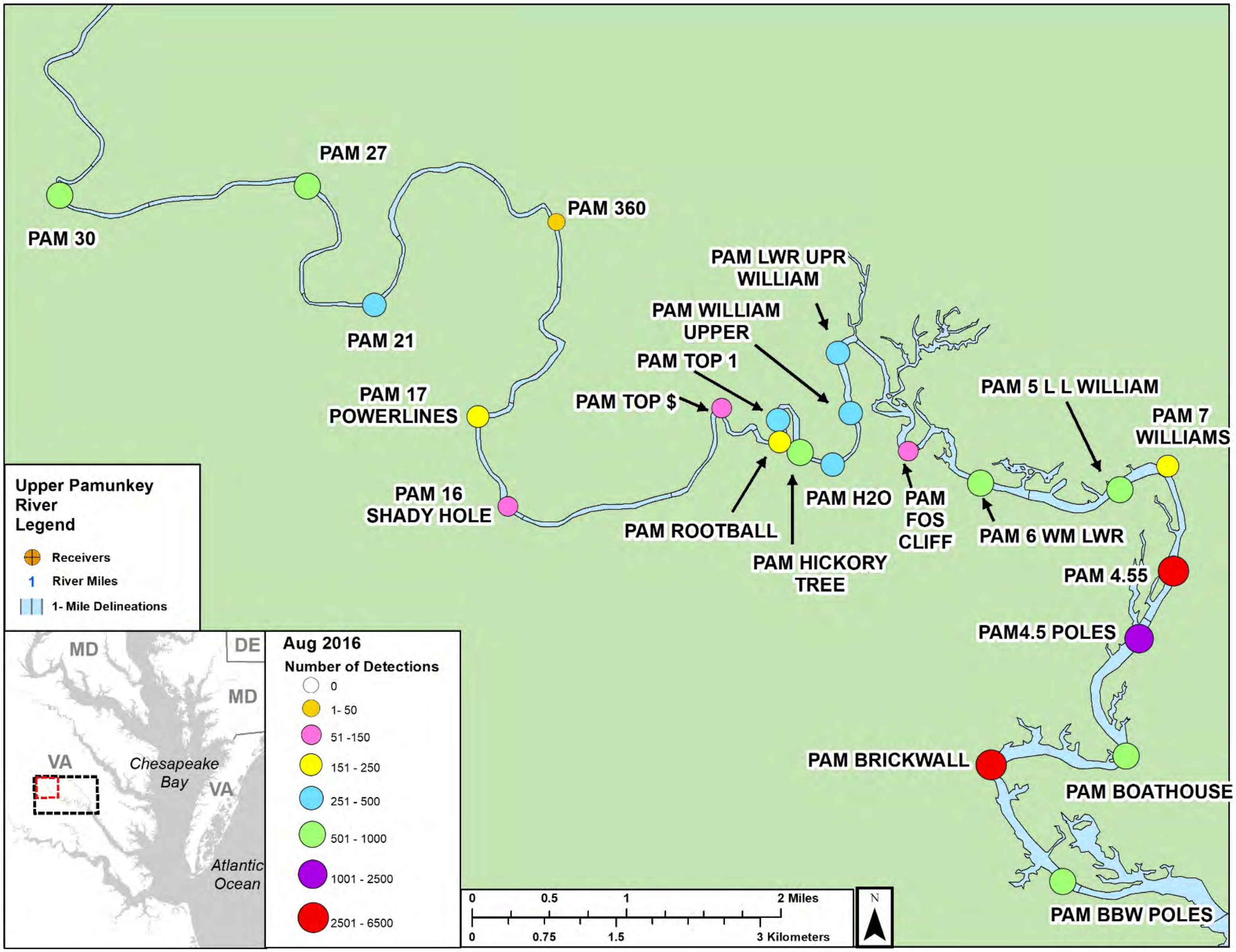
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Upper Pamunkey River Legend
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River Miles
1- Mile Delineations
MD
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MD
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Chesapeake Bay
VA
Atlantic Ocean
Aug 2016
Number of Detections
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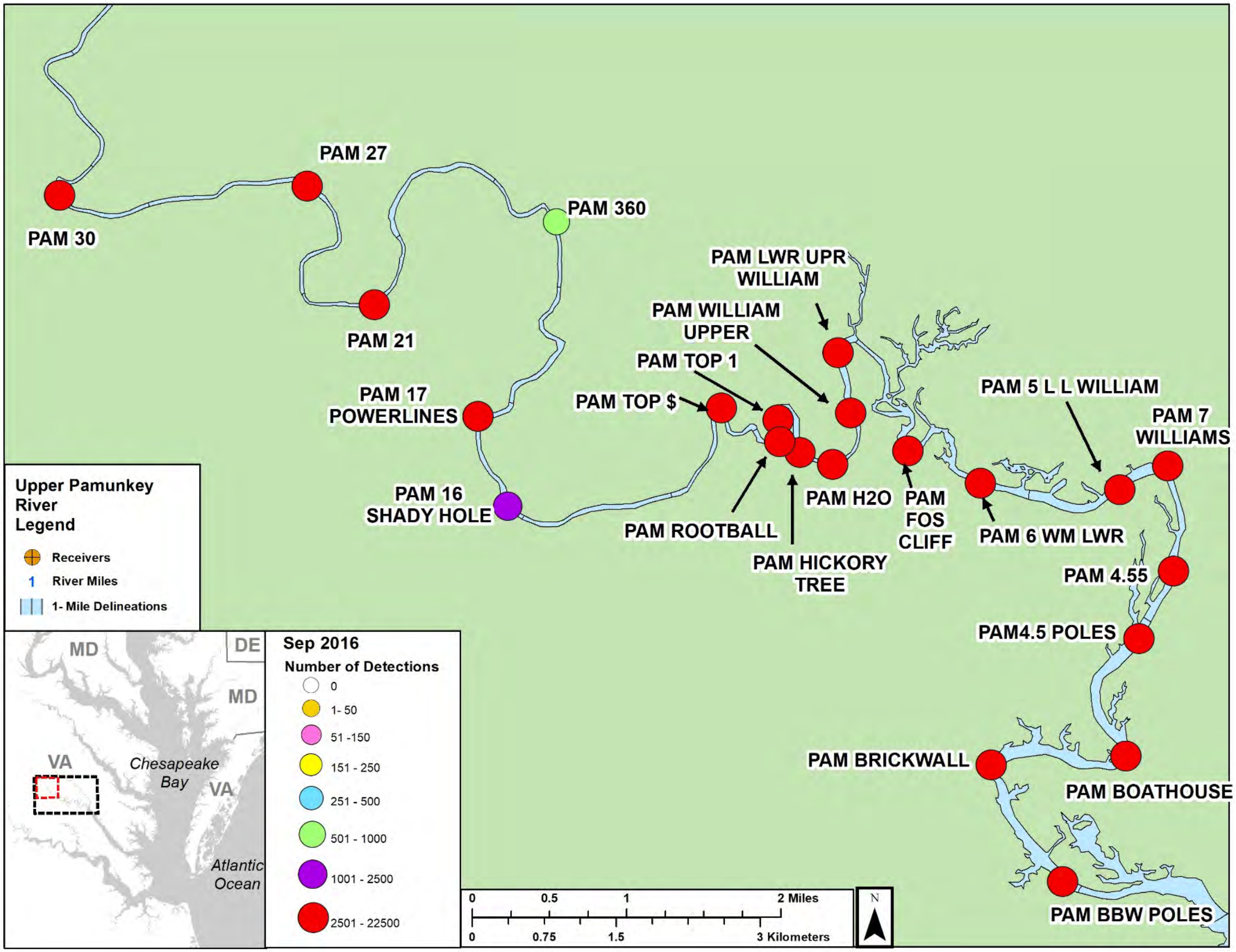
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PAM 6 WM LWR
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PAM BBW POLES
Upper Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Sep 2016
Number of Detections
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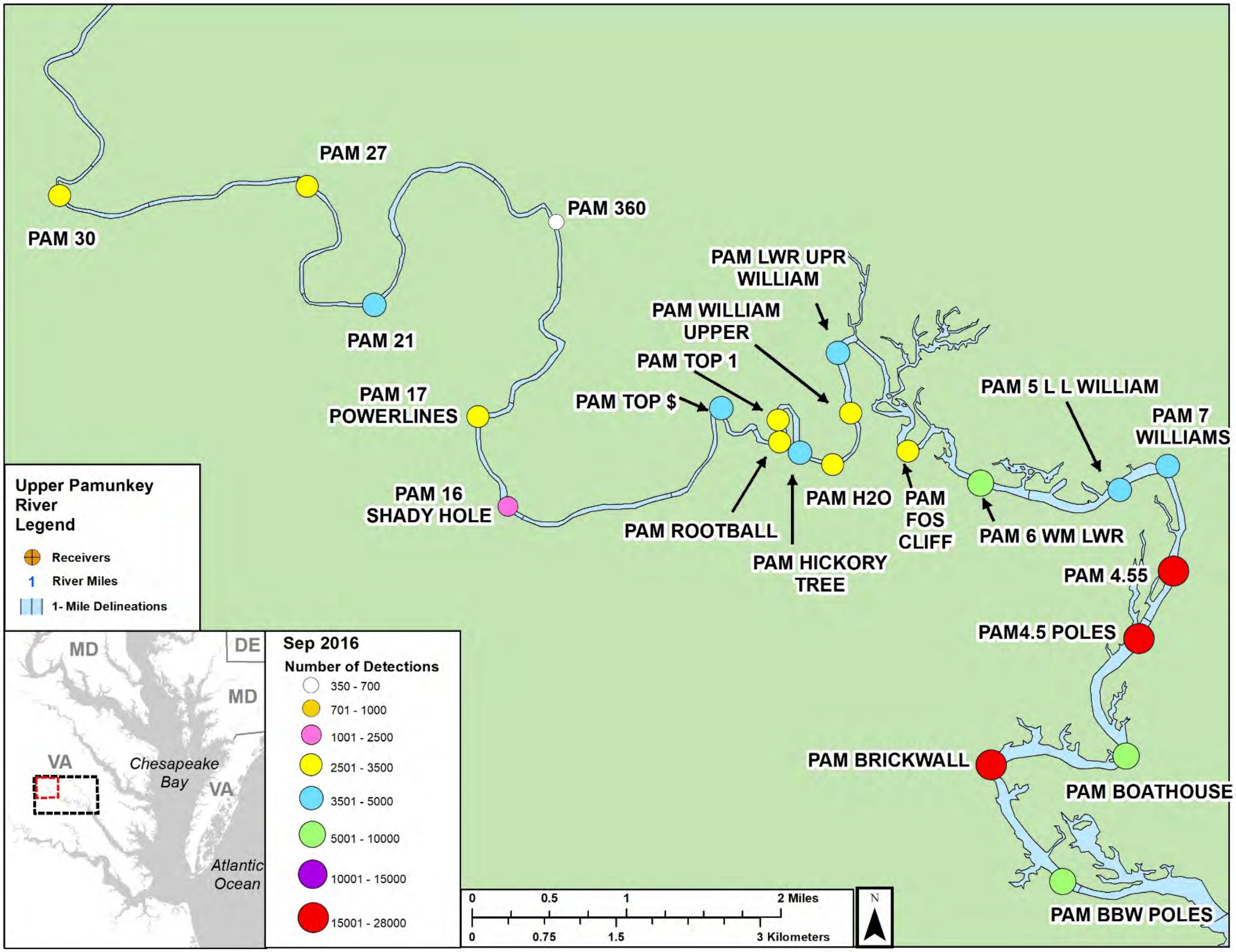
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Upper Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
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Chesapeake Bay
VA
Atlantic Ocean
Sep 2016
Number of Detections
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3 Kilometers
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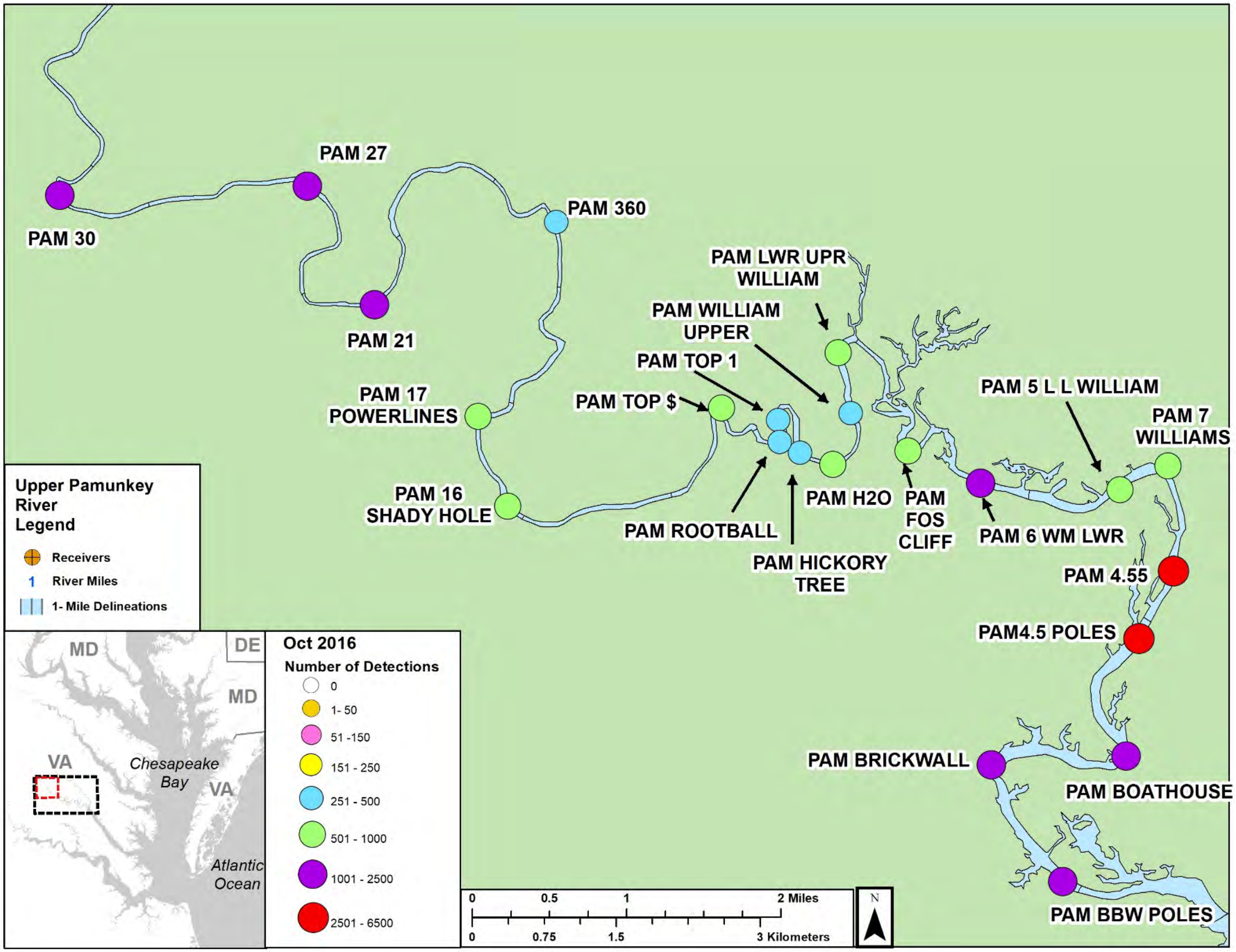
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Upper Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
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MD
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Chesapeake Bay
VA
Atlantic Ocean
Oct 2016
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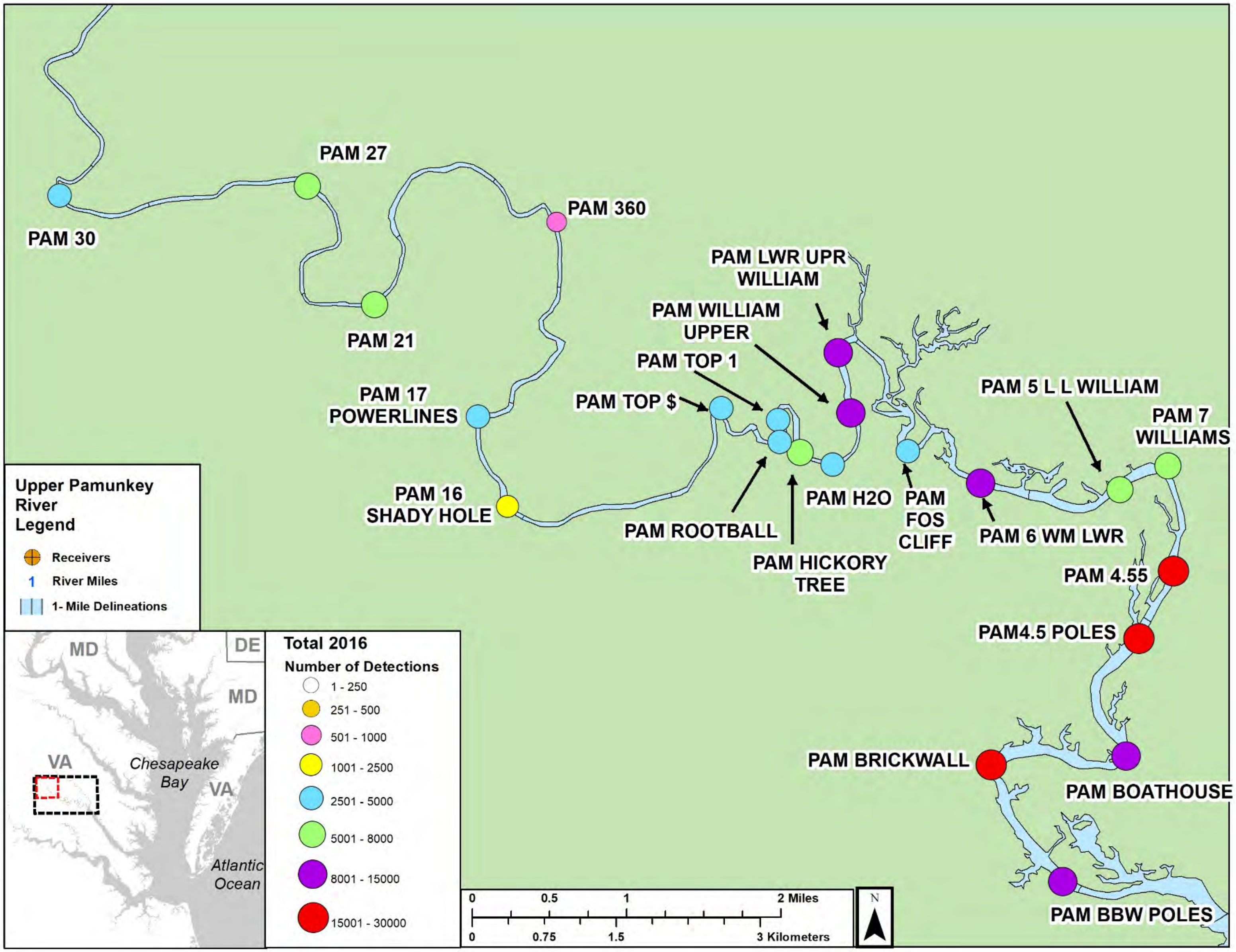
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PAM4.5 POLES
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PAM BOATHOUSE
PAM BBW POLES
Upper Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
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VA
Chesapeake Bay
VA
Atlantic Ocean
Total 2016
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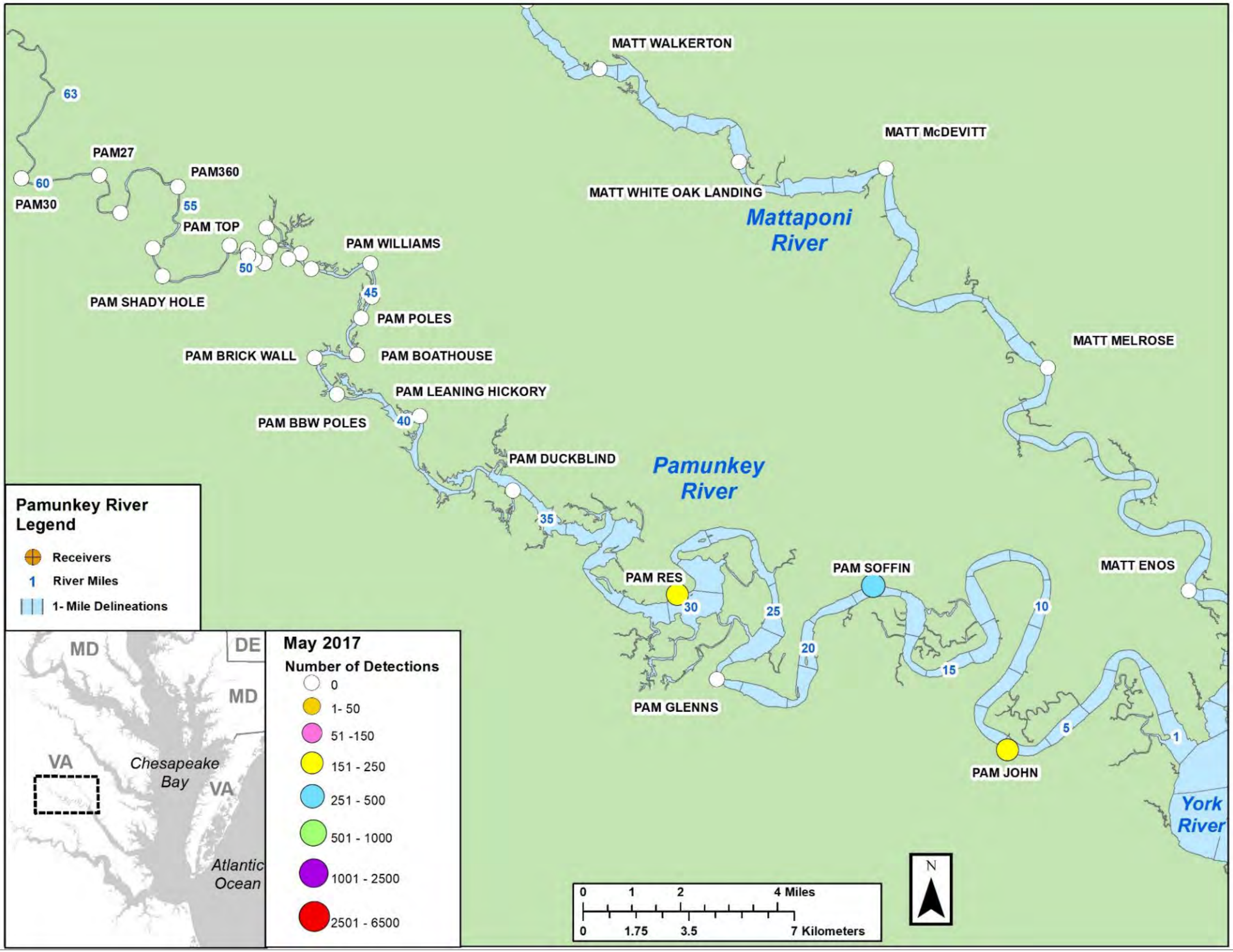
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Mattaponi River
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PAM LEANING HICKORY
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40
PAM DUCKBLIND
Pamunkey River
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PAM RES
30
25
PAM SOFFIN
20
PAM GLENNS
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10
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PAM JOHN
1
York River
Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
MD
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MD
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Chesapeake Bay
VA
Atlantic Ocean
May 2017
Number of Detections
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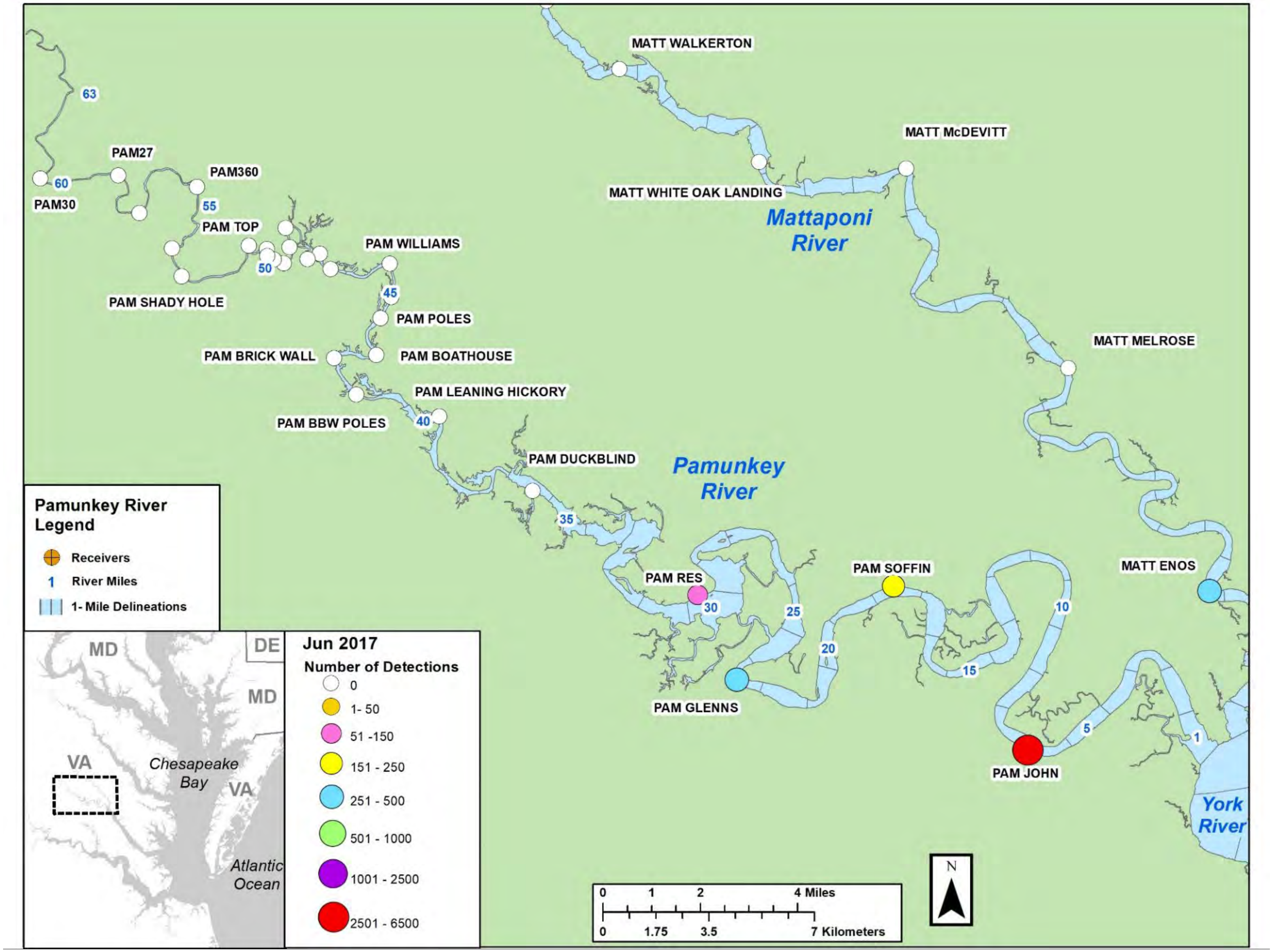
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PAM JOHN
York River
Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
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Chesapeake Bay
VA
Atlantic Ocean
Jun 2017
Number of Detections
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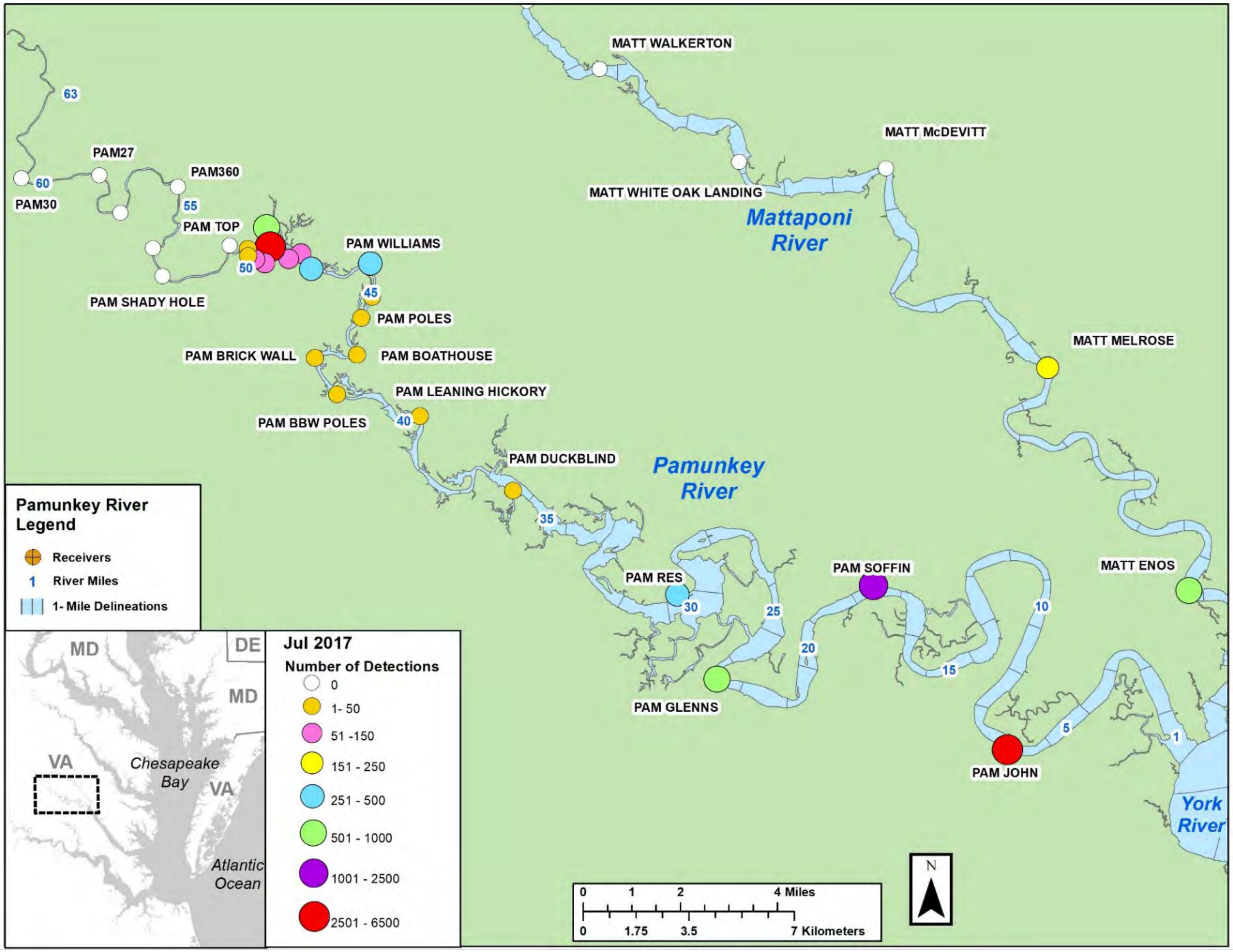

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Mattaponi River
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PAM TOP
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PAM POLES
PAM BRICK WALL
PAM BOATHOUSE
PAM LEANING HICKORY
PAM BBW POLES
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PAM DUCKBLIND
Pamunkey River
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PAM RES
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PAM SOFFIN
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PAM GLENNS
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PAM JOHN
York River
Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
MD
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VA
Chesapeake Bay
VA
Atlantic Ocean
Jul 2017
Number of Detections
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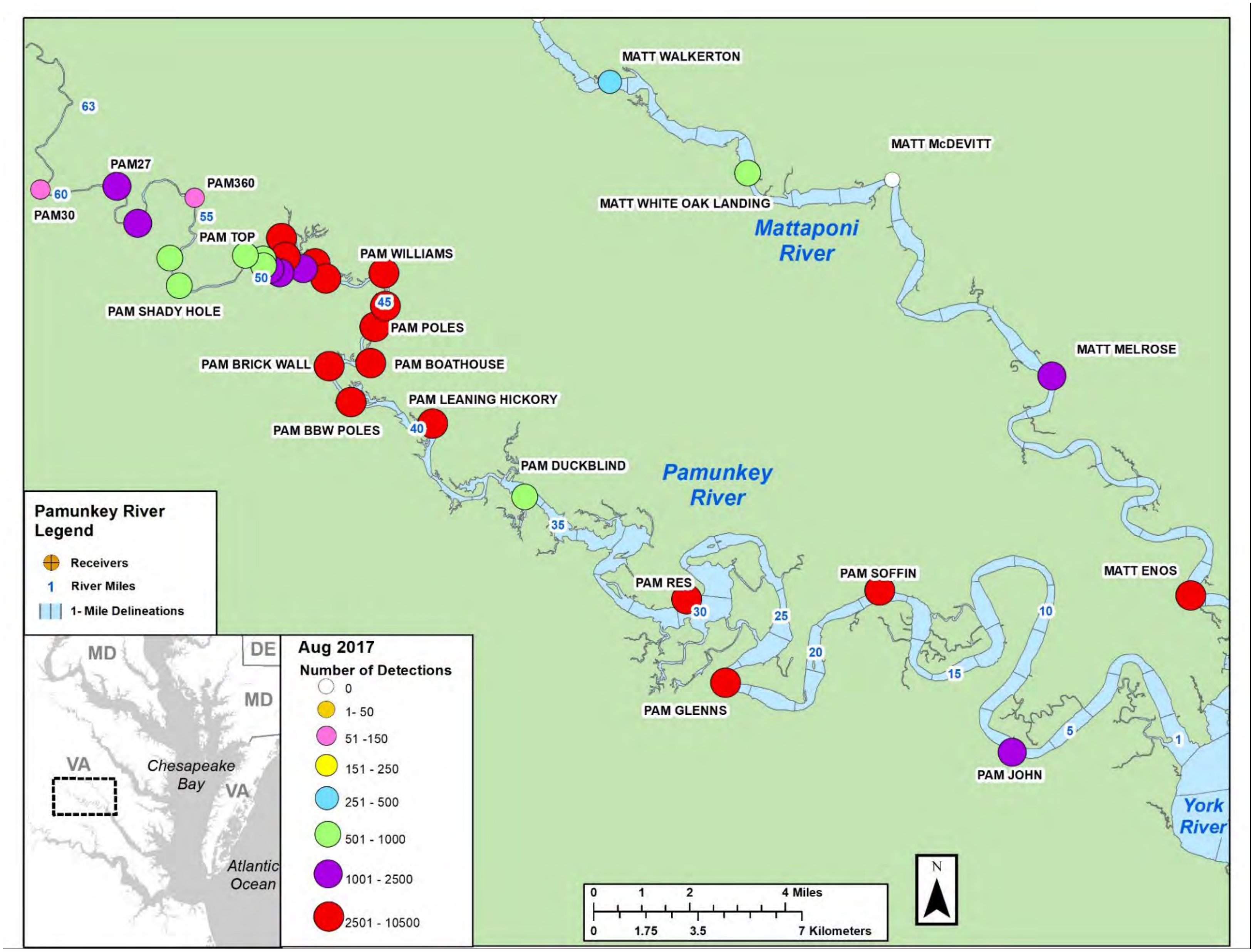
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PAM JOHN
York River
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Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
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Chesapeake Bay
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Atlantic Ocean
Aug 2017
Number of Detections
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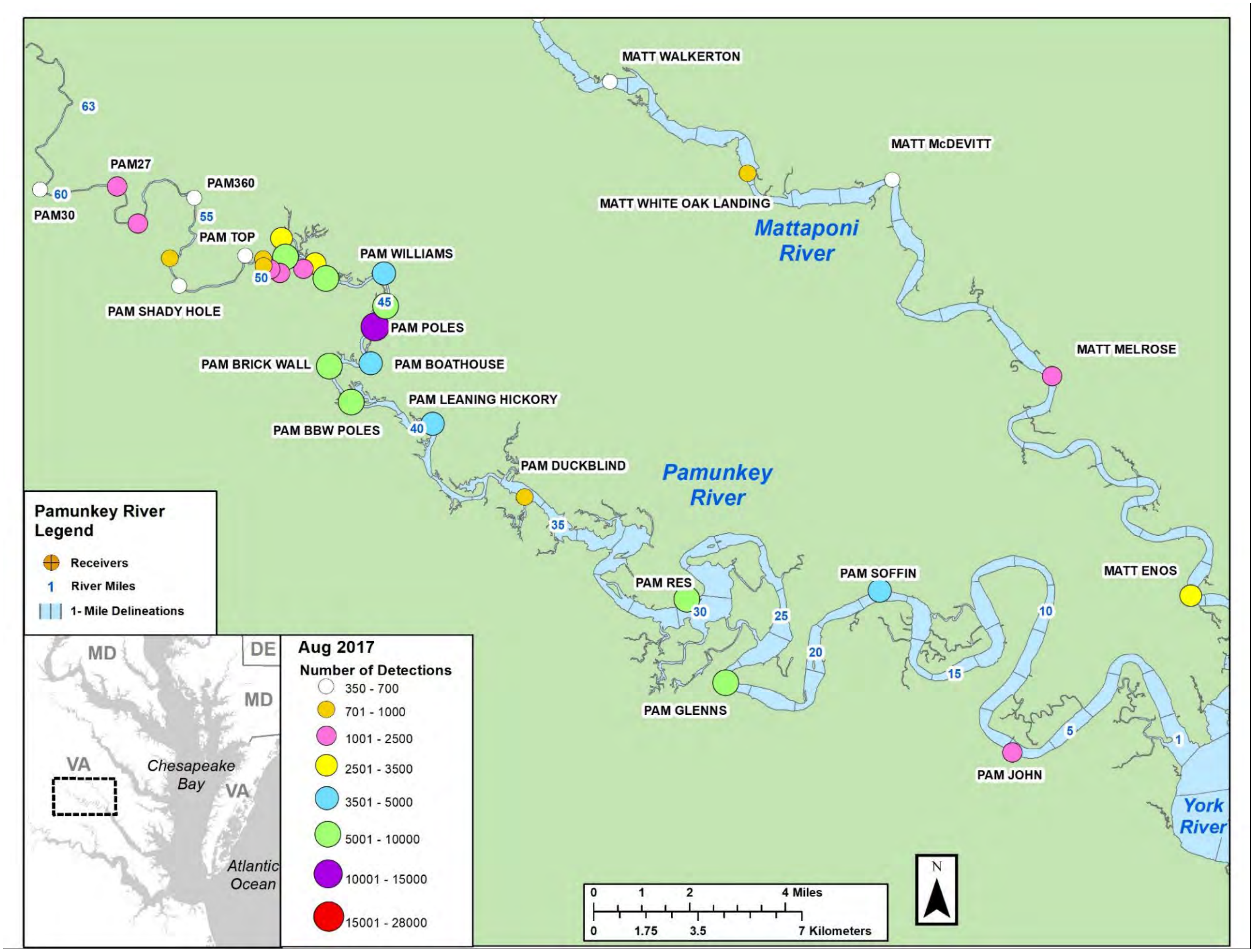
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York River
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Receivers
1 River Miles
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Chesapeake Bay
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Atlantic Ocean
Aug 2017
Number of Detections
350 - 700
701 - 1000
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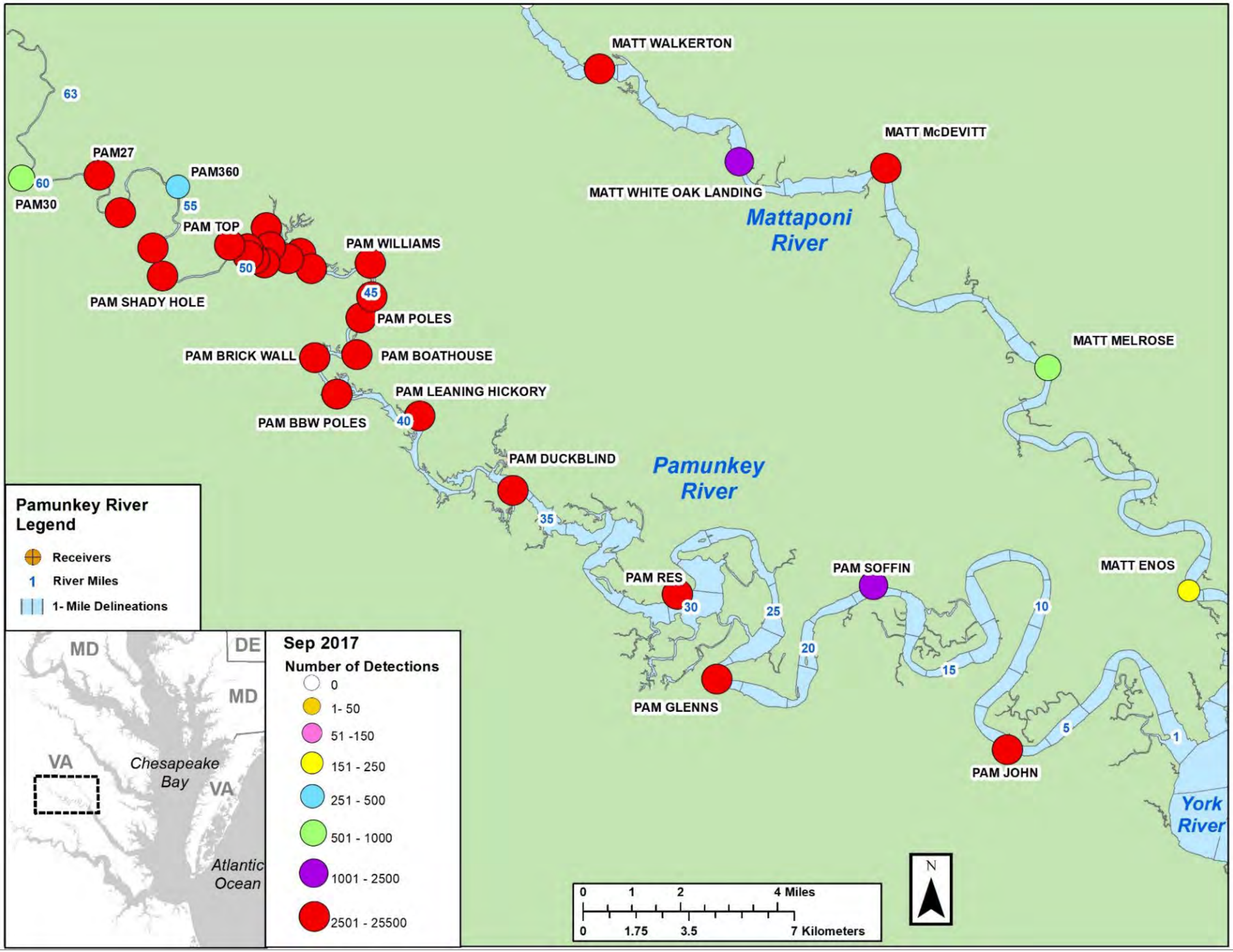
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Pamunkey River Legend
Receivers
1 River Miles
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Atlantic Ocean
Sep 2017
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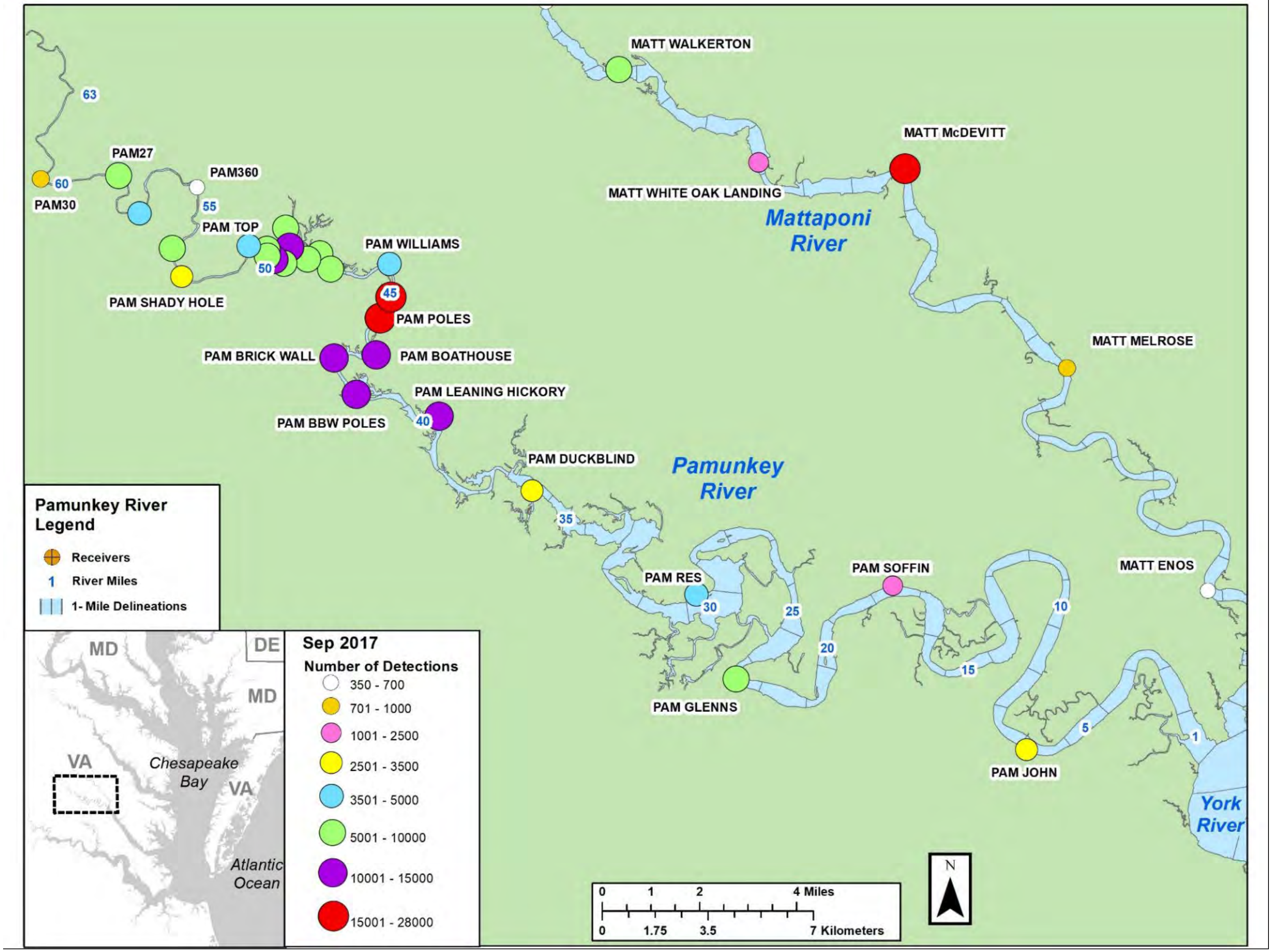
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Sep 2017
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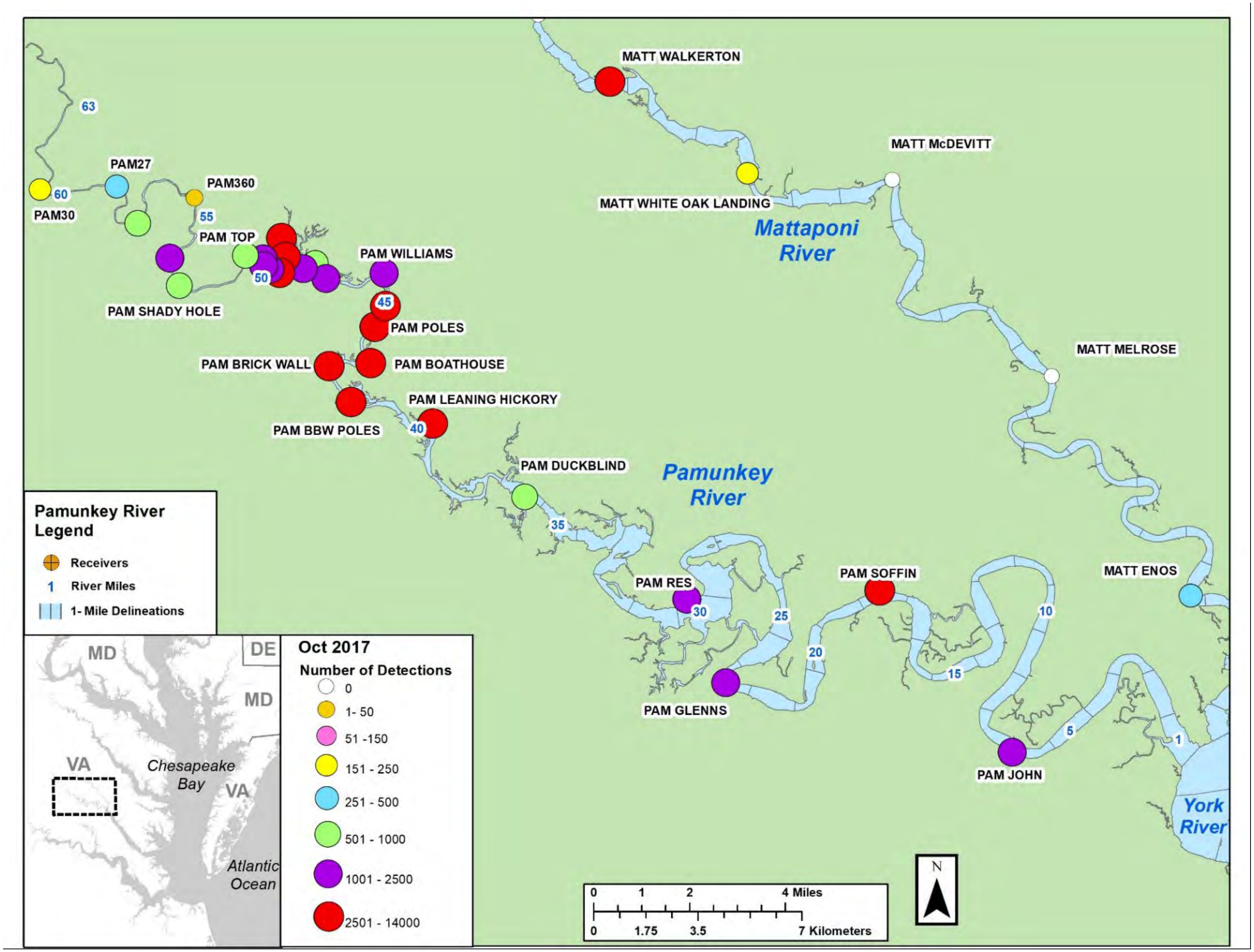
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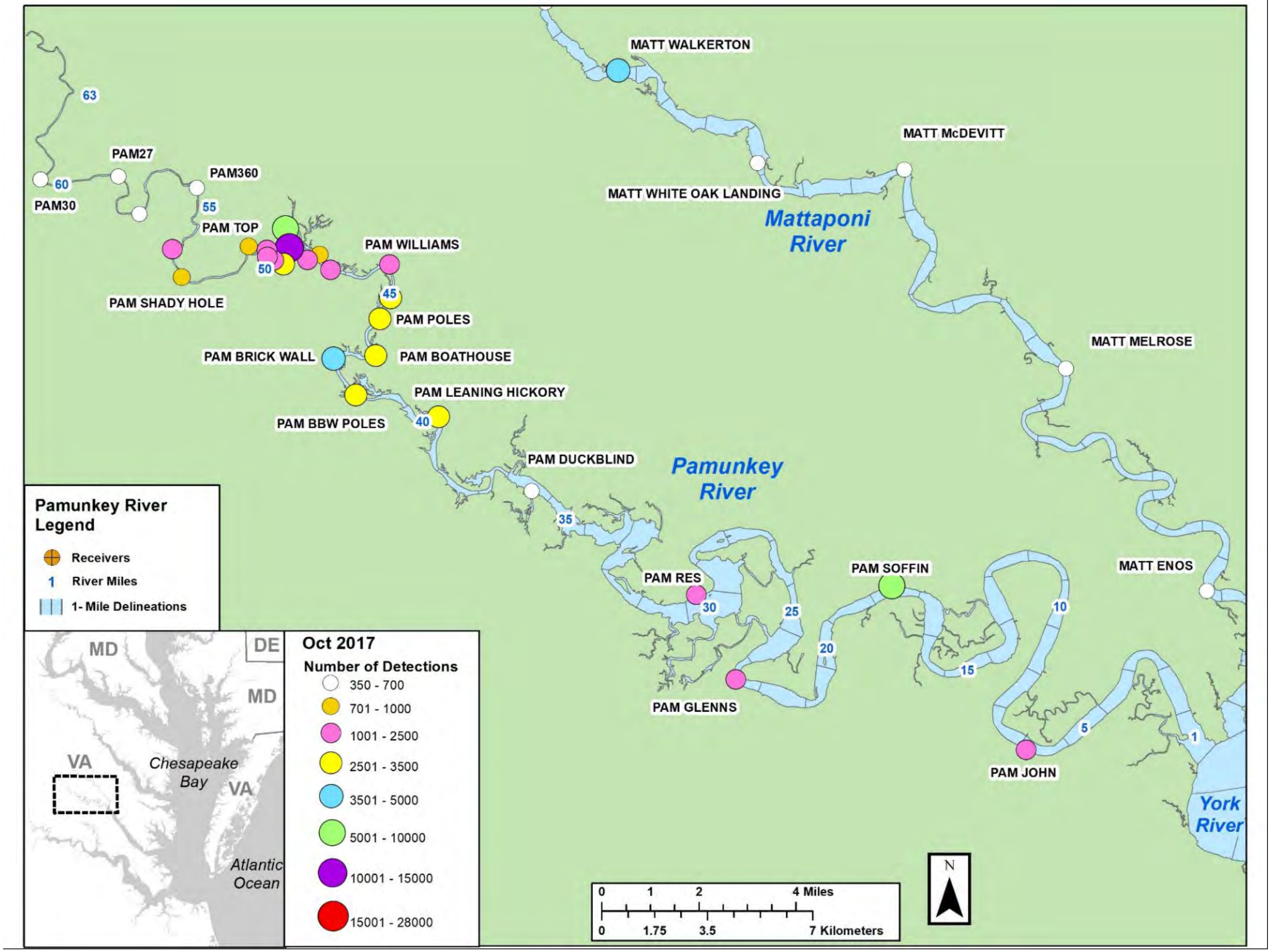
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Oct 2017
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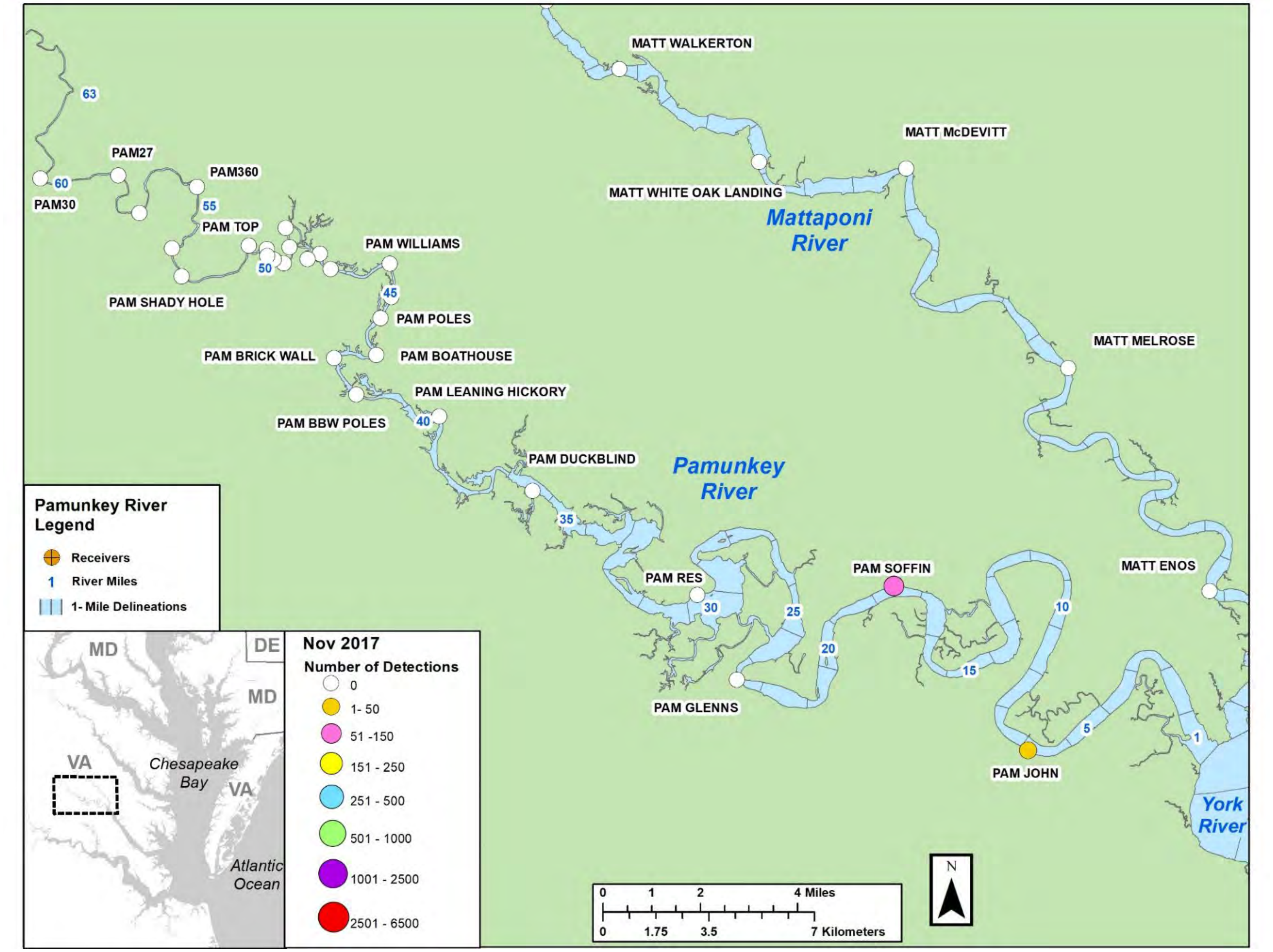
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Atlantic Ocean
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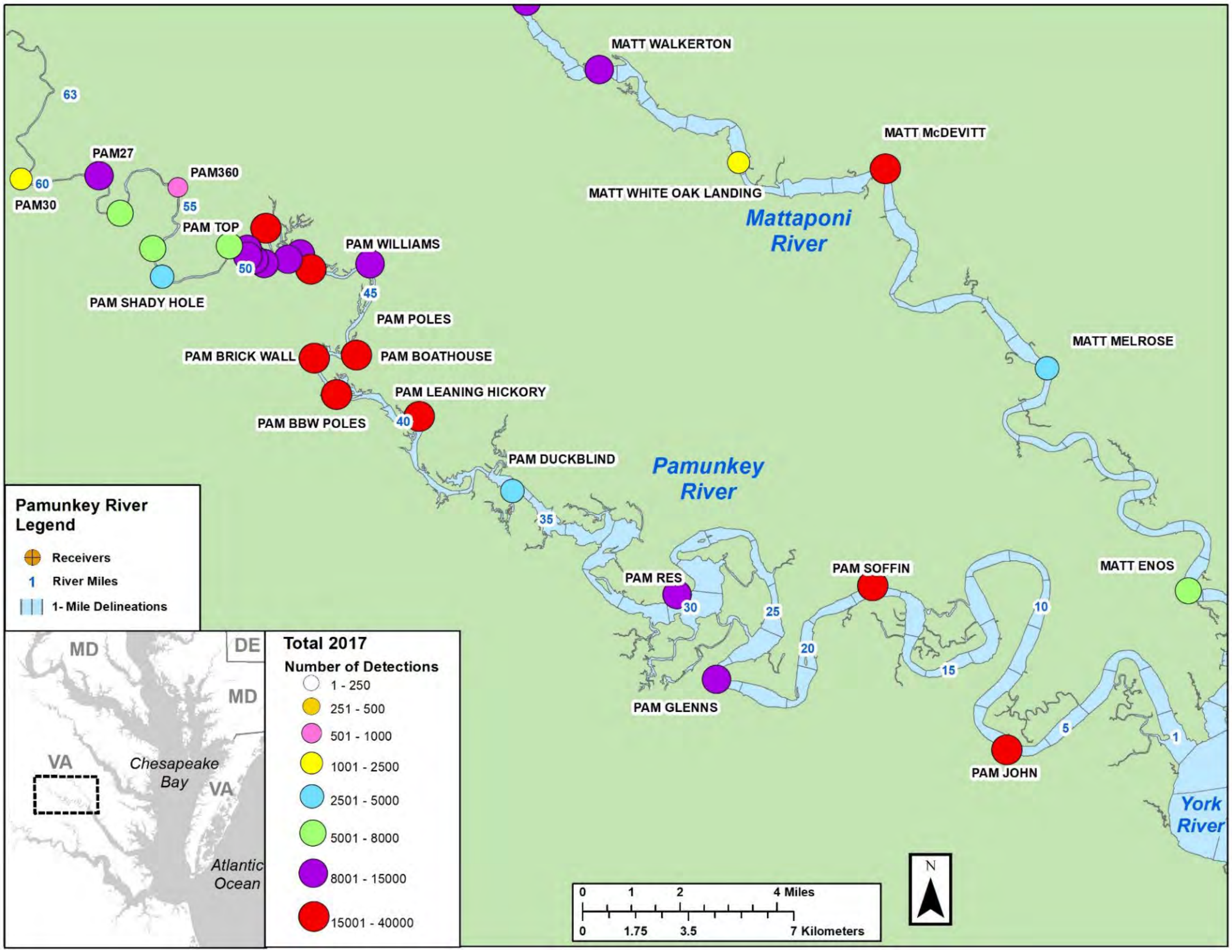
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York River
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Atlantic Ocean
Total 2017
Number of Detections
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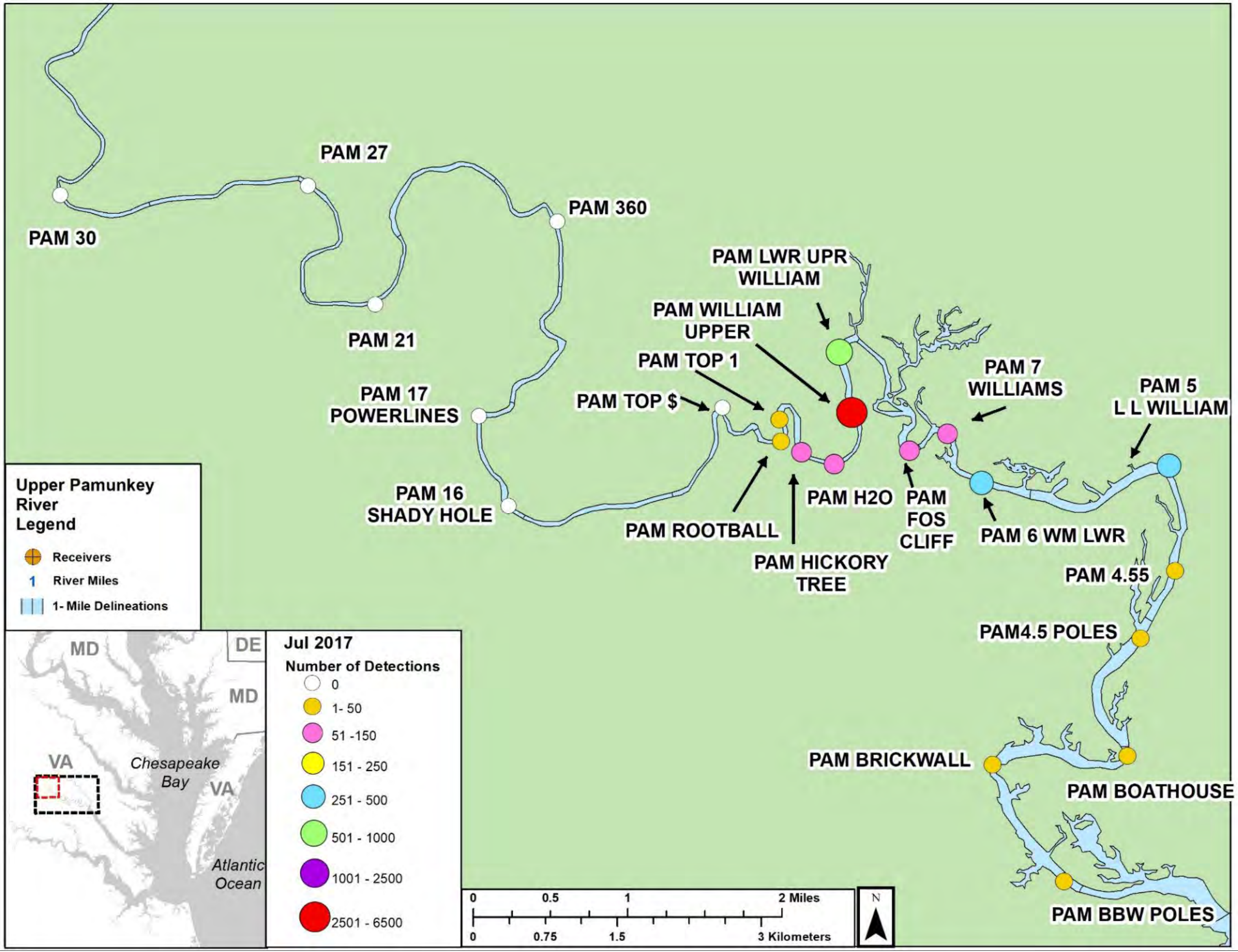
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PAM LWR UPR WILLIAM
PAM ROOTBALL
PAM HICKORY TREE
PAM H2O
PAM FOS CLIFF
PAM 7 WILLIAMS
PAM 6 WM LWR
PAM 5 L L WILLIAM
PAM 4.55
PAM4.5 POLES
PAM BRICKWALL
PAM BOATHOUSE
PAM BBW POLES
Upper Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
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Chesapeake Bay
VA
Atlantic Ocean
Jul 2017
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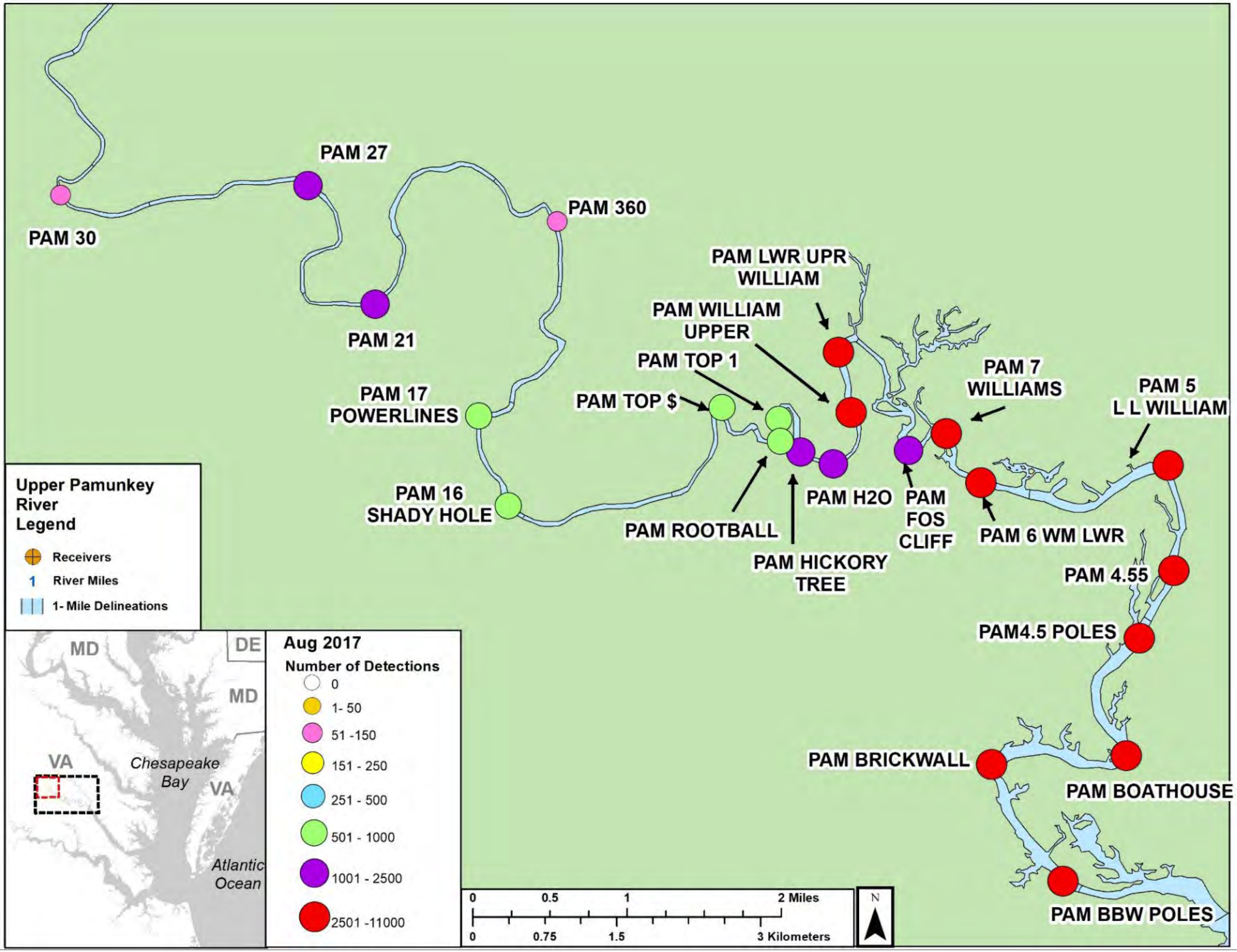
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PAM FOS CLIFF
PAM ROOTBALL
PAM HICKORY TREE
PAM 6 WM LWR
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Upper Pamunkey River Legend
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1- Mile Delineations
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Chesapeake Bay
VA
Atlantic Ocean
Aug 2017
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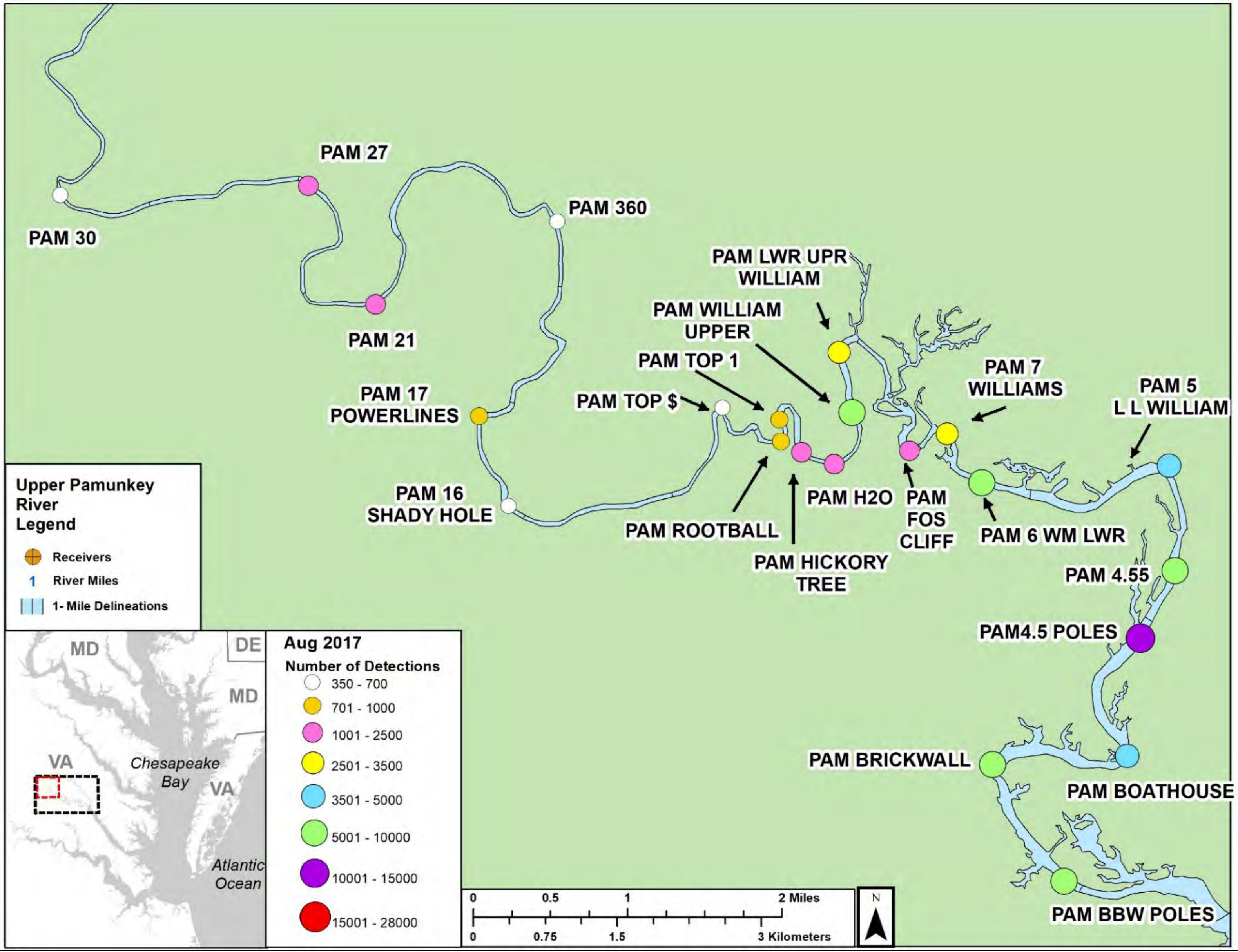
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Upper Pamunkey River Legend
Receivers
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1- Mile Delineations
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Chesapeake Bay
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Atlantic Ocean
Aug 2017
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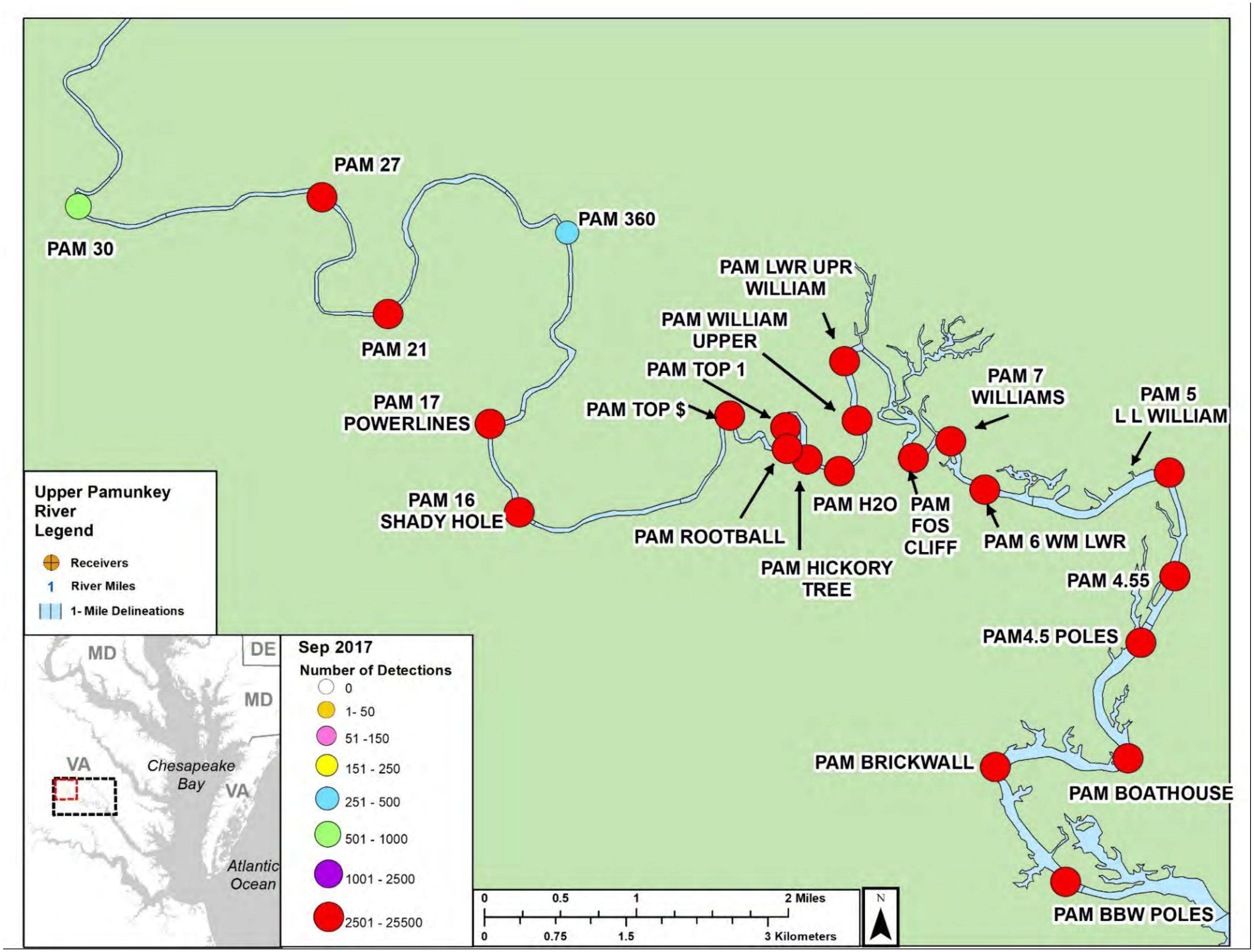
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Upper Pamunkey River Legend
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Atlantic Ocean
Sep 2017
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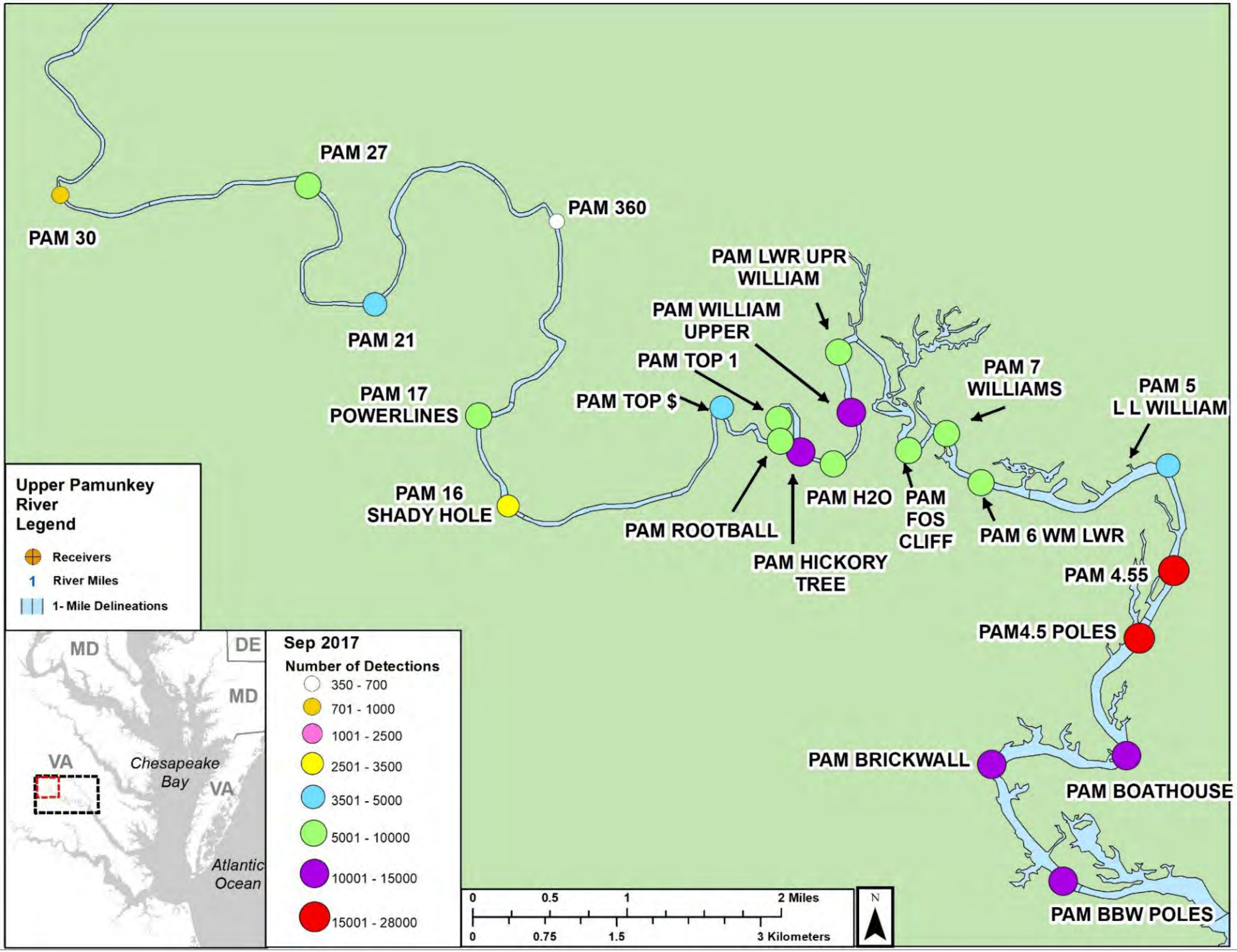
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Upper Pamunkey River Legend
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Atlantic Ocean
Sep 2017
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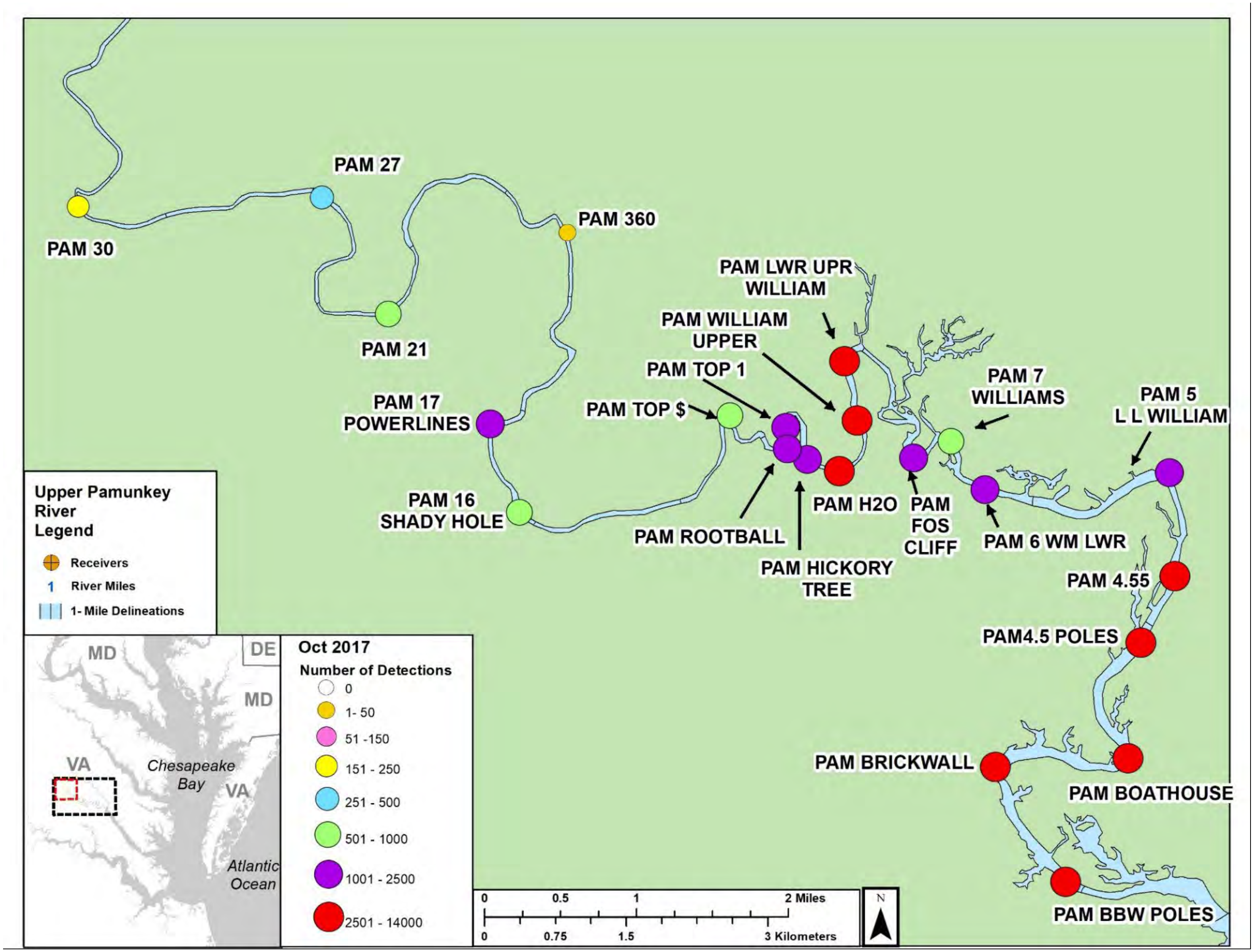
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Atlantic Ocean
Oct 2017
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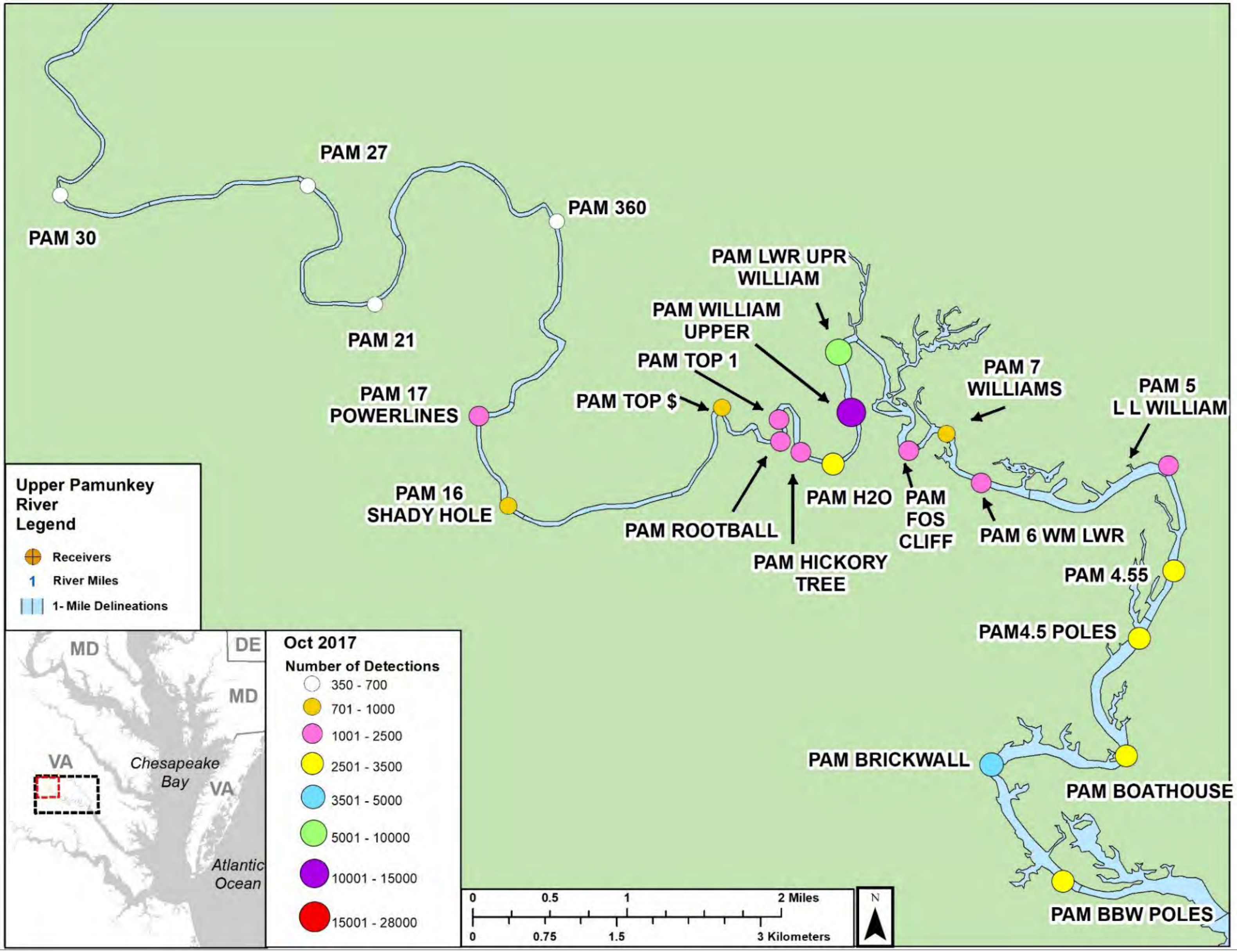
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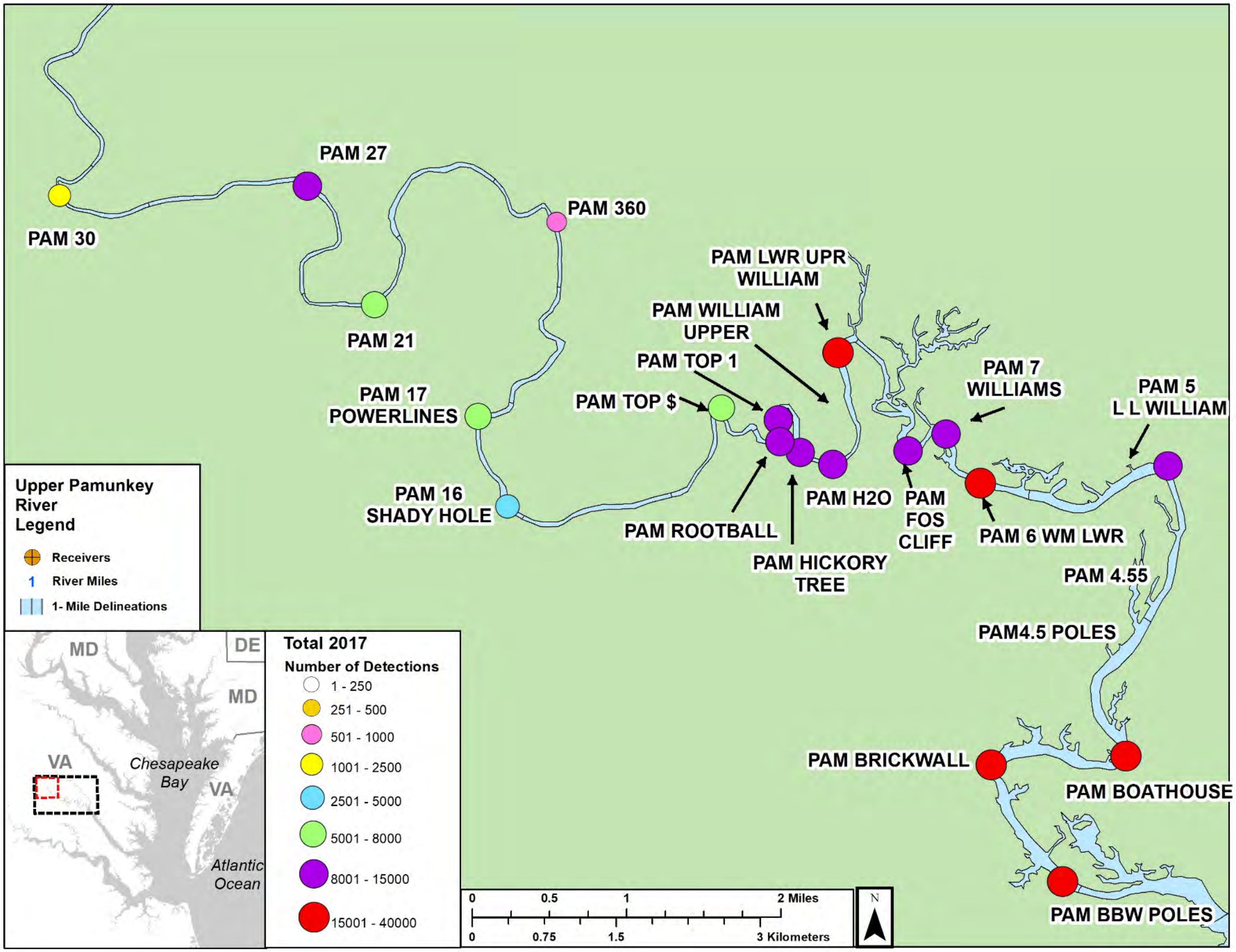
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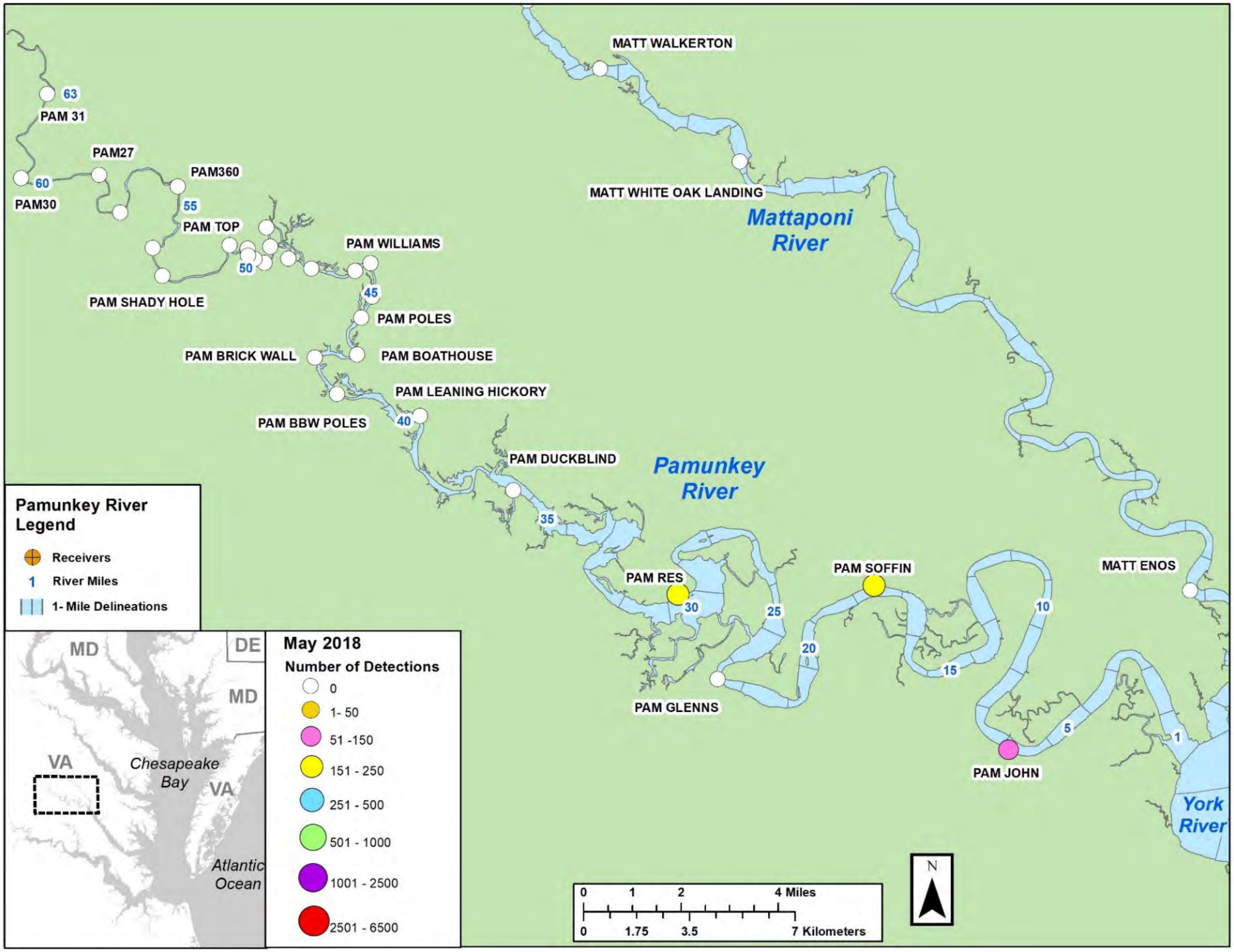
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York River
Pamunkey River Legend
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1 River Miles
1- Mile Delineations
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Chesapeake Bay
VA
Atlantic Ocean
May 2018
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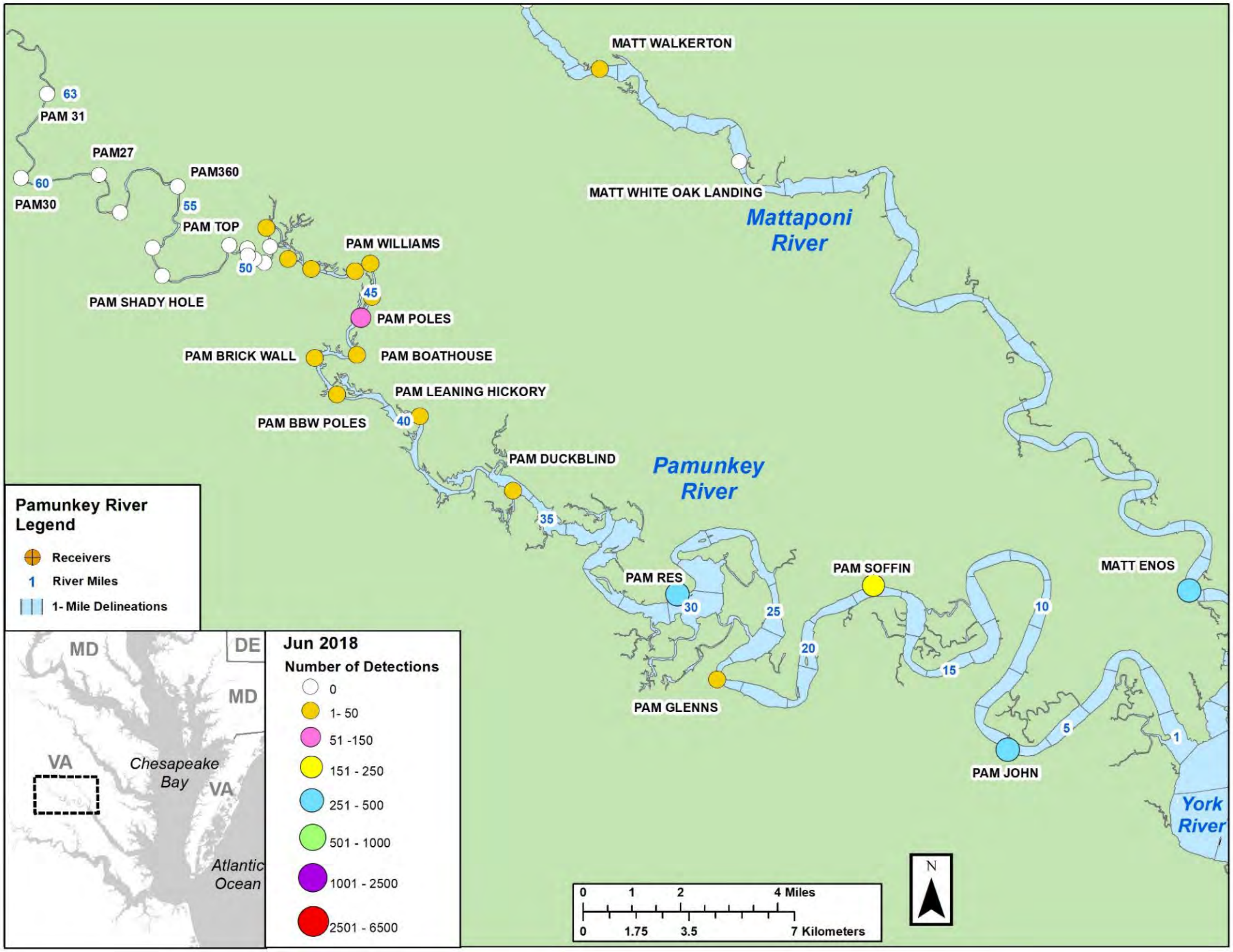
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Mattaponi River
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Atlantic Ocean
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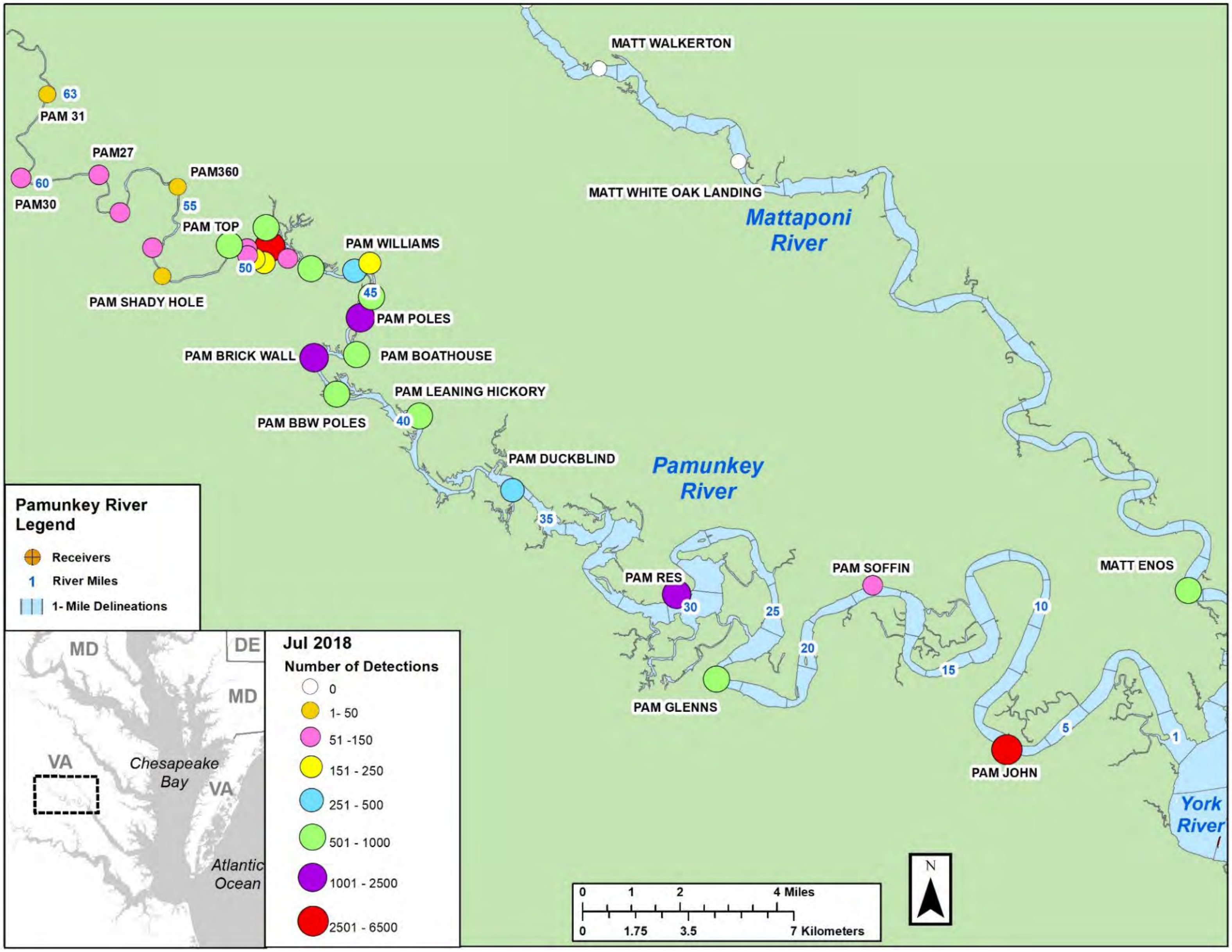
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Mattaponi River
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PAM SHADY HOLE
45
PAM POLES
PAM BRICK WALL
PAM BOATHOUSE
PAM LEANING HICKORY
PAM BBW POLES
40
PAM DUCKBLIND
Pamunkey River
35
PAM RES
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20
PAM SOFFIN
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15
MATT ENOS
PAM GLENNS
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1
PAM JOHN
York River
Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Jul 2018
Number of Detections
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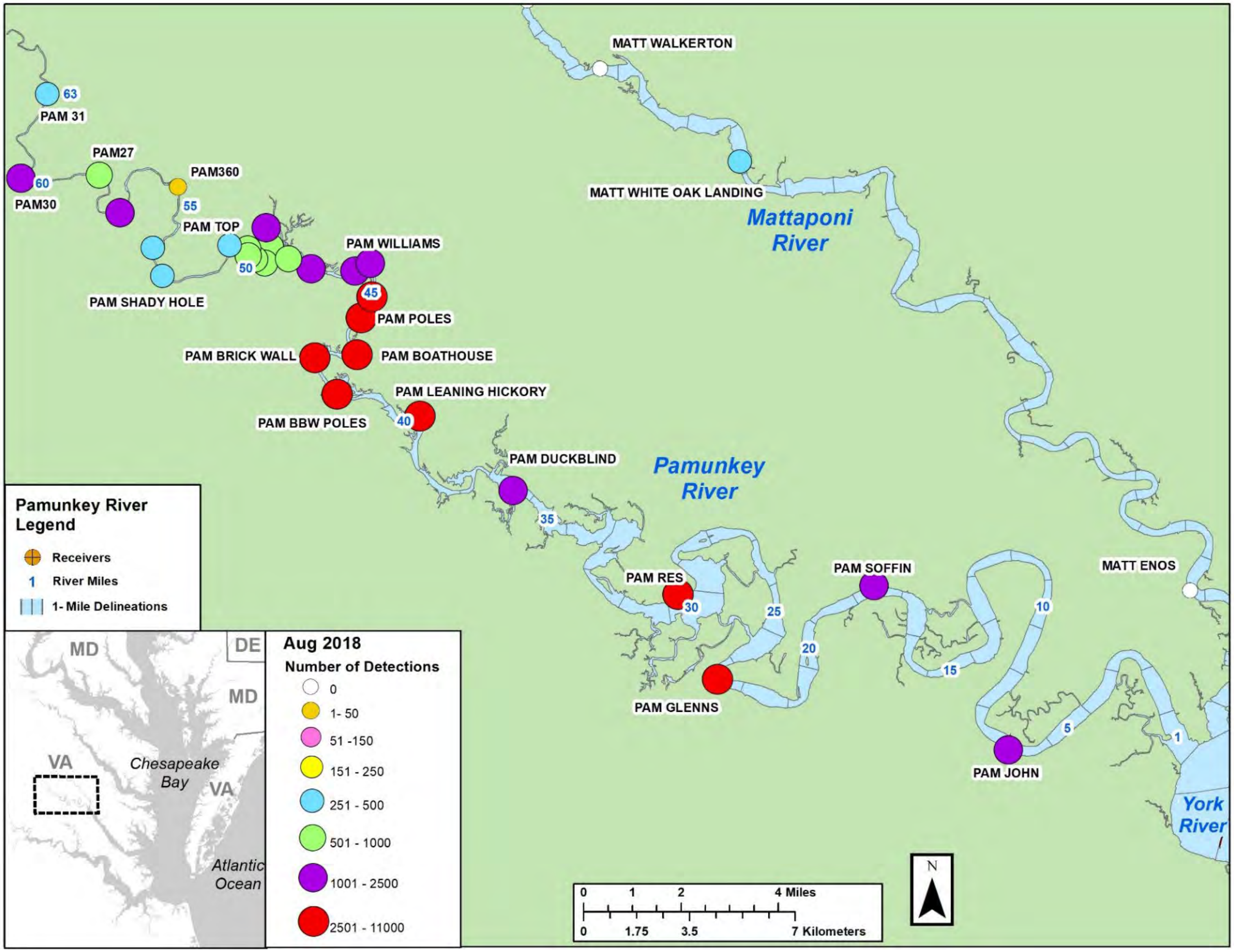
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PAM WILLIAMS
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PAM BRICK WALL
PAM BOATHOUSE
PAM LEANING HICKORY
PAM BBW POLES
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Pamunkey River
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PAM RES
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PAM SOFFIN
MATT ENOS
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York River
Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
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Chesapeake Bay
VA
Atlantic Ocean
Aug 2018
Number of Detections
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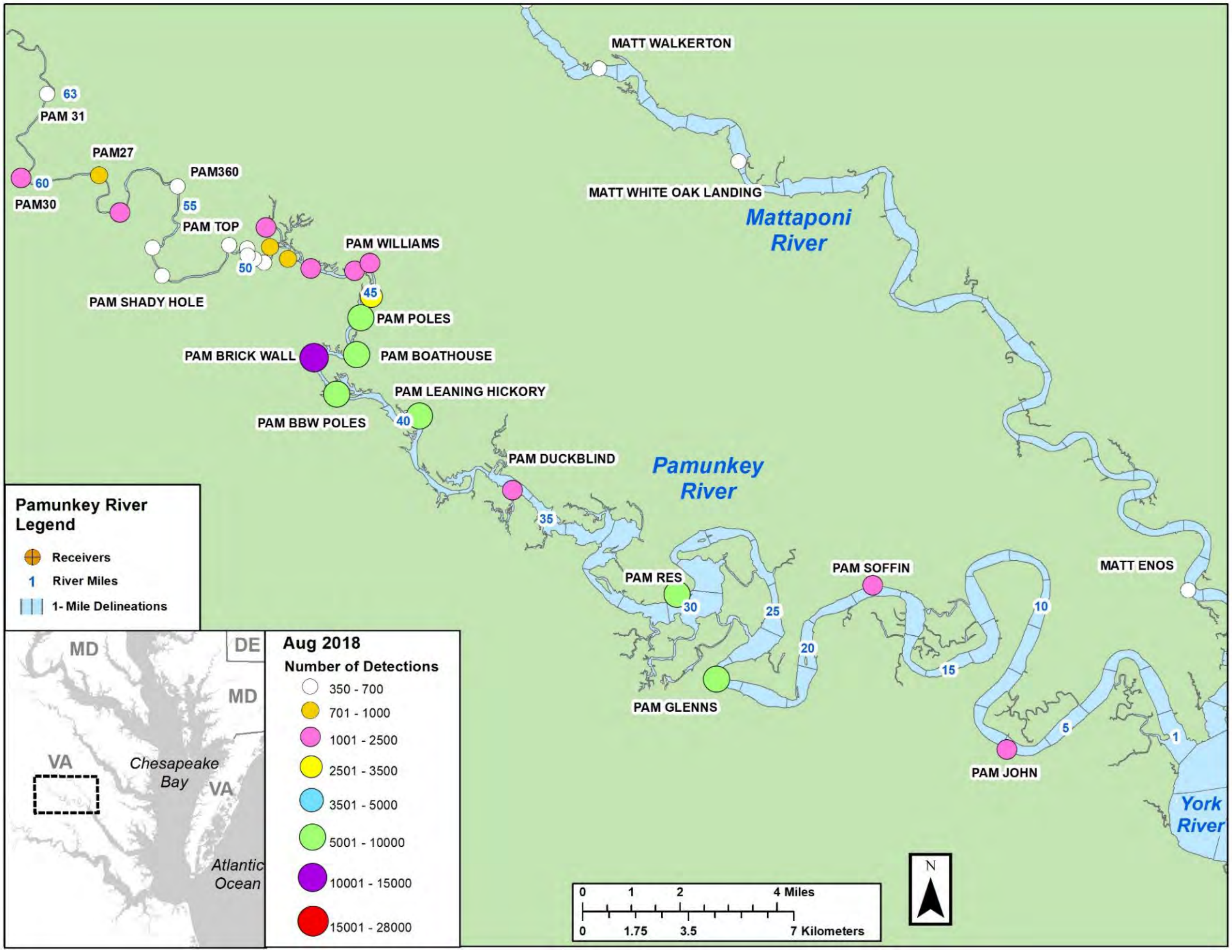
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PAM BOATHOUSE
PAM LEANING HICKORY
PAM BBW POLES
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PAM DUCKBLIND
Pamunkey River
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York River
Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
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Chesapeake Bay
VA
Atlantic Ocean
Aug 2018
Number of Detections
350 - 700
701 - 1000
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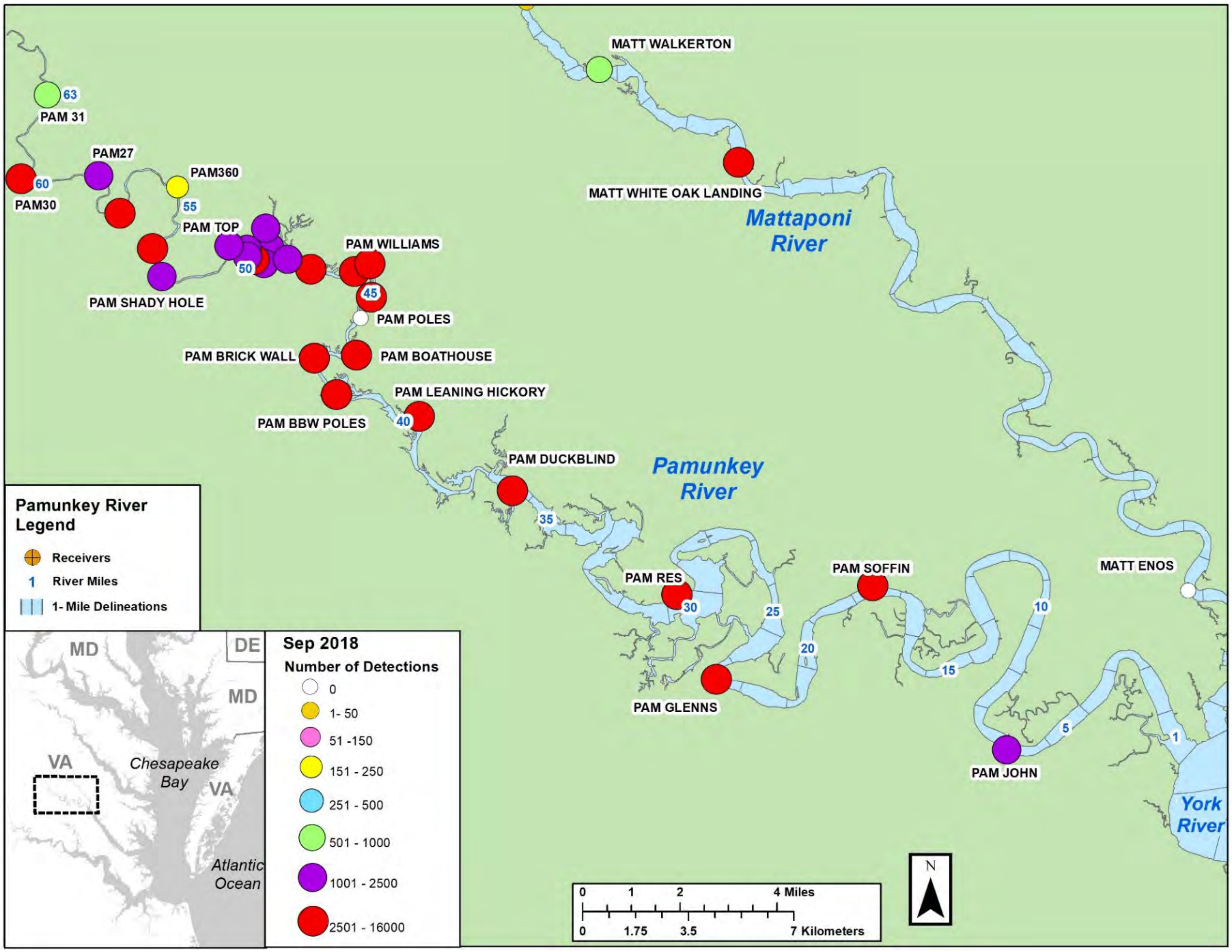
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Receivers
1 River Miles
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Chesapeake Bay
VA
Atlantic Ocean
Sep 2018
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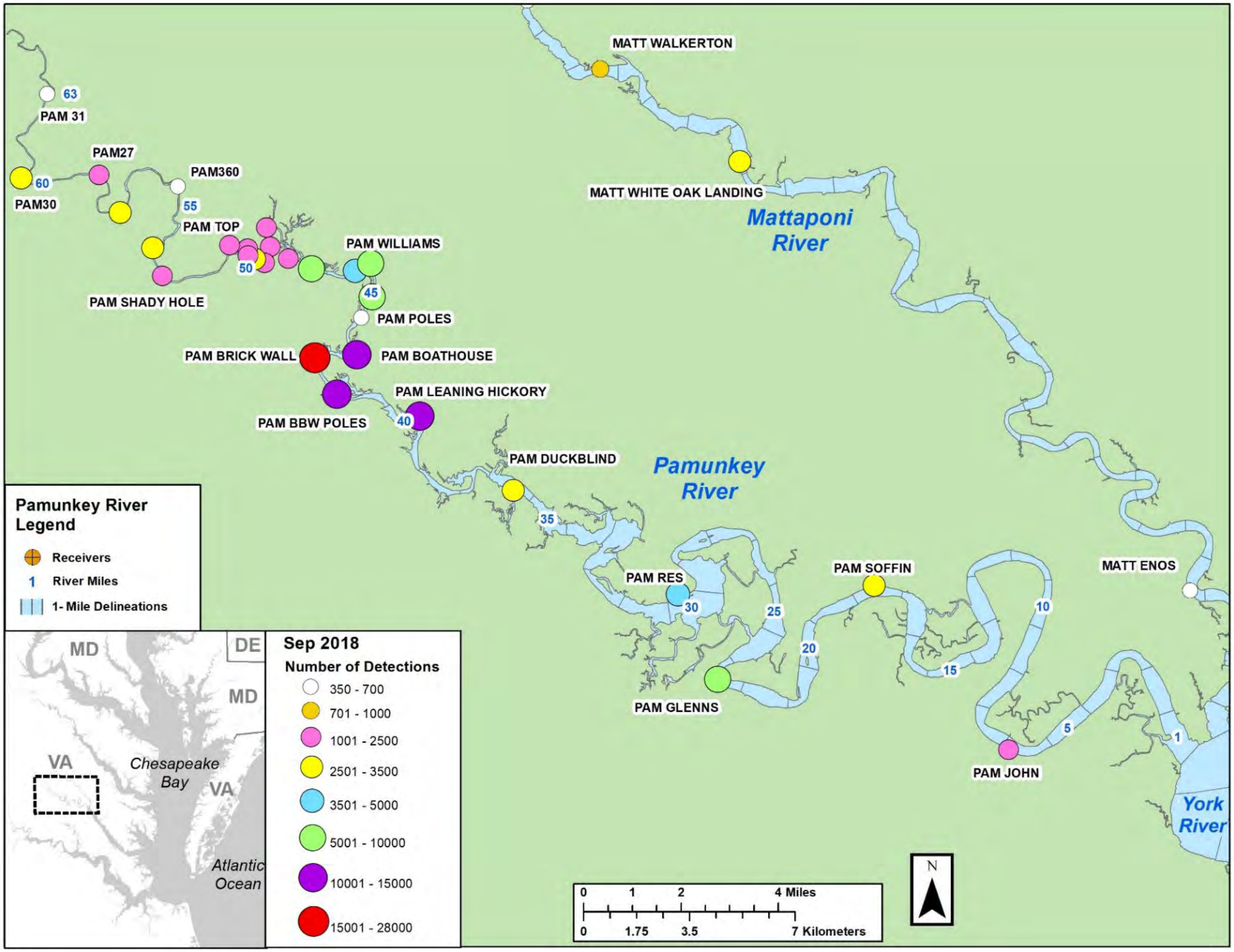
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Mattaponi River
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VA
Atlantic Ocean
Sep 2018
Number of Detections
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701 - 1000
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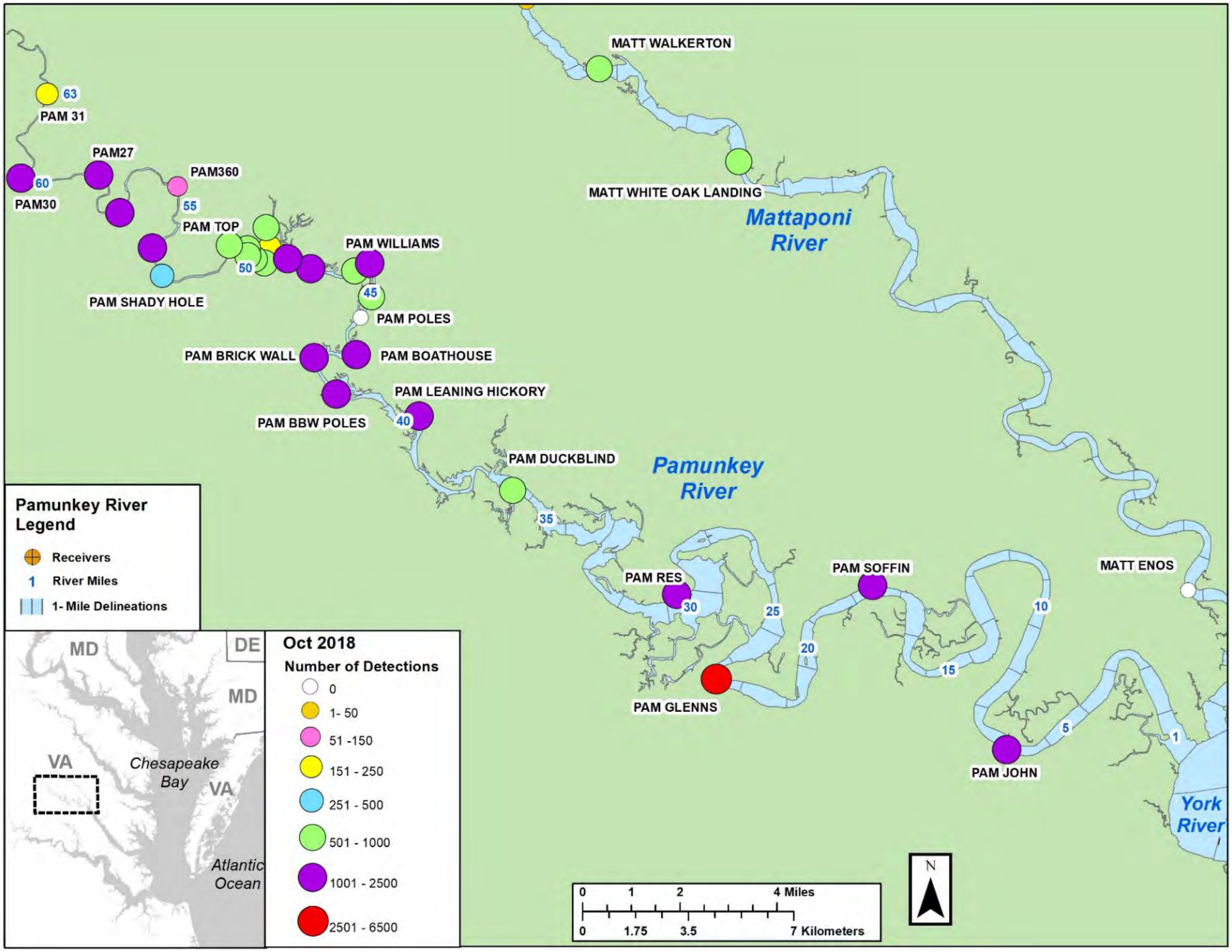
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York River
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VA
Atlantic Ocean
Oct 2018
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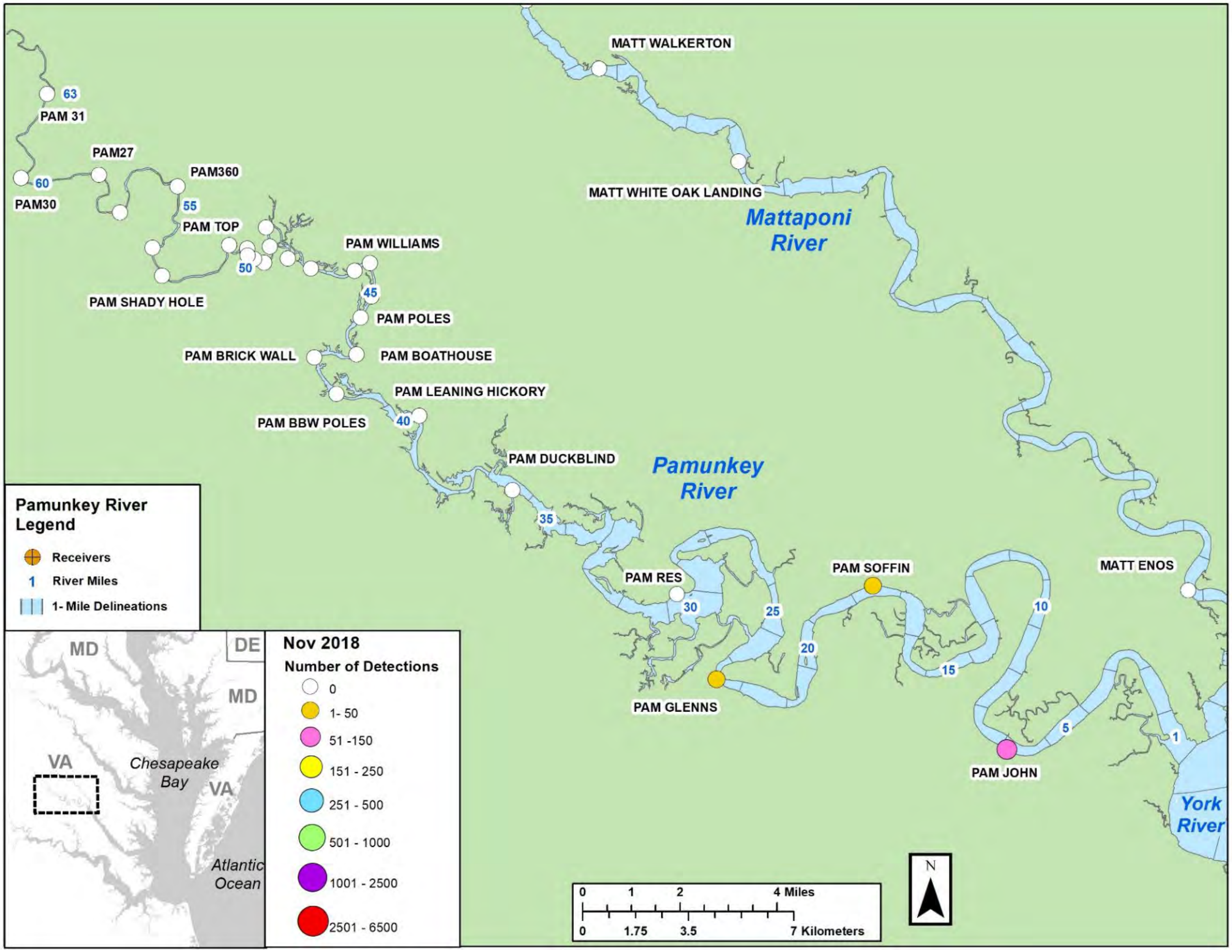
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PAM BBW POLES
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PAM DUCKBLIND
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Mattaponi River
Pamunkey River
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PAM SOFFIN
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York River
Pamunkey River Legend
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1- Mile Delineations
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Chesapeake Bay
VA
Atlantic Ocean
Nov 2018
Number of Detections
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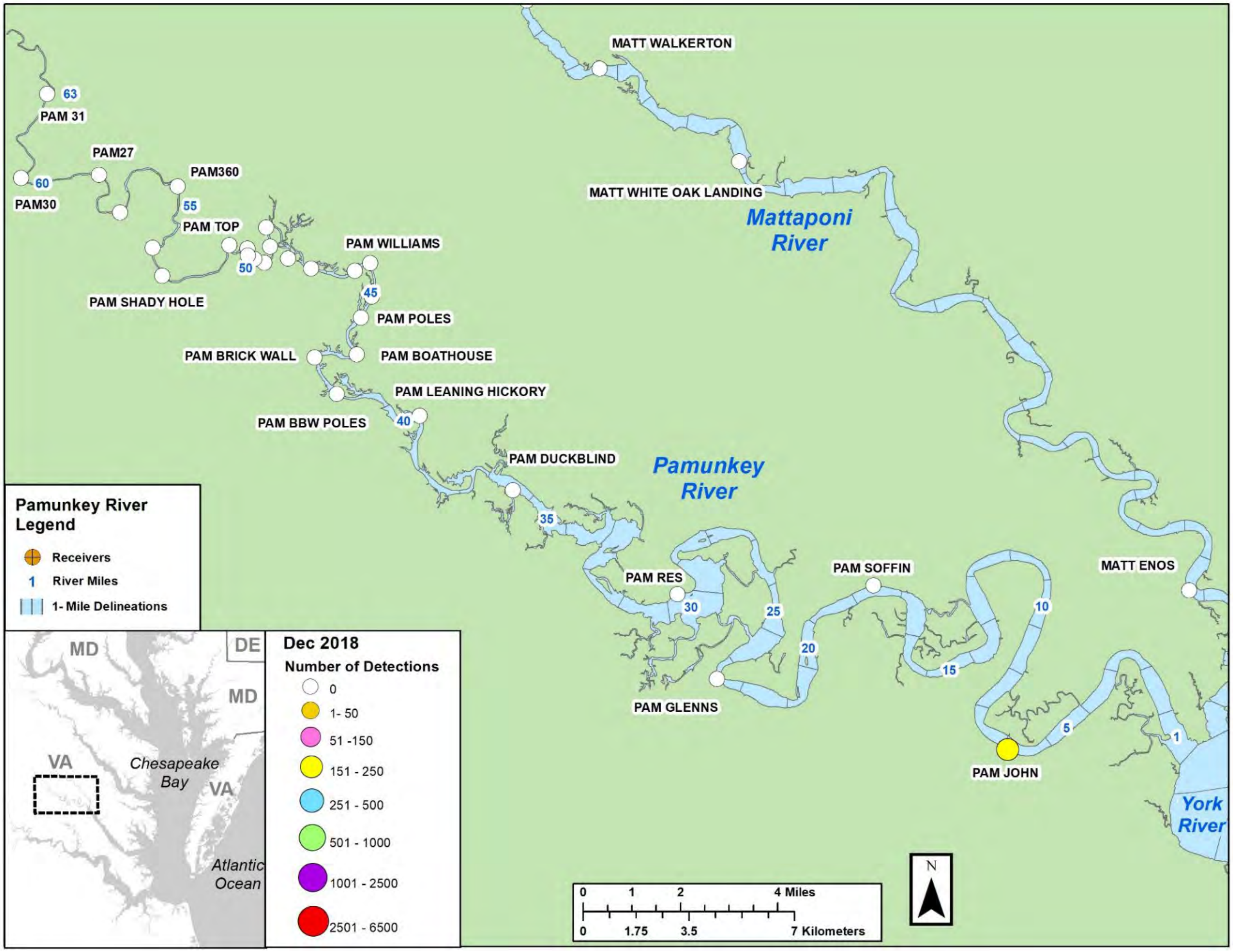
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York River
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1- Mile Delineations
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VA
Chesapeake Bay
VA
Atlantic Ocean
Dec 2018
Number of Detections
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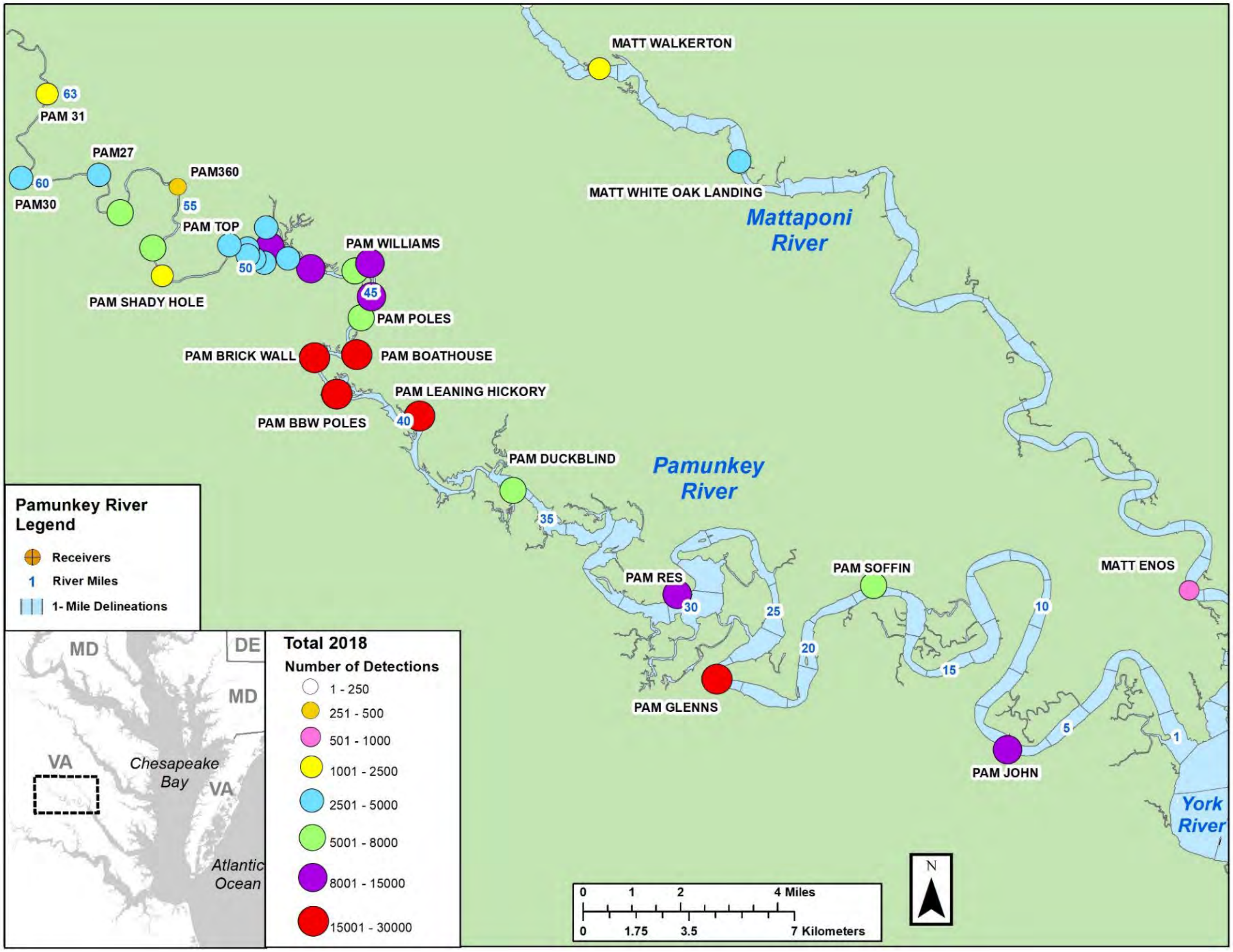
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Mattaponi River
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PAM BBW POLES
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PAM DUCKBLIND
Pamunkey River
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PAM RES
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PAM SOFFIN
MATT ENOS
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PAM GLENNS
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PAM JOHN
York River
Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
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VA
Chesapeake Bay
VA
Atlantic Ocean
Total 2018
Number of Detections
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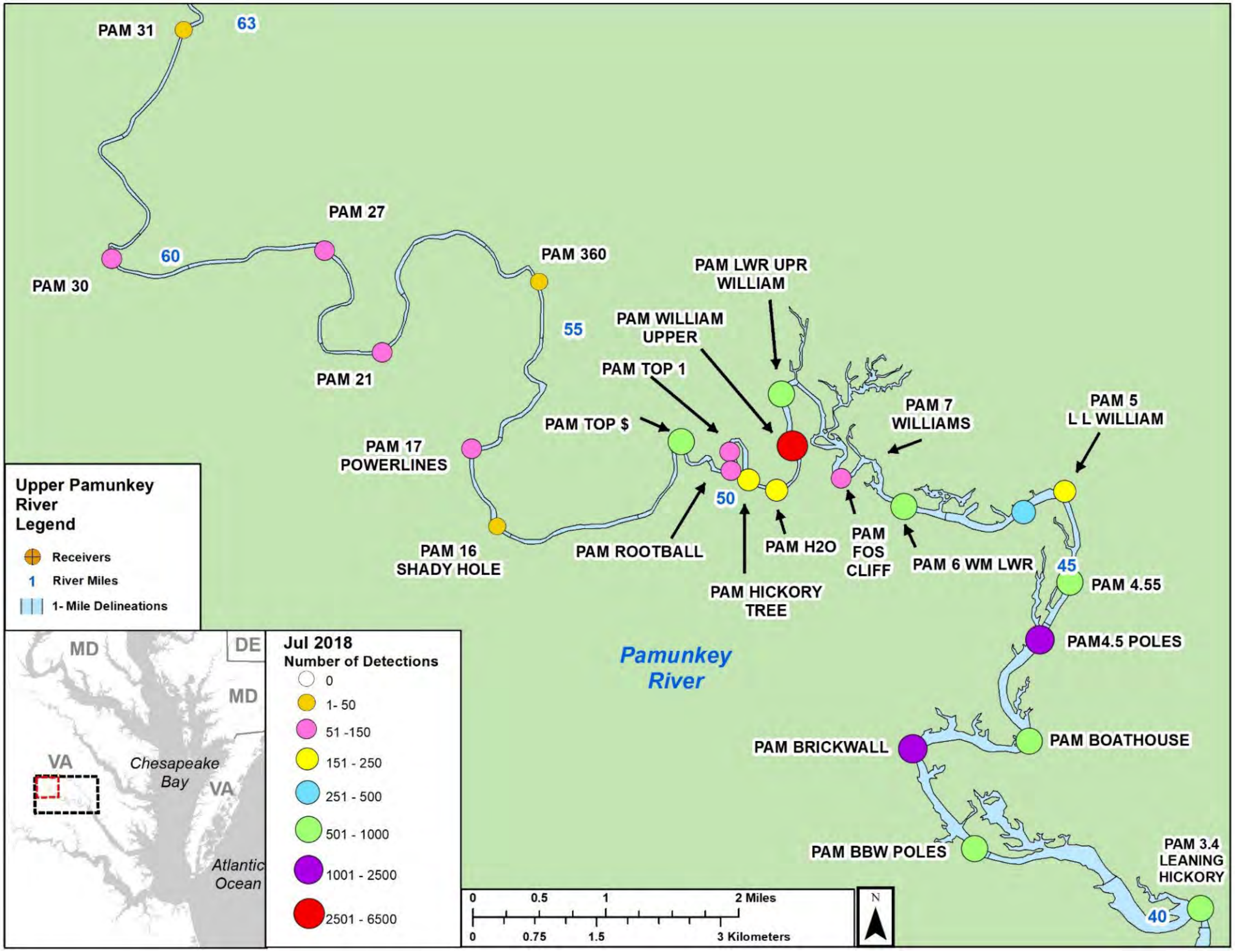
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PAM 21
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PAM TOP $
PAM 7 WILLIAMS
PAM 5 L L WILLIAM
PAM 17 POWERLINES
50
PAM 16 SHADY HOLE
PAM ROOTBALL
PAM H2O
PAM FOS CLIFF
PAM 6 WM LWR
45
PAM 4.55
PAM HICKORY TREE
PAM4.5 POLES
Pamunkey River
PAM BOATHOUSE
PAM BRICKWALL
PAM BBW POLES
PAM 3.4 LEANING HICKORY
40
Upper Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Jul 2018
Number of Detections
0
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1001 - 2500
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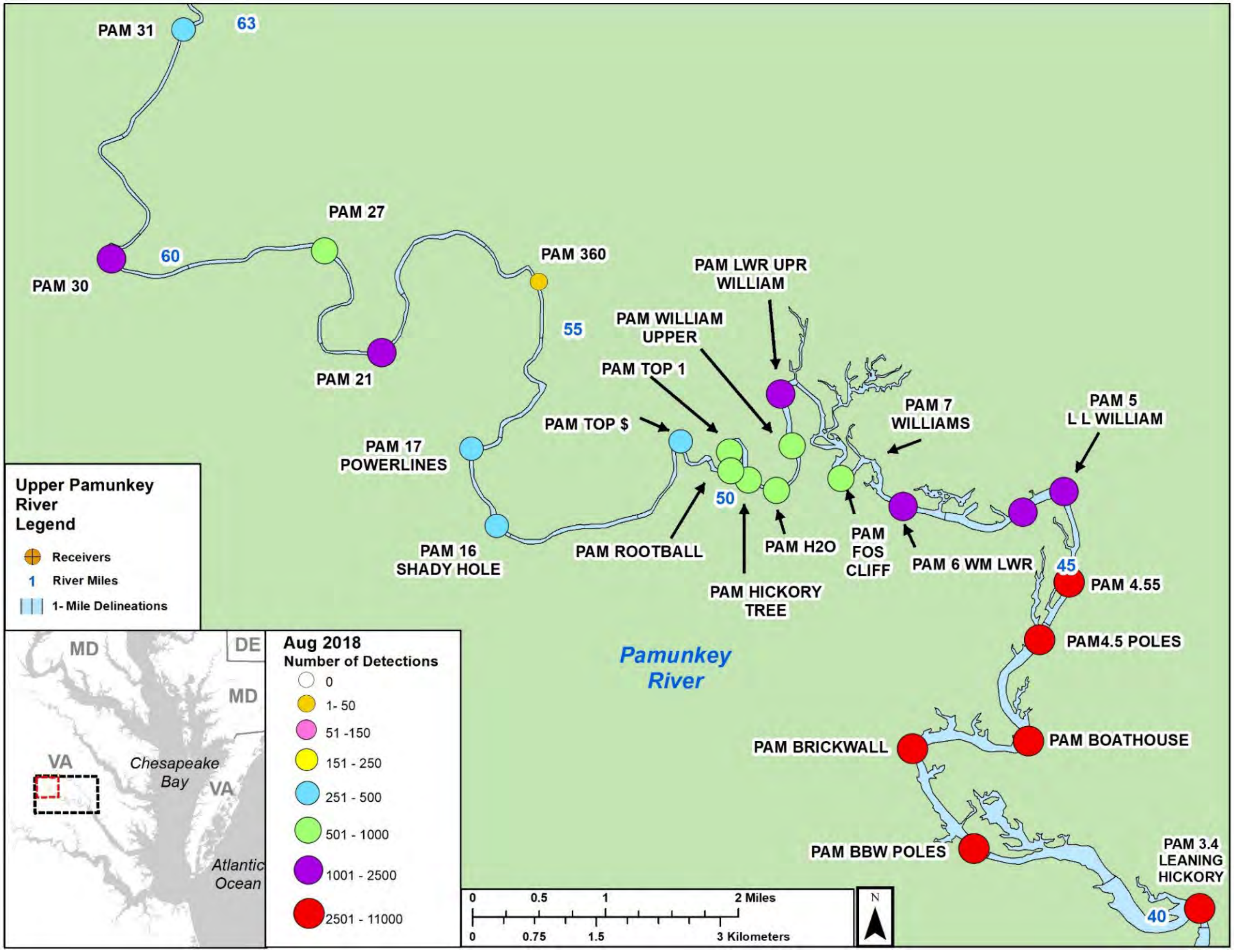
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PAM 17 POWERLINES
PAM 16 SHADY HOLE
PAM ROOTBALL
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PAM HICKORY TREE
PAM H2O
PAM FOS CLIFF
PAM 7 WILLIAMS
PAM 6 WM LWR
PAM 5 L L WILLIAM
45
PAM 4.55
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PAM BOATHOUSE
PAM BRICKWALL
PAM BBW POLES
PAM 3.4 LEANING HICKORY
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Pamunkey River
Upper Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
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VA
Chesapeake Bay
VA
Atlantic Ocean
Aug 2018
Number of Detections
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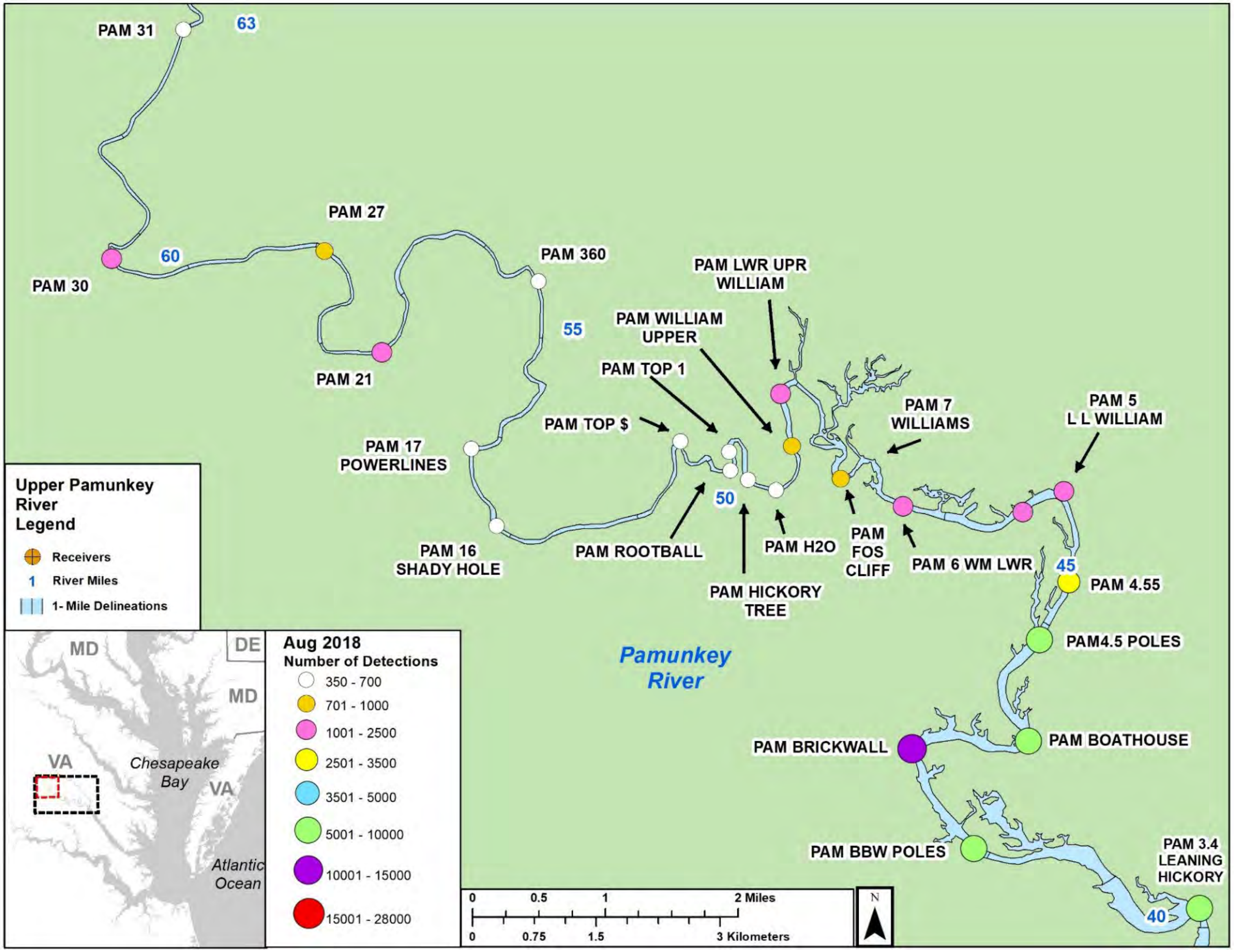
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PAM 17 POWERLINES
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PAM 16 SHADY HOLE
PAM ROOTBALL
PAM H2O
PAM FOS CLIFF
PAM 6 WM LWR
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PAM BBW POLES
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Upper Pamunkey River Legend
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1 River Miles
1- Mile Delineations
MD
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VA
Chesapeake Bay
VA
Atlantic Ocean
Aug 2018
Number of Detections
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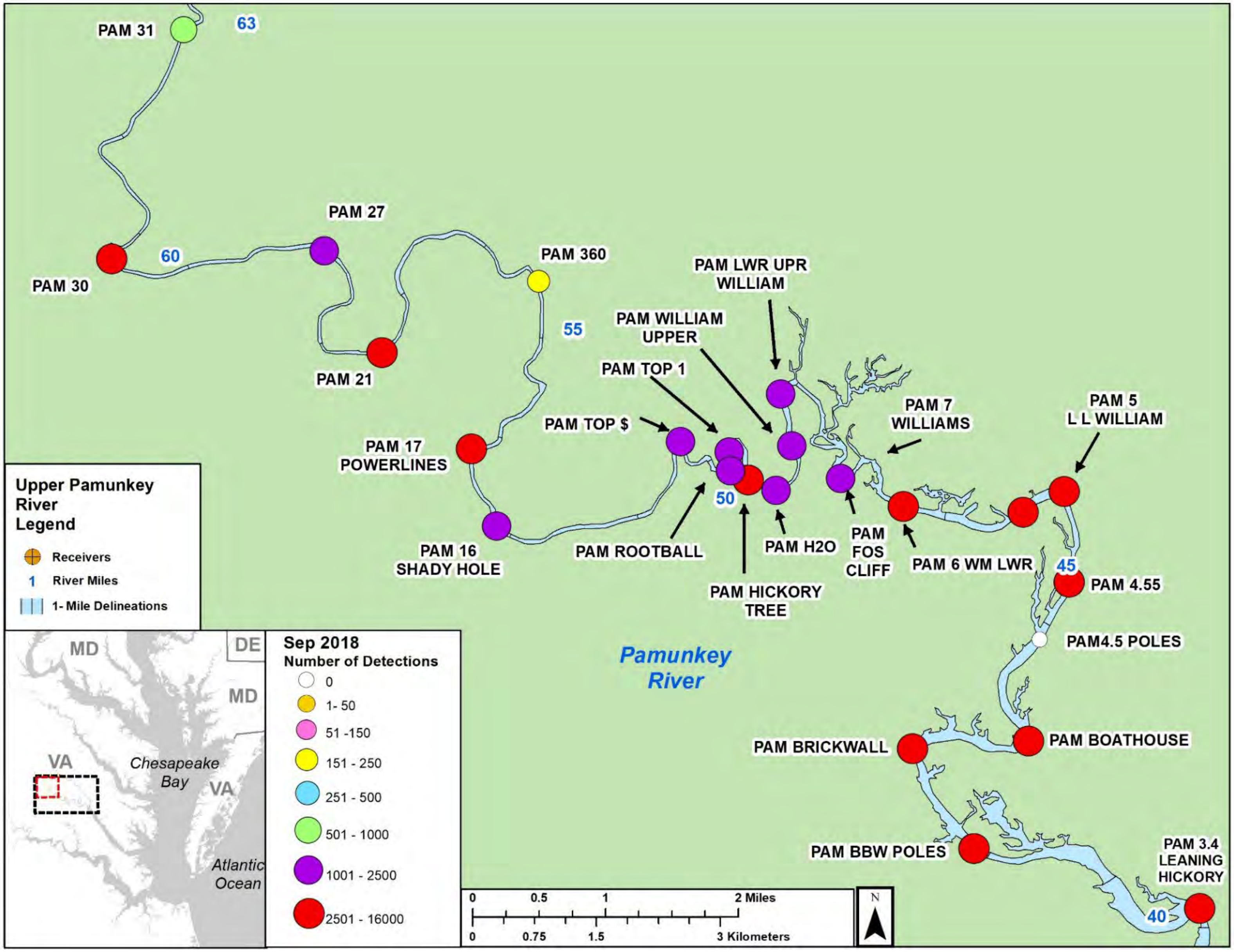
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PAM 5 L L WILLIAM
PAM 17 POWERLINES
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PAM 6 WM LWR
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Upper Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Sep 2018
Number of Detections
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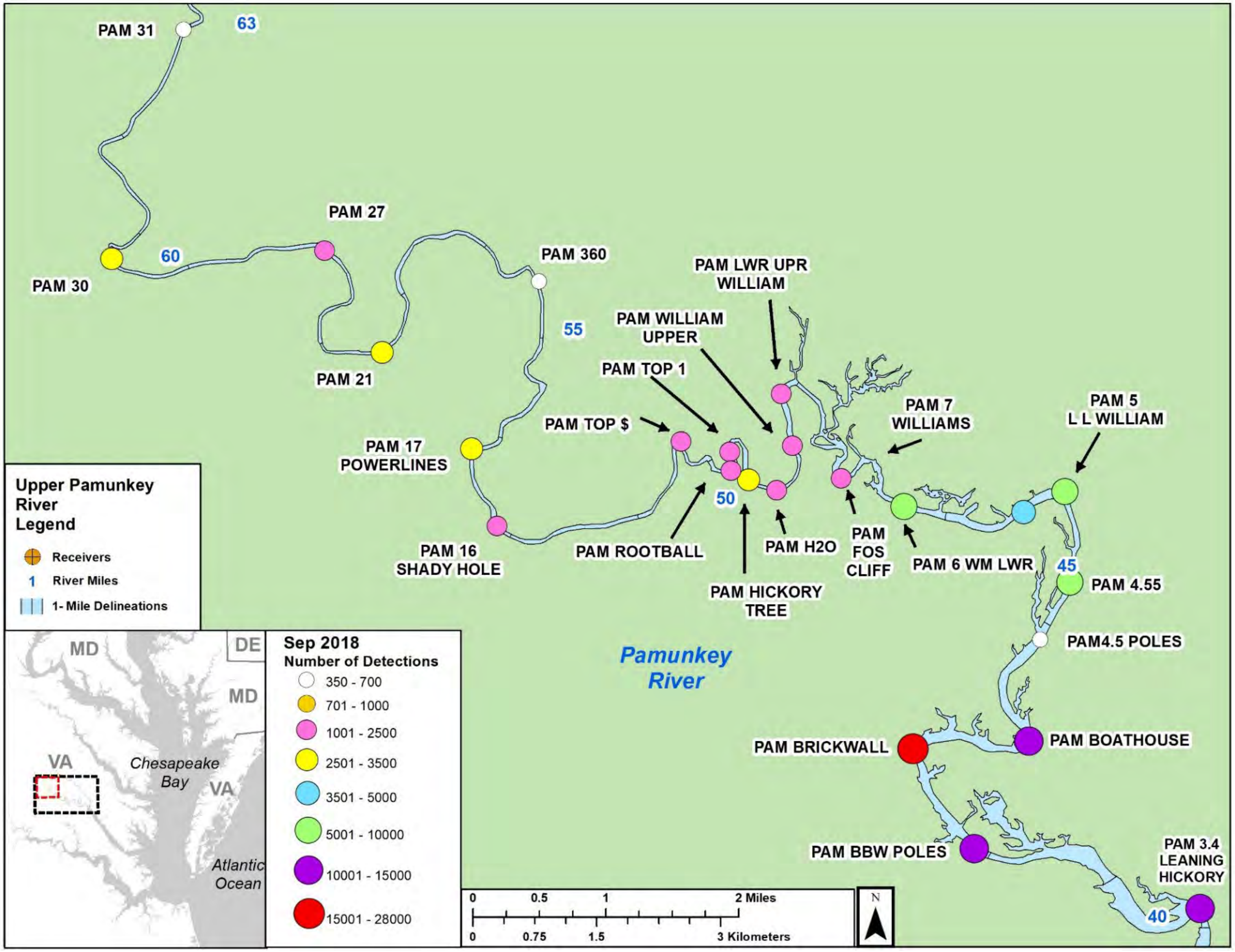
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Upper Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
MD
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MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Sep 2018
Number of Detections
350 - 700
701 - 1000
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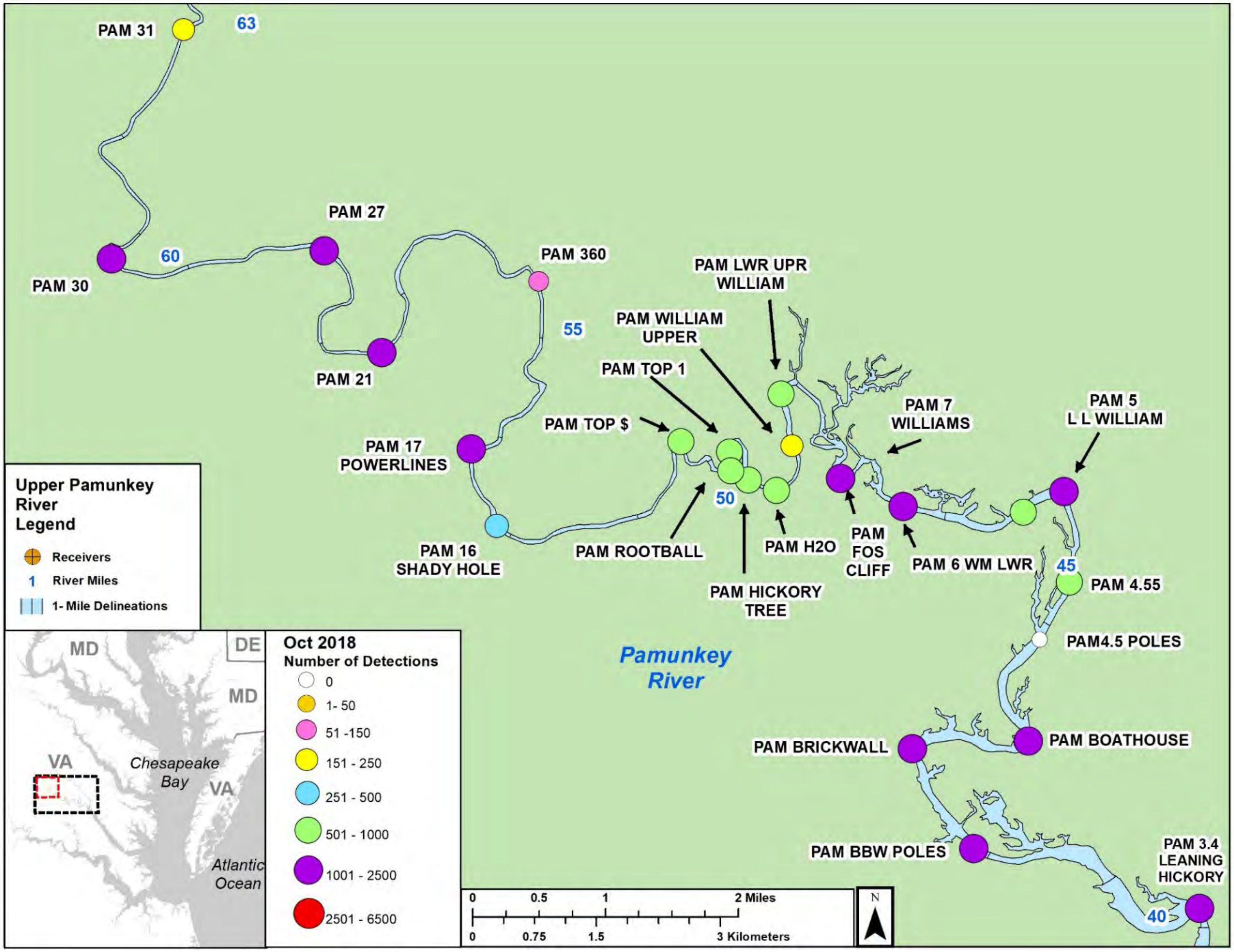
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PAM 16 SHADY HOLE
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50
PAM HICKORY TREE
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PAM FOS CLIFF
PAM 7 WILLIAMS
PAM 6 WM LWR
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PAM 4.55
PAM4.5 POLES
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PAM BRICKWALL
PAM BOATHOUSE
PAM BBW POLES
PAM 3.4 LEANING HICKORY
40
Upper Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Oct 2018
Number of Detections
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2 Miles
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1.5
3 Kilometers
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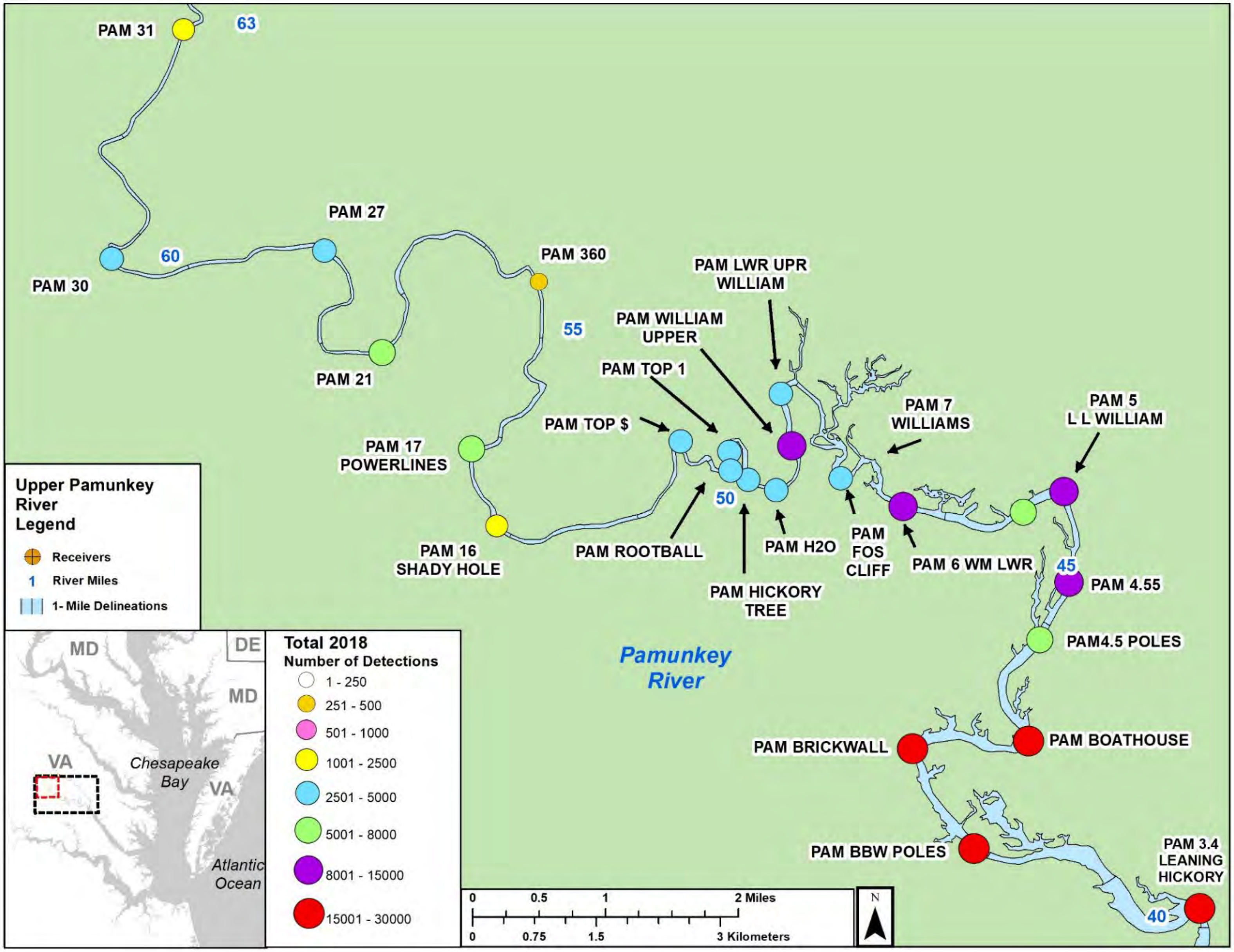
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Upper Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Total 2018
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
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2 Miles
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3 Kilometers
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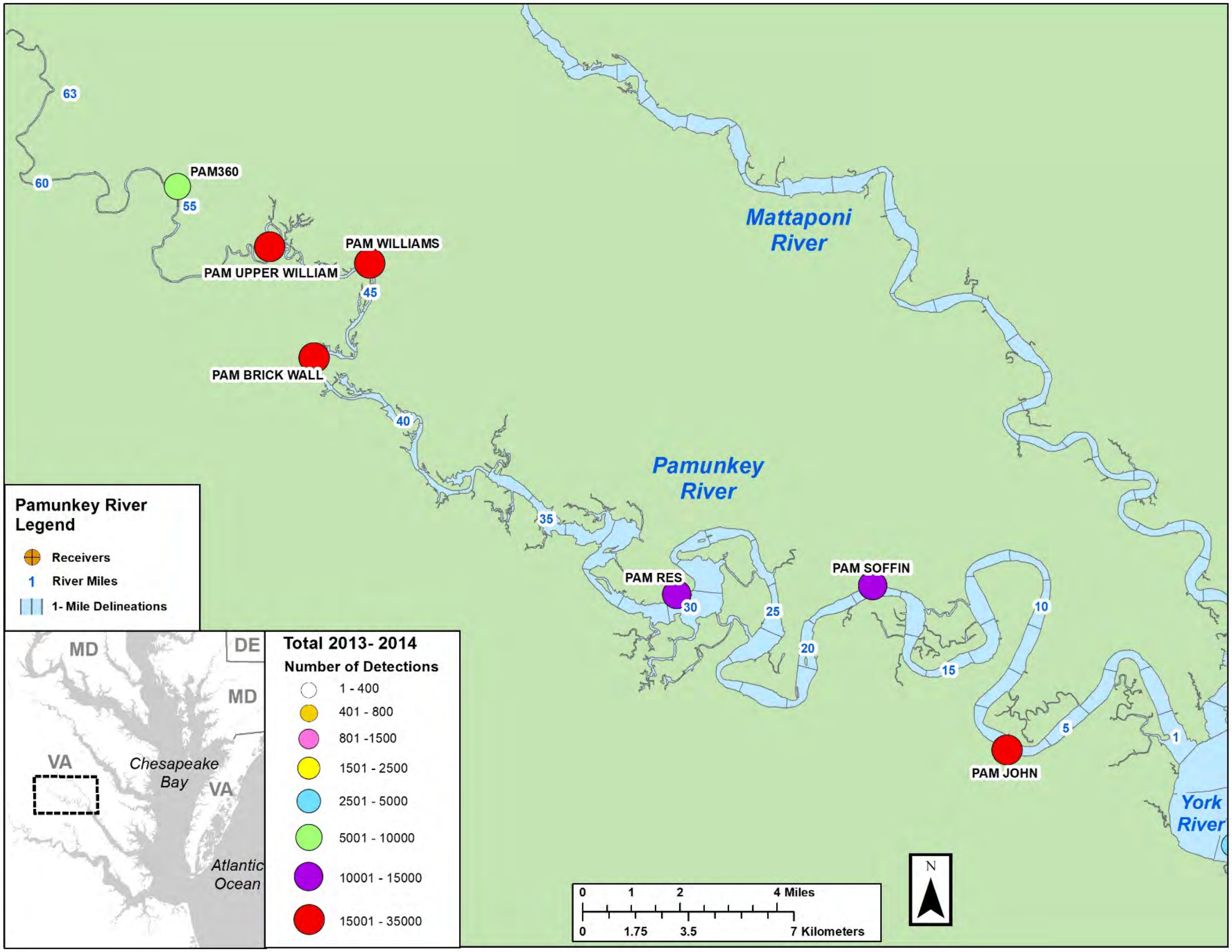
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Mattaponi River
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PAM RES
30
25
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PAM SOFFIN
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1
PAM JOHN
York River
Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
MD
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MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Total 2013- 2014
Number of Detections
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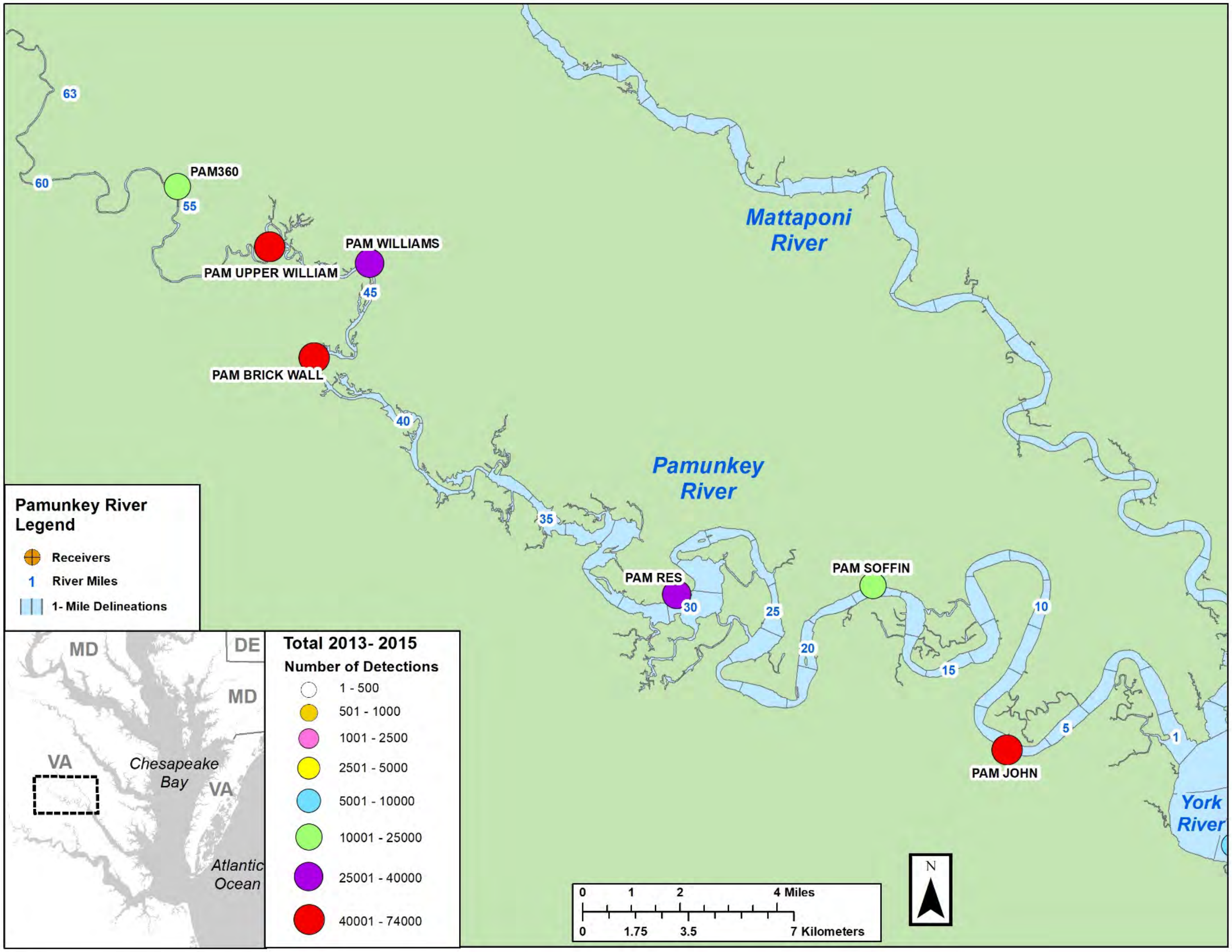
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PAM JOHN
York River
Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Total 2013- 2015
Number of Detections
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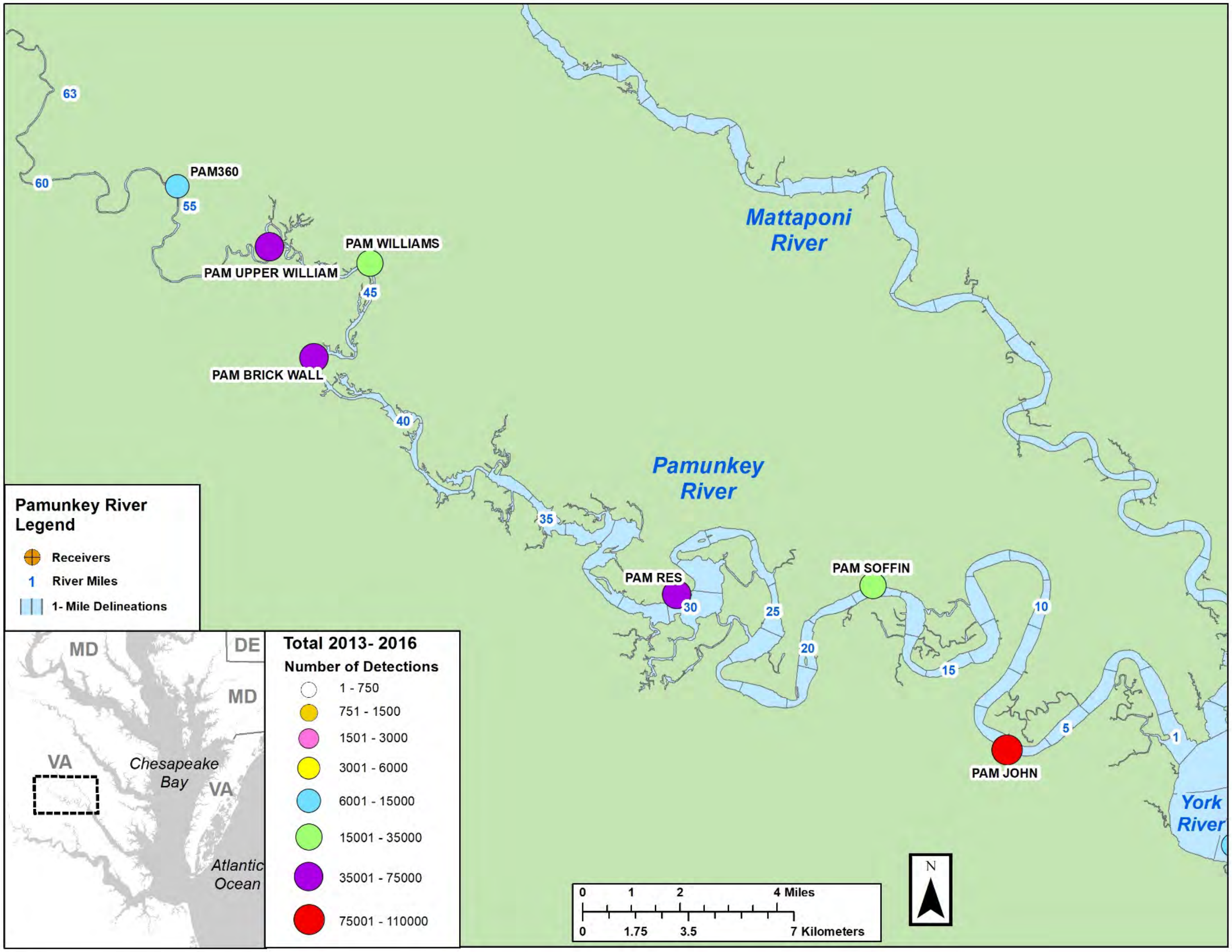
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Pamunkey River
York River
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PAM UPPER WILLIAM
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PAM RES
PAM SOFFIN
PAM JOHN
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Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
MD
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VA
Chesapeake Bay
VA
Atlantic Ocean
Total 2013- 2016
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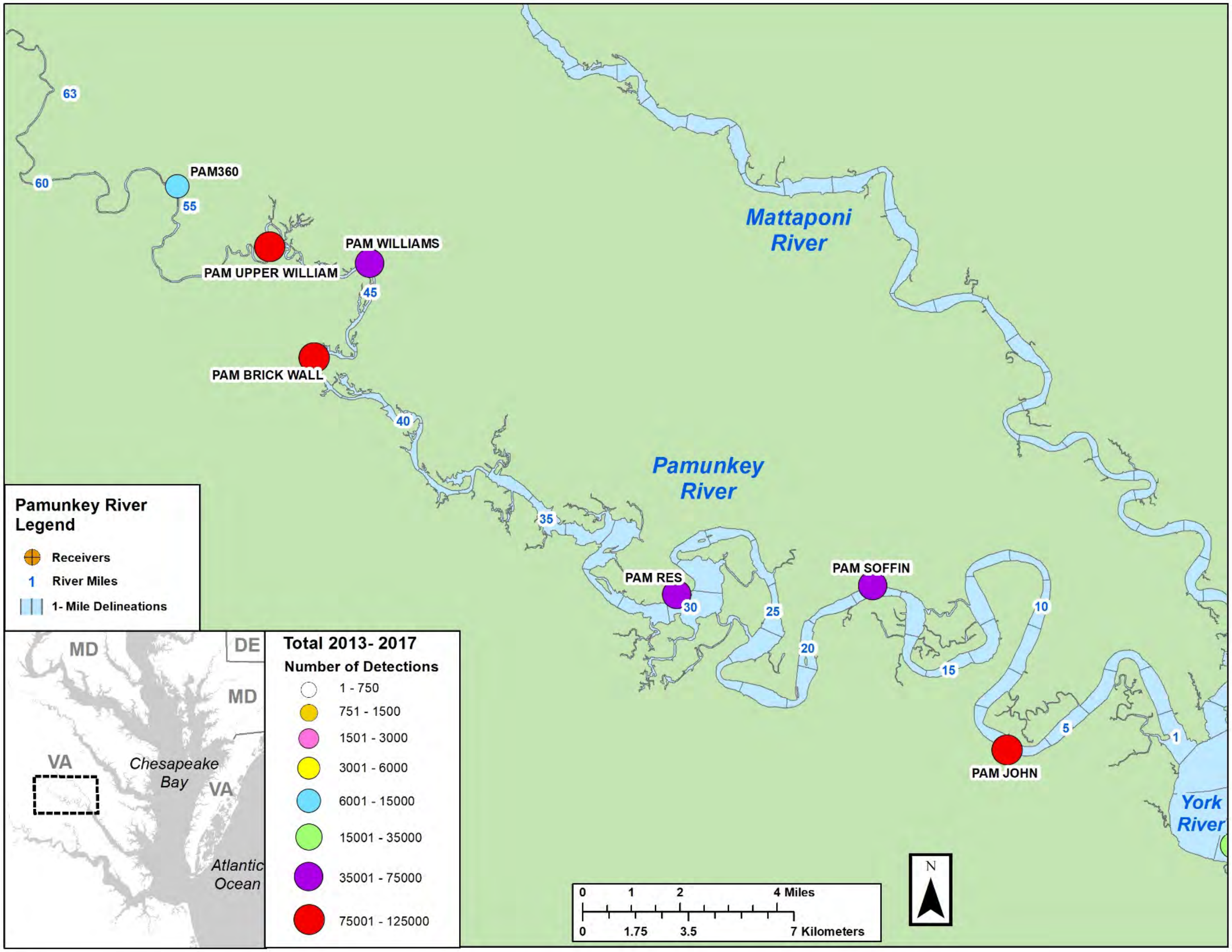
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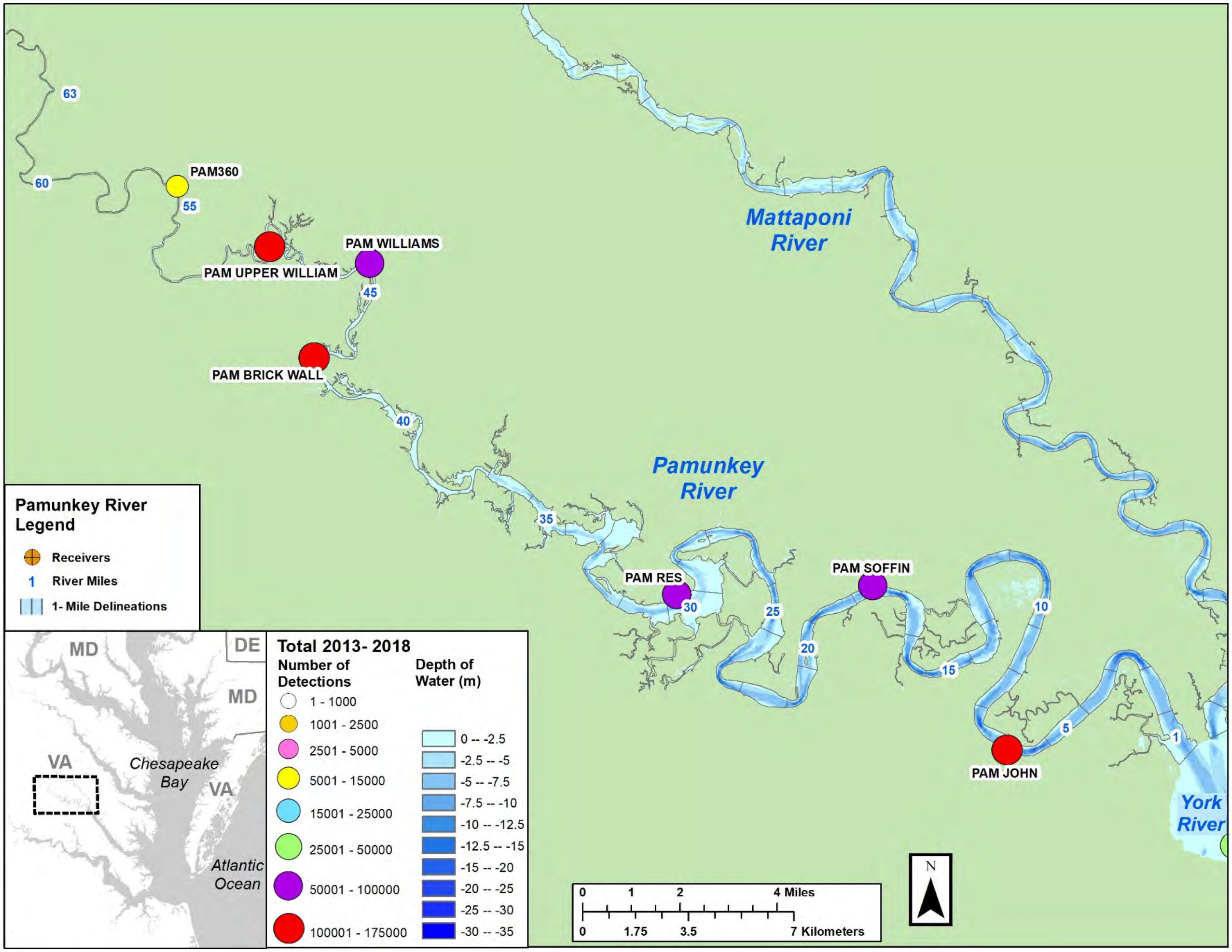
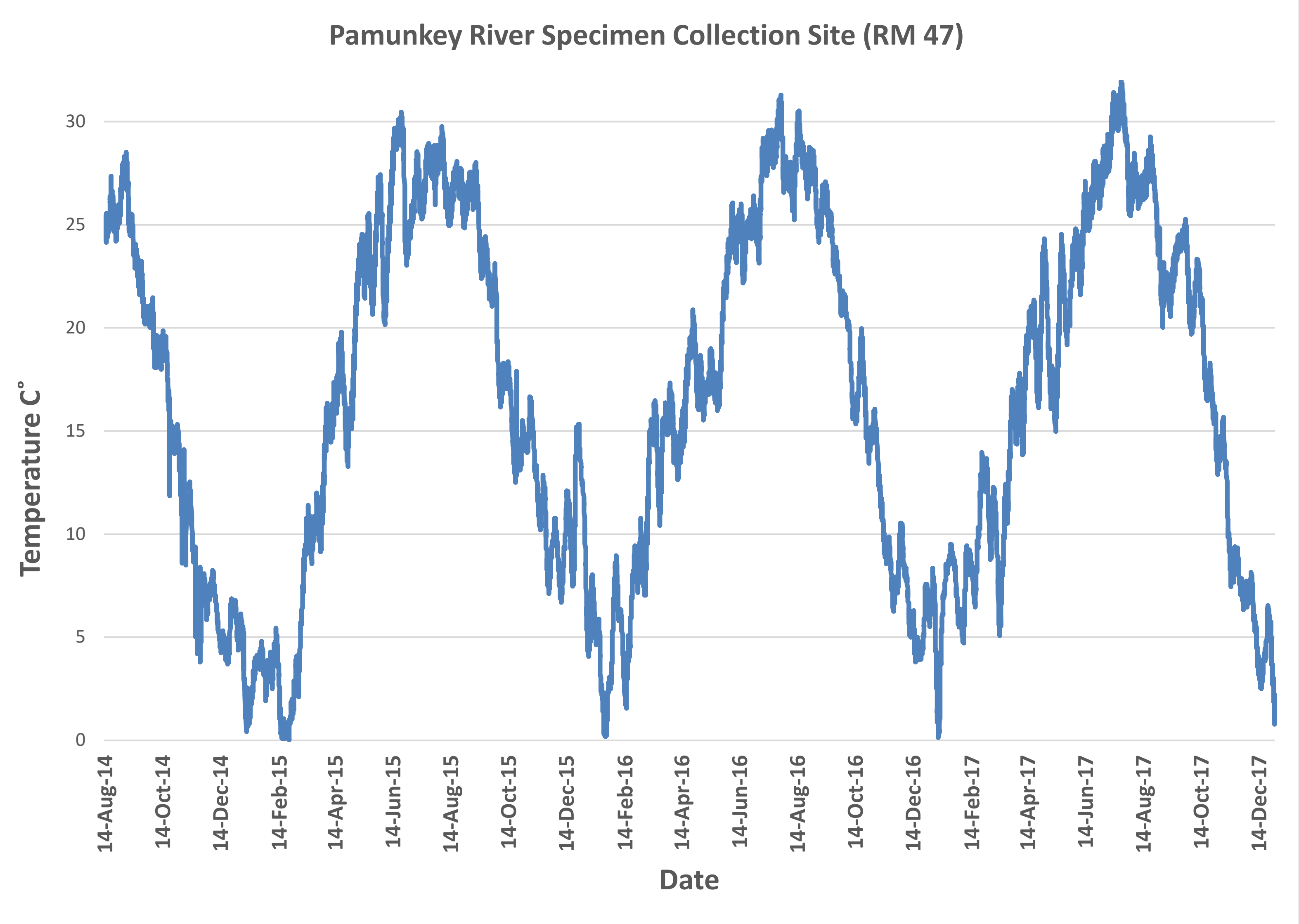
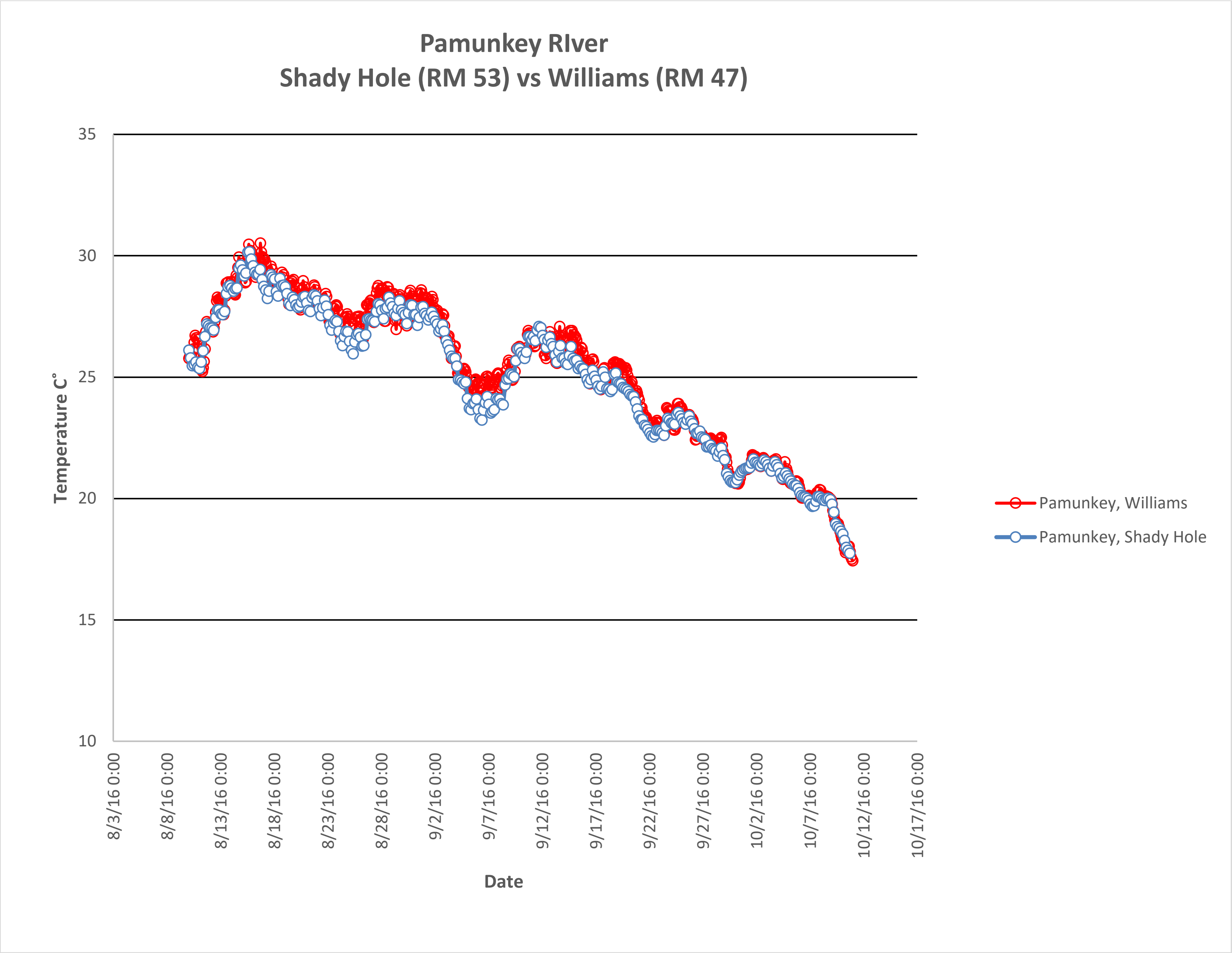
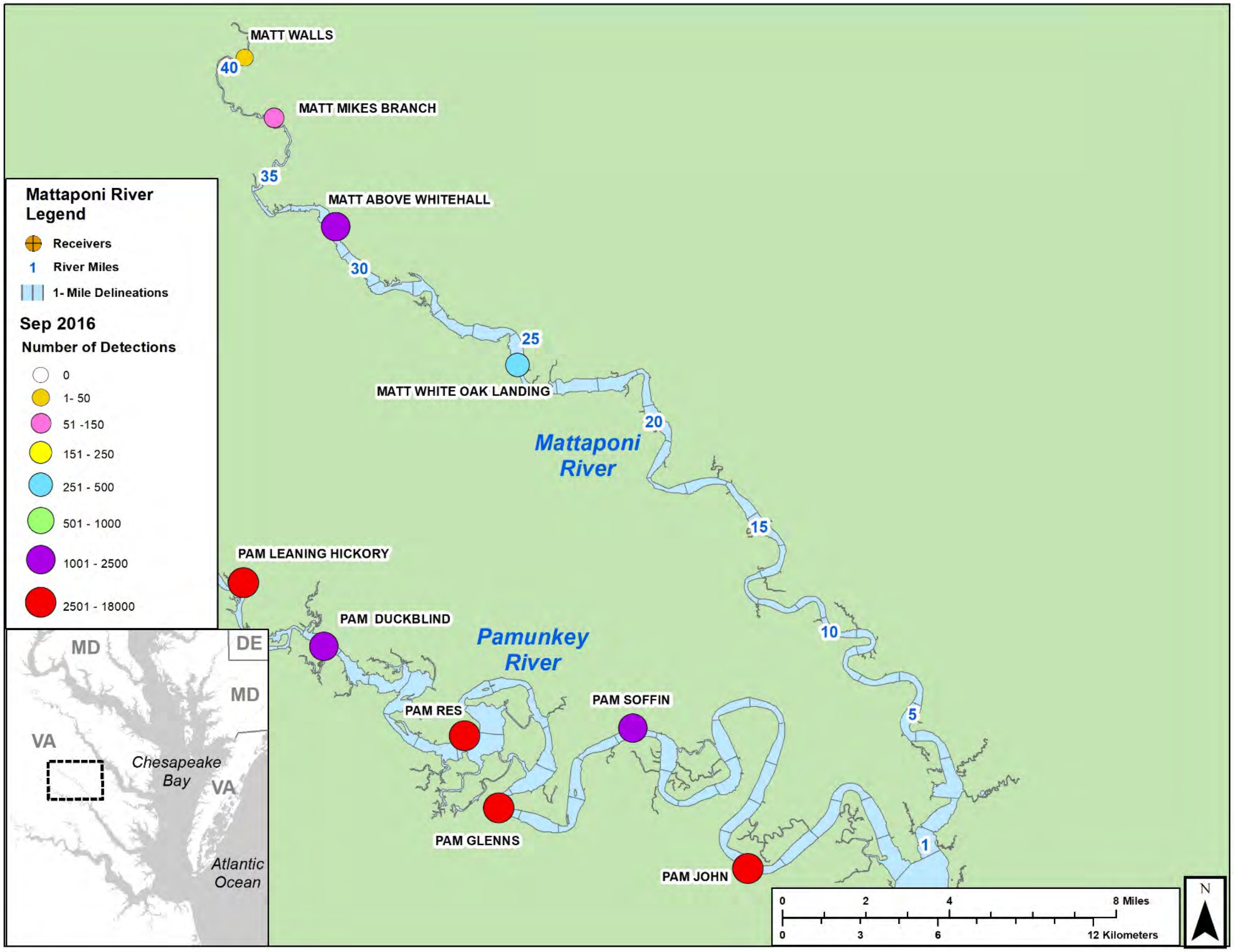
55
PAM WILLIAMS
PAM UPPER WILLIAM
45
PAM BRICK WALL
40
35
Mattaponi River
Pamunkey River
PAM RES
30
25
20
PAM SOFFIN
15
10
5
1
PAM JOHN
York River
Pamunkey River Legend
Receivers
1 River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Total 2013- 2017
Number of Detections
1 - 750
751 - 1500
1501 - 3000
3001 - 6000
6001 - 15000
15001 - 35000
35001 - 75000
75001 - 125000
0 1 2 4 Miles
0 1.75 3.5 7 Kilometers
N

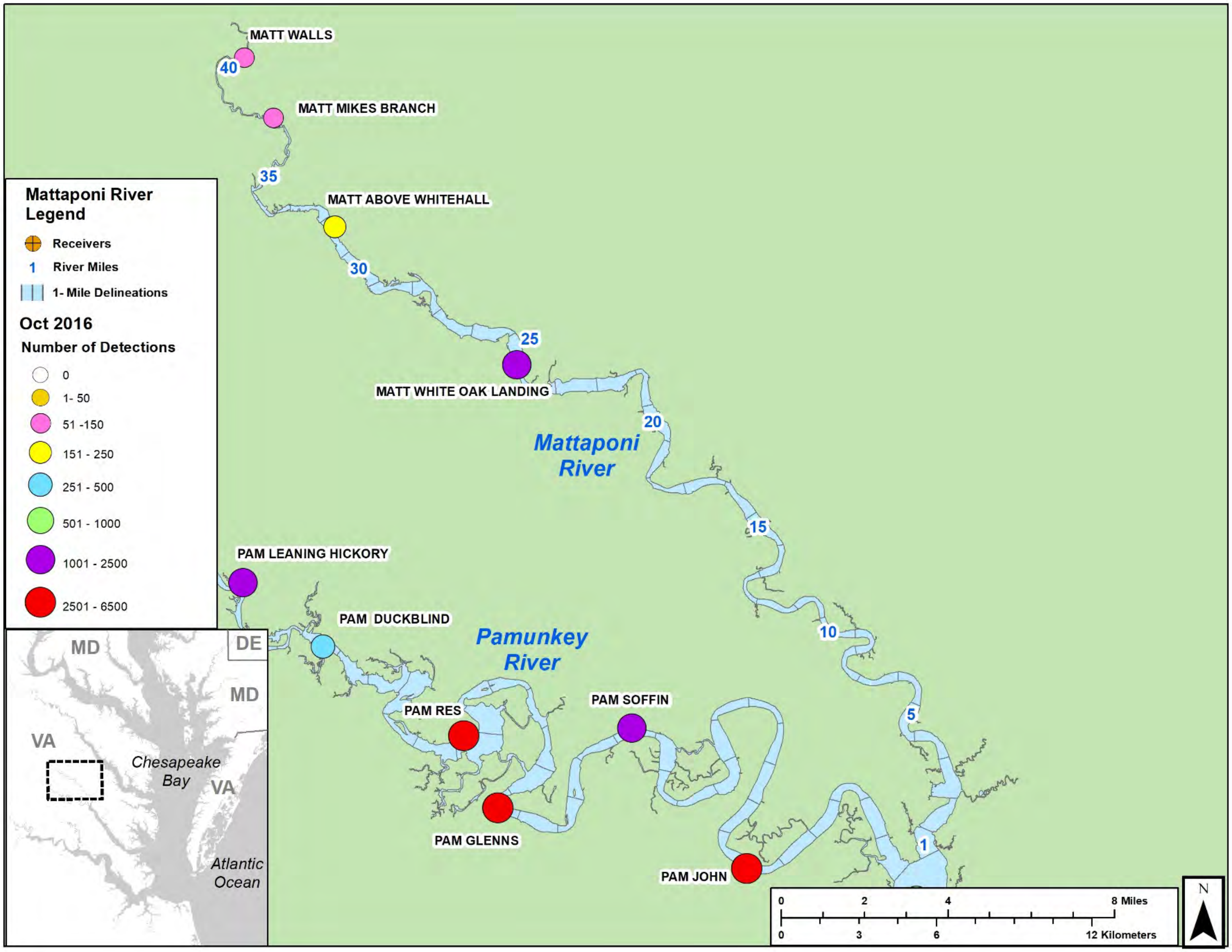

63
60
55
PAM360
PAM WILLIAMS
PAM UPPER WILLIAM
45
PAM BRICK WALL
40
Mattaponi River
Pamunkey River
35
PAM RES
30
25
20
PAM SOFFIN
15
10
5
1
PAM JOHN
York River
Pamunkey River Legend
Receivers
River Miles
1- Mile Delineations
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Total 2013- 2018
Number of Detections
1 - 1000
1001 - 2500
2501 - 5000
5001 - 15000
15001 - 25000
25001 - 50000
50001 - 100000
100001 - 175000
Depth of Water (m)
0 -- -2.5
-2.5 -- -5
-5 -- -7.5
-7.5 -- -10
-10 -- -12.5
-12.5 -- -15
-15 -- -20
-20 -- -25
-25 -- -30
-30 -- -35
0 1 2 4 Miles
0 1.75 3.5 7 Kilometers
N


Pamunkey River Specimen Collection Site (RM 47)
Temperature C°
0
5
10
15
20
25
30
Date
14-Aug-14
14-Oct-14
14-Dec-14
14-Feb-15
14-Apr-15
14-Jun-15
14-Aug-15
14-Oct-15
14-Dec-15
14-Feb-16
14-Apr-16
14-Jun-16
14-Aug-16
14-Oct-16
14-Dec-16
14-Feb-17
14-Apr-17
14-Jun-17
14-Aug-17
14-Oct-17
14-Dec-17

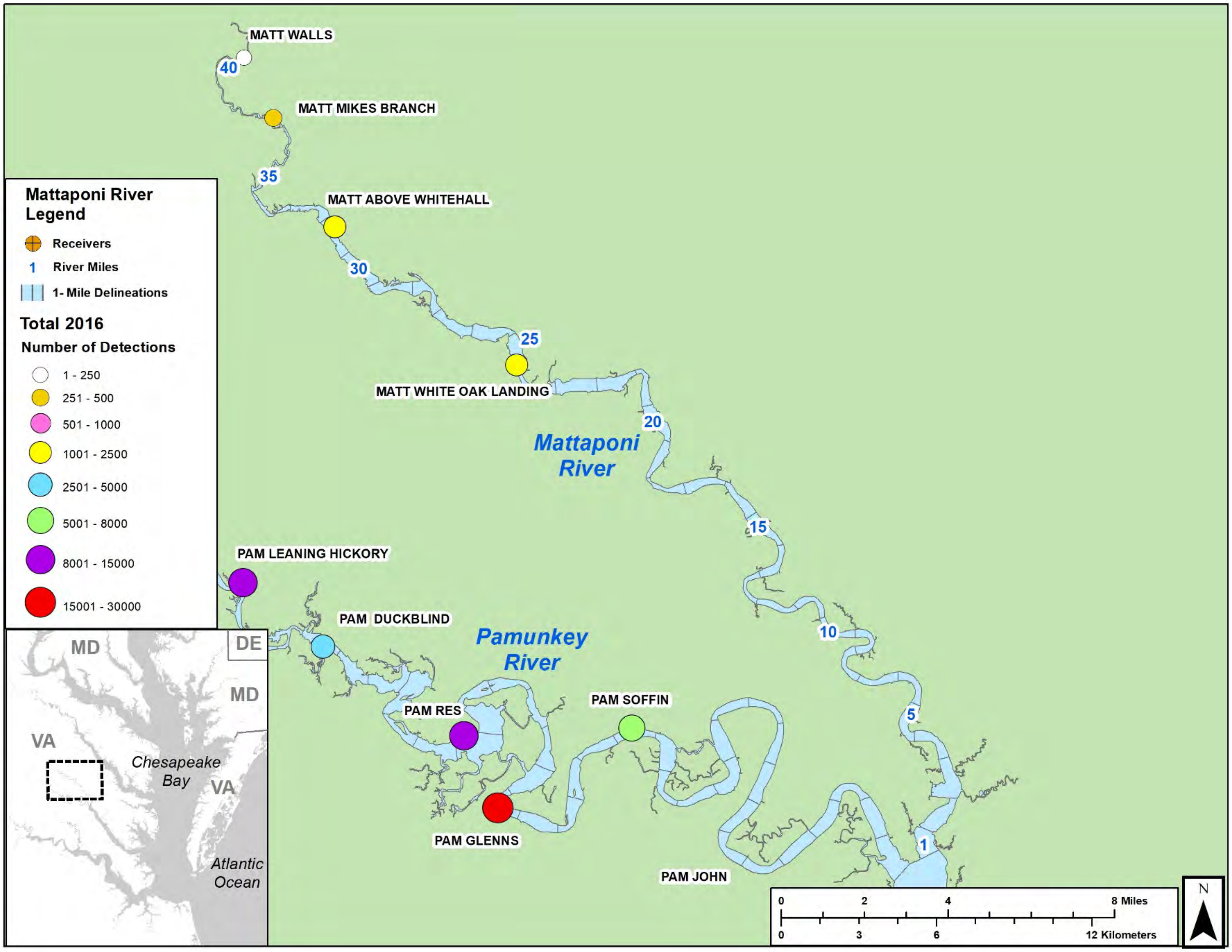

Pamunkey RIver
Shady Hole (RM 53) vs Williams (RM 47)
Temperature C˚
35
30
25
20
15
10
8/3/16 0:00
8/8/16 0:00
8/13/16 0:00
8/18/16 0:00
8/23/16 0:00
8/28/16 0:00
9/2/16 0:00
9/7/16 0:00
9/12/16 0:00
9/17/16 0:00
9/22/16 0:00
9/27/16 0:00
10/2/16 0:00
10/7/16 0:00
10/12/16 0:00
10/17/16 0:00
Date
Pamunkey, Williams
Pamunkey, Shady Hole

8.4. Appendix 8.4: Detections of Sonic-tagged Atlantic Sturgeon in the Mattaponi River Region, by Month, Year, and Overall





MATT WALLS
MATT MIKES BRANCH
MATT ABOVE WHITEHALL
MATT WHITE OAK LANDING
Mattaponi River
40
35
30
25
20
15
10
5
1
PAM LEANING HICKORY
PAM DUCKBLIND
Pamunkey River
PAM RES
PAM SOFFIN
PAM GLENNS
PAM JOHN
Mattaponi River Legend
Receivers
River Miles
1- Mile Delineations
Oct 2016
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
2
4
8 Miles
0
3
6
12 Kilometers
N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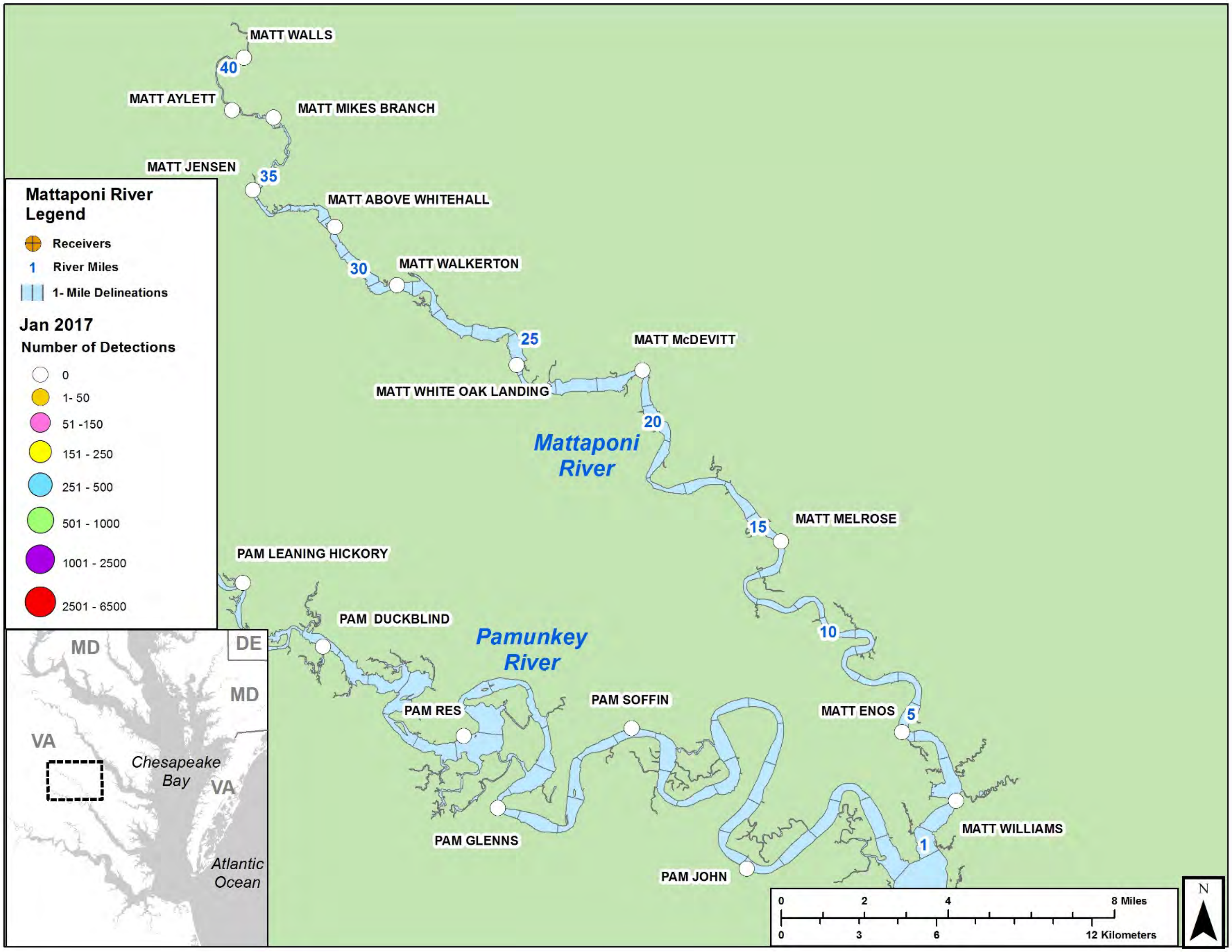
MATT MIKES BRANCH
35
MATT ABOVE WHITEHALL
30
25
MATT WHITE OAK LANDING
20
Mattaponi River
15
10
5
1
Mattaponi River Legend
Receivers
1 River Miles
1- Mile Delineations
Total 2016
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
PAM LEANING HICKORY
PAM DUCKBLIND
Pamunkey River
PAM RES
PAM SOFFIN
PAM GLENNS
PAM JOHN
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N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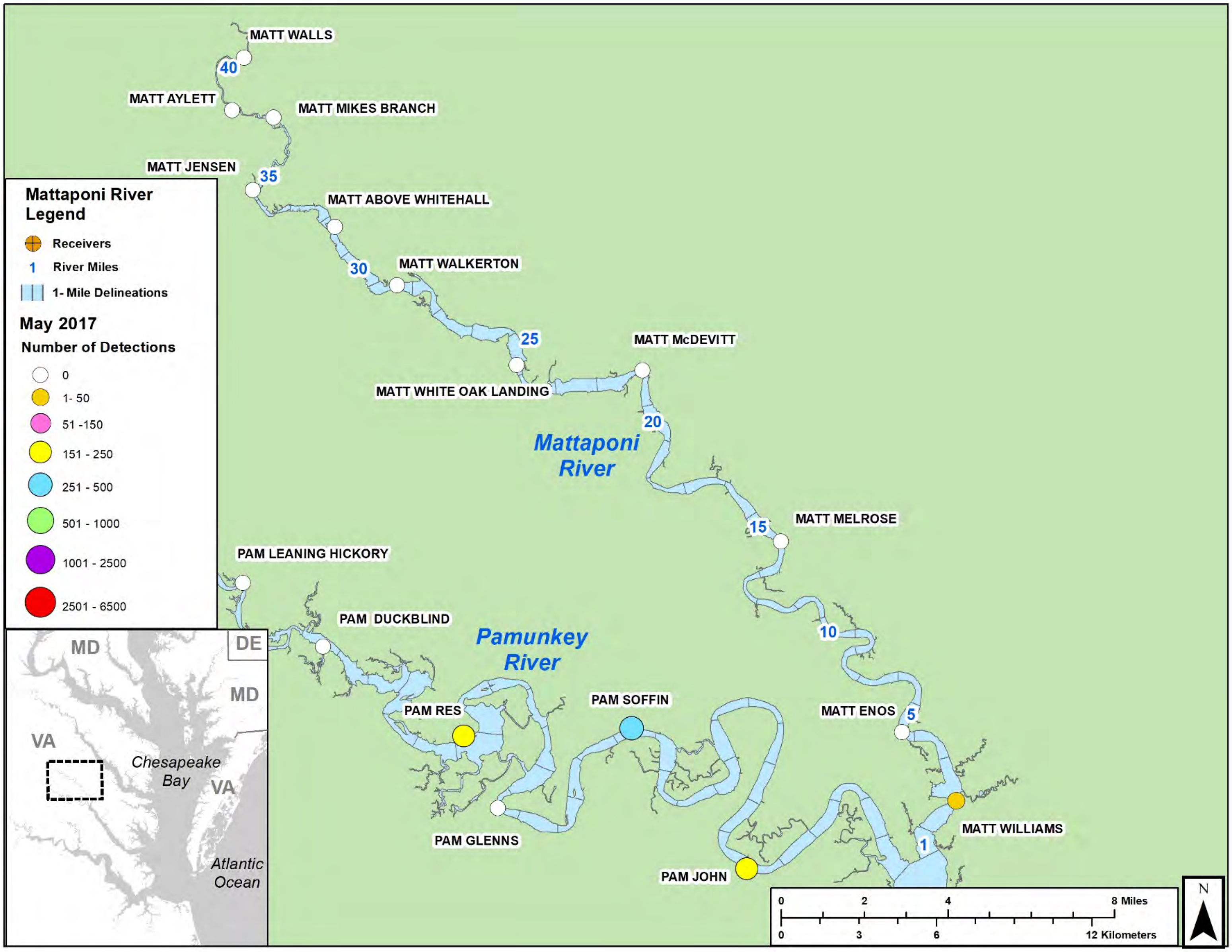
40
MATT AYLETT
MATT MIKES BRANCH
MATT JENSEN
35
MATT ABOVE WHITEHALL
30
MATT WALKERTON
25
MATT McDEVITT
MATT WHITE OAK LANDING
20
Mattaponi River
15
MATT MELROSE
10
5
MATT ENOS
MATT WILLIAMS
1
PAM LEANING HICKORY
PAM DUCKBLIND
Pamunkey River
PAM RES
PAM SOFFIN
PAM GLENNS
PAM JOHN
Mattaponi River Legend
Receivers
River Miles
1- Mile Delineations
Jan 2017
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
2
4
8 Miles
0
3
6
12 Kilometers
N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MATT MIKES BRANCH
MATT JENSEN
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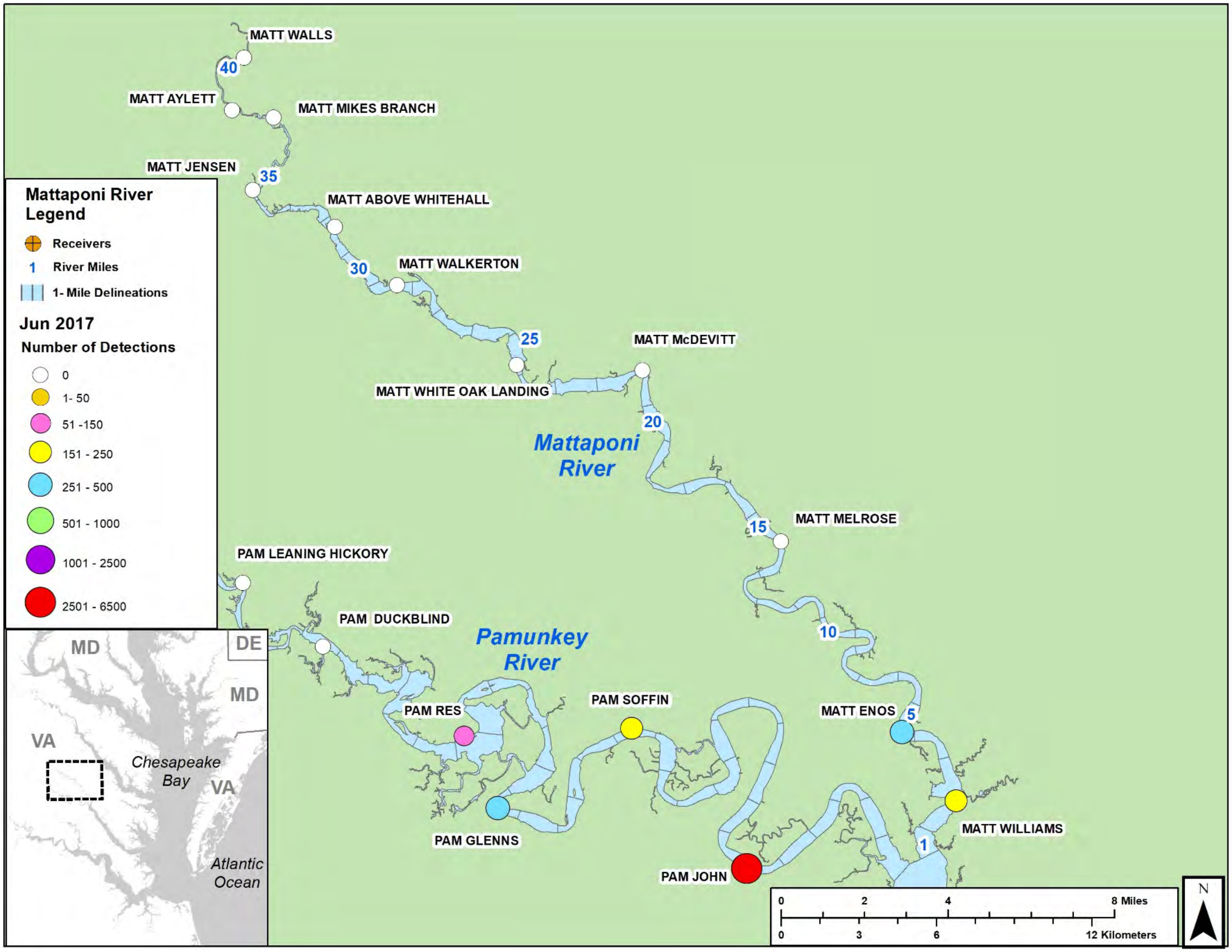
MATT ABOVE WHITEHALL
30
MATT WALKERTON
25
MATT McDEVITT
MATT WHITE OAK LANDING
20
Mattaponi River
15
MATT MELROSE
10
MATT ENOS
5
MATT WILLIAMS
1
PAM LEANING HICKORY
PAM DUCKBLIND
Pamunkey River
PAM RES
PAM SOFFIN
PAM GLENNS
PAM JOHN
Mattaponi River Legend
Receivers
River Miles
1- Mile Delineations
May 2017
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N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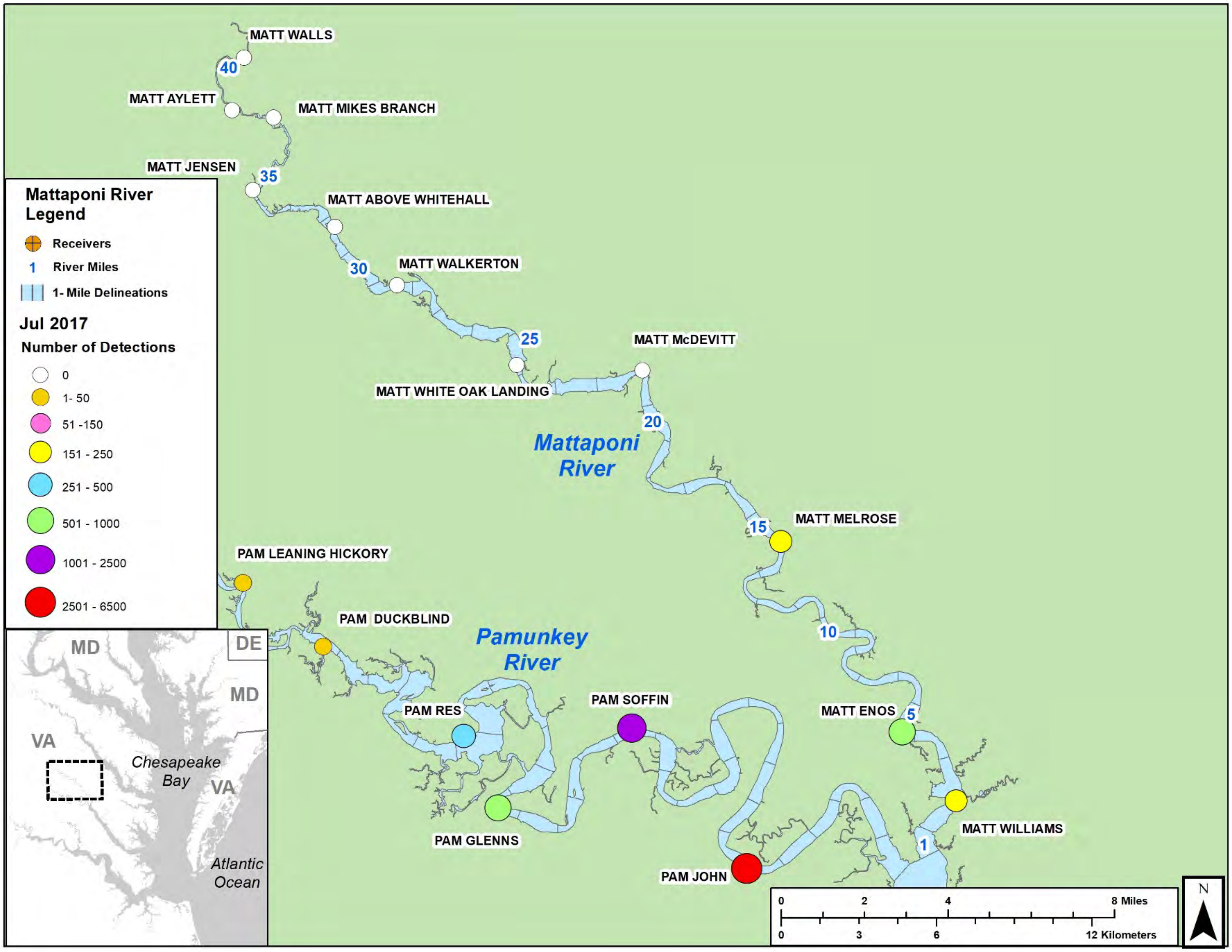
MATT JENSEN
35
MATT ABOVE WHITEHALL
30
MATT WALKERTON
25
MATT McDEVITT
MATT WHITE OAK LANDING
20
Mattaponi River
15
MATT MELROSE
PAM LEANING HICKORY
PAM DUCKBLIND
10
Pamunkey River
PAM SOFFIN
MATT ENOS
5
PAM RES
PAM GLENNS
MATT WILLIAMS
1
PAM JOHN
Mattaponi River Legend
Receivers
River Miles
1- Mile Delineations
Jun 2017
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
2
4
8 Miles
0
3
6
12 Kilometers
N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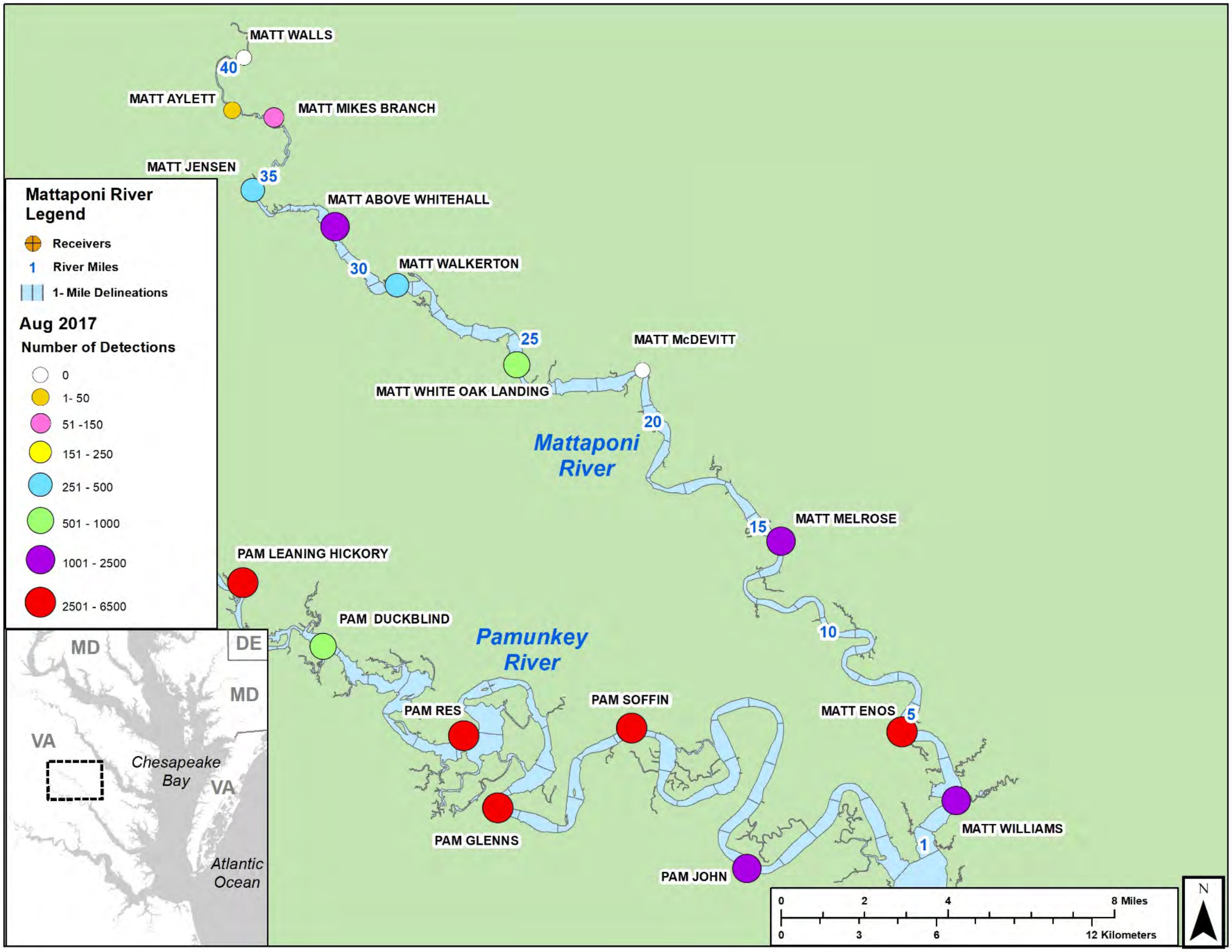
MATT MIKES BRANCH
MATT JENSEN
35
MATT ABOVE WHITEHALL
30
MATT WALKERTON
25
MATT McDEVITT
MATT WHITE OAK LANDING
20
Mattaponi River
15
MATT MELROSE
10
MATT ENOS
5
MATT WILLIAMS
1
PAM LEANING HICKORY
PAM DUCKBLIND
Pamunkey River
PAM RES
PAM SOFFIN
PAM GLENNS
PAM JOHN
Mattaponi River Legend
Receivers
River Miles
1- Mile Delineations
Jul 2017
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
2
4
8 Miles
0
3
6
12 Kilometers
N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MATT AYLETT
MATT MIKES BRANCH
MATT JENSEN
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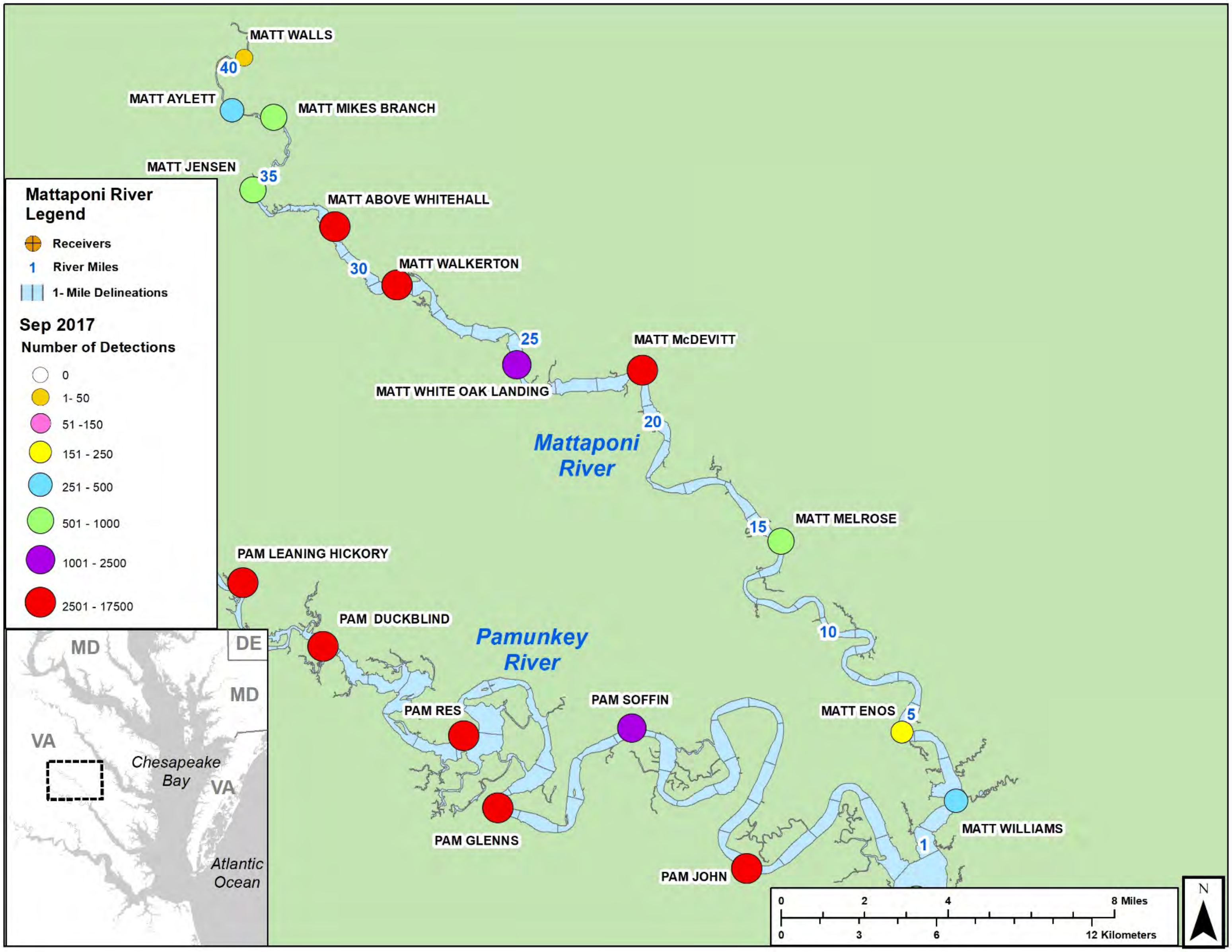
MATT ABOVE WHITEHALL
30
MATT WALKERTON
25
MATT McDEVITT
MATT WHITE OAK LANDING
20
Mattaponi River
15
MATT MELROSE
PAM LEANING HICKORY
PAM DUCKBLIND
Pamunkey River
10
PAM RES
PAM SOFFIN
MATT ENOS
5
MATT WILLIAMS
1
PAM GLENNS
PAM JOHN
Mattaponi River Legend
Receivers
1 River Miles
1- Mile Delineations
Aug 2017
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N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MATT ABOVE WHITEHALL
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MATT WALKERTON
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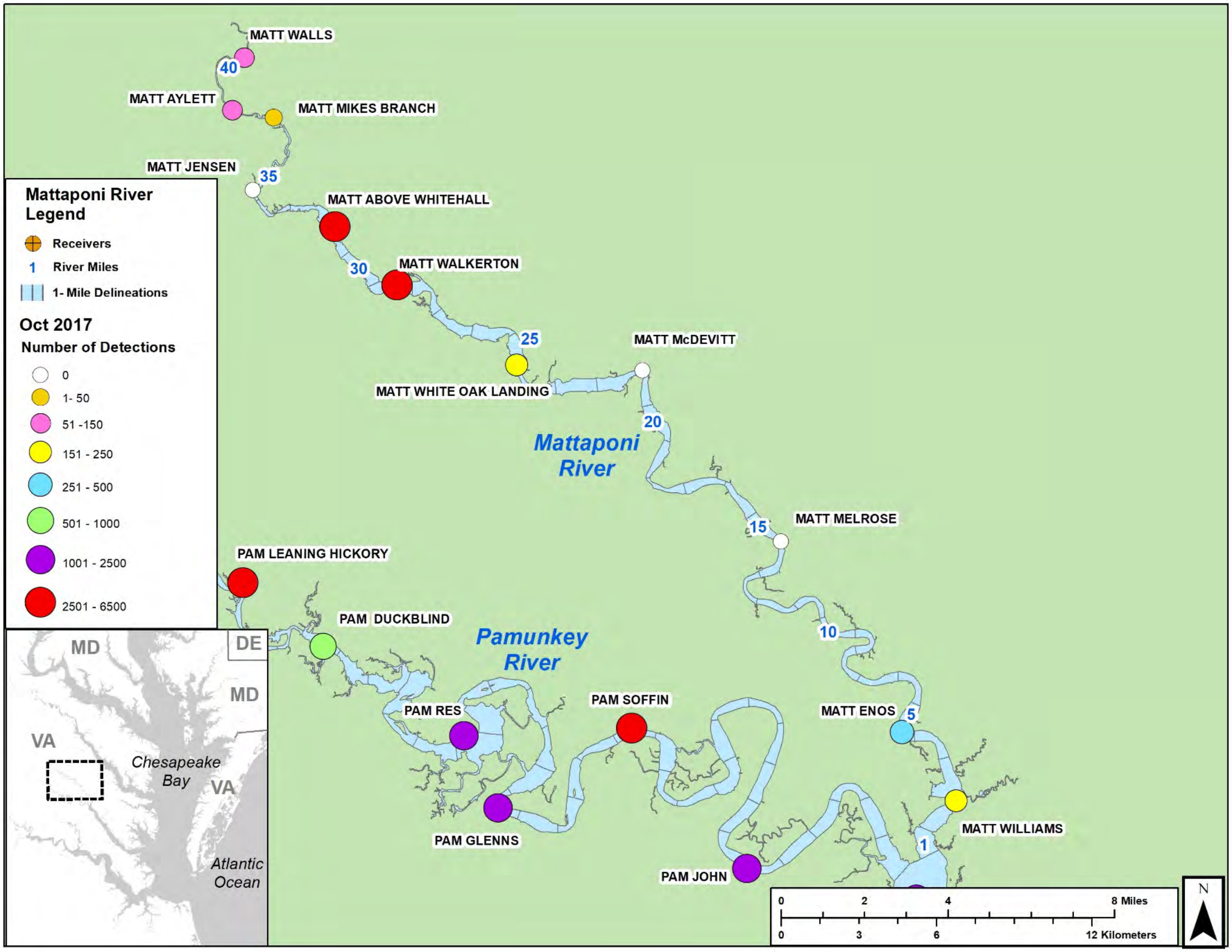
MATT McDEVITT
20
Mattaponi River
15
MATT MELROSE
10
MATT ENOS
5
MATT WILLIAMS
1
PAM LEANING HICKORY
PAM DUCKBLIND
Pamunkey River
PAM RES
PAM SOFFIN
PAM GLENNS
PAM JOHN
Mattaponi River Legend
Receivers
River Miles
1- Mile Delineations
Sep 2017
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 17500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N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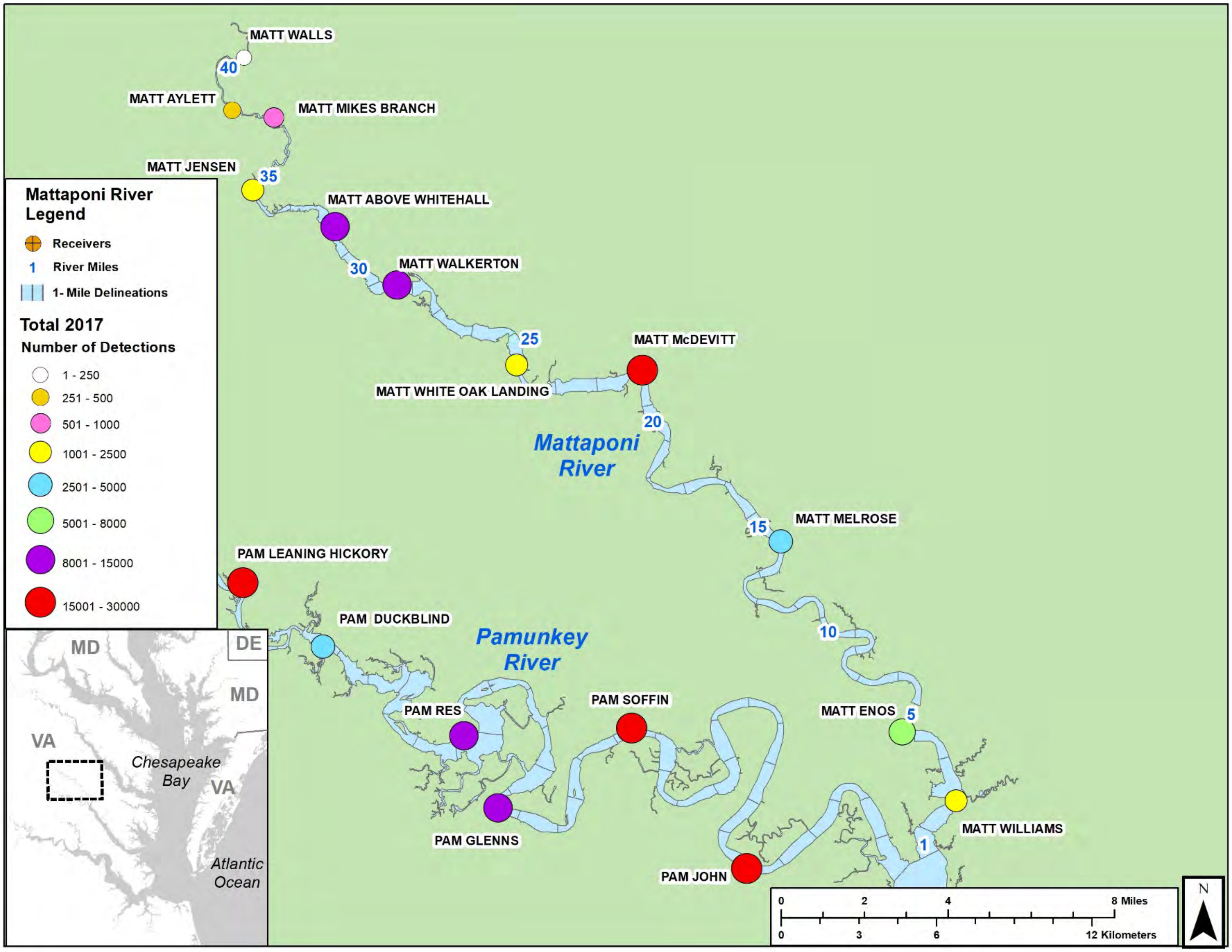
MATT AYLETT
MATT MIKES BRANCH
MATT JENSEN
35
MATT ABOVE WHITEHALL
30
MATT WALKERTON
25
MATT McDEVITT
MATT WHITE OAK LANDING
20
Mattaponi River
15
MATT MELROSE
10
MATT ENOS
5
MATT WILLIAMS
1
PAM LEANING HICKORY
PAM DUCKBLIND
Pamunkey River
PAM RES
PAM SOFFIN
PAM GLENNS
PAM JOHN
Mattaponi River Legend
Receivers
1 River Miles
1- Mile Delineations
Oct 2017
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N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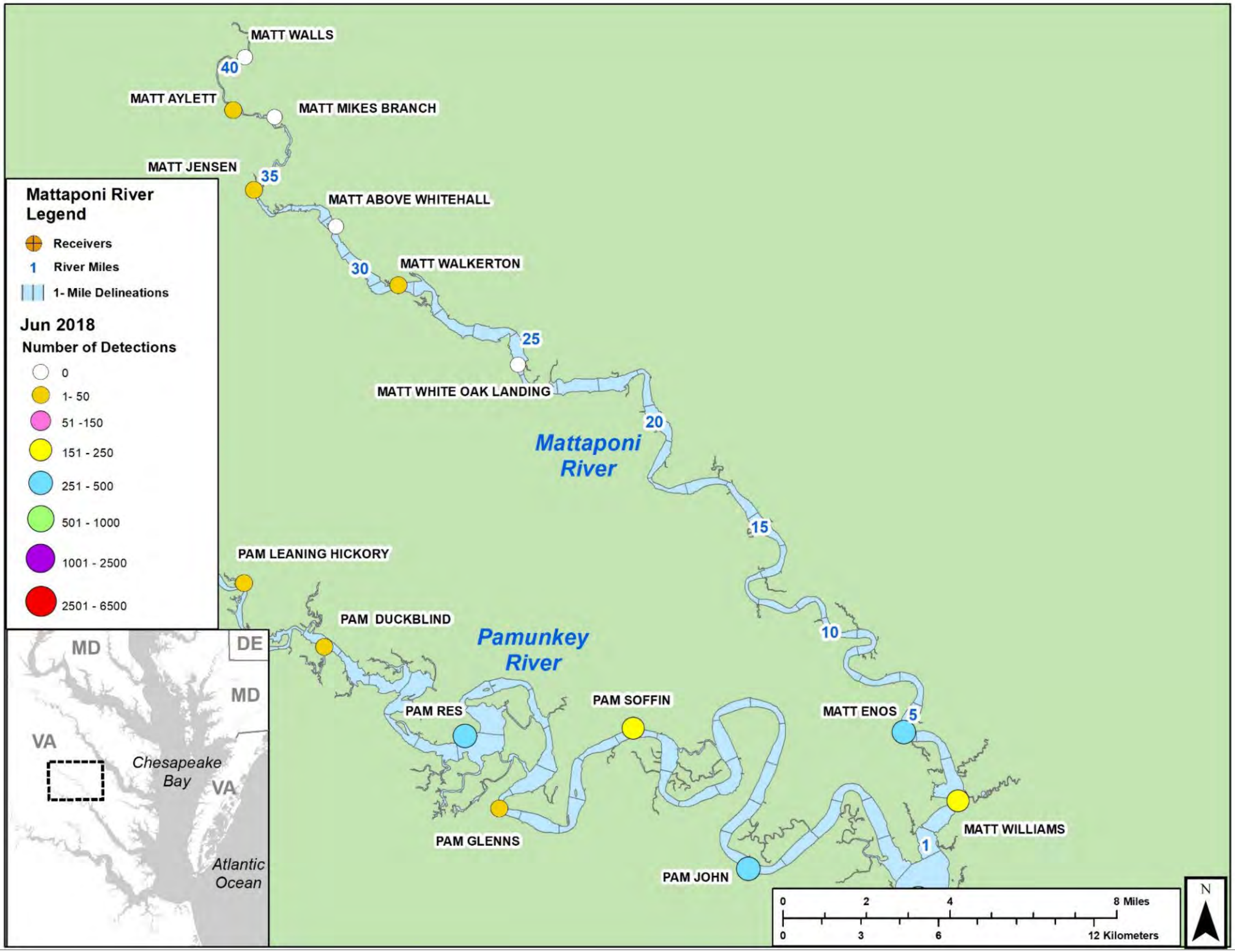
MATT AYLETT
MATT MIKES BRANCH
MATT JENSEN
35
MATT ABOVE WHITEHALL
30
MATT WALKERTON
25
MATT WHITE OAK LANDING
MATT McDEVITT
20
Mattaponi River
15
MATT MELROSE
10
5
MATT ENOS
MATT WILLIAMS
1
PAM LEANING HICKORY
PAM DUCKBLIND
Pamunkey River
PAM RES
PAM SOFFIN
PAM GLENNS
PAM JOHN
Mattaponi River Legend
Receivers
1 River Miles
1- Mile Delineations
Total 2017
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
2
4
8 Miles
0
3
6
12 Kilometers
N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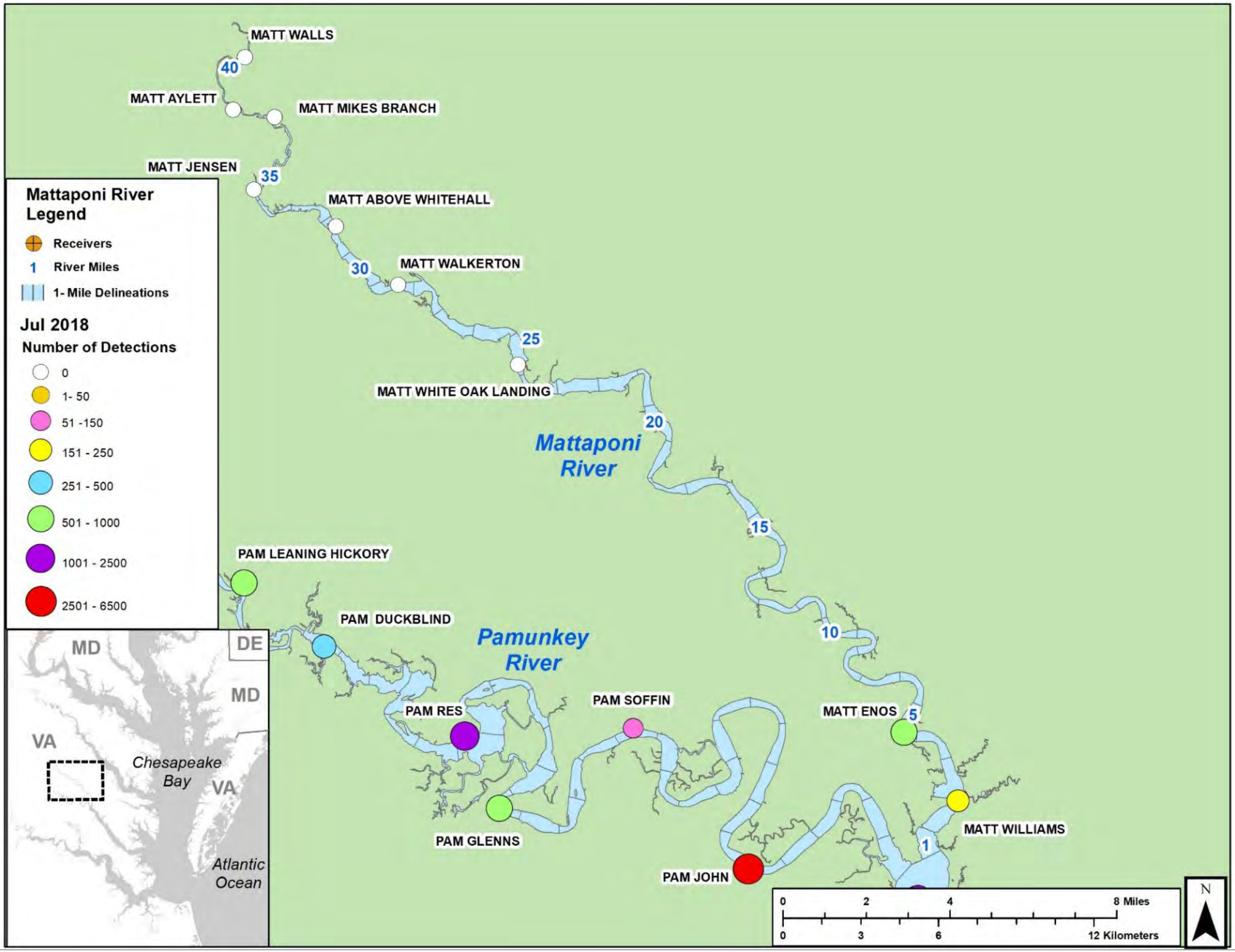
MATT AYLETT
MATT MIKES BRANCH
MATT JENSEN
35
MATT ABOVE WHITEHALL
30
MATT WALKERTON
25
MATT WHITE OAK LANDING
20
Mattaponi River
15
10
MATT ENOS
5
MATT WILLIAMS
1
PAM LEANING HICKORY
PAM DUCKBLIND
Pamunkey River
PAM RES
PAM SOFFIN
PAM GLENNS
PAM JOHN
Mattaponi River Legend
Receivers
River Miles
1- Mile Delineations
Jun 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
2
4
8 Miles
0
3
6
12 Kilometers
N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MATT AYLETT
MATT MIKES BRANCH
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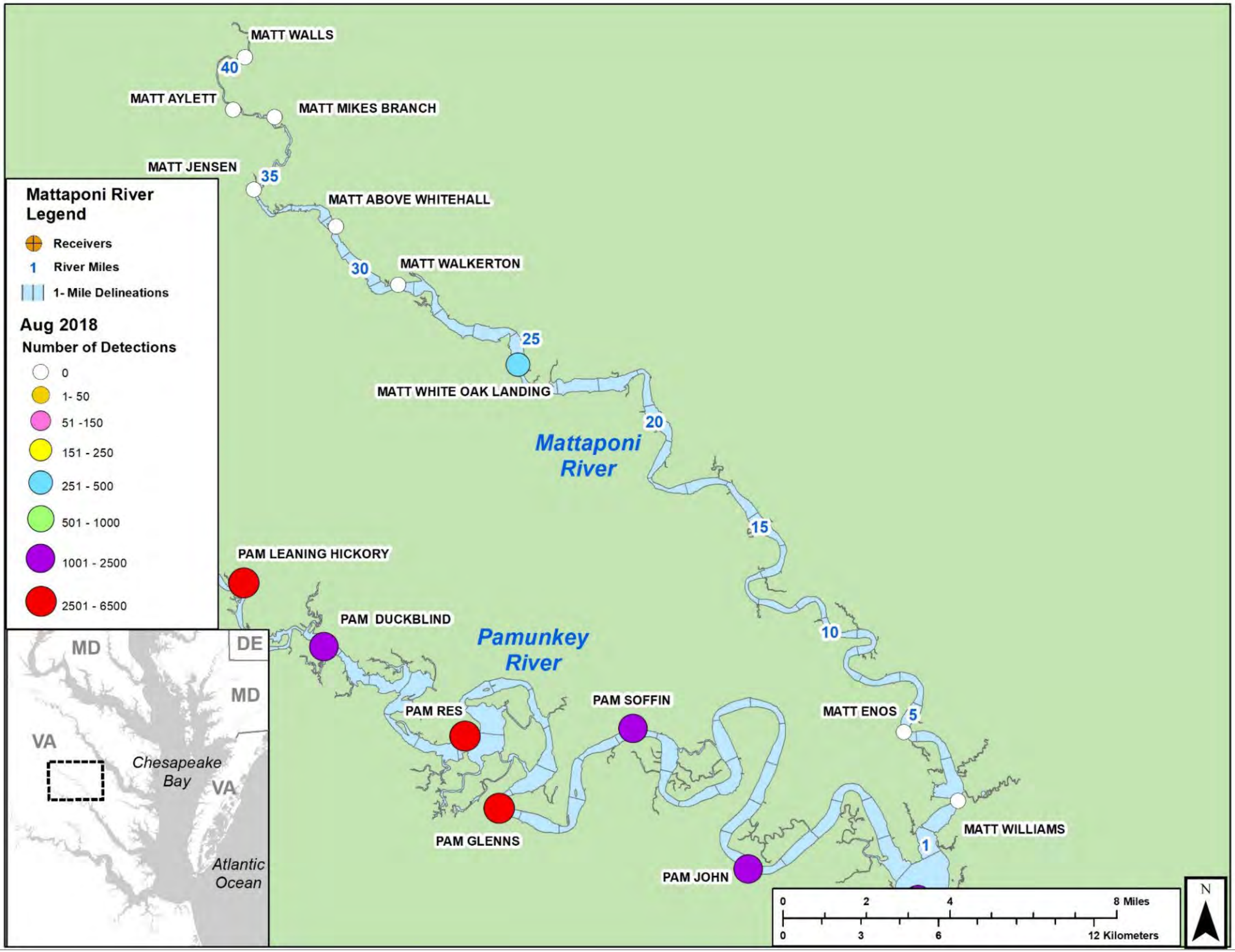
35
MATT ABOVE WHITEHALL
30
MATT WALKERTON
25
MATT WHITE OAK LANDING
20
Mattaponi River
15
10
MATT ENOS
5
MATT WILLIAMS
1
PAM LEANING HICKORY
PAM DUCKBLIND
Pamunkey River
PAM RES
PAM SOFFIN
PAM GLENNS
PAM JOHN
Mattaponi River Legend
Receivers
River Miles
1- Mile Delineations
Jul 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N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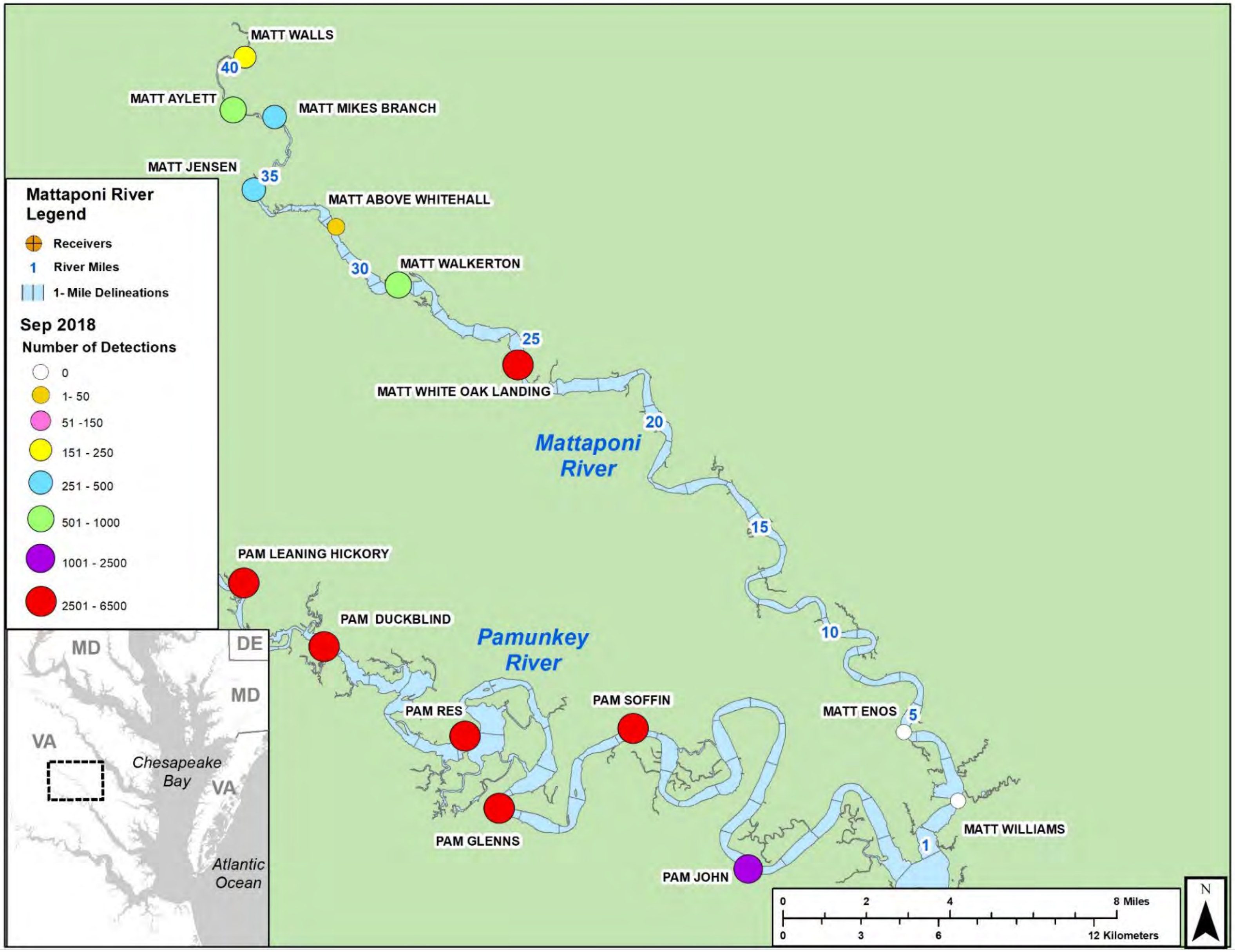
40
MATT AYLETT
MATT MIKES BRANCH
MATT JENSEN
35
MATT ABOVE WHITEHALL
30
MATT WALKERTON
25
MATT WHITE OAK LANDING
20
Mattaponi River
15
10
5
MATT ENOS
MATT WILLIAMS
1
Mattaponi River Legend
Receivers
River Miles
1- Mile Delineations
Aug 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
PAM LEANING HICKORY
PAM DUCKBLIND
Pamunkey River
PAM RES
PAM SOFFIN
PAM GLENNS
PAM JOHN
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N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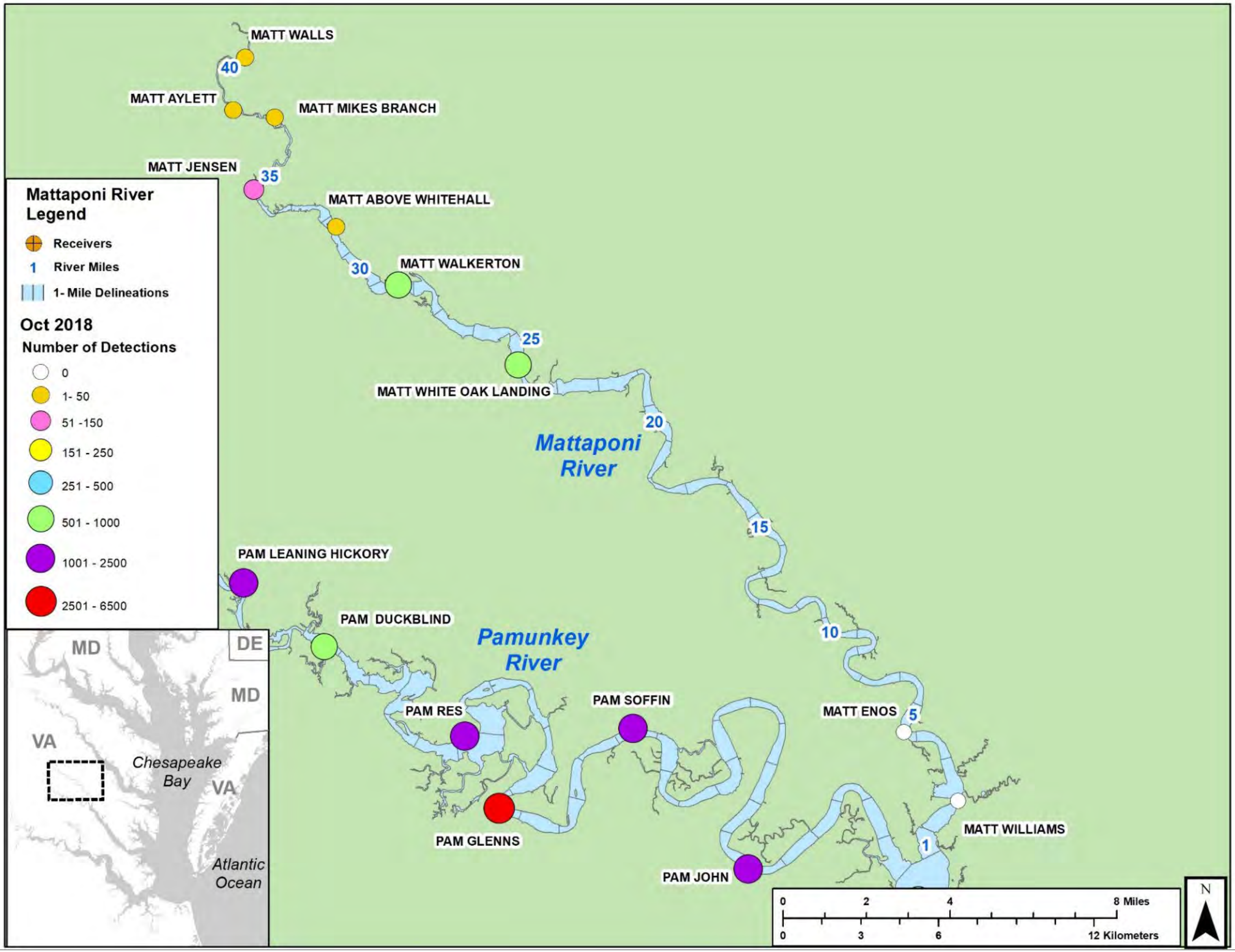
MATT ABOVE WHITEHALL
30
MATT WALKERTON
25
MATT WHITE OAK LANDING
20
Mattaponi River
15
10
MATT ENOS
5
MATT WILLIAMS
1
PAM LEANING HICKORY
PAM DUCKBLIND
Pamunkey River
PAM RES
PAM SOFFIN
PAM GLENNS
PAM JOHN
Mattaponi River Legend
Receivers
1 River Miles
1- Mile Delineations
Sep 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N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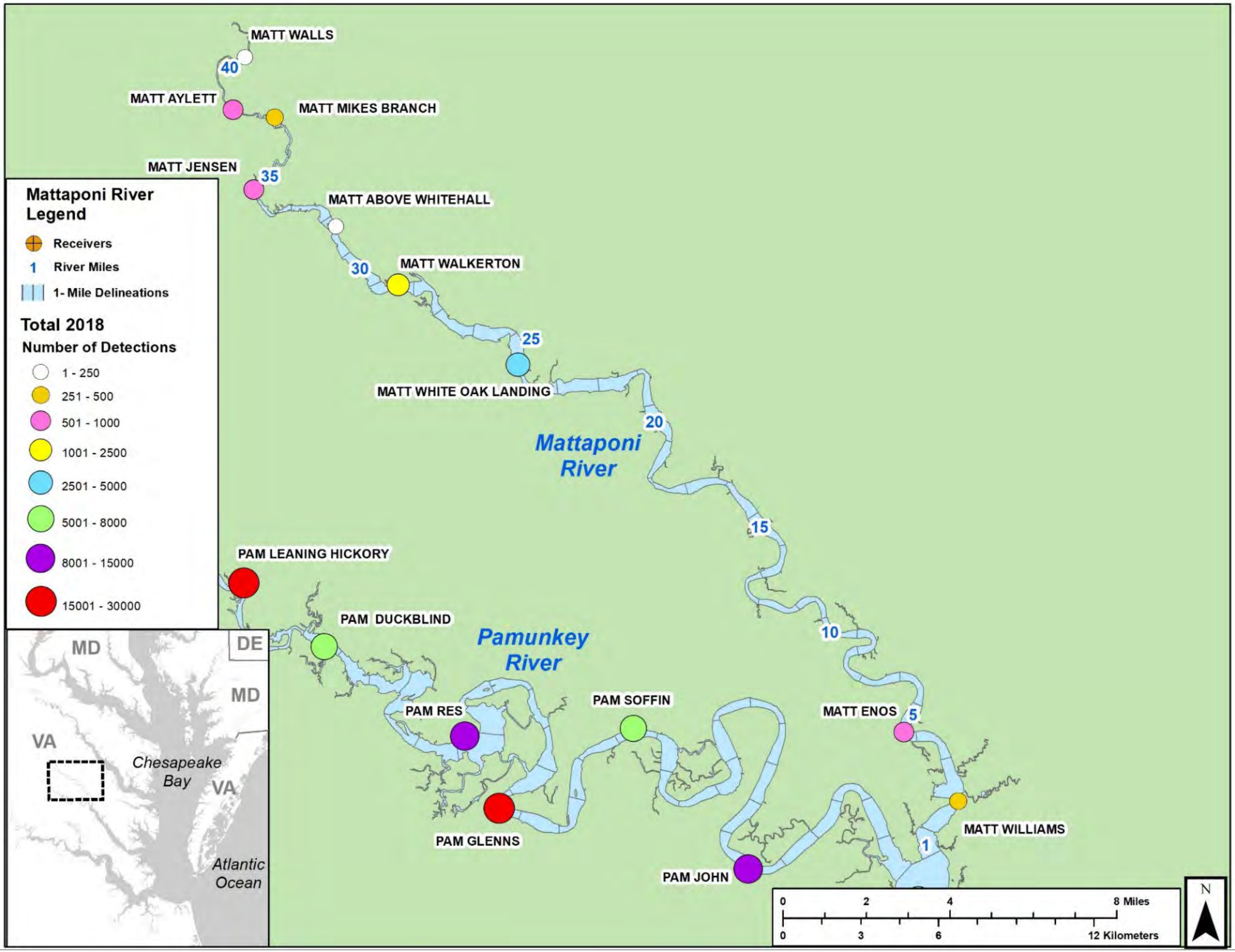
MATT AYLETT
MATT MIKES BRANCH
MATT JENSEN
35
MATT ABOVE WHITEHALL
30
MATT WALKERTON
25
MATT WHITE OAK LANDING
20
Mattaponi River
15
10
5
1
MATT ENOS
MATT WILLIAMS
PAM LEANING HICKORY
PAM DUCKBLIND
Pamunkey River
PAM RES
PAM SOFFIN
PAM GLENNS
PAM JOHN
Mattaponi River Legend
Receivers
River Miles
1- Mile Delineations
Oct 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N


MATT WALLS
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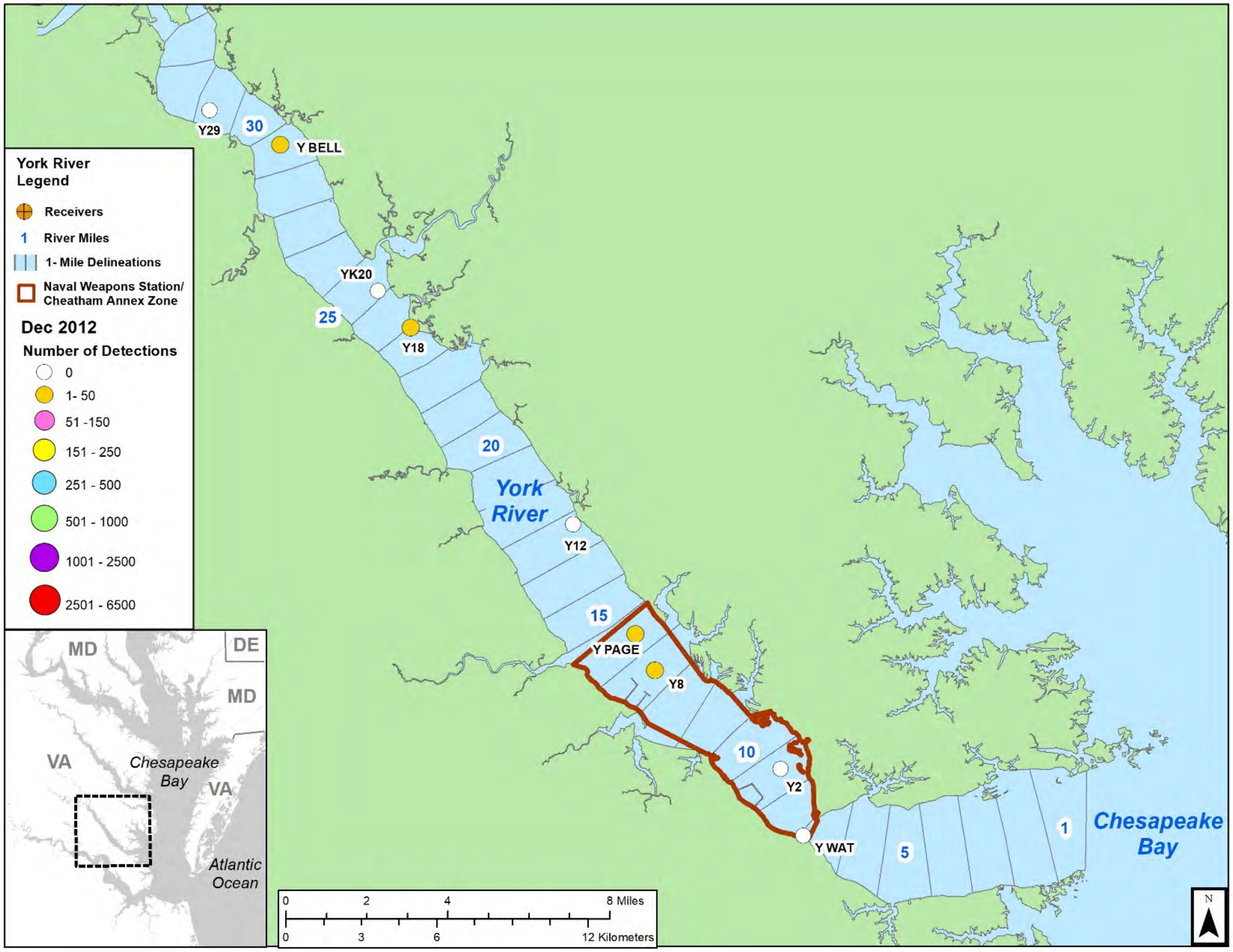
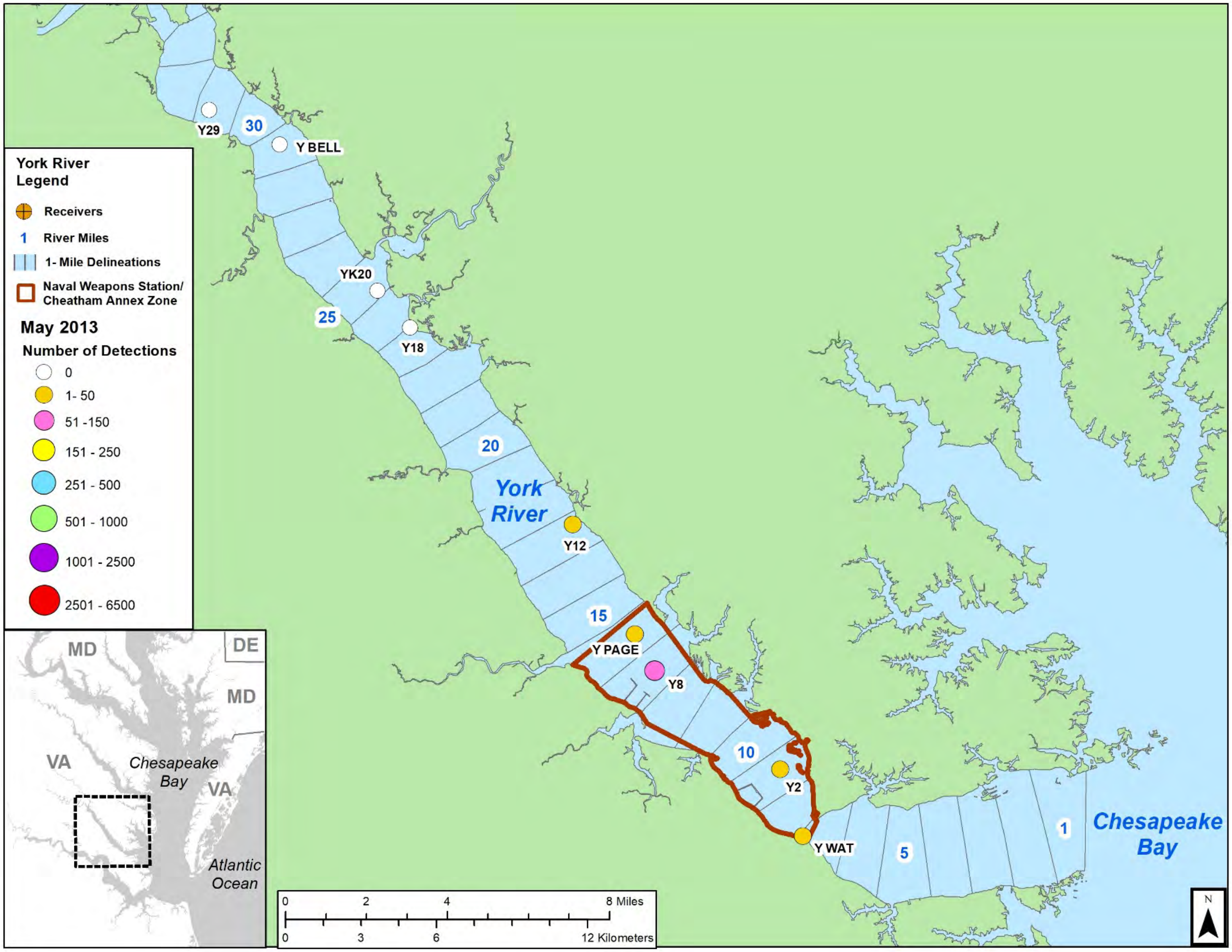
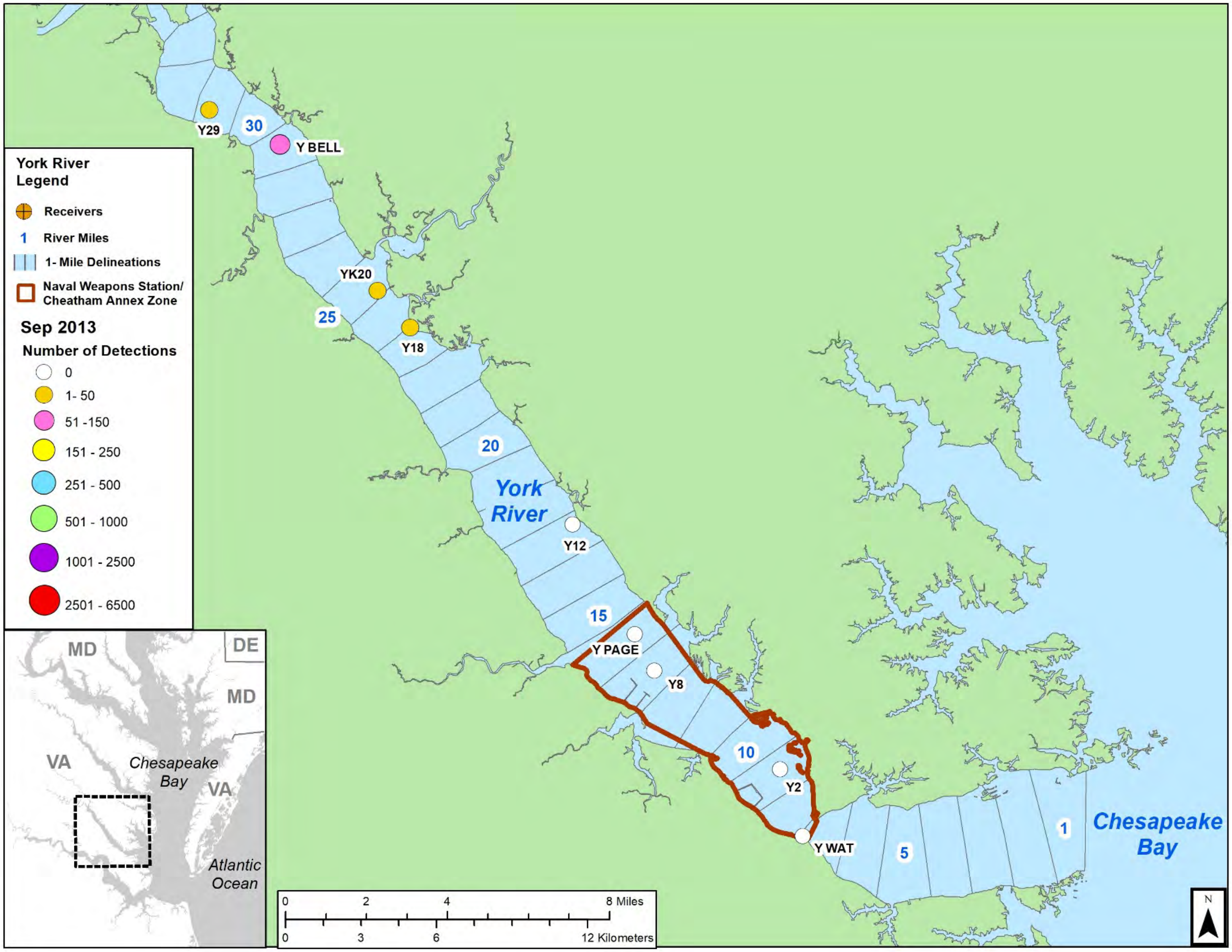
MATT AYLETT
MATT MIKES BRANCH
MATT JENSEN
35
MATT ABOVE WHITEHALL
30
MATT WALKERTON
25
MATT WHITE OAK LANDING
20
Mattaponi River
15
10
MATT ENOS
5
MATT WILLIAMS
1
PAM LEANING HICKORY
PAM DUCKBLIND
Pamunkey River
PAM RES
PAM SOFFIN
PAM GLENNS
PAM JOHN
Mattaponi River Legend
Receivers
River Miles
1- Mile Delineations
Total 2018
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
2
4
8 Miles
0
3
6
12 Kilometers
N

8.5. Appendix 8.5: Detections of Sonic-tagged Atlantic Sturgeon in the York River Region (Naval Weapons Station Yorktown and Cheatham Annex Zone), by Month, Year, and Overall




York River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
May 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Y29
30
Y BELL
YK20
25
Y18
20
York River
Y12
15
Y PAGE
Y8
10
Y2
Y WAT
5
1
Chesapeake Bay
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N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1 River Miles
1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Sep 2013
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Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
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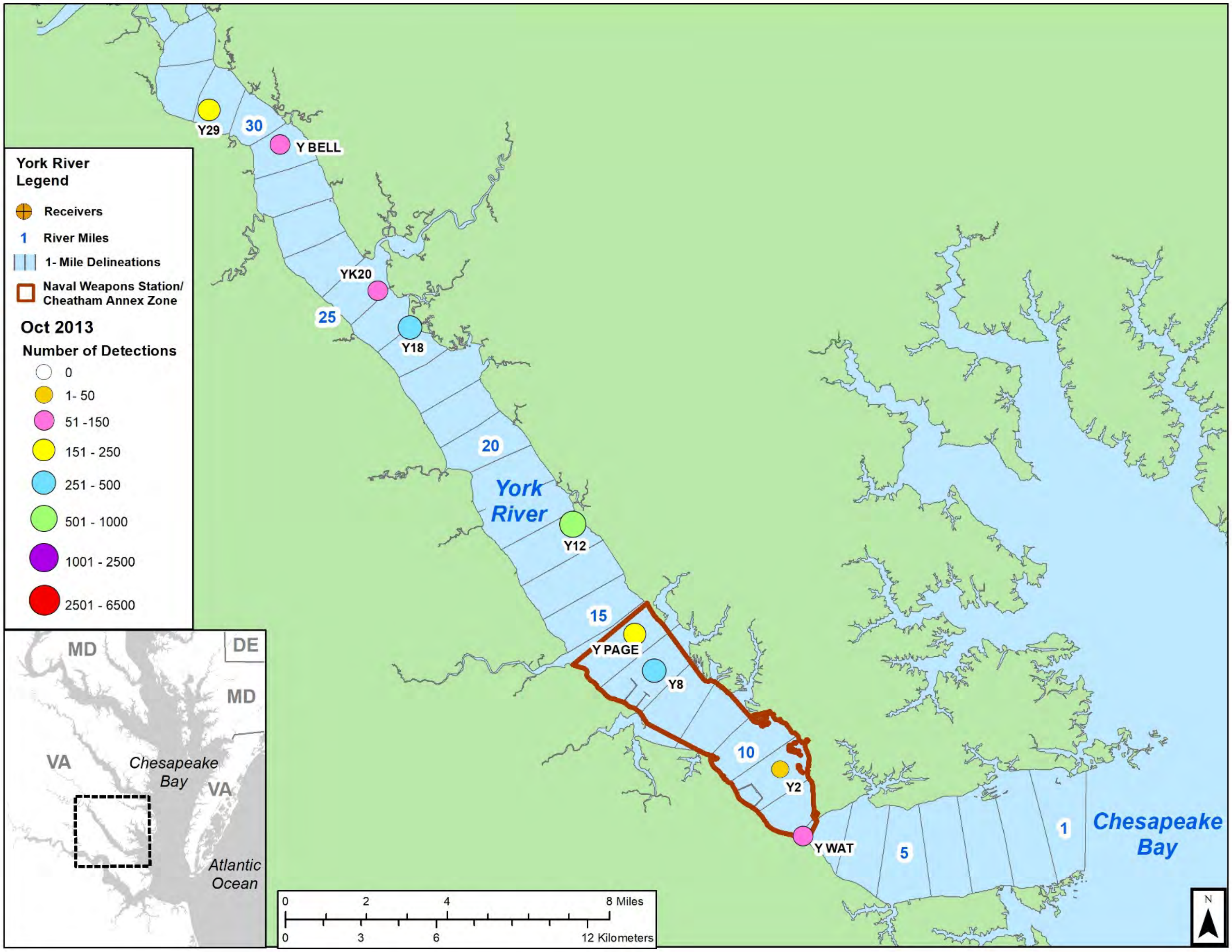
York River Legend
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Naval Weapons Station/ Cheatham Annex Zone
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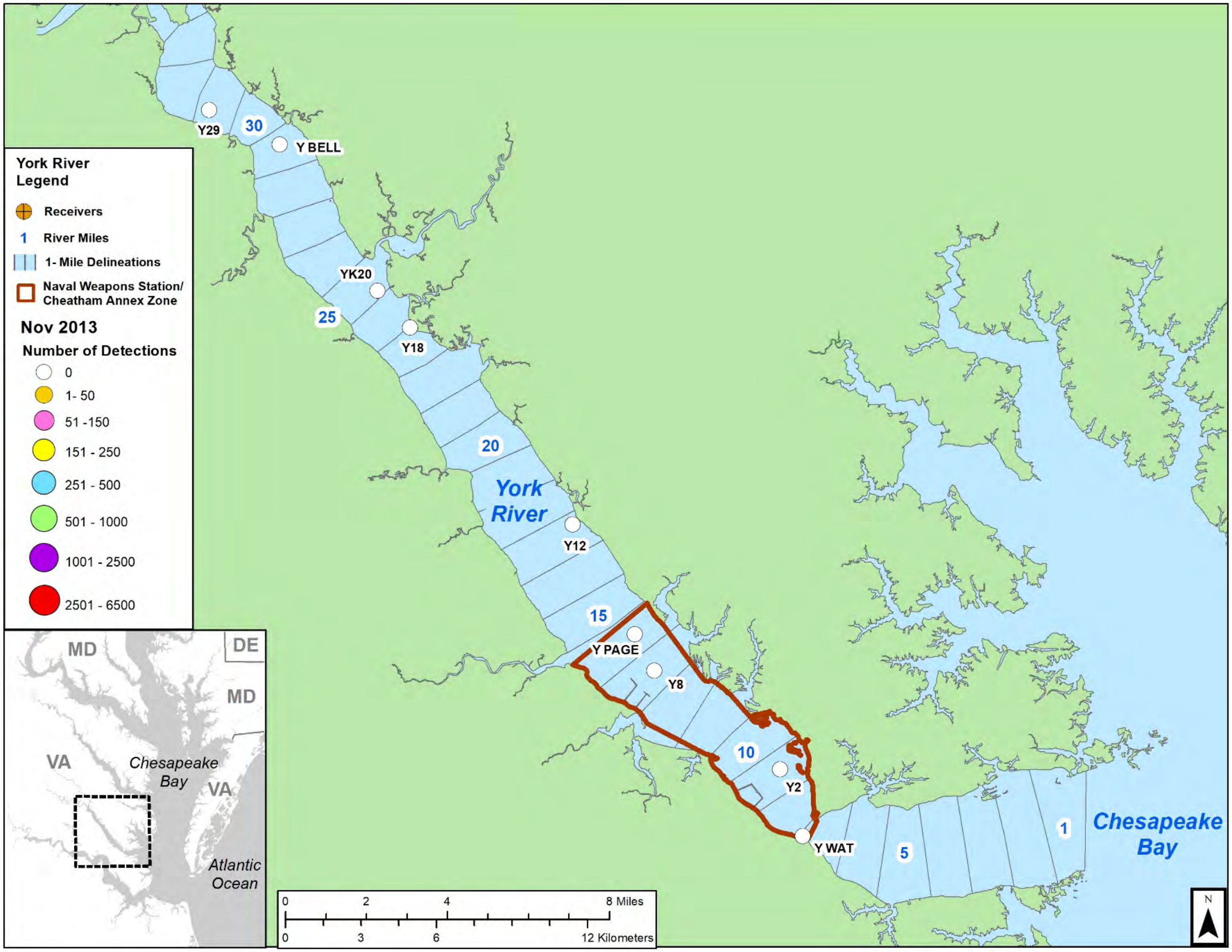

York River
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Naval Weapons Station/ Cheatham Annex Zone
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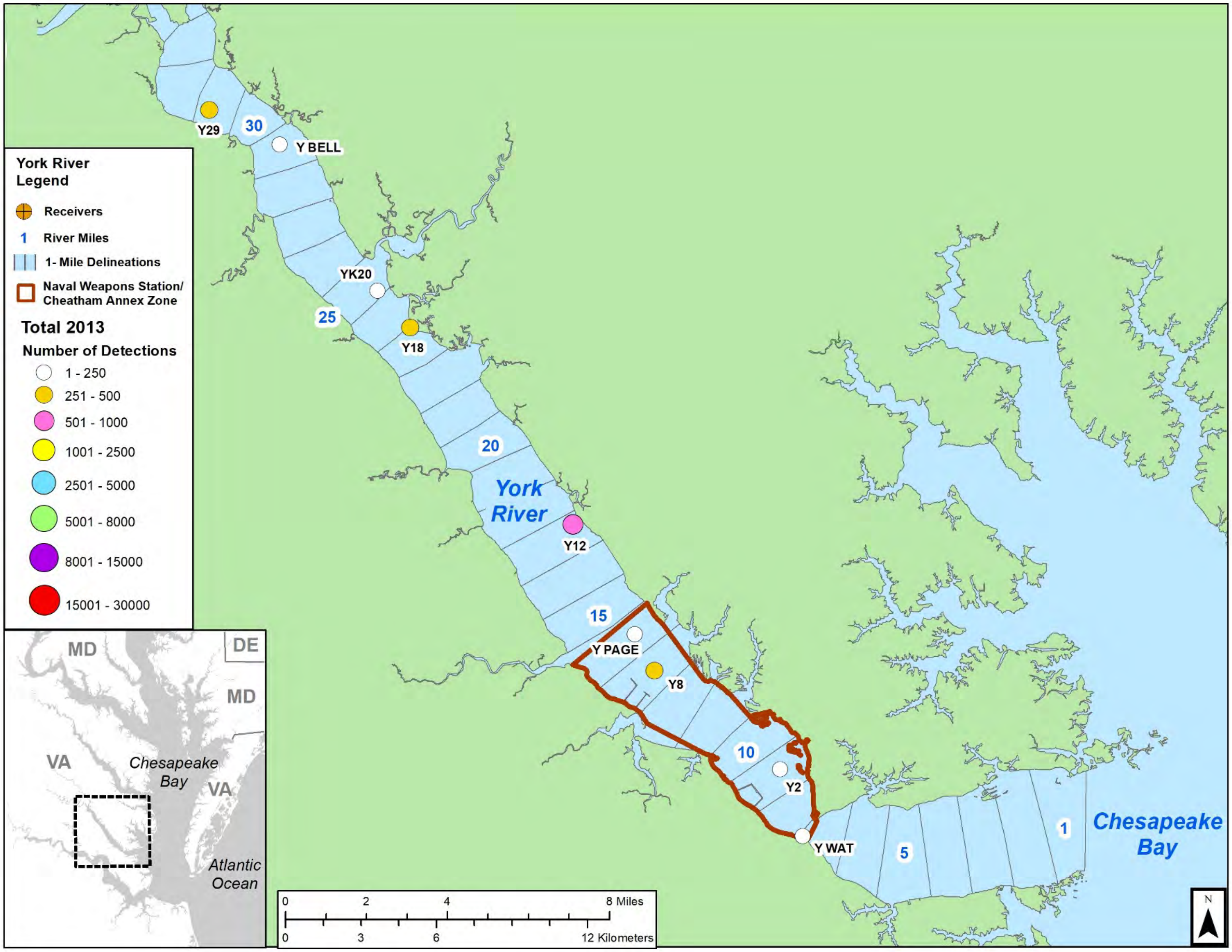
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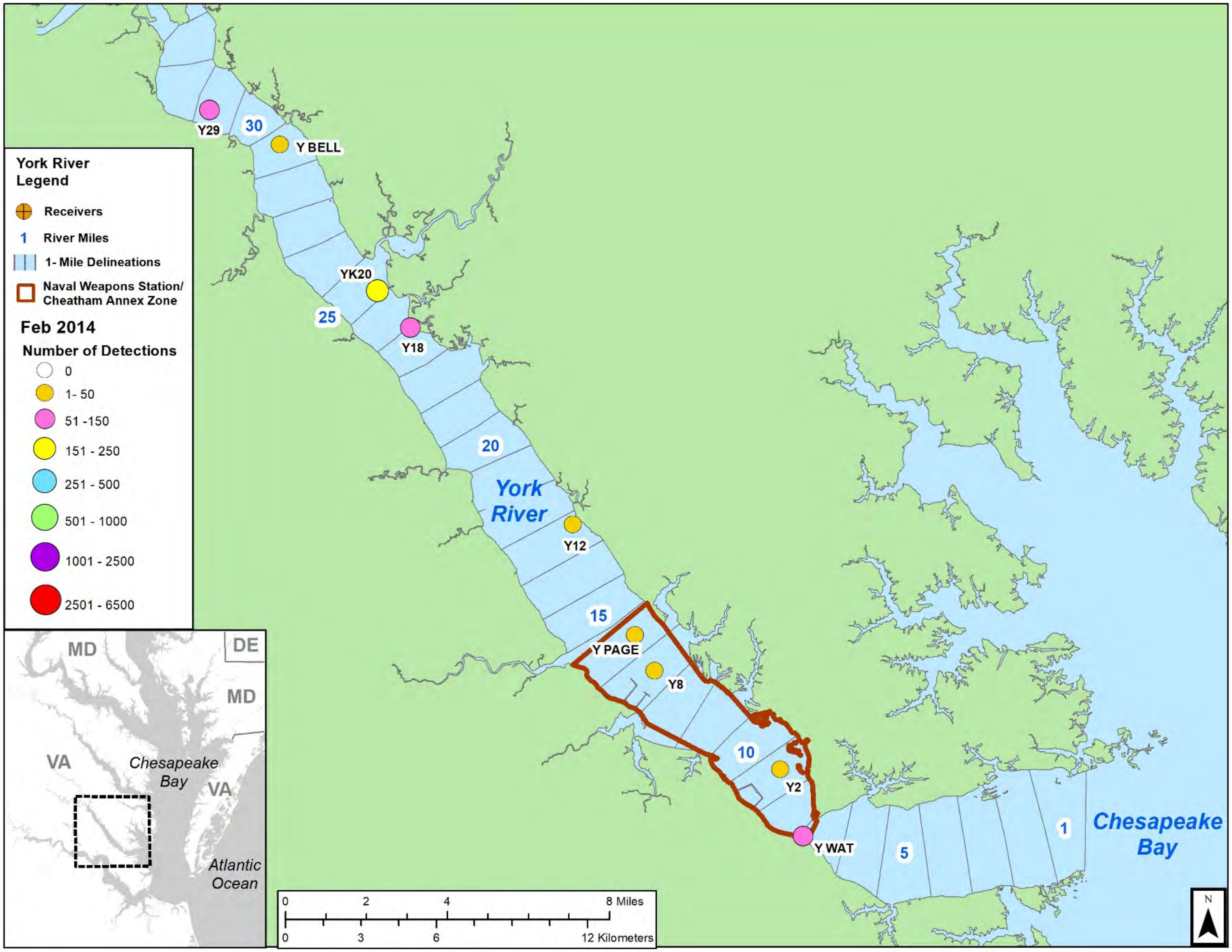
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Atlantic Ocean
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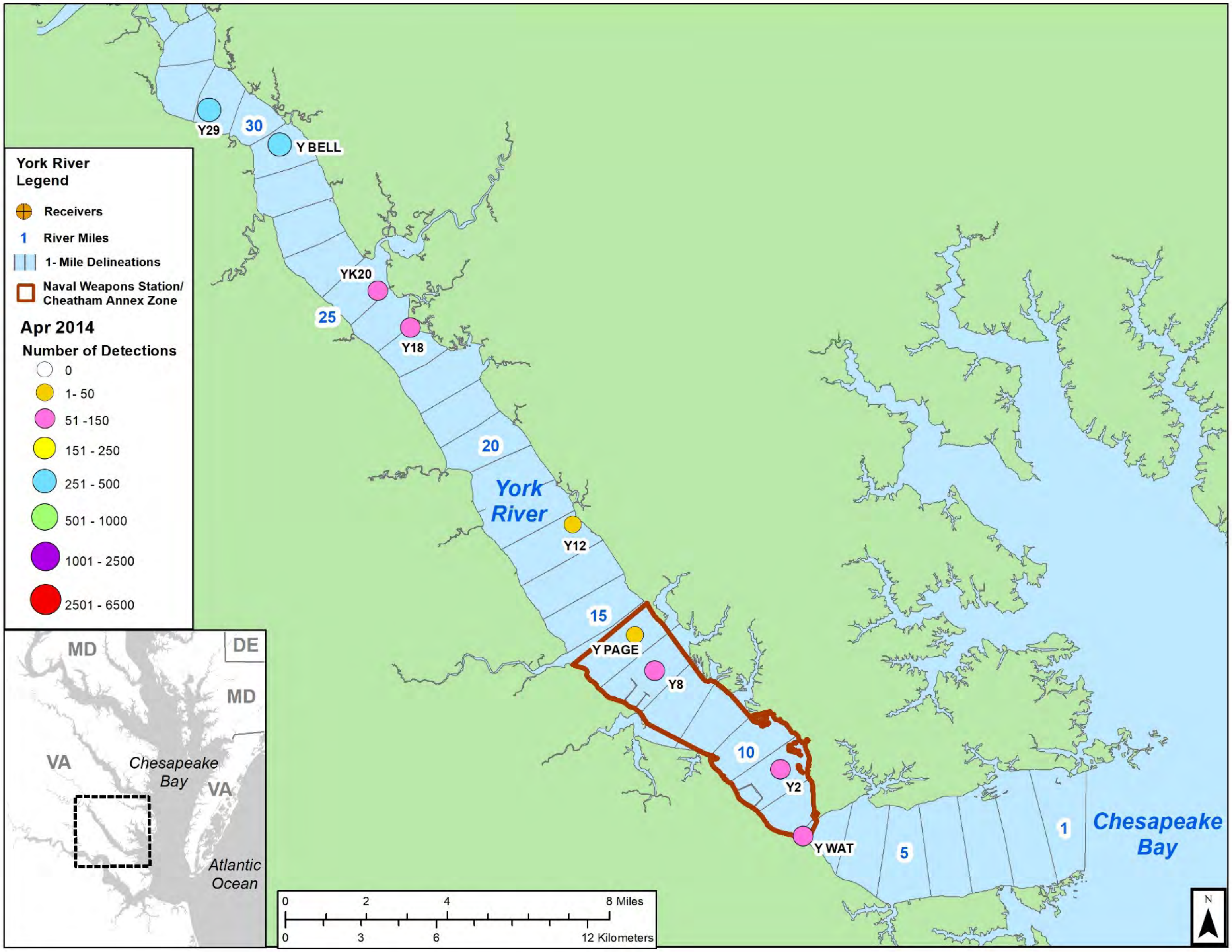
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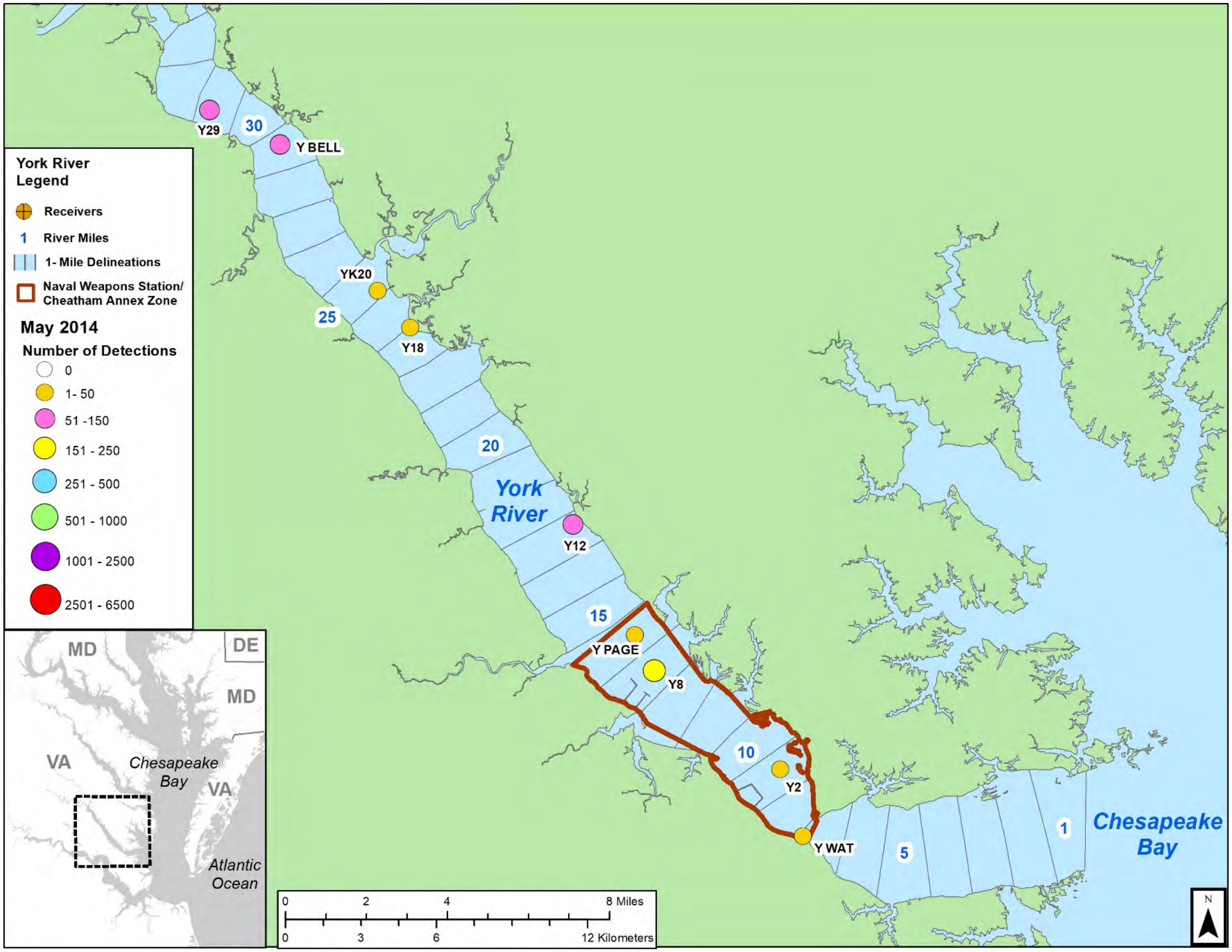
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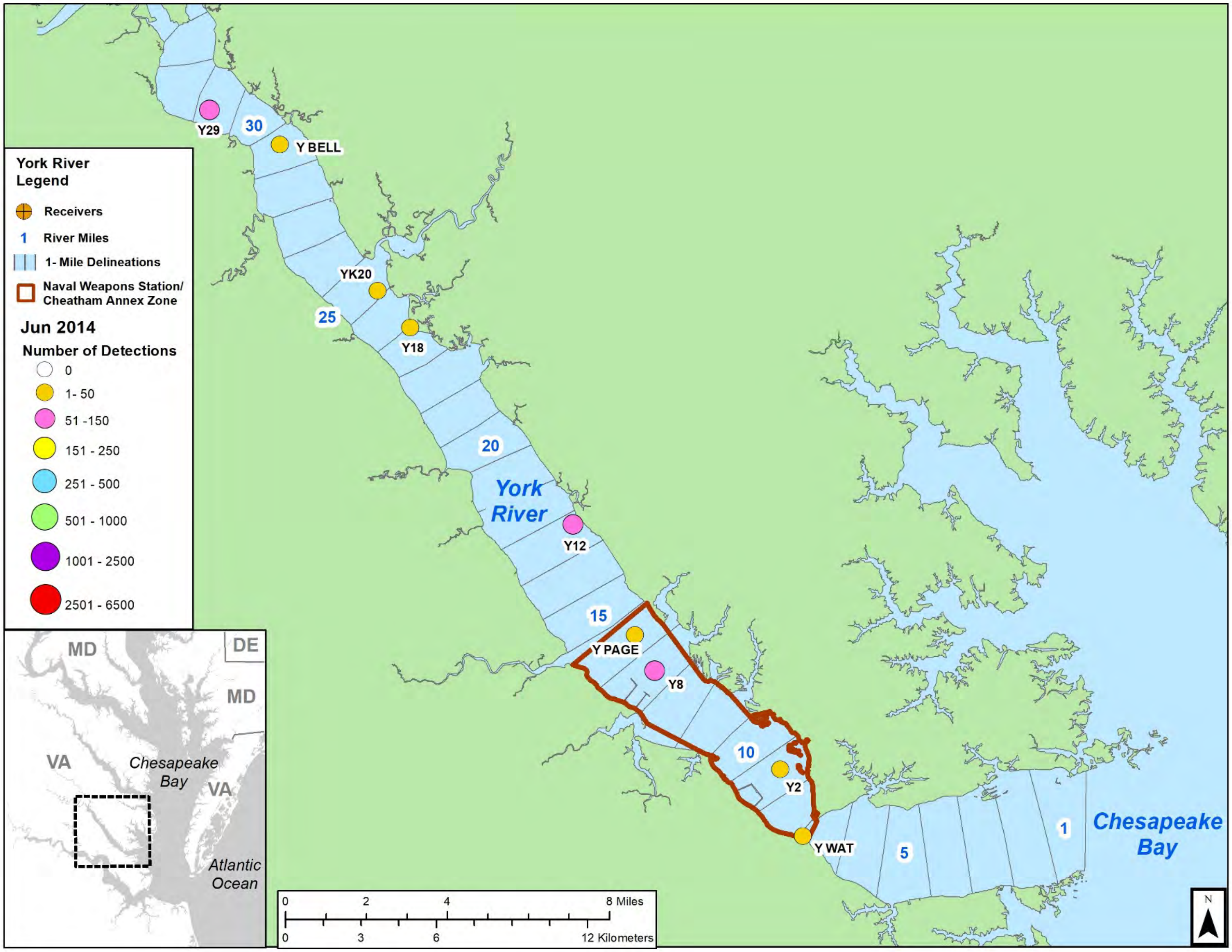
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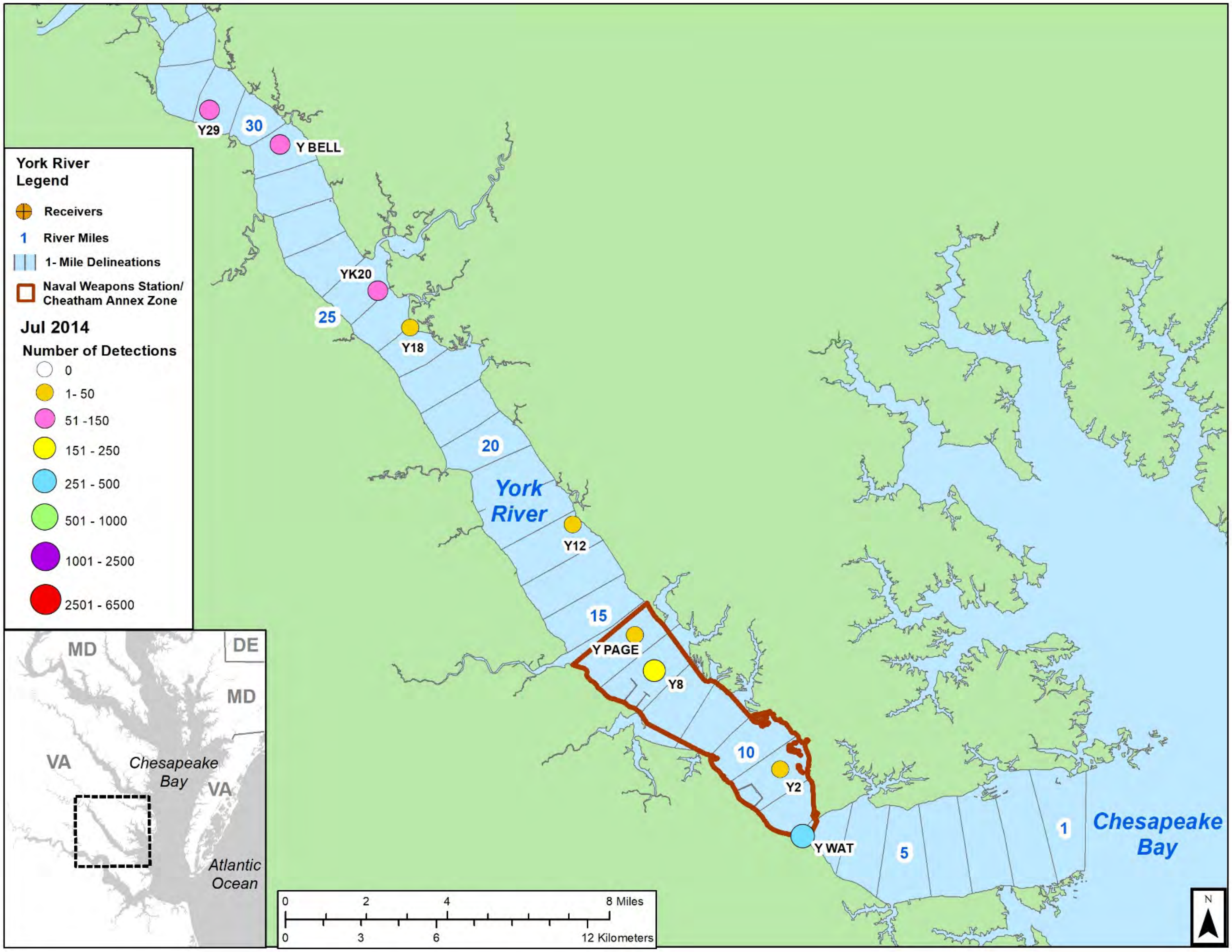
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Atlantic Ocean
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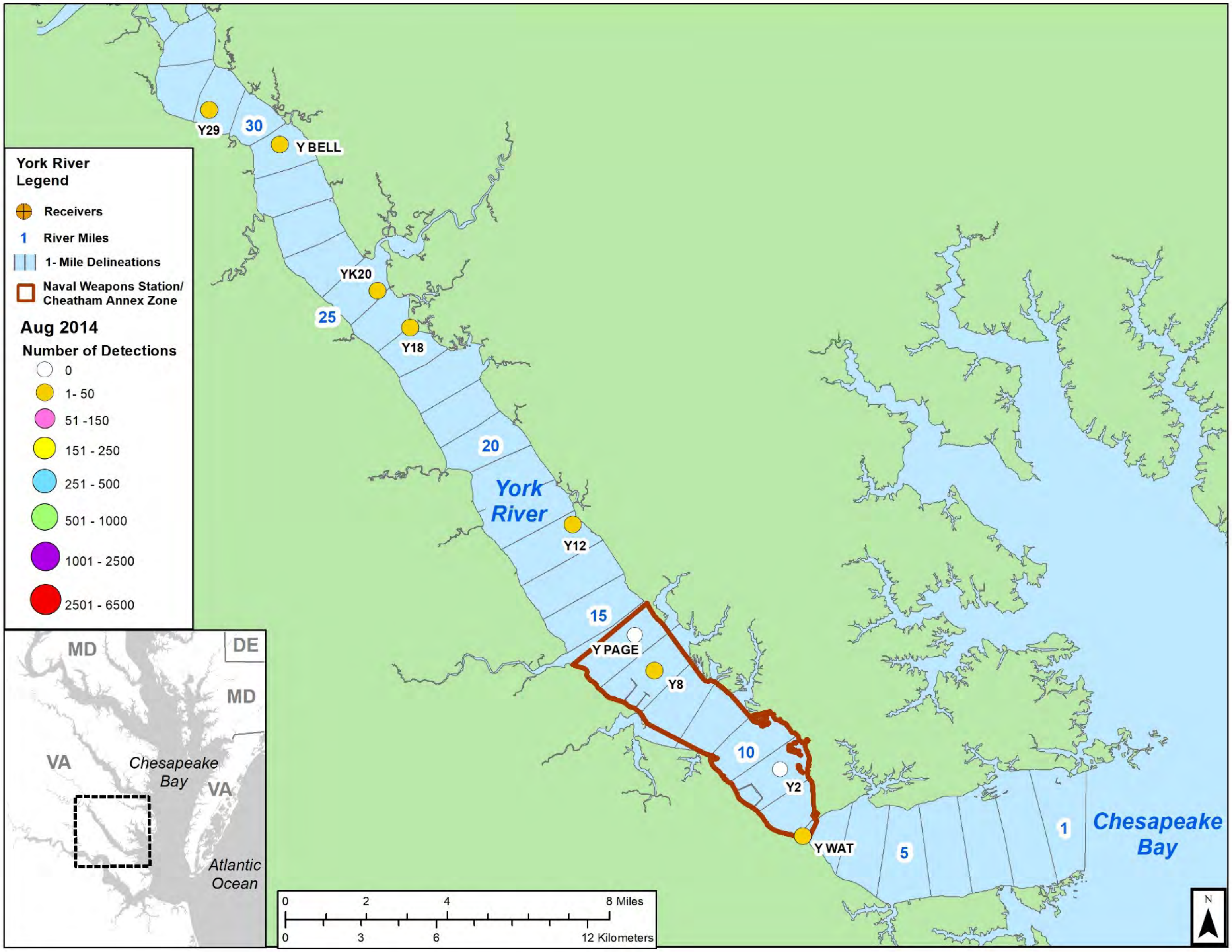
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Naval Weapons Station/ Cheatham Annex Zone
Aug 2014
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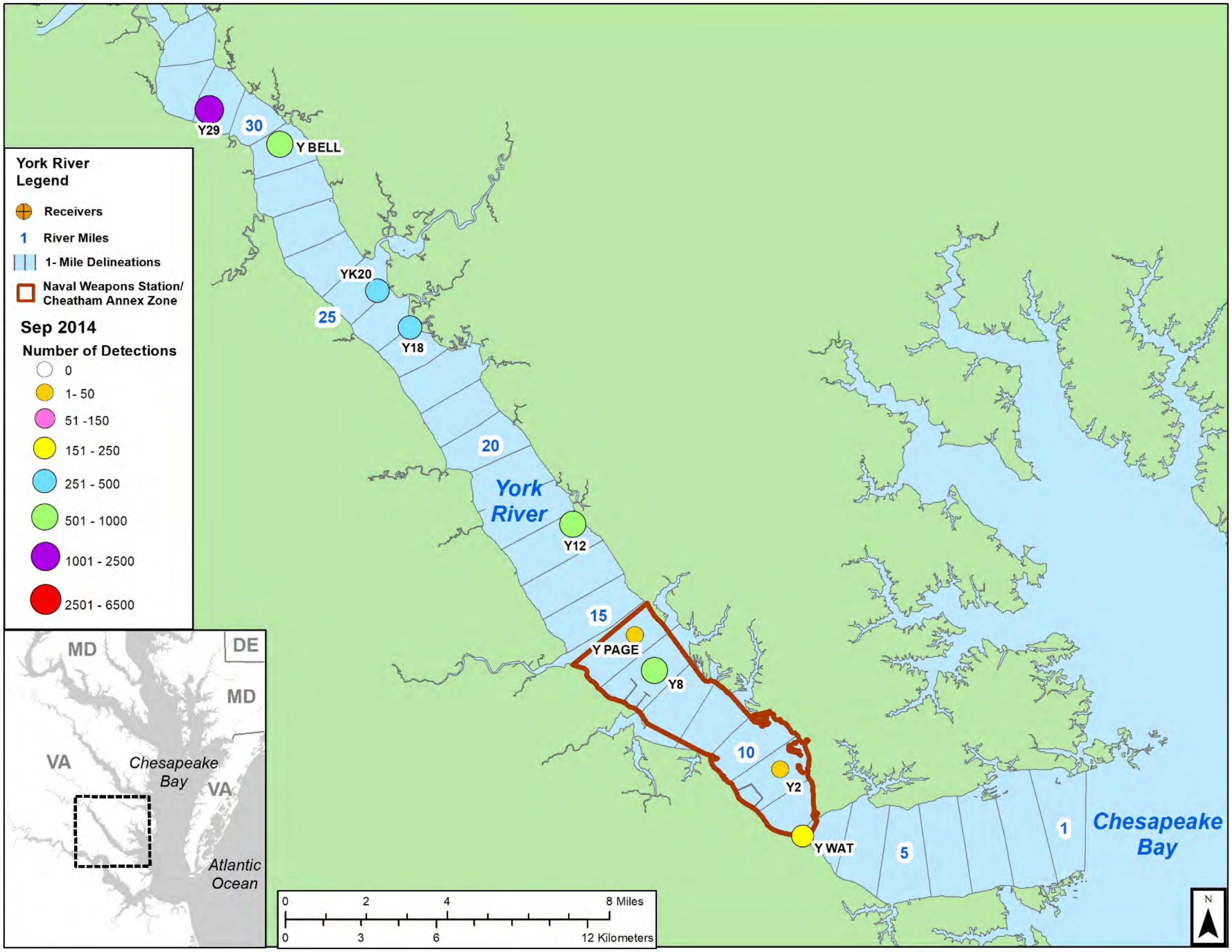
York River Legend
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Naval Weapons Station/ Cheatham Annex Zone
Sep 2014
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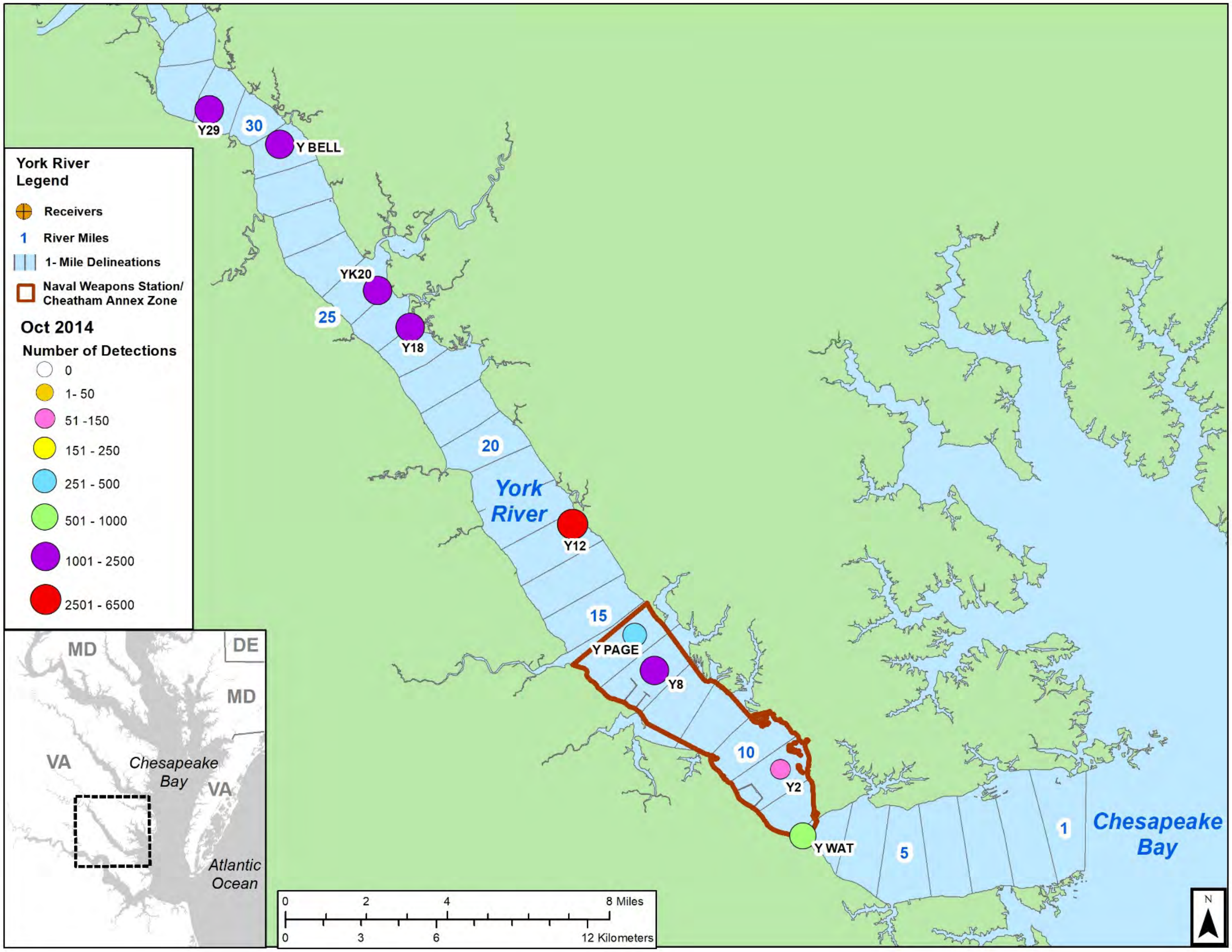
York River Legend
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Naval Weapons Station/ Cheatham Annex Zone
Oct 2014
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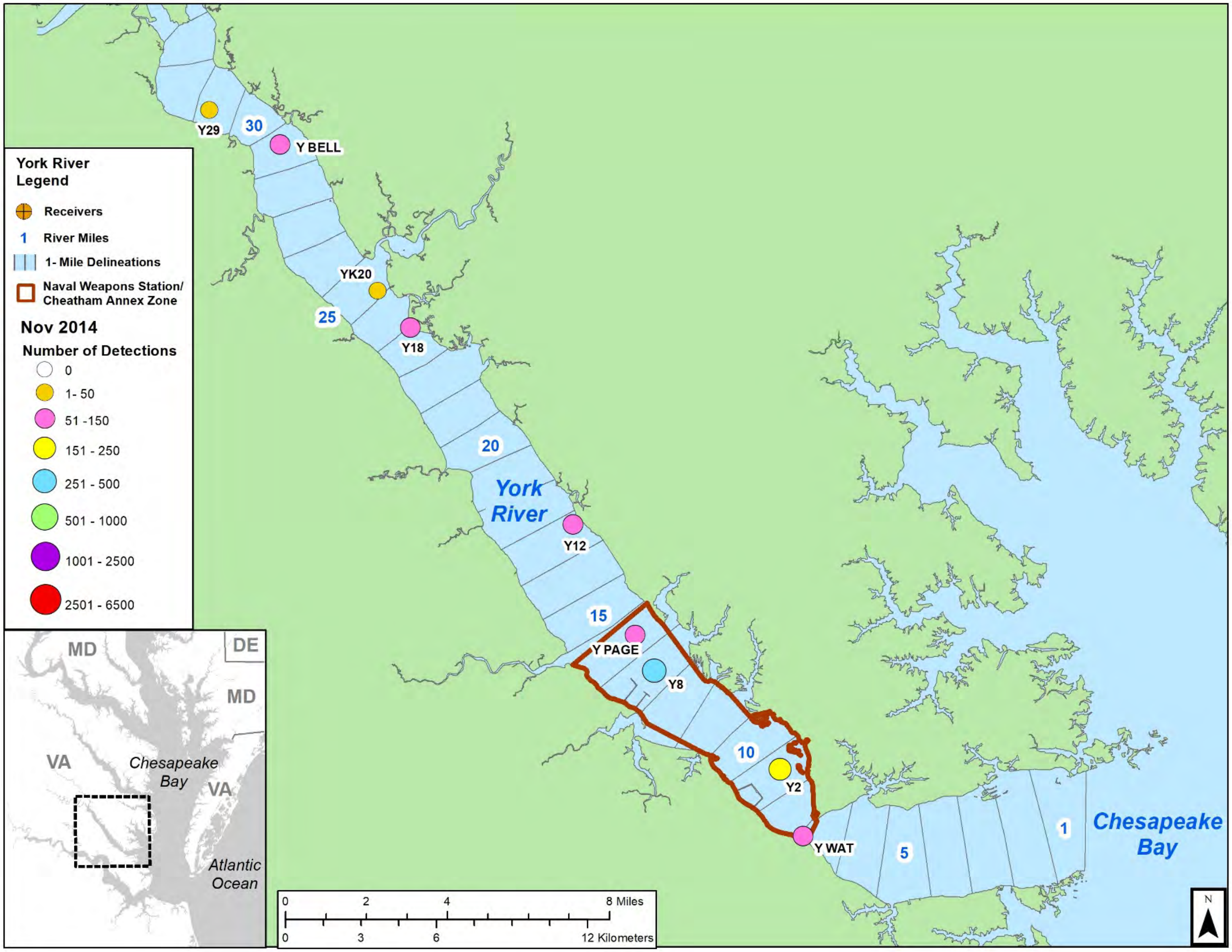
York River Legend
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Nov 2014
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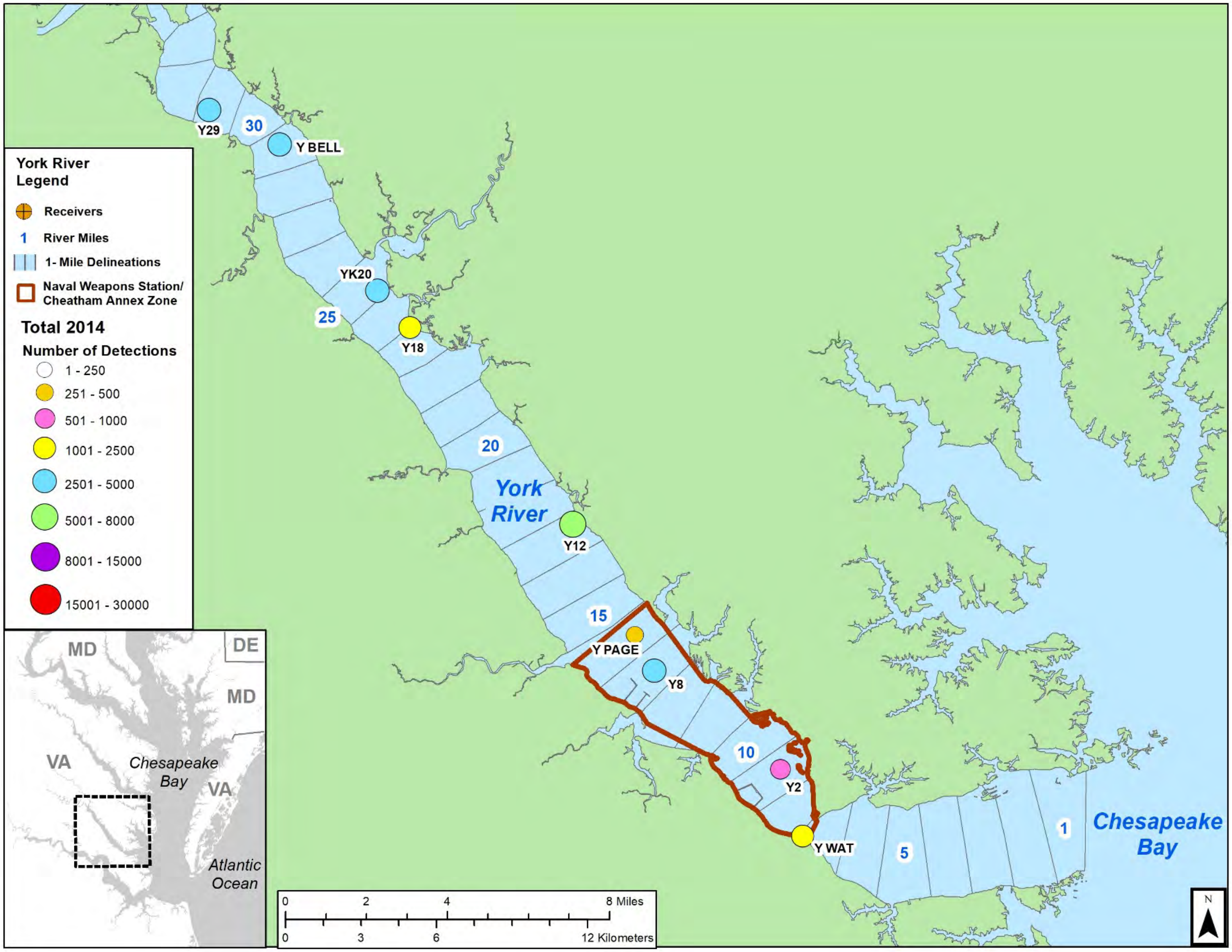
York River
Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Total 2014
Number of Detections
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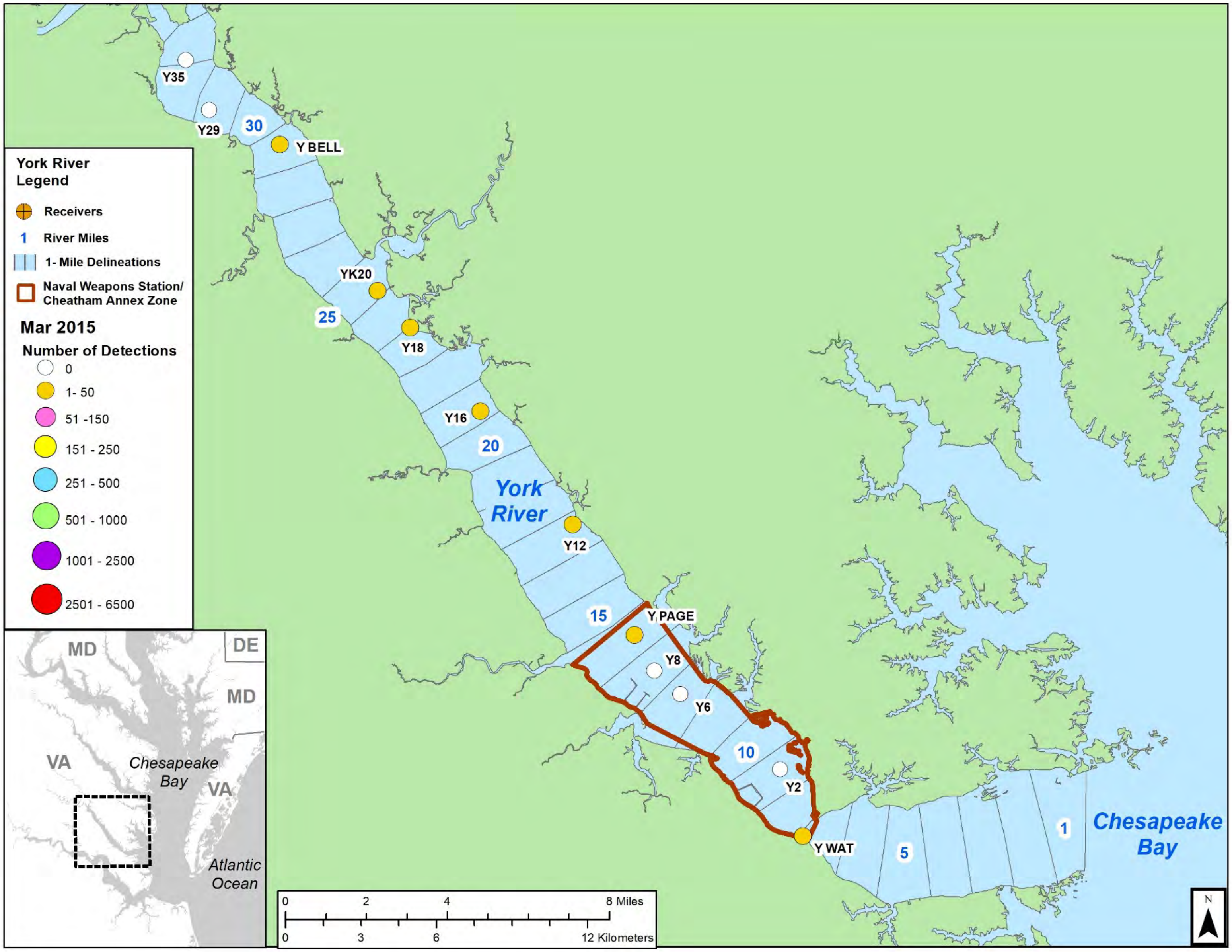
York River Legend
Receivers
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Naval Weapons Station/ Cheatham Annex Zone
Mar 2015
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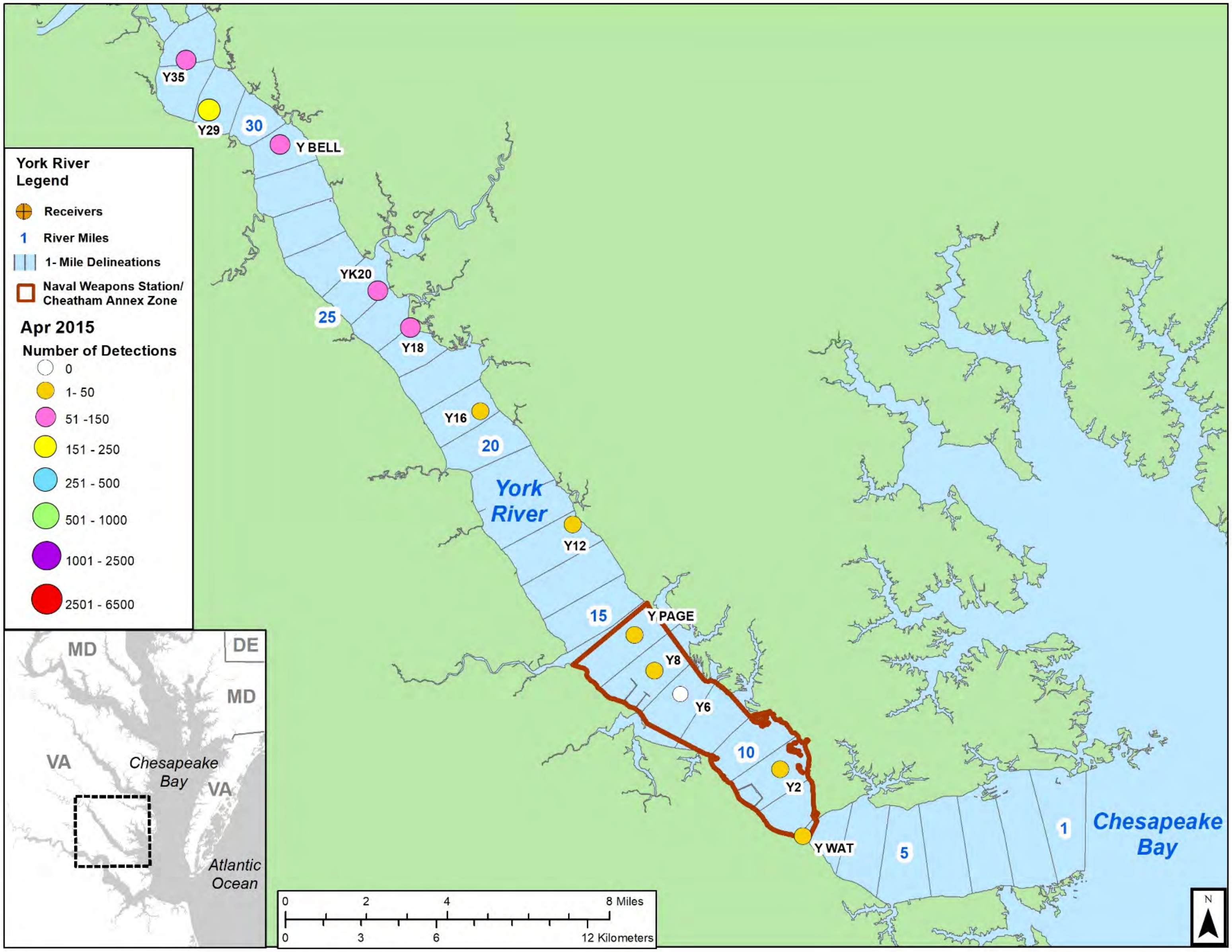
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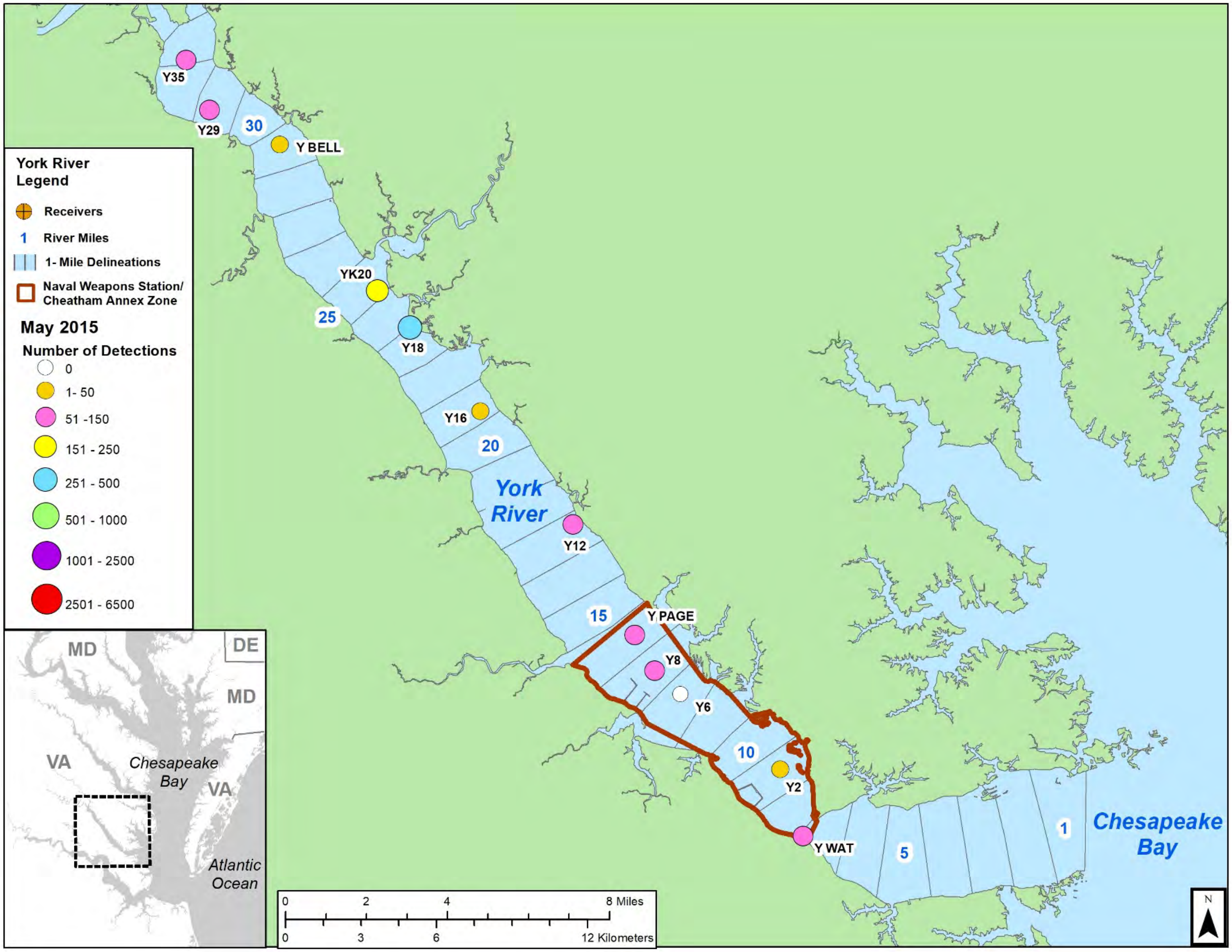
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Naval Weapons Station/ Cheatham Annex Zone
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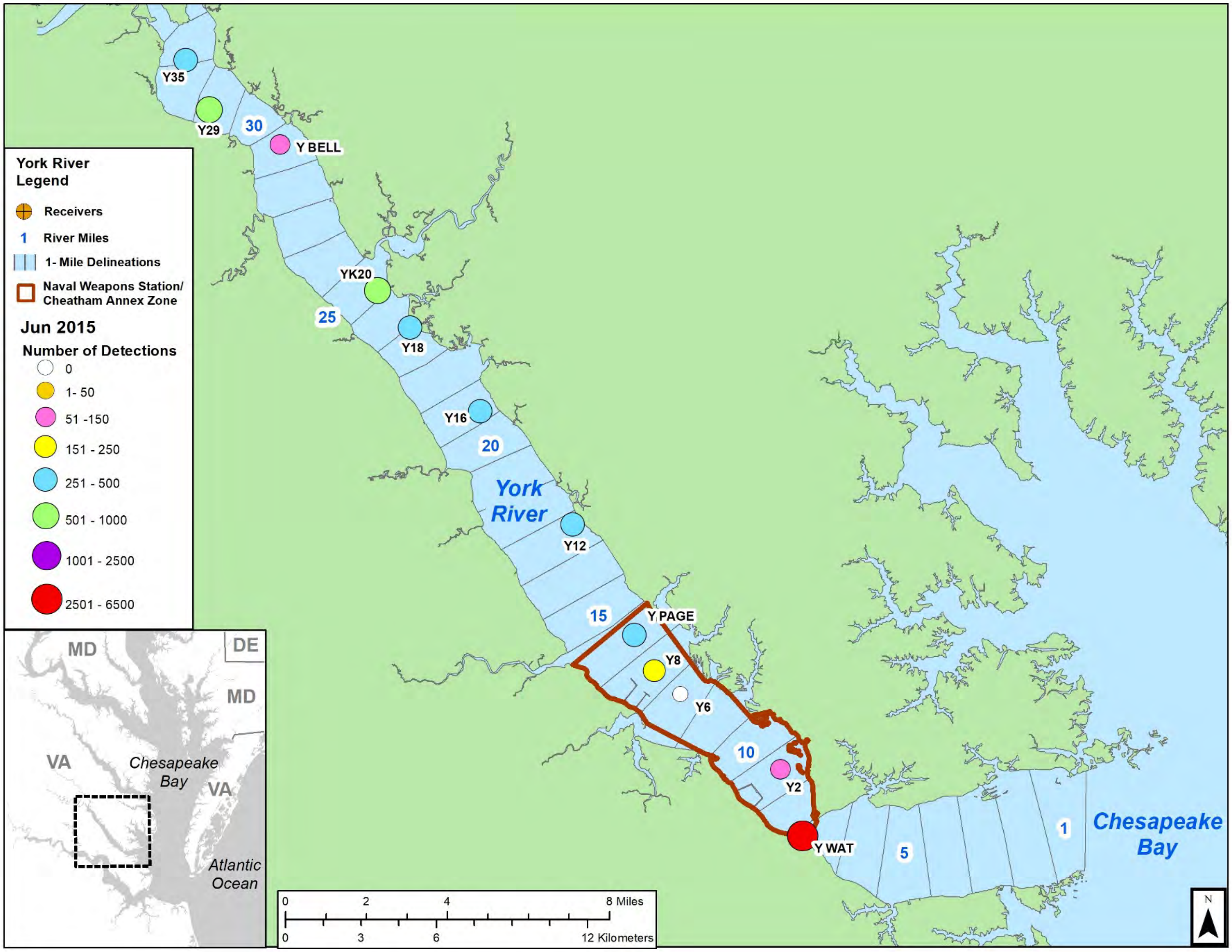
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Naval Weapons Station/ Cheatham Annex Zone
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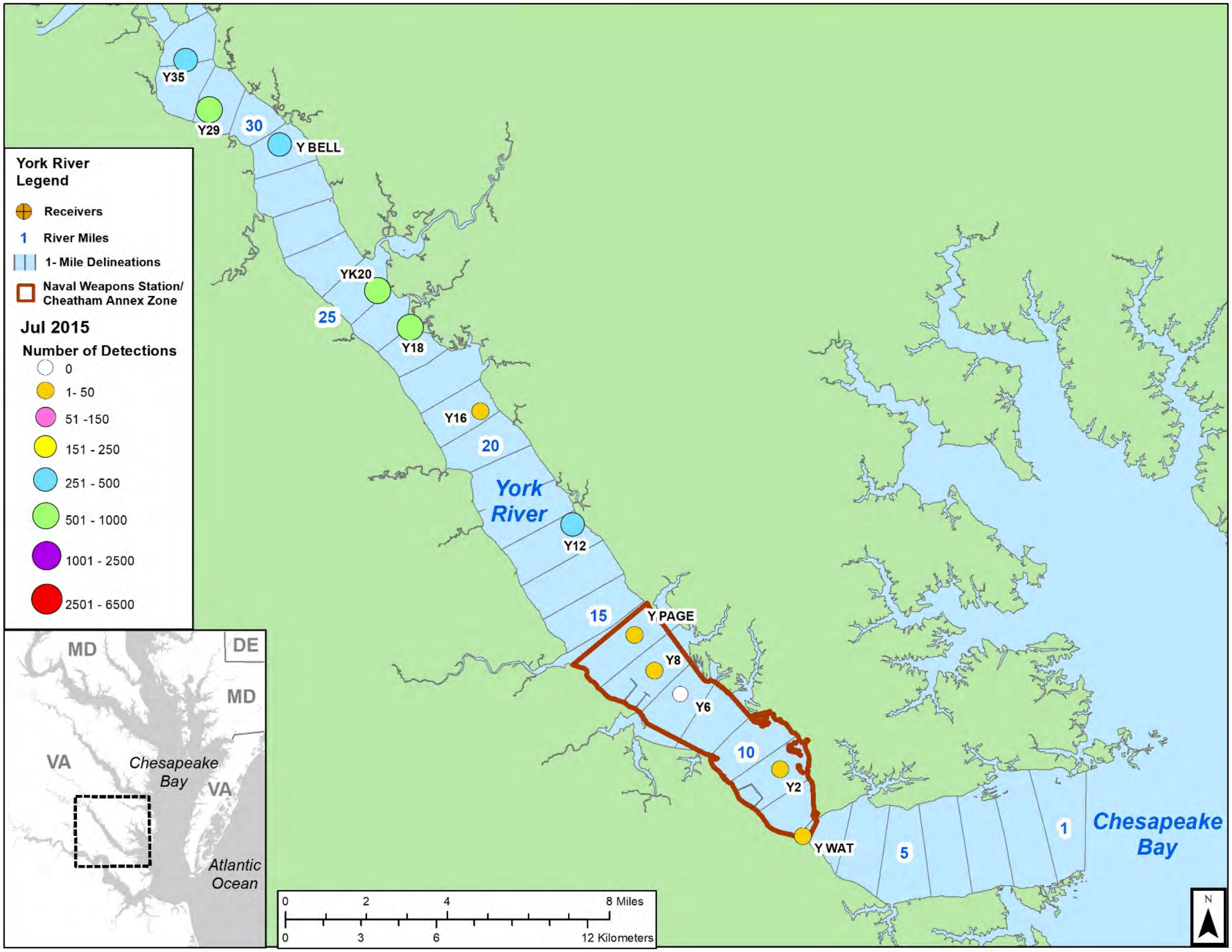
York River
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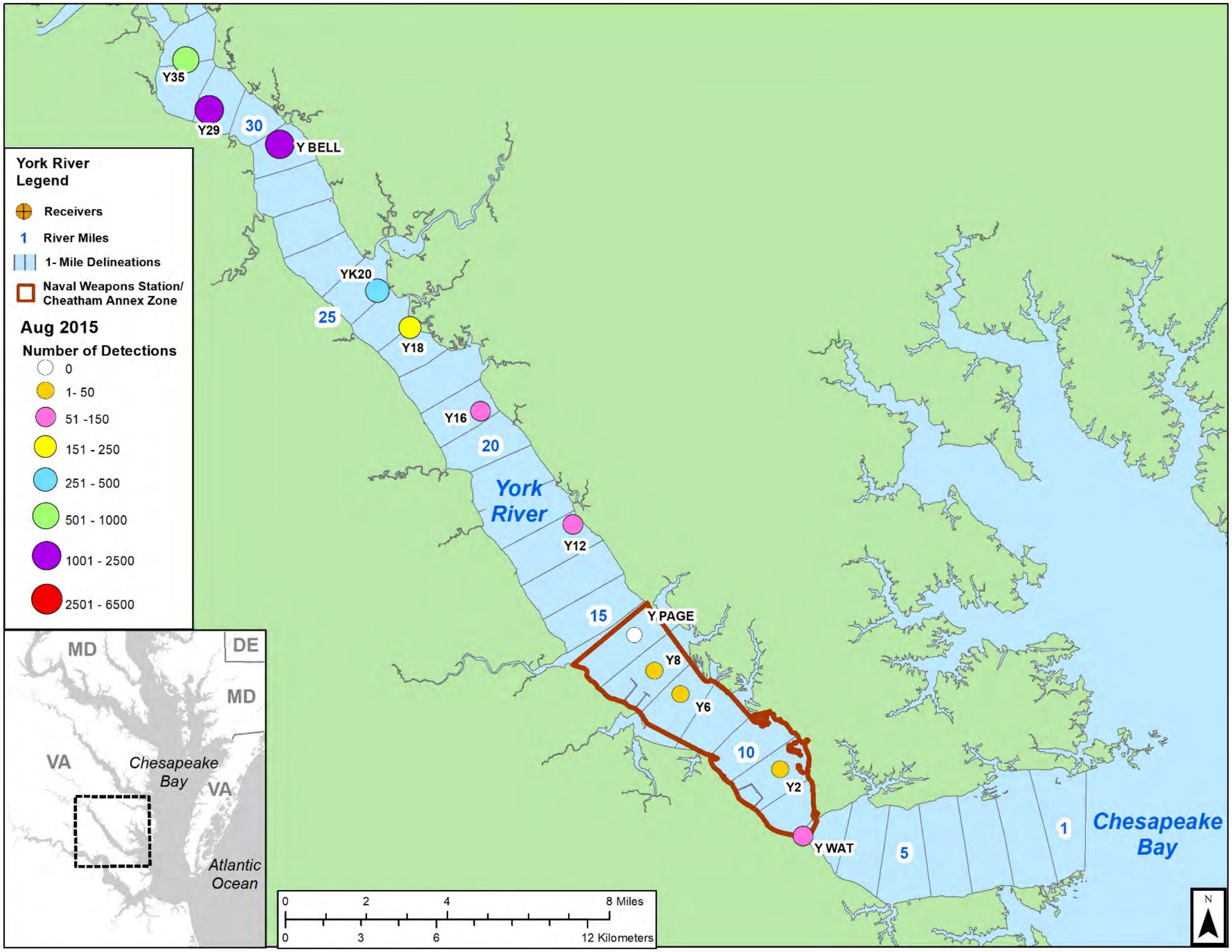
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Naval Weapons Station/ Cheatham Annex Zone
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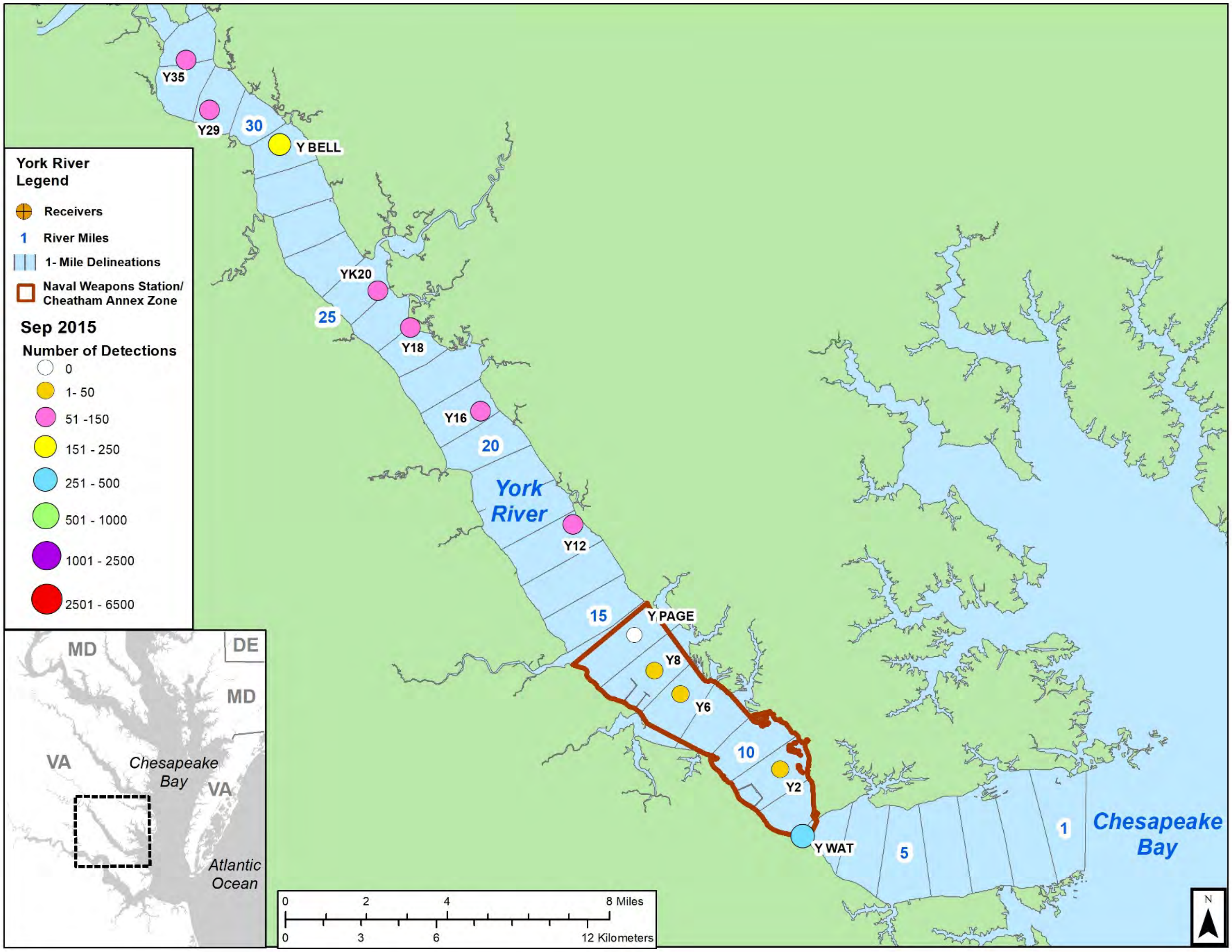
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Naval Weapons Station/ Cheatham Annex Zone
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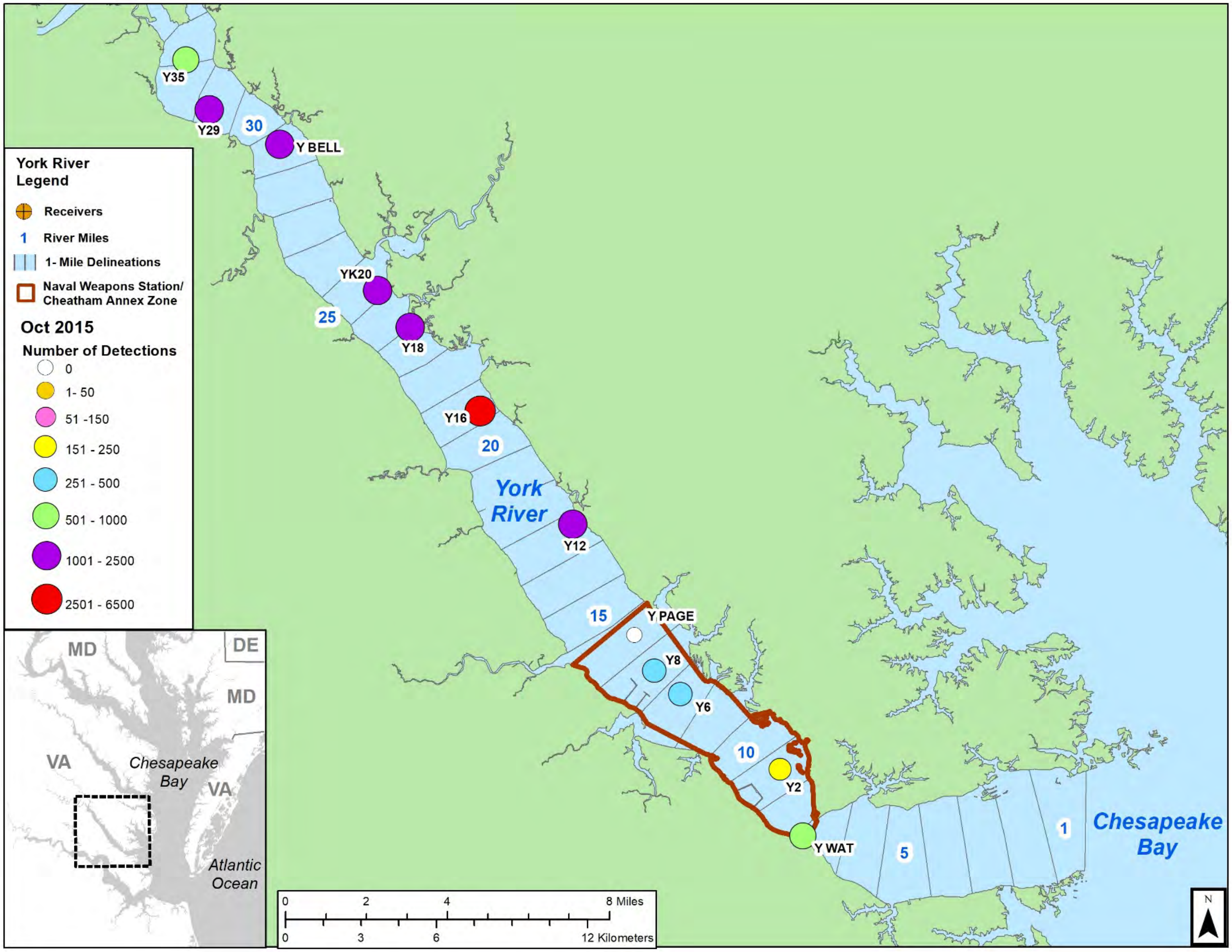
York River Legend
Receivers
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1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Oct 2015
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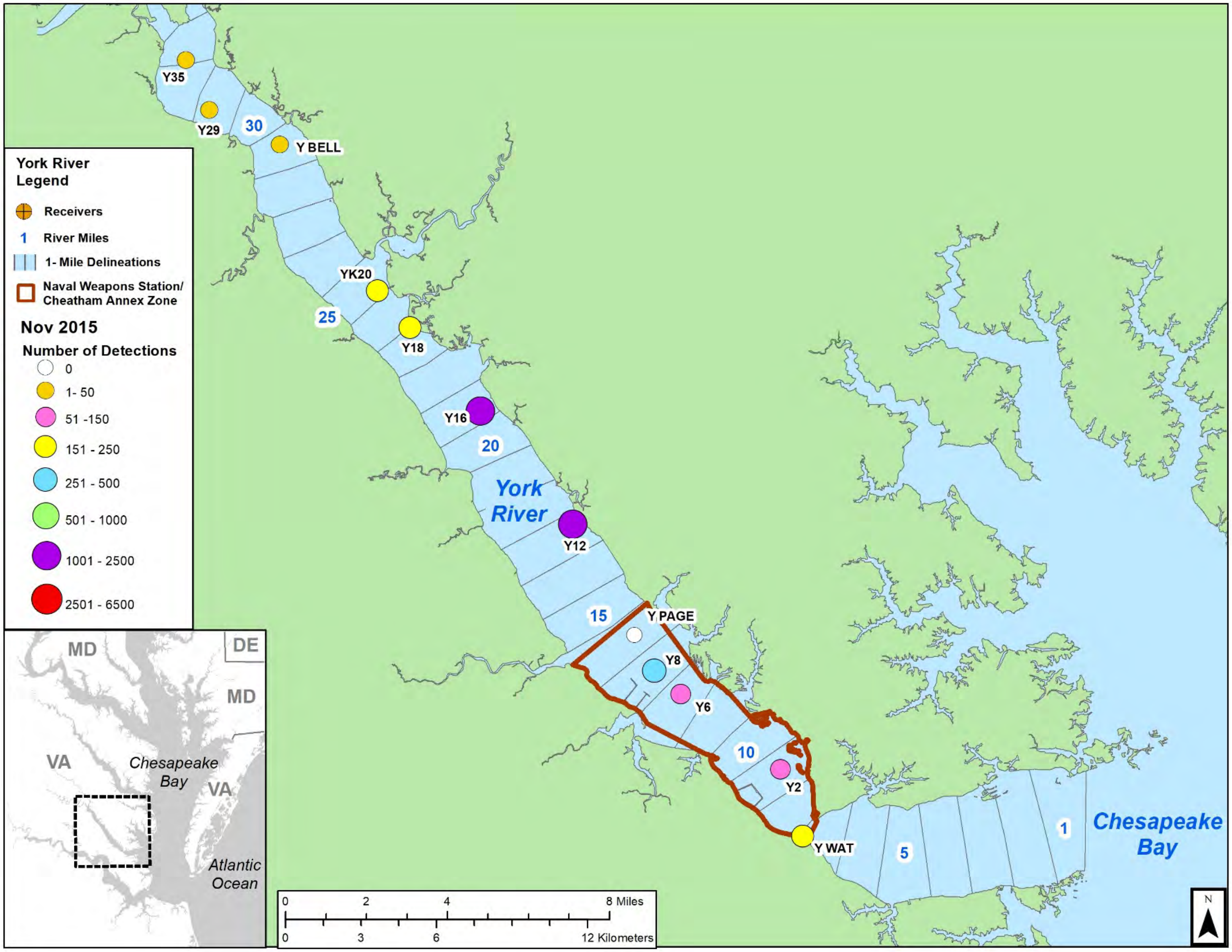
York River Legend
Receivers
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1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Nov 2015
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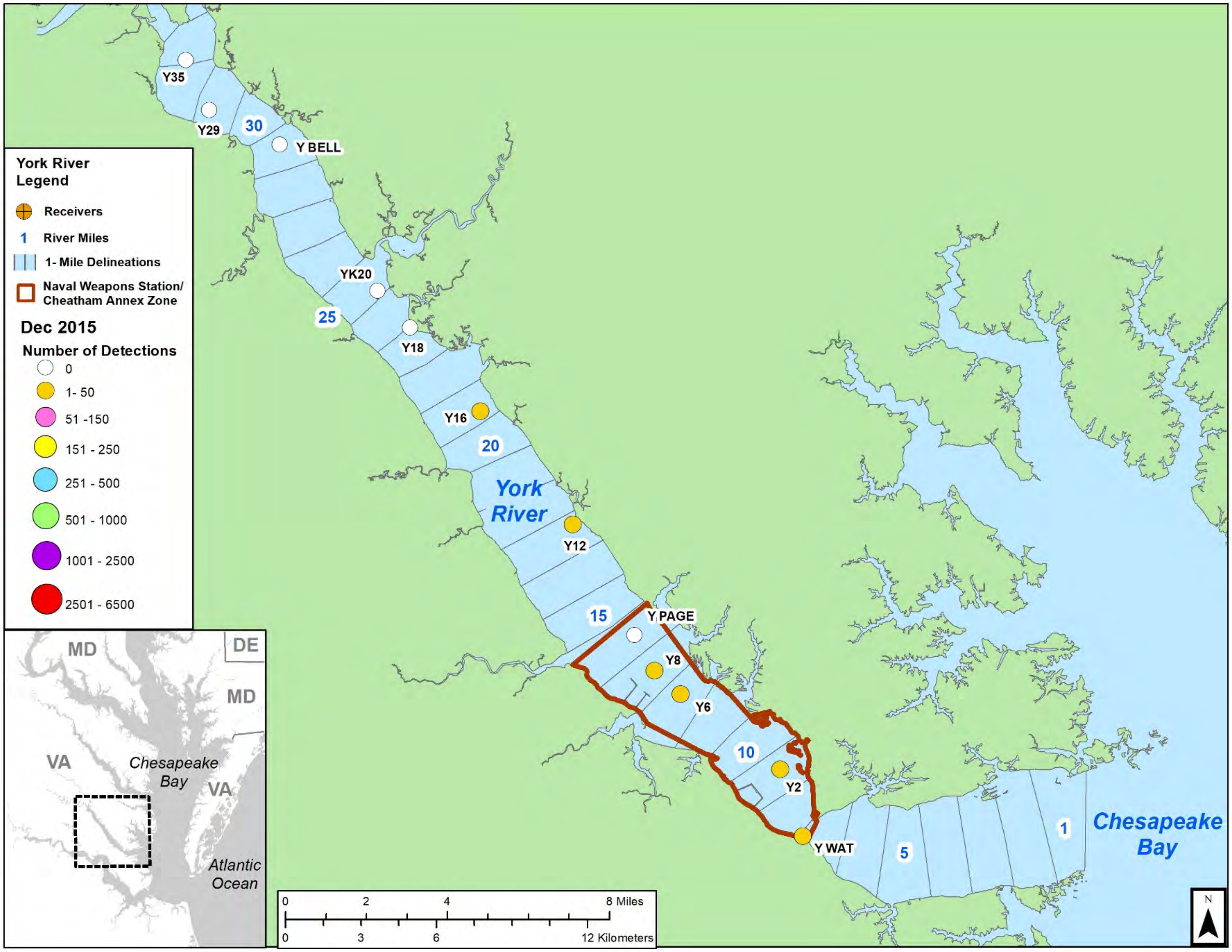
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1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Dec 2015
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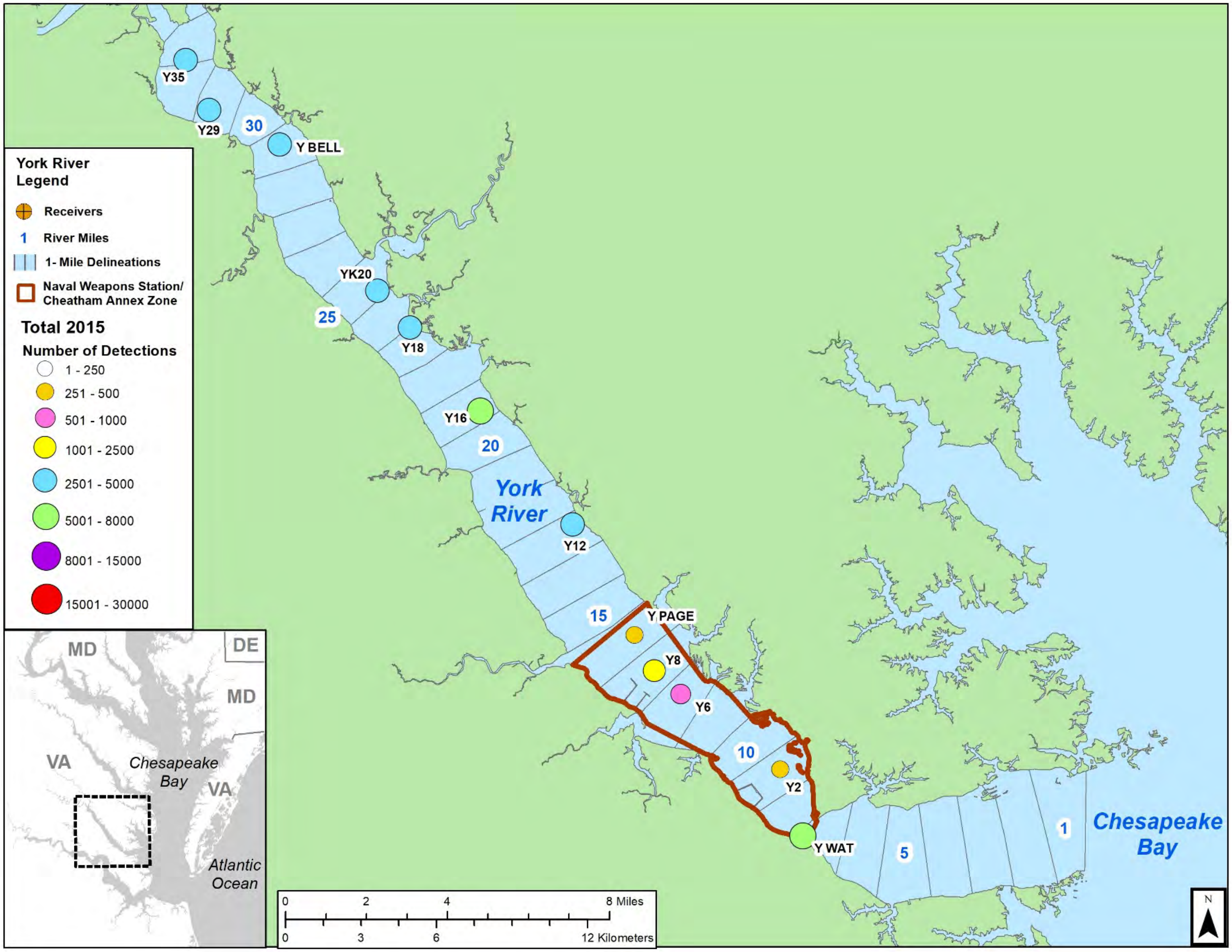
York River Legend
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1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Total 2015
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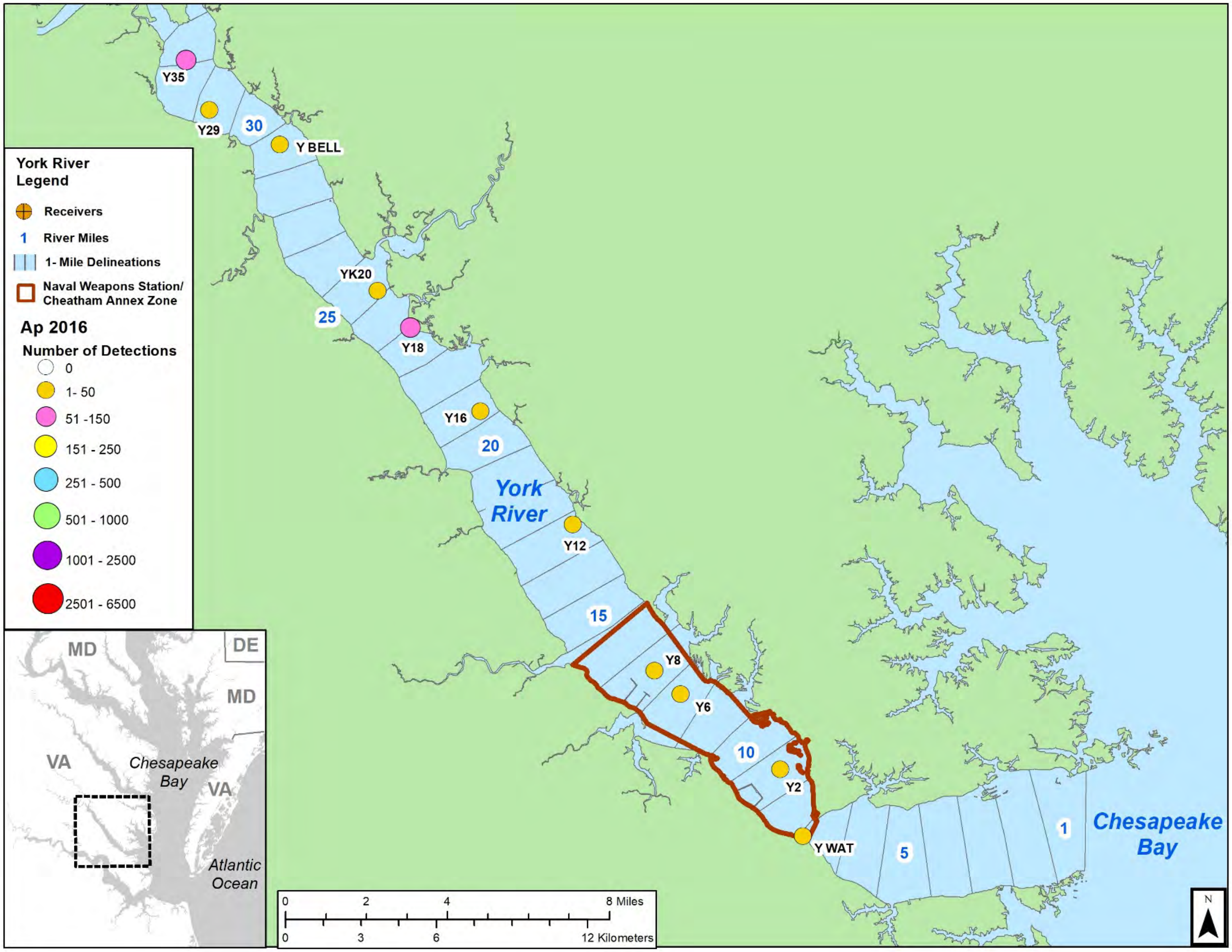
York River Legend
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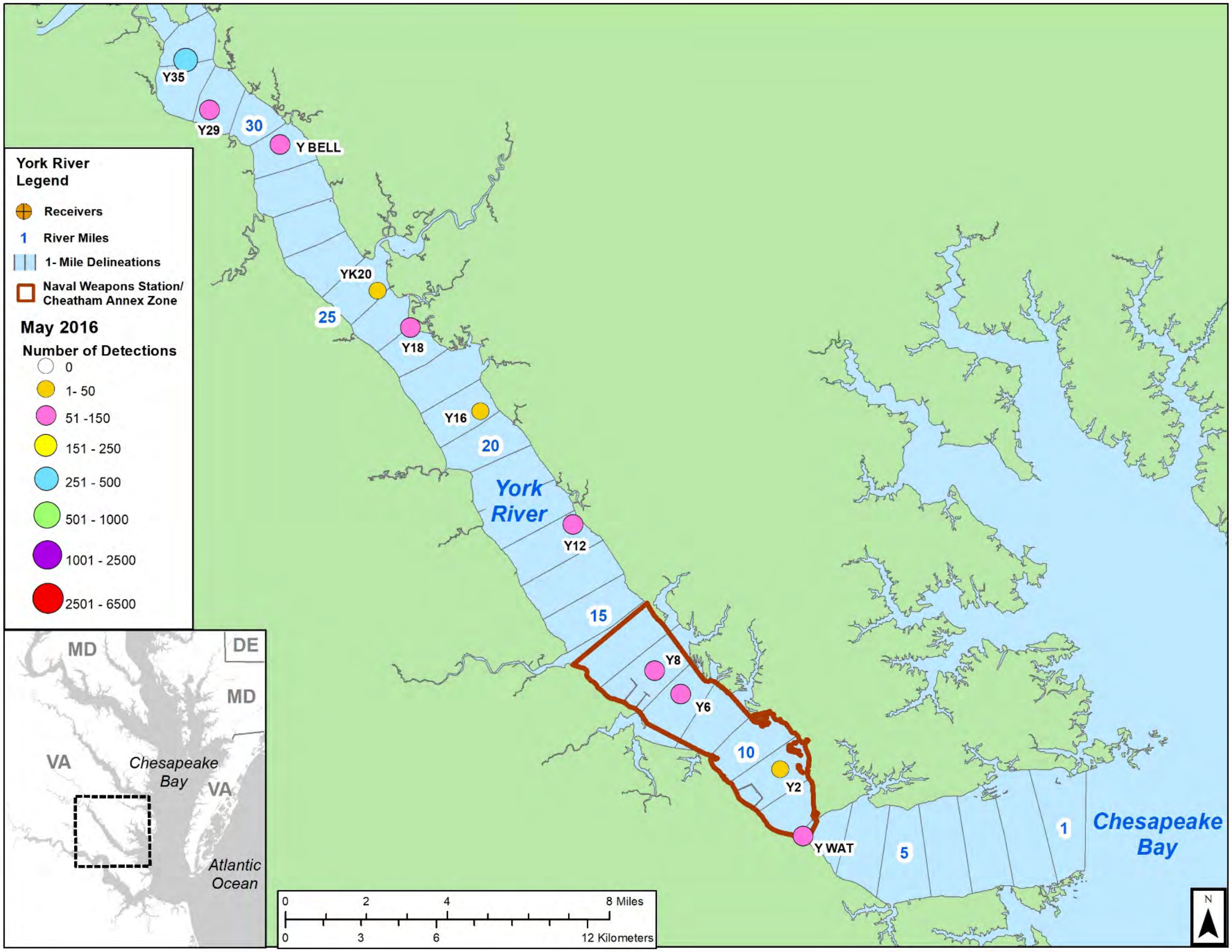
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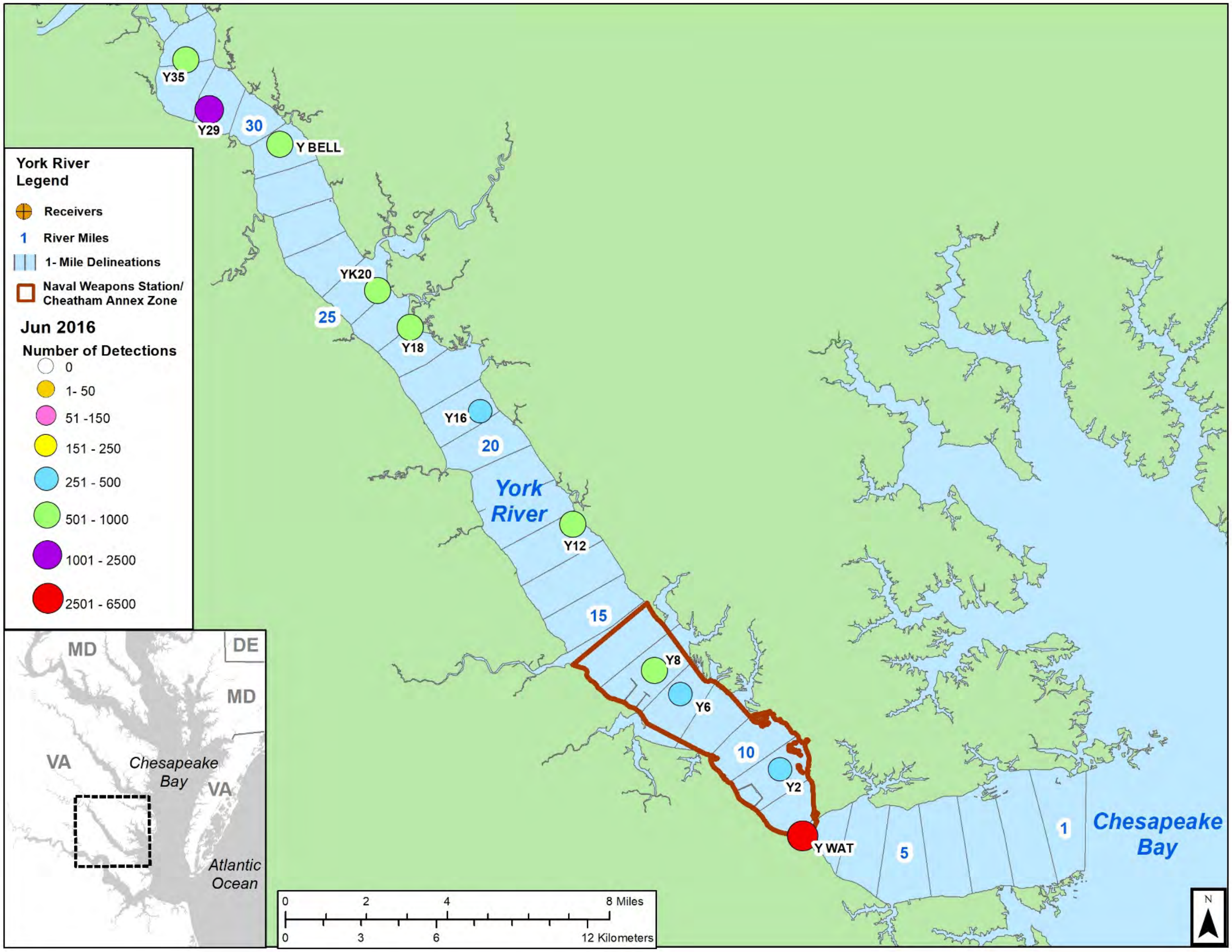
York River Legend
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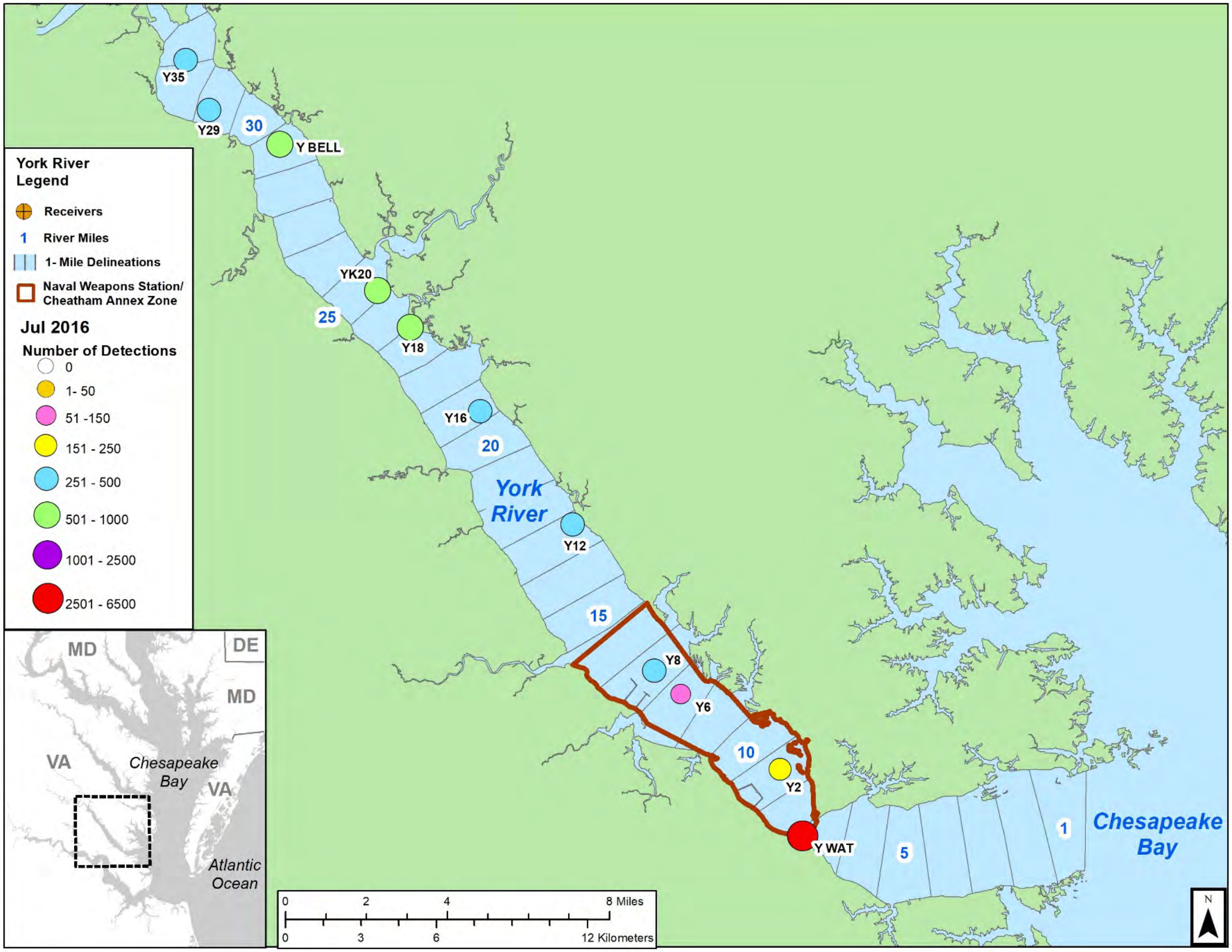
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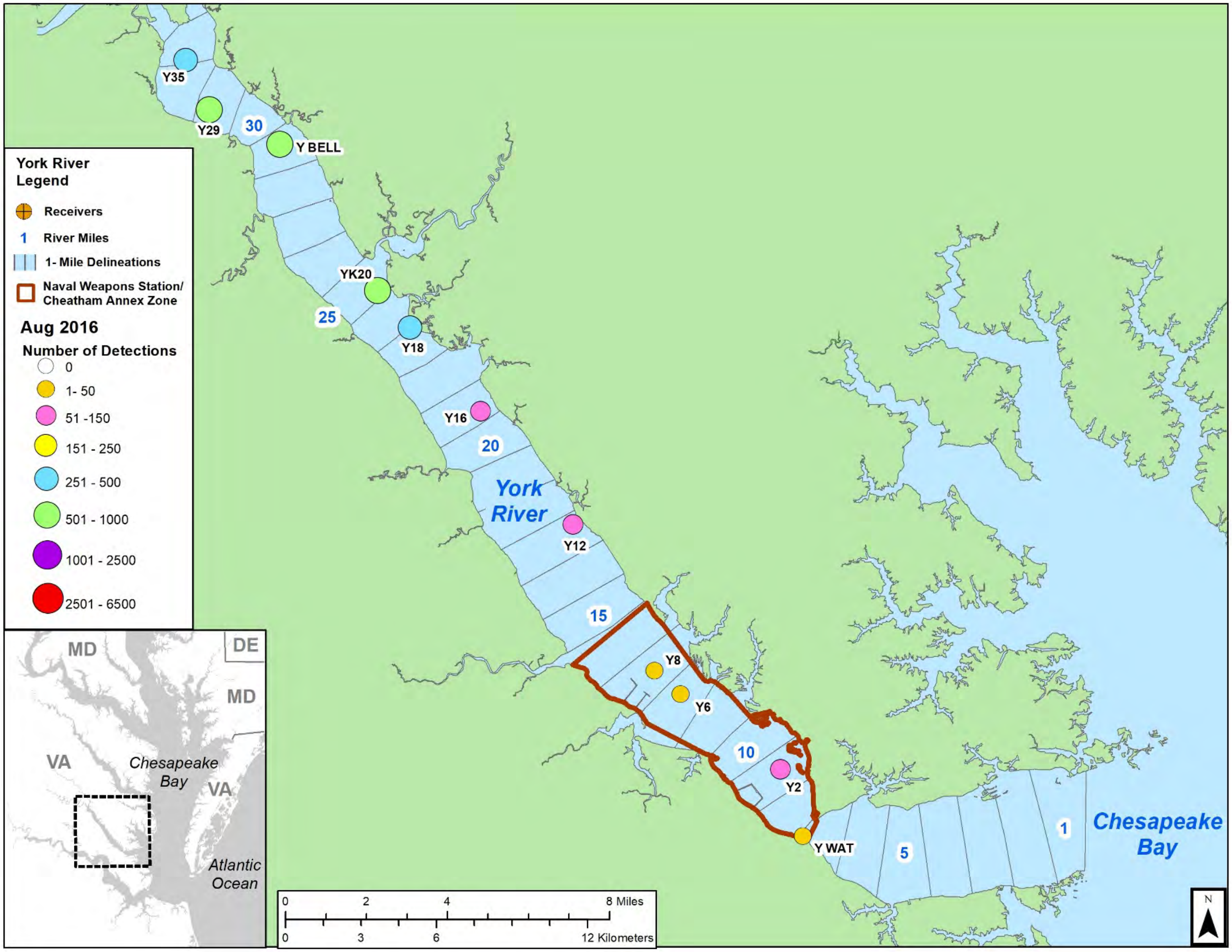
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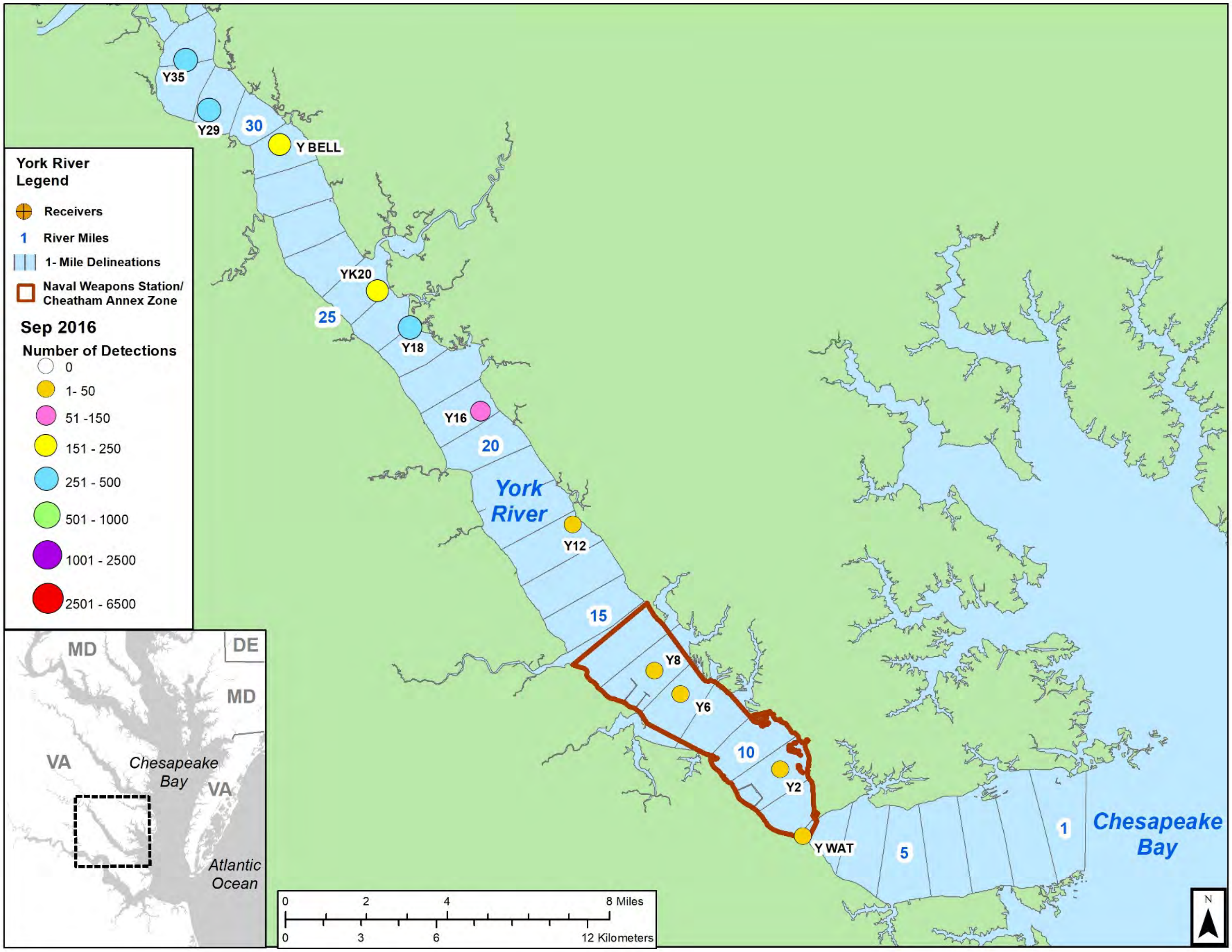
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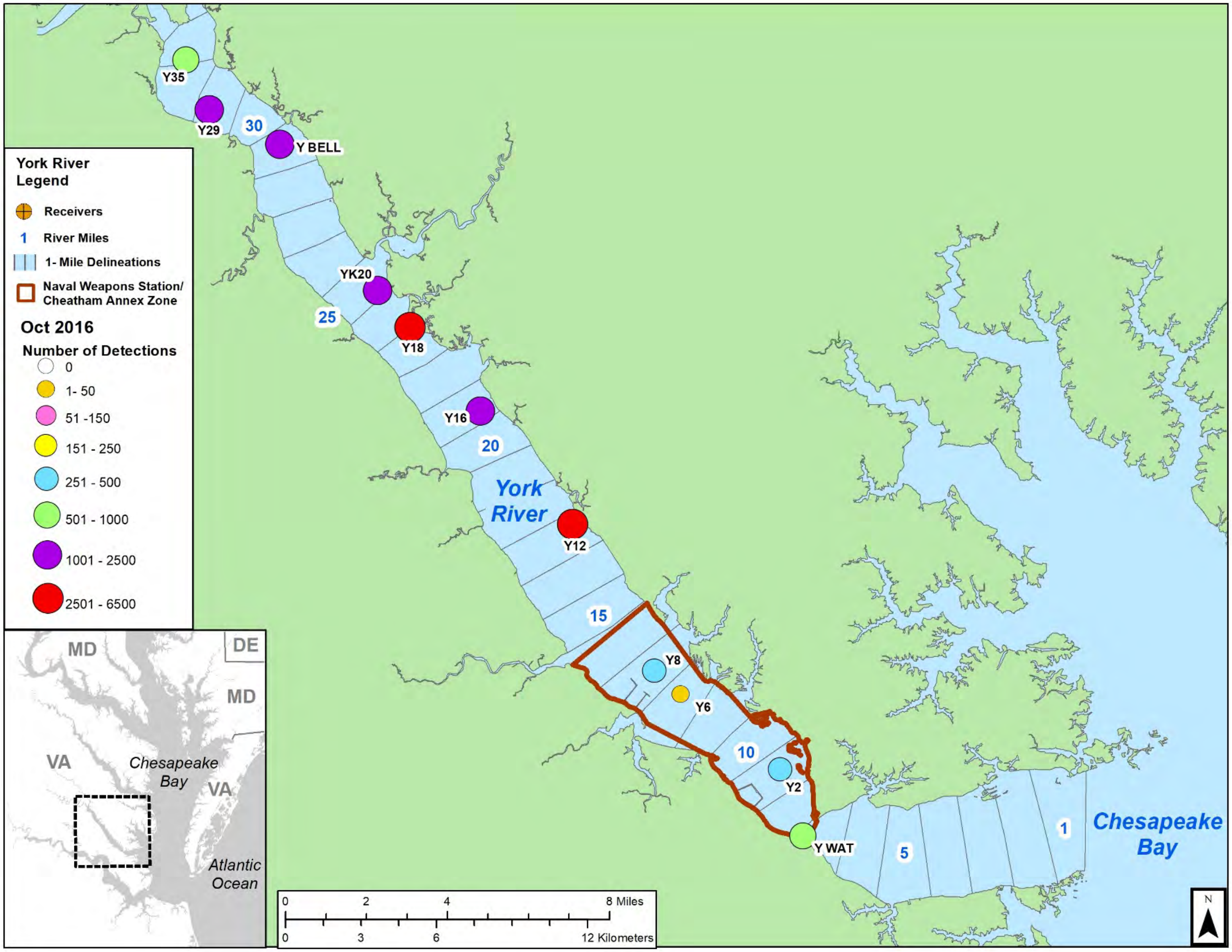
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Naval Weapons Station/ Cheatham Annex Zone
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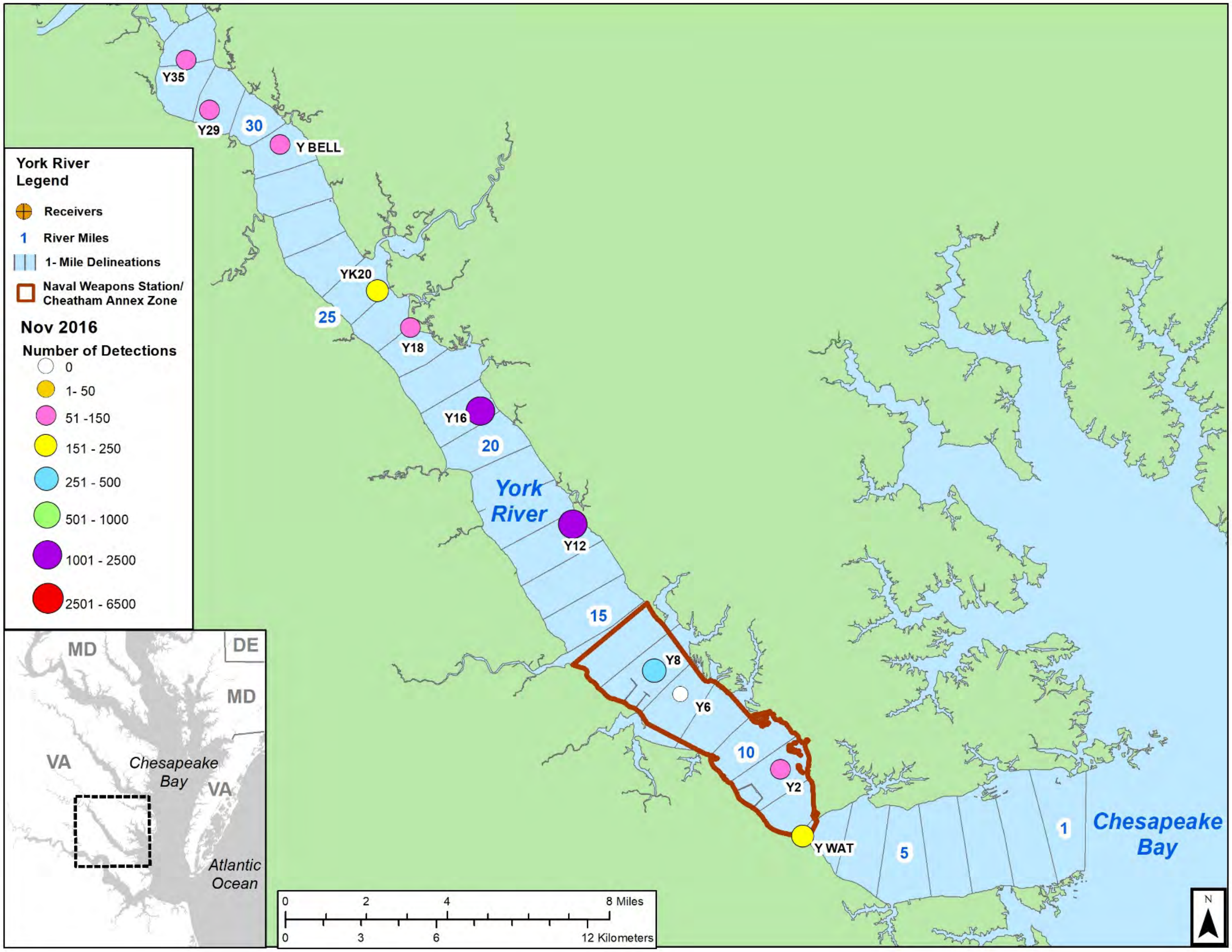
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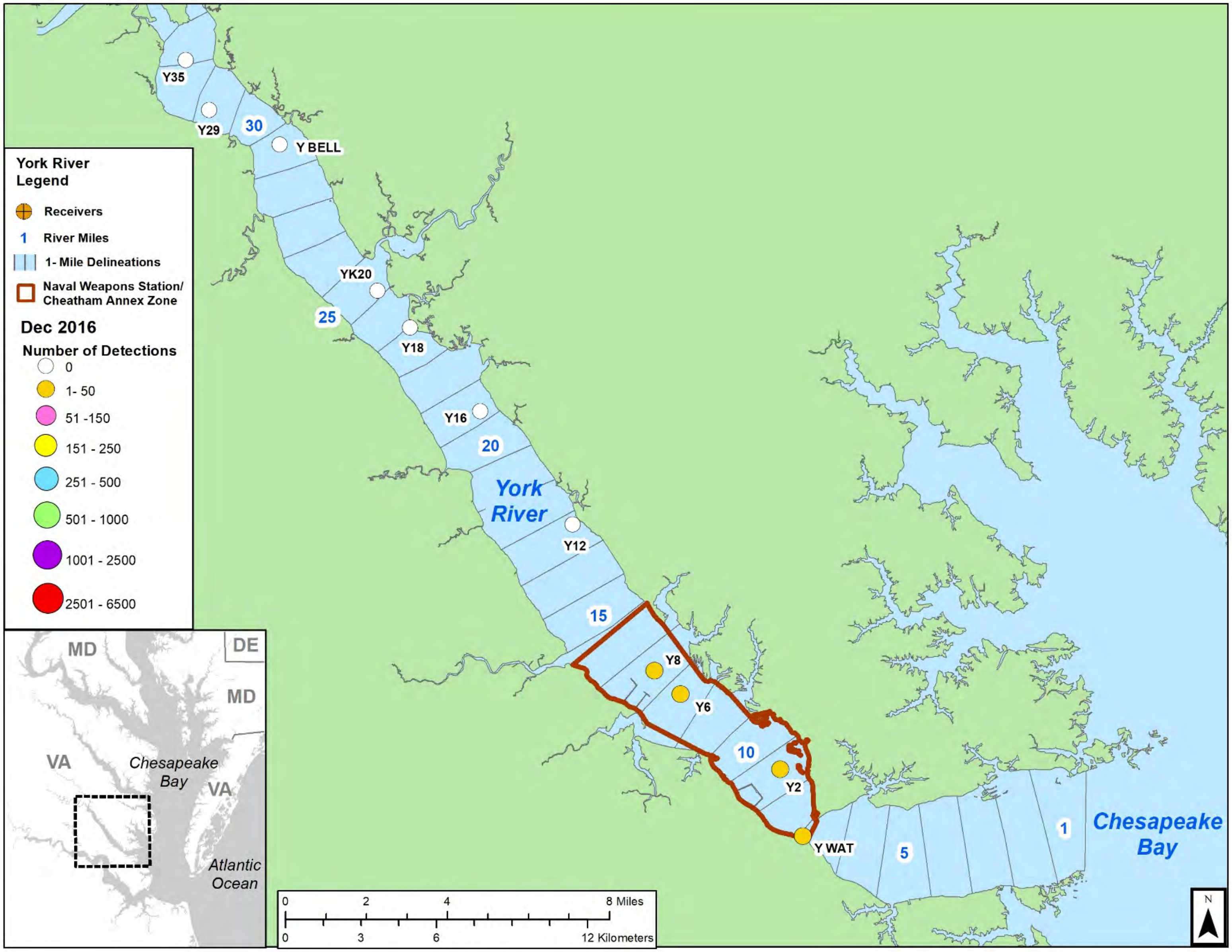
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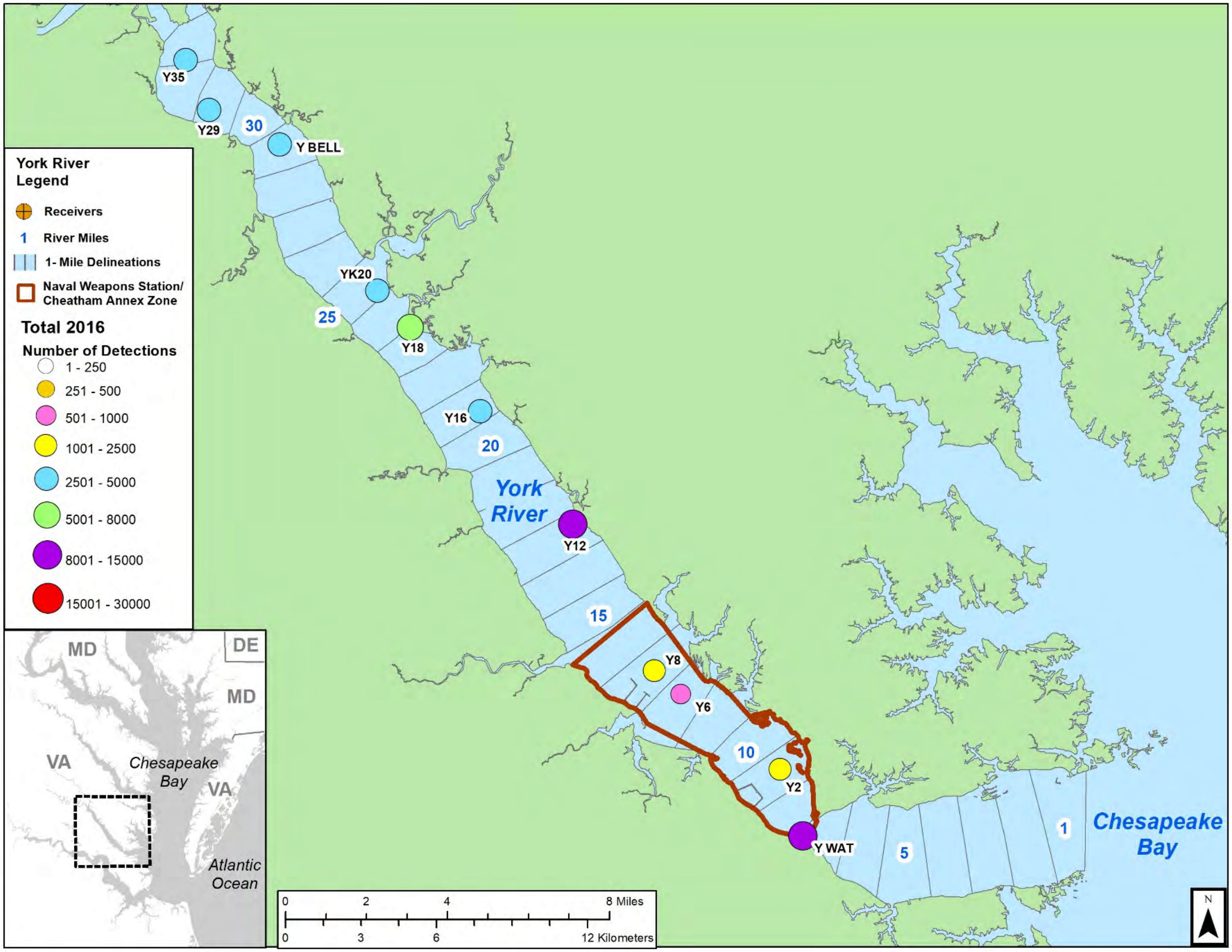
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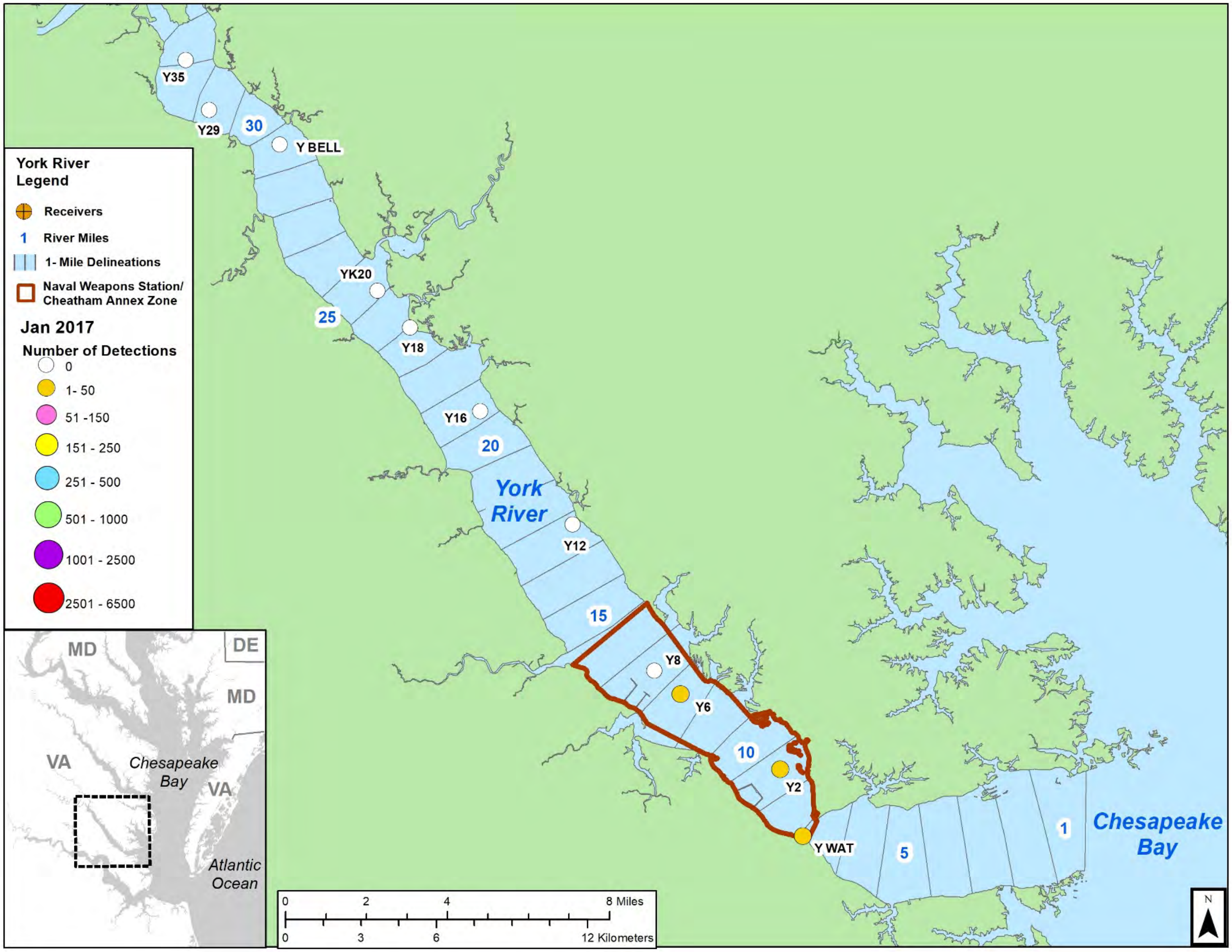
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Naval Weapons Station/ Cheatham Annex Zone
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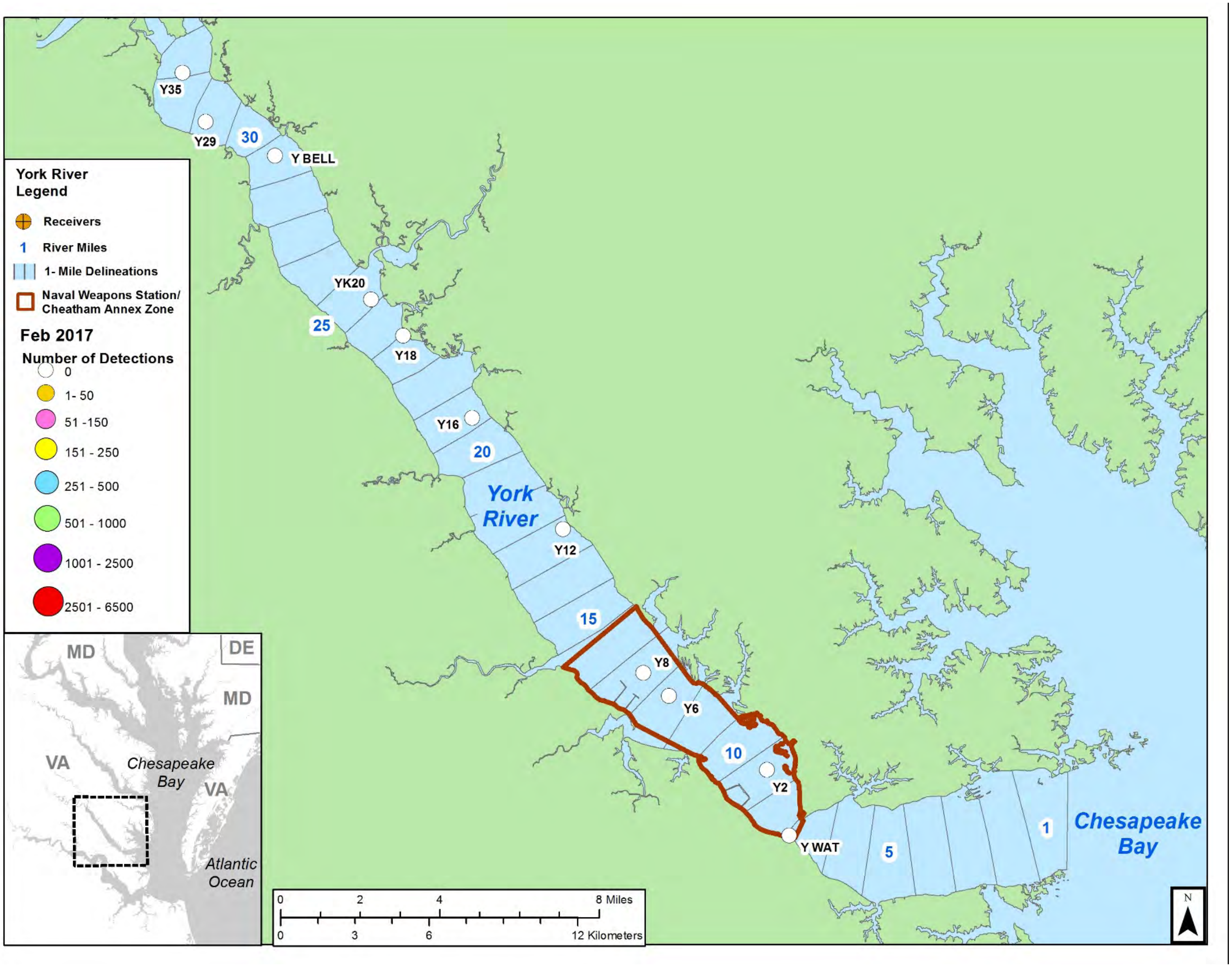
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Naval Weapons Station/ Cheatham Annex Zone
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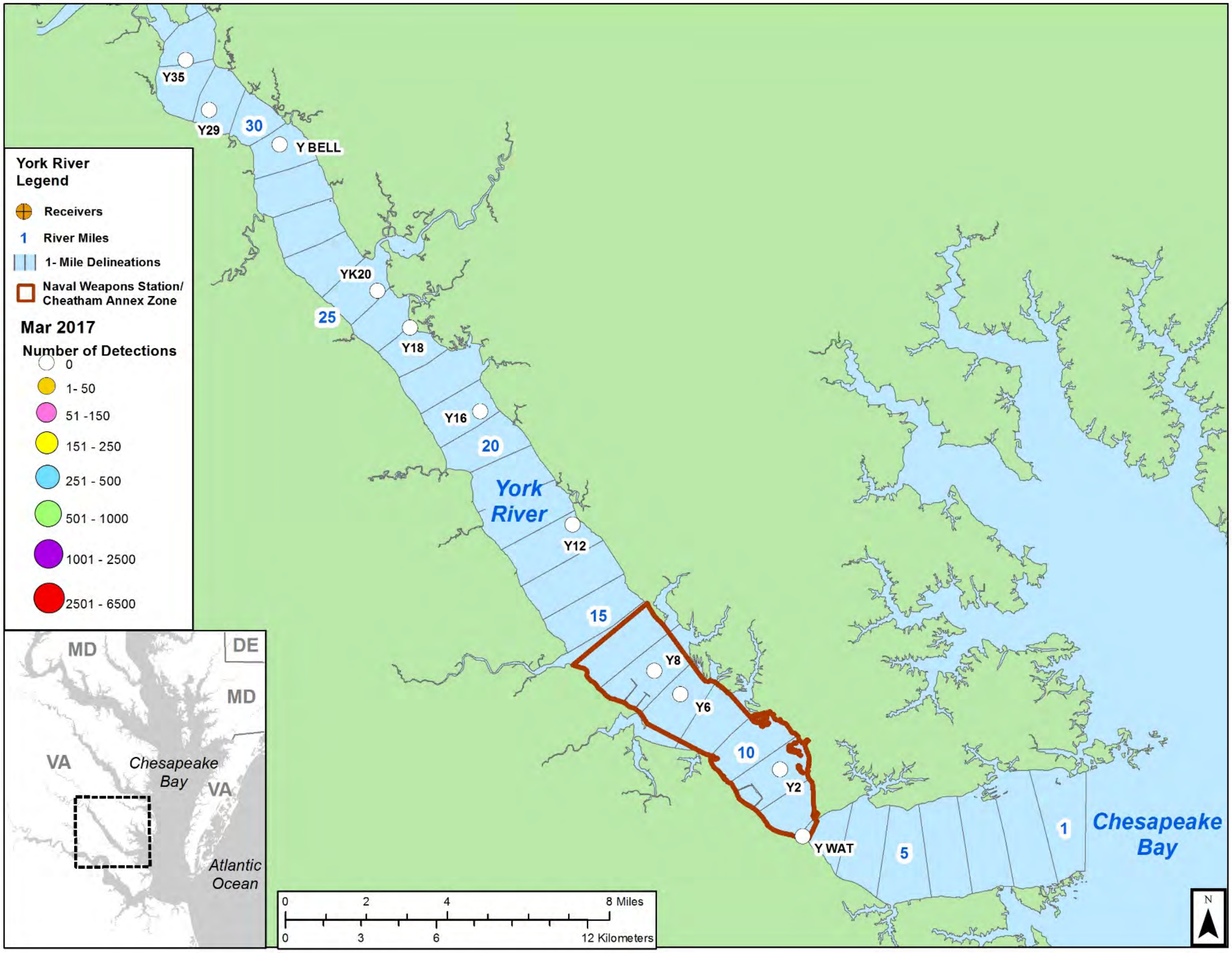
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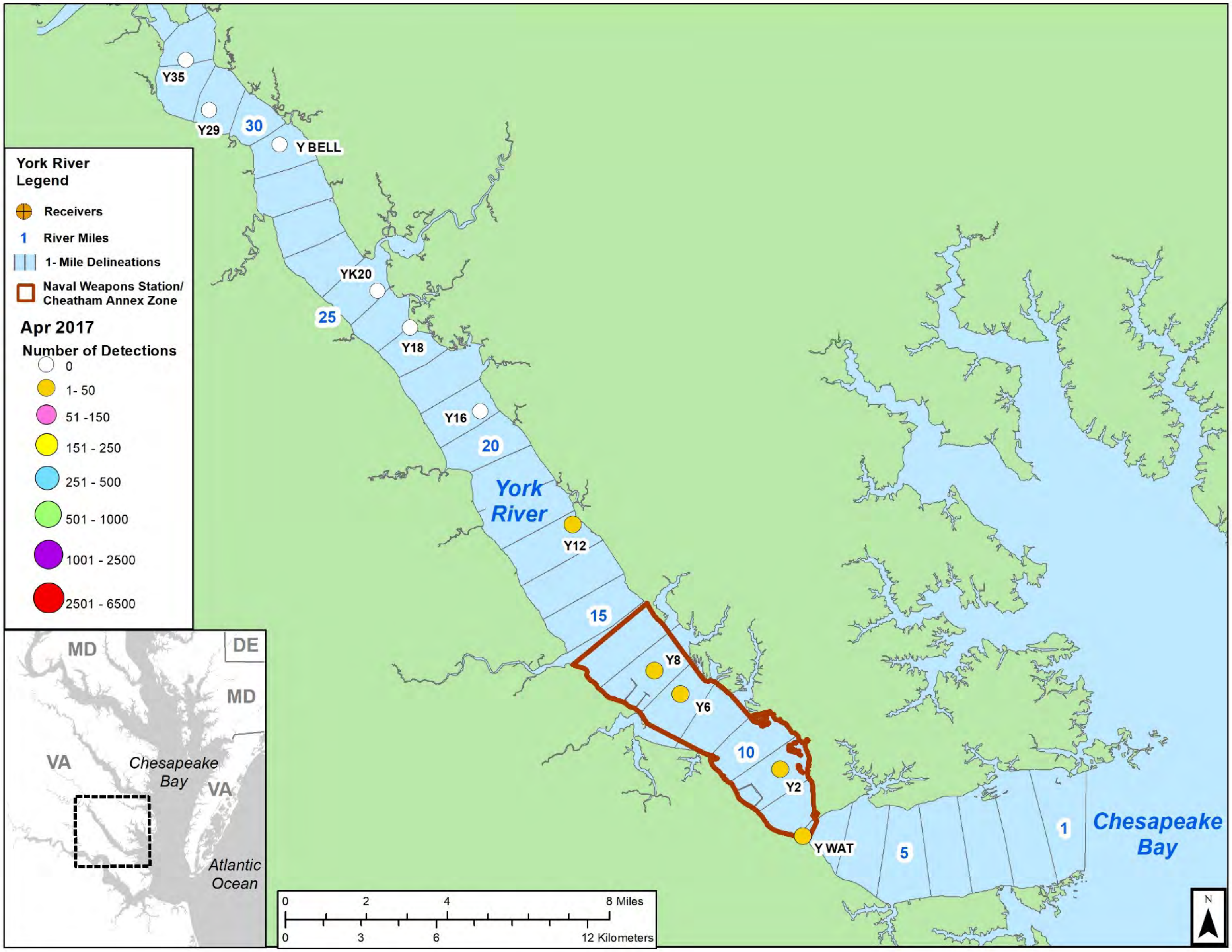
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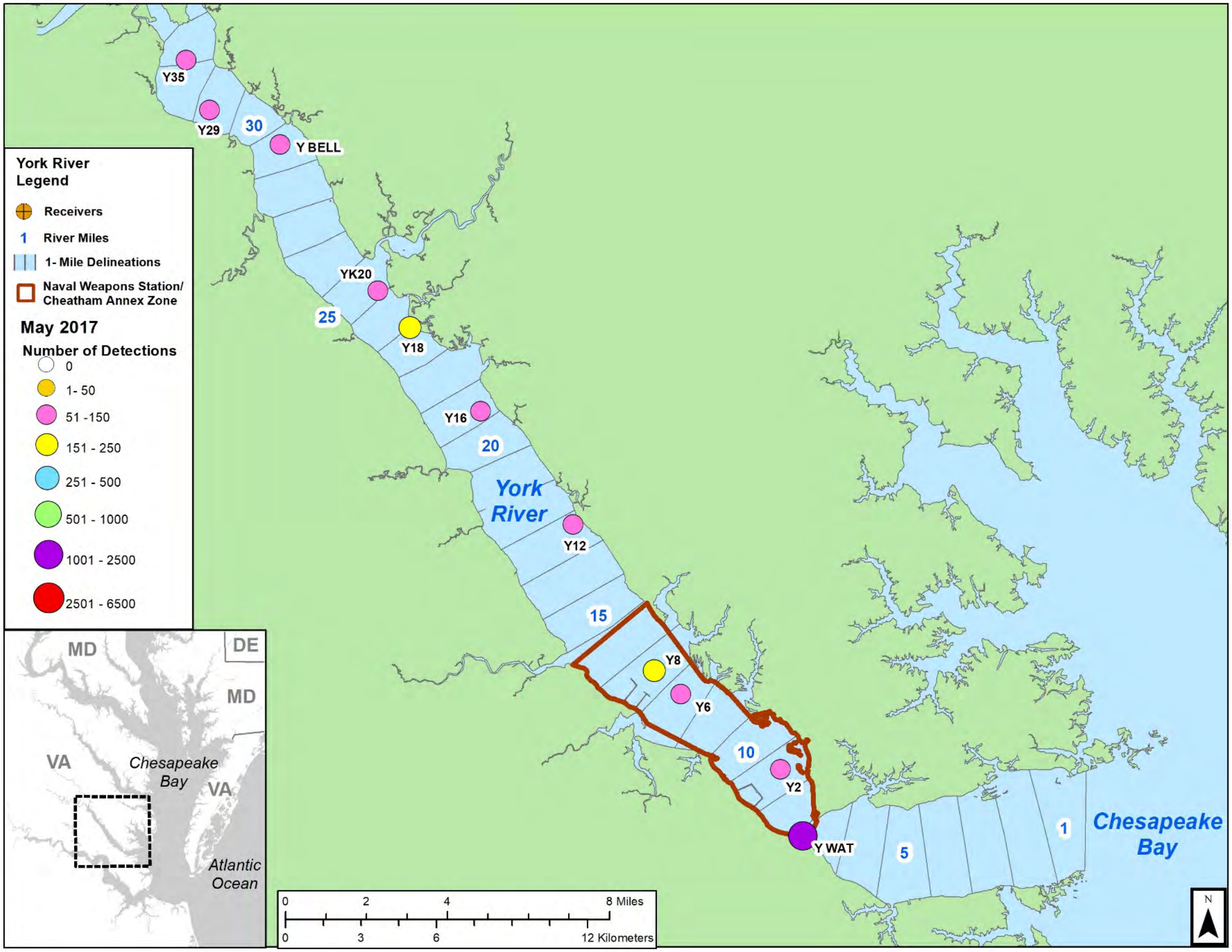
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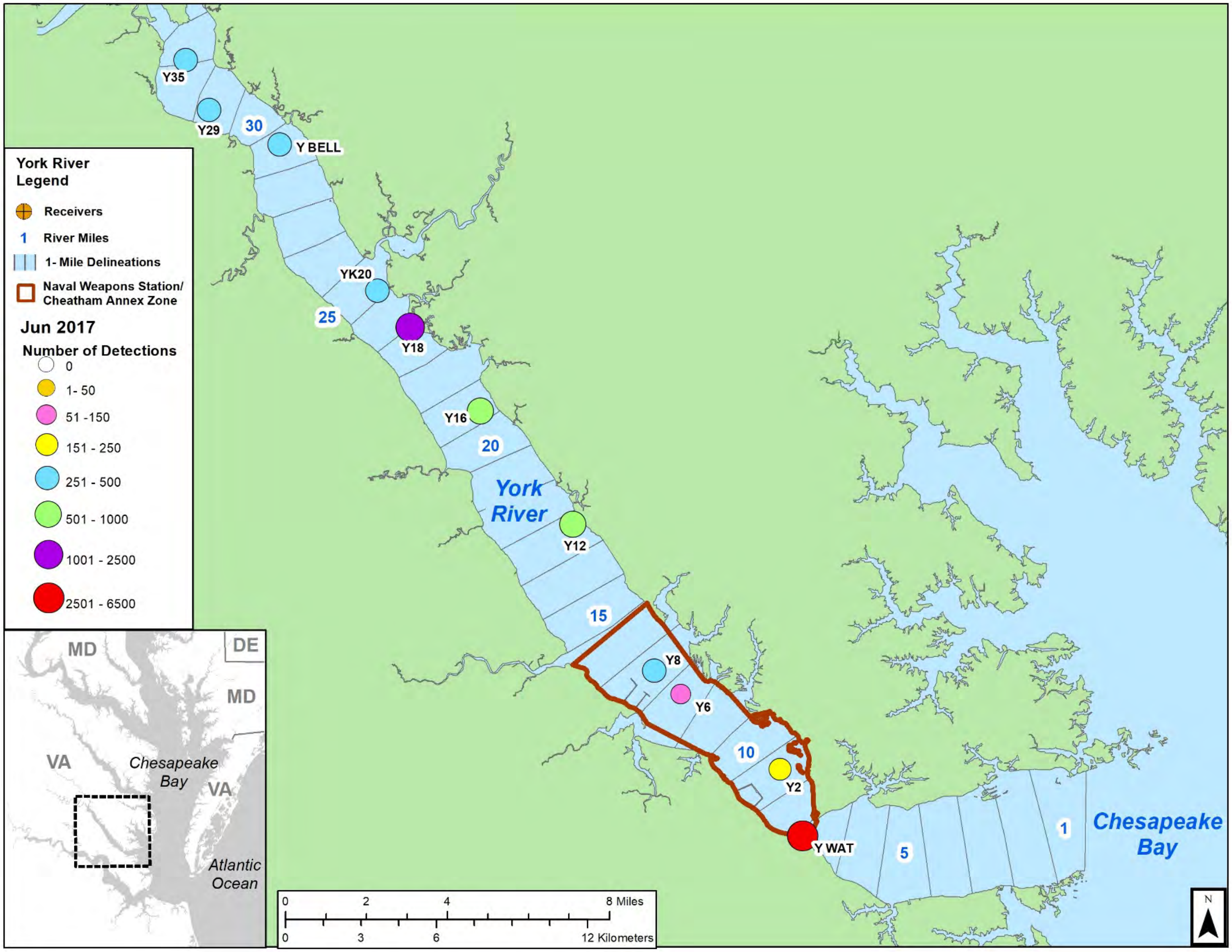
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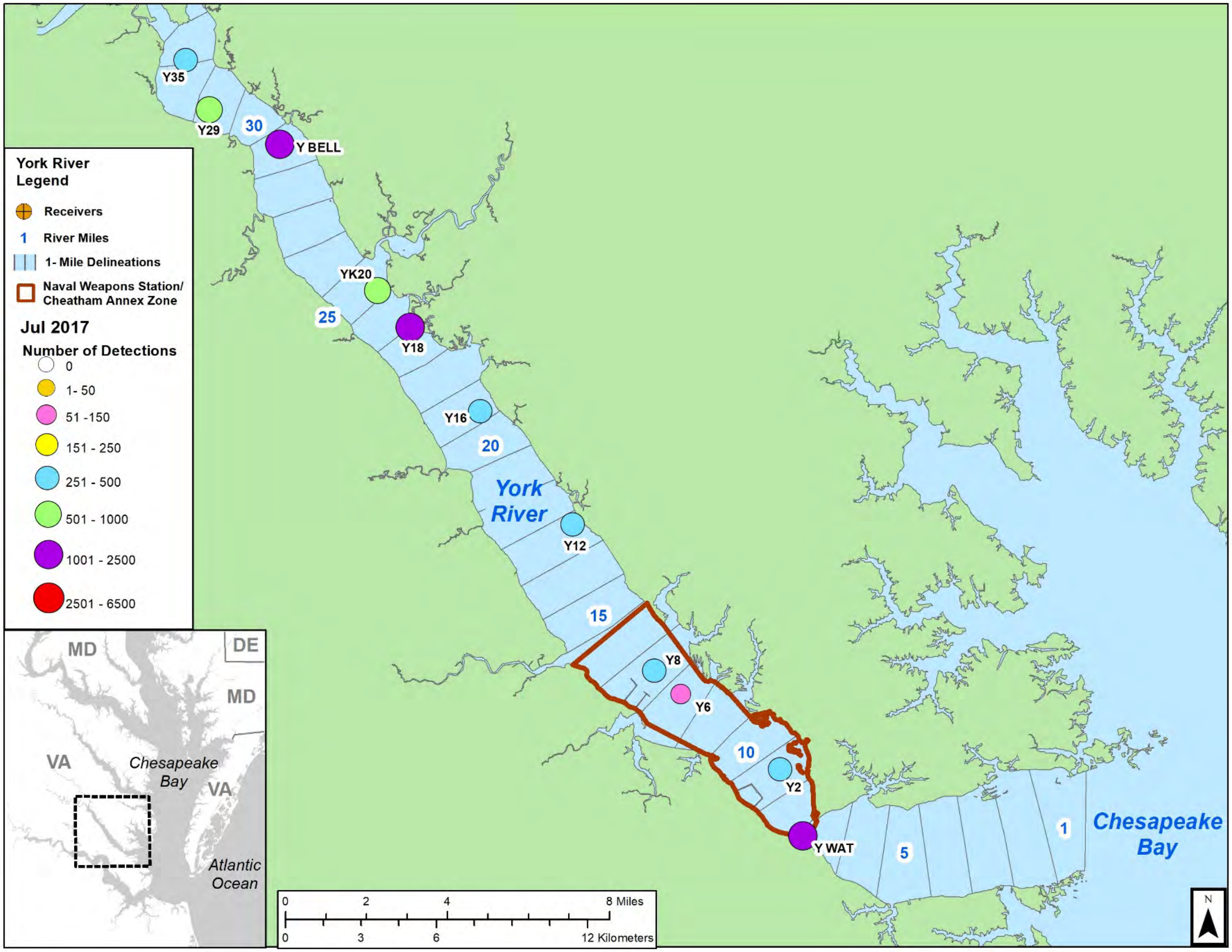
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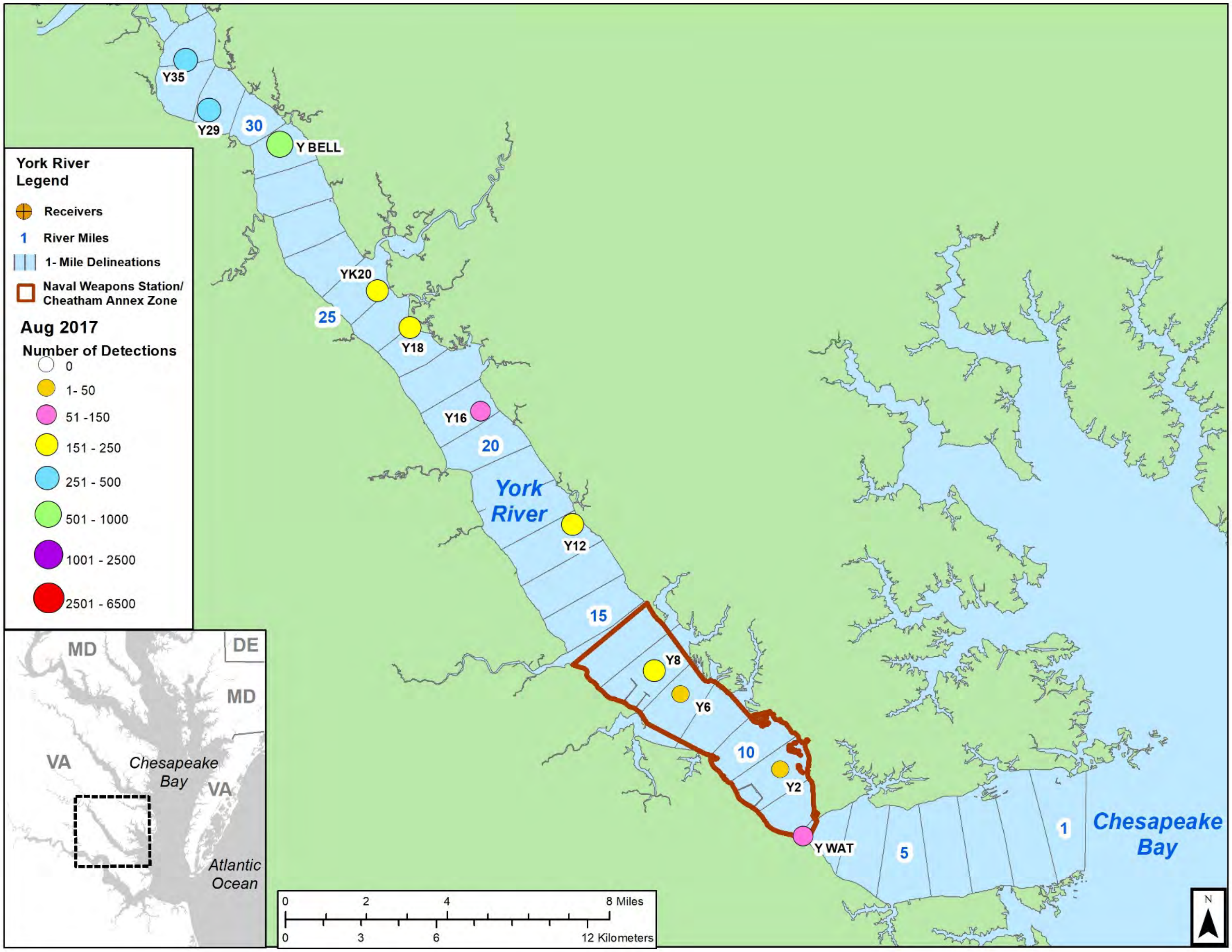
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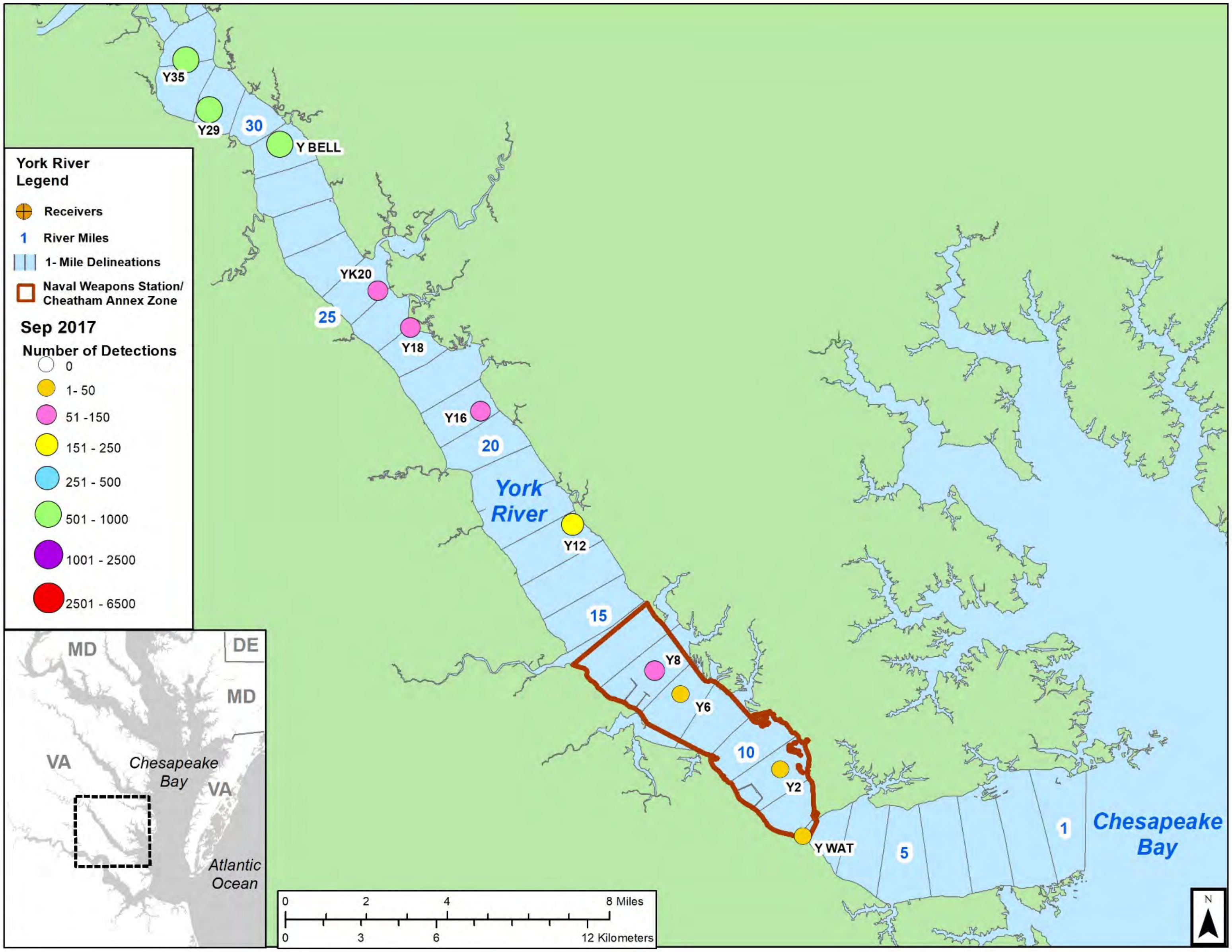
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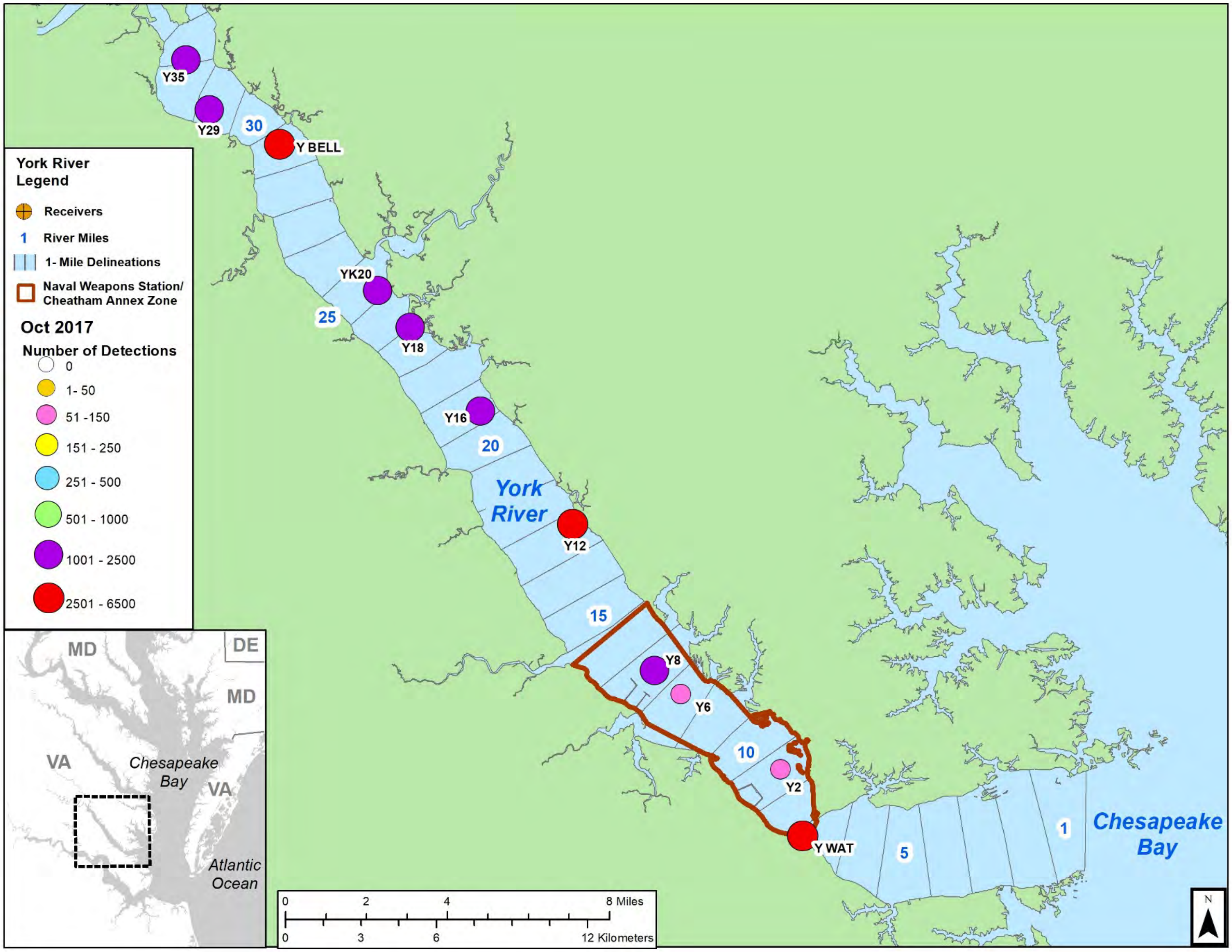
York River Legend
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Naval Weapons Station/ Cheatham Annex Zone
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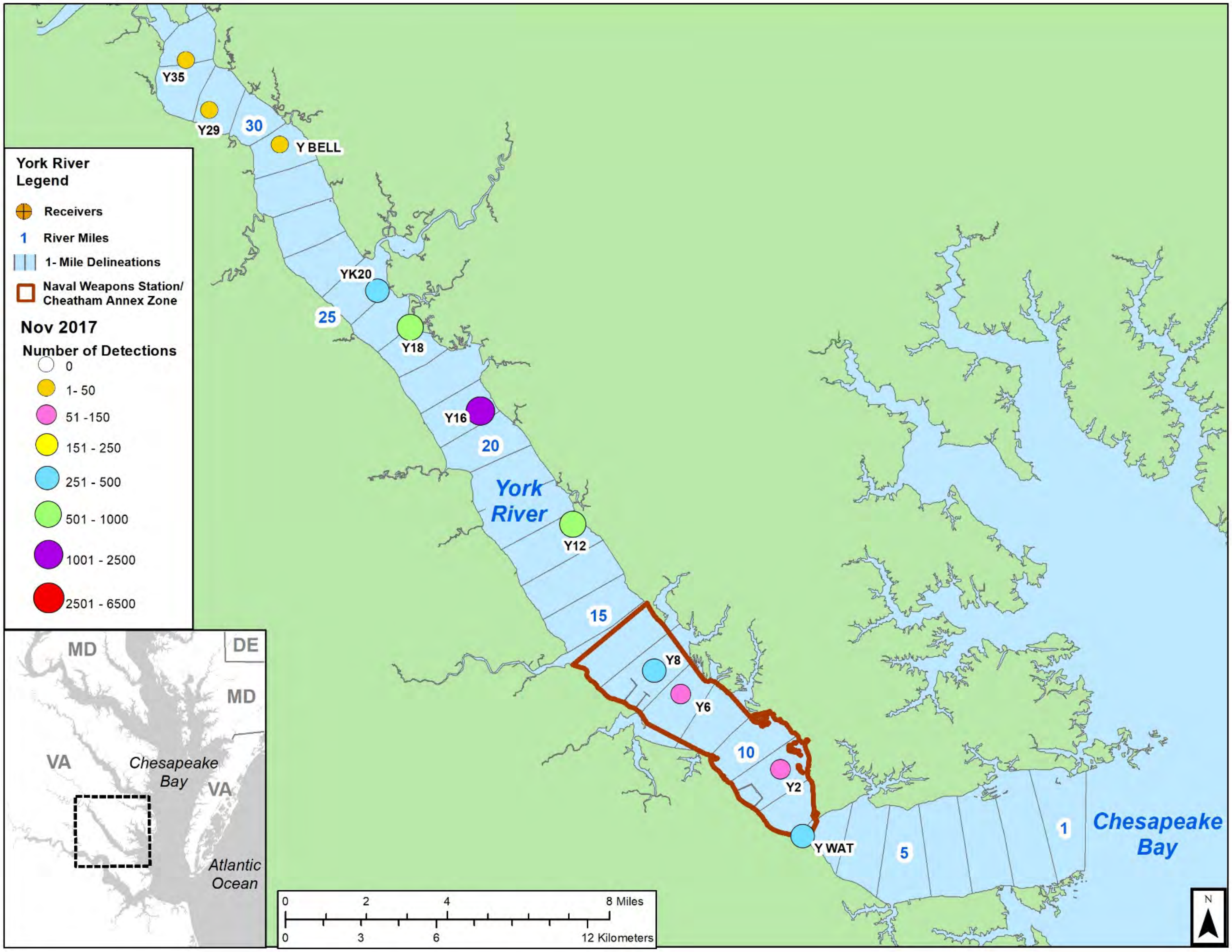
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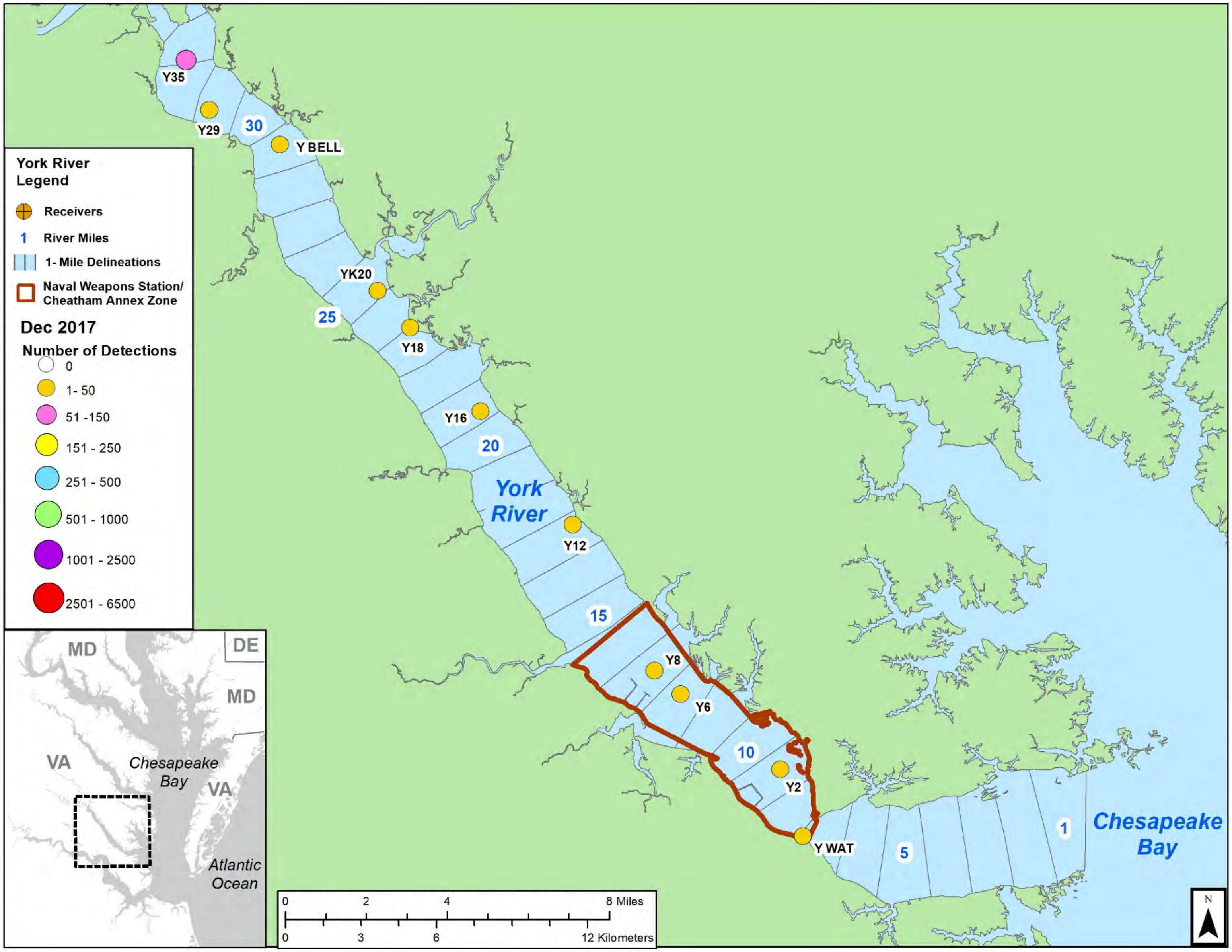
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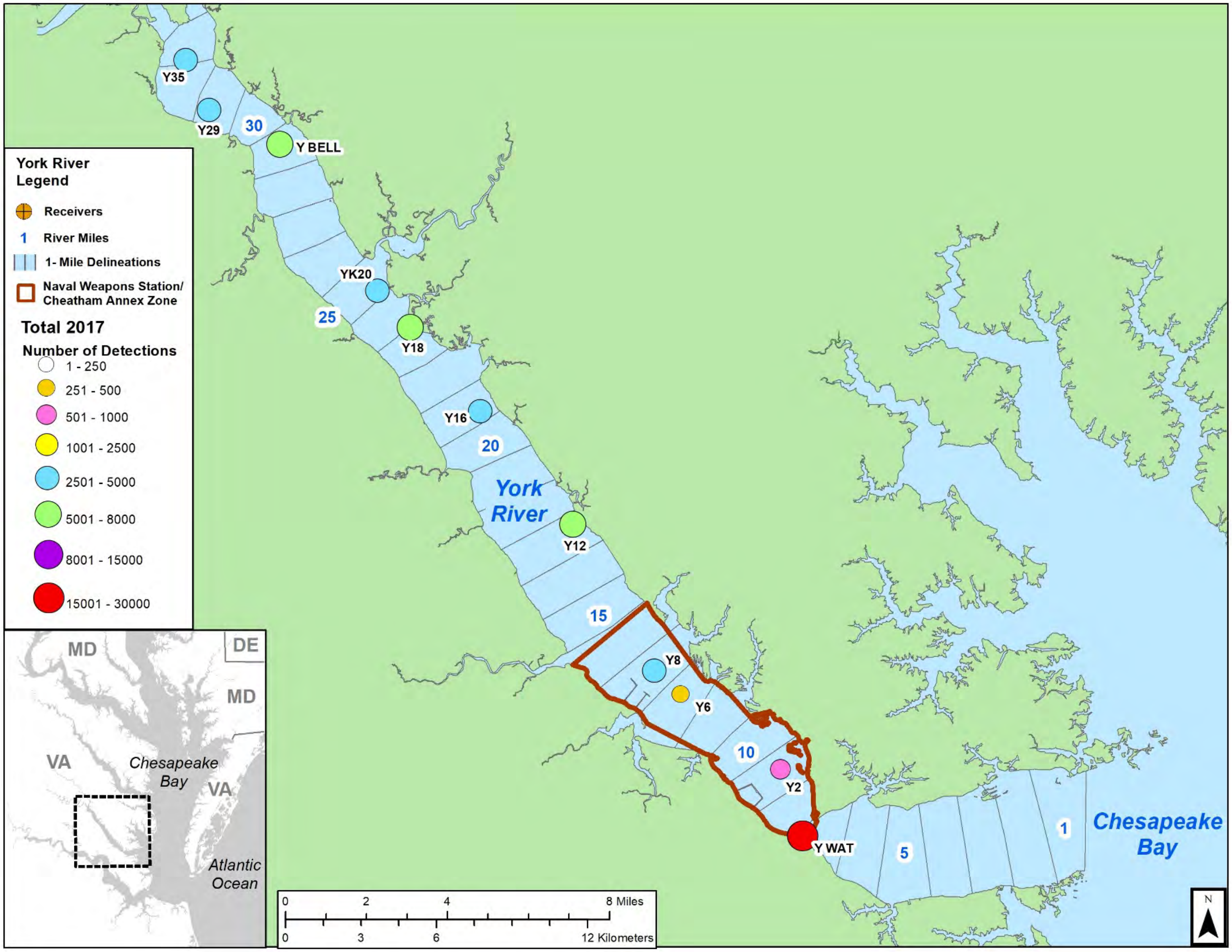
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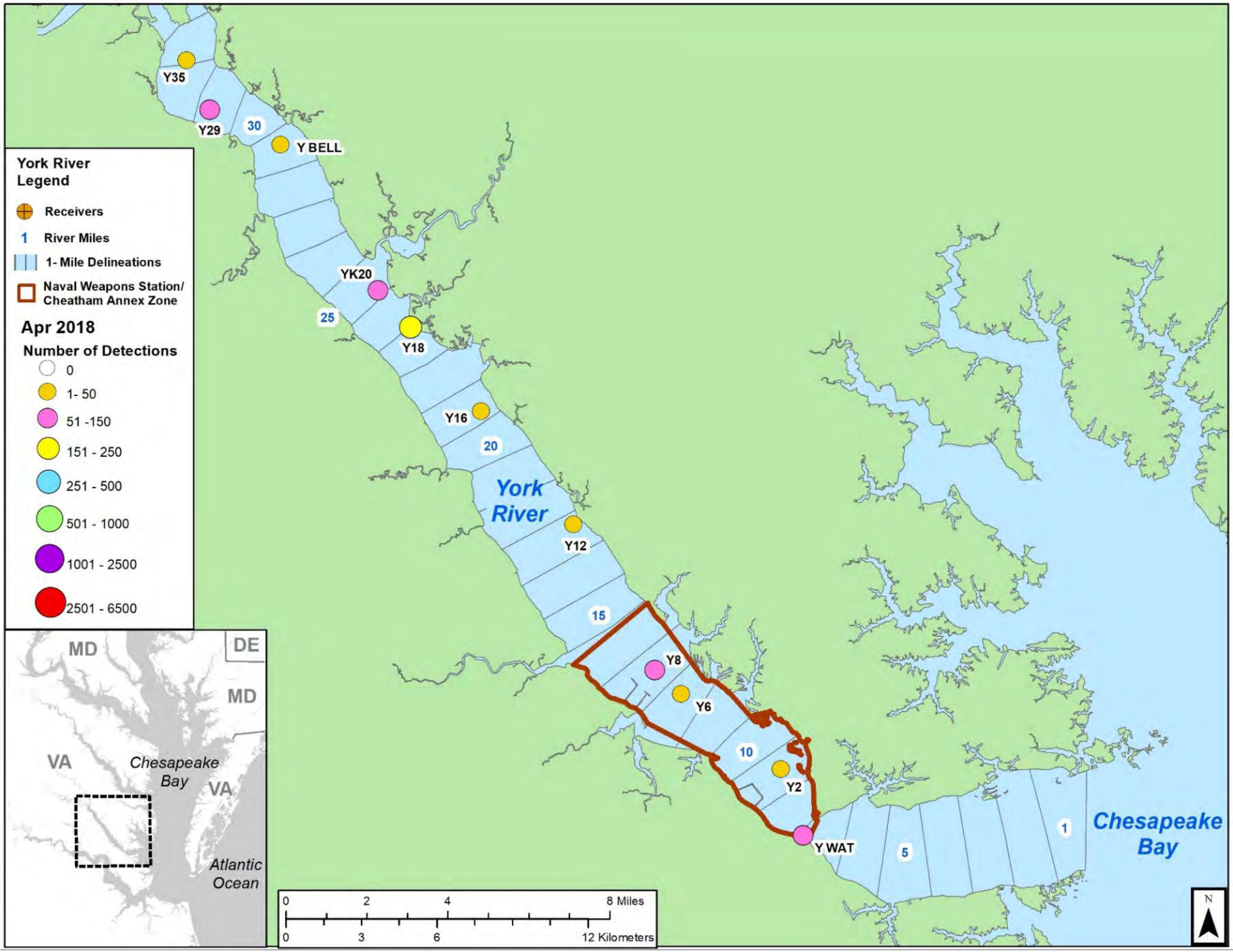
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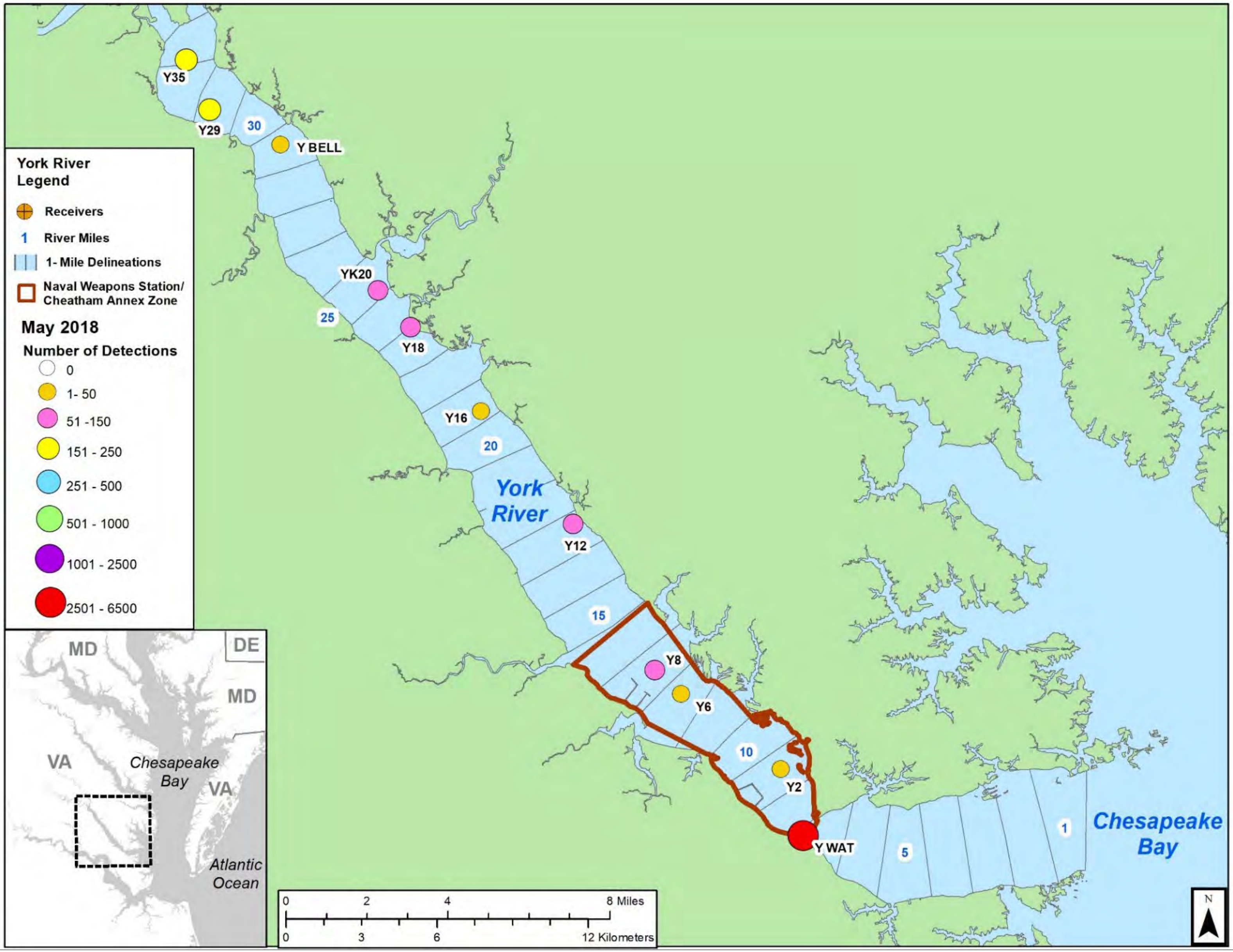
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Naval Weapons Station/ Cheatham Annex Zone
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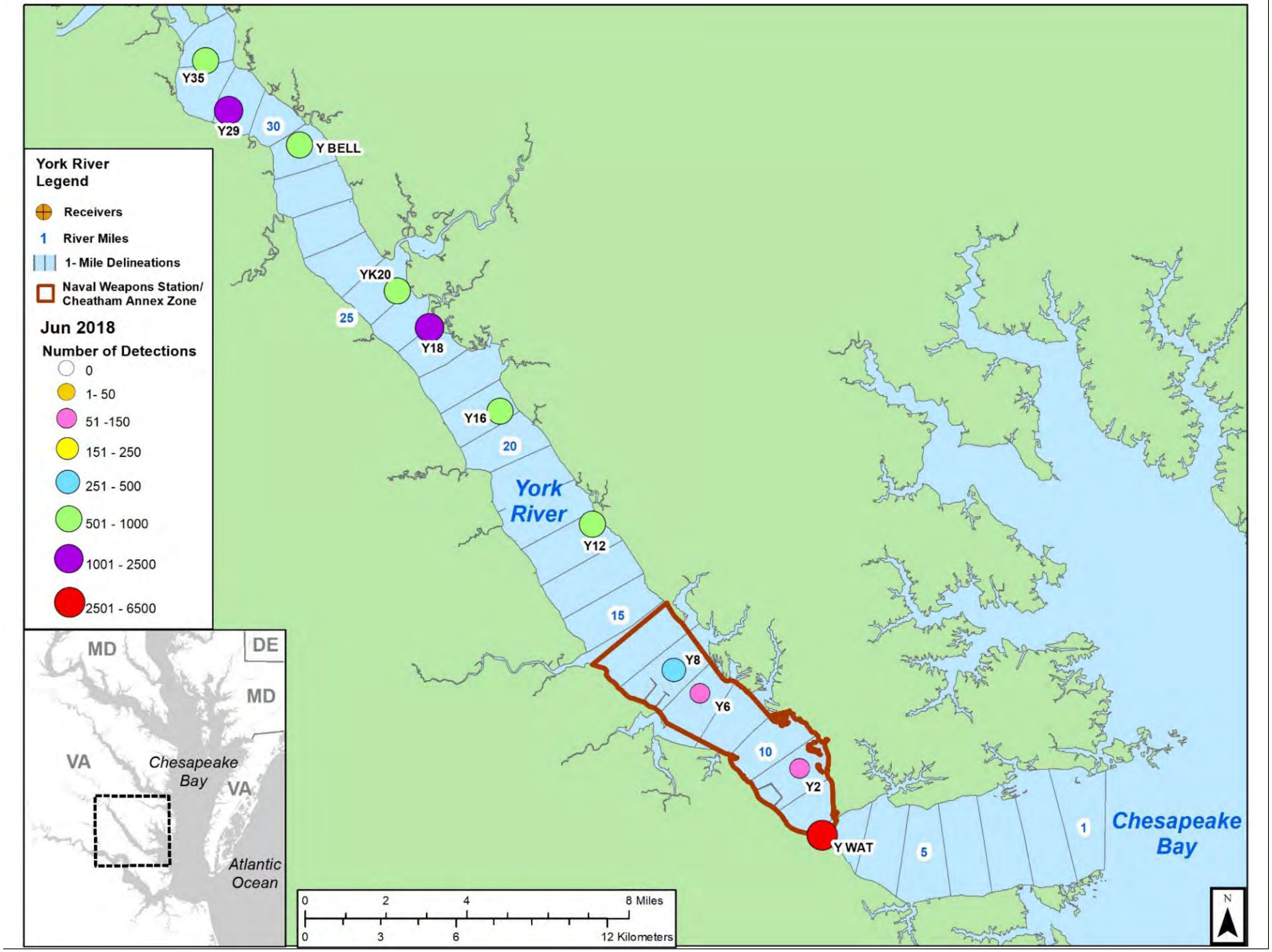
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12 Kilometers
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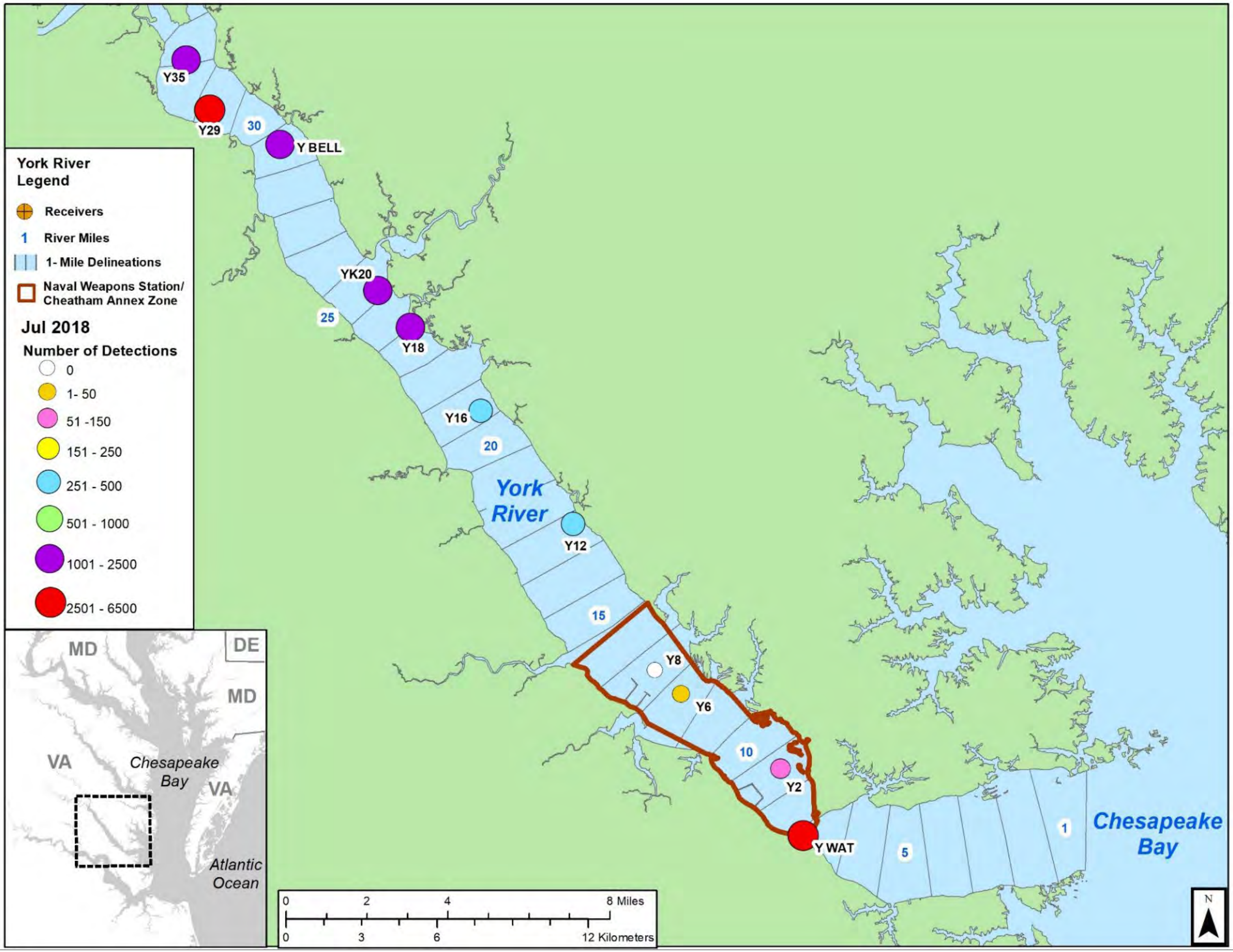
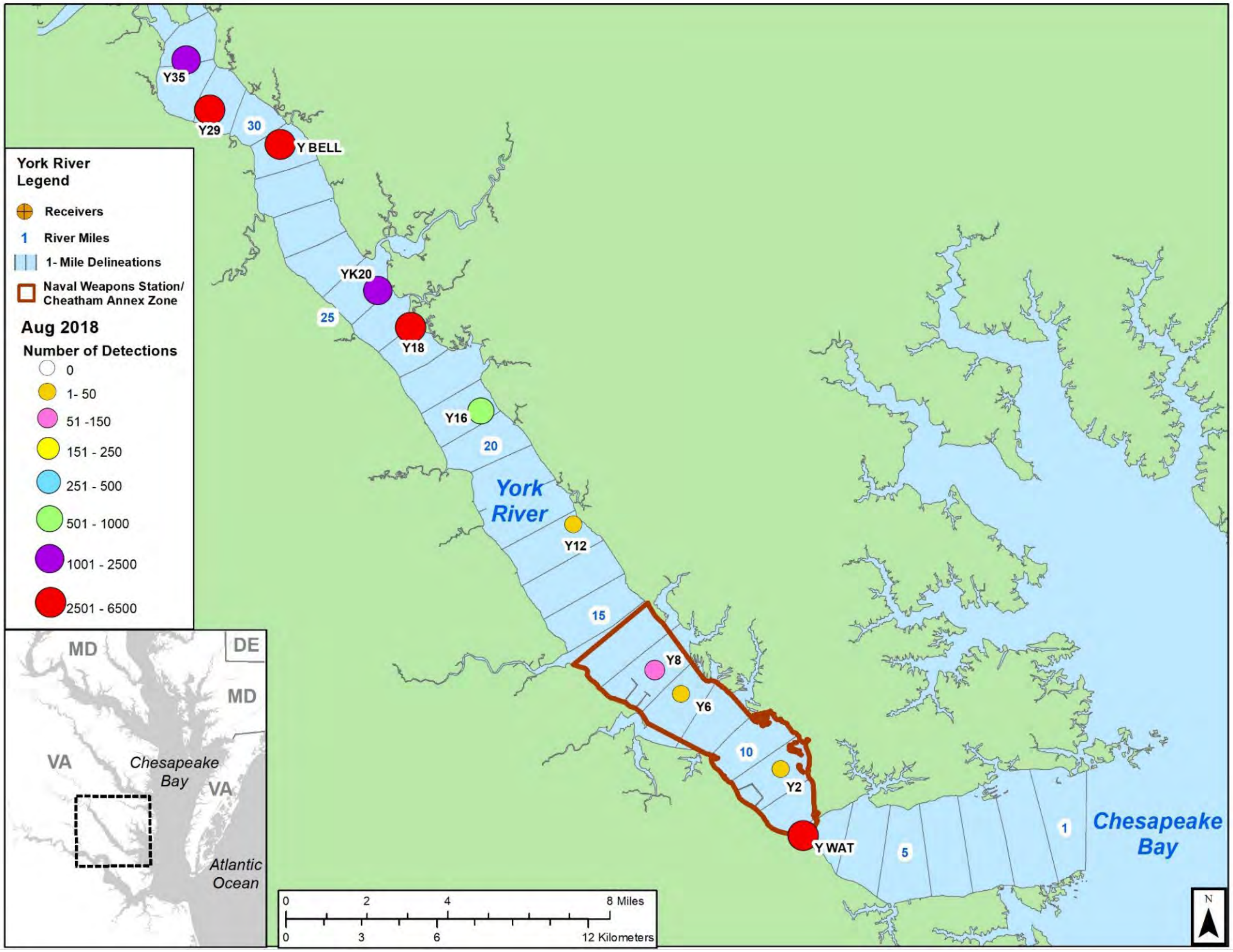
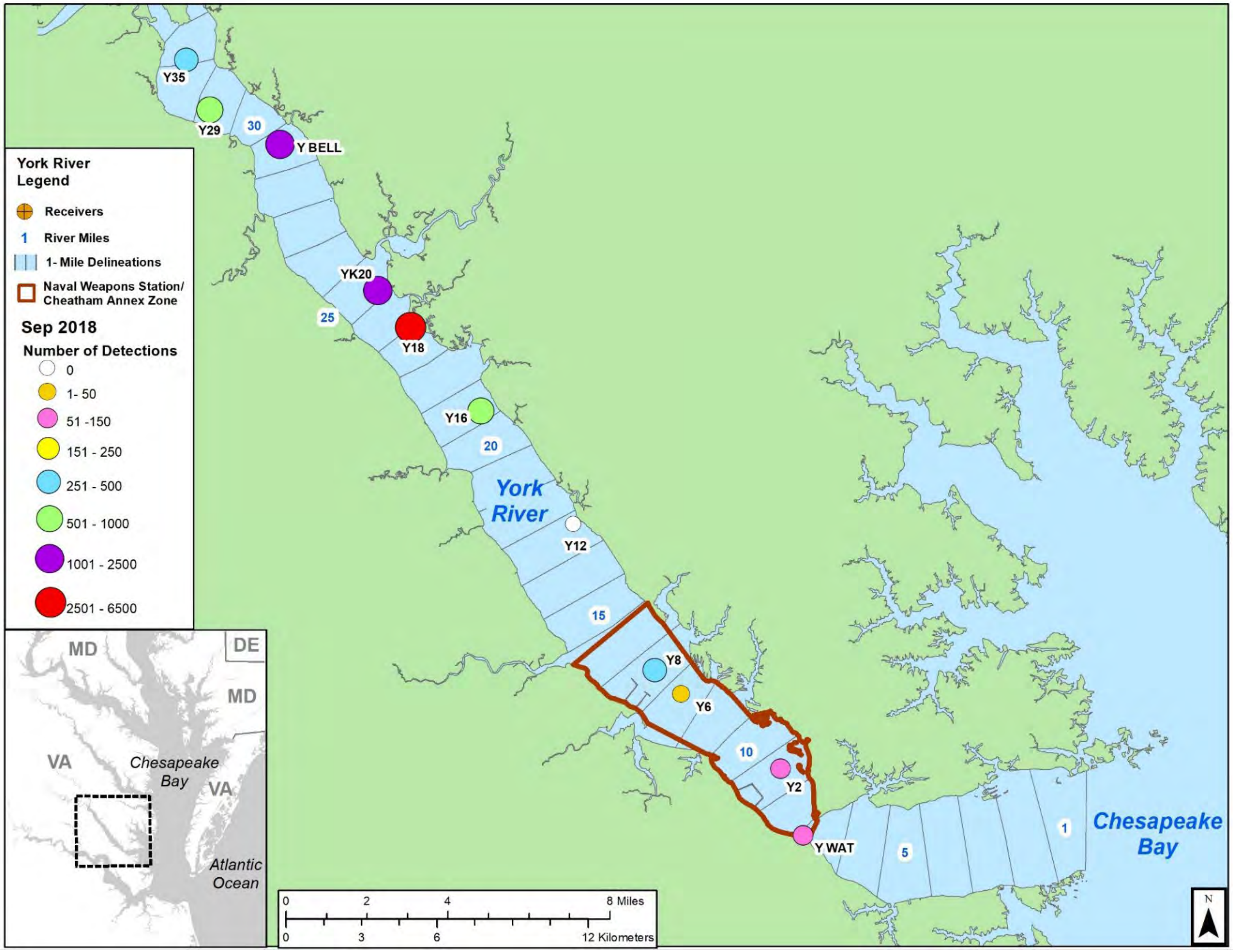
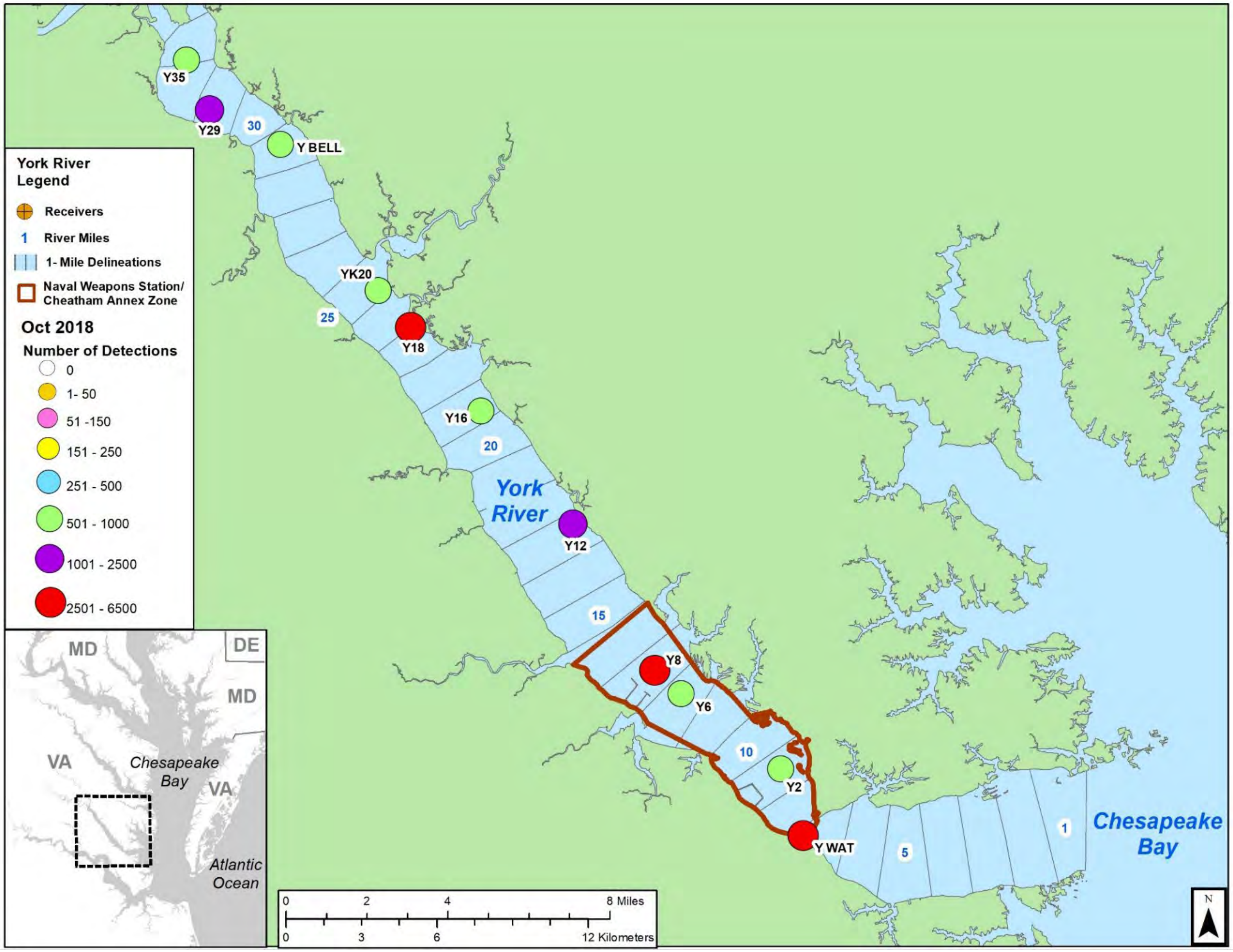
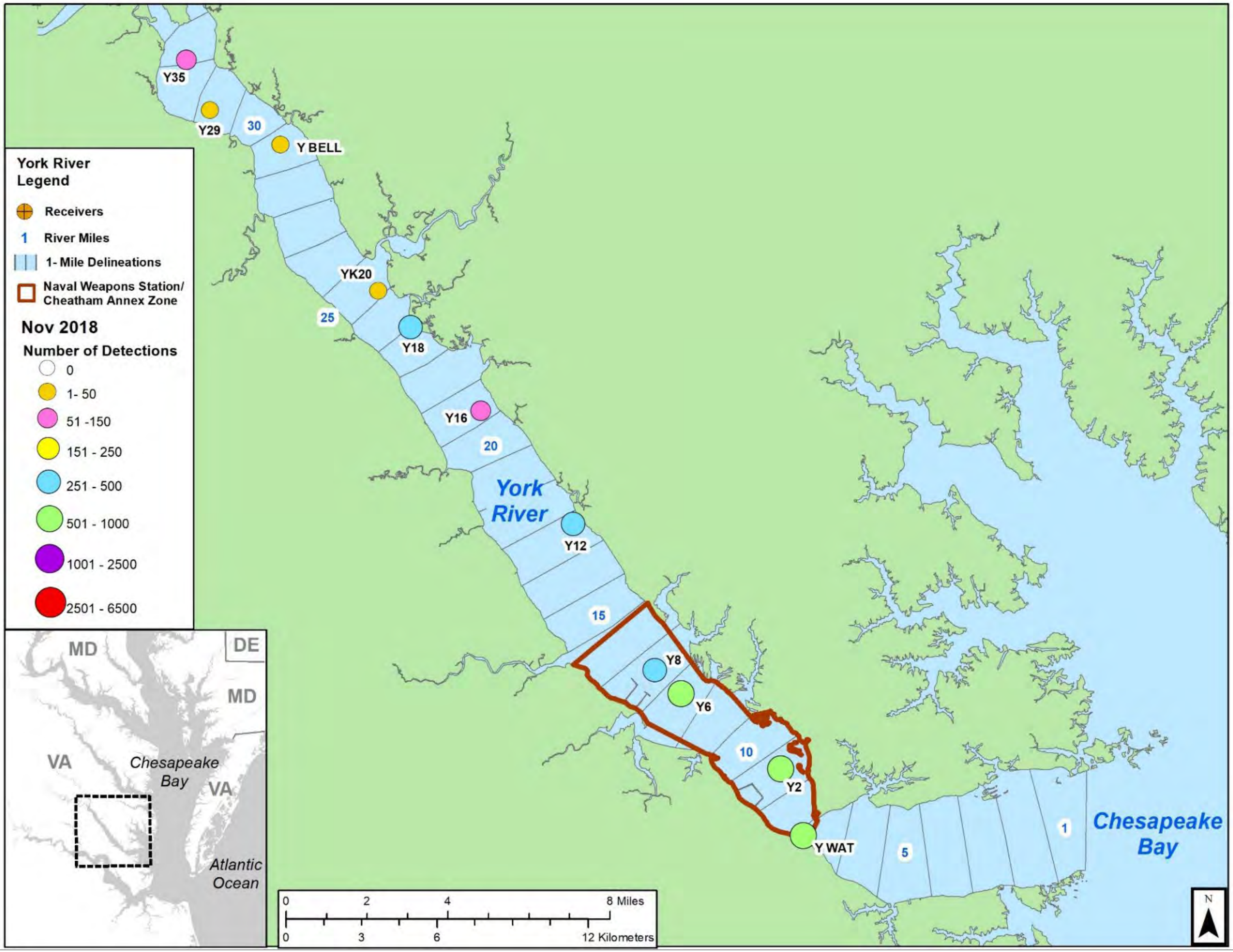
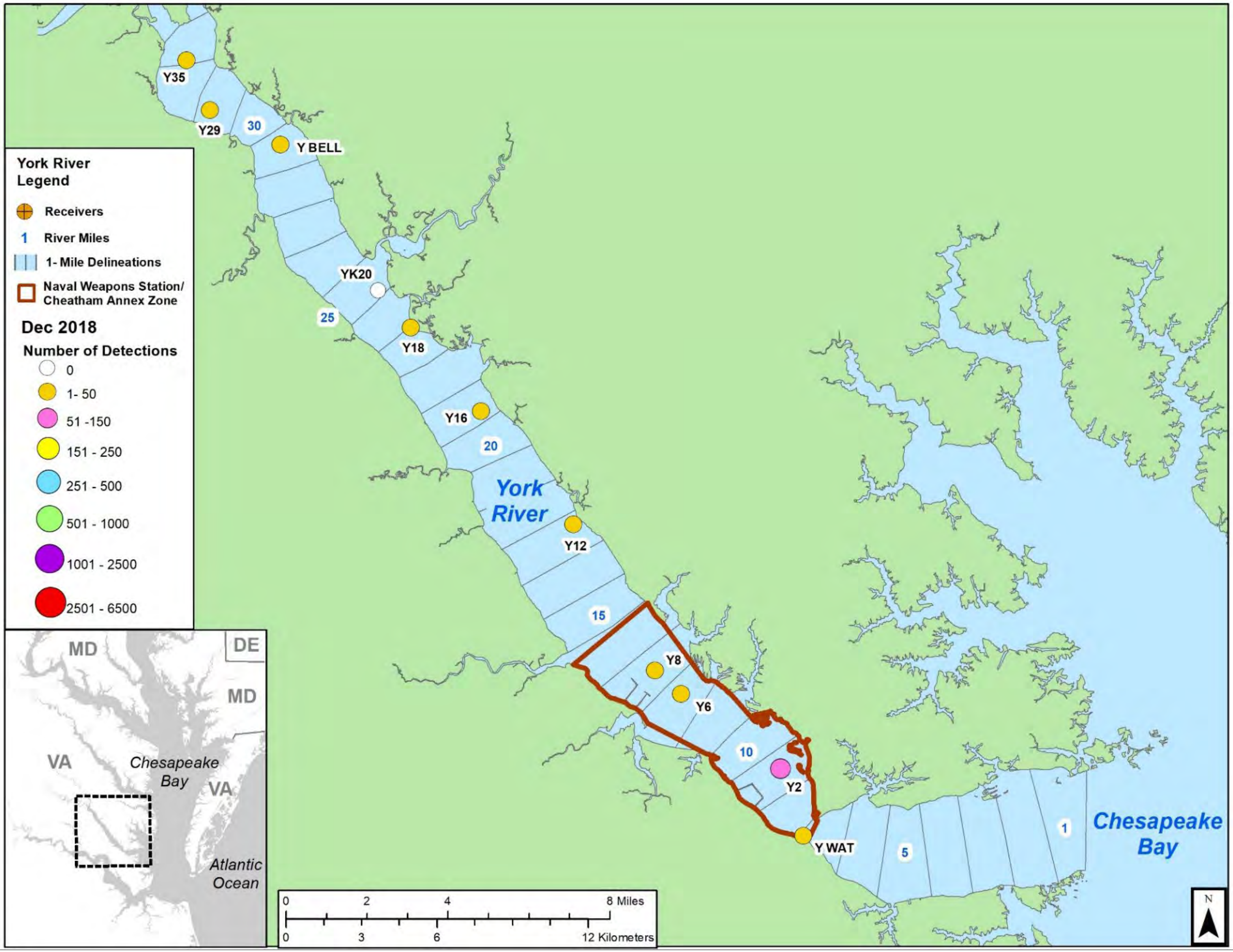

York River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Jul 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Y35
Y29
30
Y BELL
YK20
25
Y18
Y16
20
York River
Y12
15
Y8
Y6
10
Y2
Y WAT
5
1
Chesapeake Bay
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
2
4
8 Miles
0
3
6
12 Kilometers
N

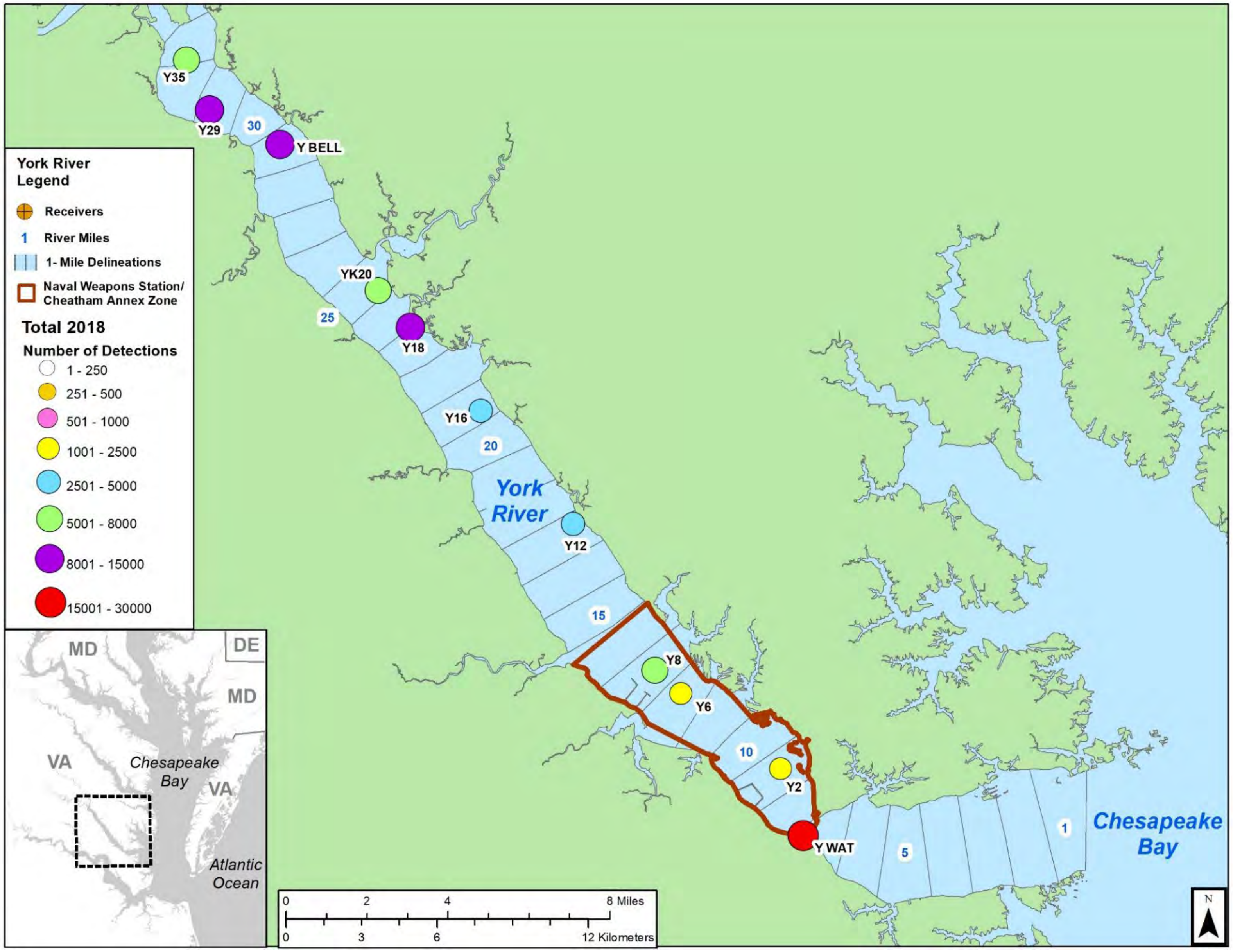

York River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Aug 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Y35
Y29
30
Y BELL
YK20
25
Y18
Y16
20
York River
Y12
15
Y8
Y6
10
Y2
Y WAT
5
1
Chesapeake Bay
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
2
4
8 Miles
0
3
6
12 Kilometers
N

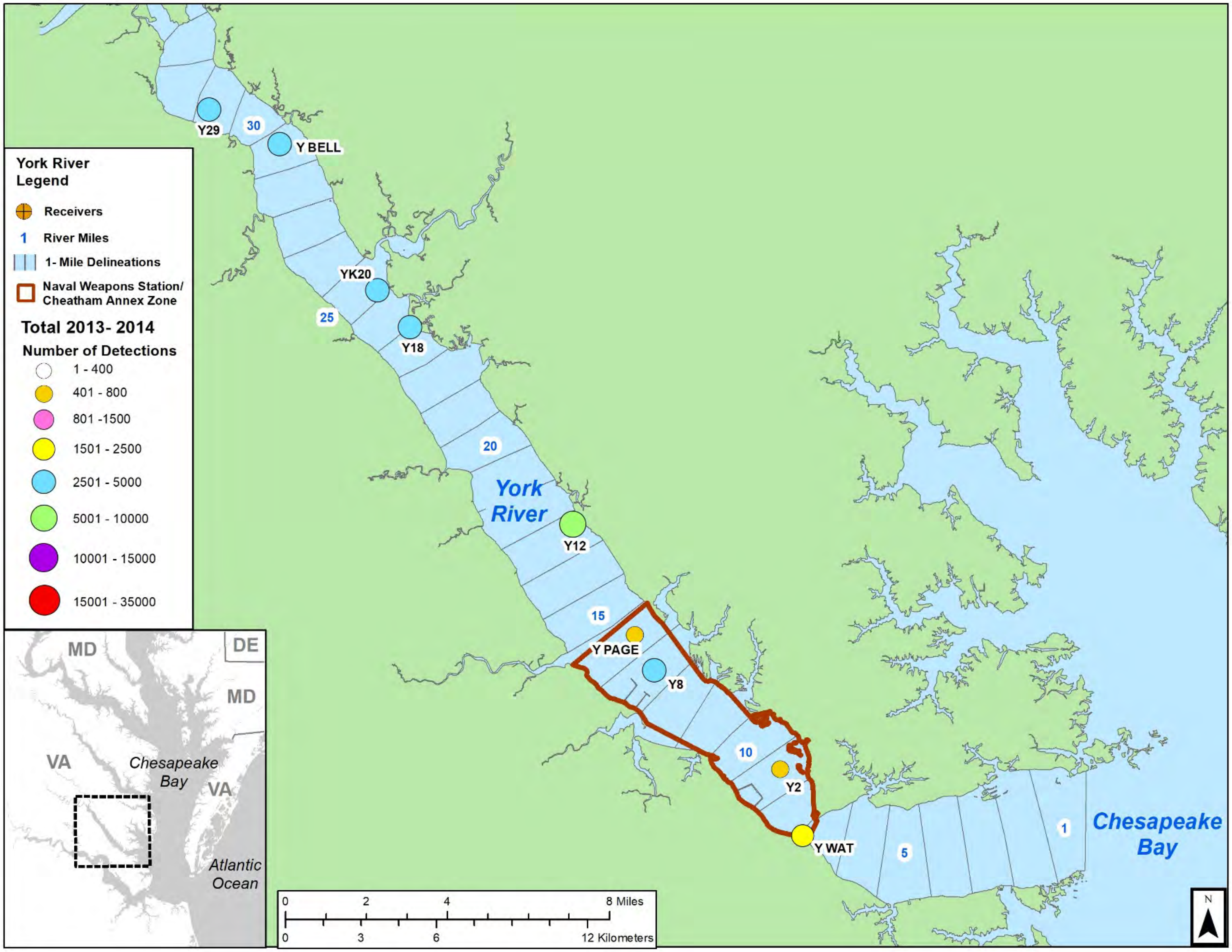

York River Legend
Receivers
River Miles
1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Sep 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Y35
Y29
30
Y BELL
YK20
25
Y18
Y16
20
York River
Y12
15
Y8
Y6
10
Y2
Y WAT
5
1
Chesapeake Bay
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N

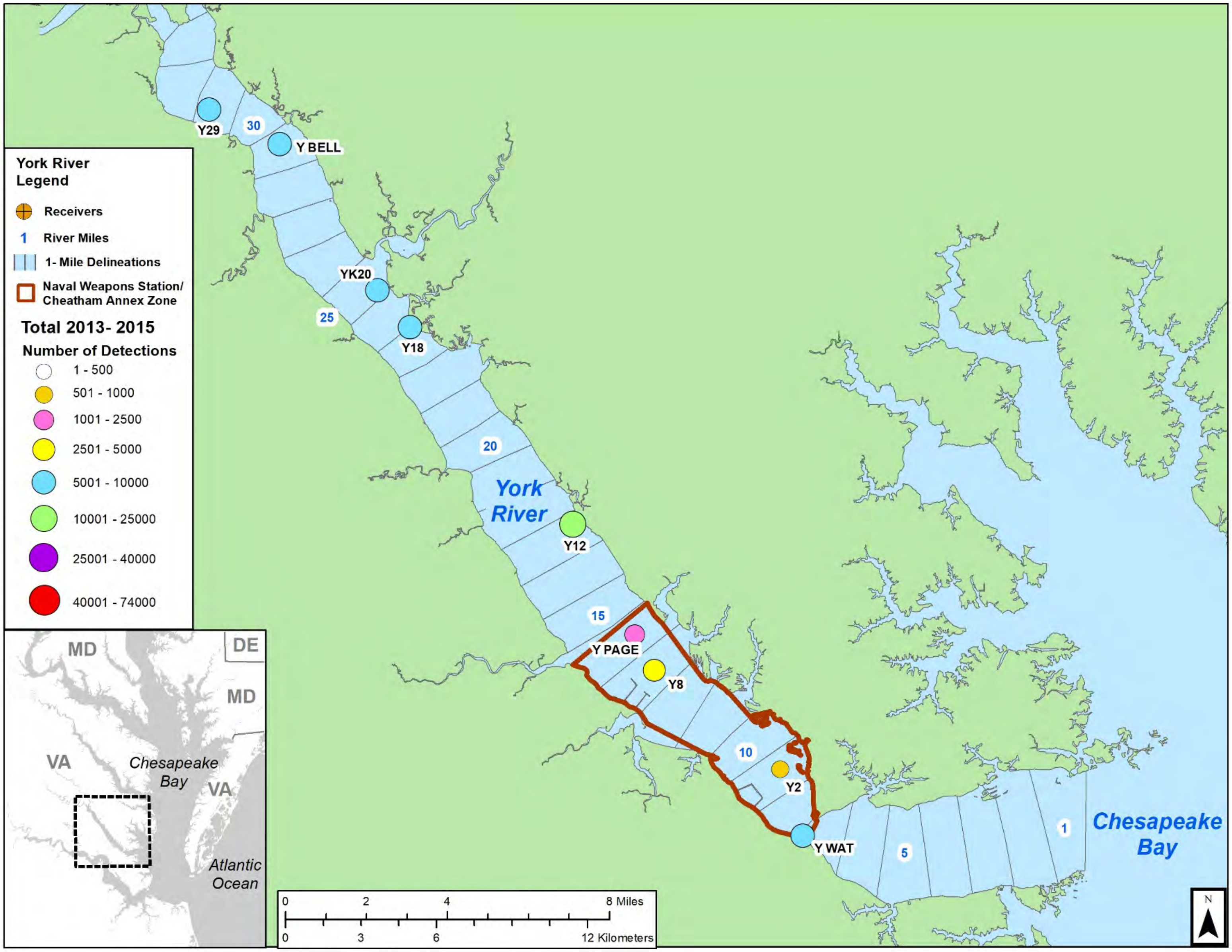

York River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Oct 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Y35
Y29
30
Y BELL
YK20
25
Y18
Y16
20
York River
Y12
15
Y8
Y6
10
Y2
Y WAT
5
1
Chesapeake Bay
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N

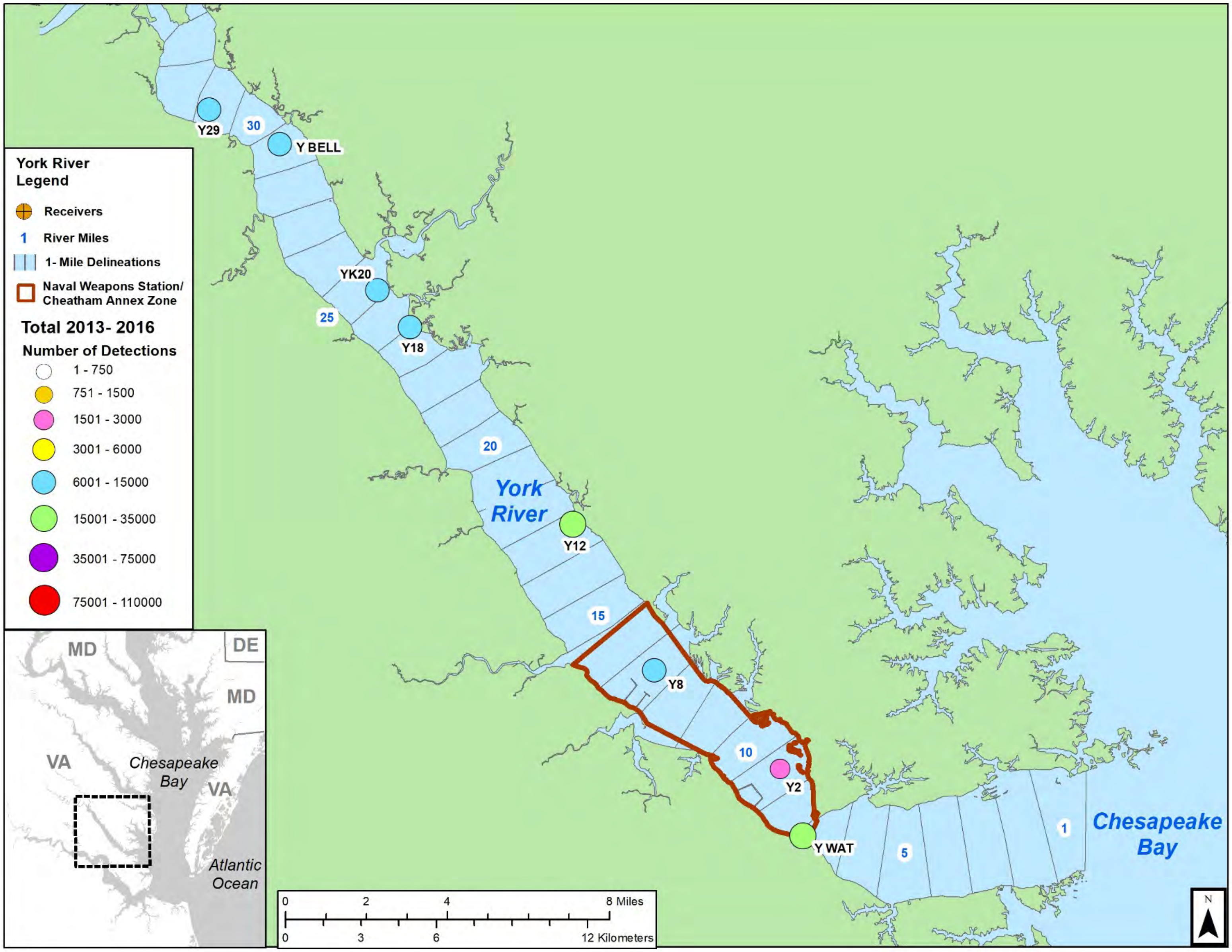

York River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Nov 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Y35
Y29
30
Y BELL
YK20
25
Y18
Y16
20
York River
Y12
15
Y8
Y6
10
Y2
Y WAT
5
1
Chesapeake Bay
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N

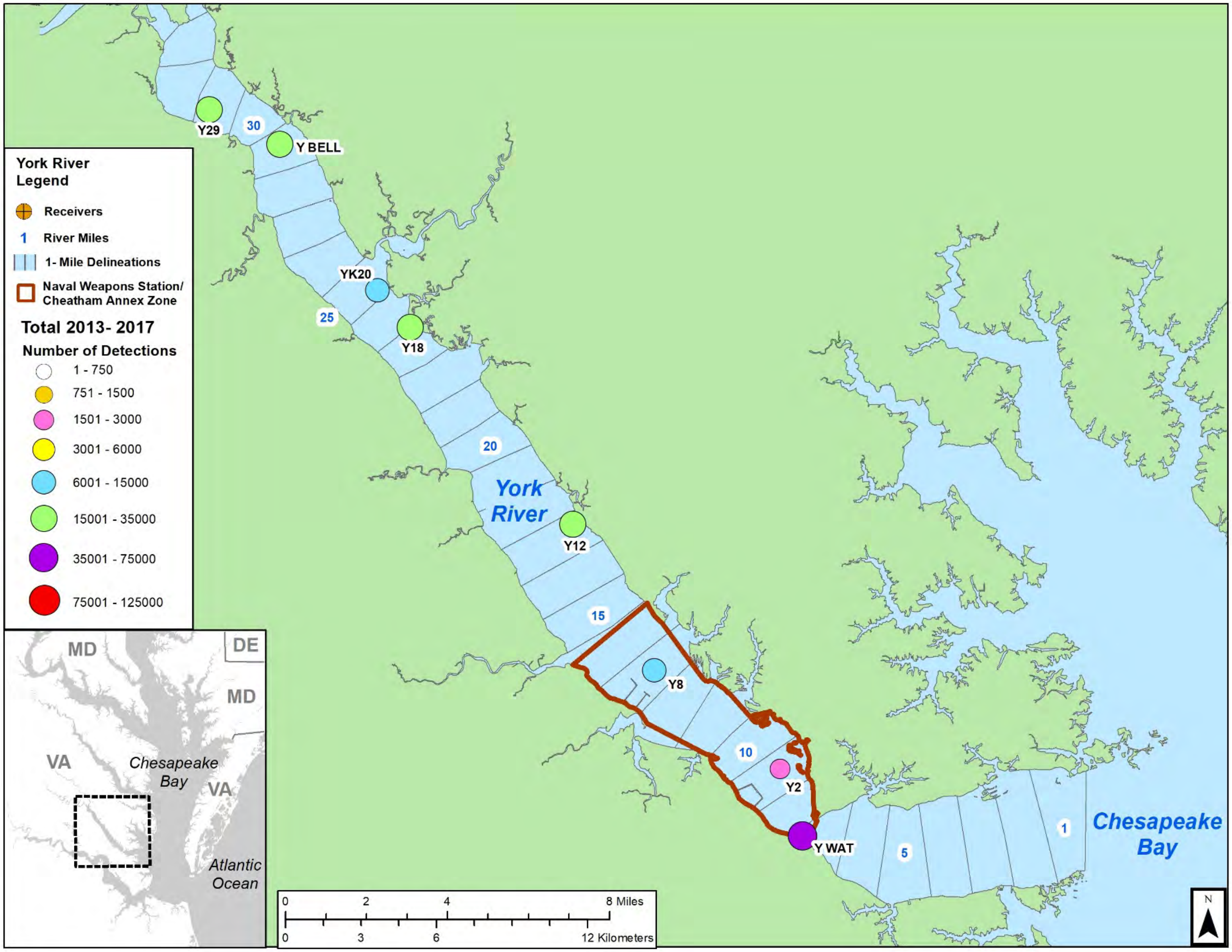

York River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Dec 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Y35
Y29
30
Y BELL
YK20
25
Y18
Y16
20
York River
Y12
15
Y8
Y6
10
Y2
Y WAT
5
1
Chesapeake Bay
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N

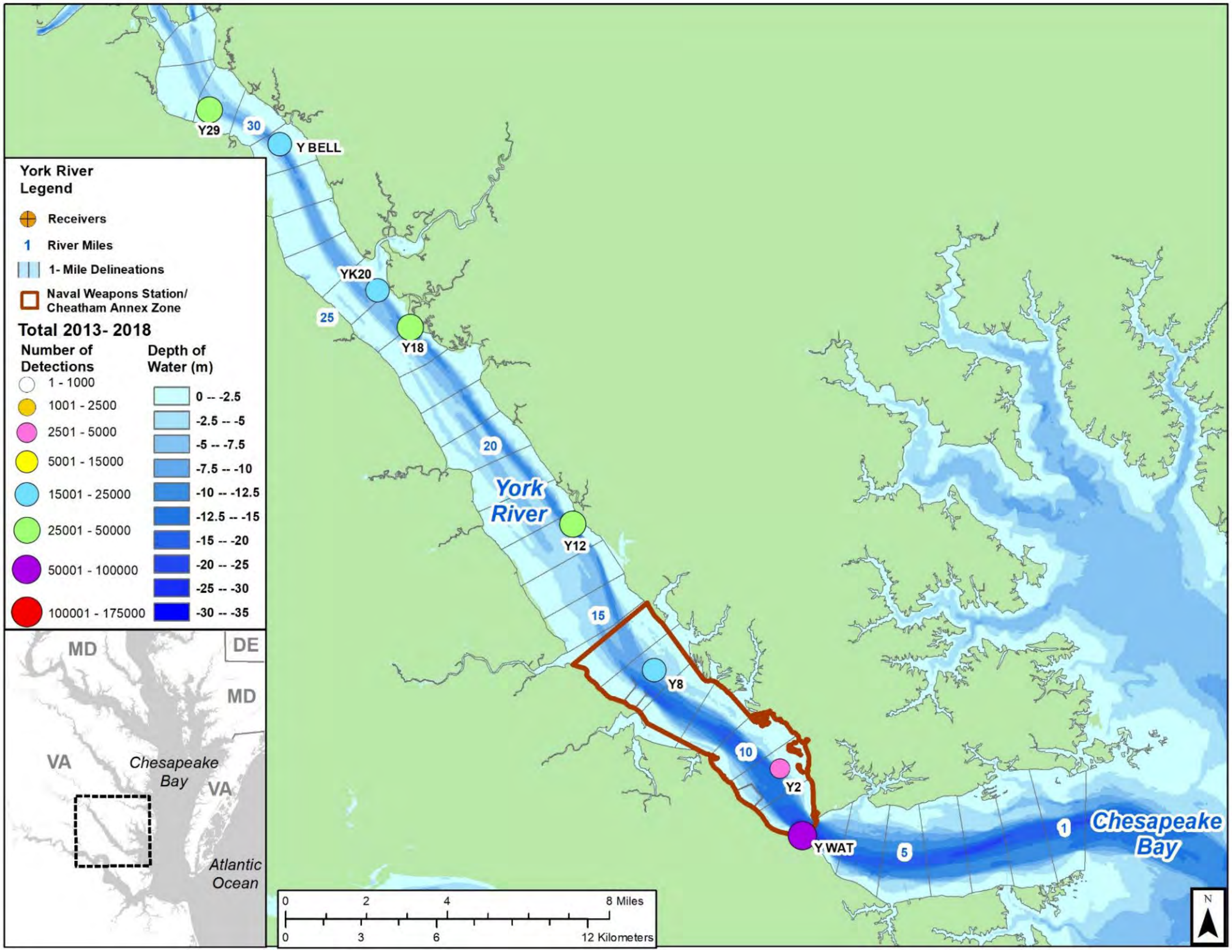

York River
Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Total 2018
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
Y35
Y29
30
Y BELL
YK20
25
Y18
Y16
20
York River
Y12
15
Y8
Y6
10
Y2
Y WAT
5
1
Chesapeake Bay
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N

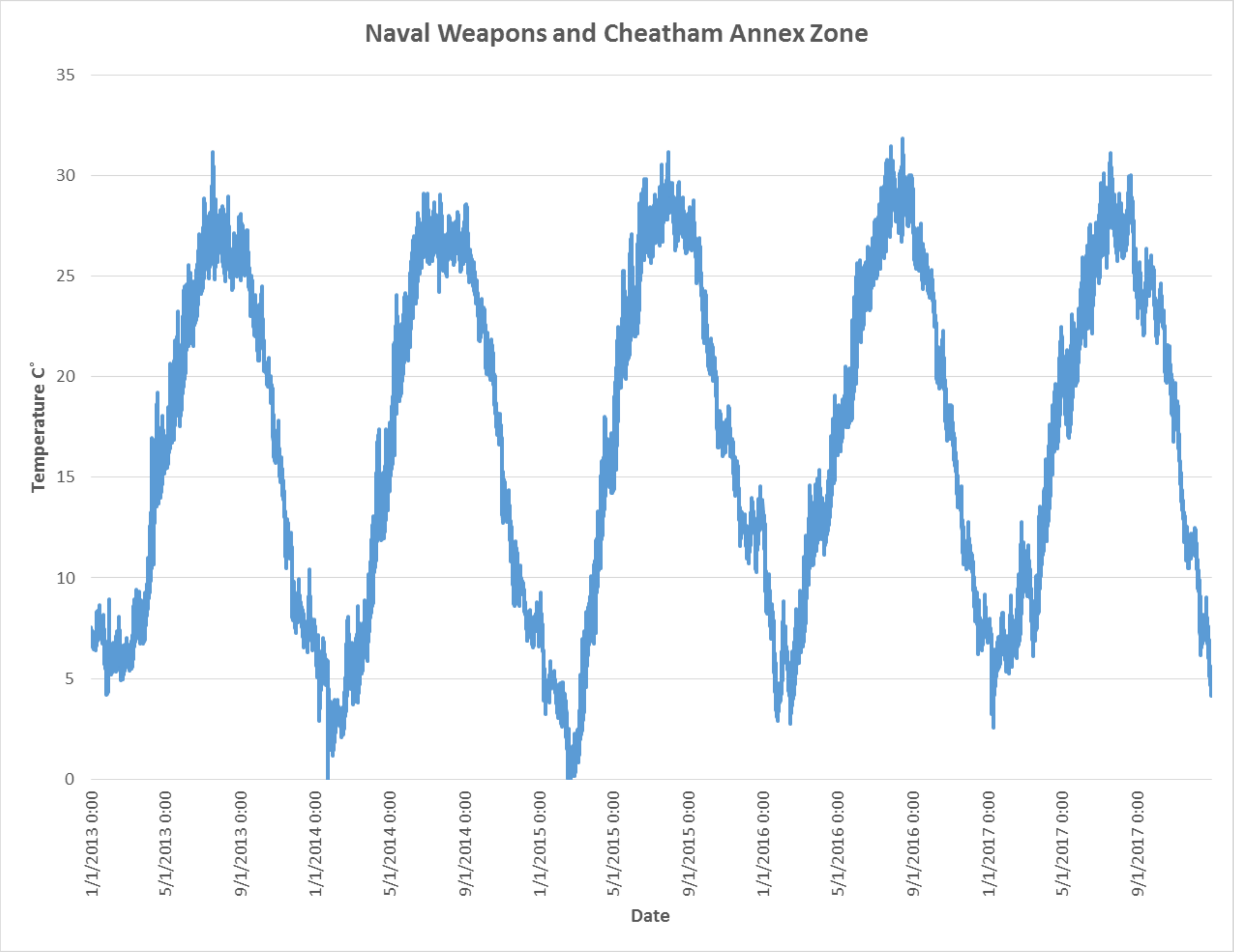

York River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Total 2013- 2014
Number of Detections
1 - 400
401 - 800
801 -1500
1501 - 2500
2501 - 5000
5001 - 10000
10001 - 15000
15001 - 35000
Y29
30
Y BELL
YK20
25
Y18
20
York River
Y12
15
Y PAGE
Y8
10
Y2
Y WAT
5
1
Chesapeake Bay
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N


York River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Total 2013- 2015
Number of Detections
1 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 10000
10001 - 25000
25001 - 40000
40001 - 74000
Y29
30
Y BELL
YK20
25
Y18
20
York River
Y12
15
Y PAGE
Y8
10
Y2
Y WAT
5
1
Chesapeake Bay
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N

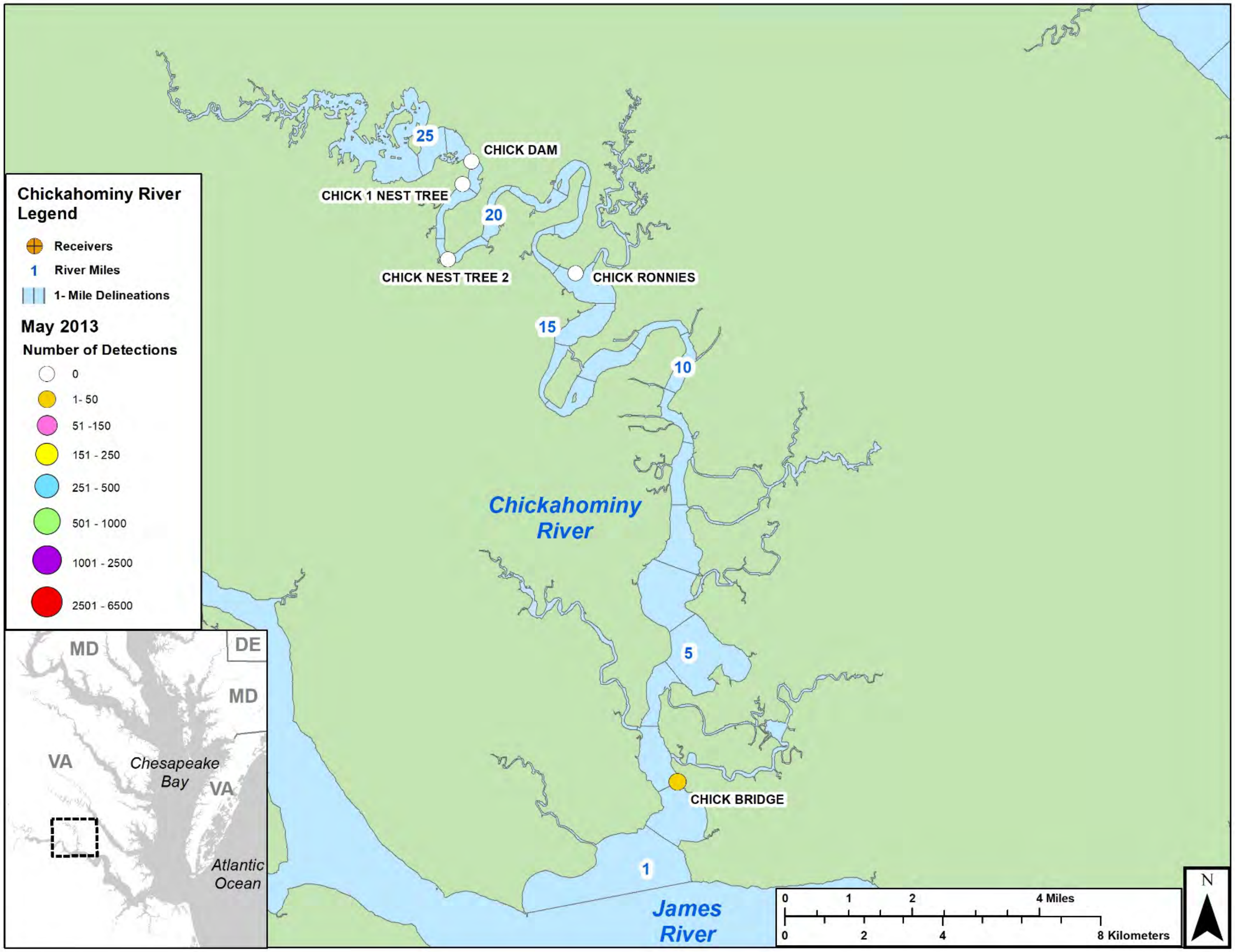

York River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Total 2013- 2016
Number of Detections
1 - 750
751 - 1500
1501 - 3000
3001 - 6000
6001 - 15000
15001 - 35000
35001 - 75000
75001 - 110000
Y29
30
Y BELL
YK20
25
Y18
20
York River
Y12
15
Y8
10
Y2
Y WAT
5
1
Chesapeake Bay
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 2 4 8 Miles
0 3 6 12 Kilometers
N

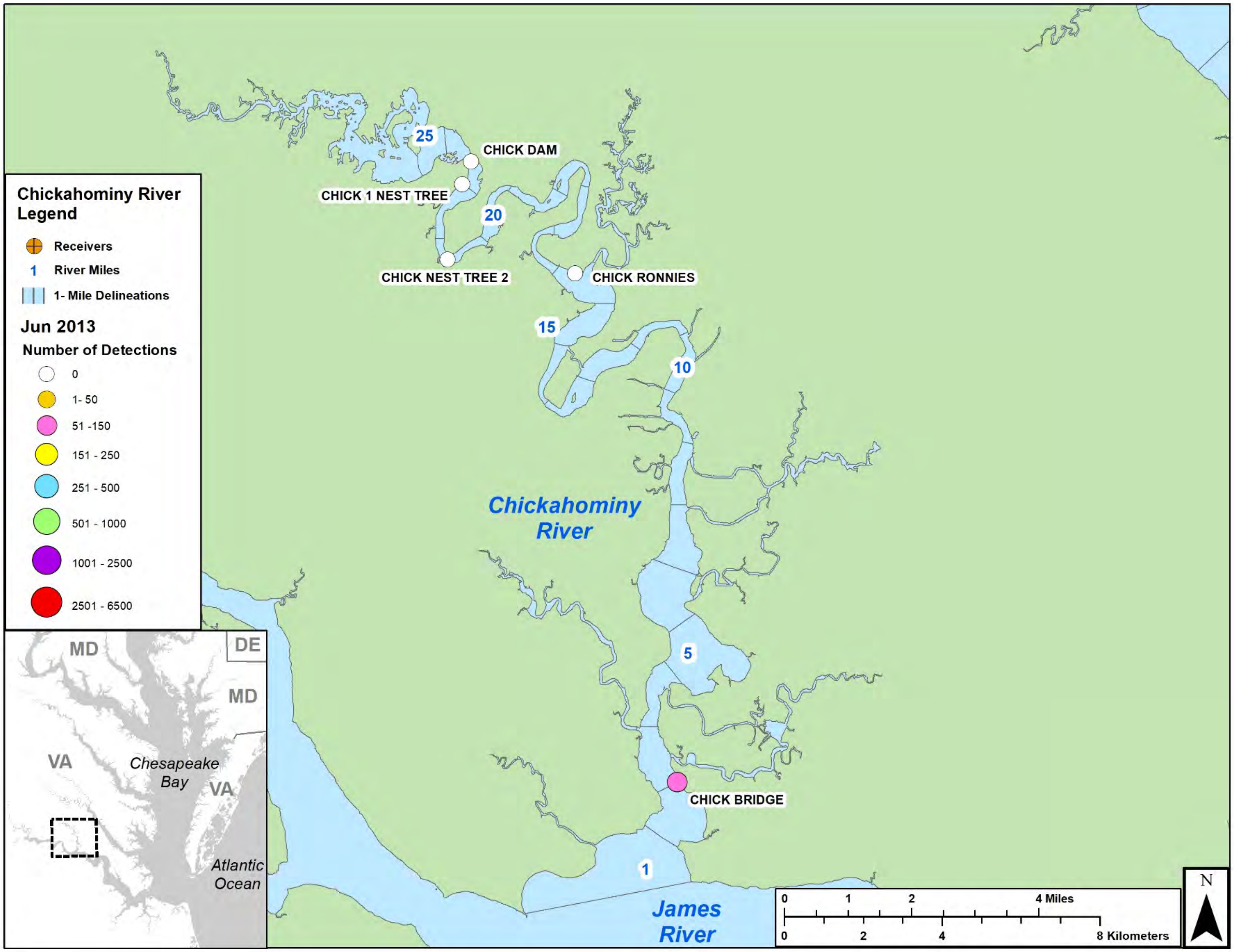

York River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Total 2013- 2017
Number of Detections
1 - 750
751 - 1500
1501 - 3000
3001 - 6000
6001 - 15000
15001 - 35000
35001 - 75000
75001 - 125000
Y29
30
Y BELL
YK20
25
Y18
20
York River
Y12
15
Y8
10
Y2
Y WAT
5
1
Chesapeake Bay
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
2
4
8 Miles
0
3
6
12 Kilometers
N

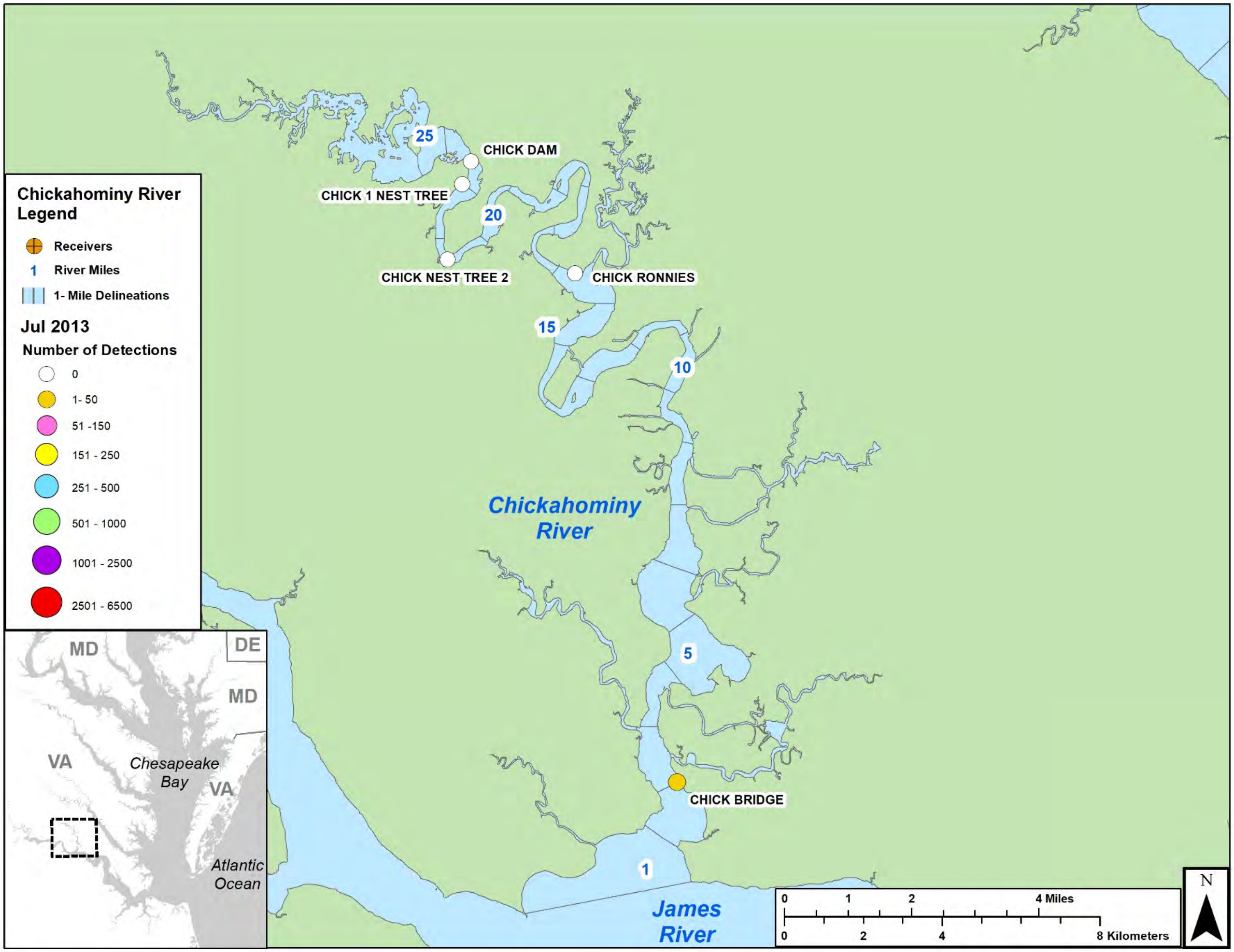

York River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Weapons Station/ Cheatham Annex Zone
Total 2013- 2018
Number of Detections
1 - 1000
1001 - 2500
2501 - 5000
5001 - 15000
15001 - 25000
25001 - 50000
50001 - 100000
100001 - 175000
Depth of Water (m)
0 -- -2.5
-2.5 -- -5
-5 -- -7.5
-7.5 -- -10
-10 -- -12.5
-12.5 -- -15
-15 -- -20
-20 -- -25
-25 -- -30
-30 -- -35
Y29
30
Y BELL
YK20
25
Y18
20
York River
Y12
15
Y8
10
Y2
Y WAT
5
1
Chesapeake Bay
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
2
4
8 Miles
0
3
6
12 Kilometers
N

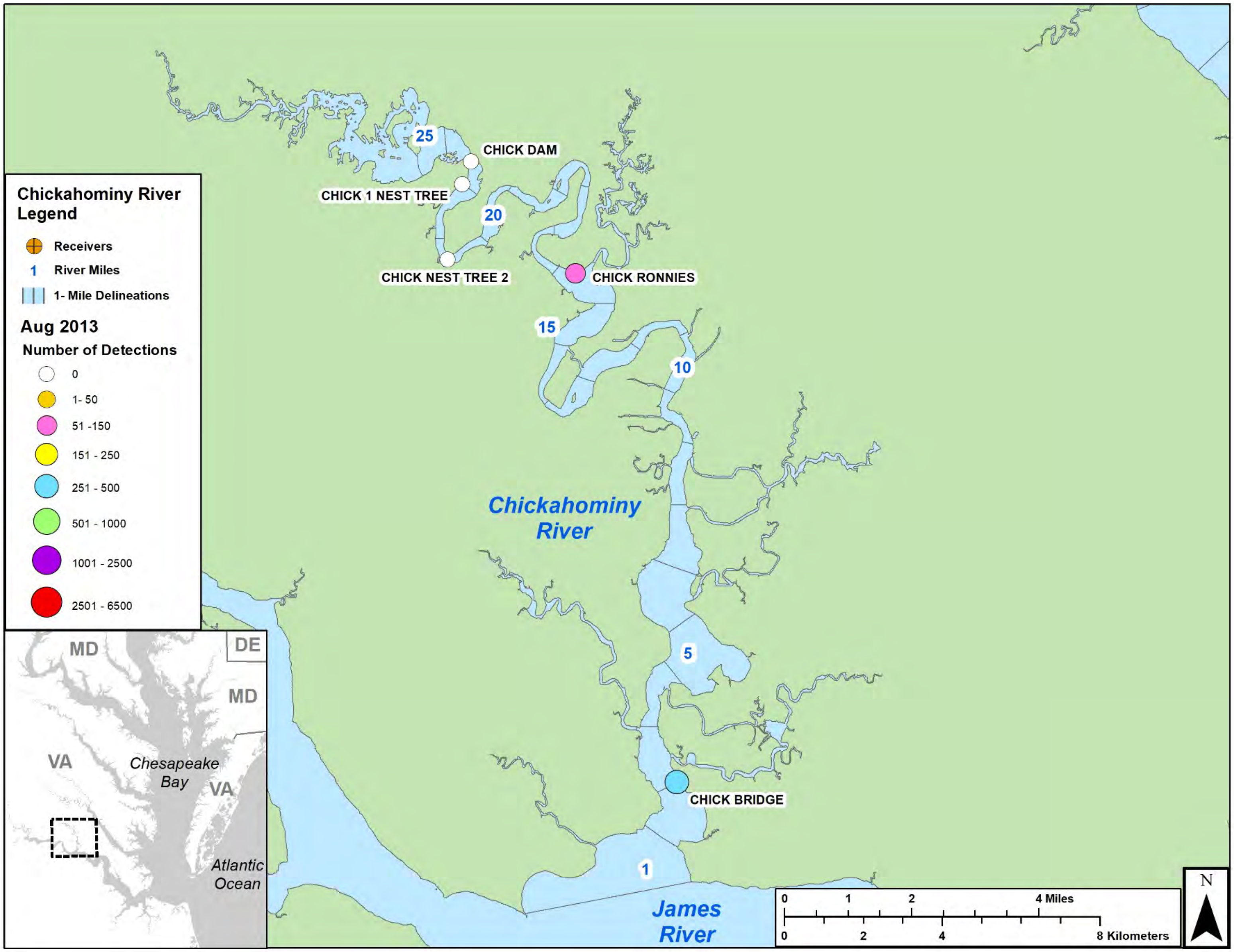

Naval Weapons and Cheatham Annex Zone
Temperature C˚
35
30
25
20
15
10
5
0
1/1/2013 0:00
5/1/2013 0:00
9/1/2013 0:00
1/1/2014 0:00
5/1/2014 0:00
9/1/2014 0:00
1/1/2015 0:00
5/1/2015 0:00
9/1/2015 0:00
1/1/2016 0:00
5/1/2016 0:00
9/1/2016 0:00
1/1/2017 0:00
5/1/2017 0:00
9/1/2017 0:00
Date

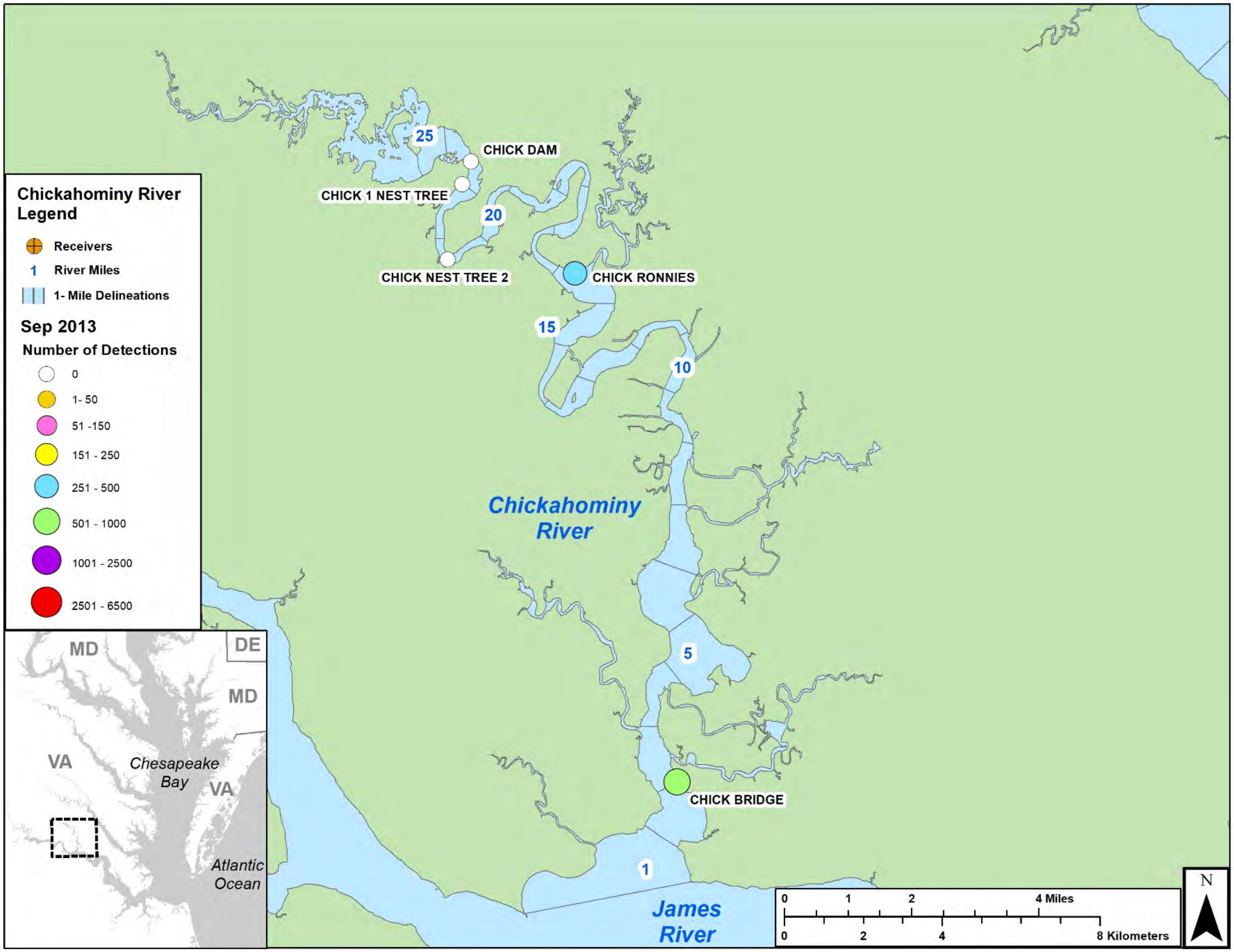
8.6. Appendix 8.6: Detections of Sonic-tagged Atlantic Sturgeon in the Chickahominy Region, by Month, Year and Overall

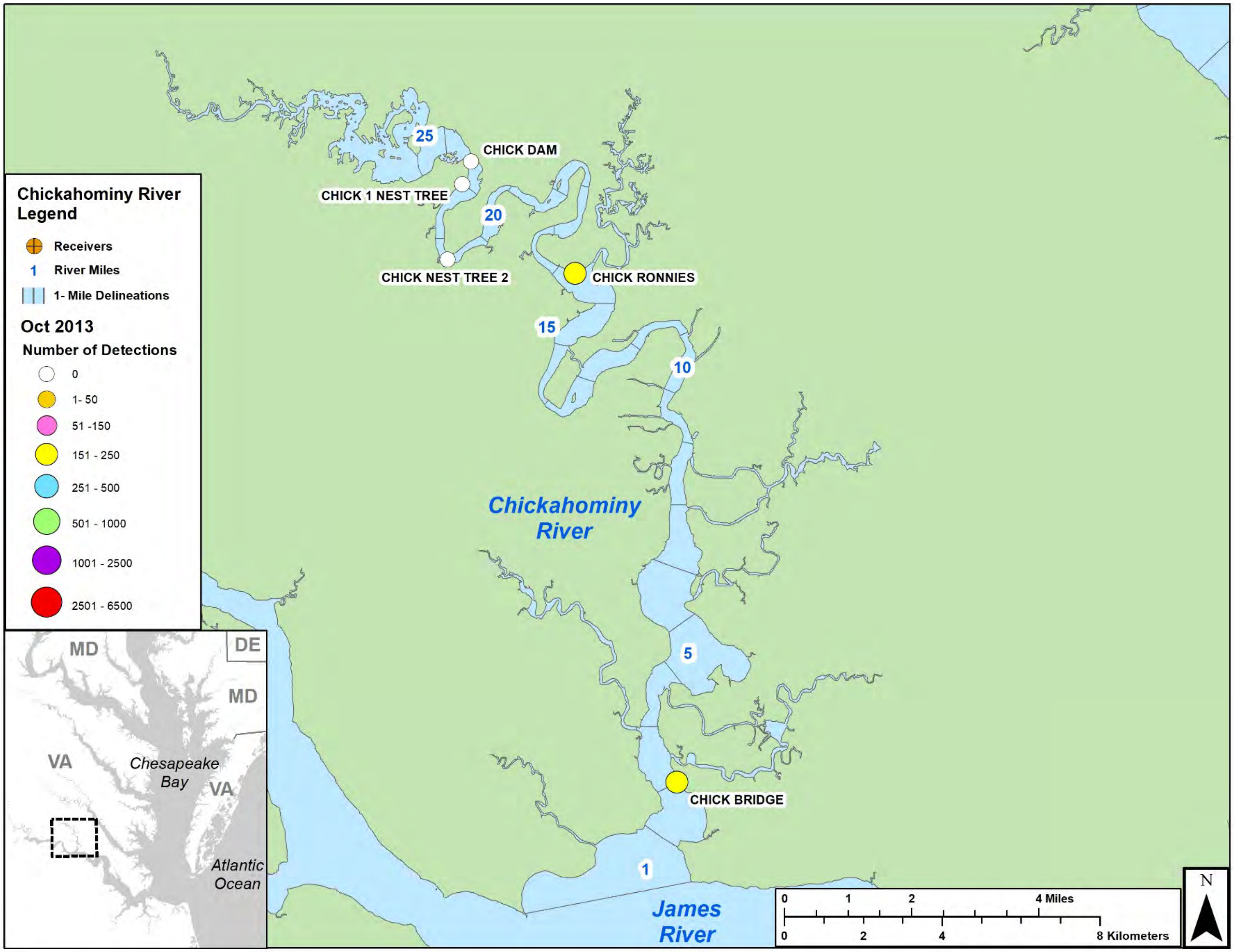


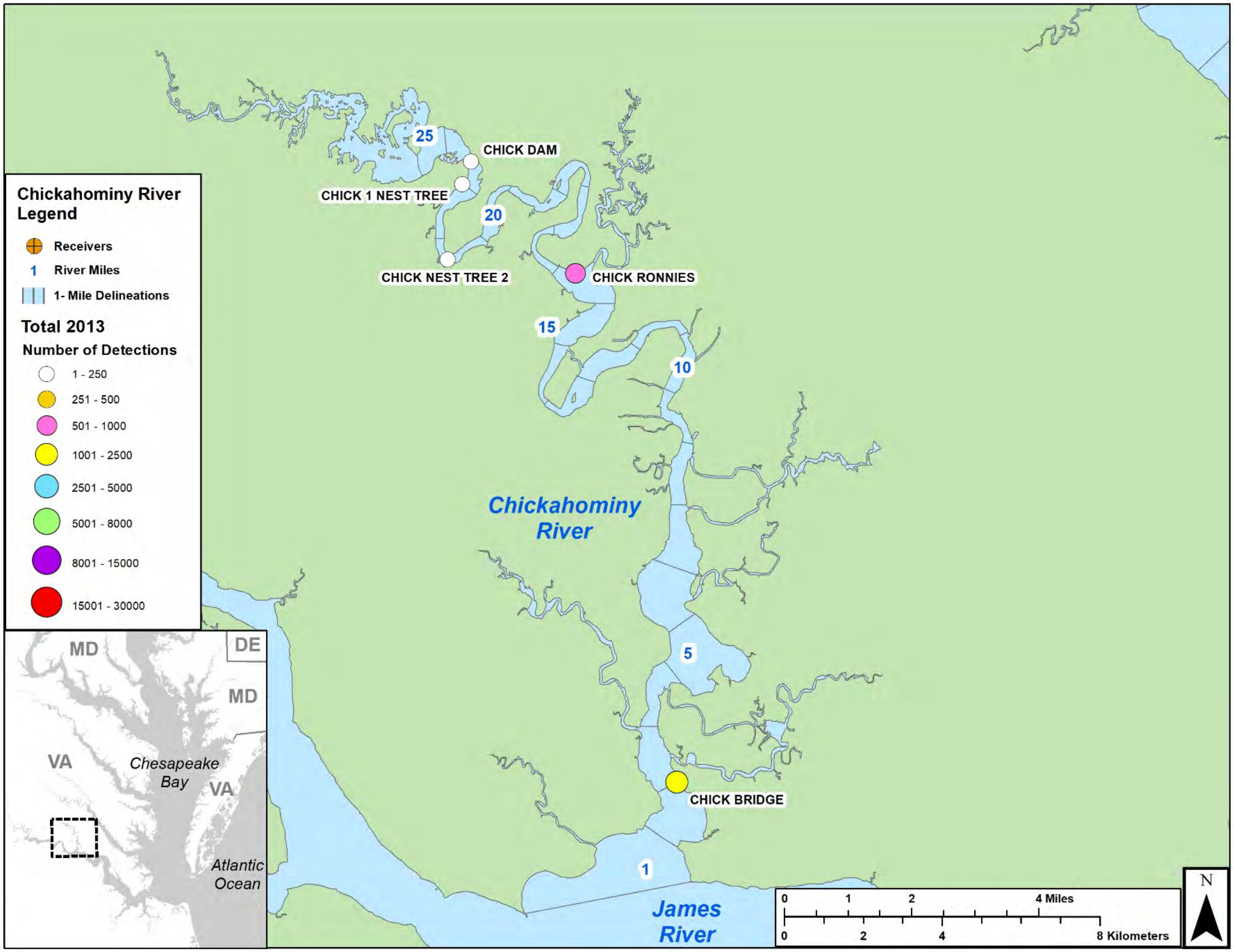

Chickahominy River Legend
Receivers
River Miles
1- Mile Delineations
Jun 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
25
20
15
10
5
1
CHICK DAM
CHICK 1 NEST TREE
CHICK NEST TREE 2
CHICK RONNIES
CHICK BRIDGE
Chickahominy River
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 1 2 4 Miles
0 2 4 8 Kilometers
N


Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Jul 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
CHICK DAM
CHICK 1 NEST TREE
CHICK NEST TREE 2
CHICK RONNIES
CHICK BRIDGE
25
20
15
10
5
1
Chickahominy River
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
1
2
4 Miles
0
2
4
8 Kilometers
N

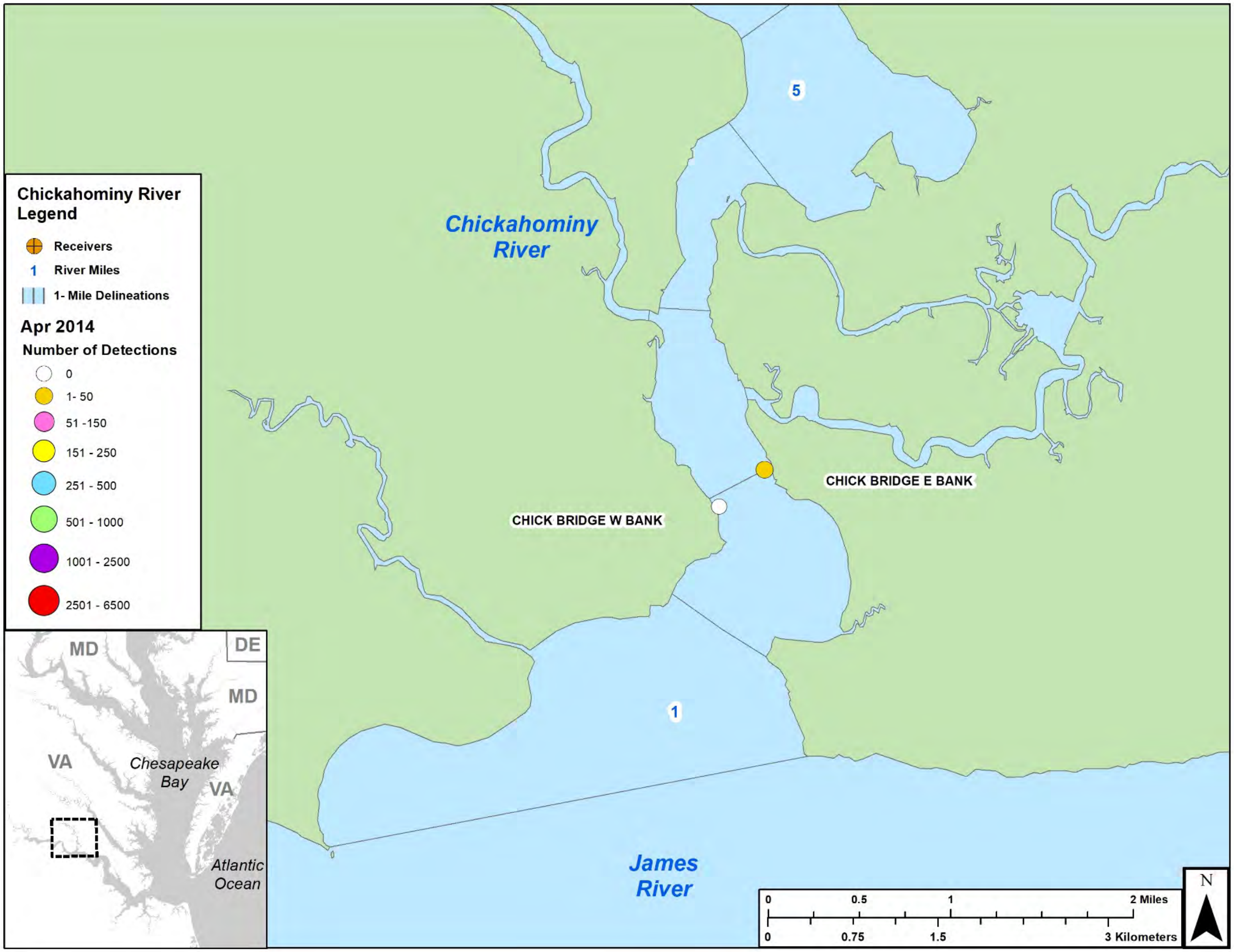

Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Aug 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
25
CHICK DAM
CHICK 1 NEST TREE
20
CHICK NEST TREE 2
CHICK RONNIES
15
10
Chickahominy River
5
CHICK BRIDGE
1
James River
0 1 2 4 Miles
0 2 4 8 Kilometers
N
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean

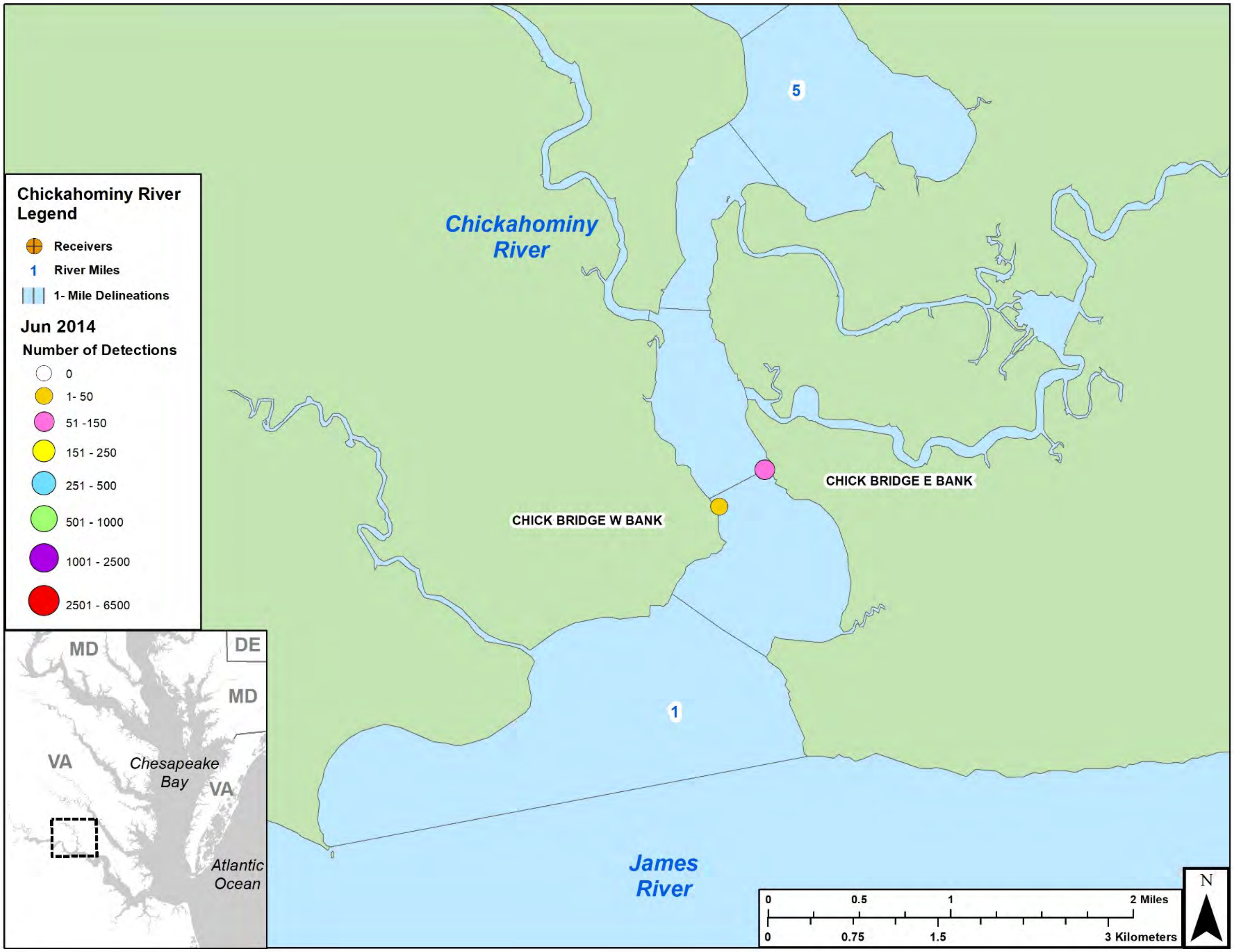

Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Sep 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
25
20
15
10
5
1
CHICK DAM
CHICK 1 NEST TREE
CHICK NEST TREE 2
CHICK RONNIES
CHICK BRIDGE
Chickahominy River
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 1 2 4 Miles
0 2 4 8 Kilometers
N

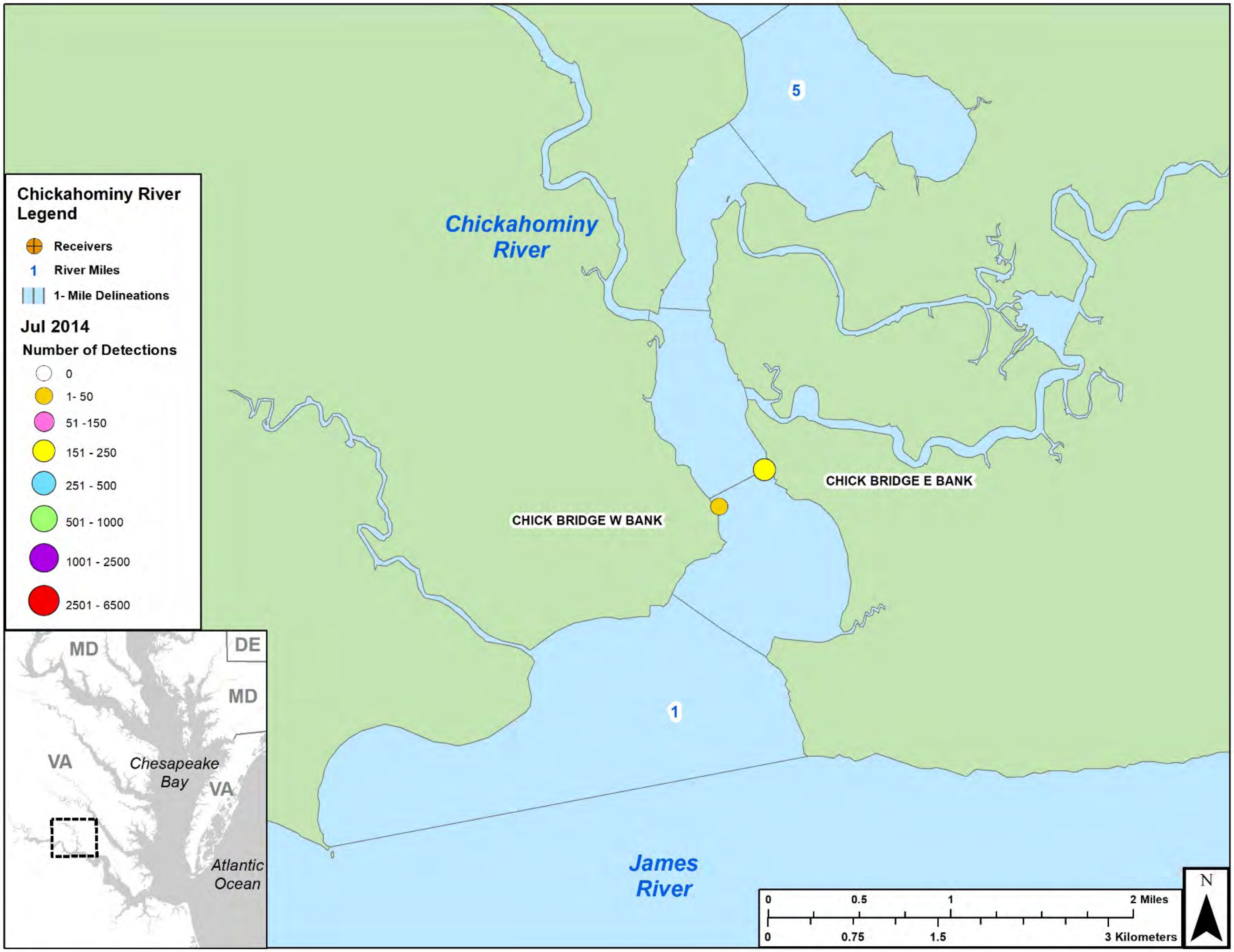

Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Oct 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
CHICK DAM
CHICK 1 NEST TREE
CHICK NEST TREE 2
CHICK RONNIES
CHICK BRIDGE
25
20
15
10
5
1
Chickahominy River
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 1 2 4 Miles
0 2 4 8 Kilometers
N

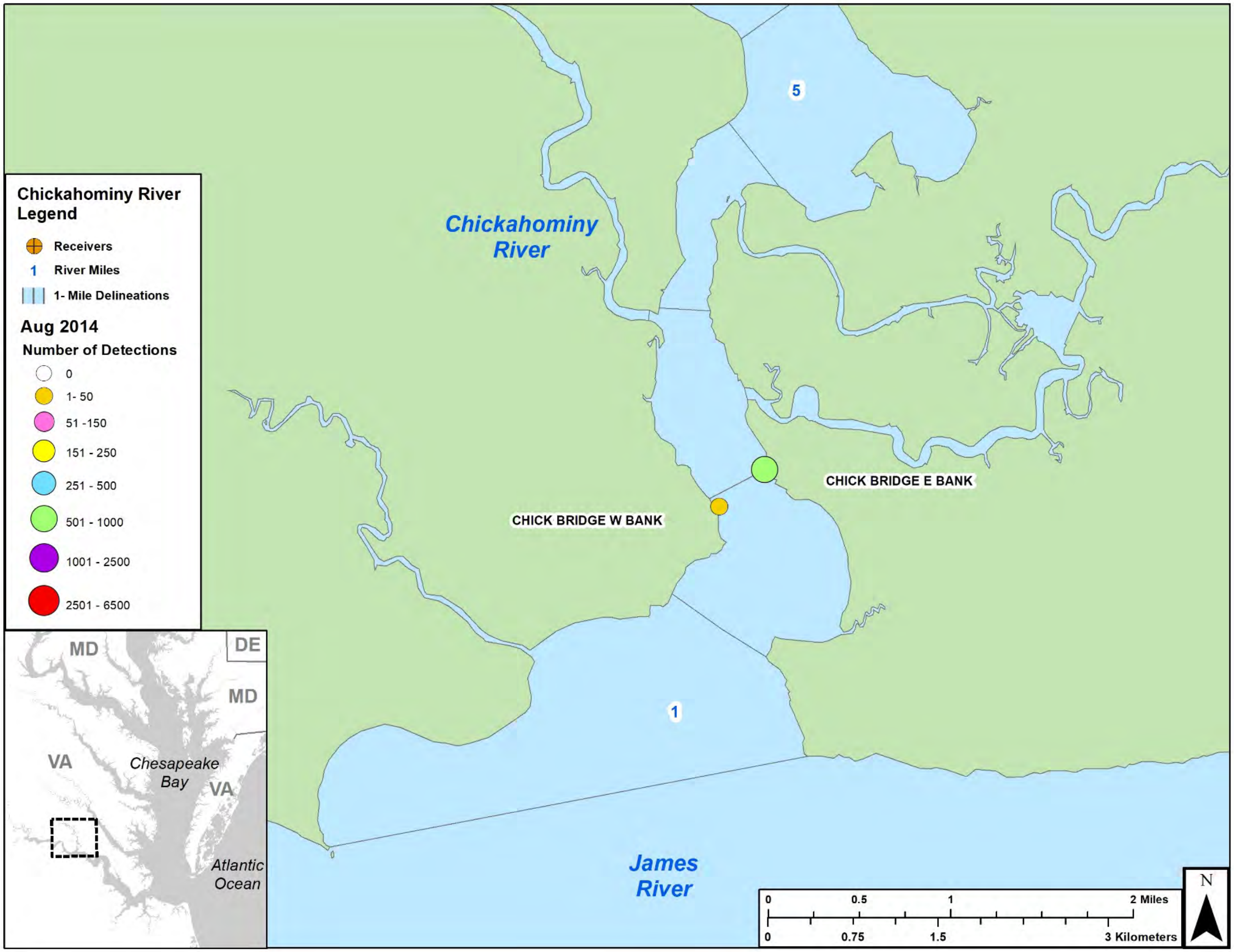


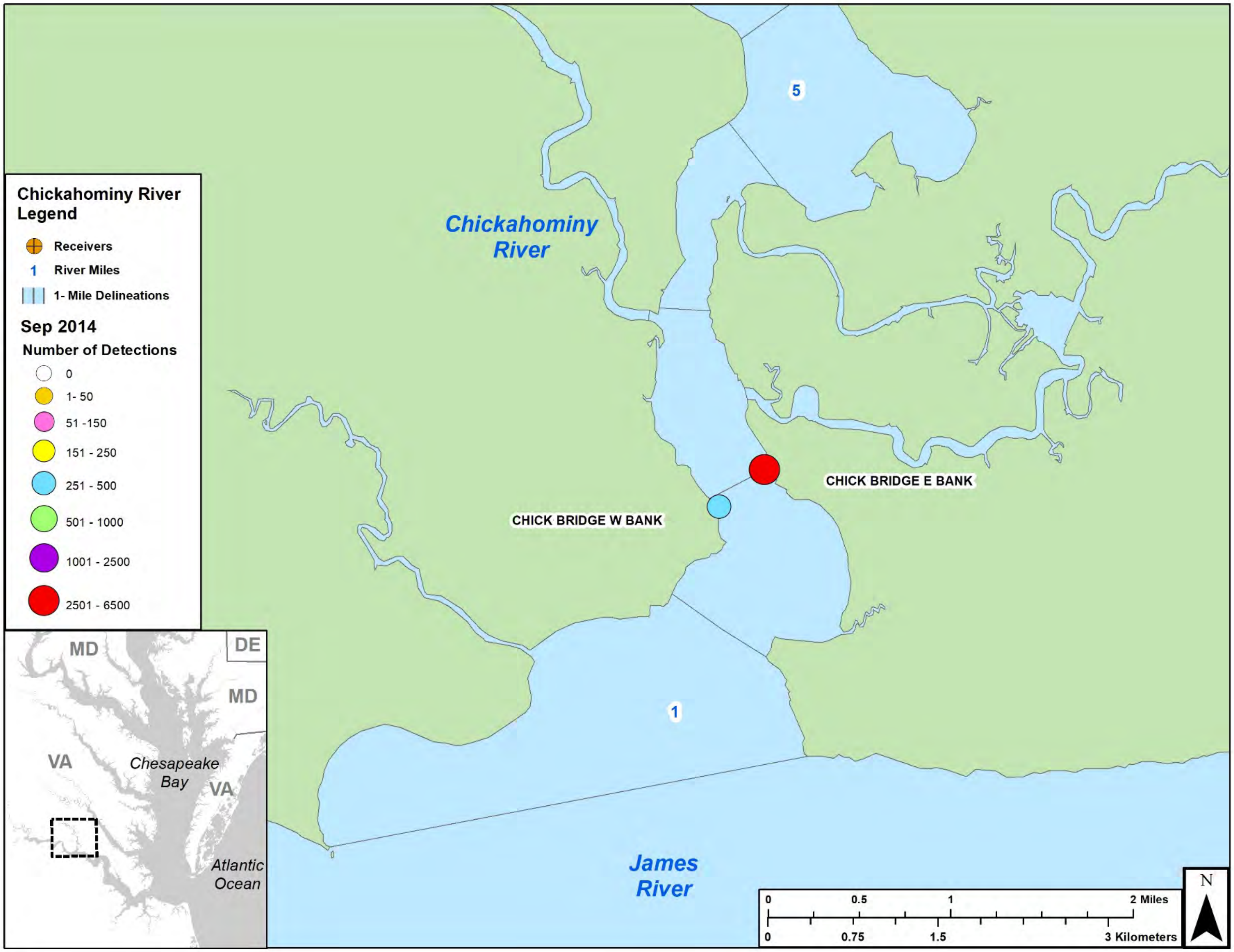
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Total 2013
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
25
CHICK DAM
CHICK 1 NEST TREE
20
CHICK NEST TREE 2
CHICK RONNIES
15
10
Chickahominy River
5
CHICK BRIDGE
1
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 1 2 4 Miles
0 2 4 8 Kilometers
N

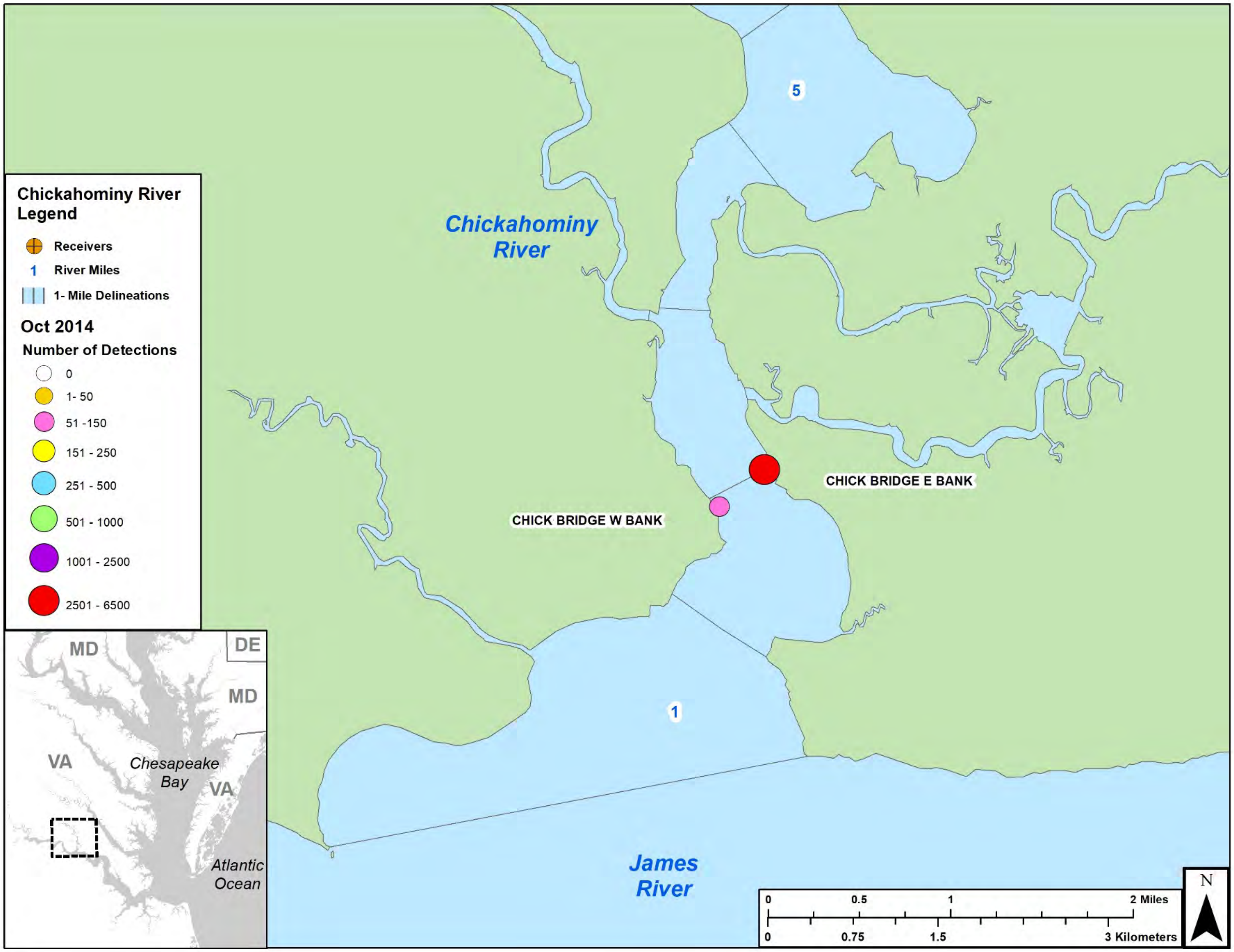

Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Apr 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
James River
5
1
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N

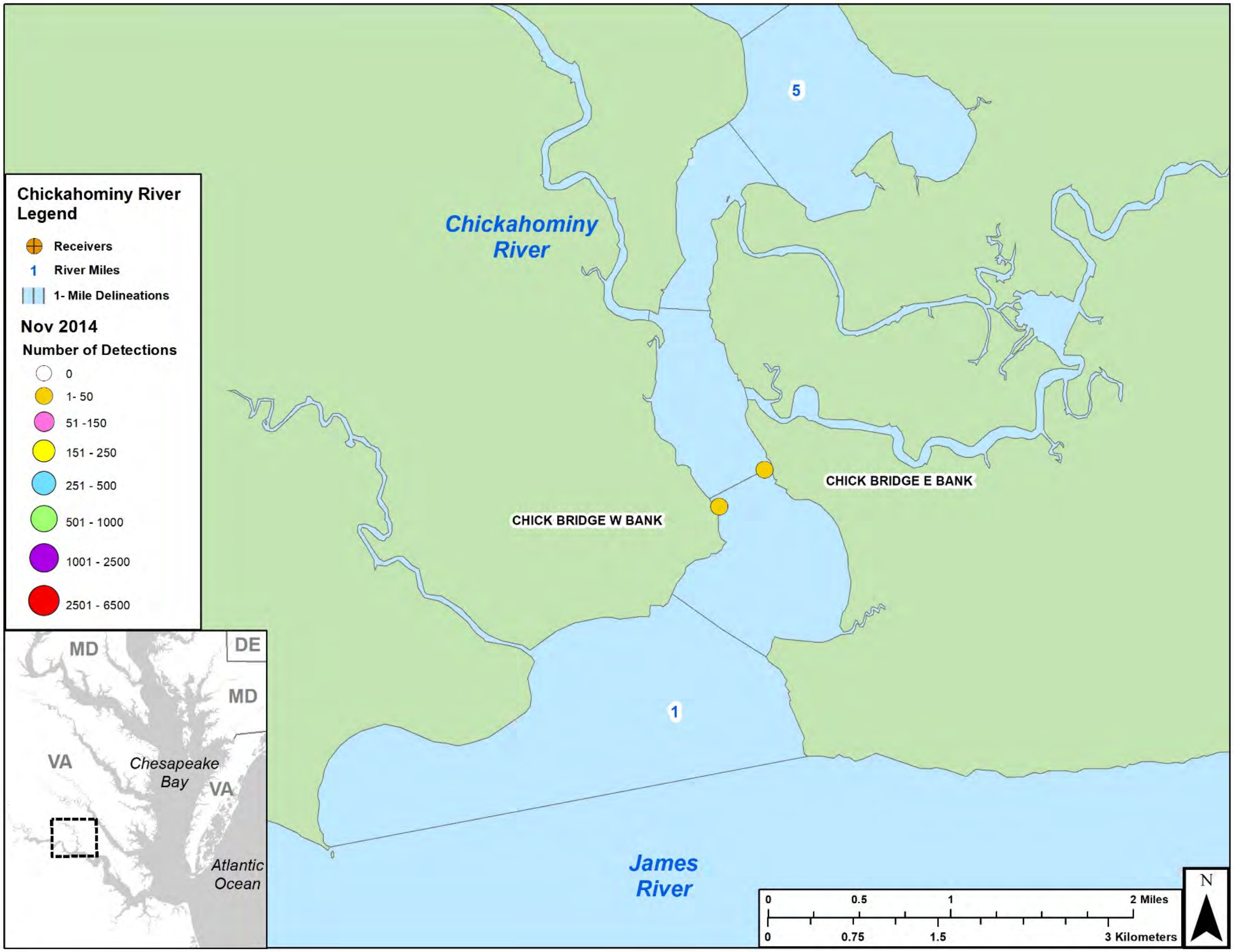

Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Jun 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
5
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
1
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N

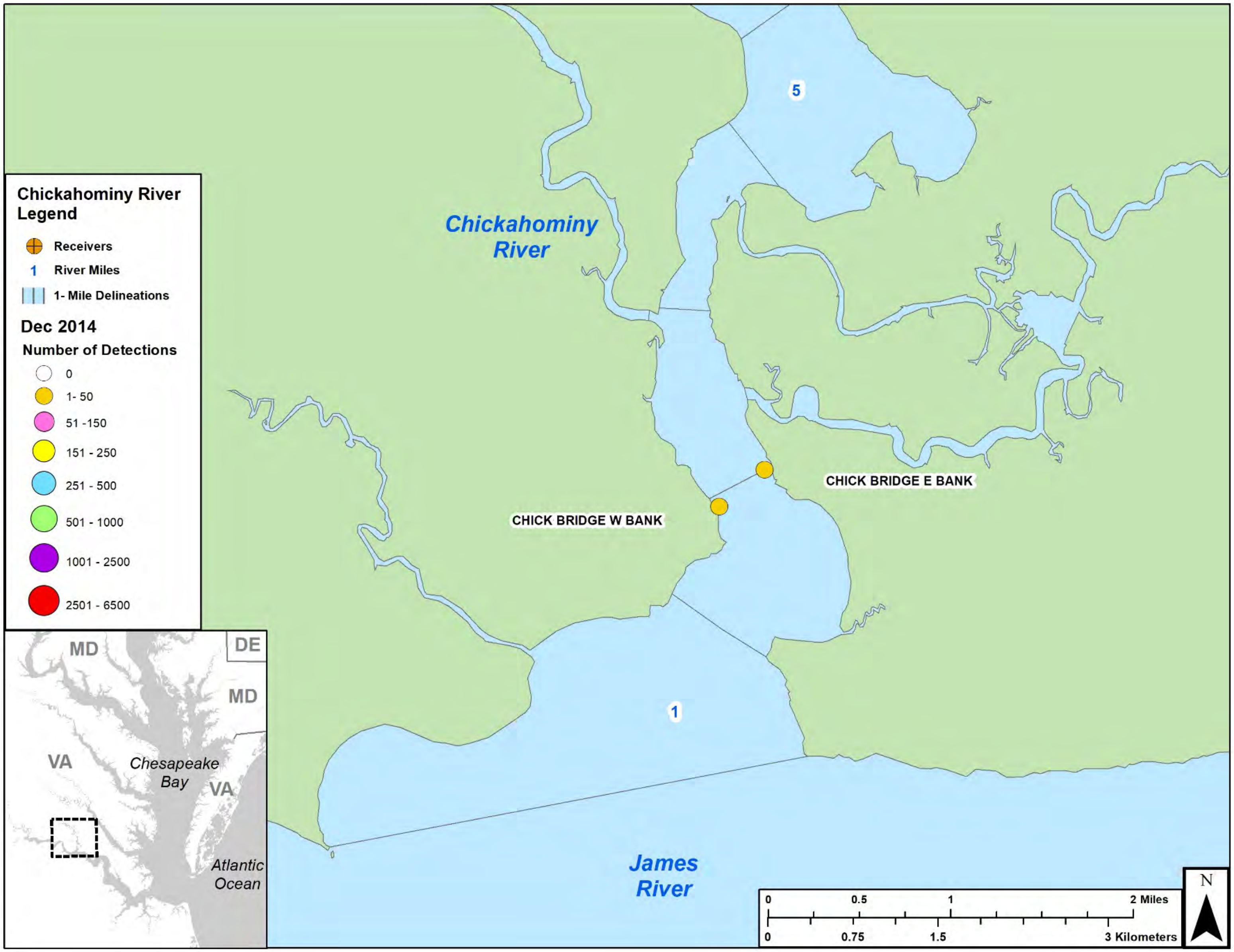

Chickahominy River
Legend
Receivers
1 River Miles
1- Mile Delineations
Jul 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
5
1
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N


Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Aug 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
5
1
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N


Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Sep 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
5
1
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N


Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Oct 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
5
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
1
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N


Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Nov 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
James River
5
1
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N


Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Dec 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
James River
5
1
CHICK BRIDGE W BANK
CHICK BRIDGE E BANK
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
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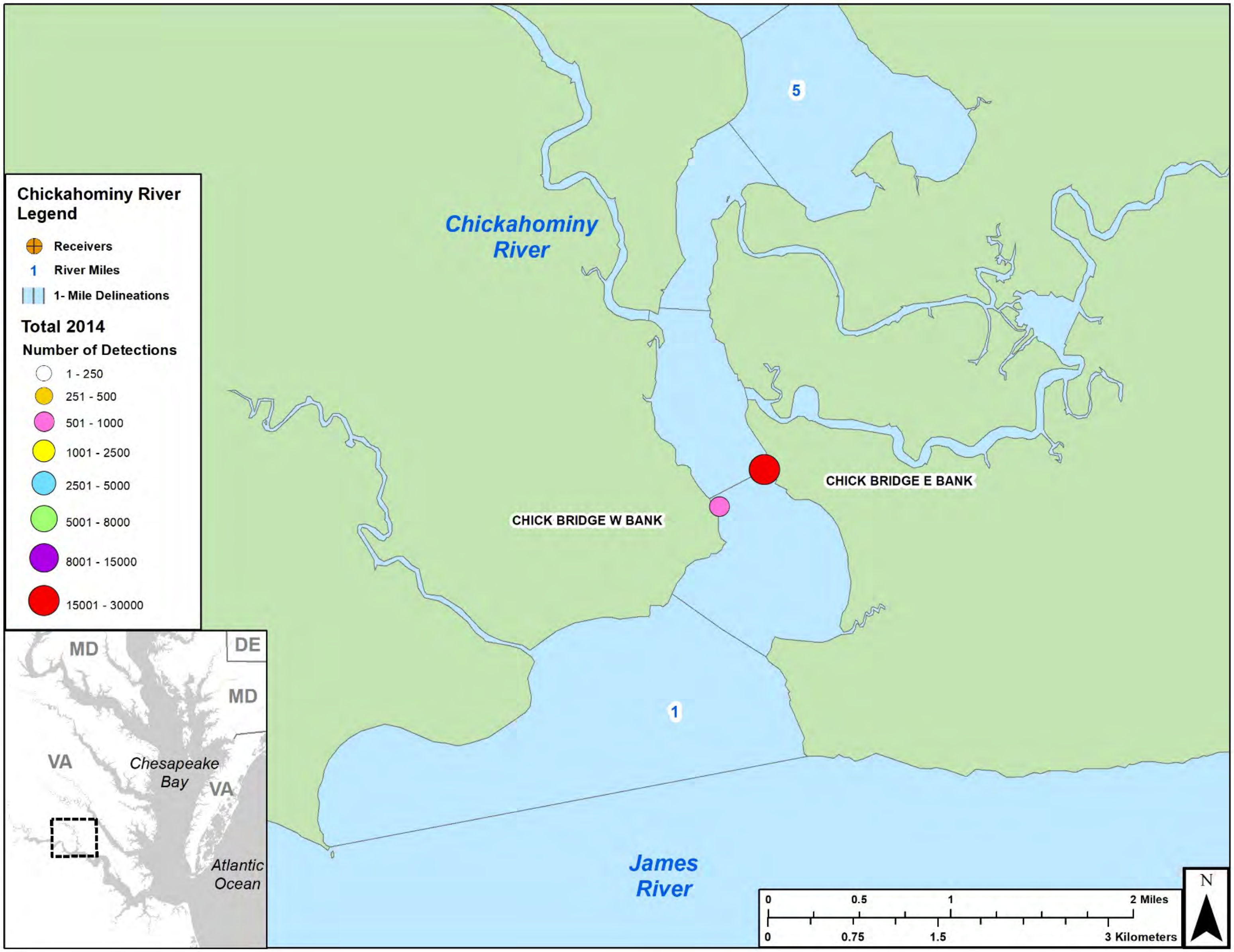
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Total 2014
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
Chickahominy River
5
1
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
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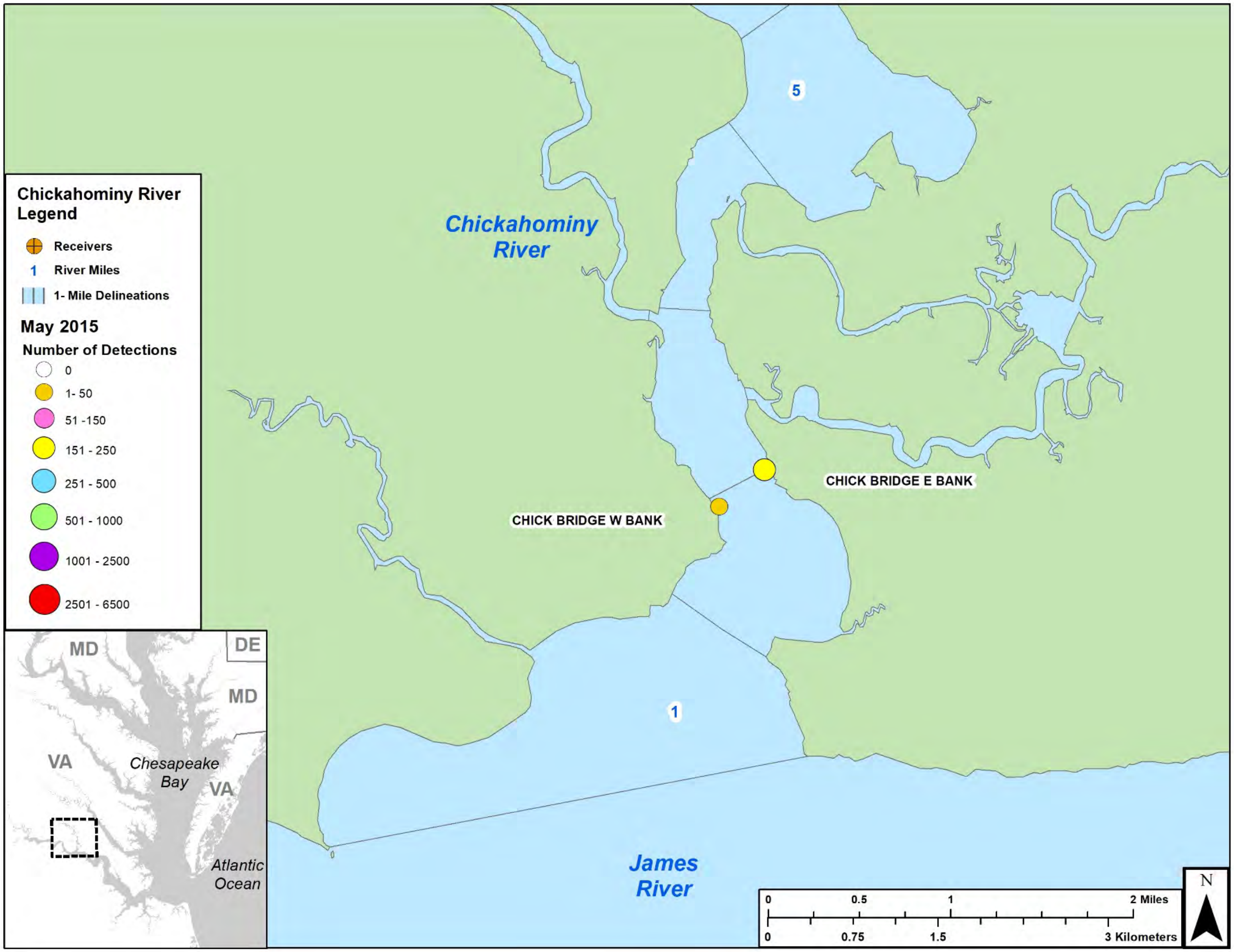
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
May 2015
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
5
1
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
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1
2 Miles
0
0.75
1.5
3 Kilometers
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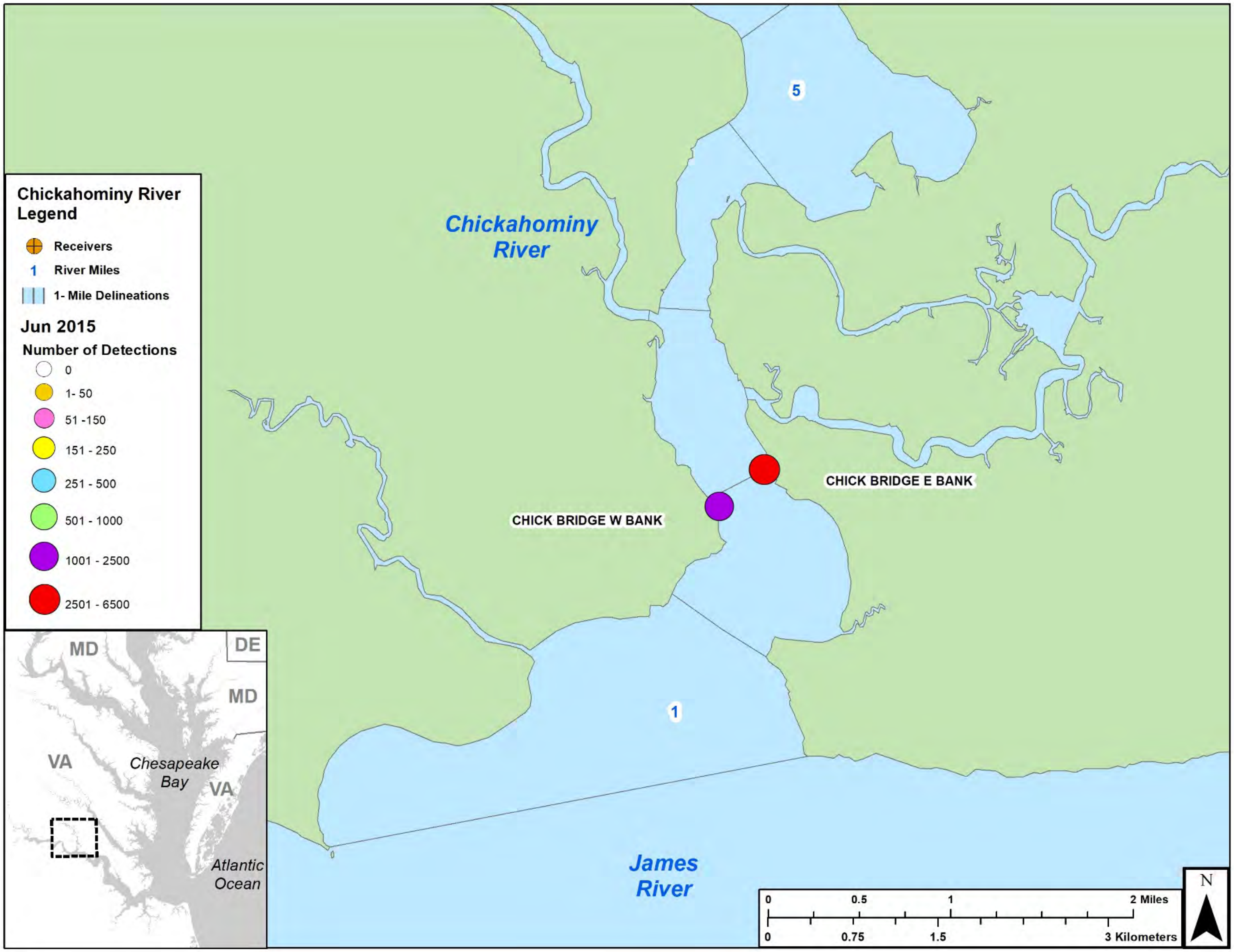
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Jun 2015
Number of Detections
0
1- 50
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151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
5
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
1
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
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1
2 Miles
0
0.75
1.5
3 Kilometers
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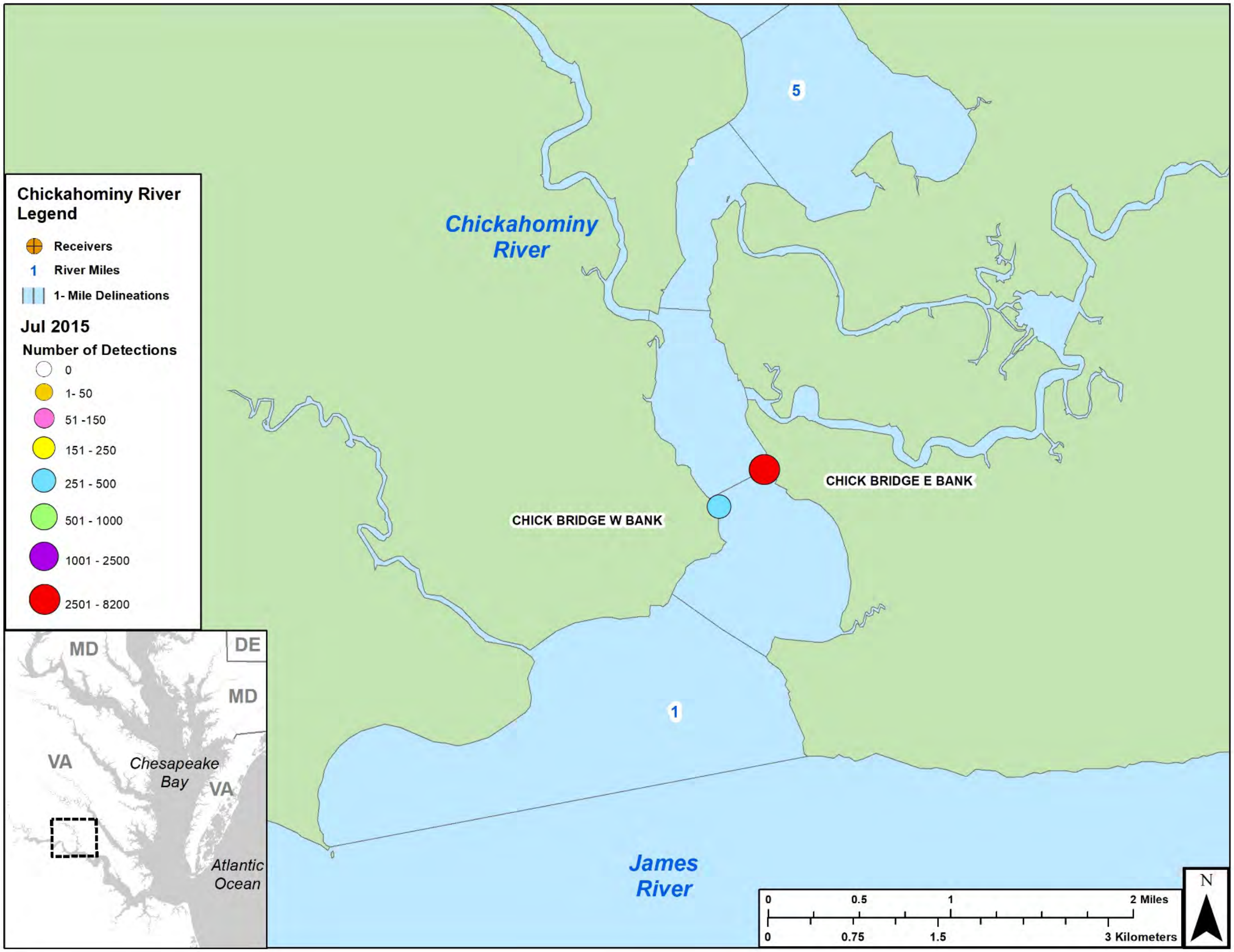
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Jul 2015
Number of Detections
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51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 8200
Chickahominy River
5
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
1
James River
MD
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Chesapeake Bay
VA
Atlantic Ocean
0
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2 Miles
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0.75
1.5
3 Kilometers
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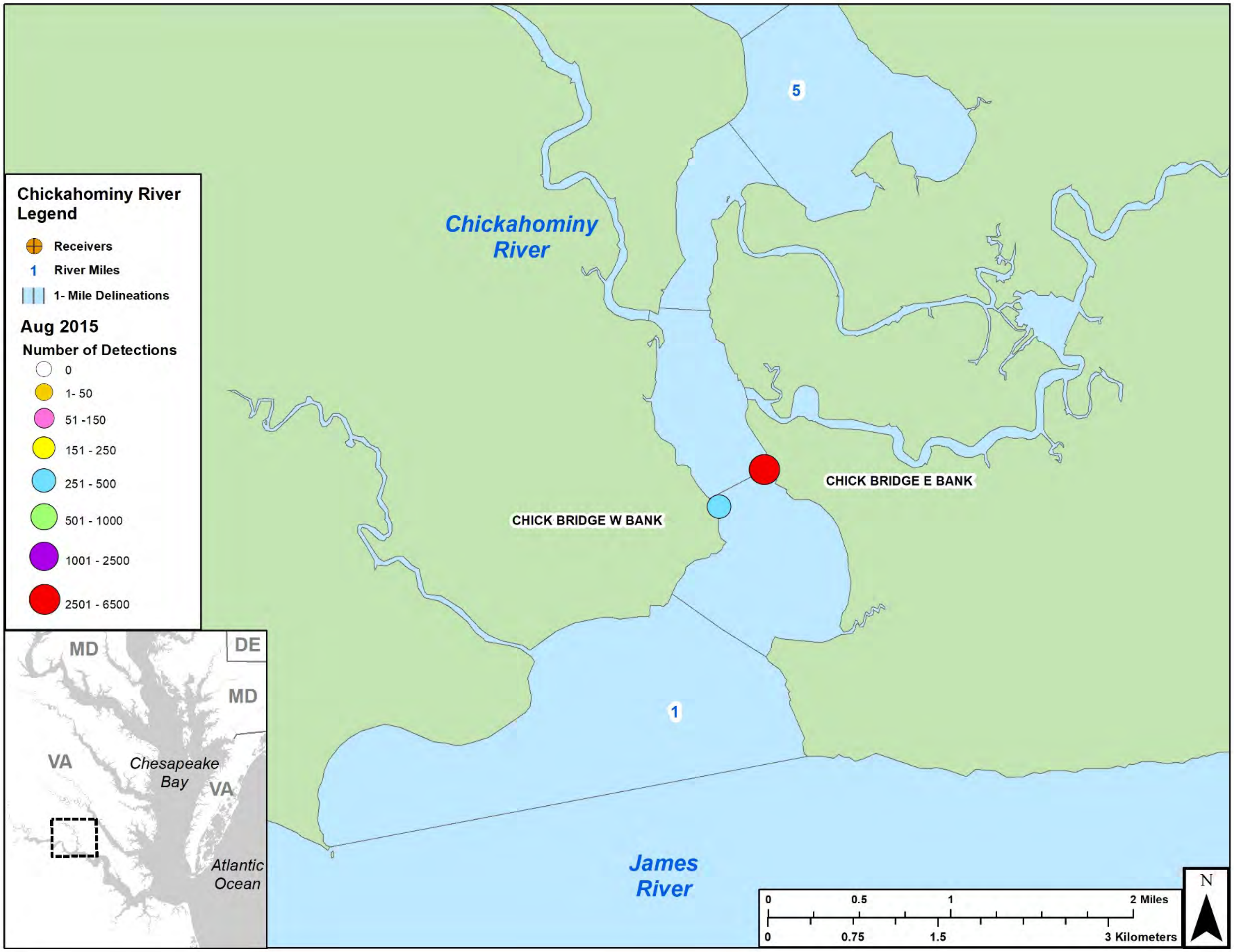
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Aug 2015
Number of Detections
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51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
James River
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
5
1
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VA
Chesapeake Bay
VA
Atlantic Ocean
0
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2 Miles
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0.75
1.5
3 Kilometers
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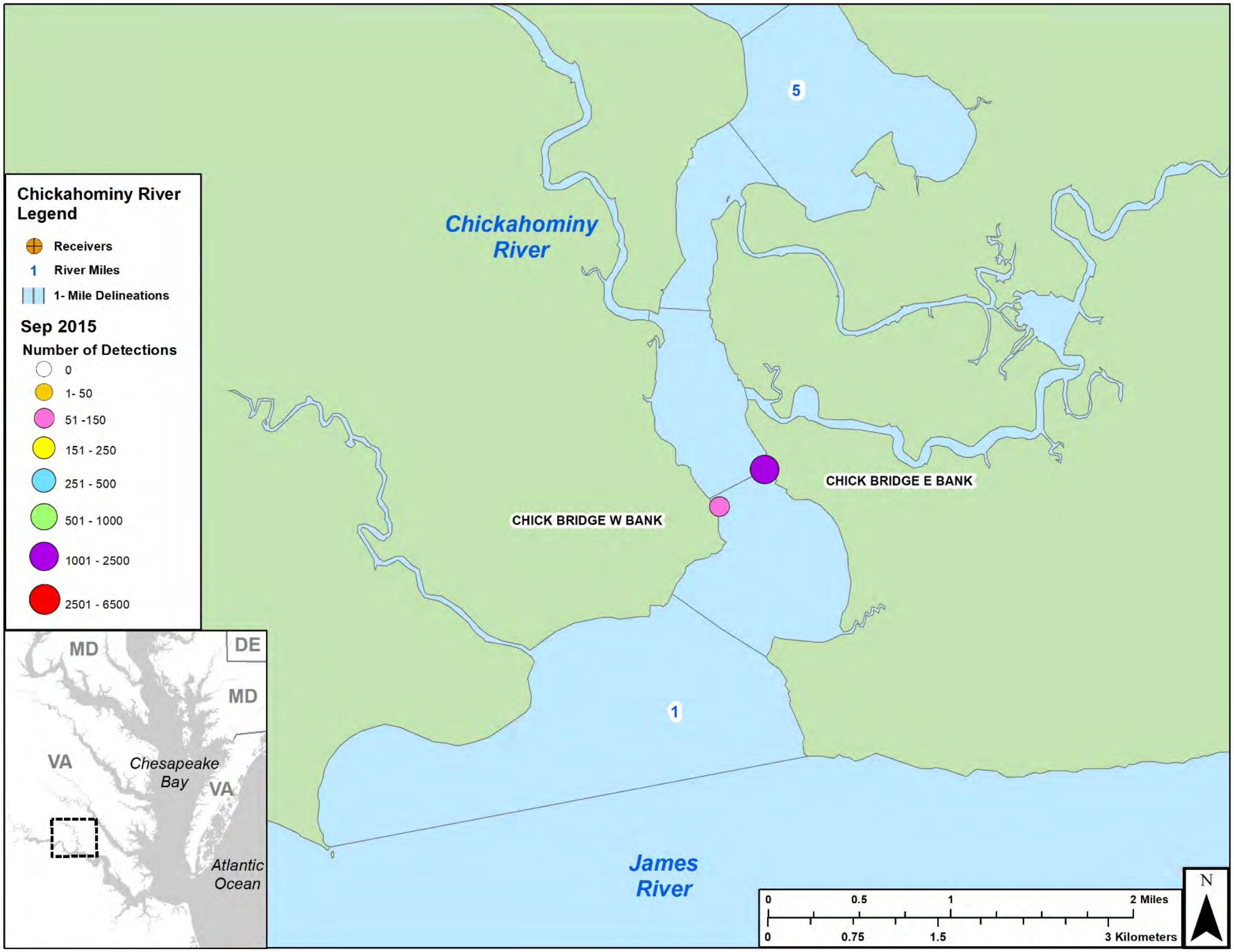
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Sep 2015
Number of Detections
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151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
5
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
1
James River
MD
DE
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Chesapeake Bay
VA
Atlantic Ocean
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2 Miles
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0.75
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3 Kilometers
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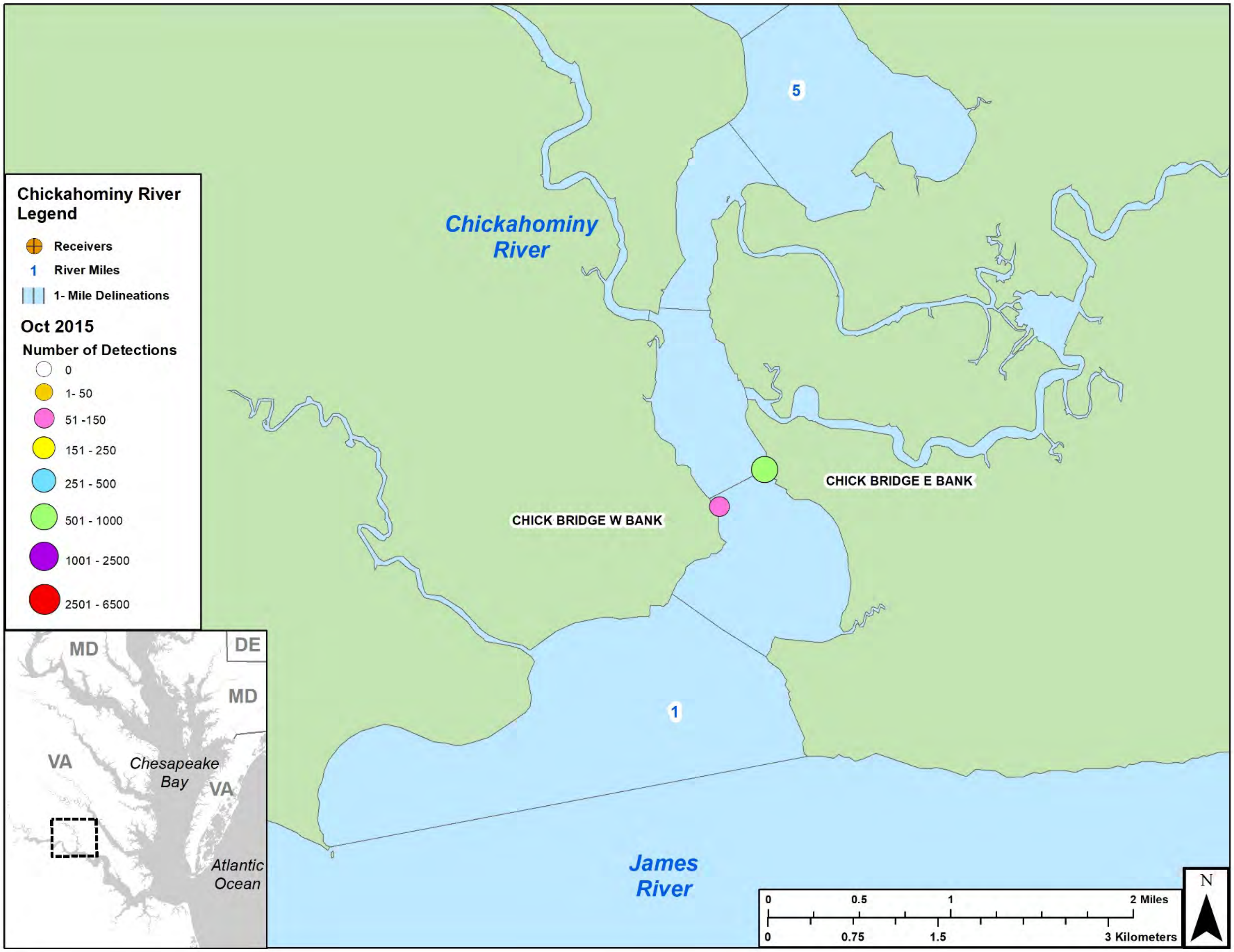
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Oct 2015
Number of Detections
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51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
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James River
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Chesapeake Bay
VA
Atlantic Ocean
0
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2 Miles
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0.75
1.5
3 Kilometers
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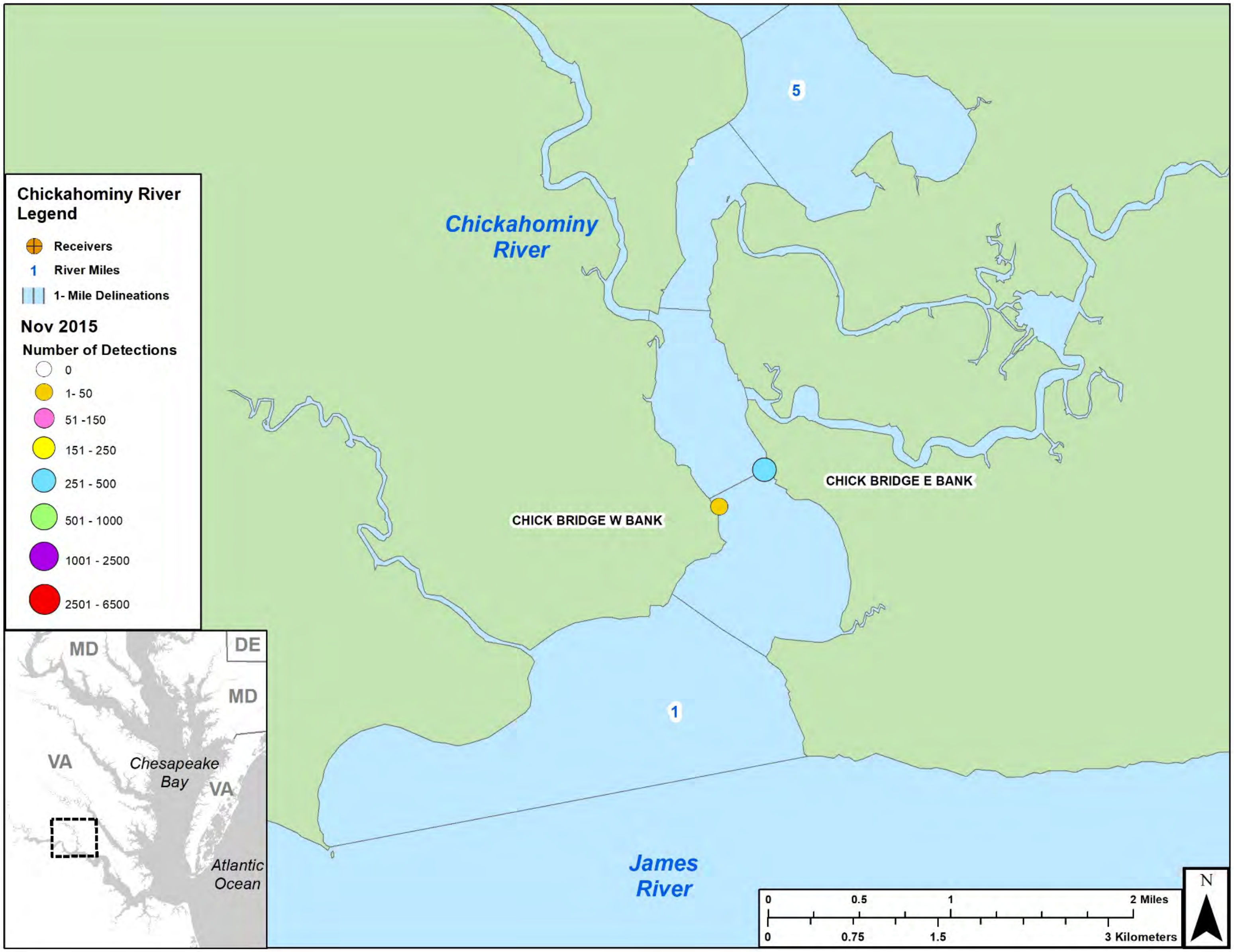
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Nov 2015
Number of Detections
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151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
James River
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Chesapeake Bay
VA
Atlantic Ocean
0
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2 Miles
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1.5
3 Kilometers
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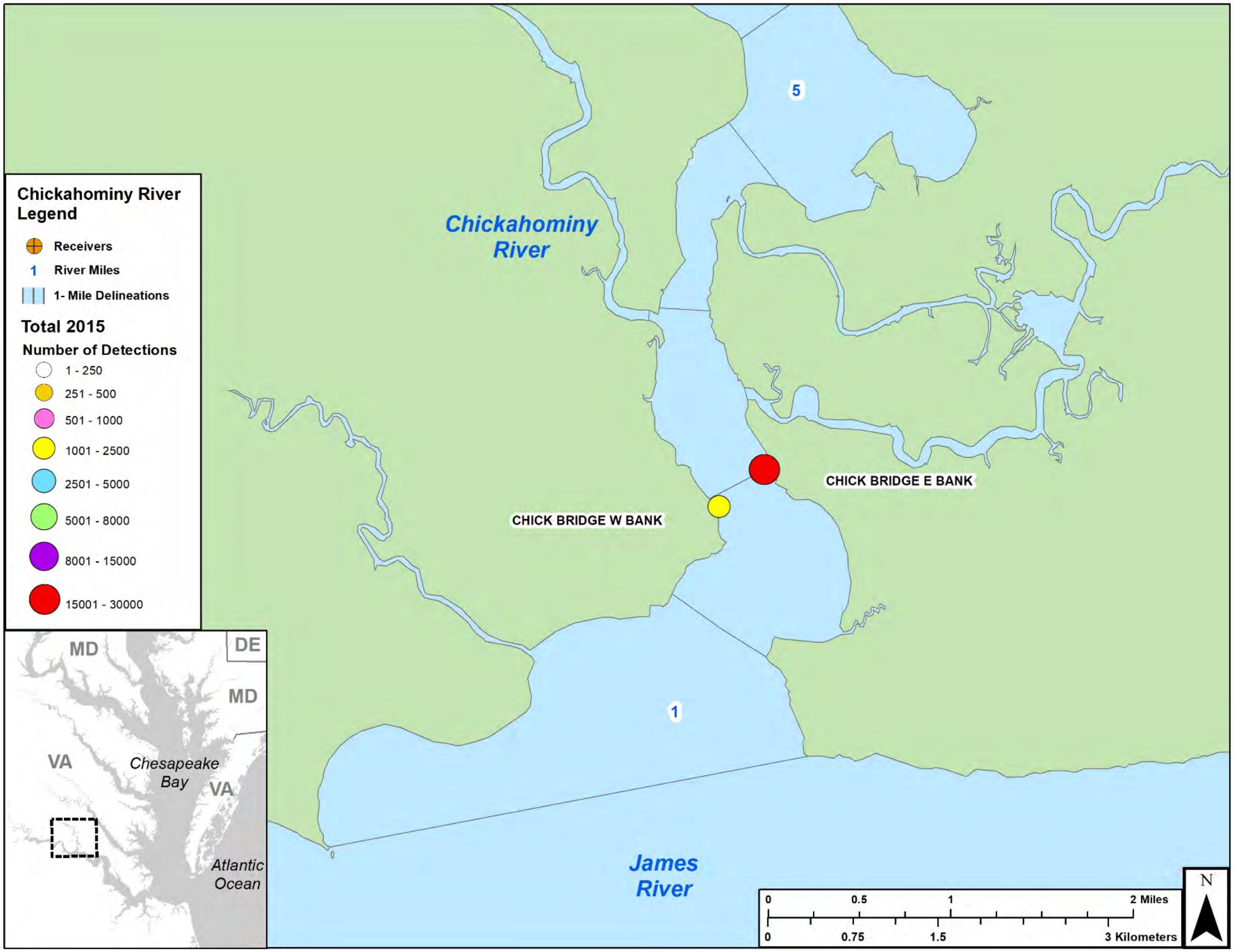
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Total 2015
Number of Detections
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501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
Chickahominy River
James River
5
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
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Chesapeake Bay
VA
Atlantic Ocean
0
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2 Miles
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0.75
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3 Kilometers
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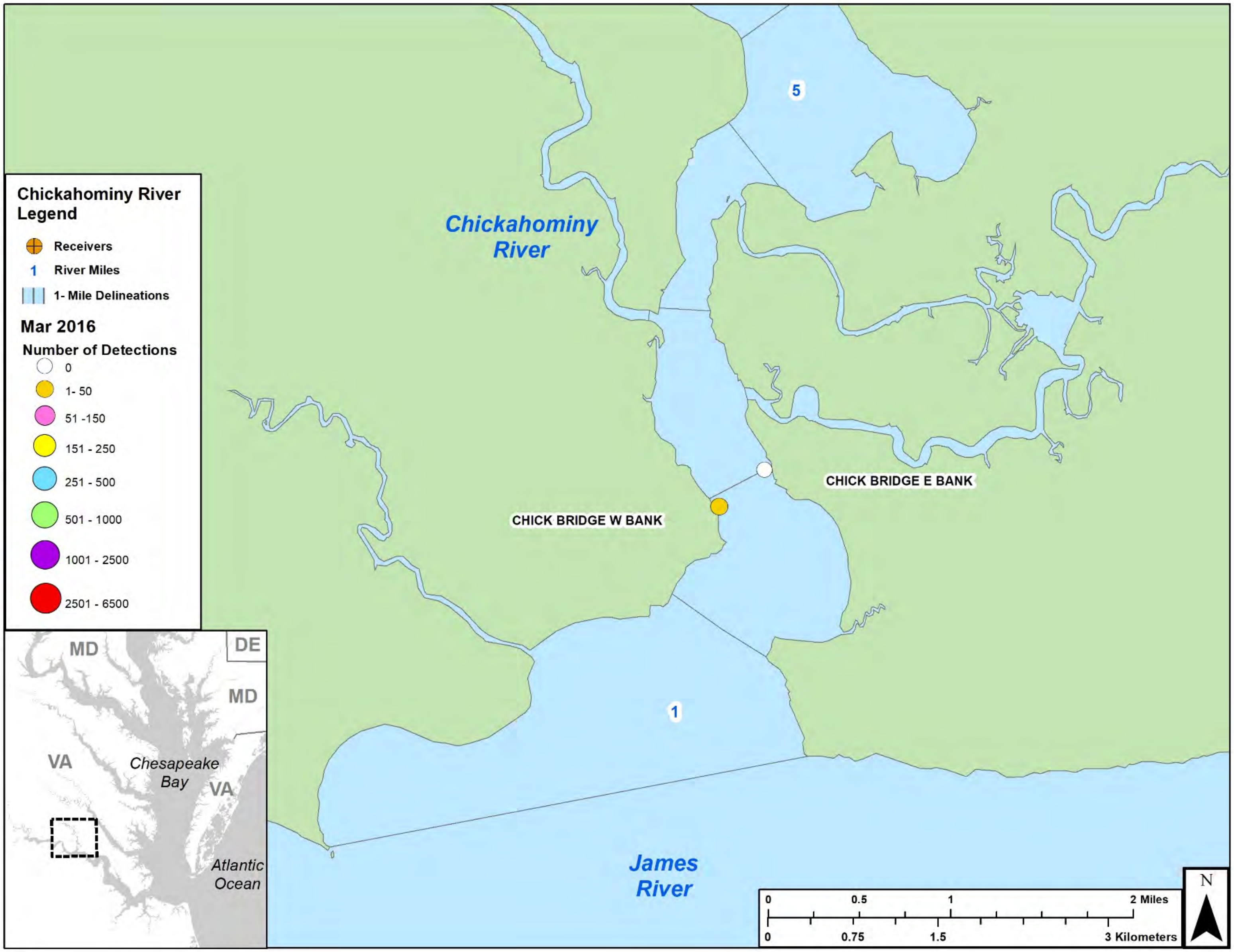
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Mar 2016
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Chickahominy River
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
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James River
0
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2 Miles
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3 Kilometers
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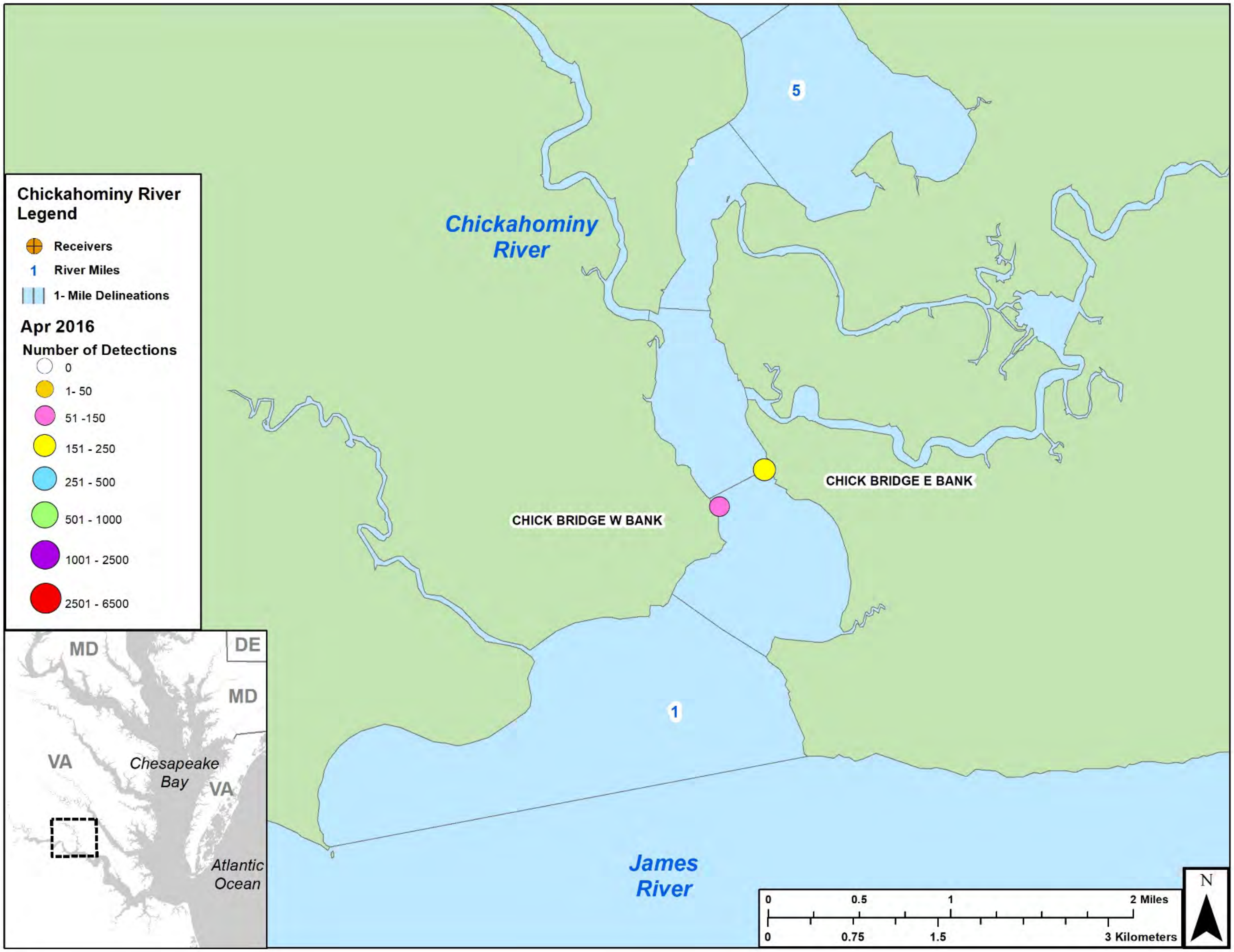
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Apr 2016
Number of Detections
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51 -150
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1001 - 2500
2501 - 6500
Chickahominy River
James River
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
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Chesapeake Bay
VA
Atlantic Ocean
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2 Miles
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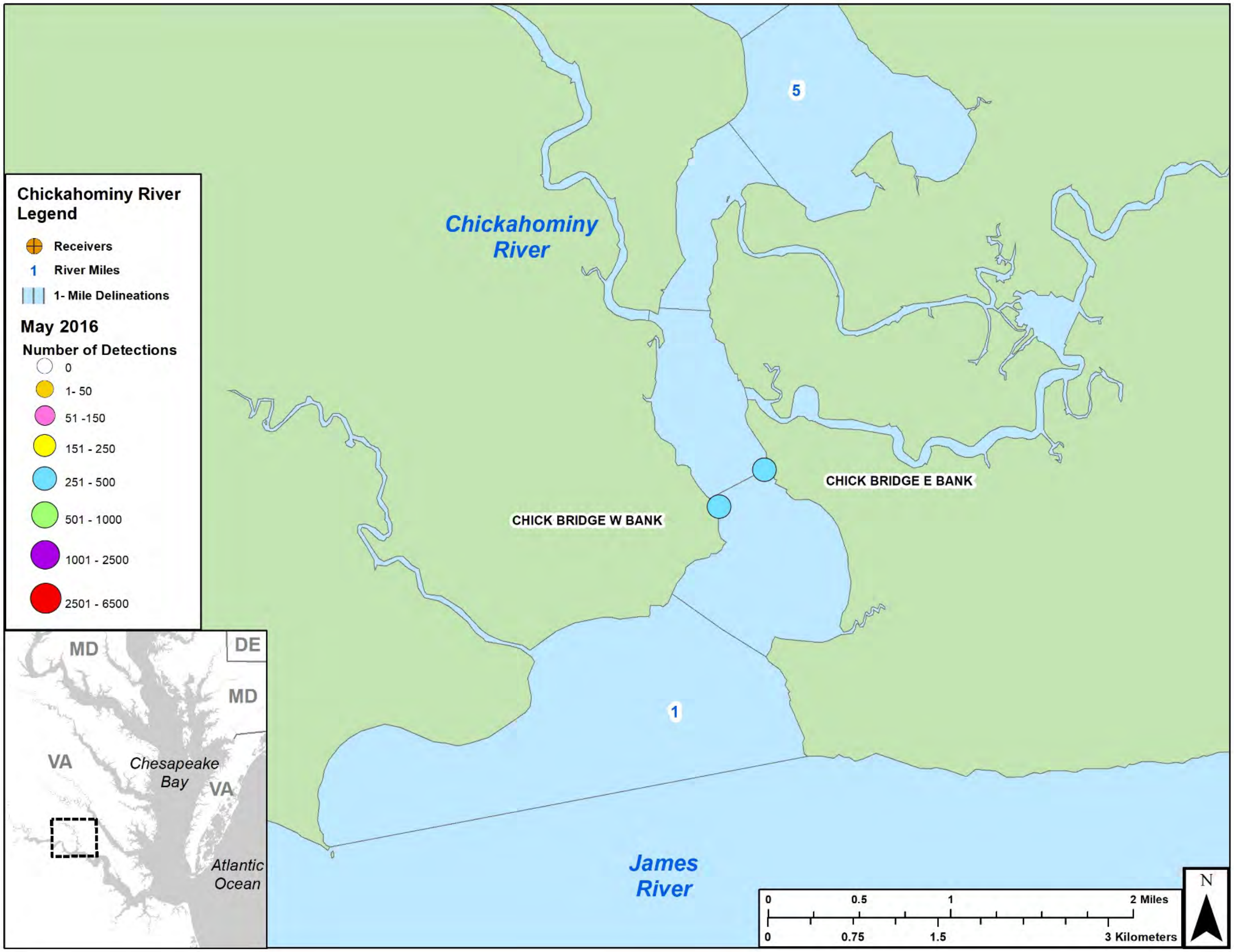
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
May 2016
Number of Detections
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51 -150
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501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
James River
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
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Chesapeake Bay
VA
Atlantic Ocean
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2 Miles
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3 Kilometers
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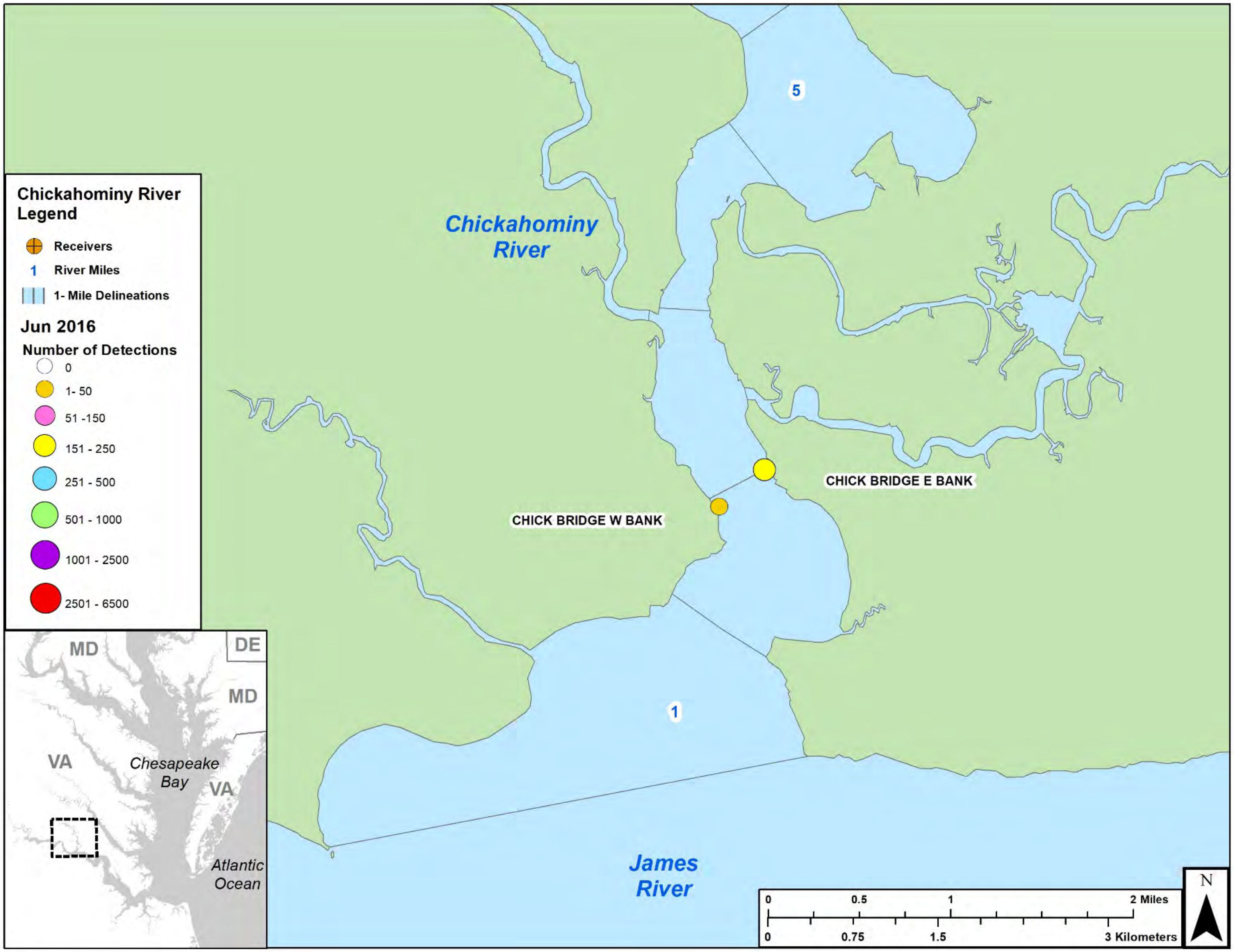
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Jun 2016
Number of Detections
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51 -150
151 - 250
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501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
James River
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
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Chesapeake Bay
VA
Atlantic Ocean
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2 Miles
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3 Kilometers
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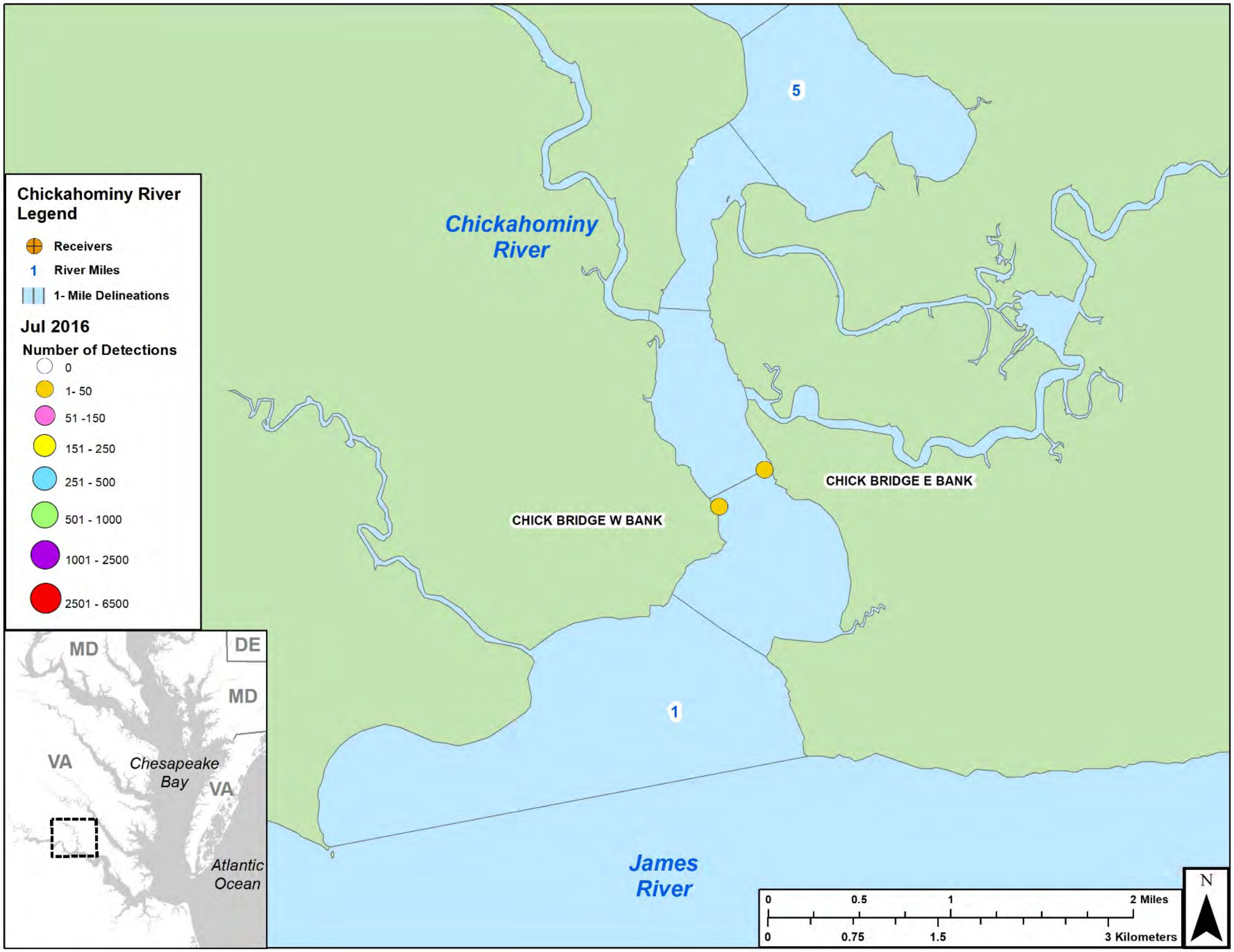
Chickahominy River
Legend
Receivers
1 River Miles
1- Mile Delineations
Jul 2016
Number of Detections
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51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
5
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CHICK BRIDGE W BANK
CHICK BRIDGE E BANK
James River
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VA
Chesapeake Bay
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Atlantic Ocean
0
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2 Miles
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3 Kilometers
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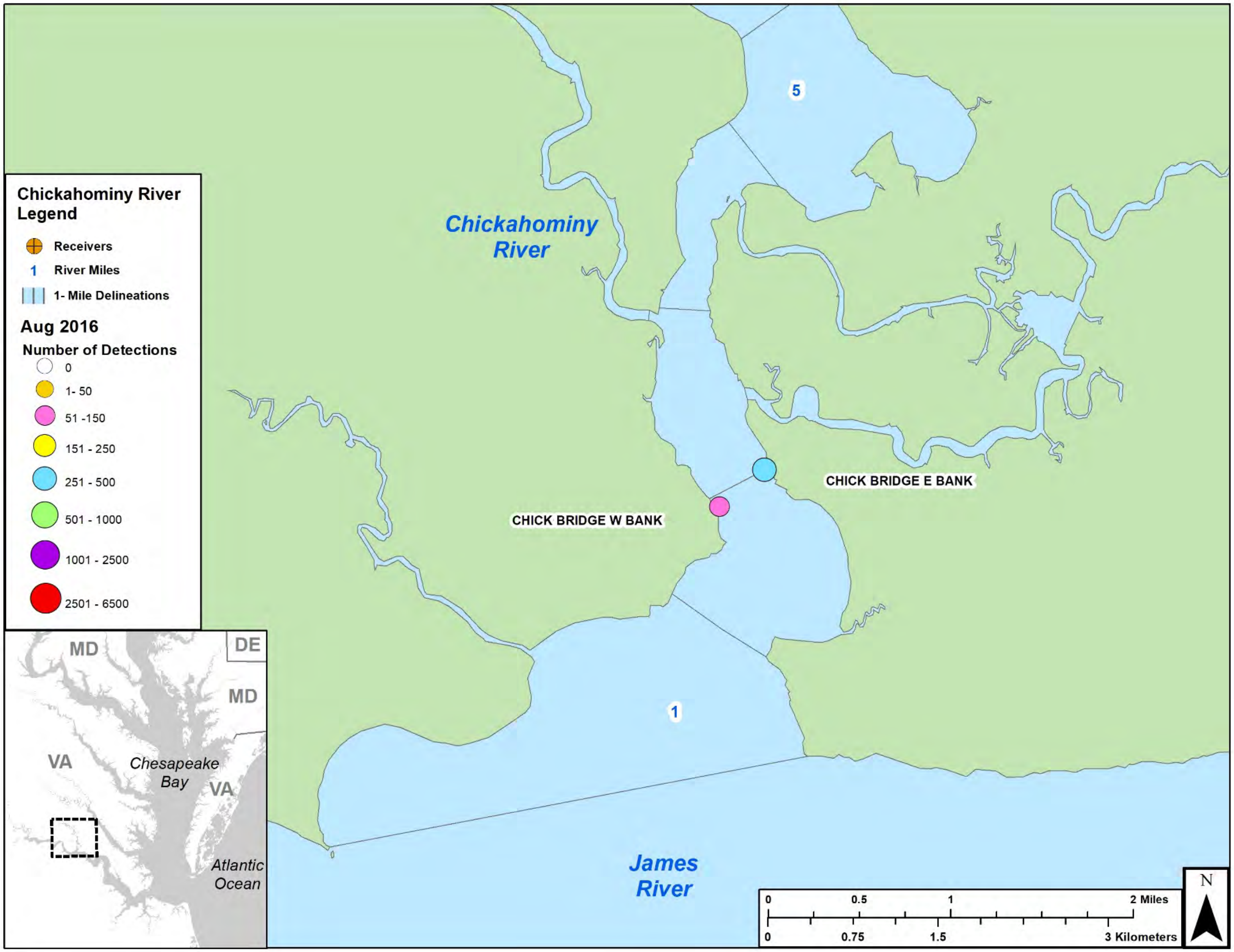
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Aug 2016
Number of Detections
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51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
James River
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Chesapeake Bay
VA
Atlantic Ocean
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2 Miles
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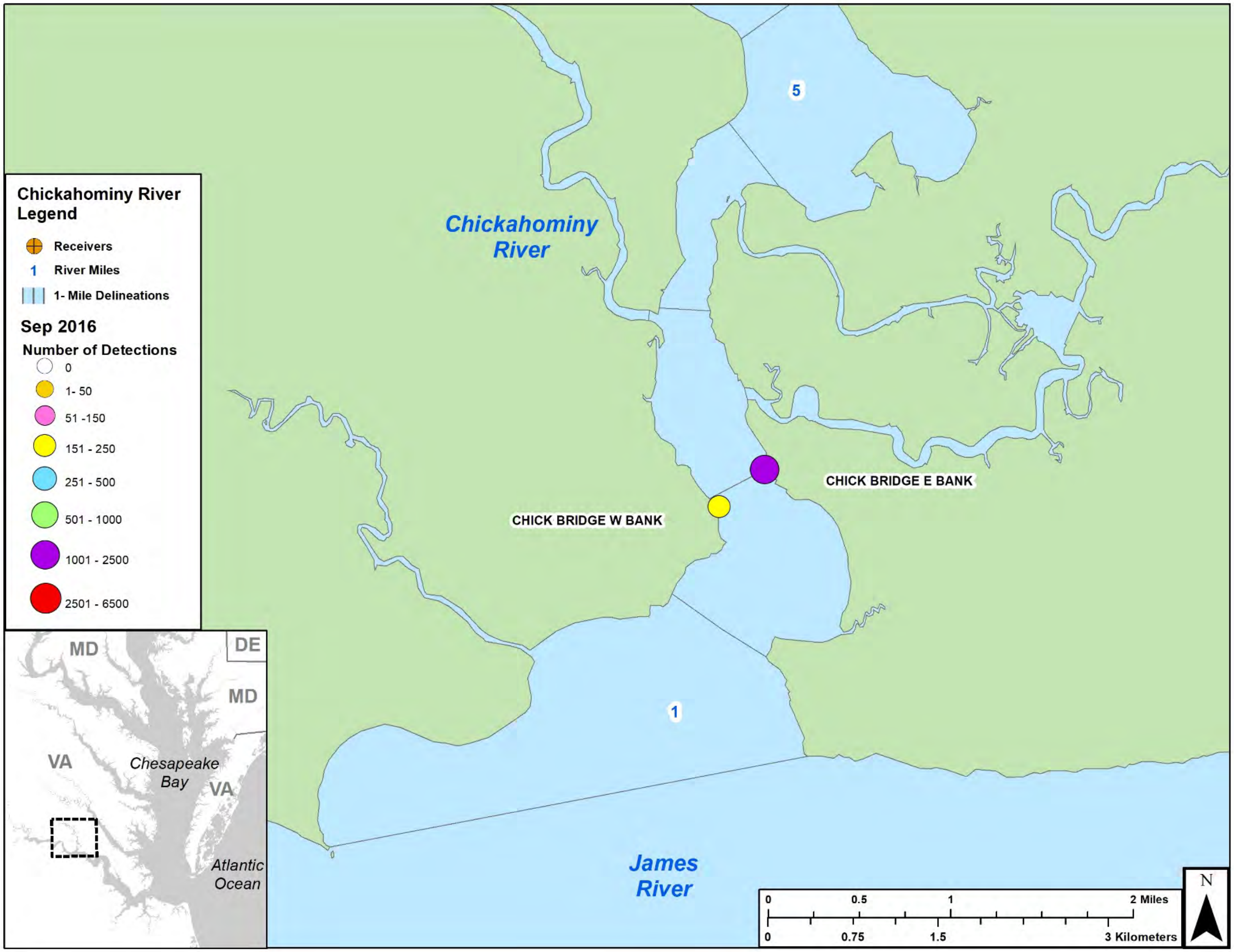
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Sep 2016
Number of Detections
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151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
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James River
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Atlantic Ocean
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1
2 Miles
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3 Kilometers
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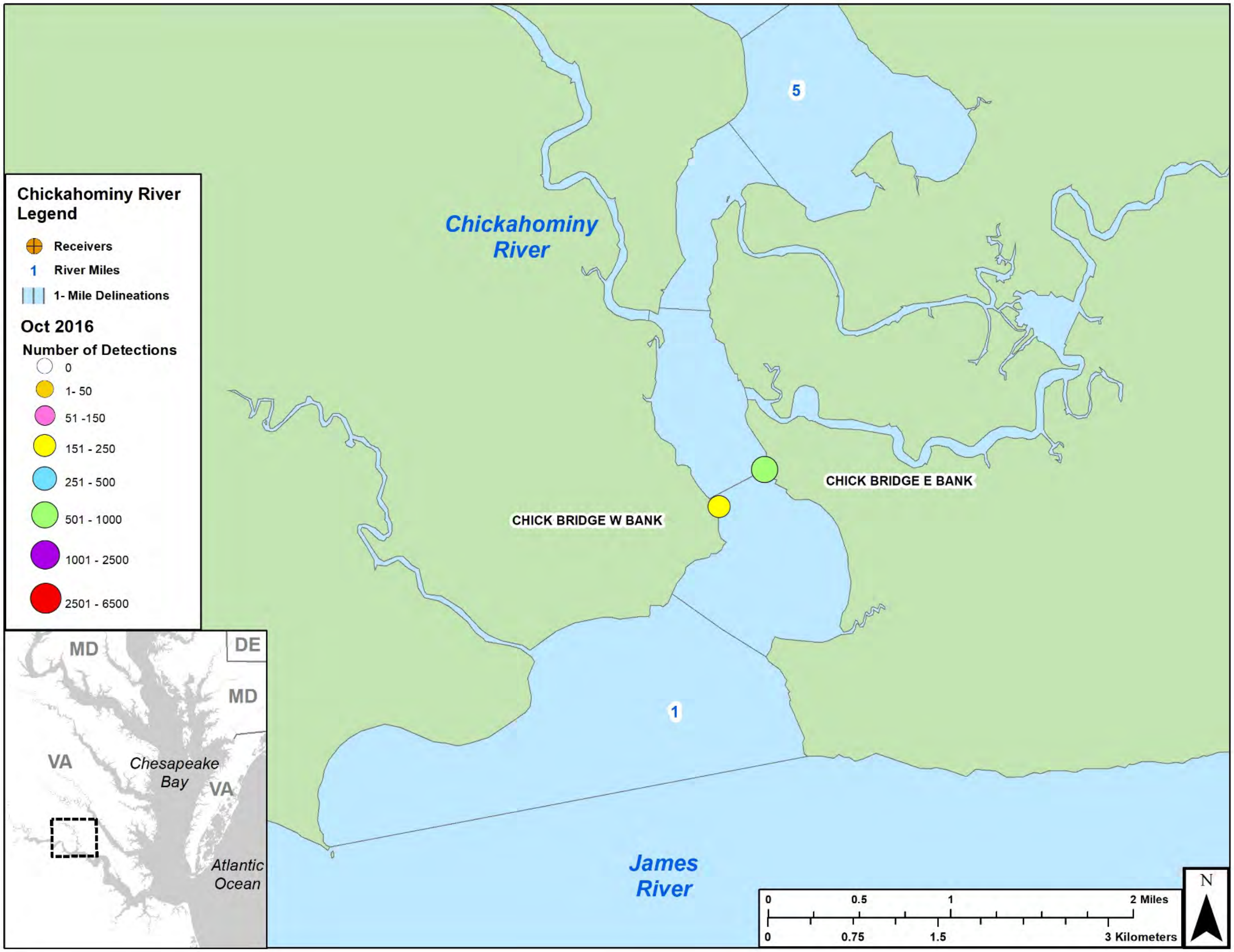
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Oct 2016
Number of Detections
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151 - 250
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501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
James River
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
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Atlantic Ocean
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2 Miles
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3 Kilometers
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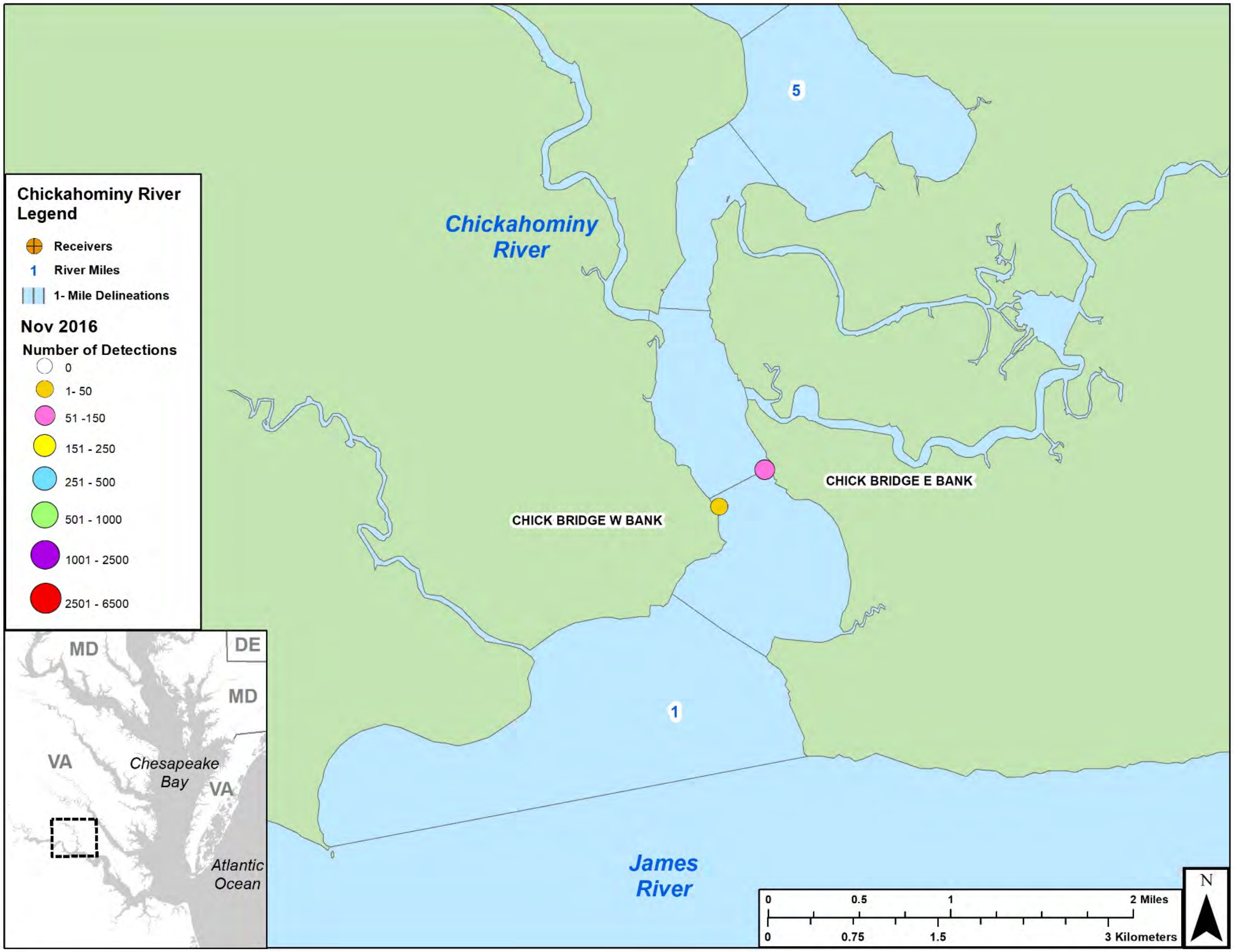
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Nov 2016
Number of Detections
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501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
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James River
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Atlantic Ocean
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2 Miles
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1.5
3 Kilometers
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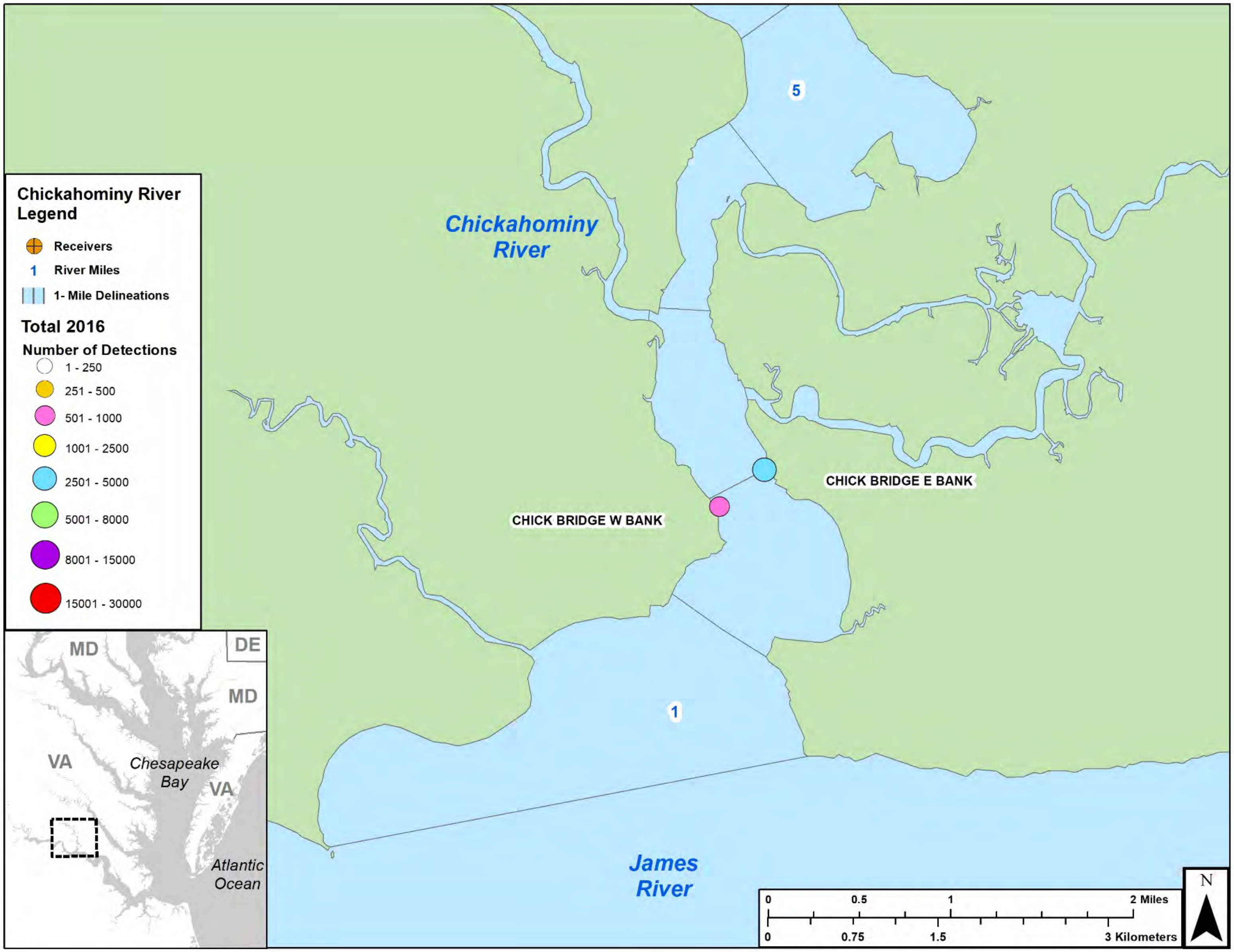
Chickahominy River
Legend
Receivers
1 River Miles
1- Mile Delineations
Total 2016
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
Chickahominy River
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
James River
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Chesapeake Bay
VA
Atlantic Ocean
0
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2 Miles
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3 Kilometers
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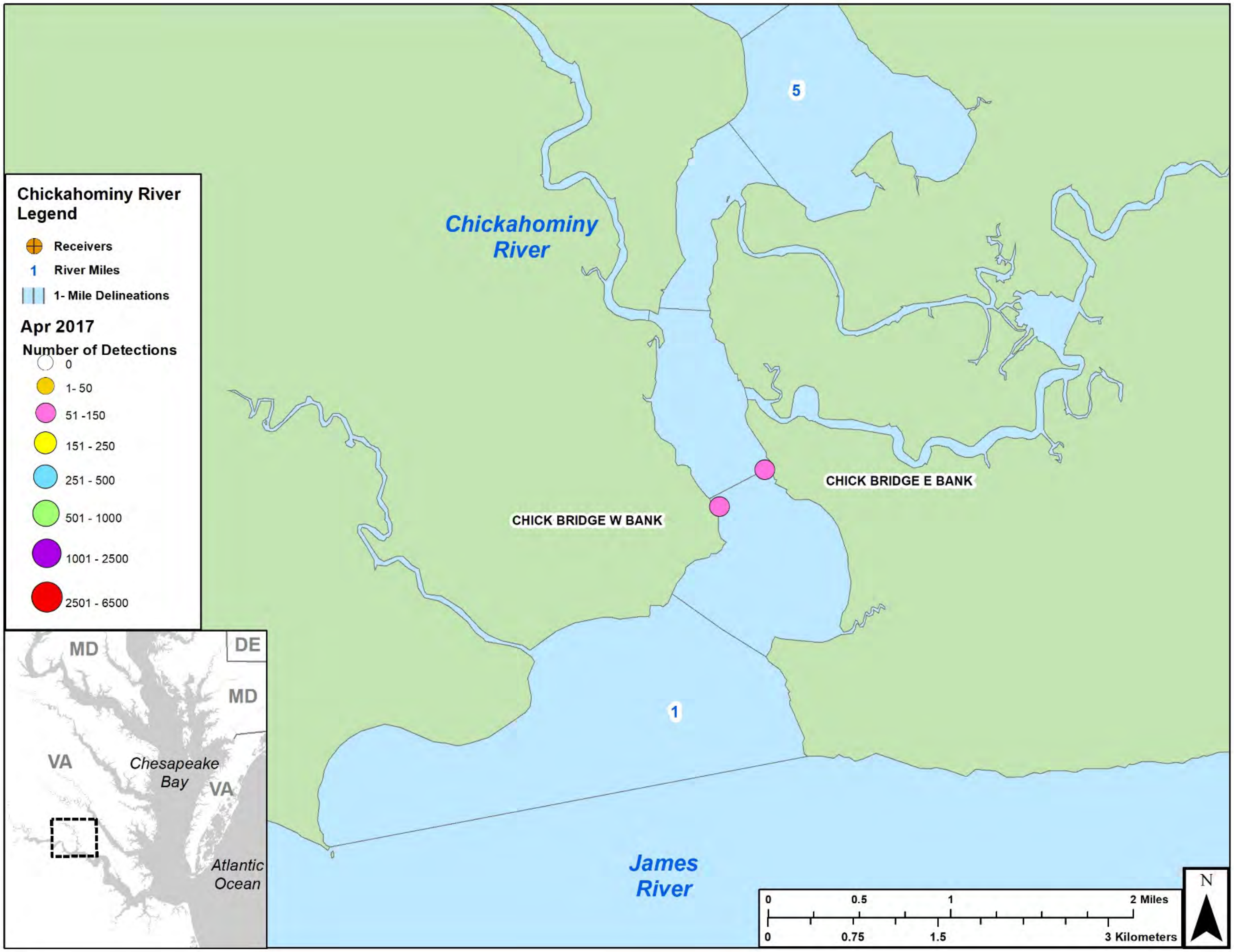
Chickahominy River
Legend
Receivers
1 River Miles
1- Mile Delineations
Apr 2017
Number of Detections
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51 -150
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501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
James River
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
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Chesapeake Bay
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Atlantic Ocean
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2 Miles
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3 Kilometers
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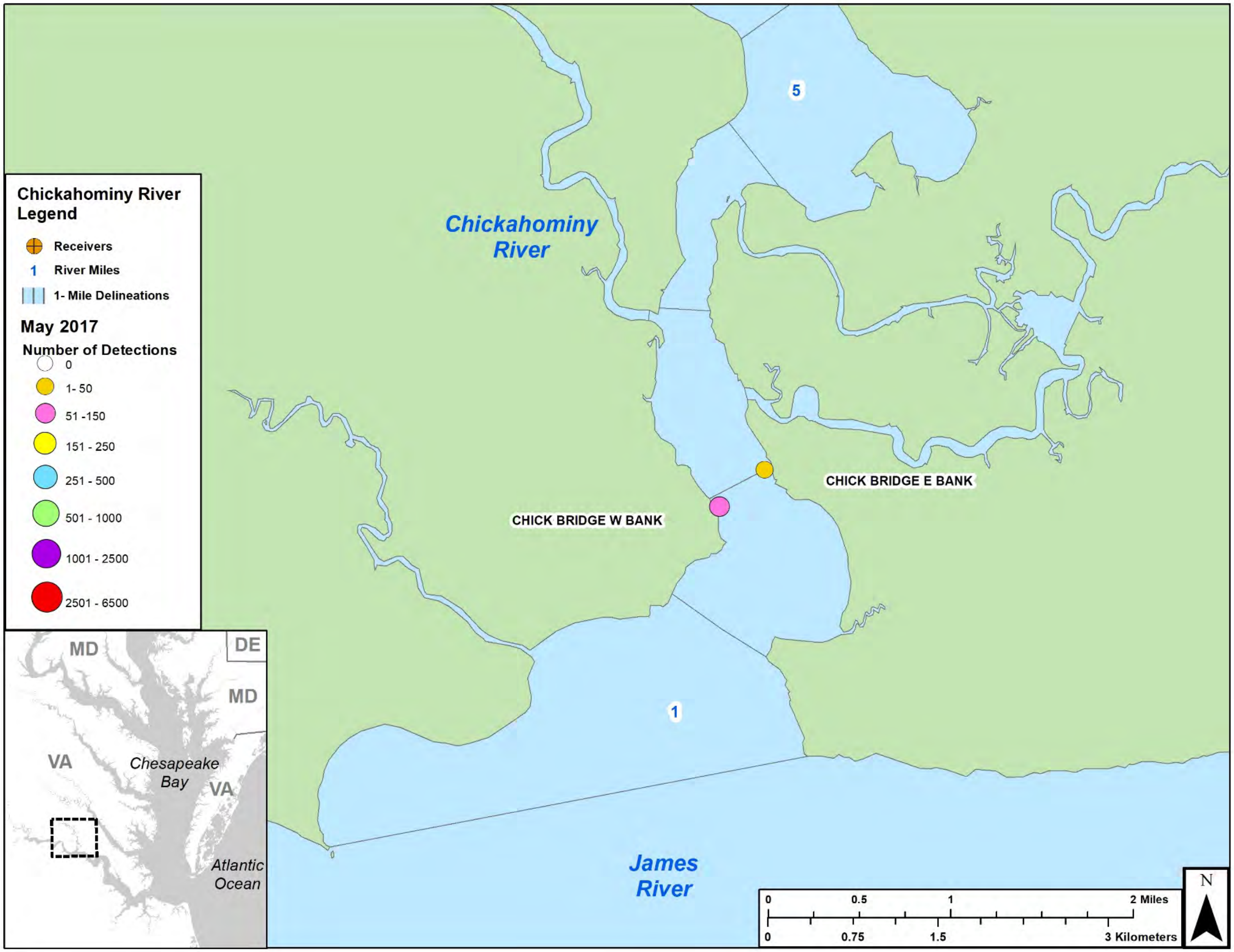
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
May 2017
Number of Detections
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51 -150
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251 - 500
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1001 - 2500
2501 - 6500
Chickahominy River
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
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James River
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Chesapeake Bay
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Atlantic Ocean
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2 Miles
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3 Kilometers
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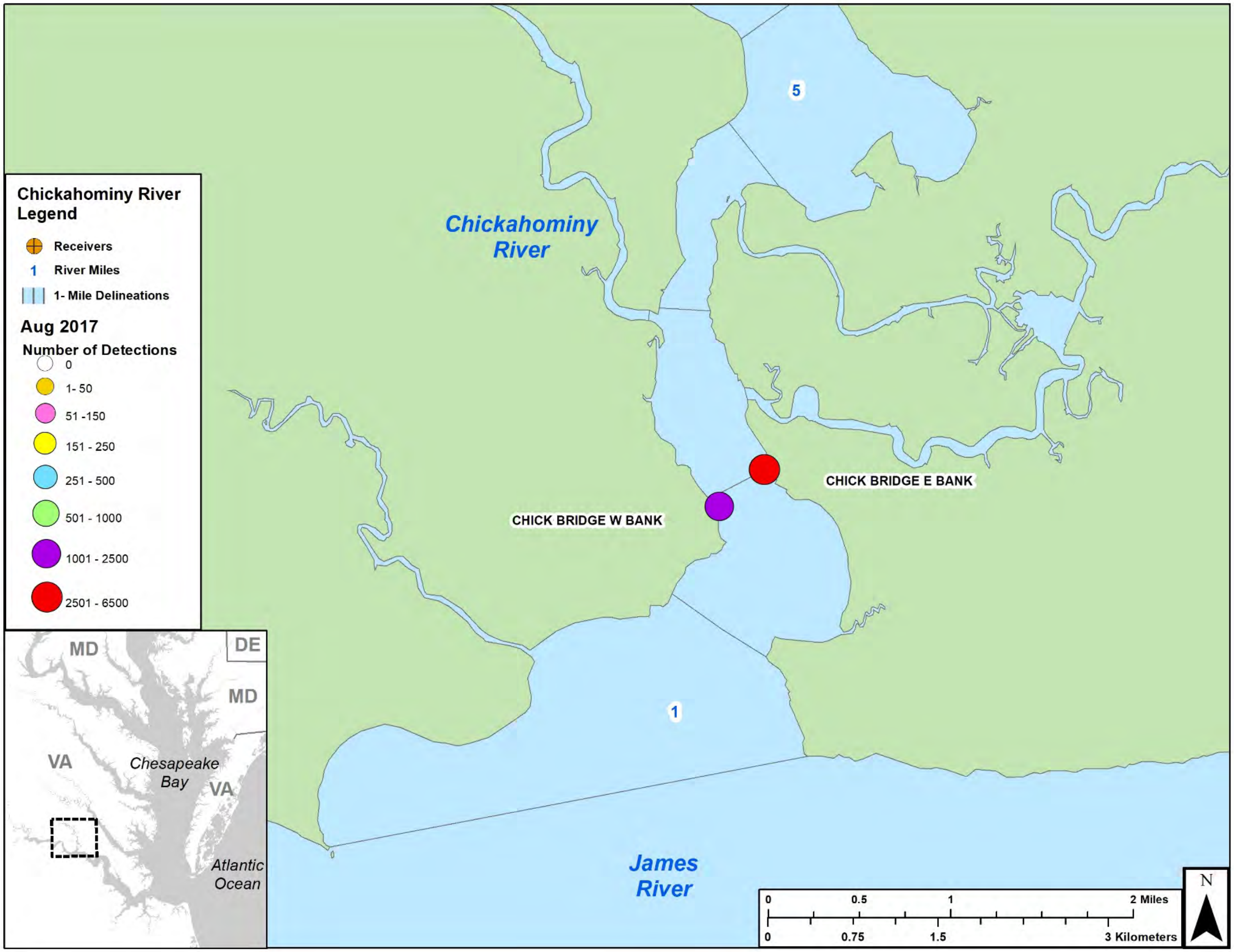
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Aug 2017
Number of Detections
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151 - 250
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501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
1
James River
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DE
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Chesapeake Bay
VA
Atlantic Ocean
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2 Miles
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1.5
3 Kilometers
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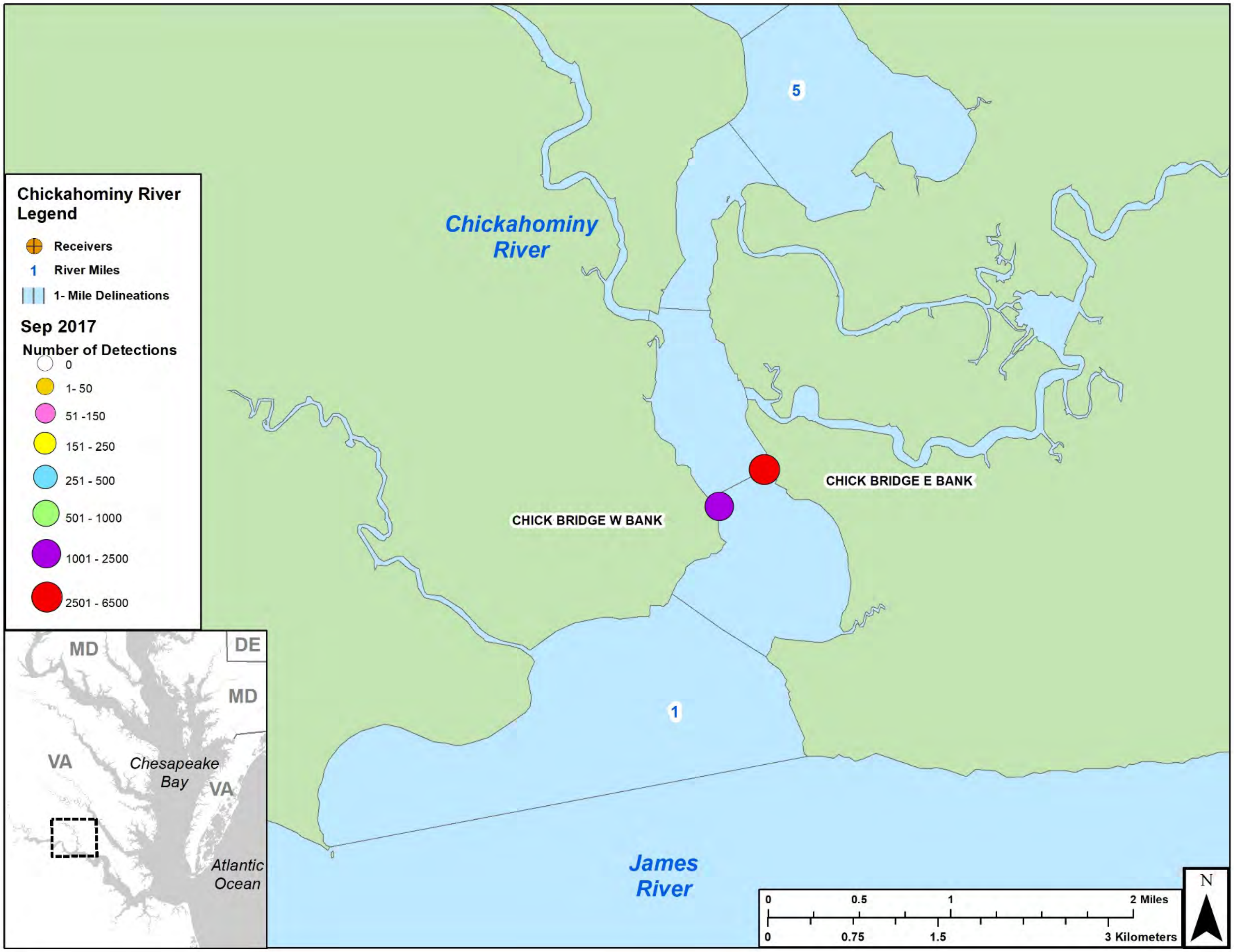
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Sep 2017
Number of Detections
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51 -150
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1001 - 2500
2501 - 6500
Chickahominy River
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
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James River
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Atlantic Ocean
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2 Miles
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3 Kilometers
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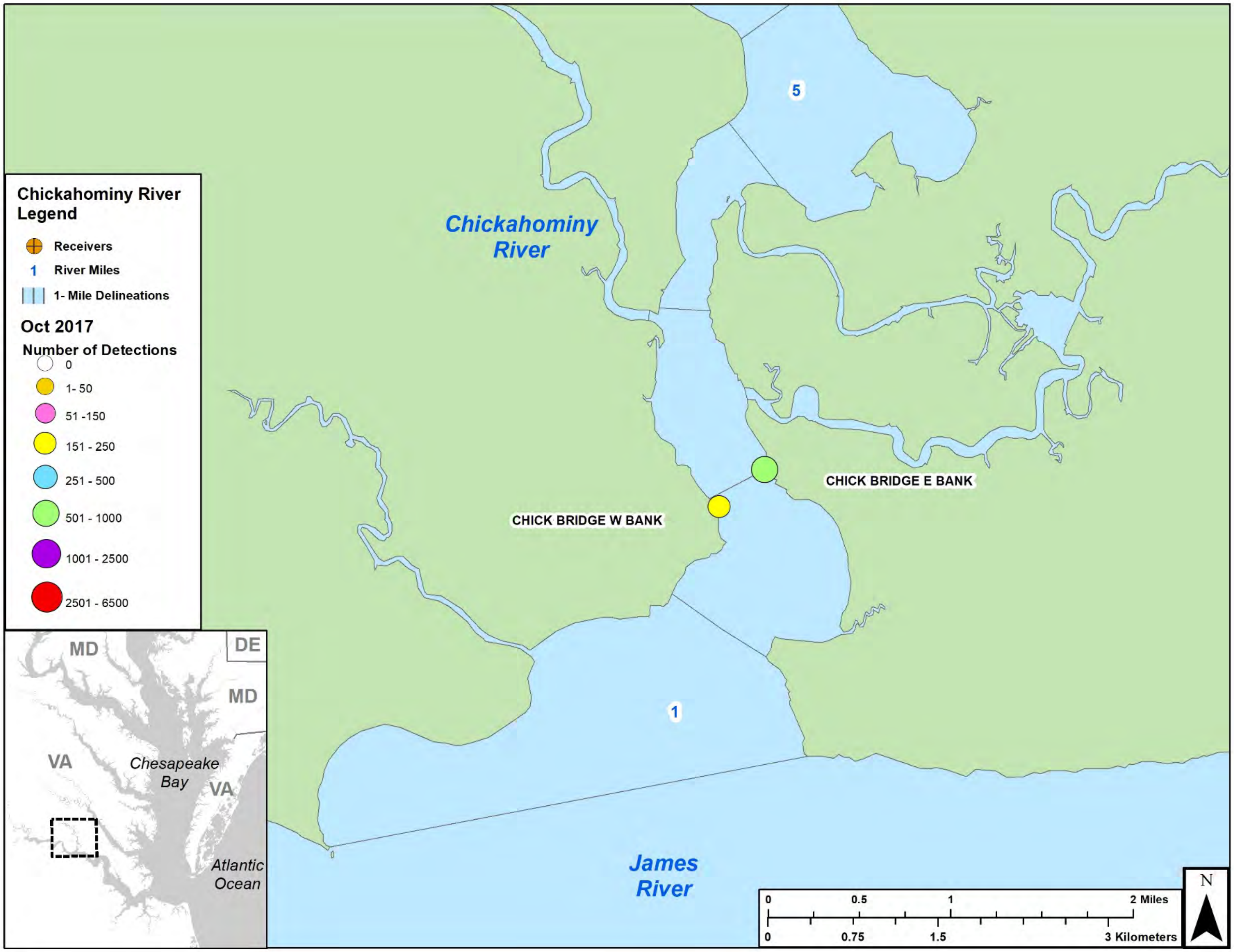
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Oct 2017
Number of Detections
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1001 - 2500
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Chickahominy River
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
James River
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VA
Chesapeake Bay
VA
Atlantic Ocean
0 0.5 1 2 Miles
0 0.75 1.5 3 Kilometers
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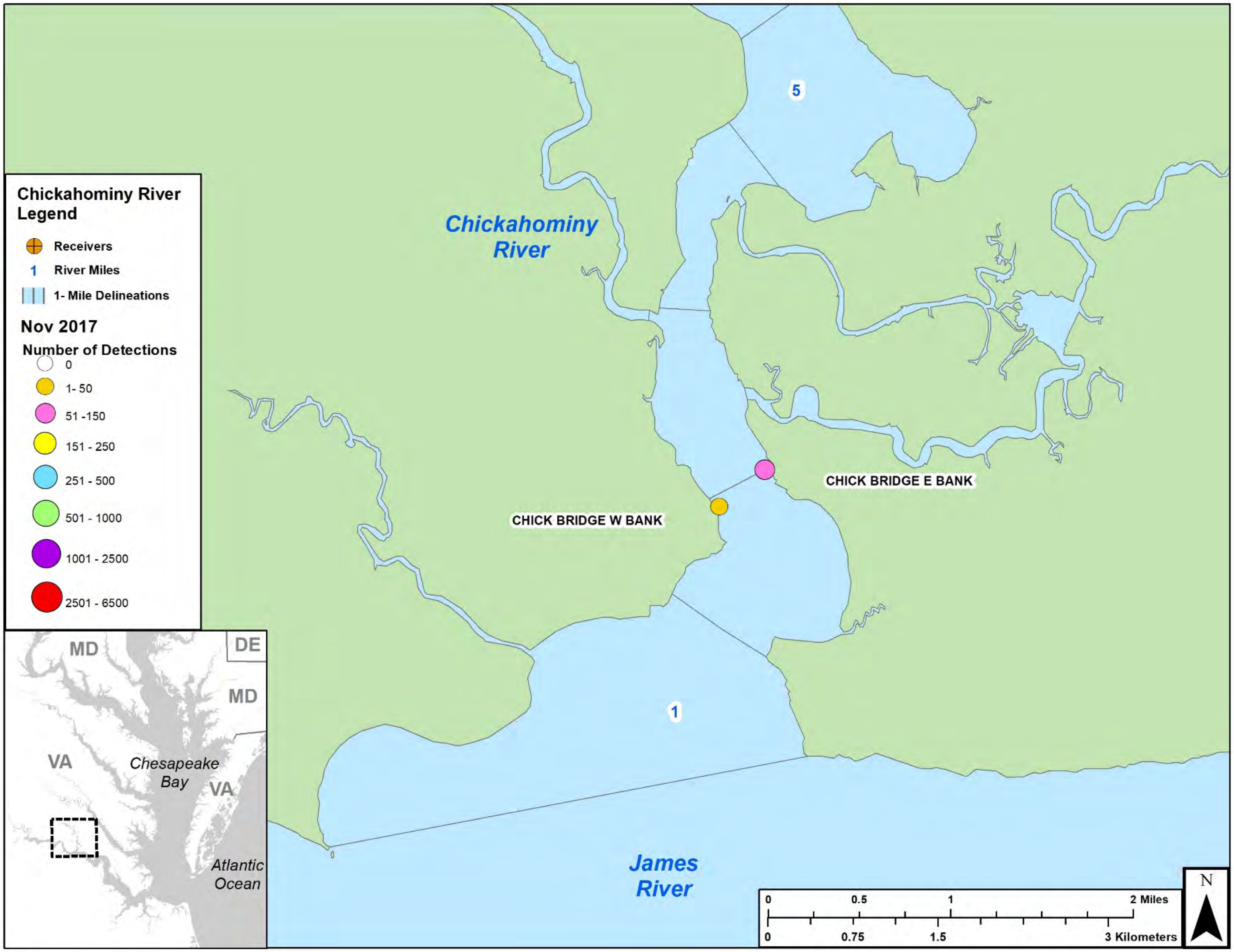
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Nov 2017
Number of Detections
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1001 - 2500
2501 - 6500
Chickahominy River
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
James River
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Atlantic Ocean
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2 Miles
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0.75
1.5
3 Kilometers
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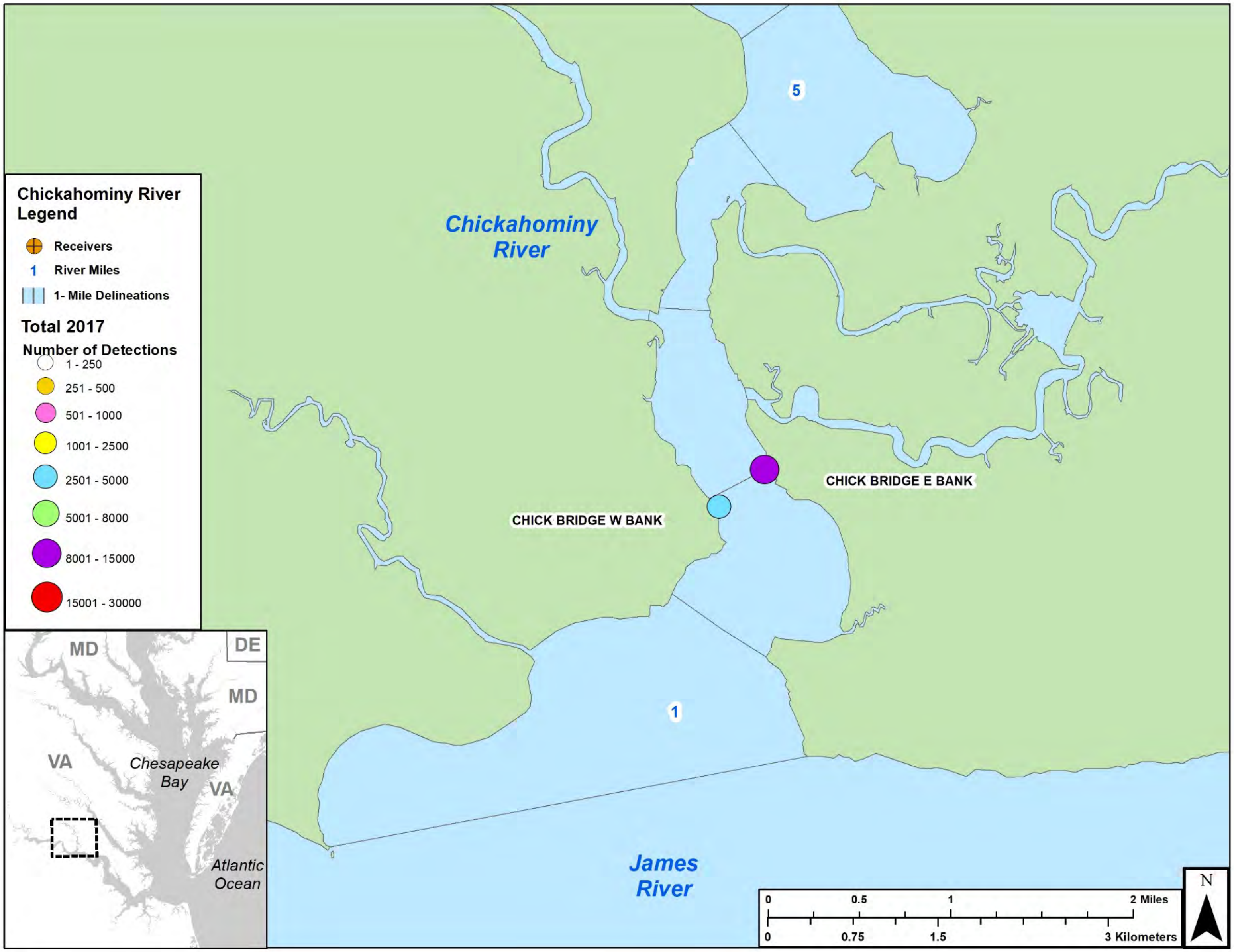
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Total 2017
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
Chickahominy River
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
James River
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Atlantic Ocean
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1
2 Miles
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0.75
1.5
3 Kilometers
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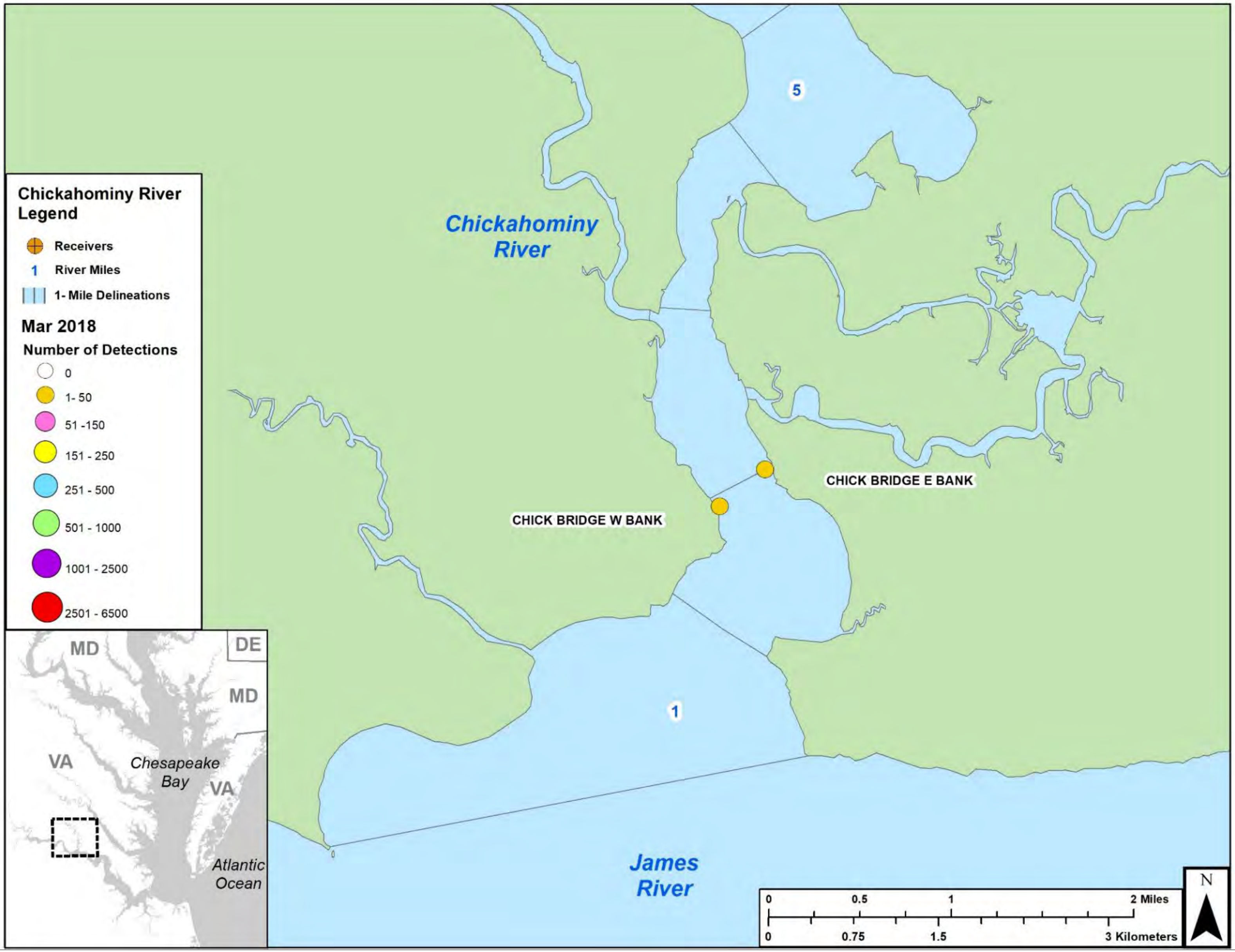
Chickahominy River
Legend
Receivers
1 River Miles
1- Mile Delineations
Mar 2018
Number of Detections
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1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
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CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
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James River
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Atlantic Ocean
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2 Miles
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0.75
1.5
3 Kilometers
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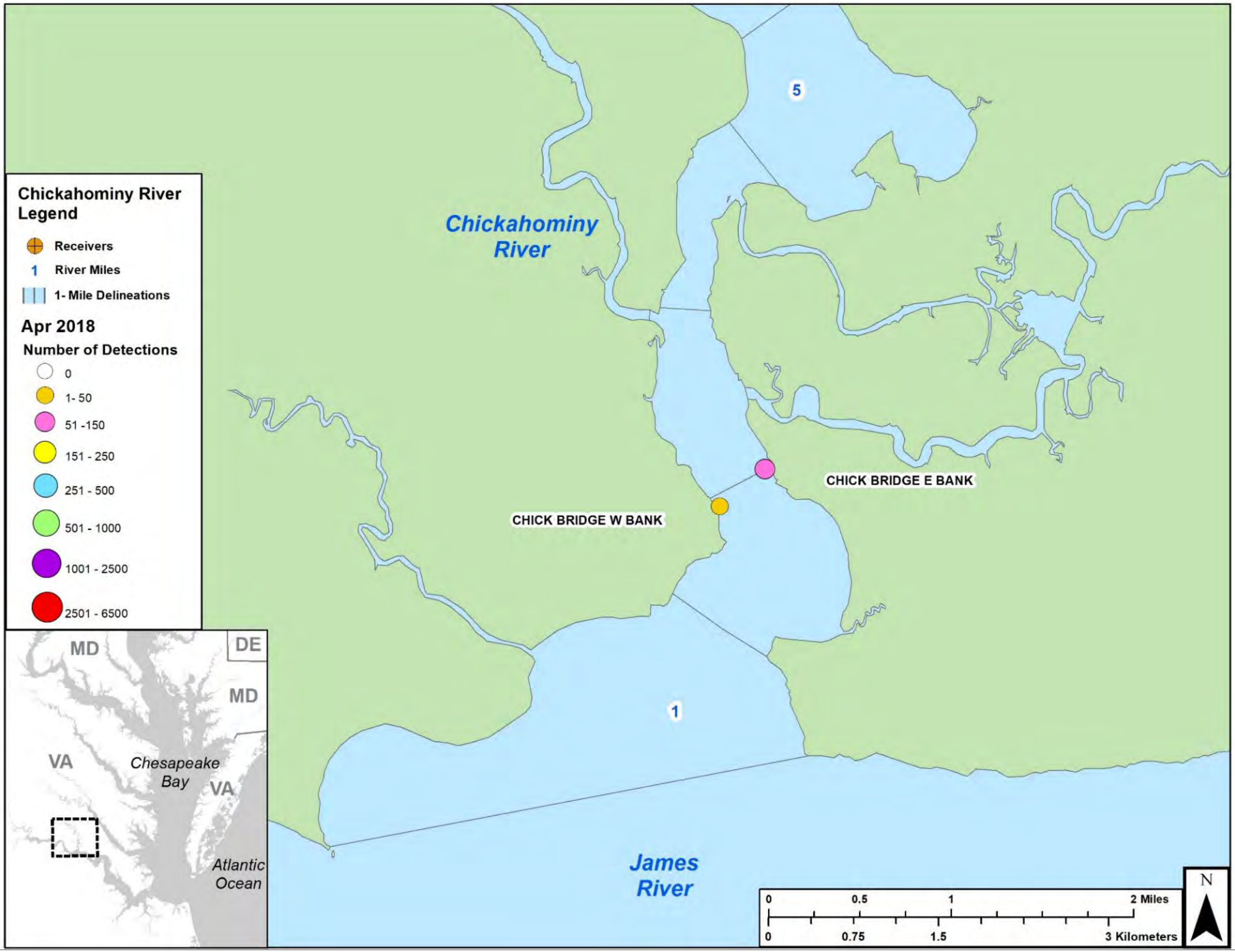
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Apr 2018
Number of Detections
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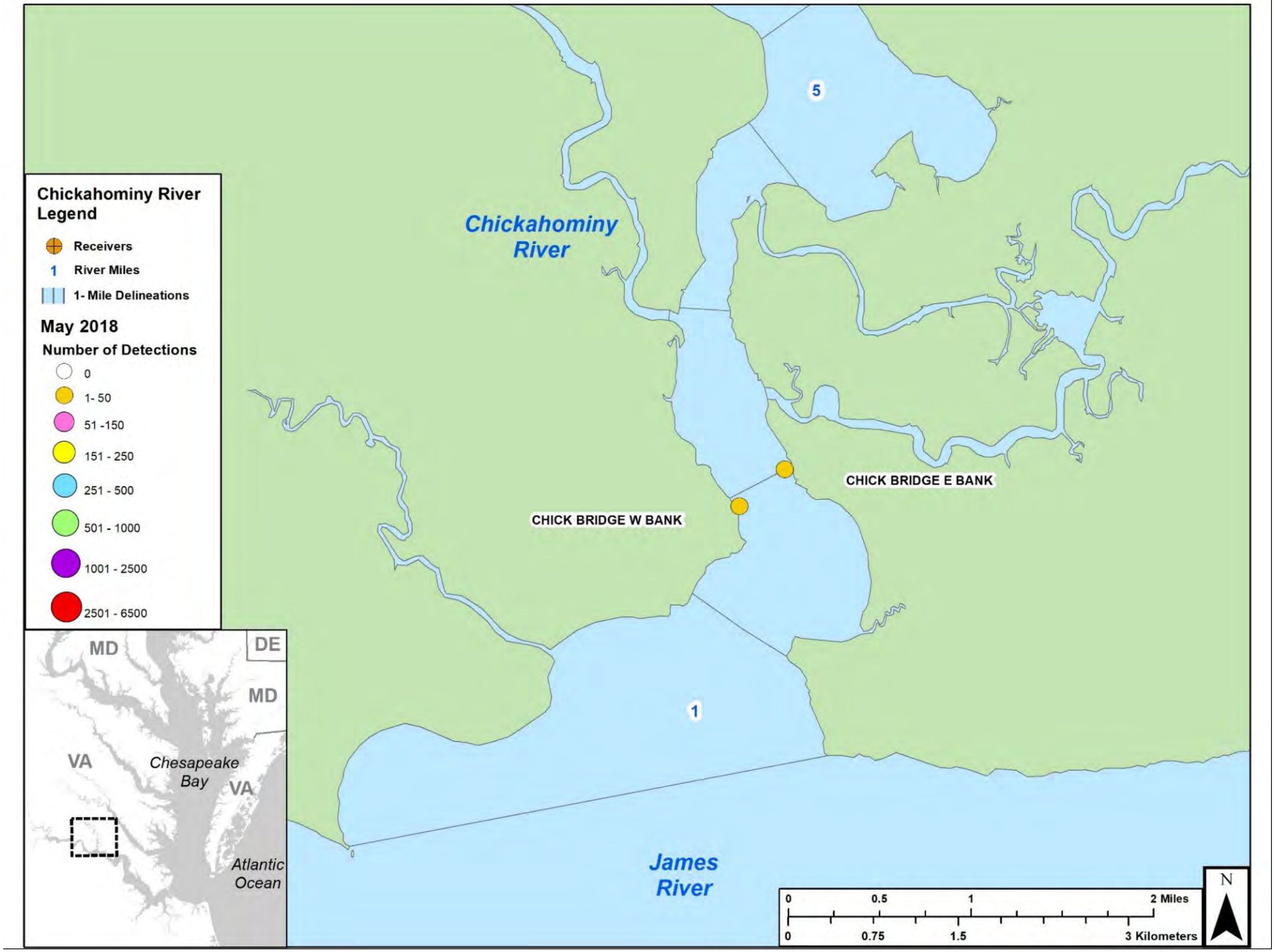
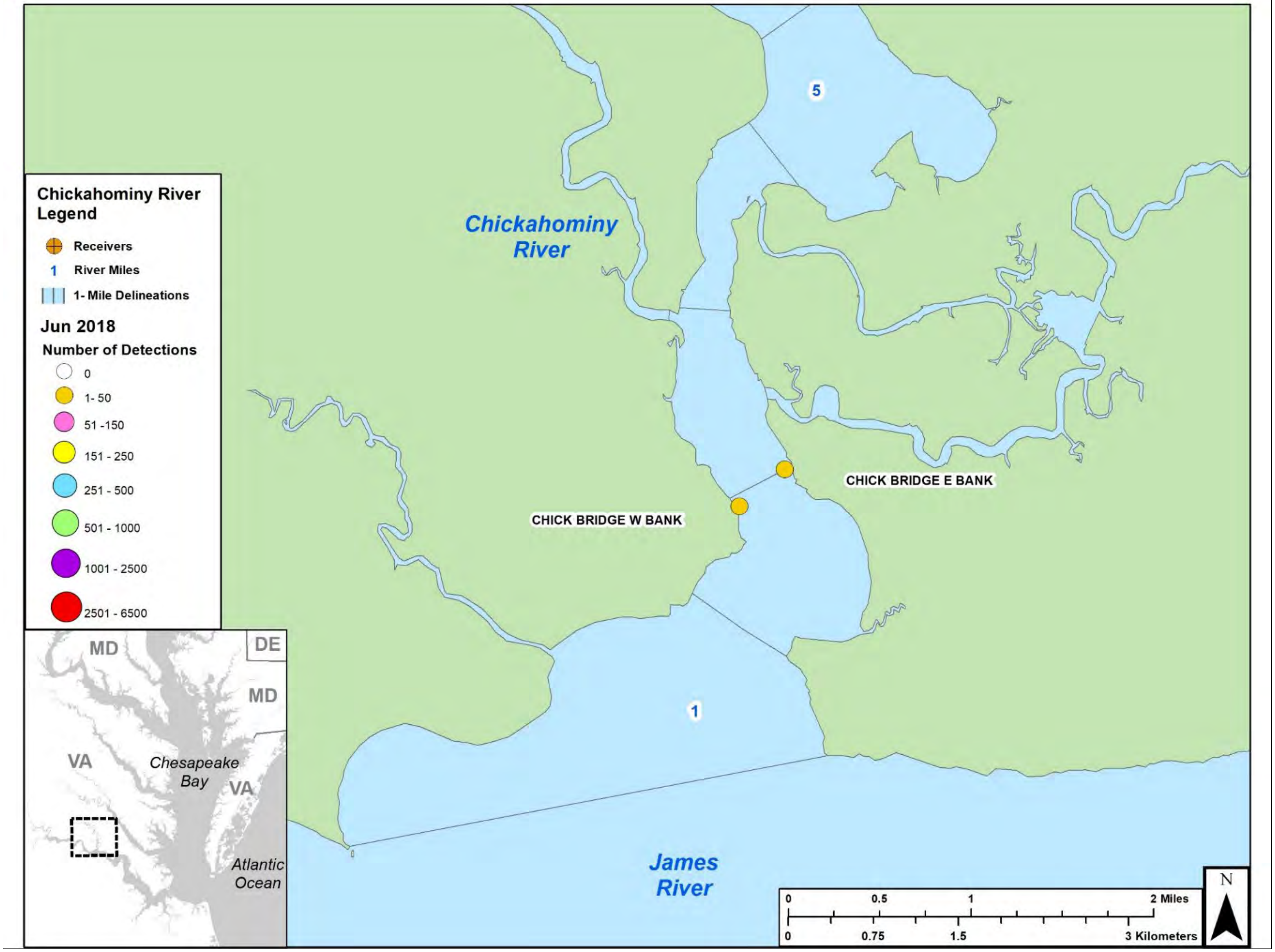
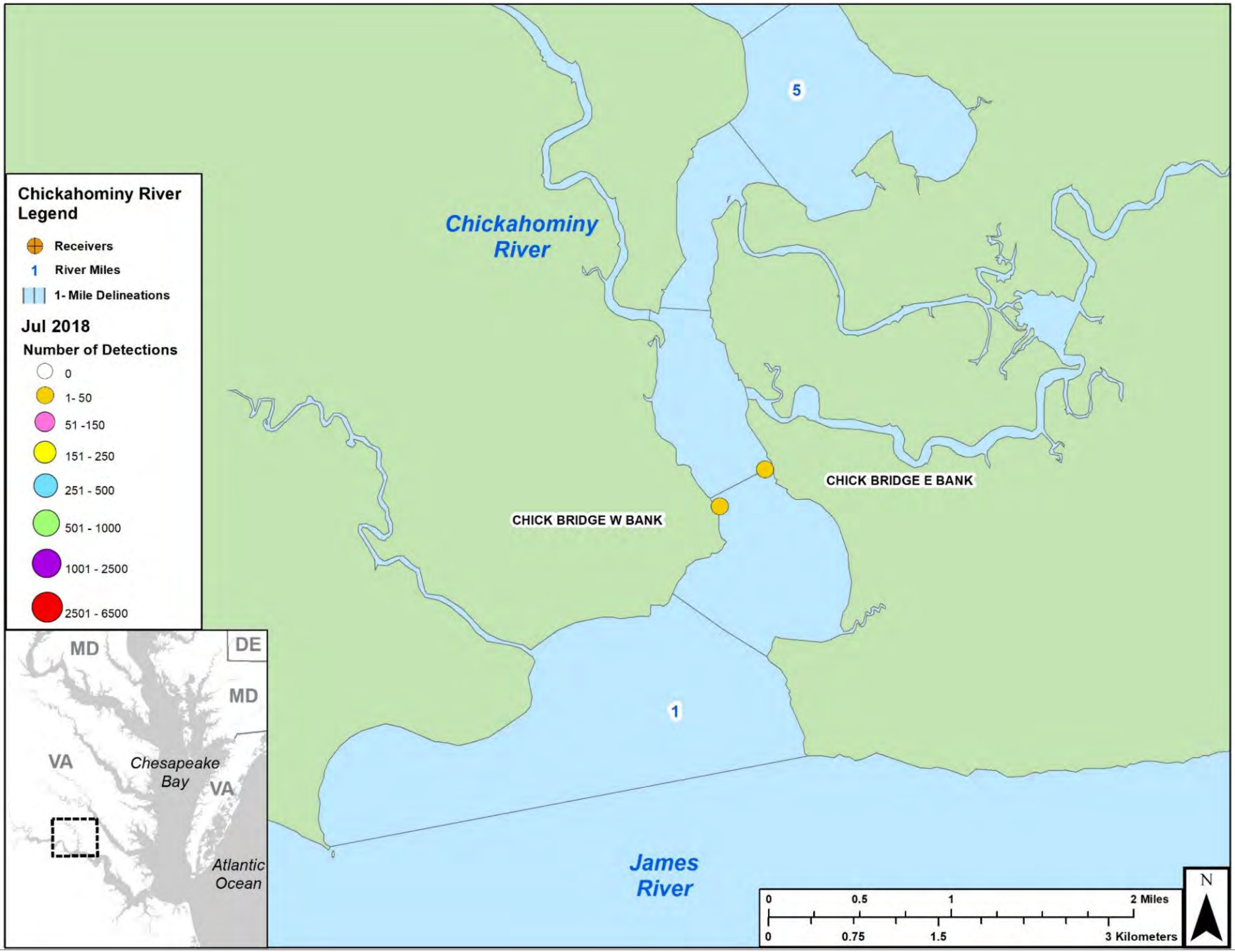
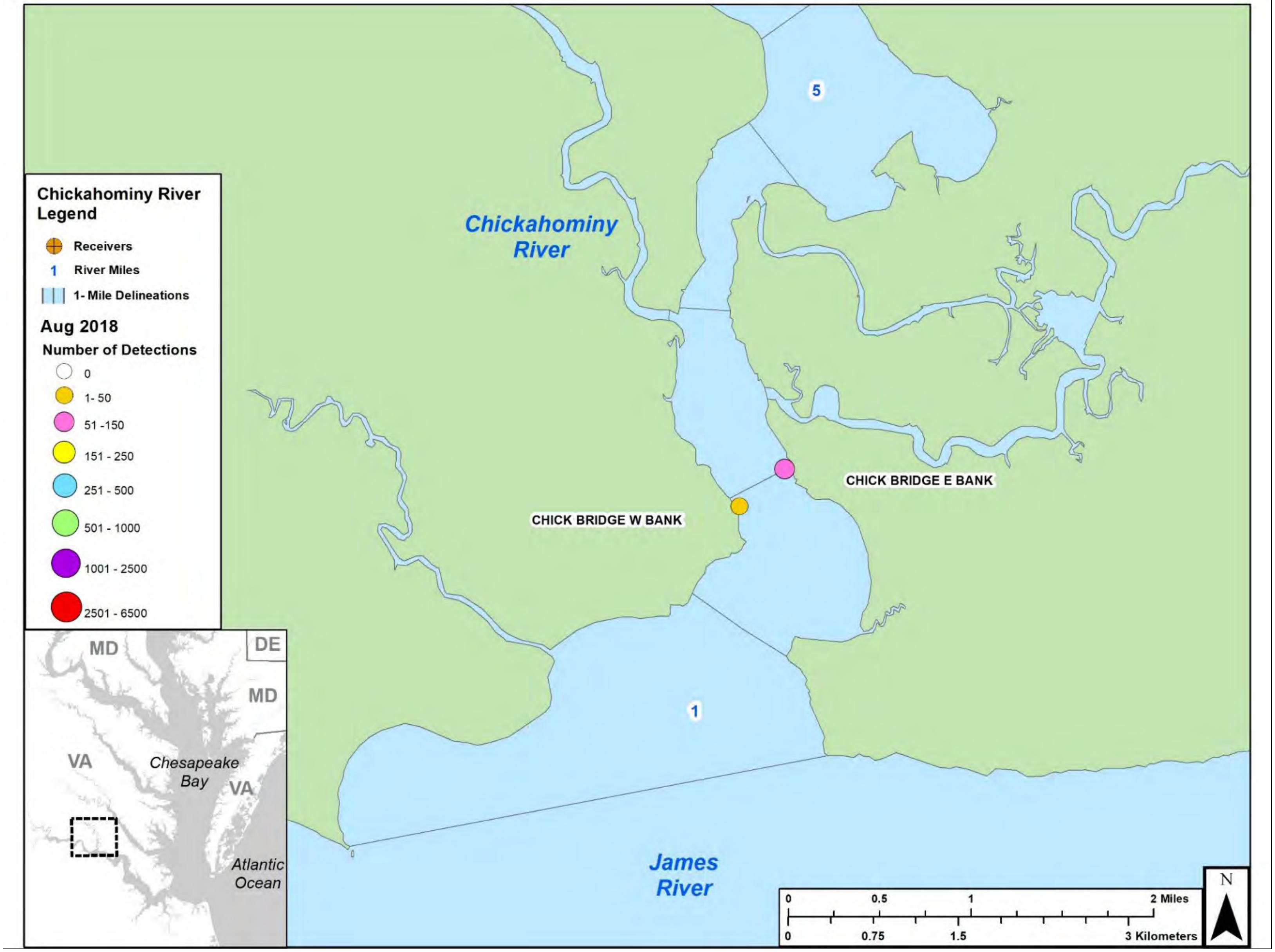
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
5
1
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N

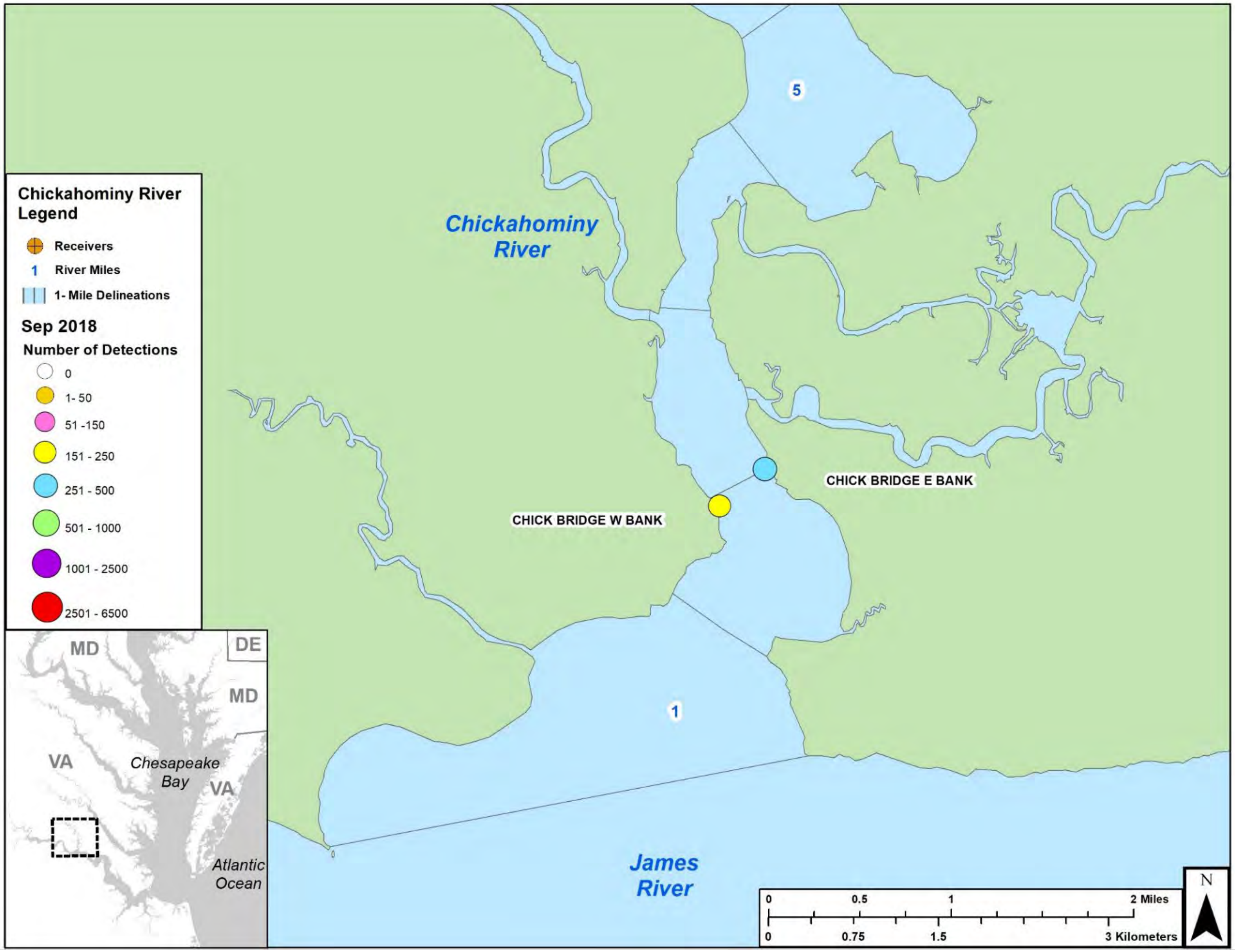

Chickahominy River
Legend
Receivers
1 River Miles
1- Mile Delineations
May 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
5
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
1
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N

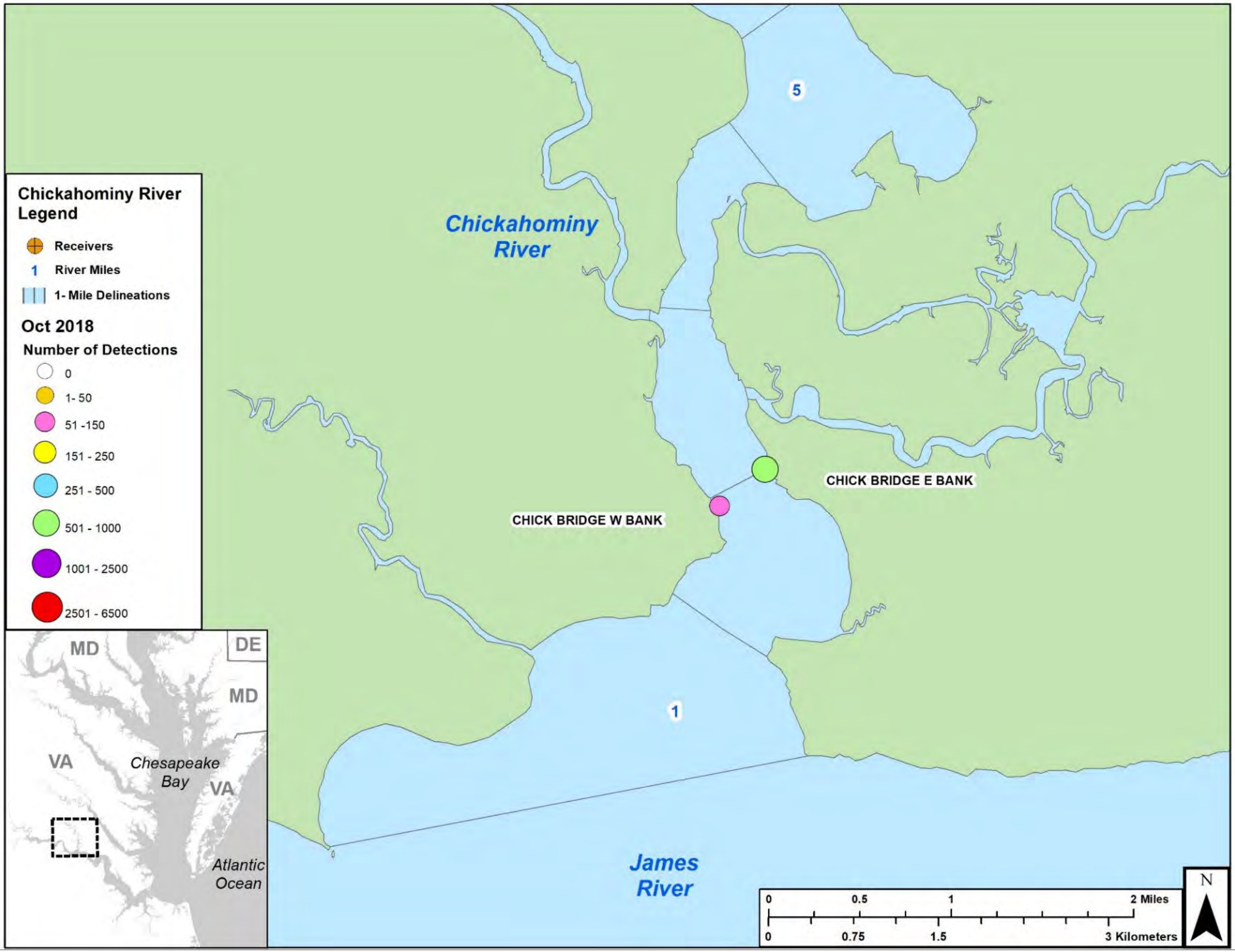

Chickahominy River Legend
Receivers
River Miles
1- Mile Delineations
Jun 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
James River
5
1
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N

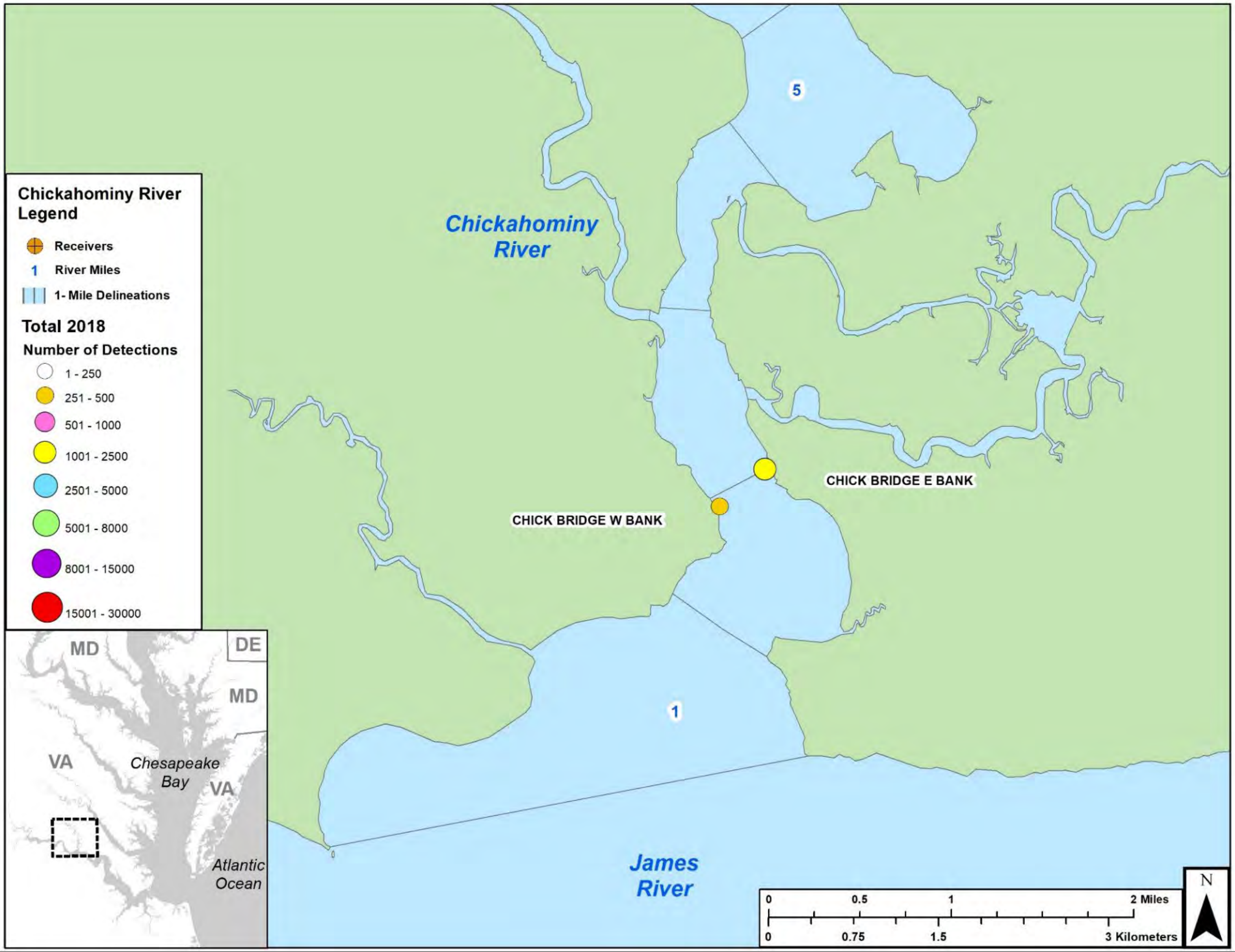


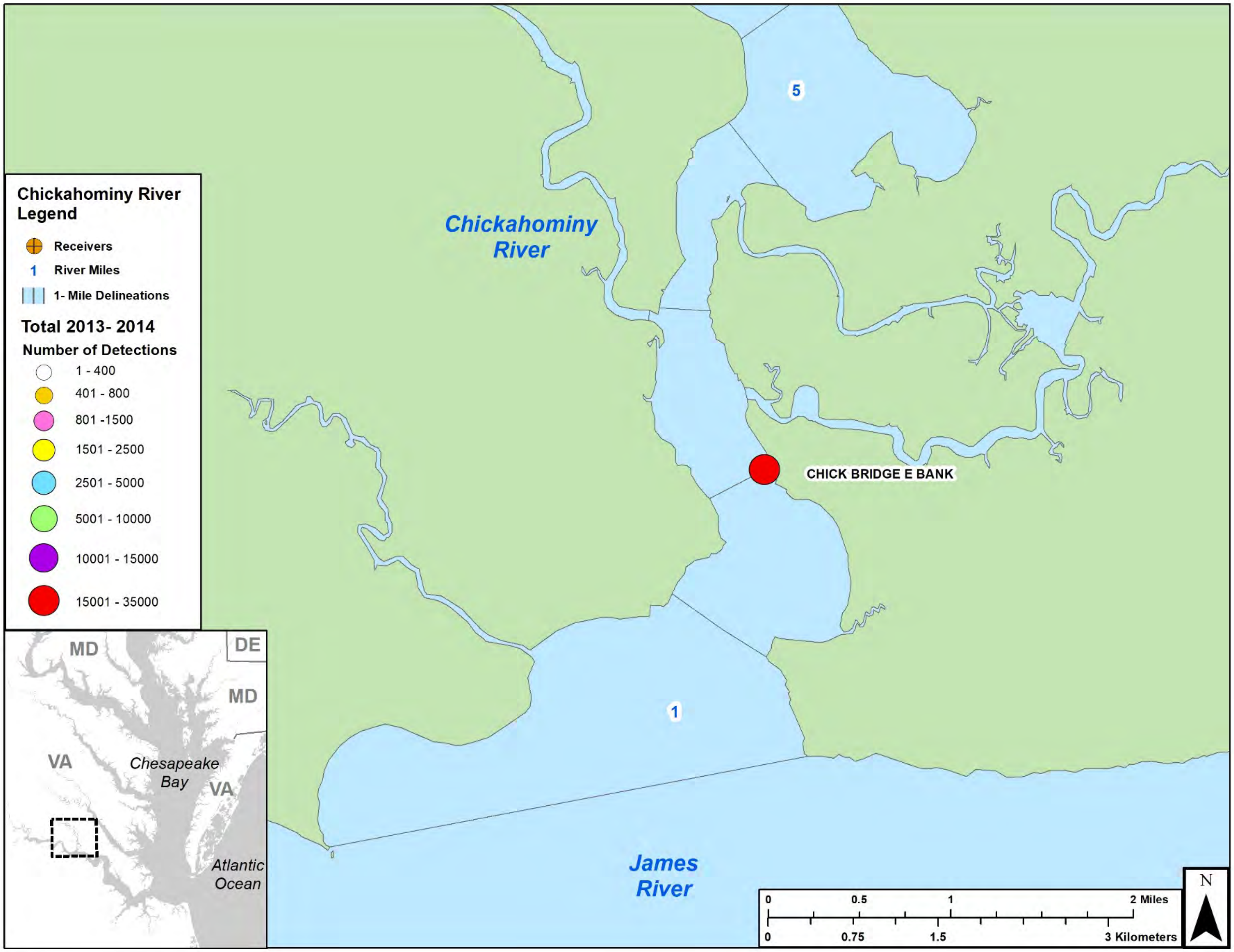
Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Jul 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
5
1
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N

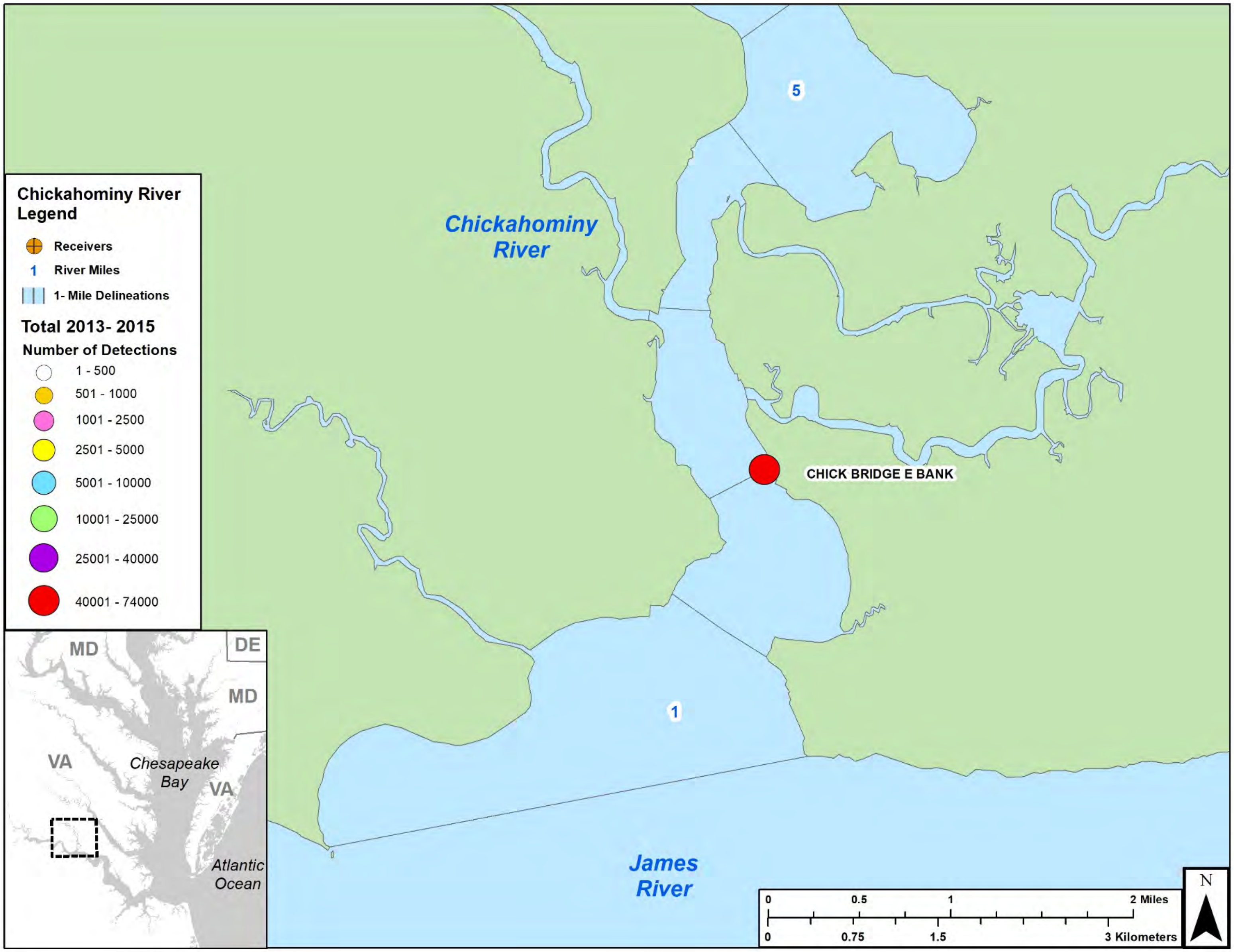

Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Aug 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
James River
5
1
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N

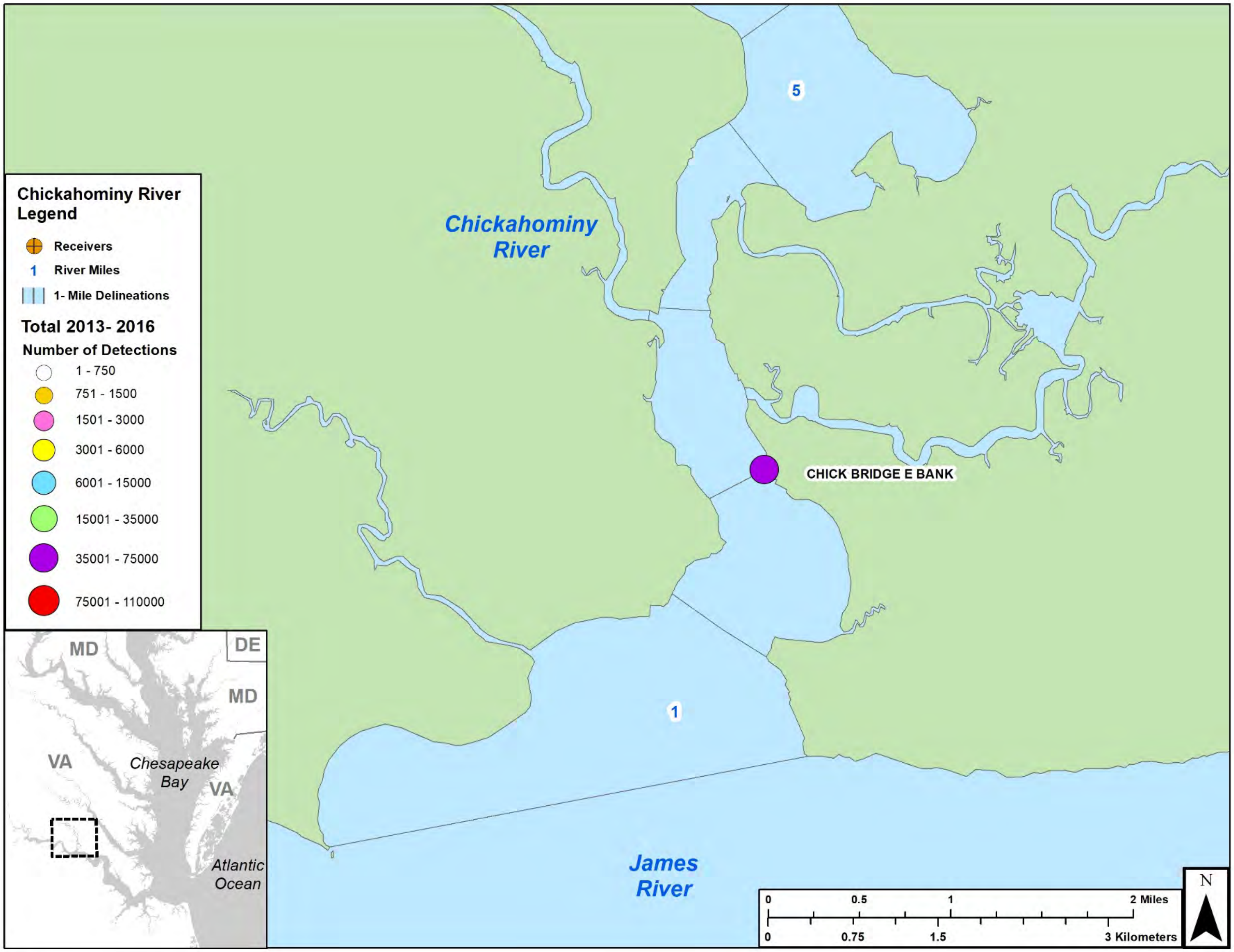

Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Sep 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Chickahominy River
5
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
1
James River
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N

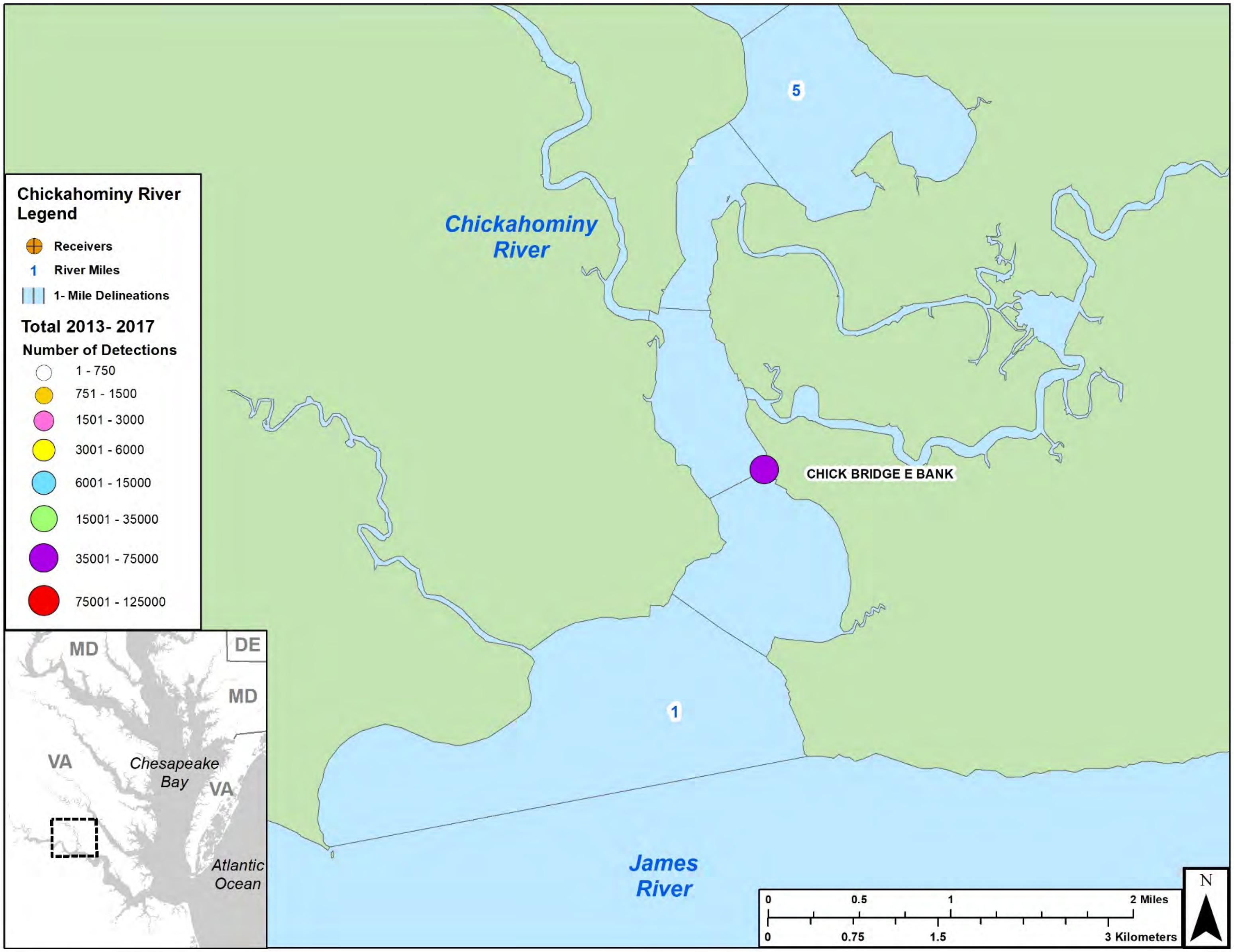

Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Oct 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chickahominy River
5
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
1
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N

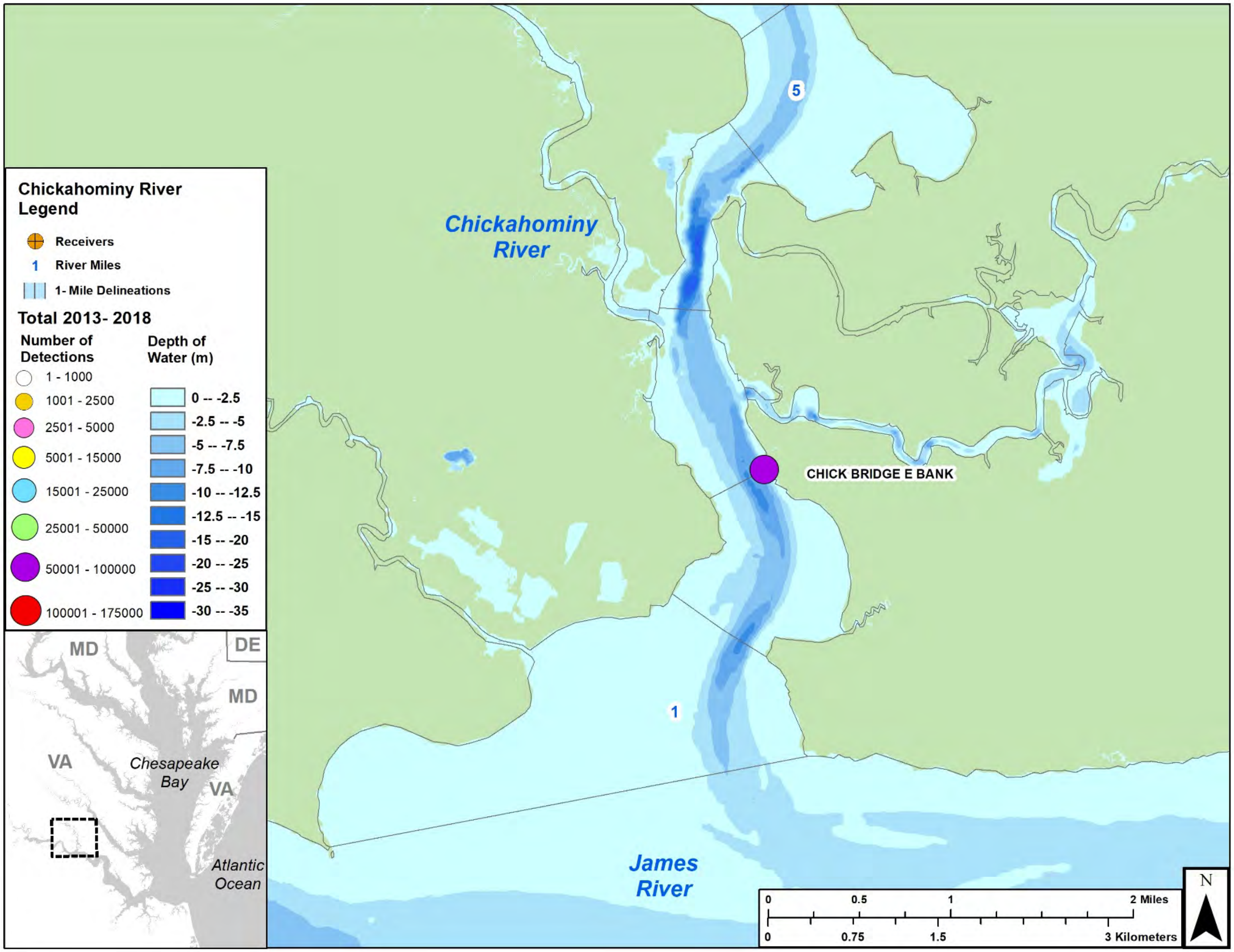

Chickahominy River
Legend
Receivers
1 River Miles
1- Mile Delineations
Total 2018
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
Chickahominy River
5
1
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N


Chickahominy River
Legend
Receivers
1 River Miles
1- Mile Delineations
Total 2013- 2014
Number of Detections
1 - 400
401 - 800
801 -1500
1501 - 2500
2501 - 5000
5001 - 10000
10001 - 15000
15001 - 35000
Chickahominy River
5
CHICK BRIDGE E BANK
1
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N

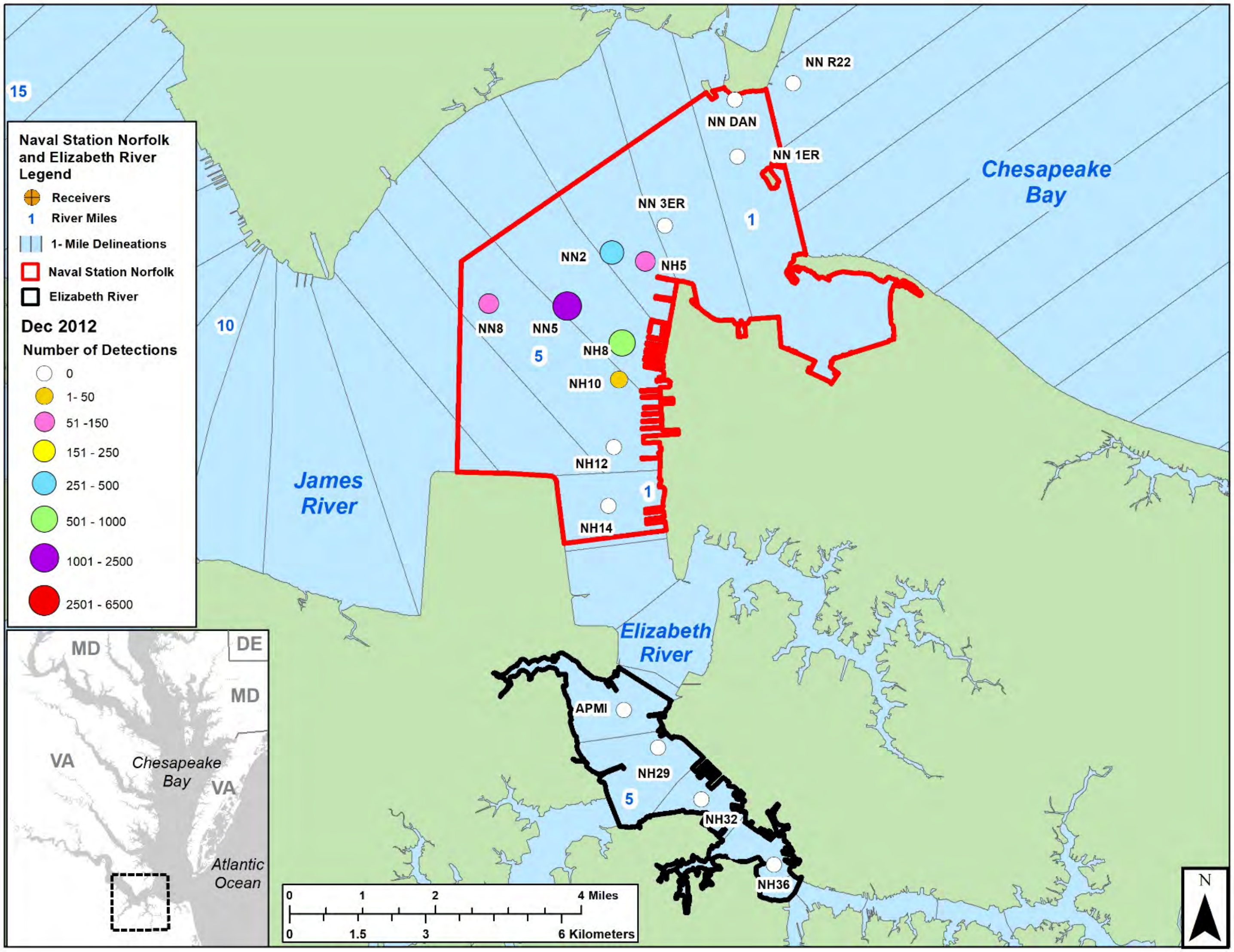

Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Total 2013- 2015
Number of Detections
1 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 10000
10001 - 25000
25001 - 40000
40001 - 74000
Chickahominy River
James River
CHICK BRIDGE E BANK
5
1
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N

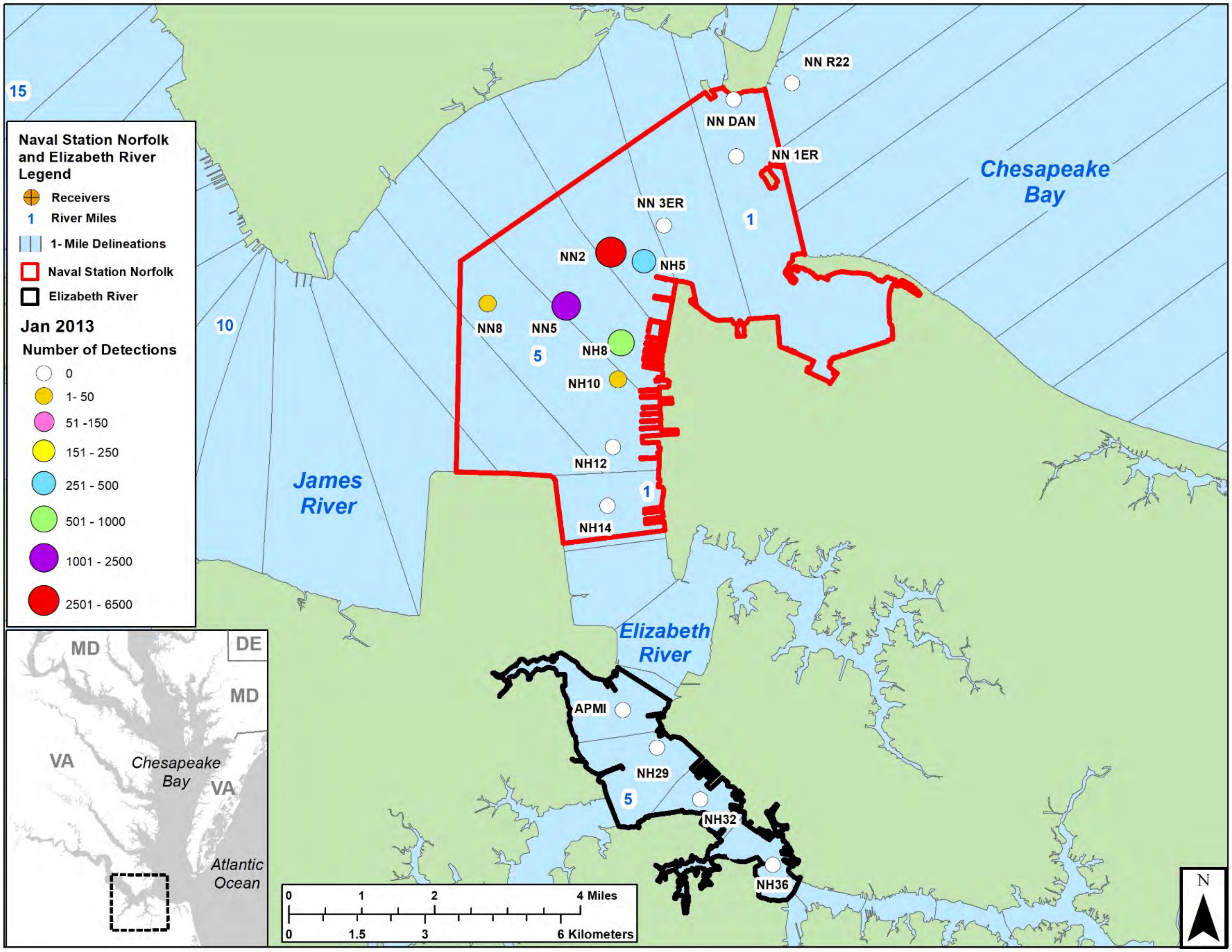

Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Total 2013- 2016
Number of Detections
1 - 750
751 - 1500
1501 - 3000
3001 - 6000
6001 - 15000
15001 - 35000
35001 - 75000
75001 - 110000
Chickahominy River
5
1
CHICK BRIDGE E BANK
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N

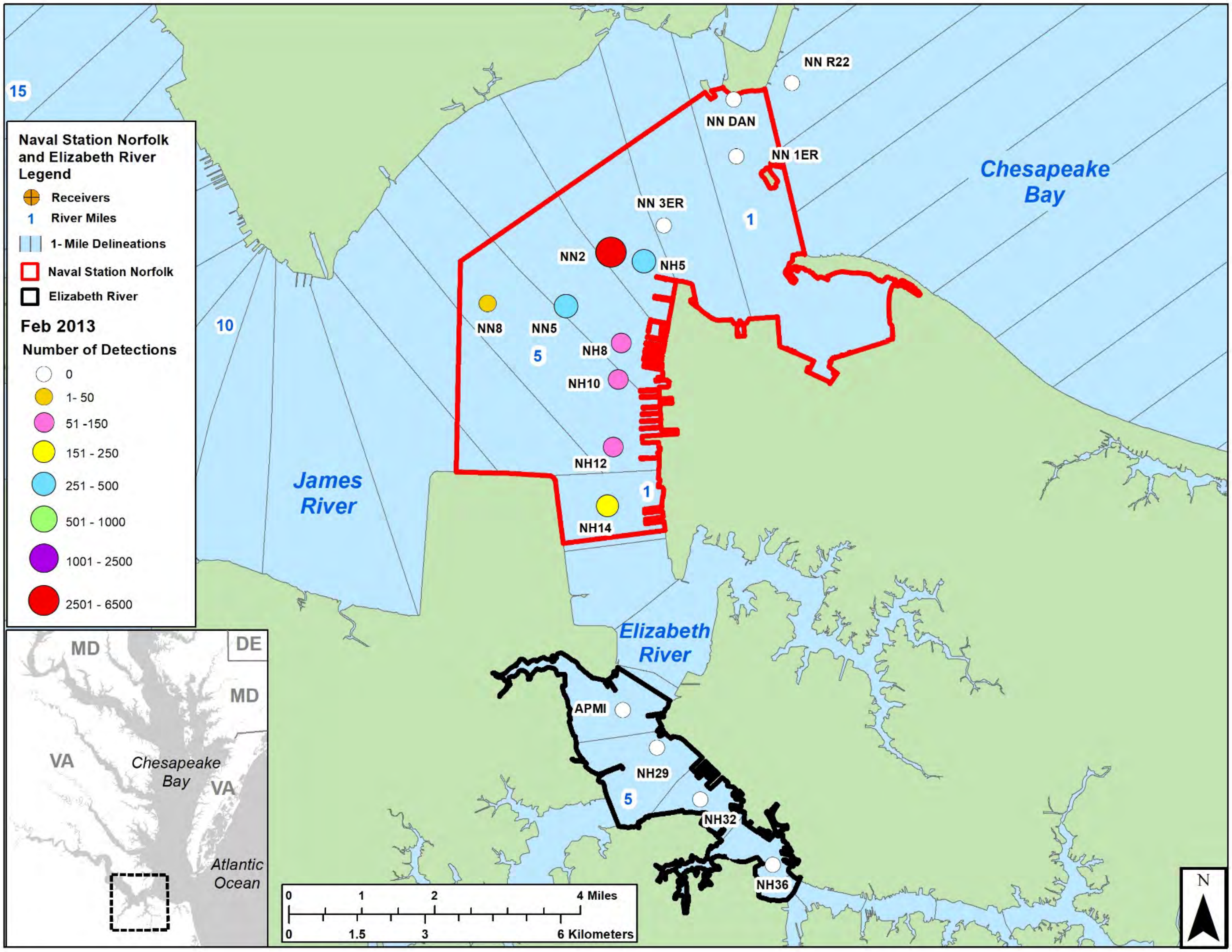

Chickahominy River Legend
⊕ Receivers
1 River Miles
1- Mile Delineations
Total 2013- 2017
Number of Detections
1 - 750
751 - 1500
1501 - 3000
3001 - 6000
6001 - 15000
15001 - 35000
35001 - 75000
75001 - 125000
Chickahominy River
5
1
CHICK BRIDGE E BANK
James River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N


Chickahominy River Legend
Receivers
1 River Miles
1- Mile Delineations
Total 2013- 2018
Number of Detections
1 - 1000
1001 - 2500
2501 - 5000
5001 - 15000
15001 - 25000
25001 - 50000
50001 - 100000
100001 - 175000
Depth of Water (m)
0 -- -2.5
-2.5 -- -5
-5 -- -7.5
-7.5 -- -10
-10 -- -12.5
-12.5 -- -15
-15 -- -20
-20 -- -25
-25 -- -30
-30 -- -35
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Chickahominy River
5
1
CHICK BRIDGE E BANK
James River
0
0.5
1
2 Miles
0
0.75
1.5
3 Kilometers
N

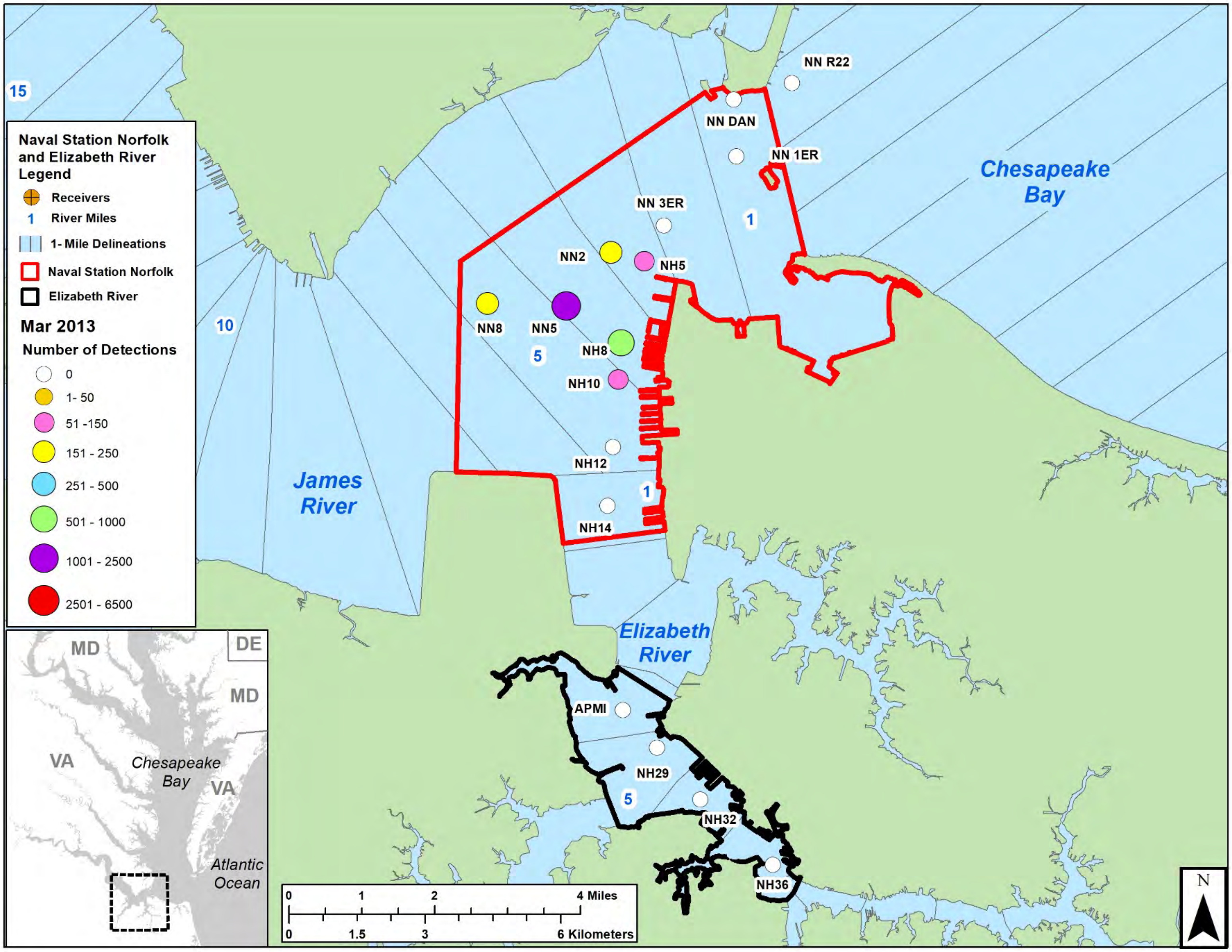
8.7. Appendix 8.7: Detections of Sonic-tagged Atlantic Sturgeon in the James River Region (Naval Station Norfolk and Elizabeth River), by Month, Year, and Overall



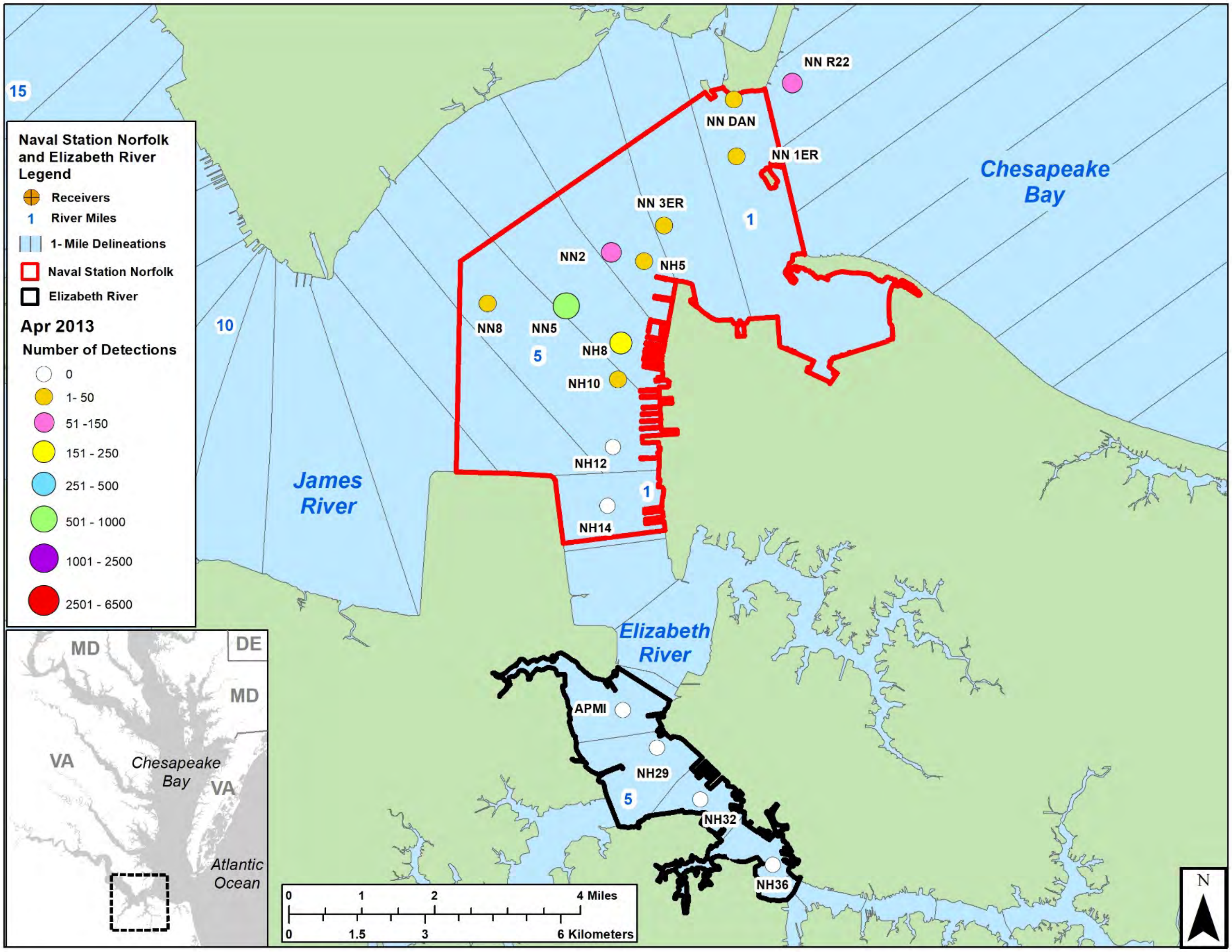

Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Jan 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0
1
2
4 Miles
1.5
3
6 Kilometers
N

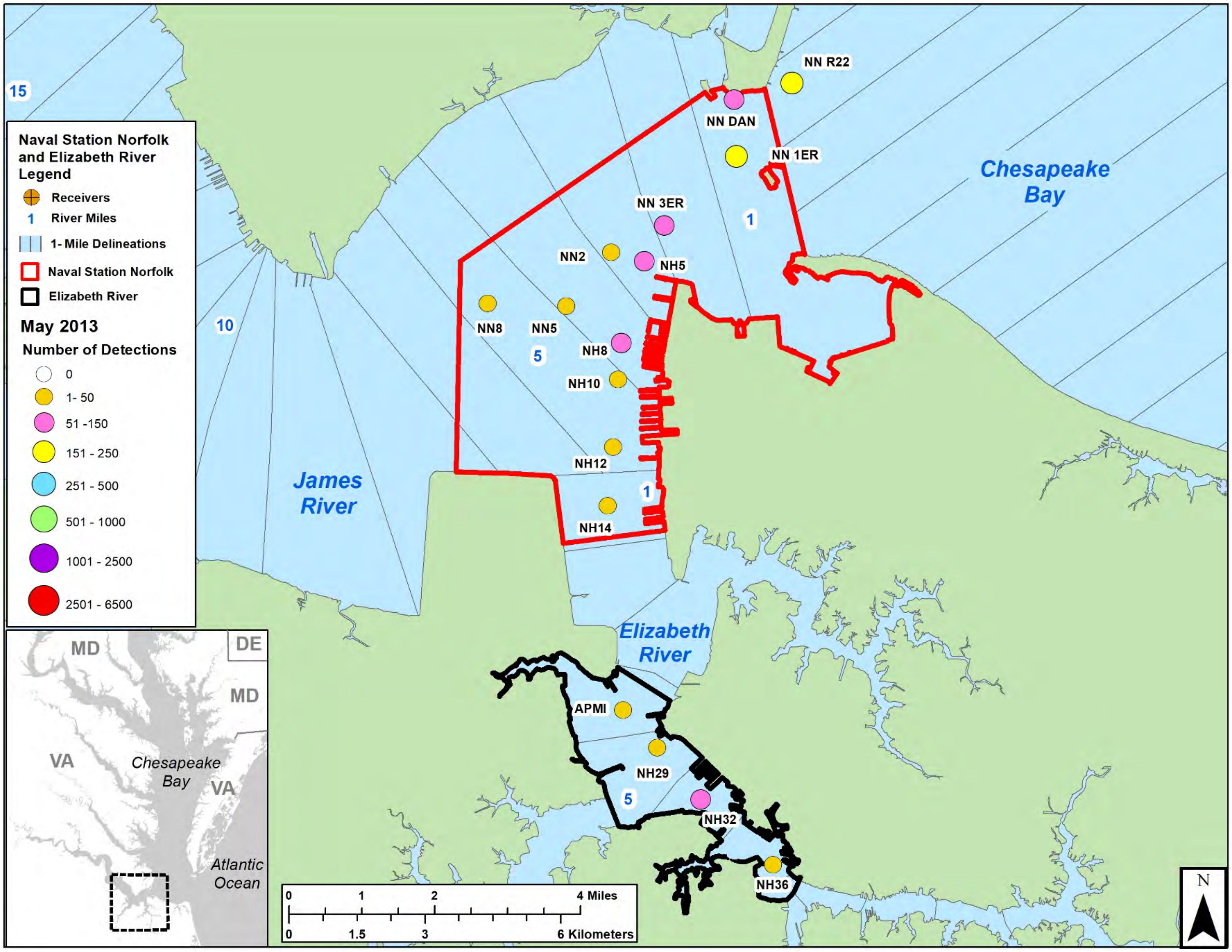

Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Feb 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

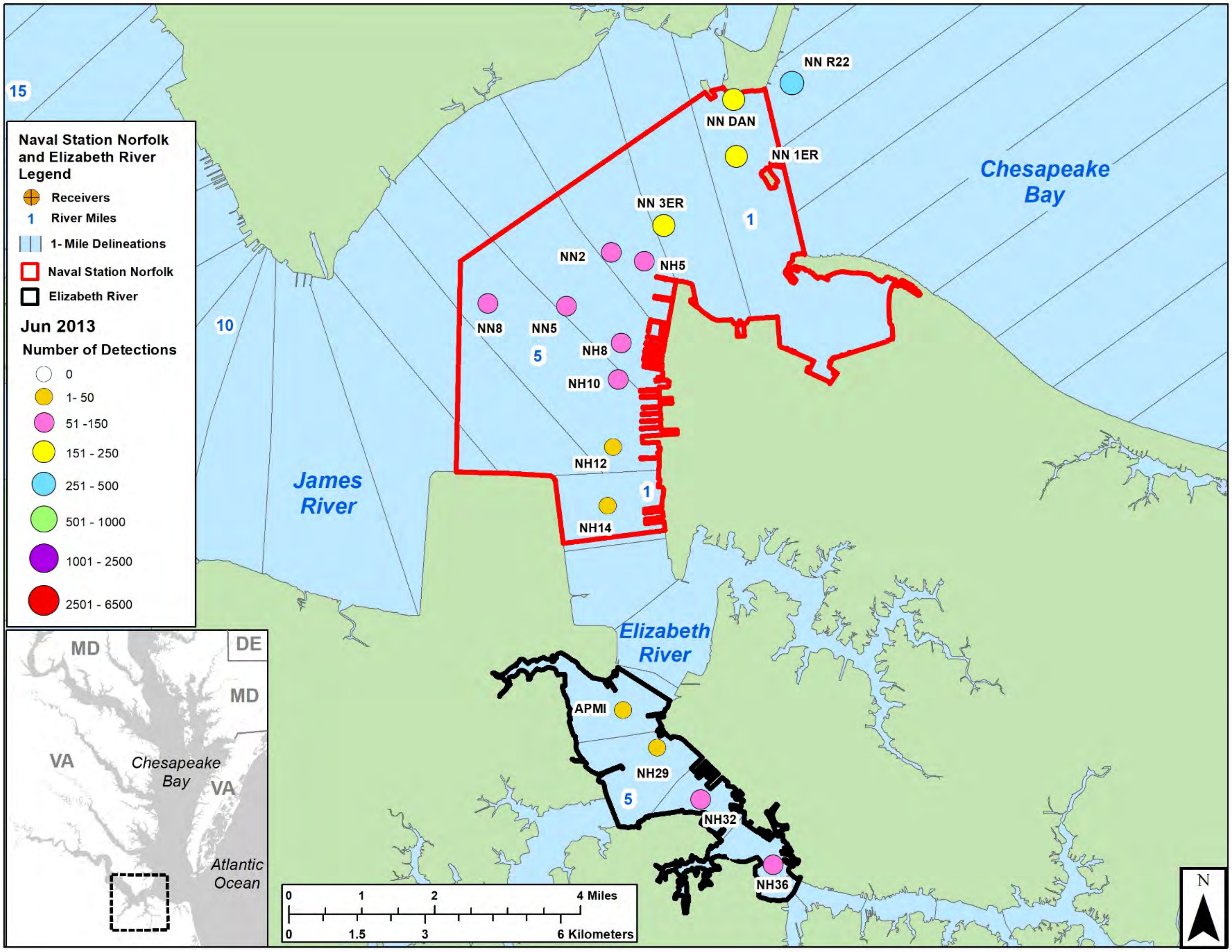
]

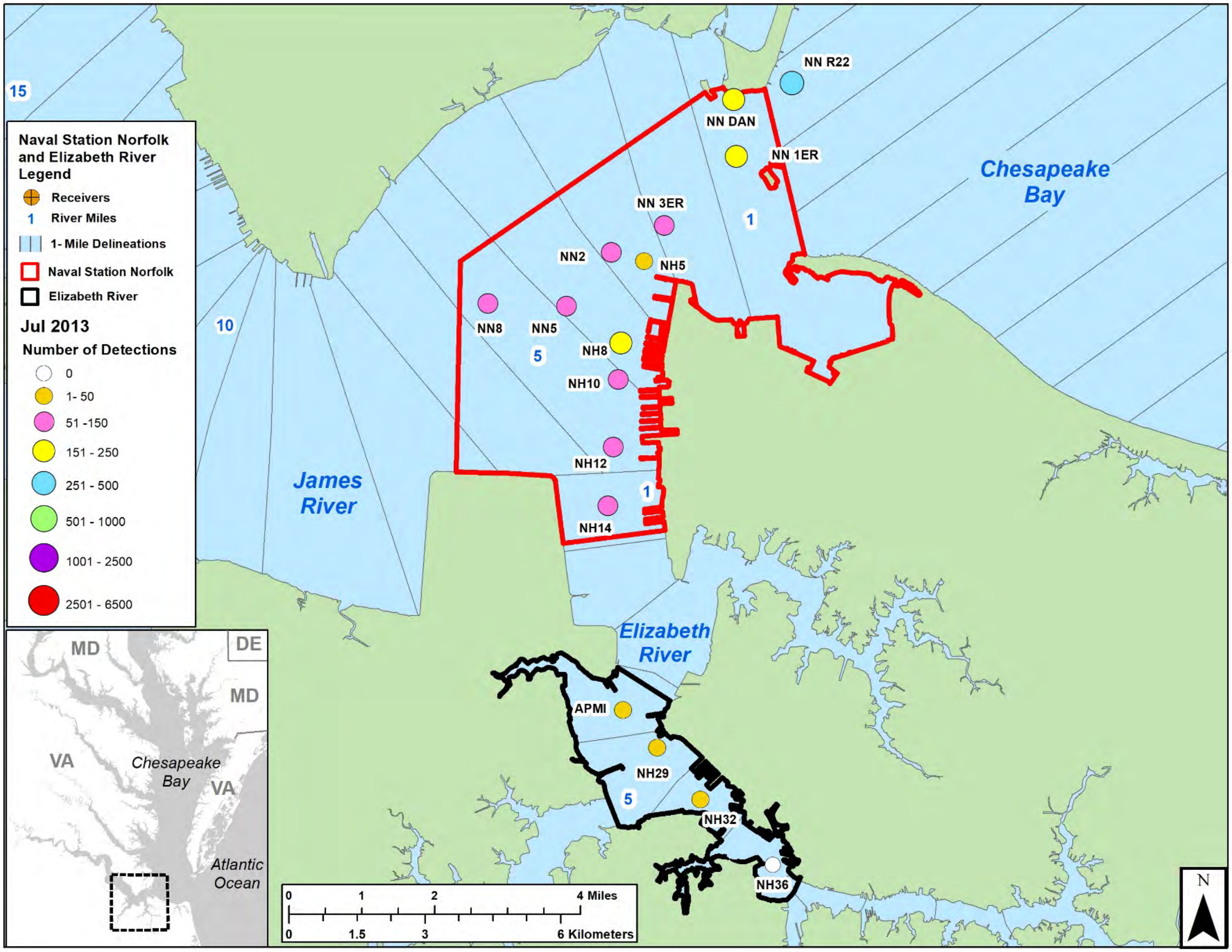


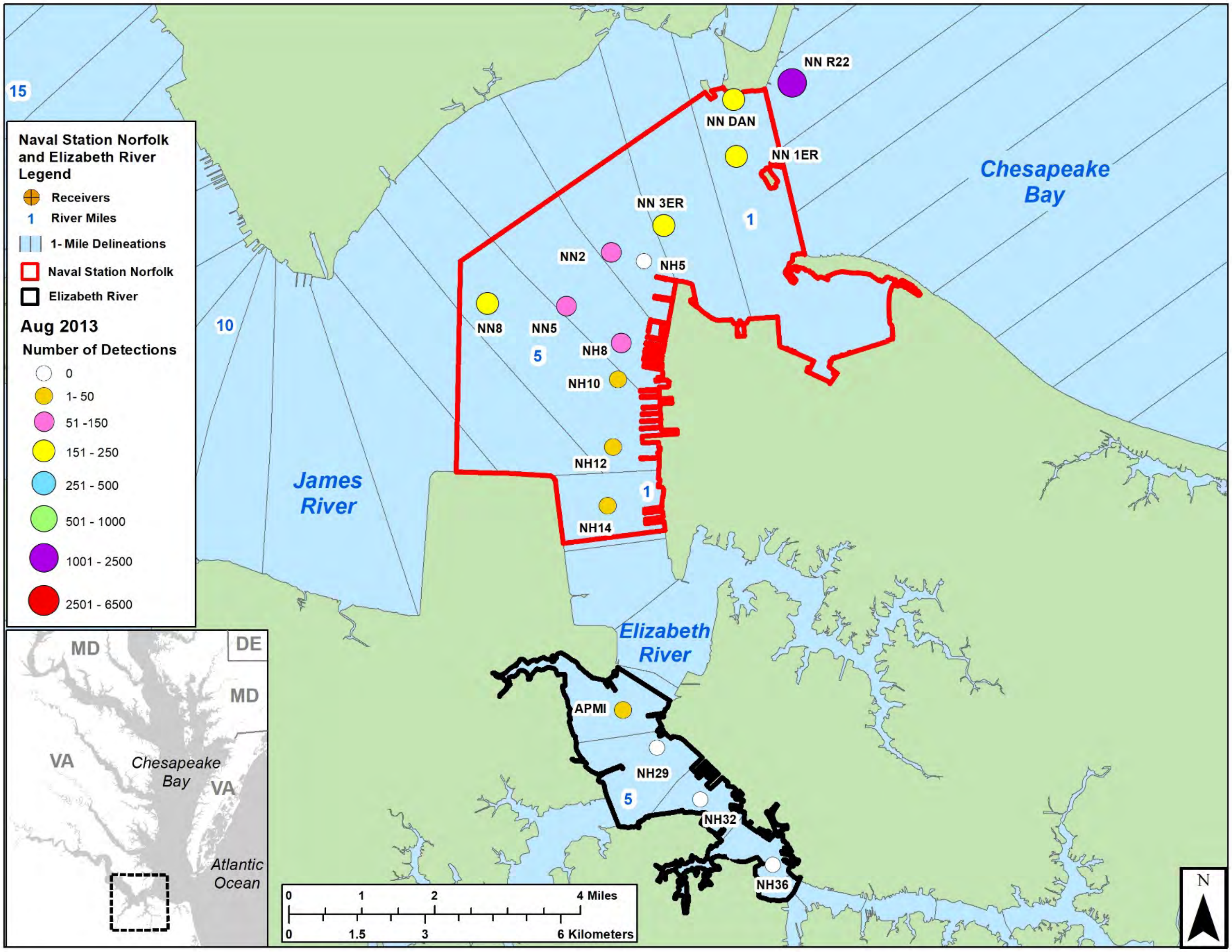
Naval Station Norfolk and Elizabeth River Legend
Receivers
River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Mar 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
James River
Chesapeake Bay
Elizabeth River
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

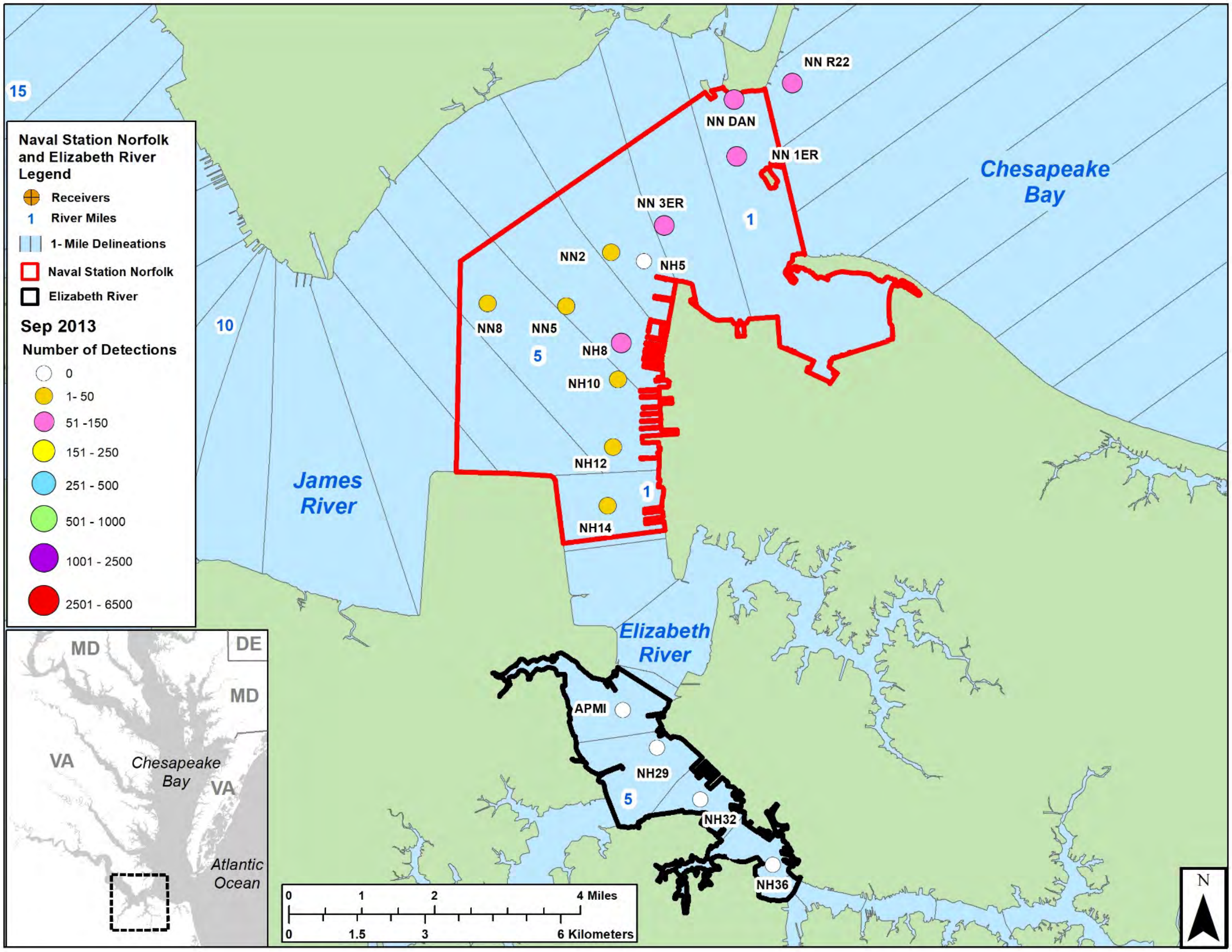

Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Apr 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

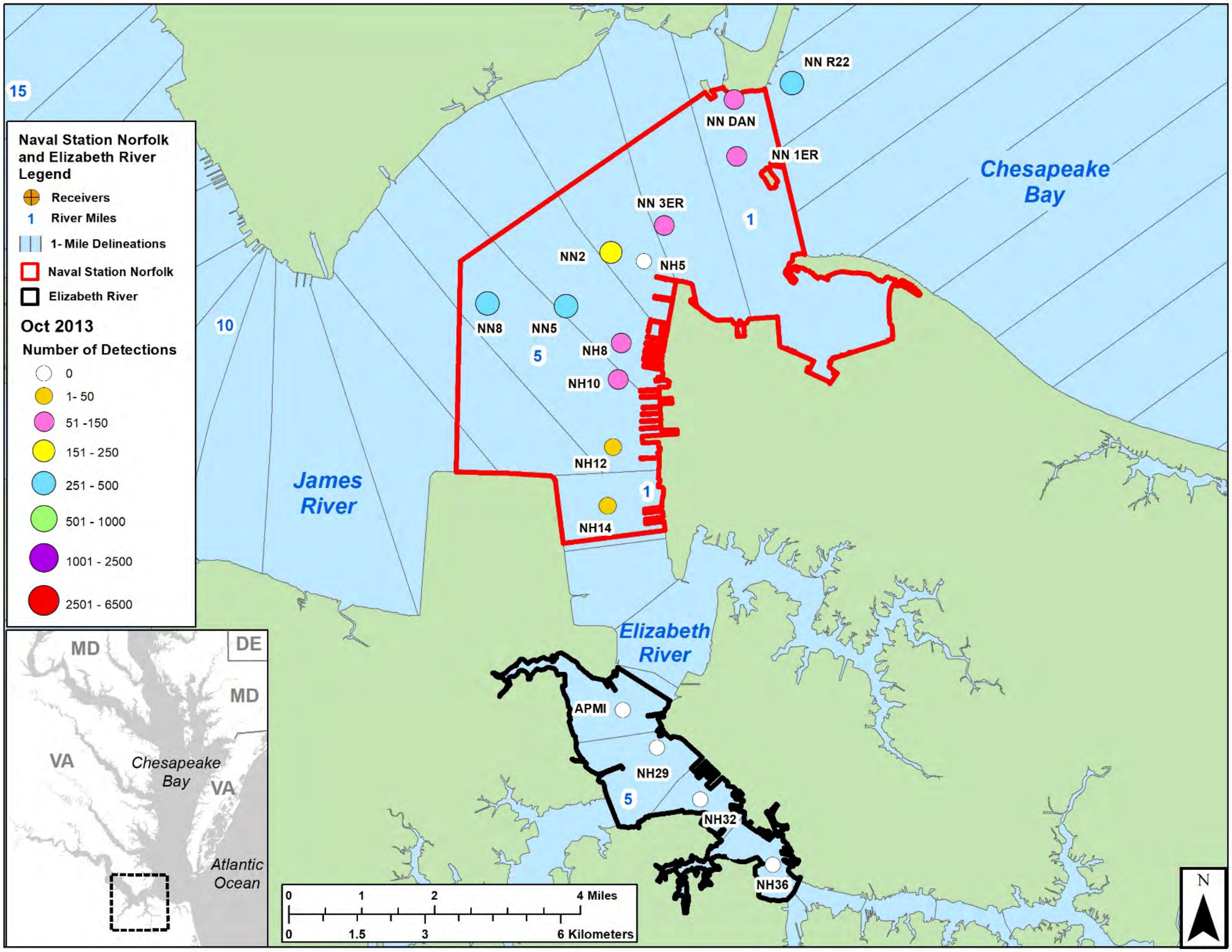

Naval Station Norfolk and Elizabeth River Legend
Receivers
River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
May 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0
1
2
4 Miles
1.5
3
6 Kilometers
N

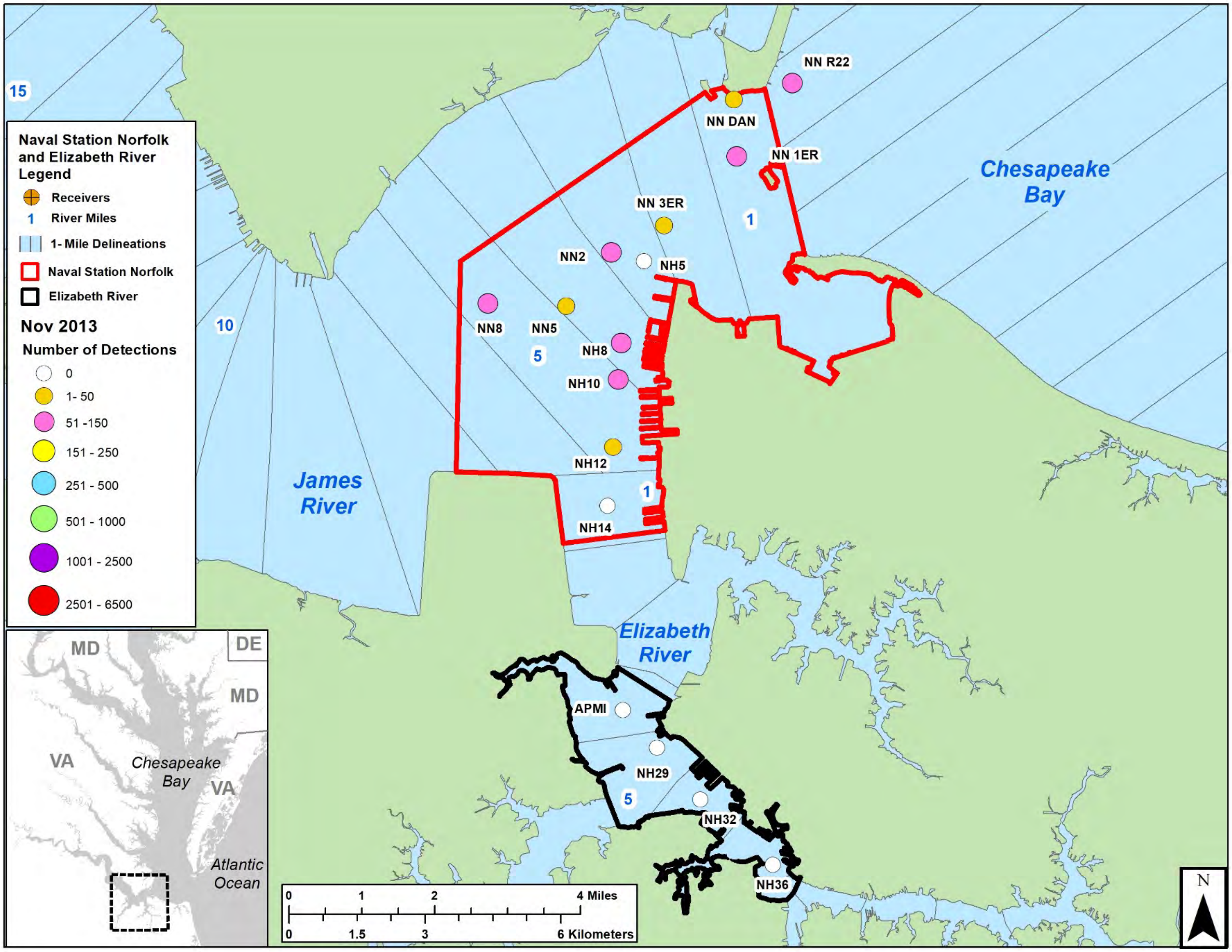

Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Jun 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
Chesapeake Bay
James River
Elizabeth River
APMI
NH29
NH32
NH36
MD
DE
VA
Chesapeake Bay
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

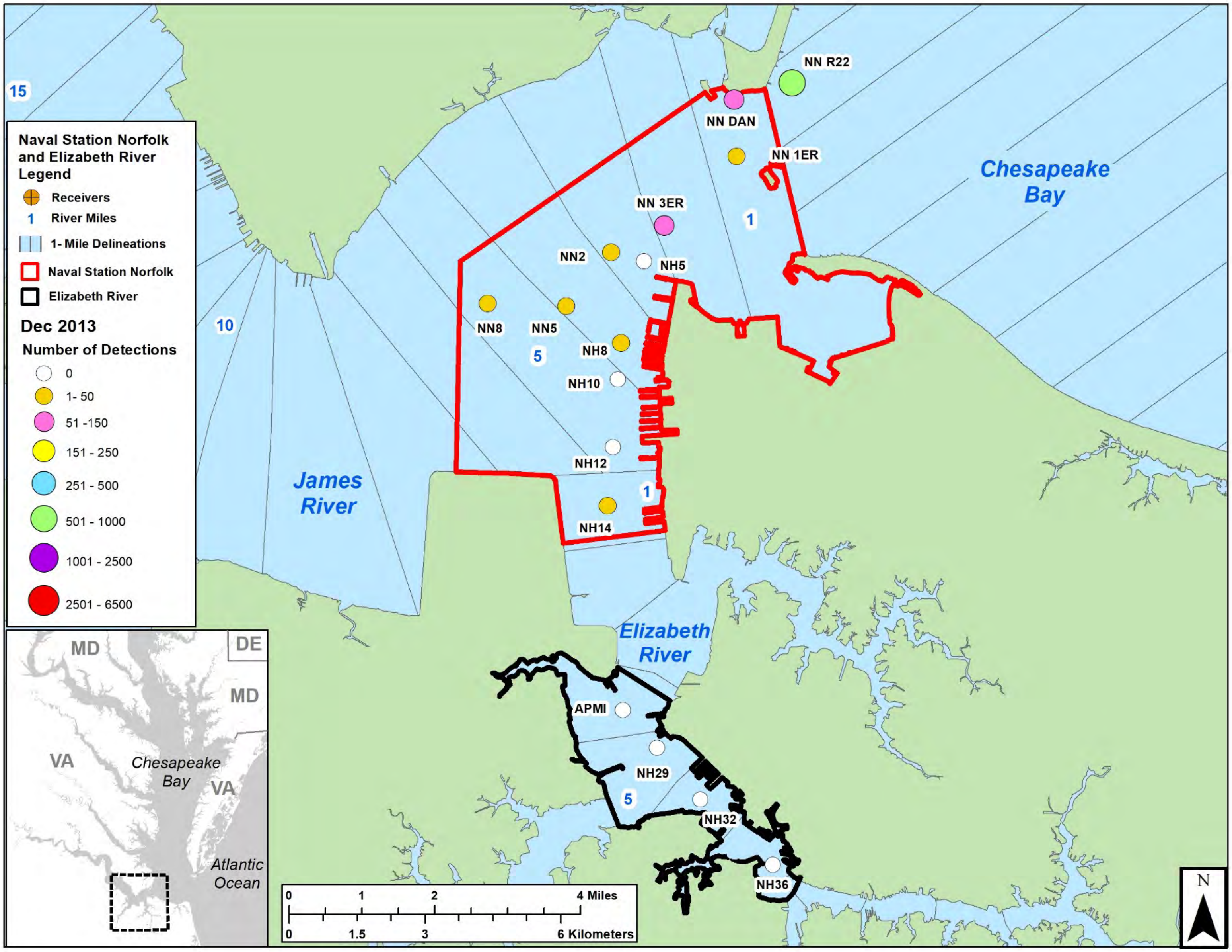

15
10
5
1
5
1
1
5
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
Naval Station Norfolk and Elizabeth River Legend
Receivers
River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Jul 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
1
2
4 Miles
0
1.5
3
6 Kilometers
N

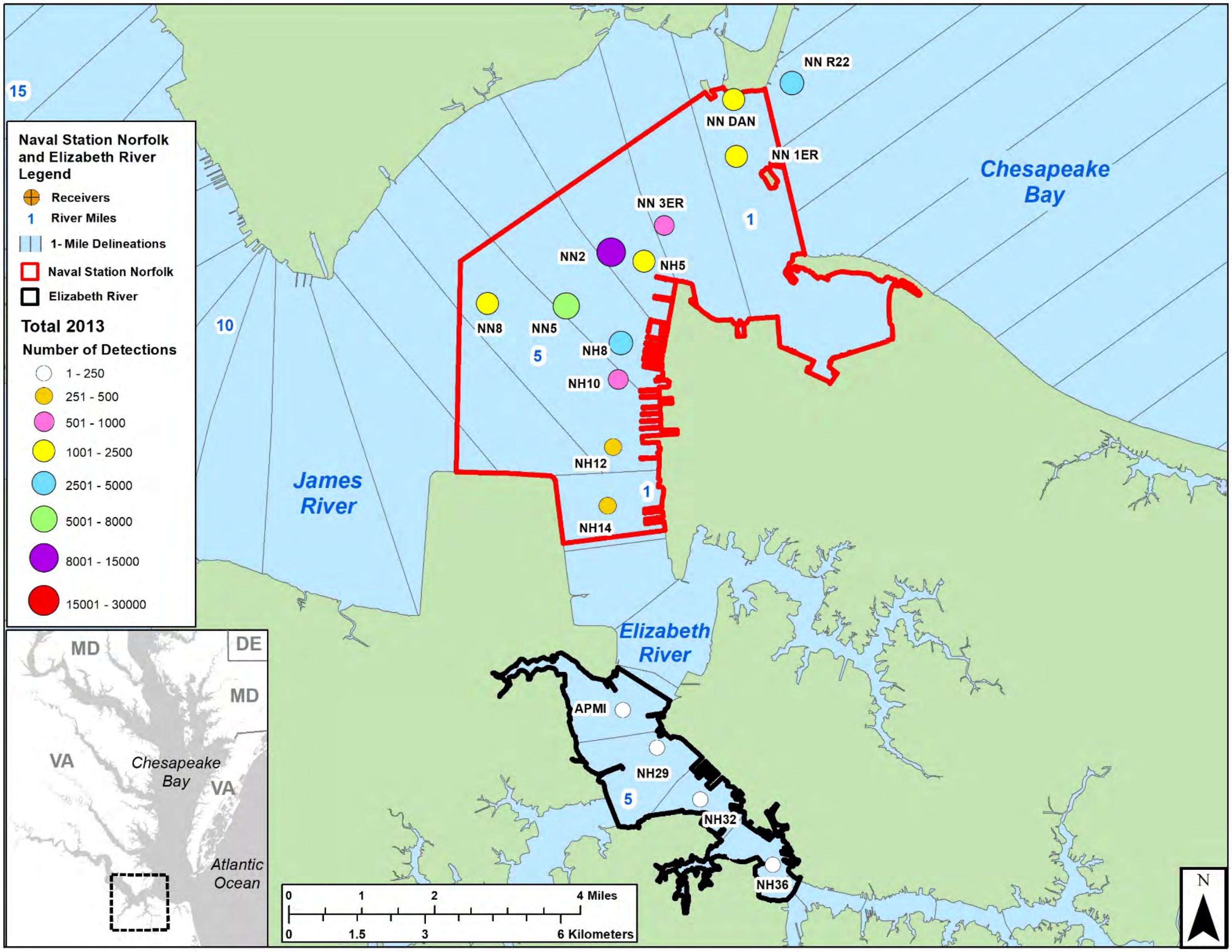

Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Aug 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
James River
Chesapeake Bay
Elizabeth River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

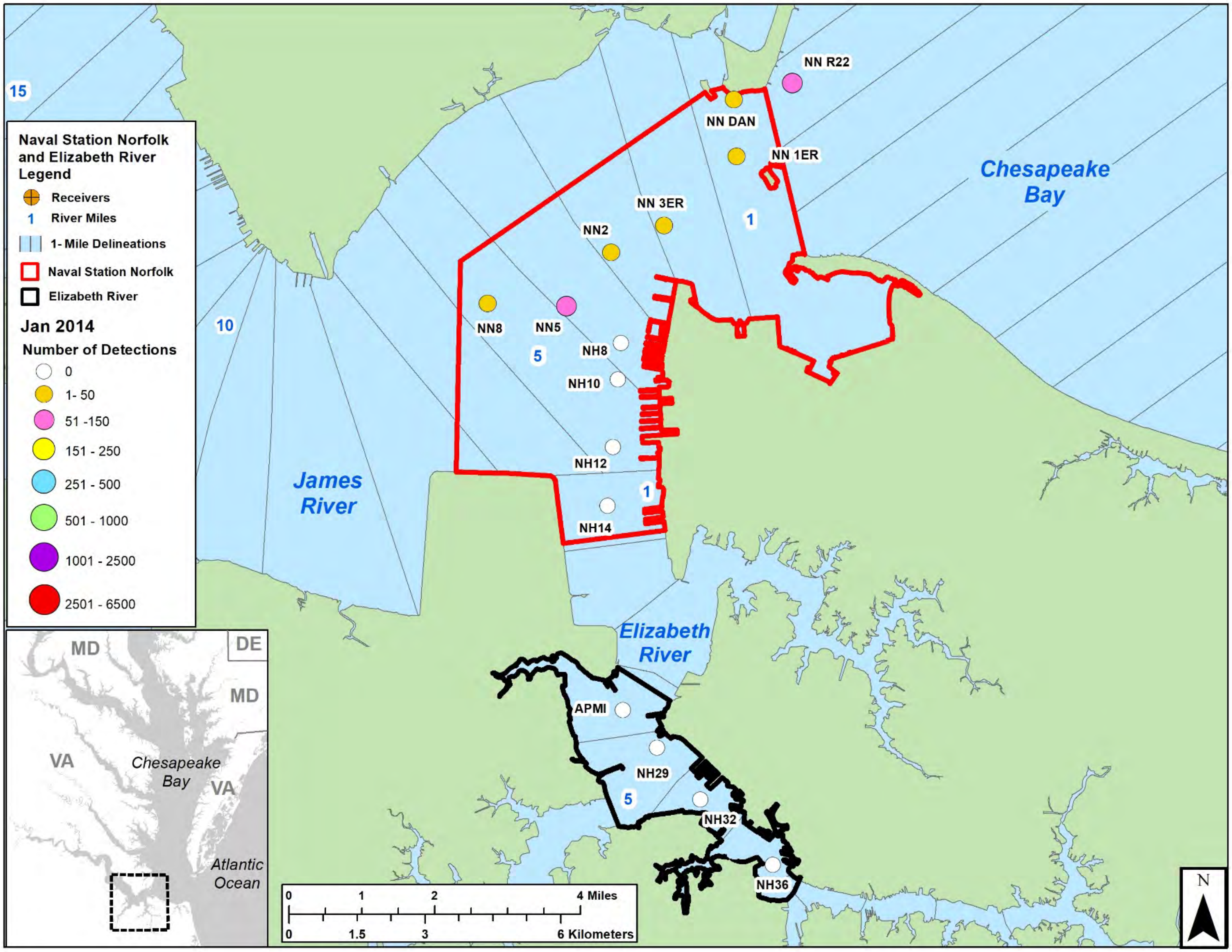

Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Sep 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N


Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Oct 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Chesapeake Bay
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N


Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Nov 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N


Naval Station Norfolk and Elizabeth River Legend
Receivers
River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Dec 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0
1
2
4 Miles
1.5
3
6 Kilometers
N


Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Total 2013
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N


Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Jan 2014
Number of Detections
0
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151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
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James River
Chesapeake Bay
Elizabeth River
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
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NN5
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NH36
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DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
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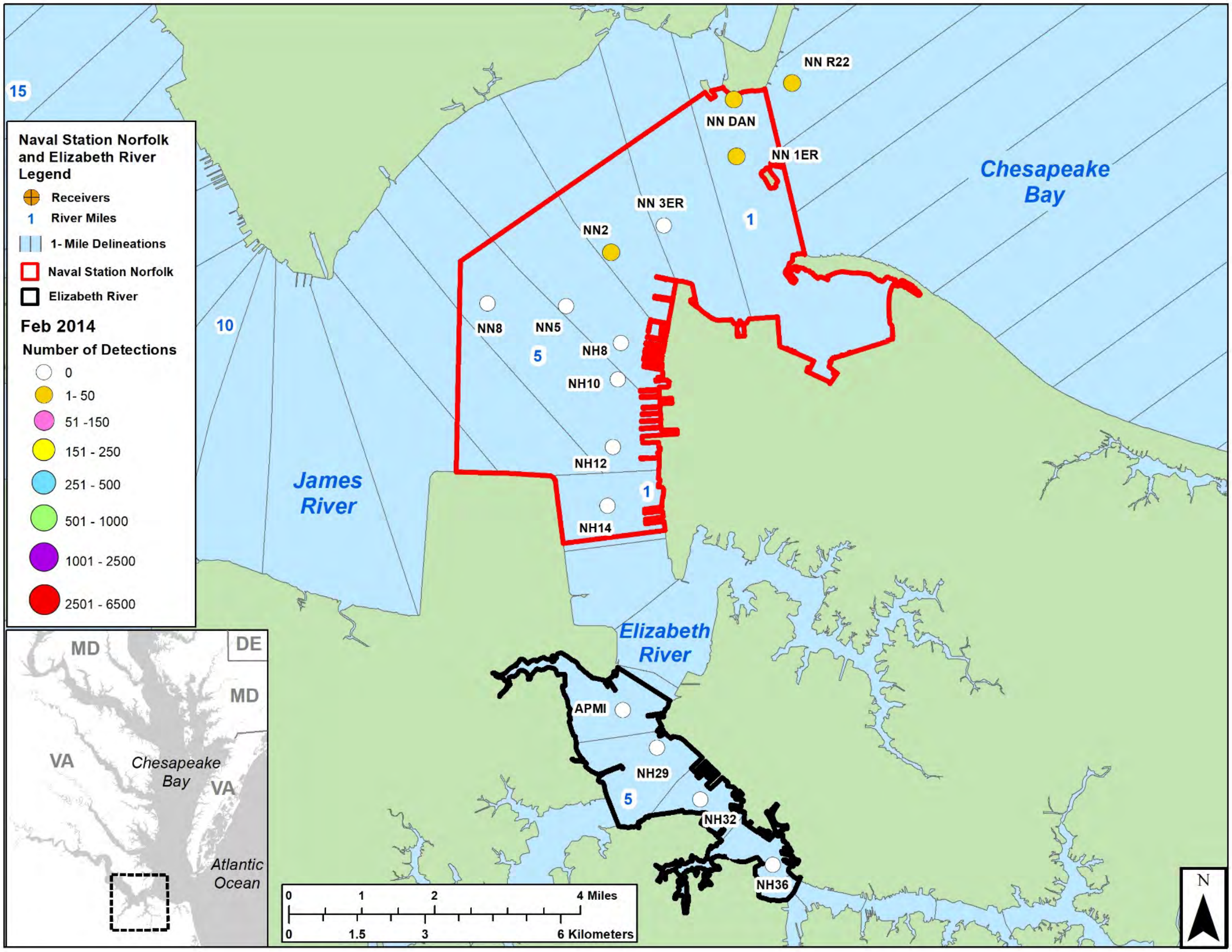
Naval Station Norfolk and Elizabeth River Legend
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River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Feb 2014
Number of Detections
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151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
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NN R22
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NN 1ER
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Chesapeake Bay
James River
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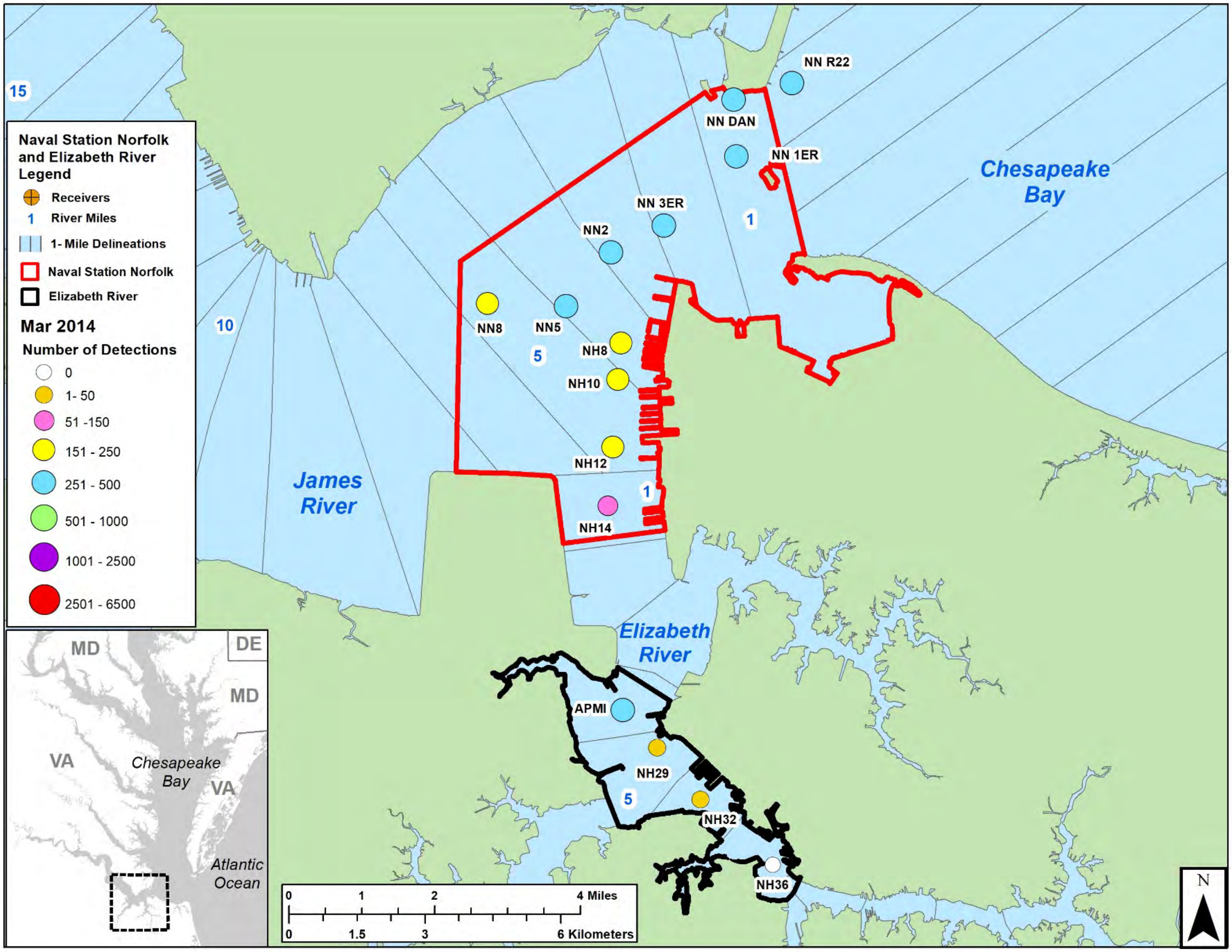
Naval Station Norfolk and Elizabeth River Legend
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1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Mar 2014
Number of Detections
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1001 - 2500
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Chesapeake Bay
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Atlantic Ocean
0 1 2 4 Miles
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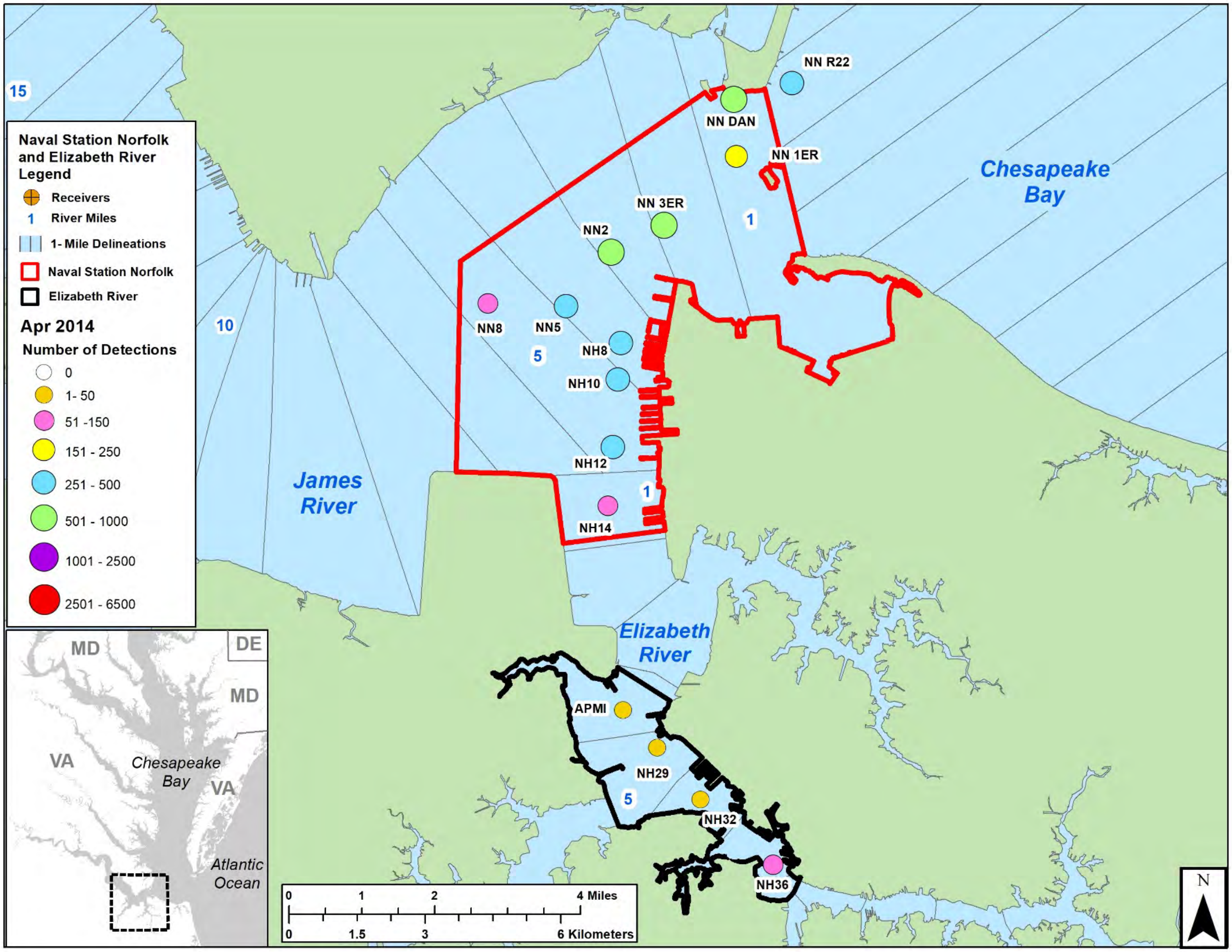
Naval Station Norfolk and Elizabeth River Legend
Receivers
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1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Apr 2014
Number of Detections
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Elizabeth River
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Atlantic Ocean
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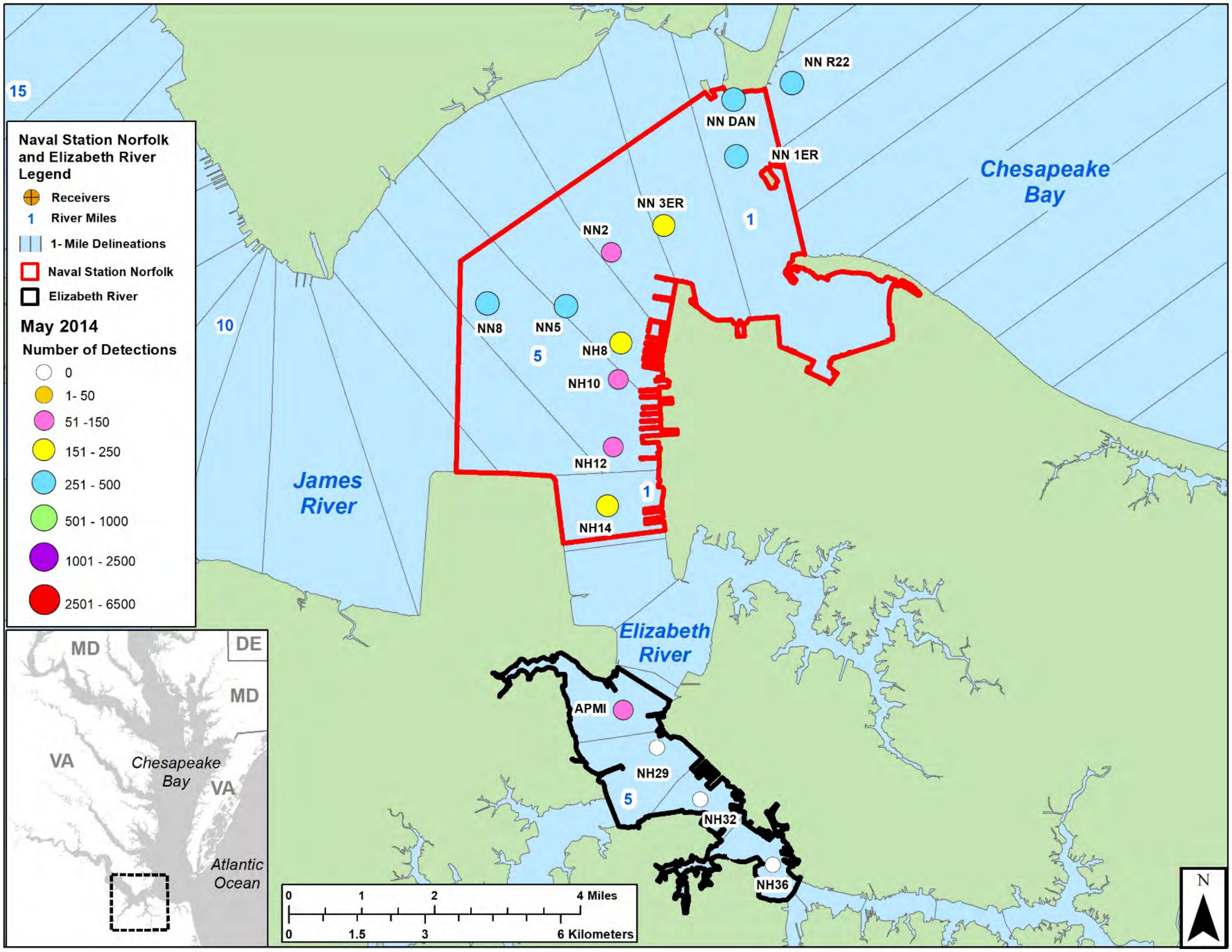
Naval Station Norfolk and Elizabeth River Legend
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1- Mile Delineations
Naval Station Norfolk
Elizabeth River
May 2014
Number of Detections
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Atlantic Ocean
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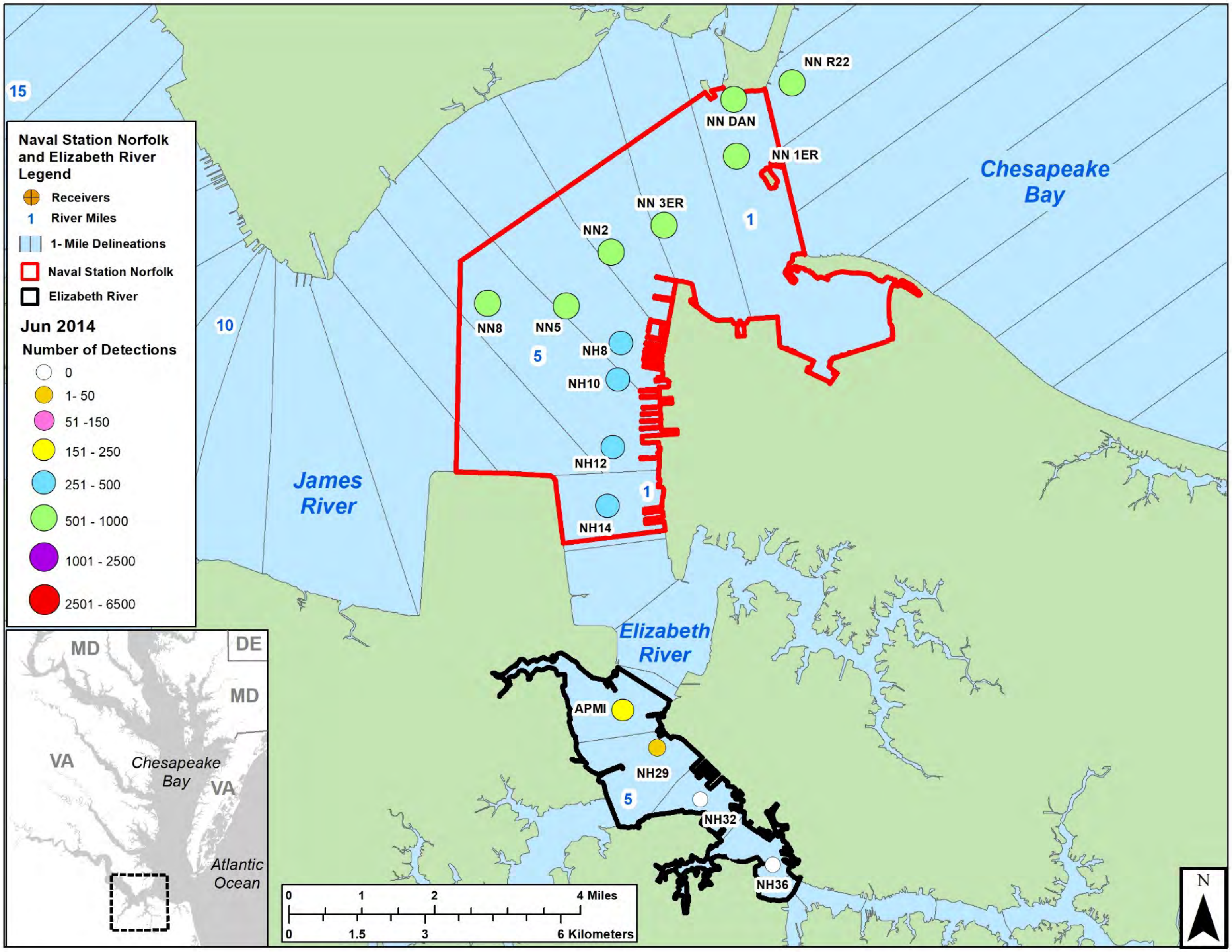
Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Jun 2014
Number of Detections
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Elizabeth River
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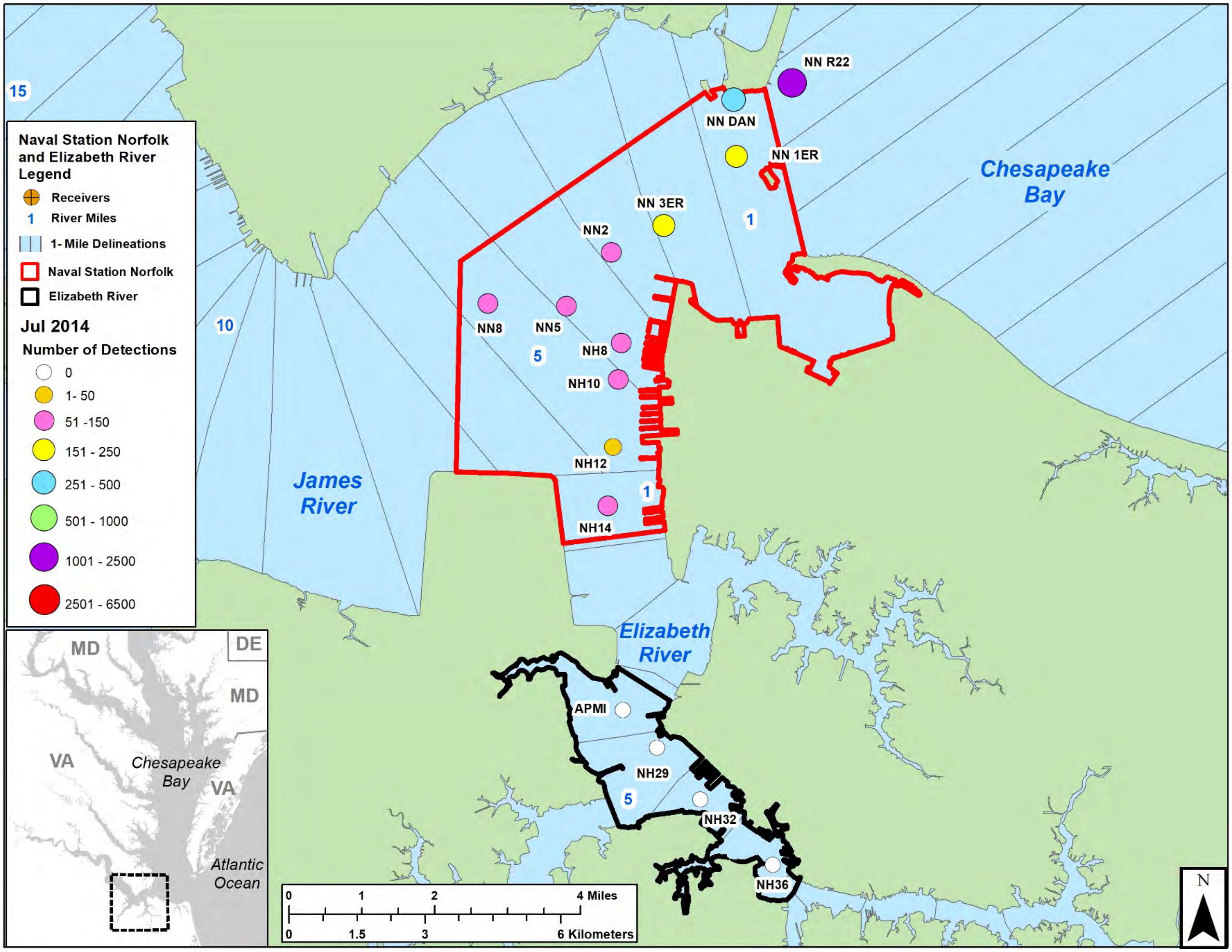
Naval Station Norfolk and Elizabeth River Legend
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Naval Station Norfolk
Elizabeth River
Jul 2014
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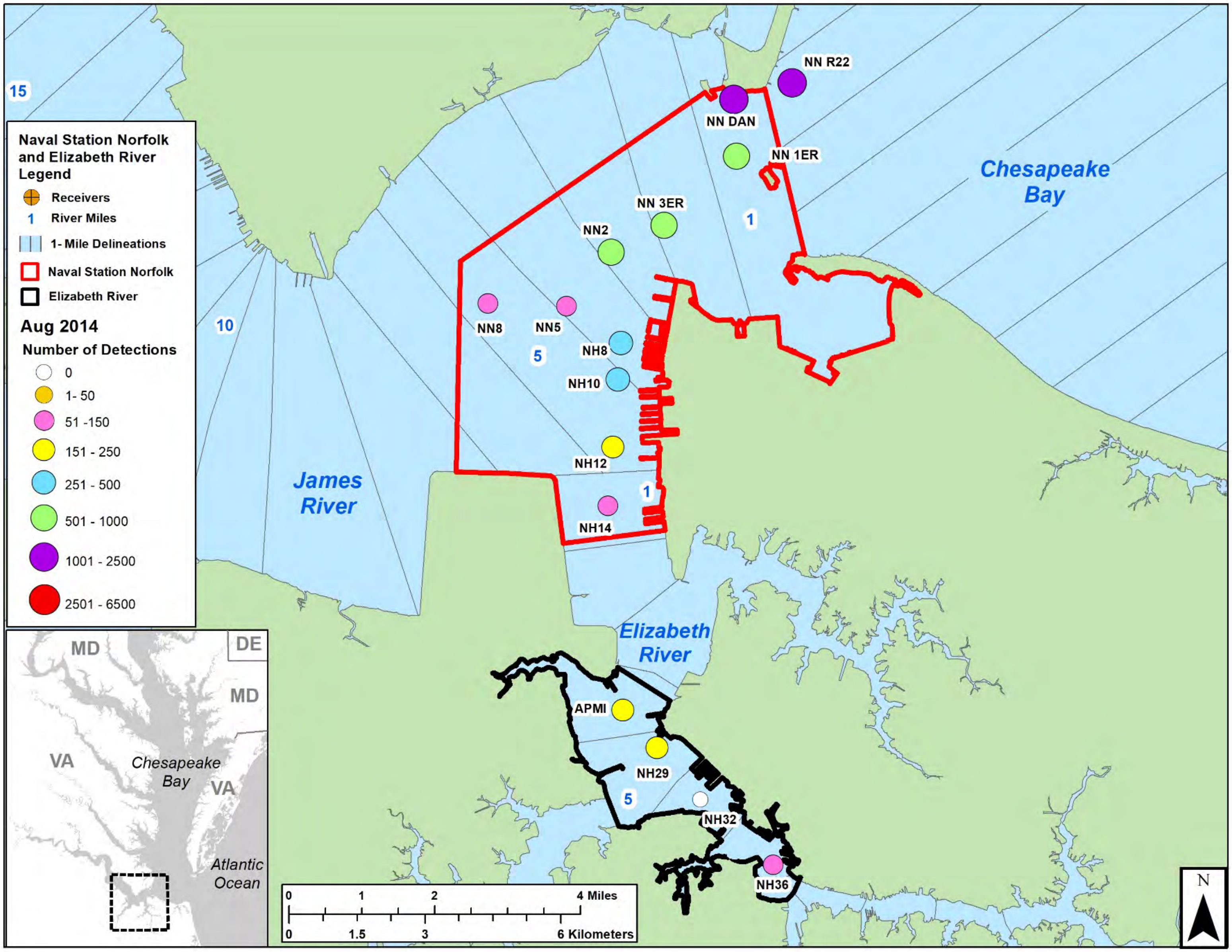
Naval Station Norfolk and Elizabeth River Legend
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1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Aug 2014
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Chesapeake Bay
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Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
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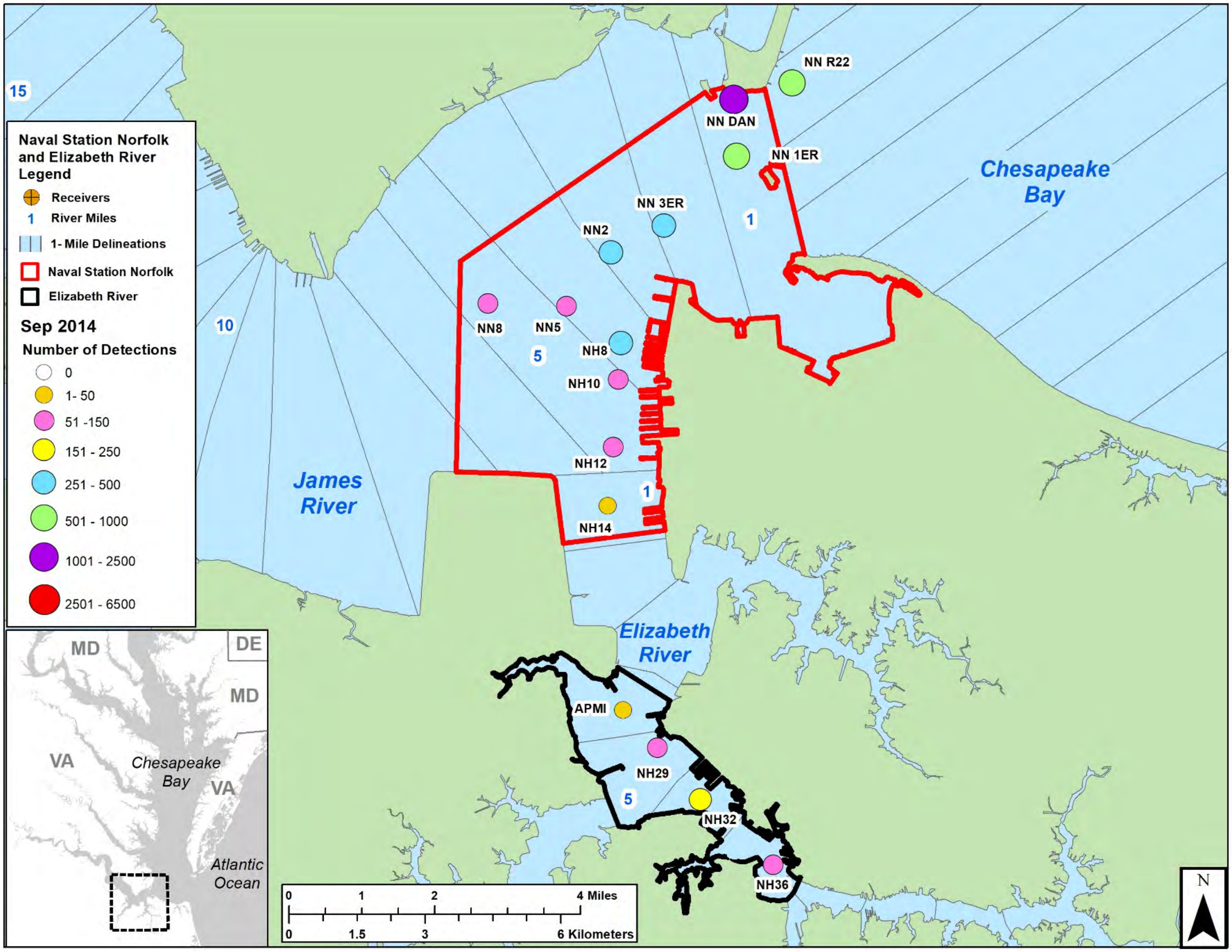
Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Sep 2014
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James River
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Elizabeth River
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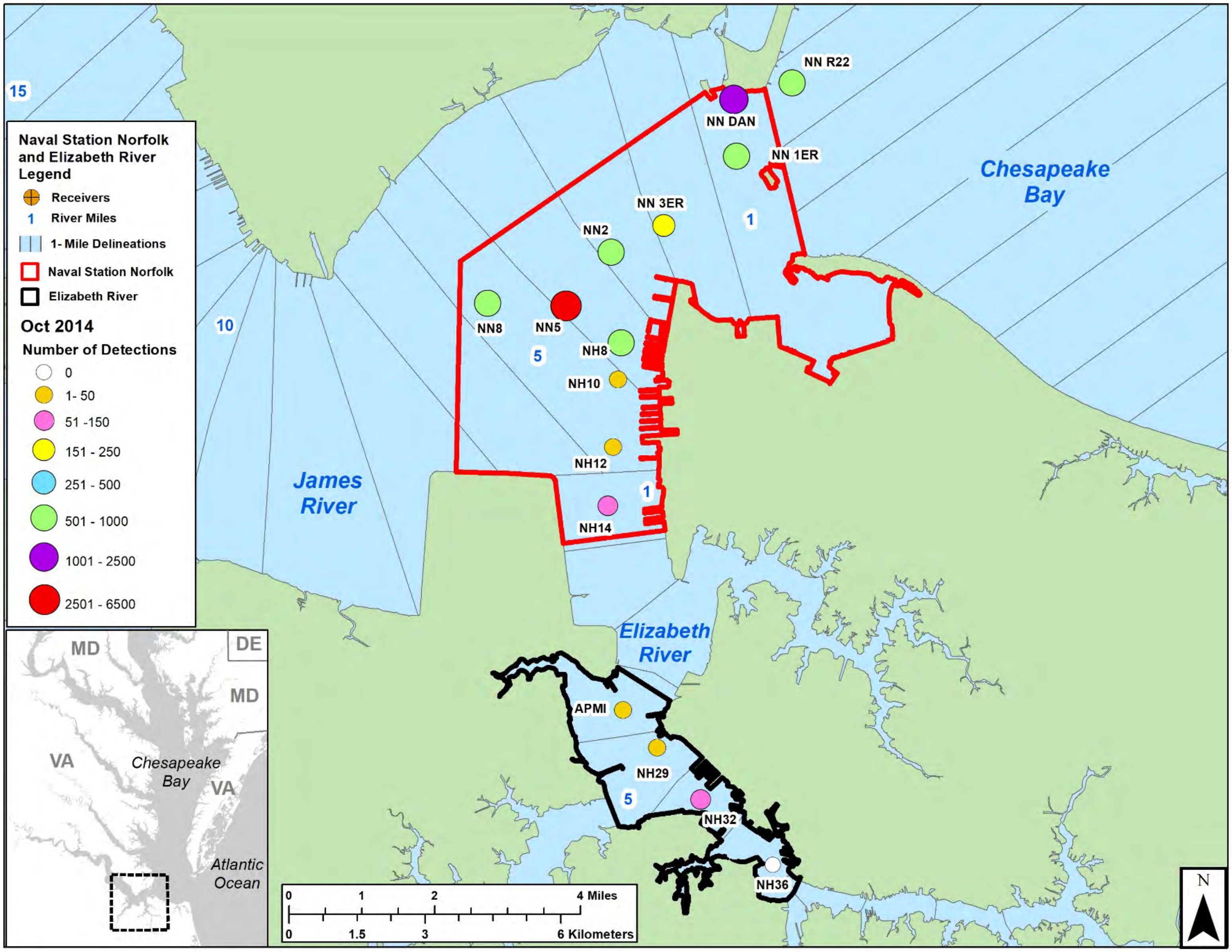
Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Oct 2014
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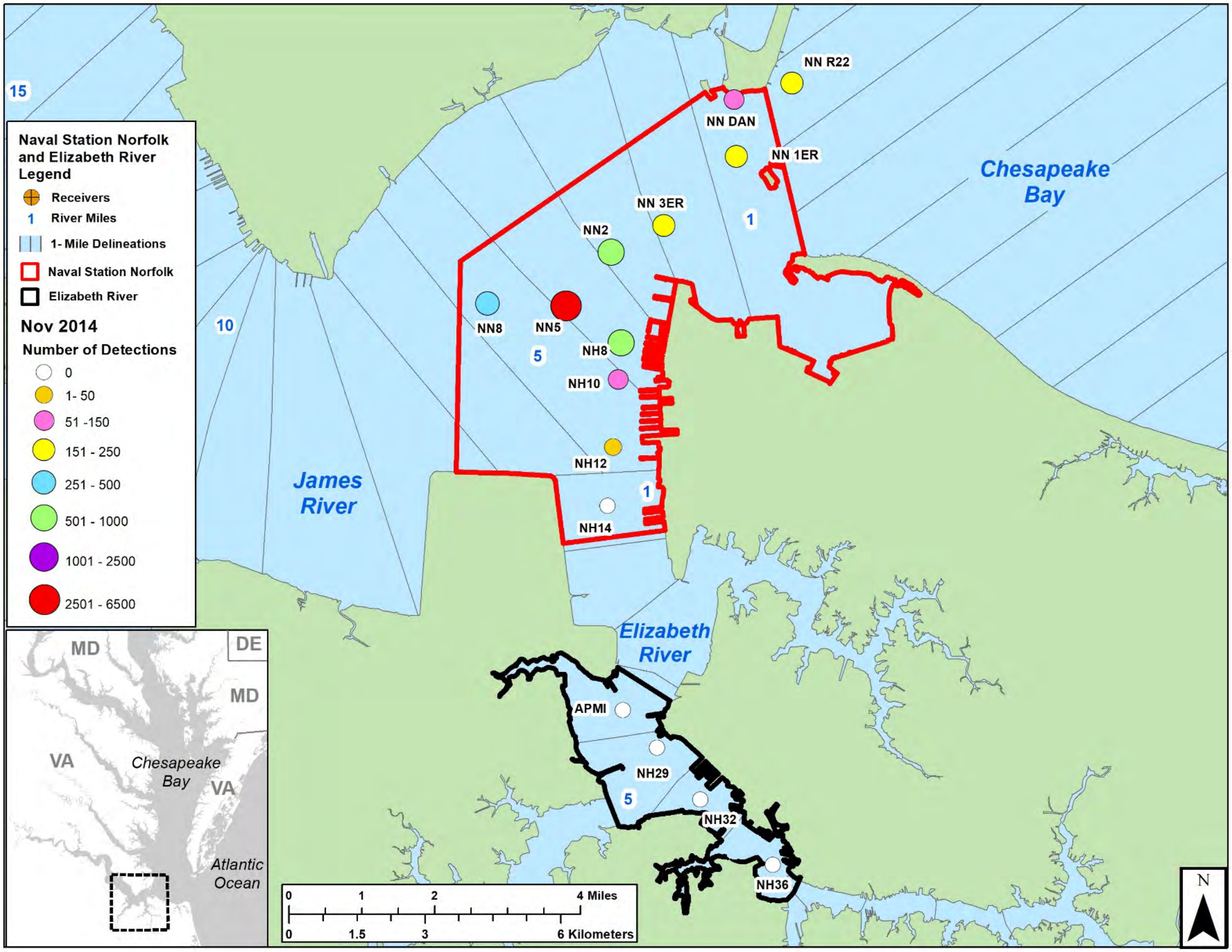
Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Nov 2014
Number of Detections
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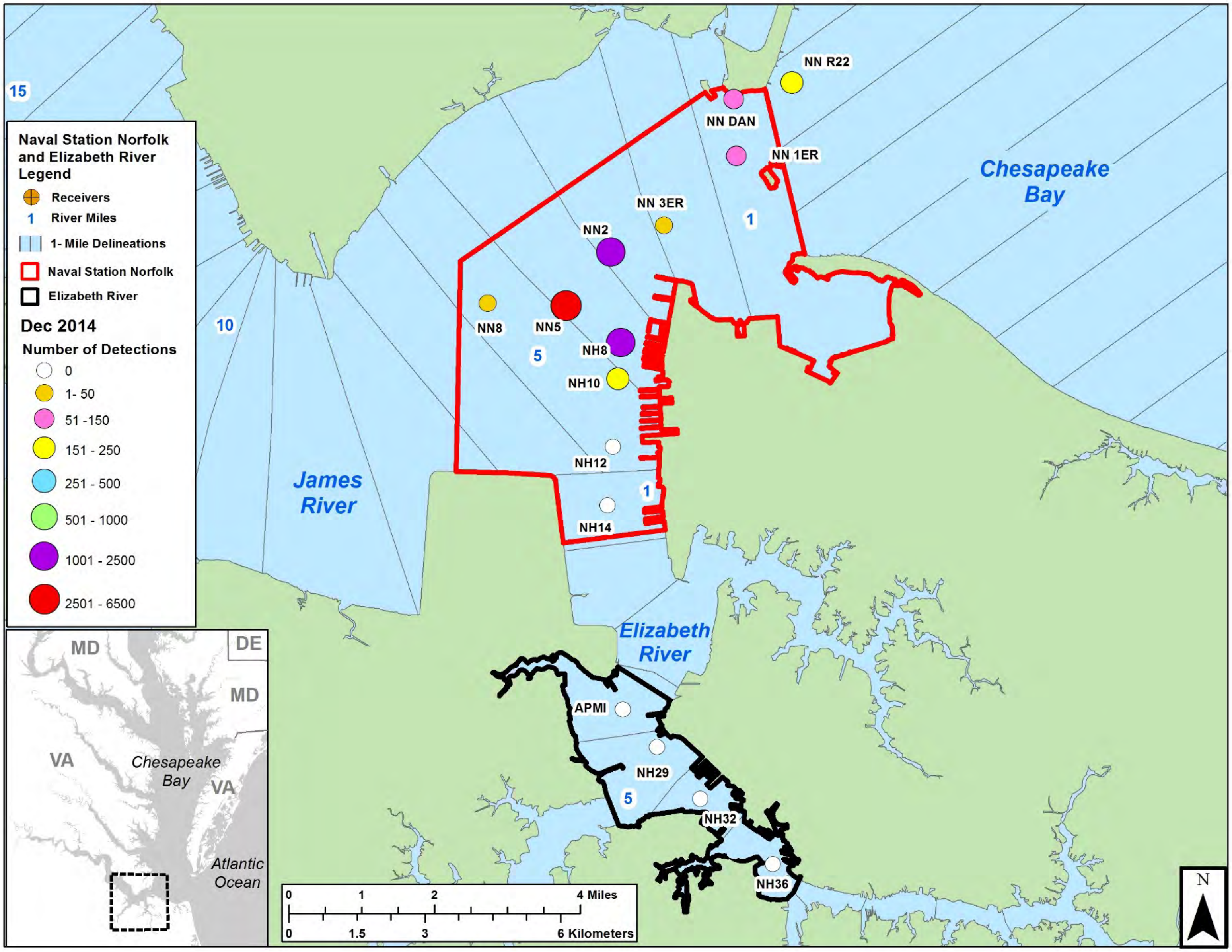
Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Dec 2014
Number of Detections
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2501 - 6500
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Atlantic Ocean
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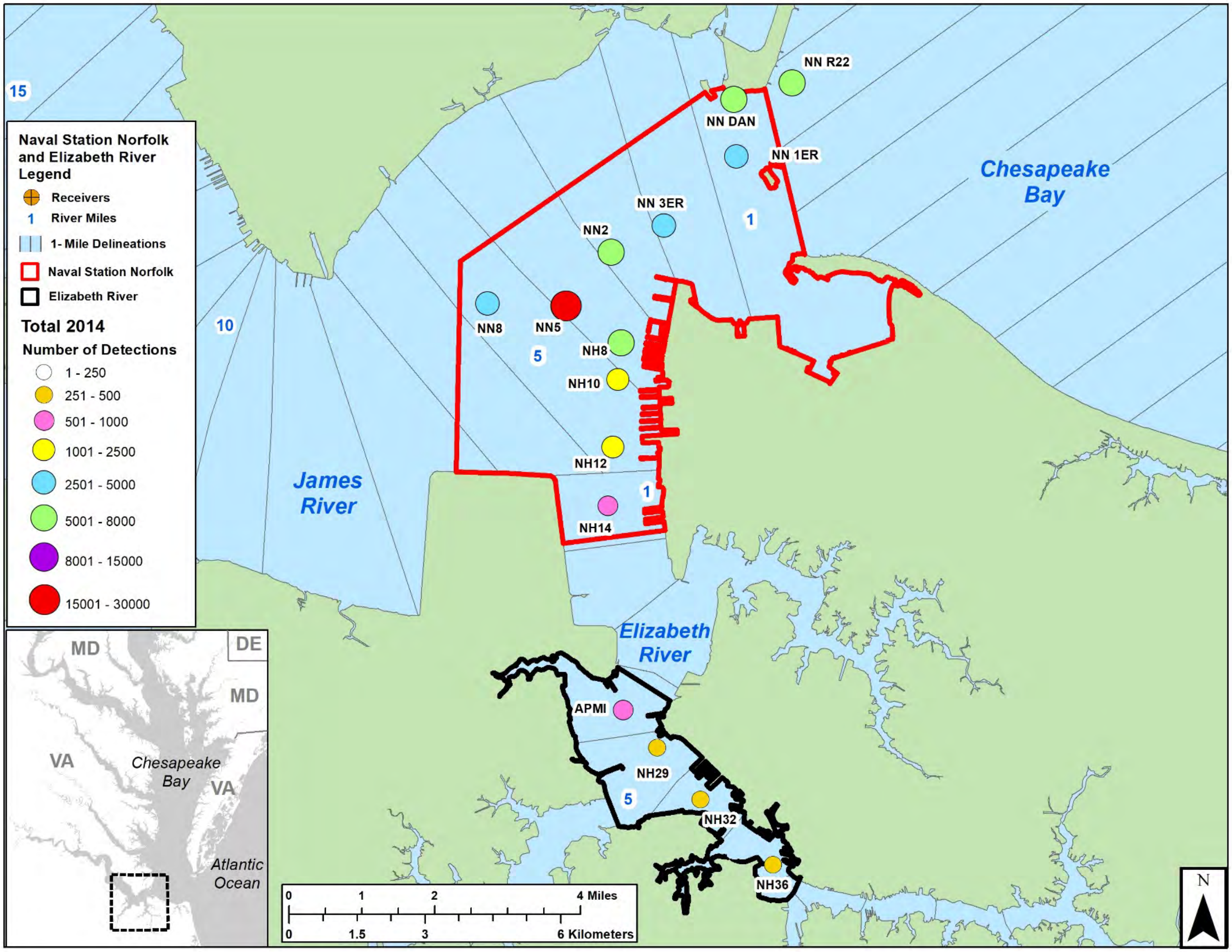
Naval Station Norfolk and Elizabeth River Legend
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Naval Station Norfolk
Elizabeth River
Total 2014
Number of Detections
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1001 - 2500
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5001 - 8000
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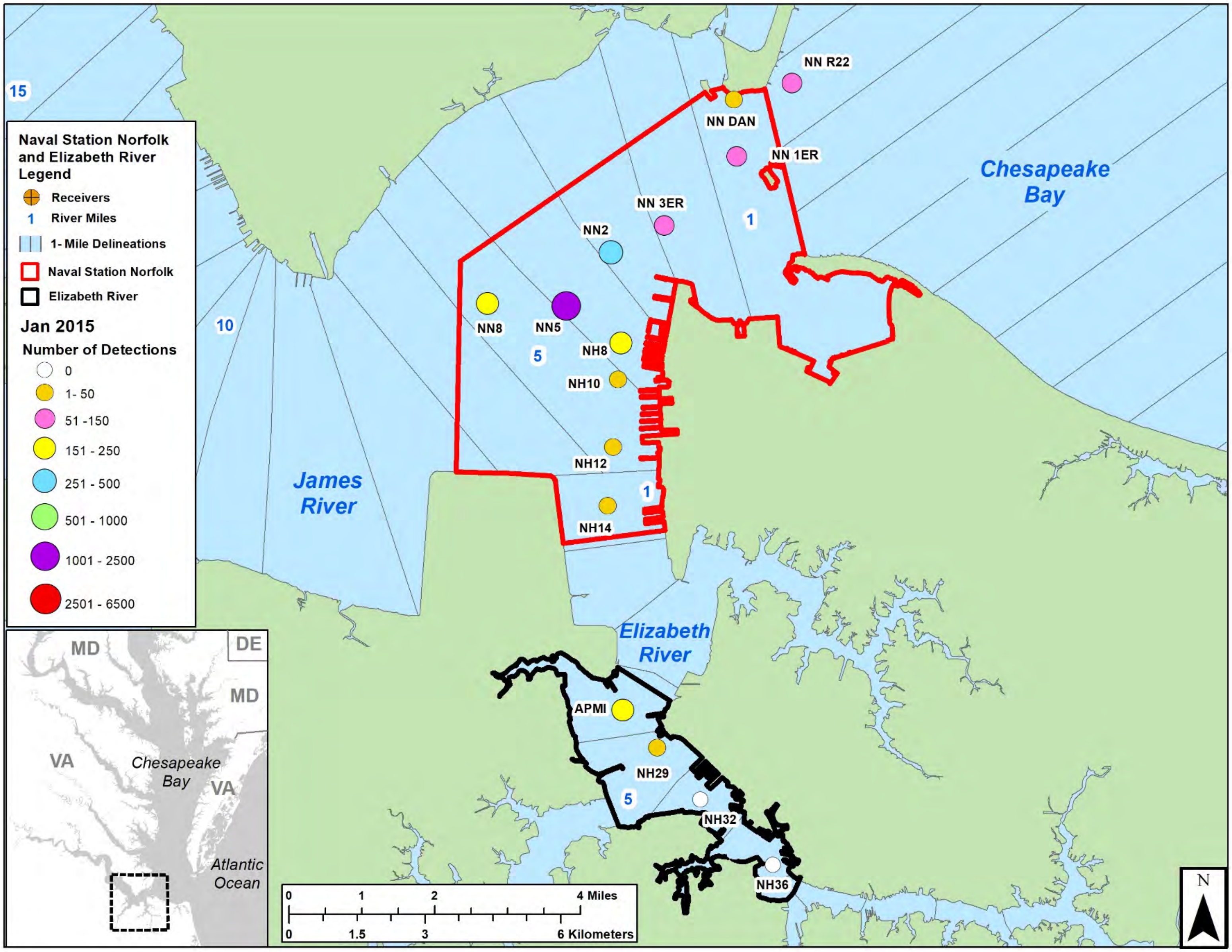
Naval Station Norfolk and Elizabeth River Legend
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River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Jan 2015
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James River
Chesapeake Bay
Elizabeth River
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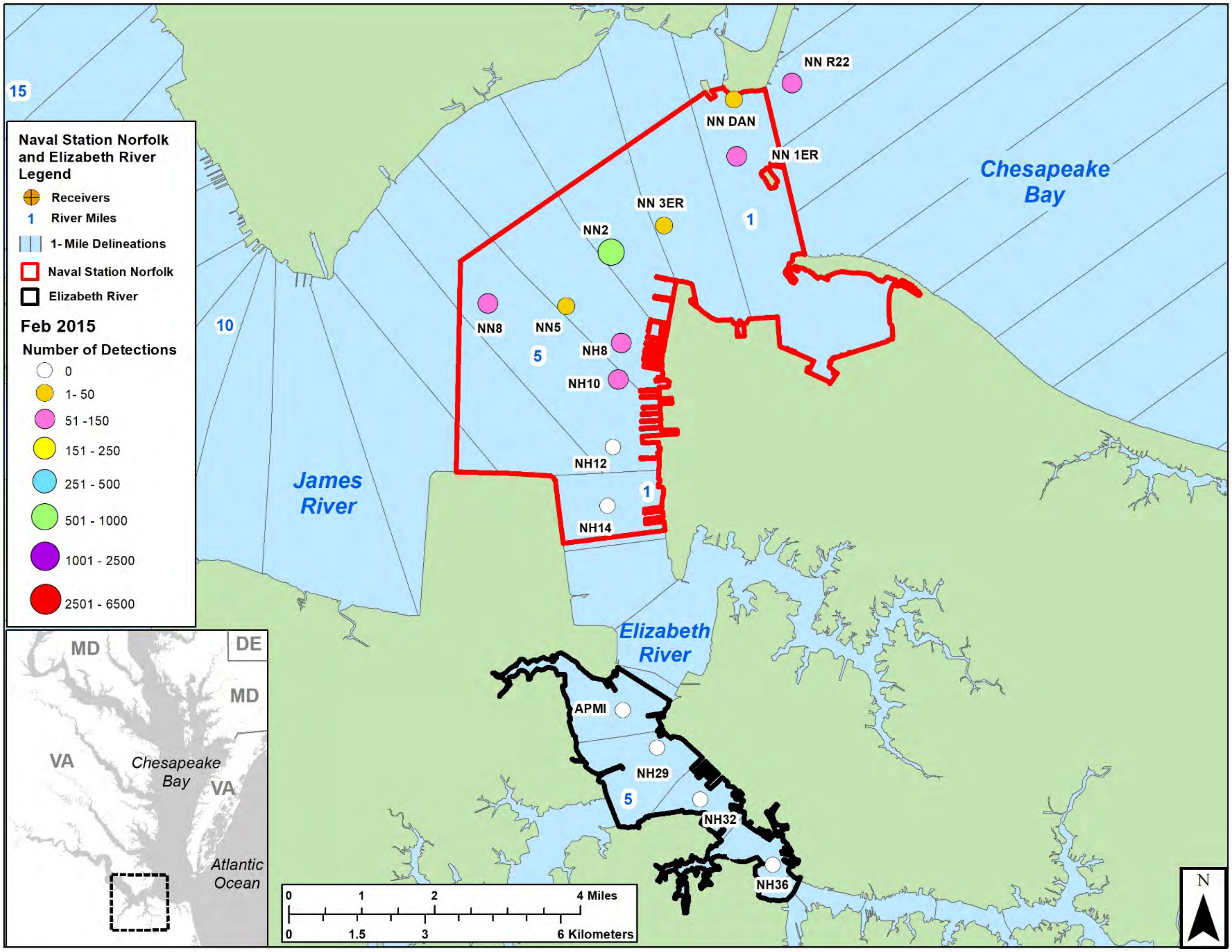
Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Feb 2015
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James River
Chesapeake Bay
Elizabeth River
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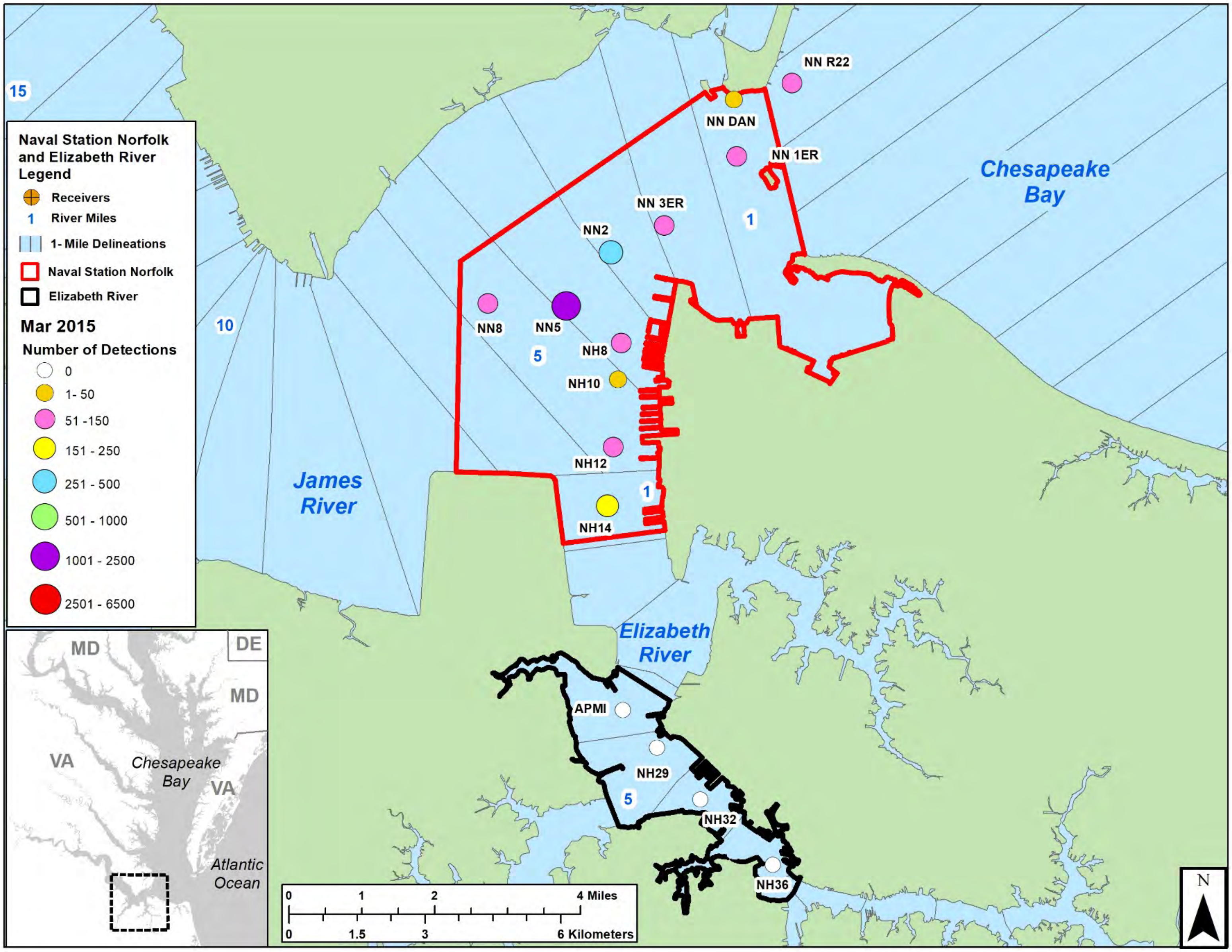
Naval Station Norfolk and Elizabeth River Legend
Receivers
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Naval Station Norfolk
Elizabeth River
Mar 2015
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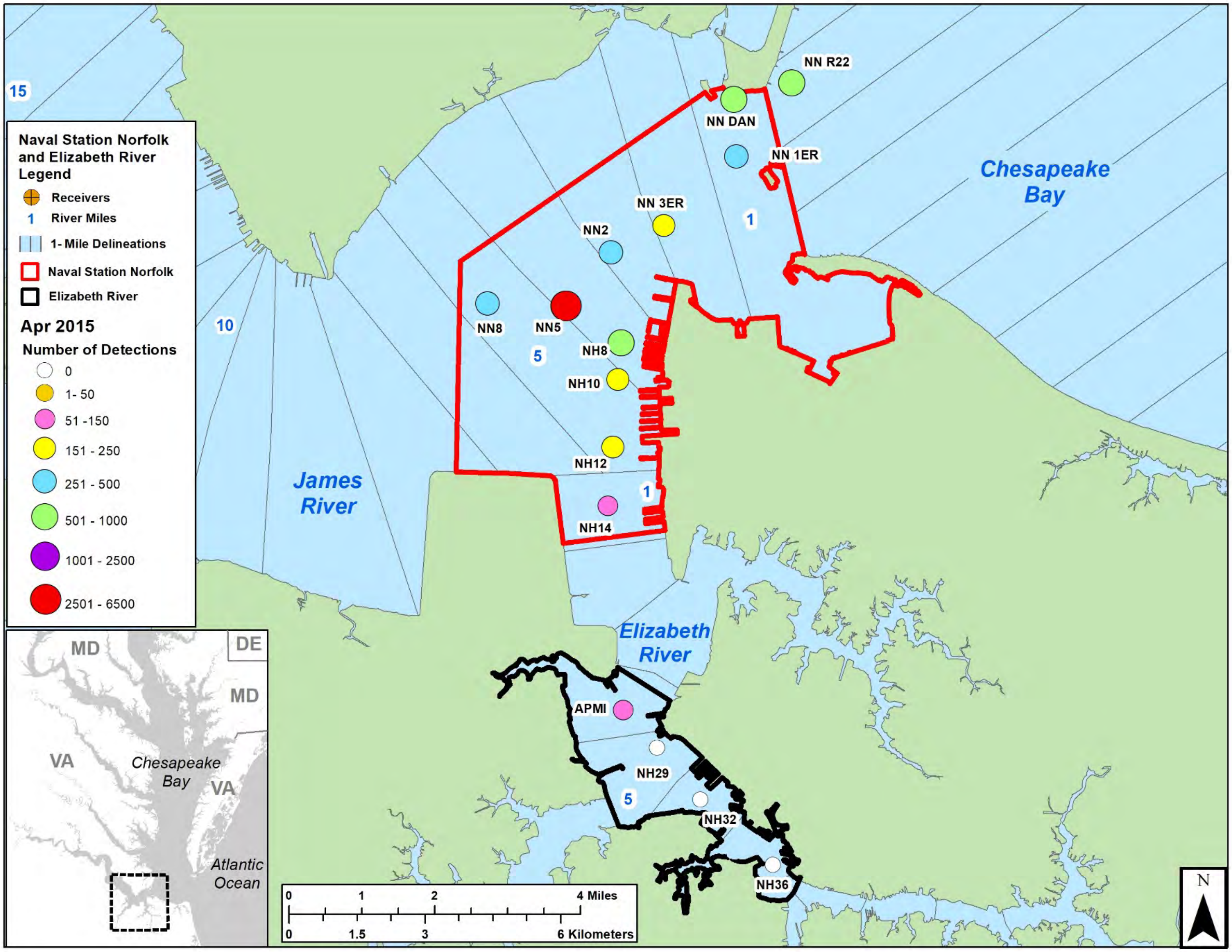
Naval Station Norfolk and Elizabeth River Legend
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Naval Station Norfolk
Elizabeth River
Apr 2015
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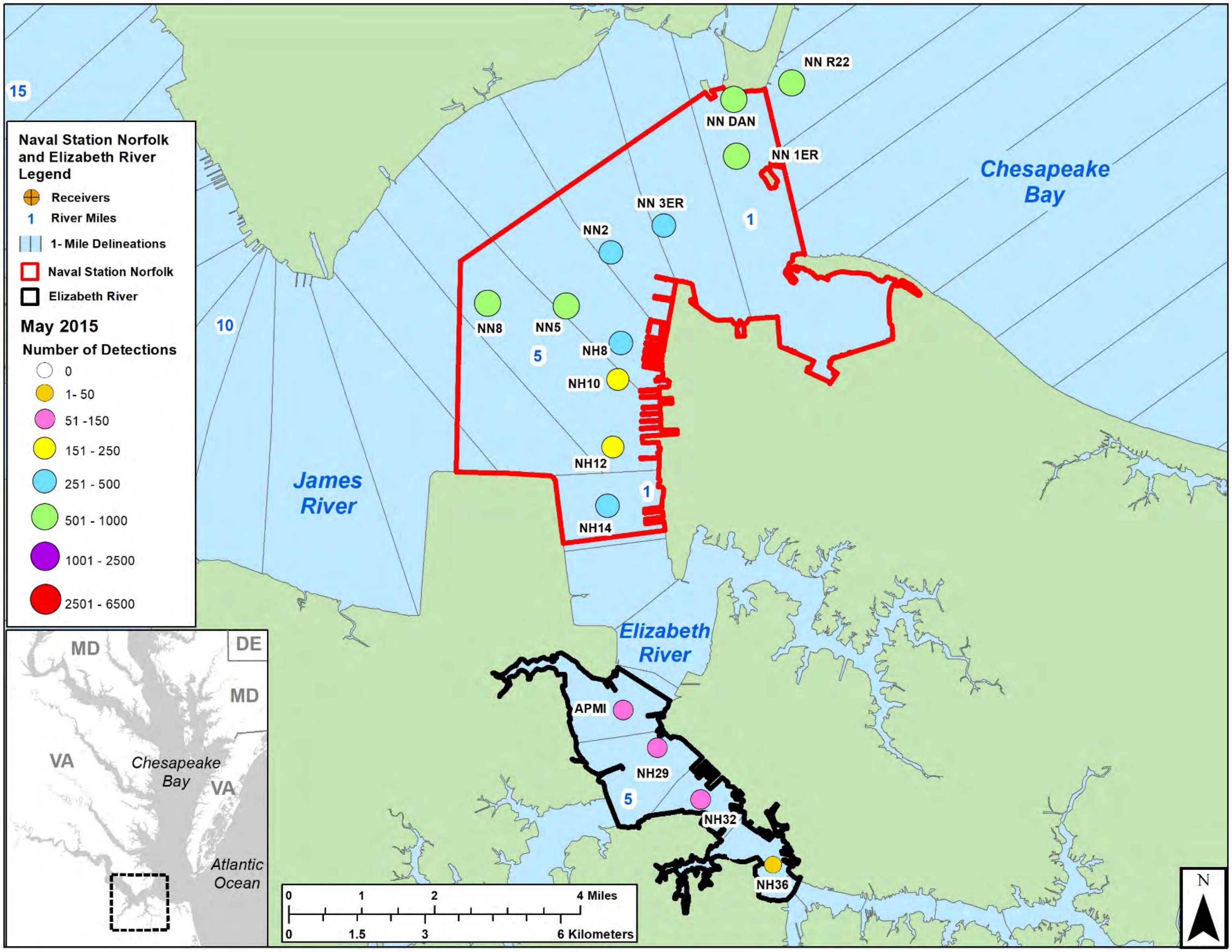
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Naval Station Norfolk and Elizabeth River Legend
Receivers
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1- Mile Delineations
Naval Station Norfolk
Elizabeth River
May 2015
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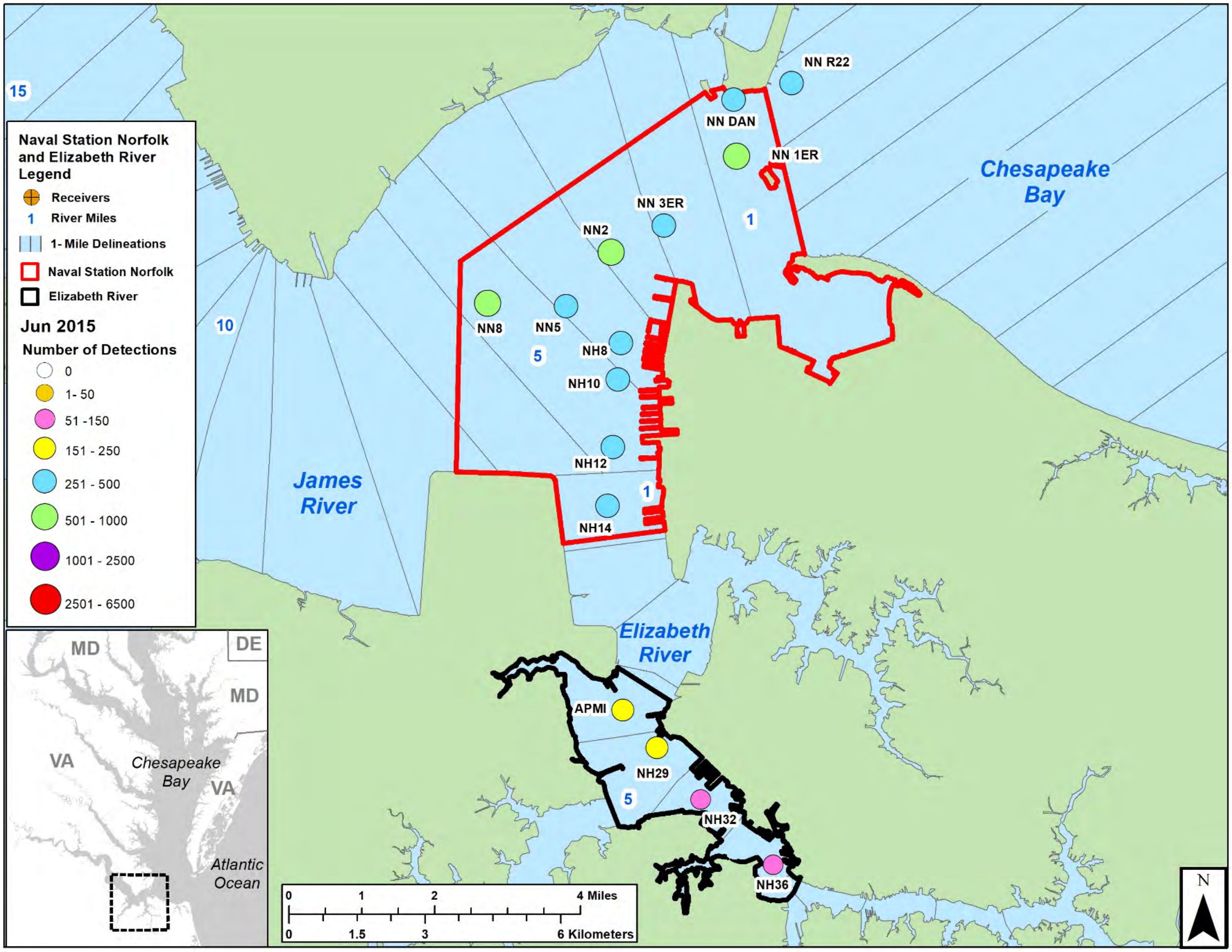
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Naval Station Norfolk and Elizabeth River Legend
Receivers
River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Jun 2015
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Atlantic Ocean
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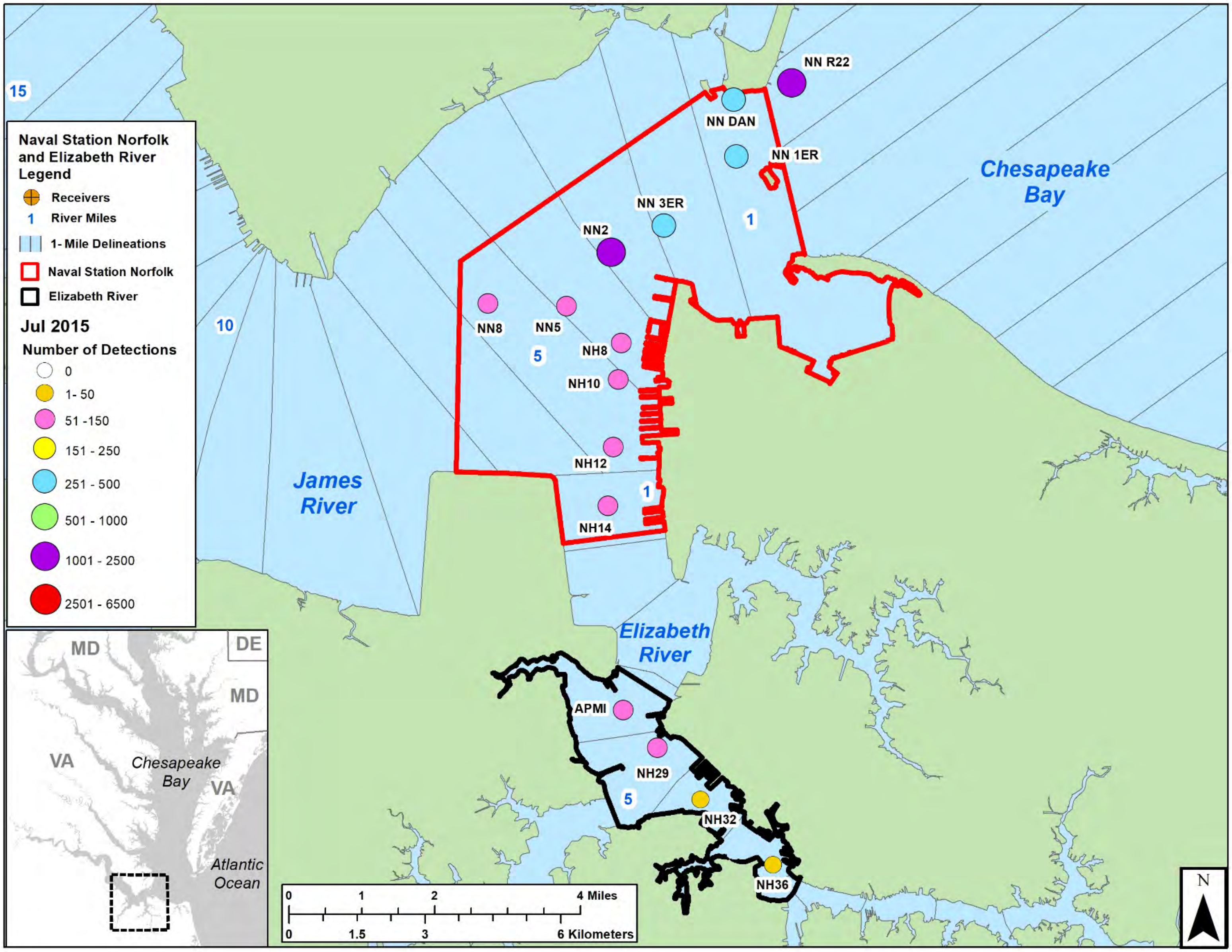

Naval Station Norfolk and Elizabeth River Legend
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1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Jul 2015
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Chesapeake Bay
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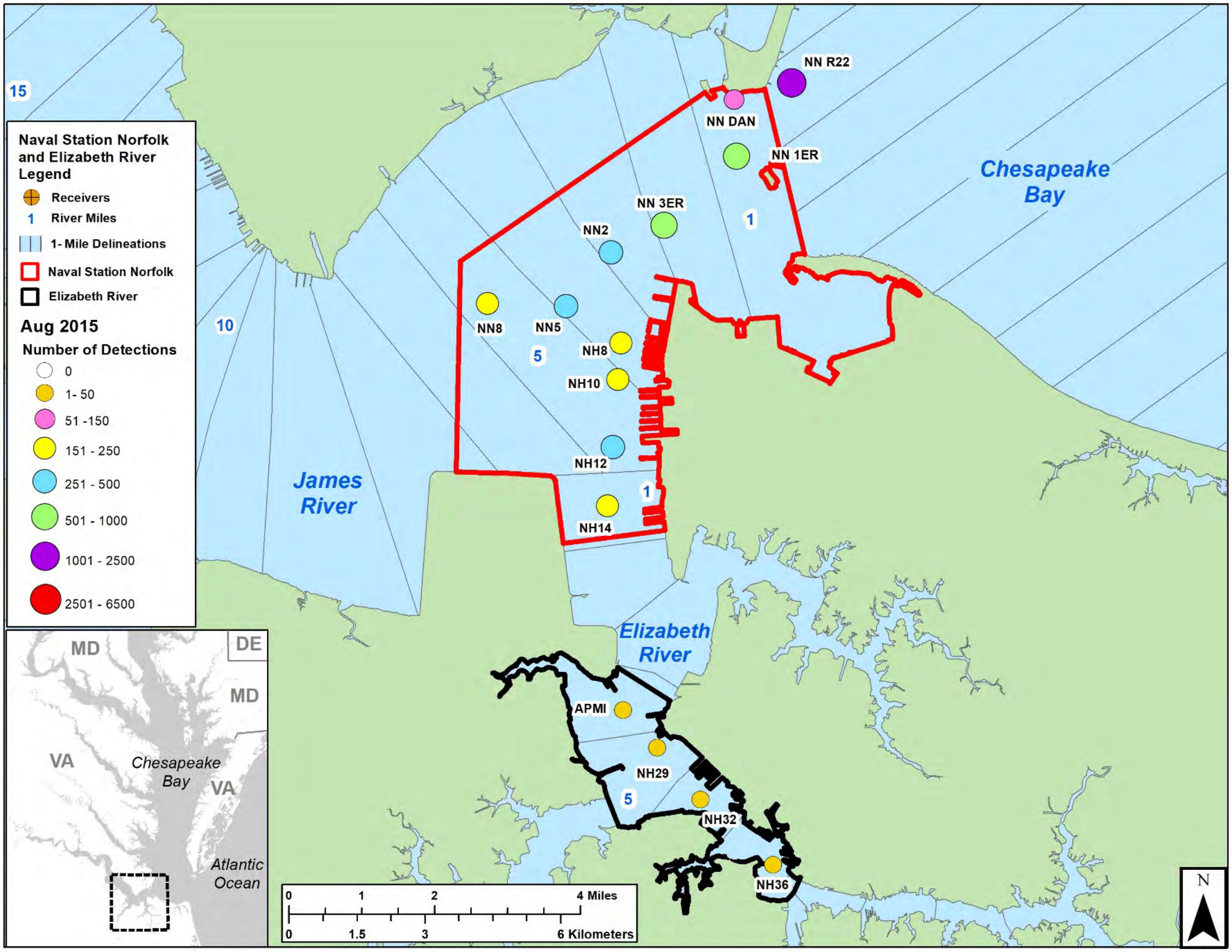
Naval Station Norfolk and Elizabeth River Legend
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River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Aug 2015
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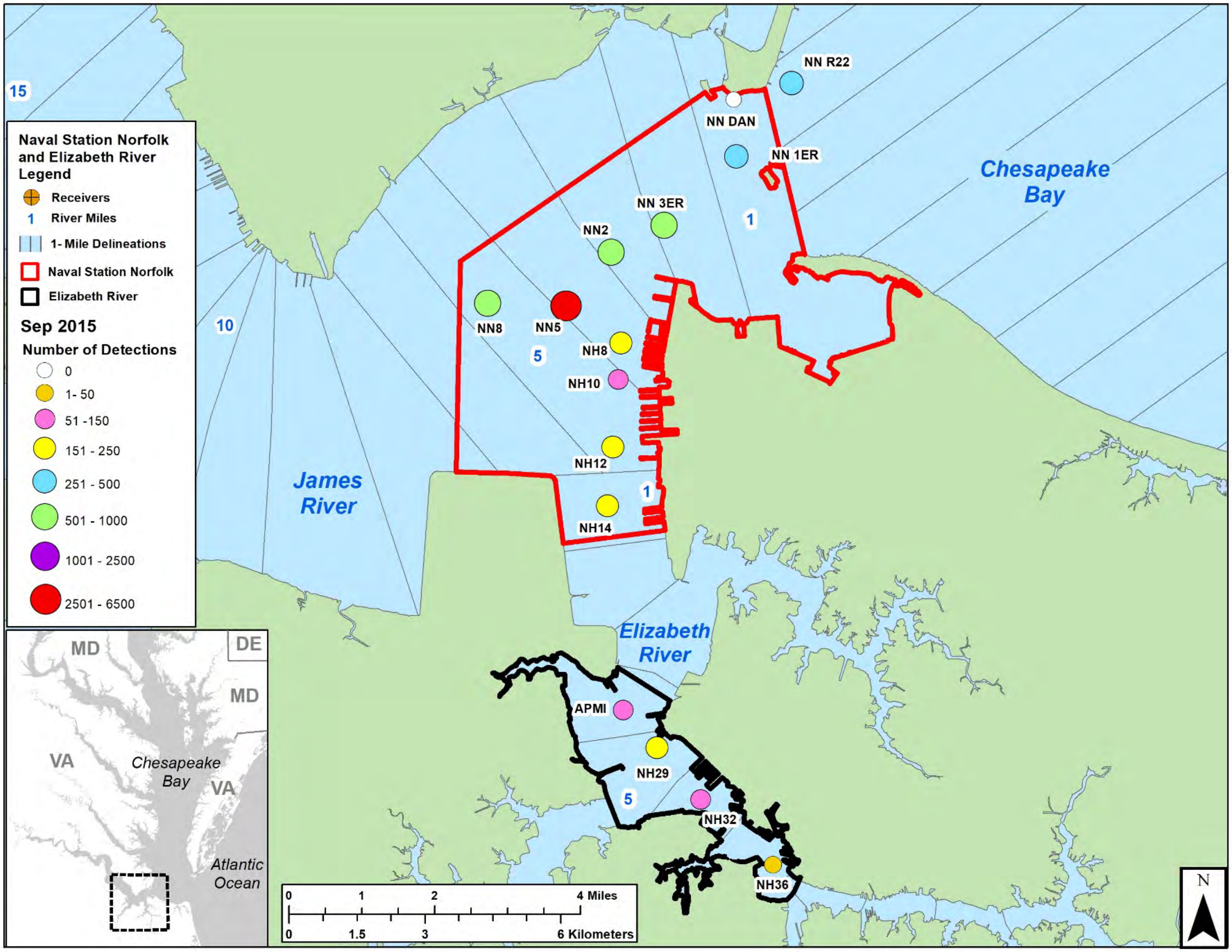
Naval Station Norfolk and Elizabeth River Legend
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Naval Station Norfolk
Elizabeth River
Sep 2015
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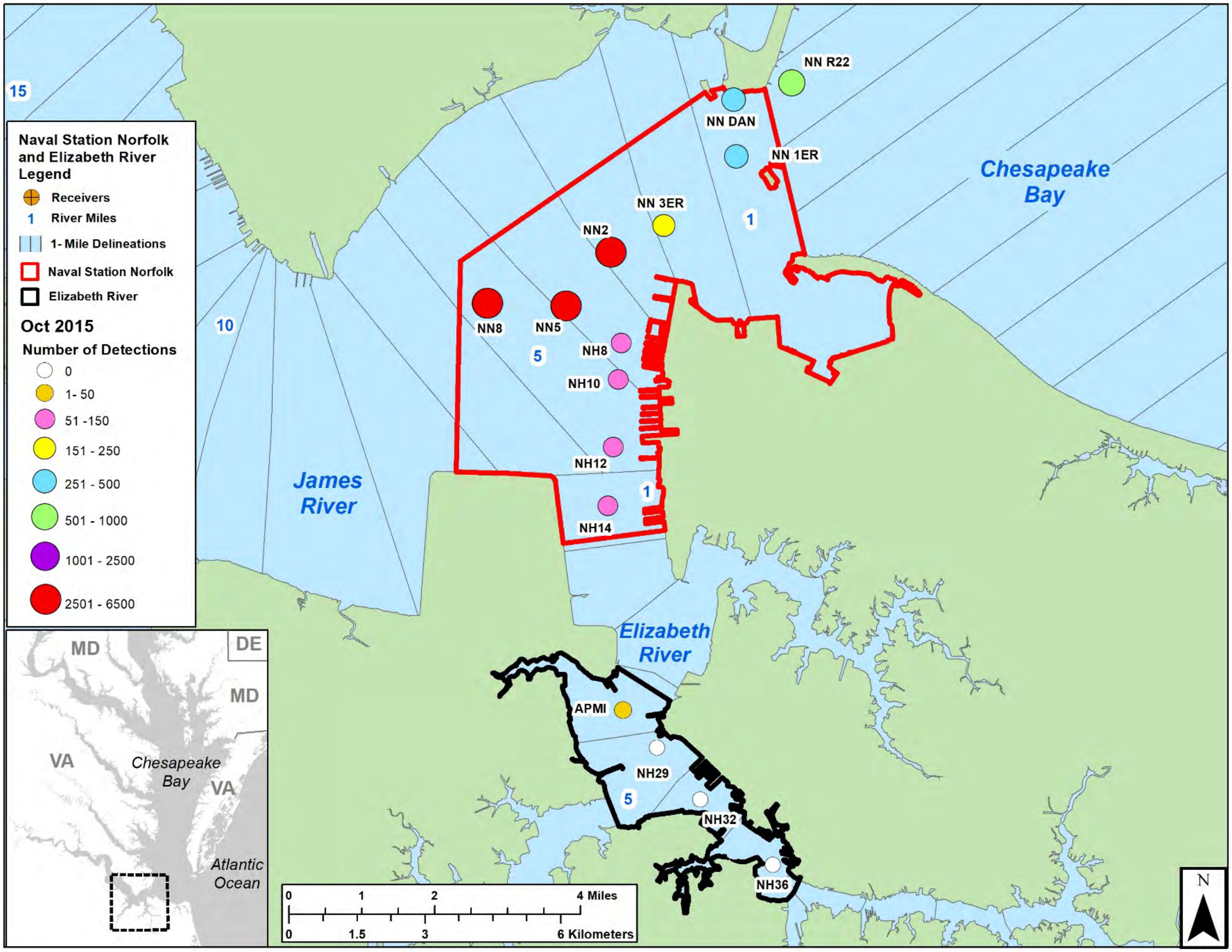
Naval Station Norfolk and Elizabeth River Legend
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Naval Station Norfolk
Elizabeth River
Oct 2015
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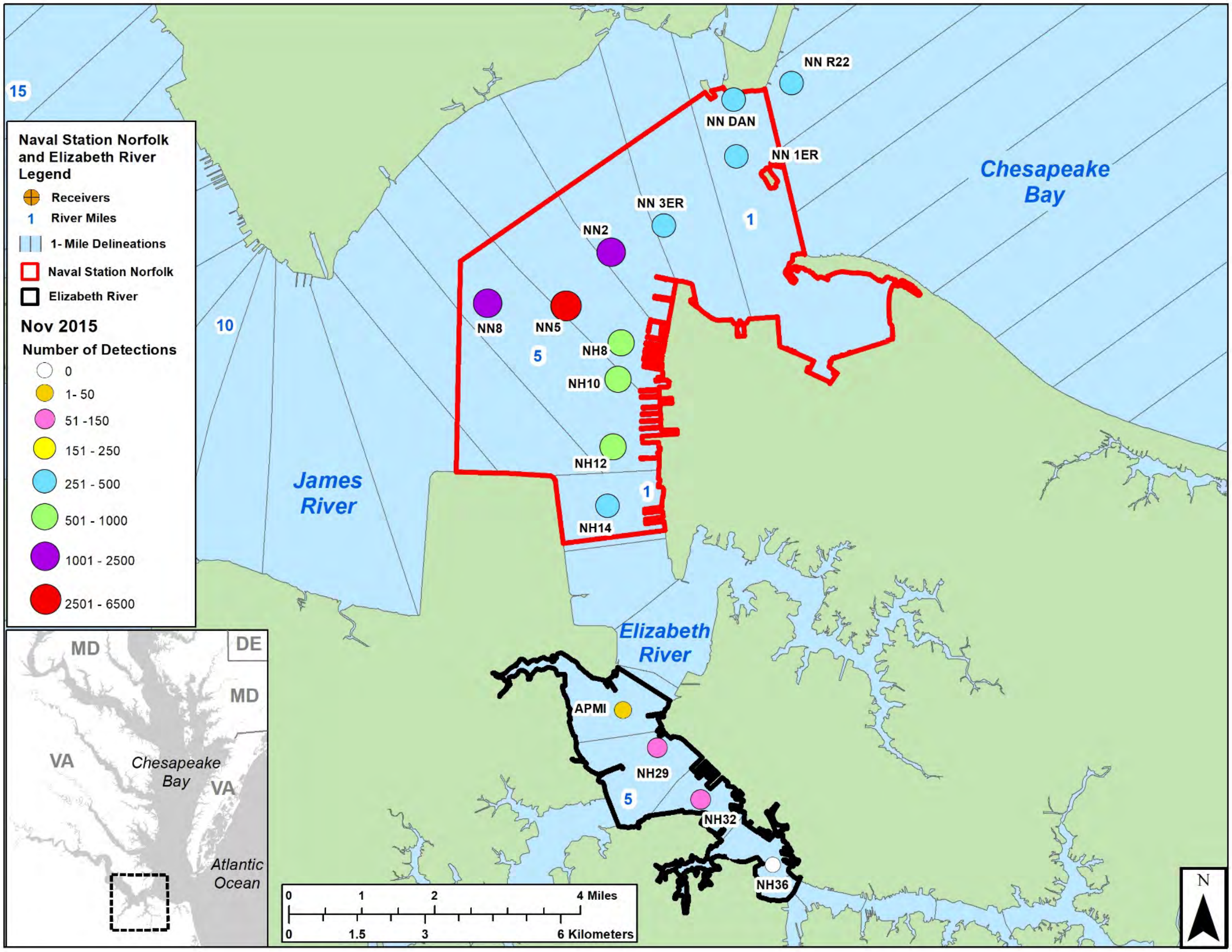
Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Nov 2015
Number of Detections
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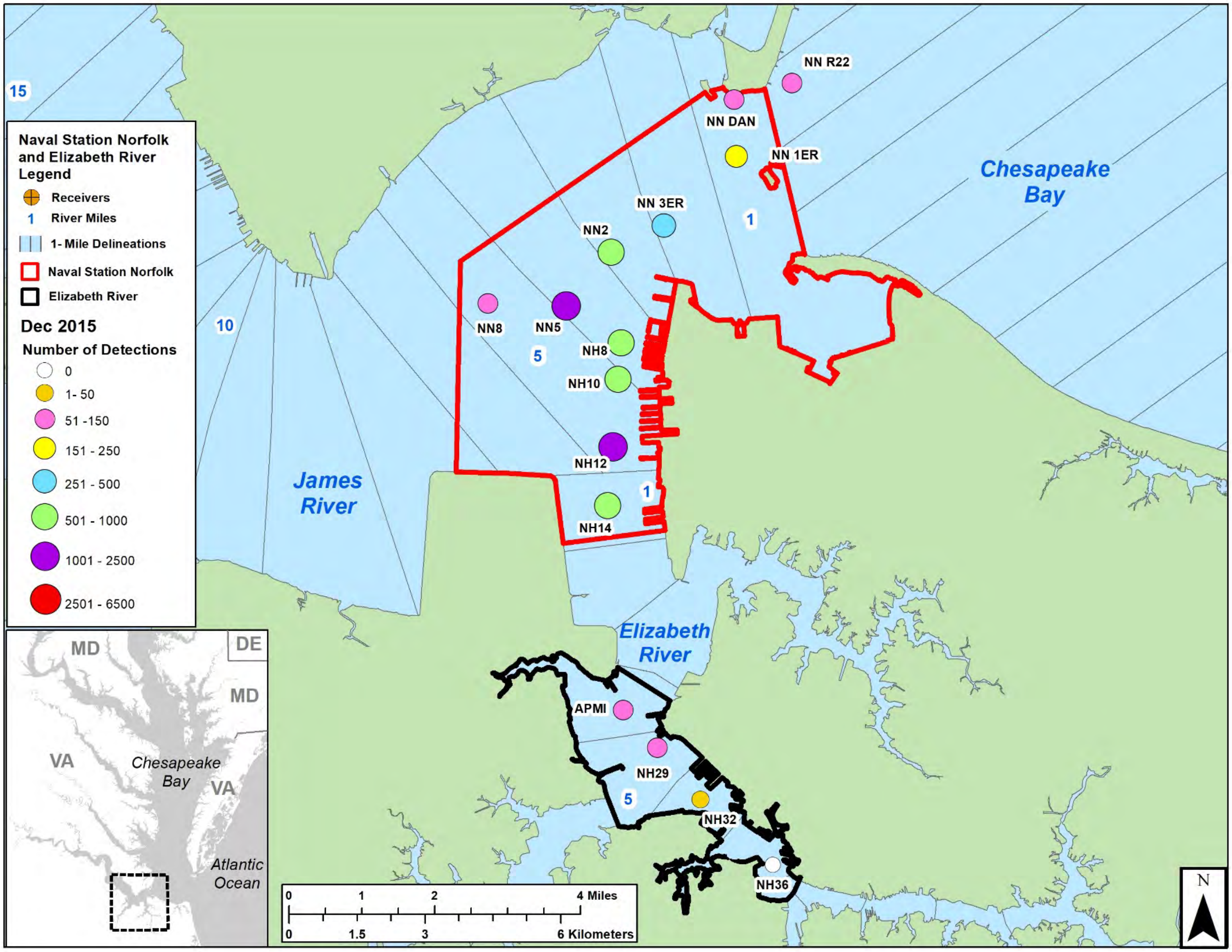
Naval Station Norfolk and Elizabeth River Legend
Receivers
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1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Dec 2015
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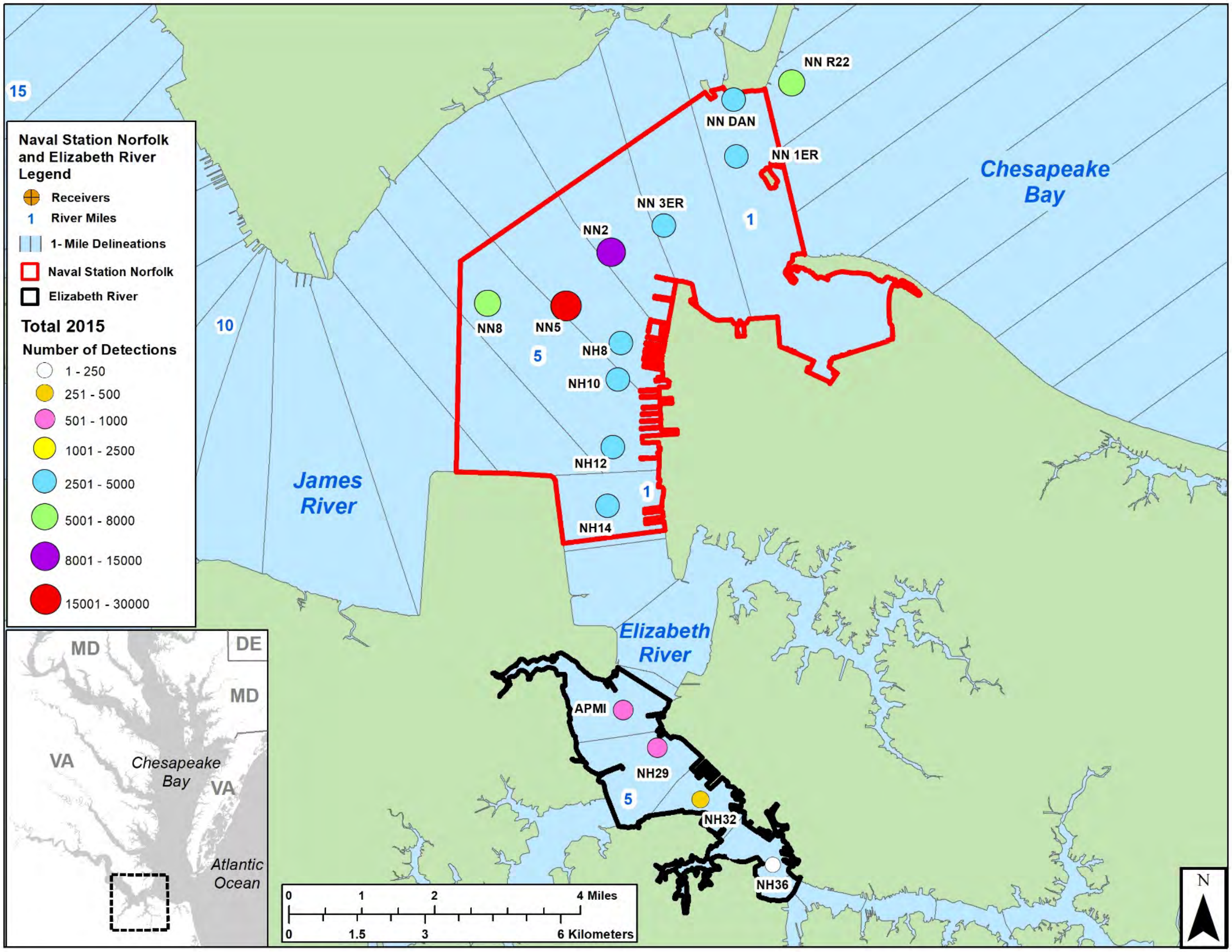
Naval Station Norfolk and Elizabeth River Legend
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1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Total 2015
Number of Detections
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251 - 500
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1001 - 2500
2501 - 5000
5001 - 8000
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James River
Chesapeake Bay
Elizabeth River
NN R22
NN DAN
NN 1ER
NN 3ER
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NN8
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NH10
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NH14
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Atlantic Ocean
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0 1.5 3 6 Kilometers
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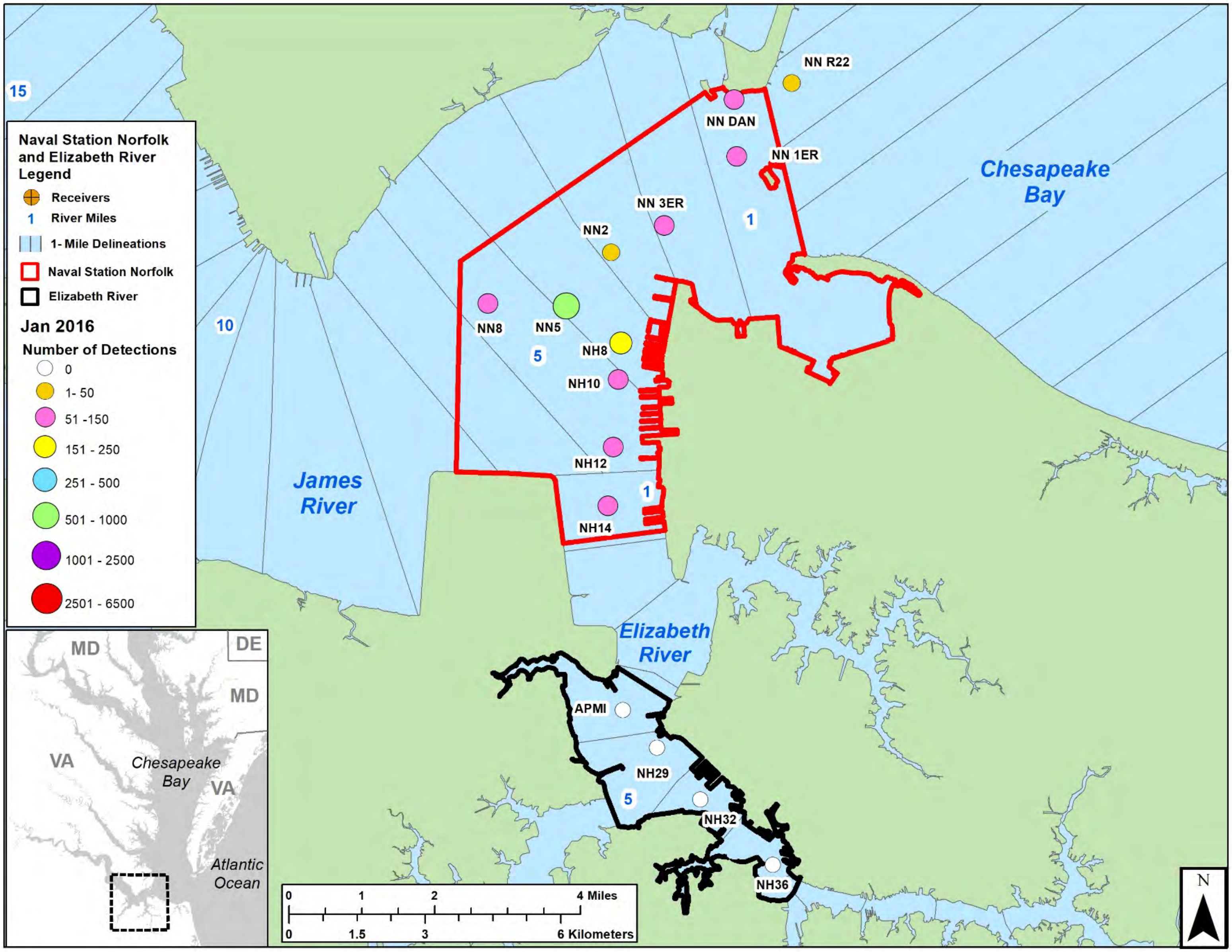
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Naval Station Norfolk and Elizabeth River Legend
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1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Jan 2016
Number of Detections
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NN R22
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NN 1ER
NN 3ER
NN2
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NH14
Chesapeake Bay
Elizabeth River
APMI
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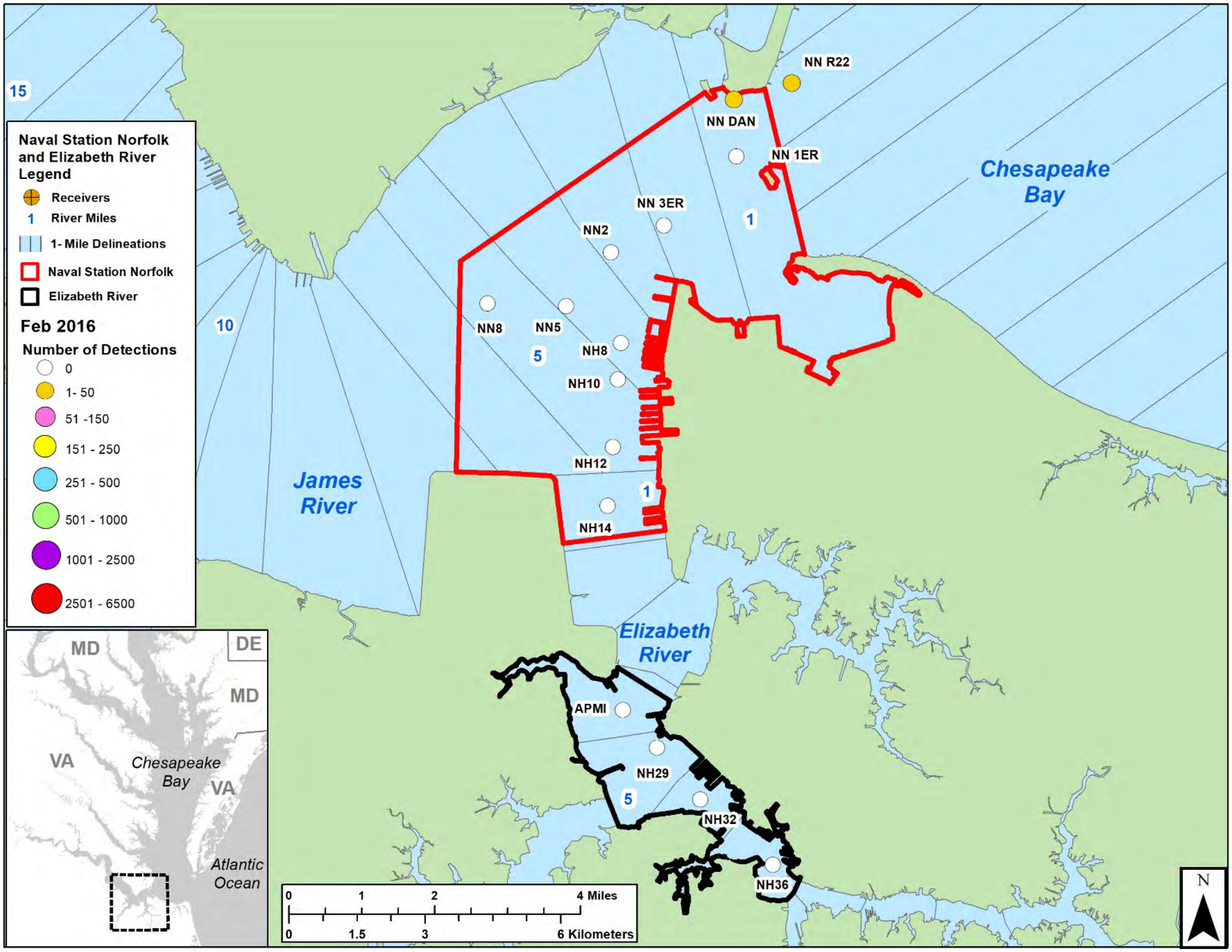
Naval Station Norfolk and Elizabeth River Legend
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1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Feb 2016
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VA
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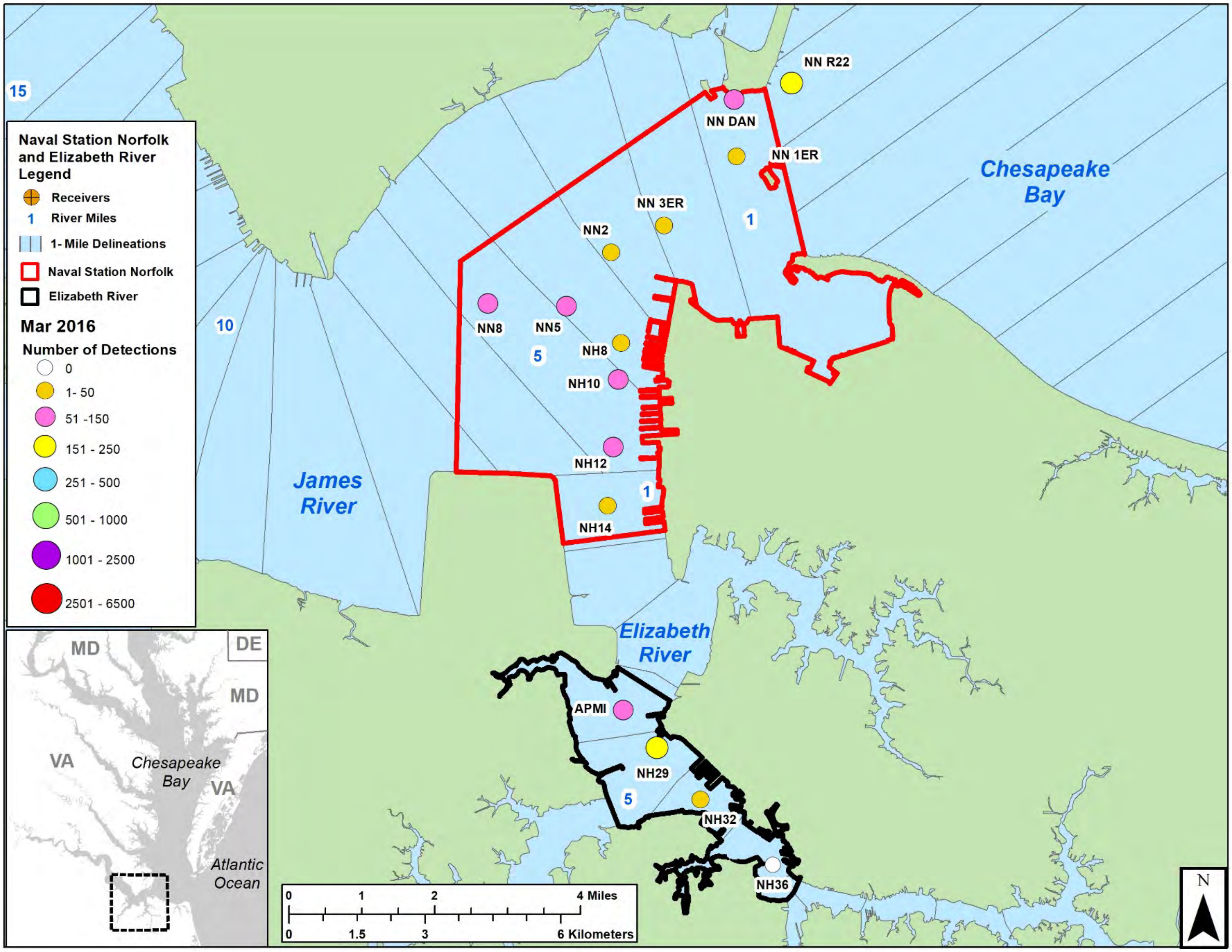
Naval Station Norfolk and Elizabeth River Legend
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1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Mar 2016
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Chesapeake Bay
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Atlantic Ocean
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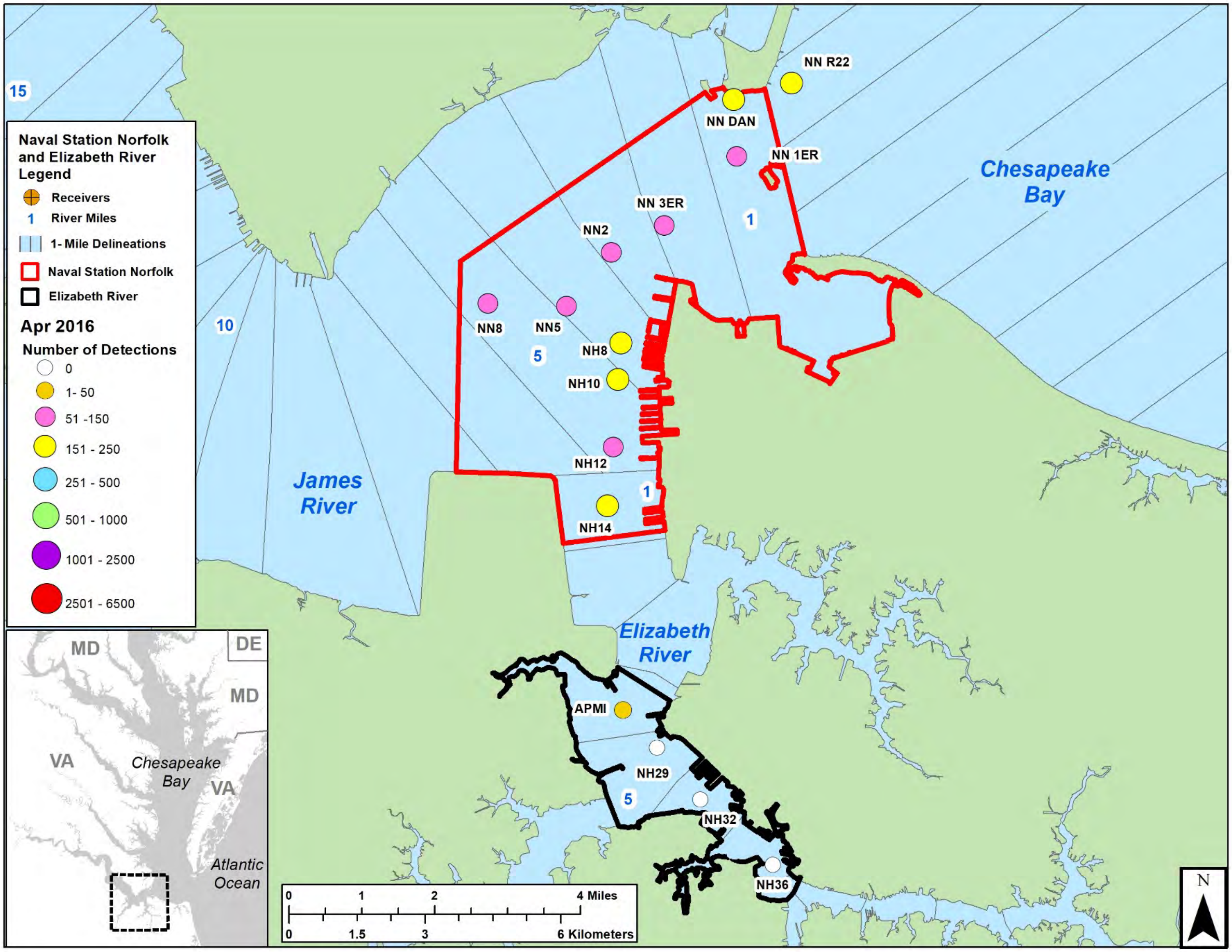
Naval Station Norfolk and Elizabeth River Legend
Receivers
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1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Apr 2016
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Elizabeth River
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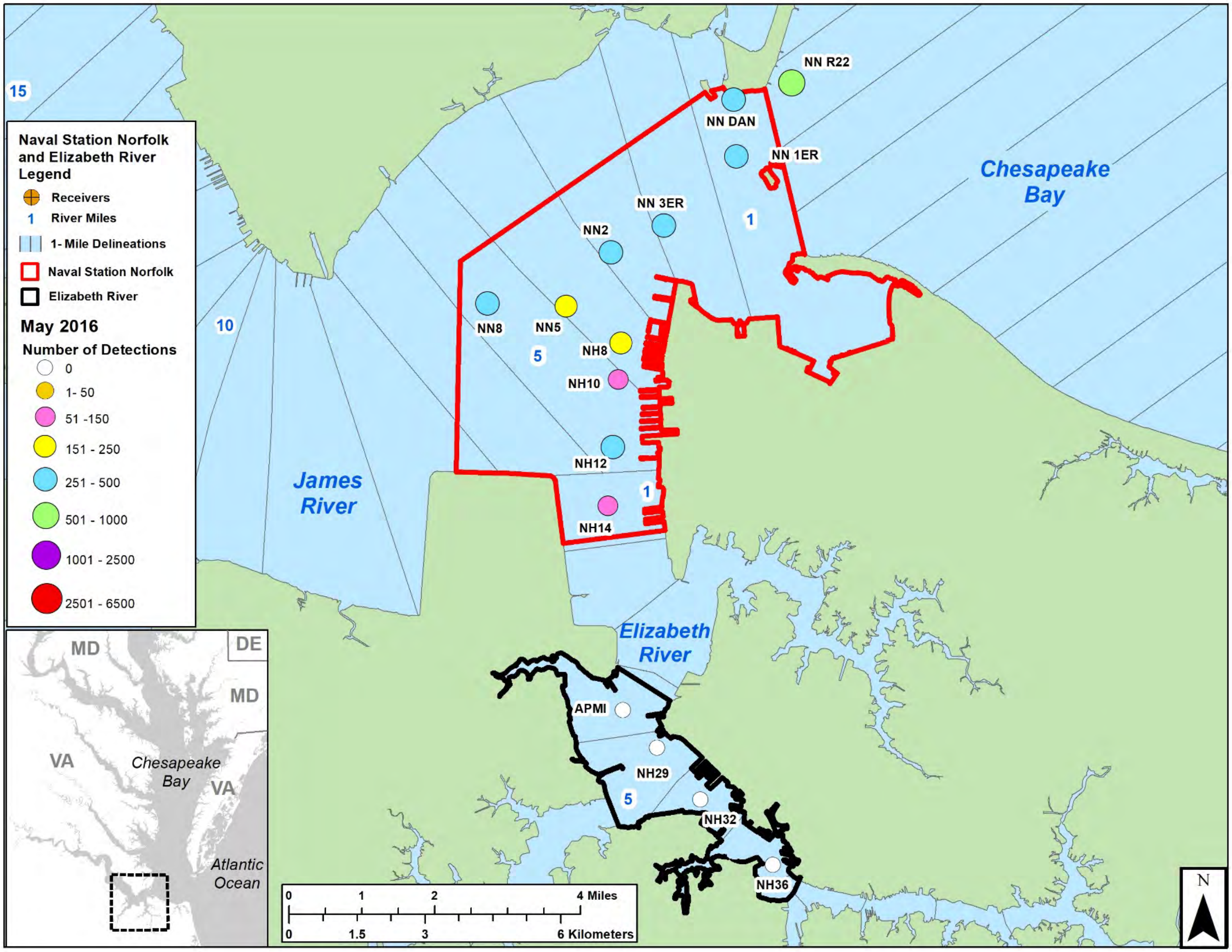
Naval Station Norfolk and Elizabeth River Legend
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1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
May 2016
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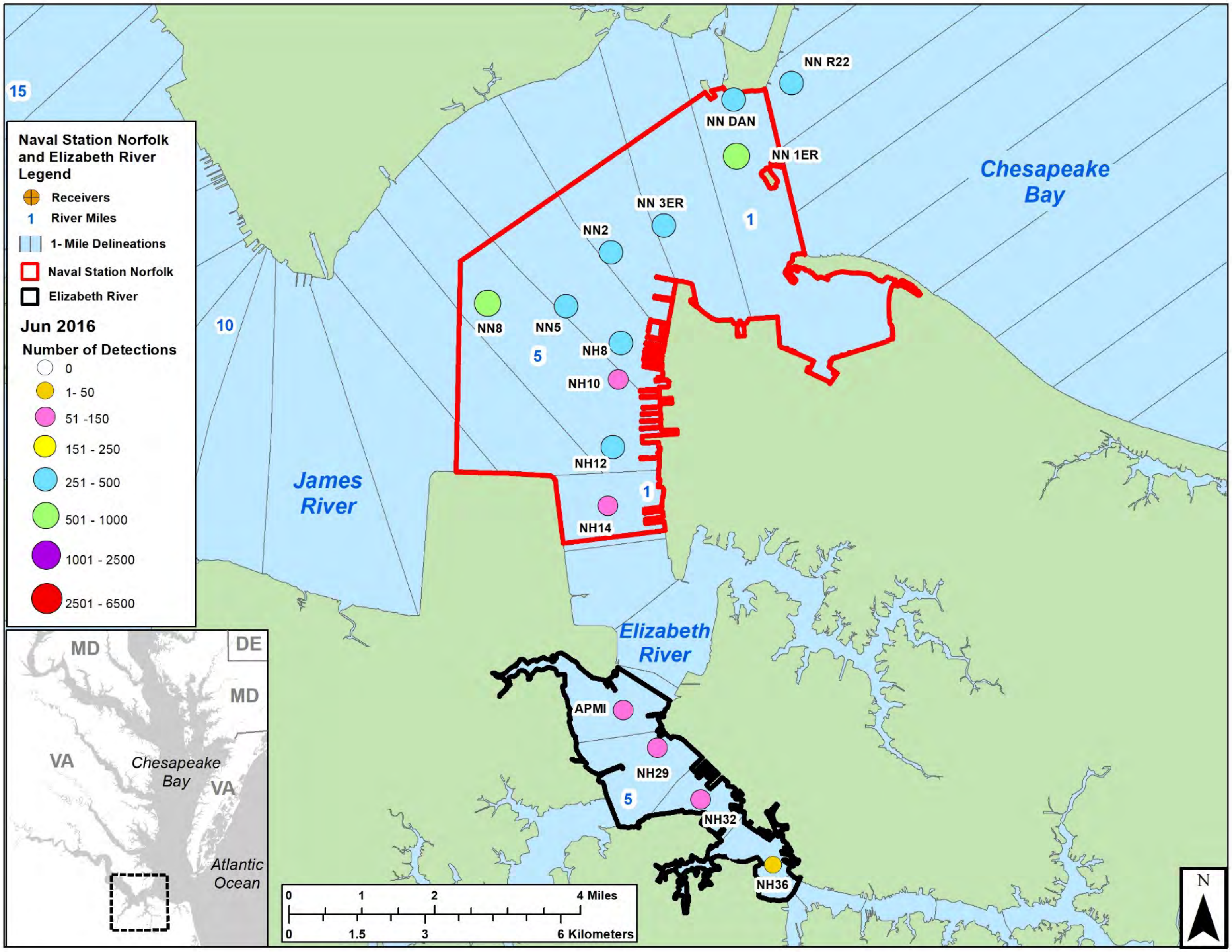
Naval Station Norfolk and Elizabeth River Legend
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1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Jun 2016
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Chesapeake Bay
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Atlantic Ocean
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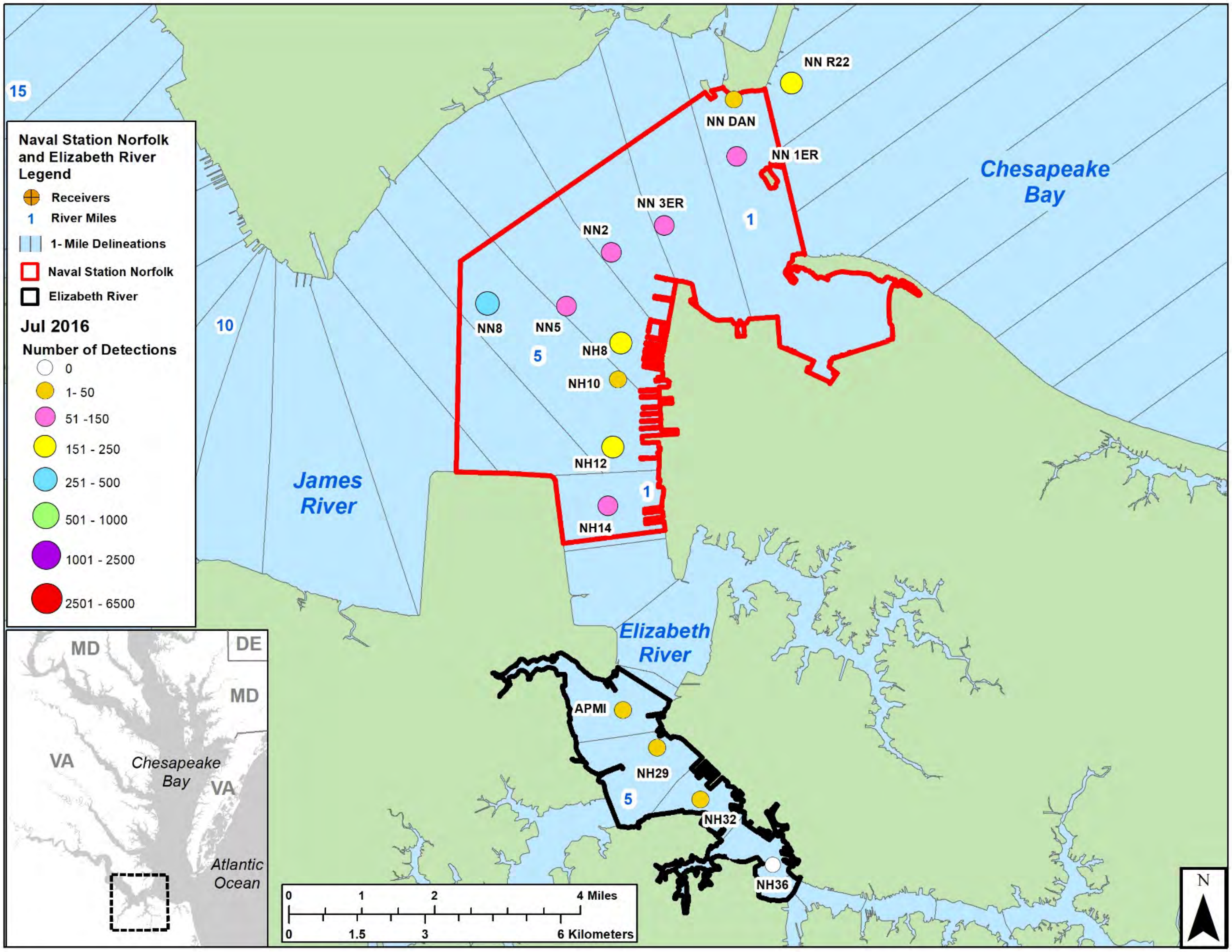
Naval Station Norfolk and Elizabeth River Legend
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1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Jul 2016
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Elizabeth River
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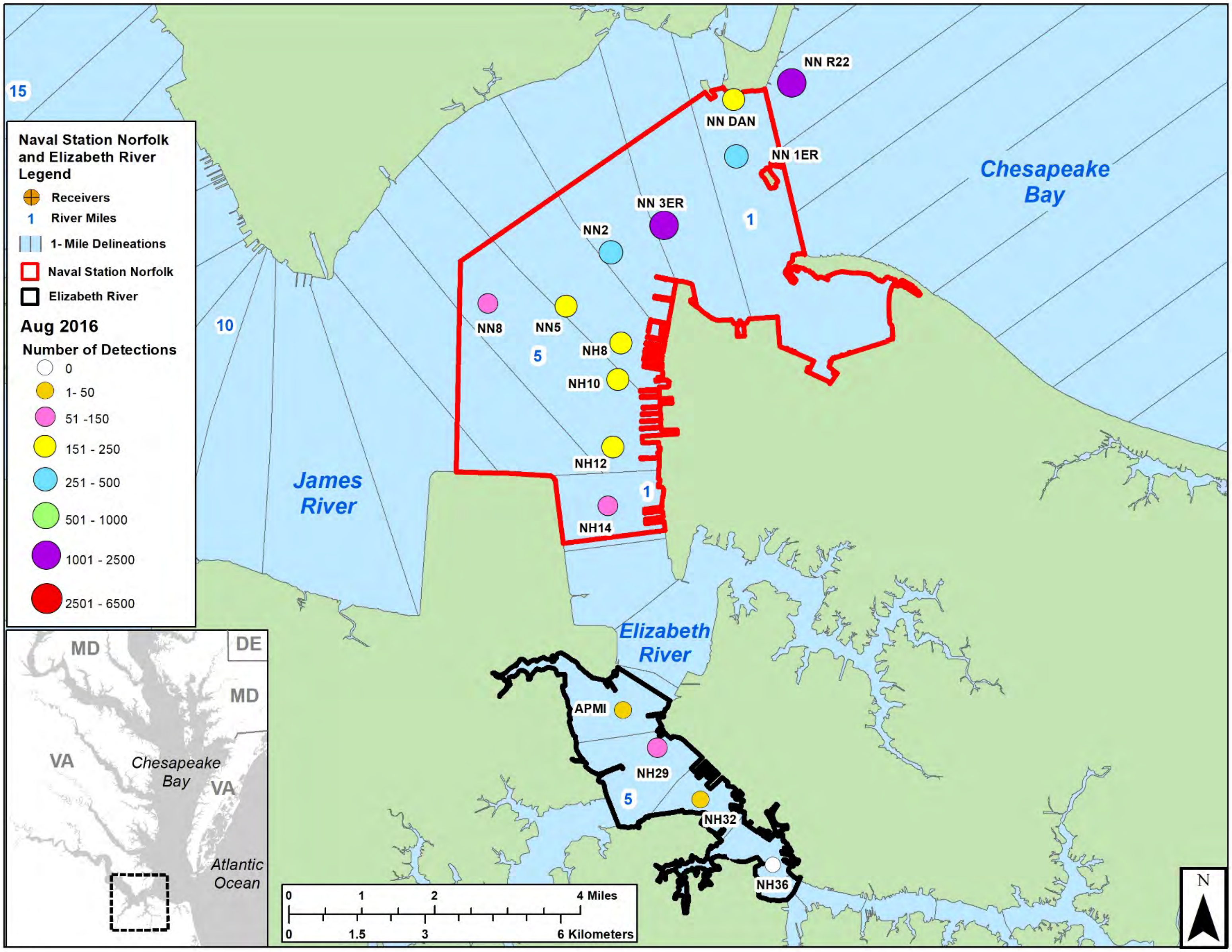
Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Aug 2016
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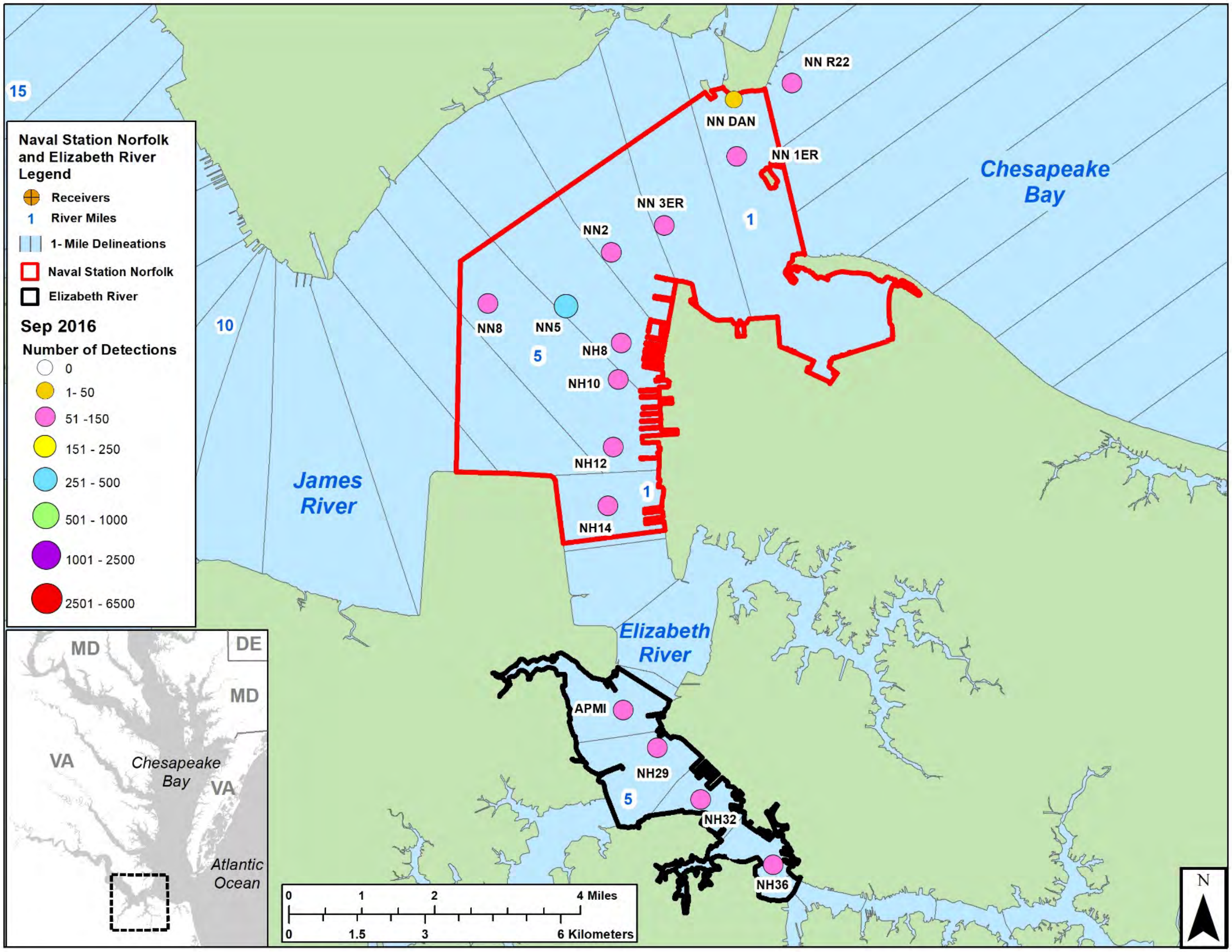

Naval Station Norfolk and Elizabeth River Legend
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1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Sep 2016
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Elizabeth River
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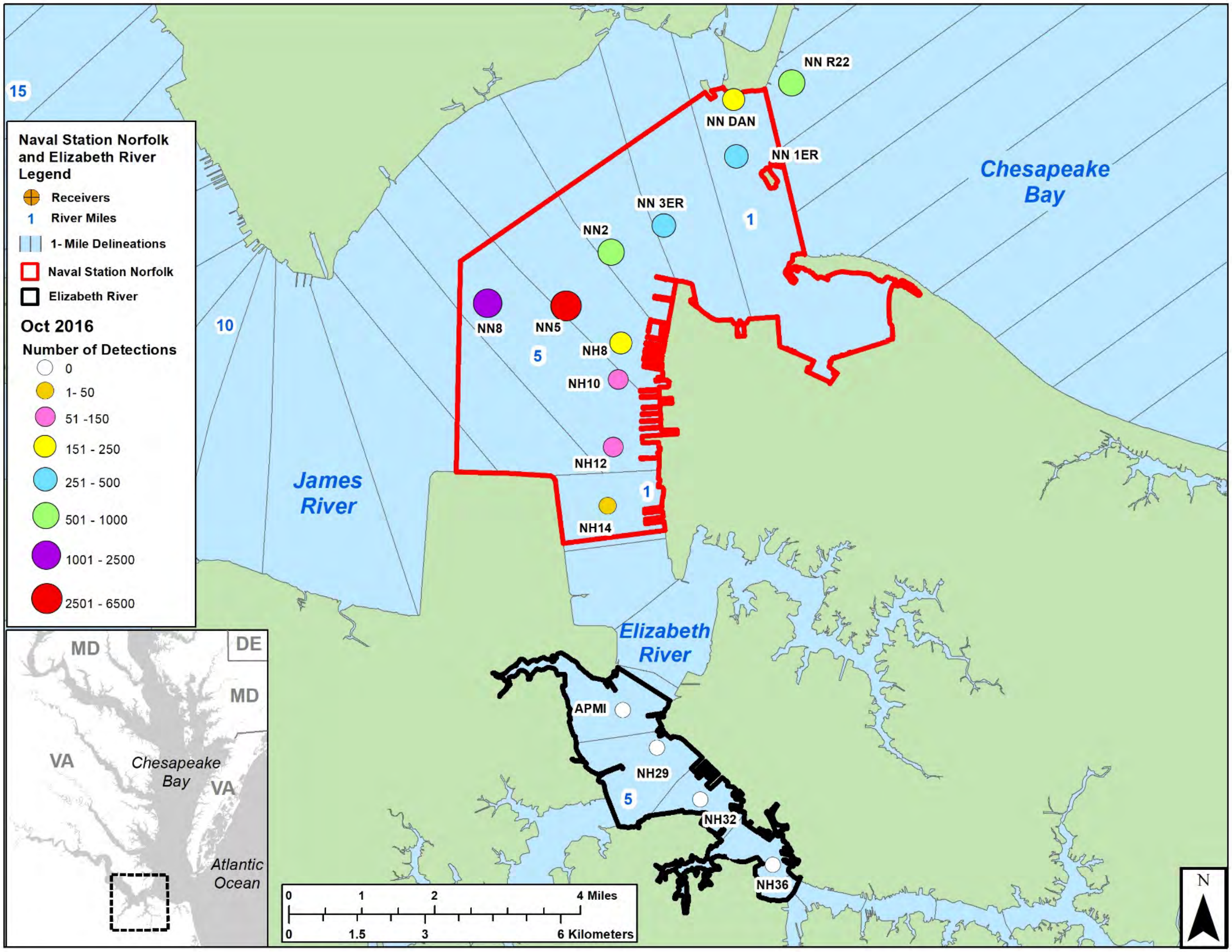
Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Oct 2016
Number of Detections
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Atlantic Ocean
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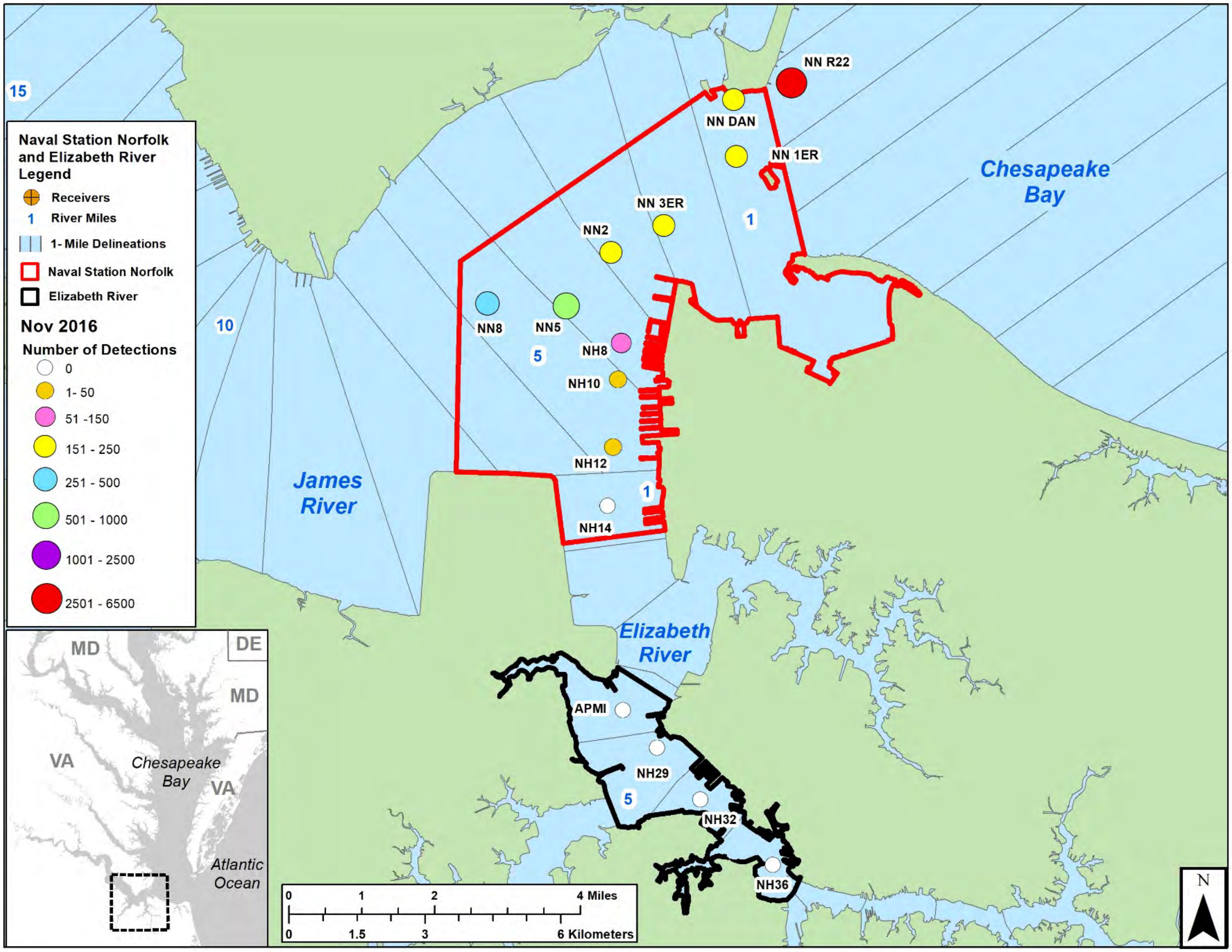
Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Nov 2016
Number of Detections
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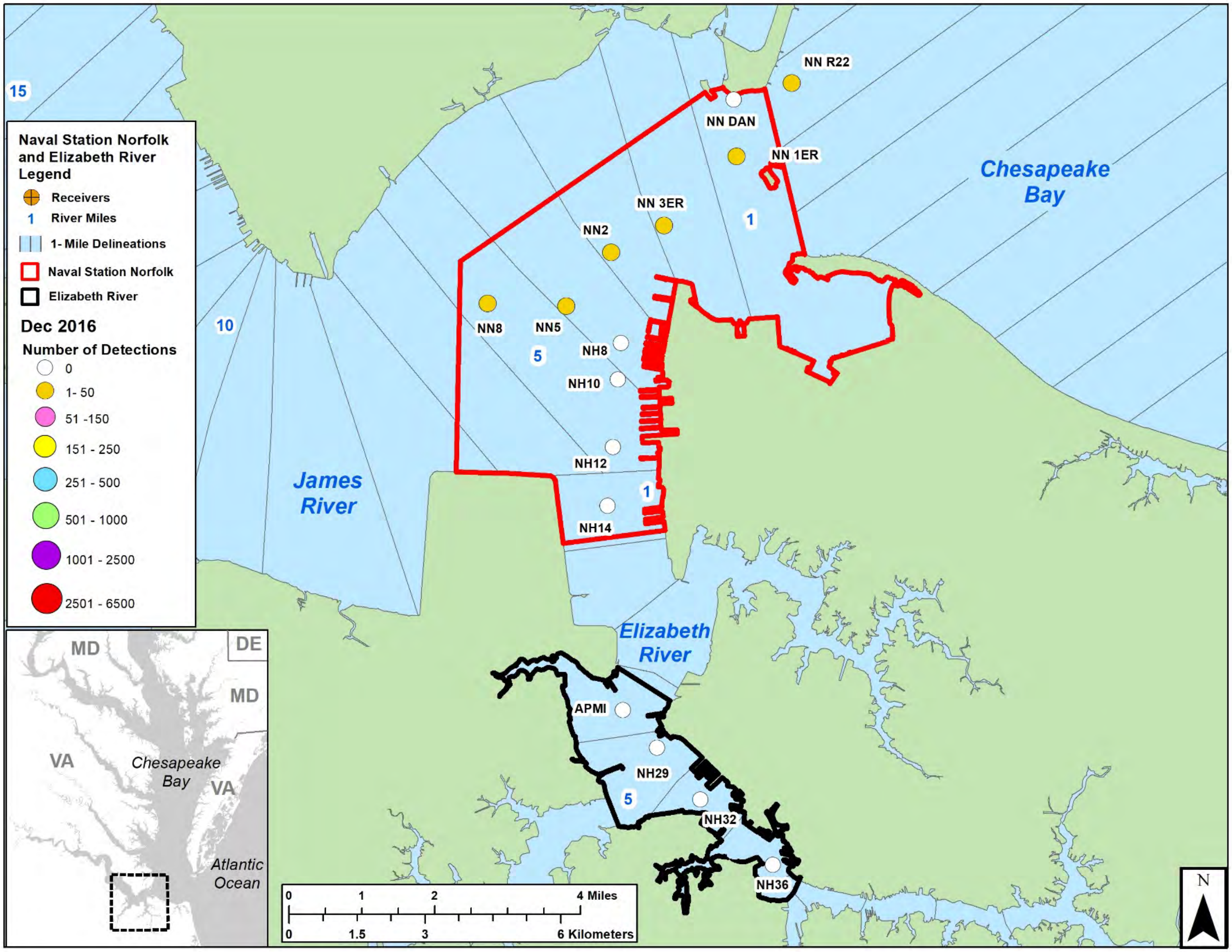
Naval Station Norfolk and Elizabeth River Legend
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Naval Station Norfolk
Elizabeth River
Dec 2016
Number of Detections
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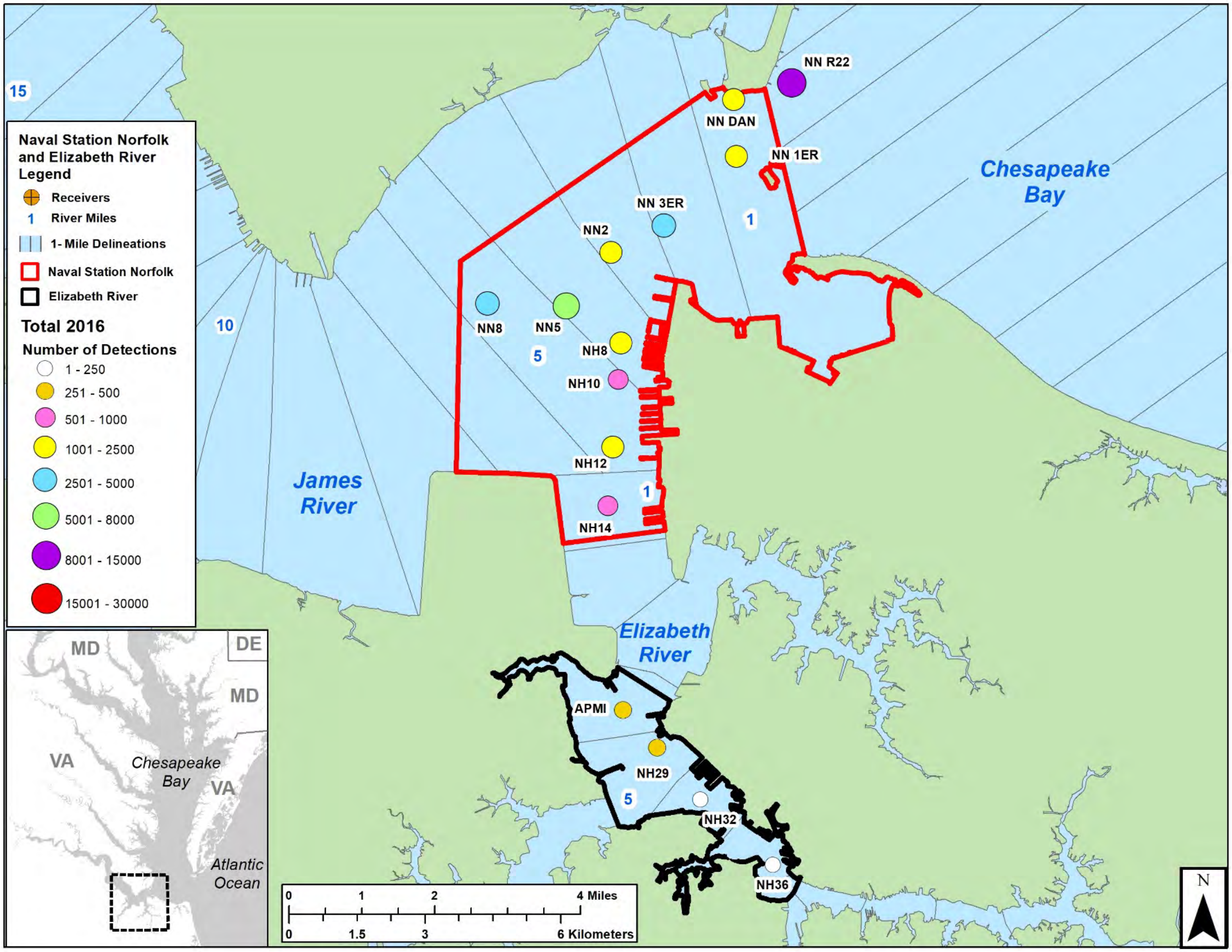
Naval Station Norfolk and Elizabeth River Legend
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Naval Station Norfolk
Elizabeth River
Total 2016
Number of Detections
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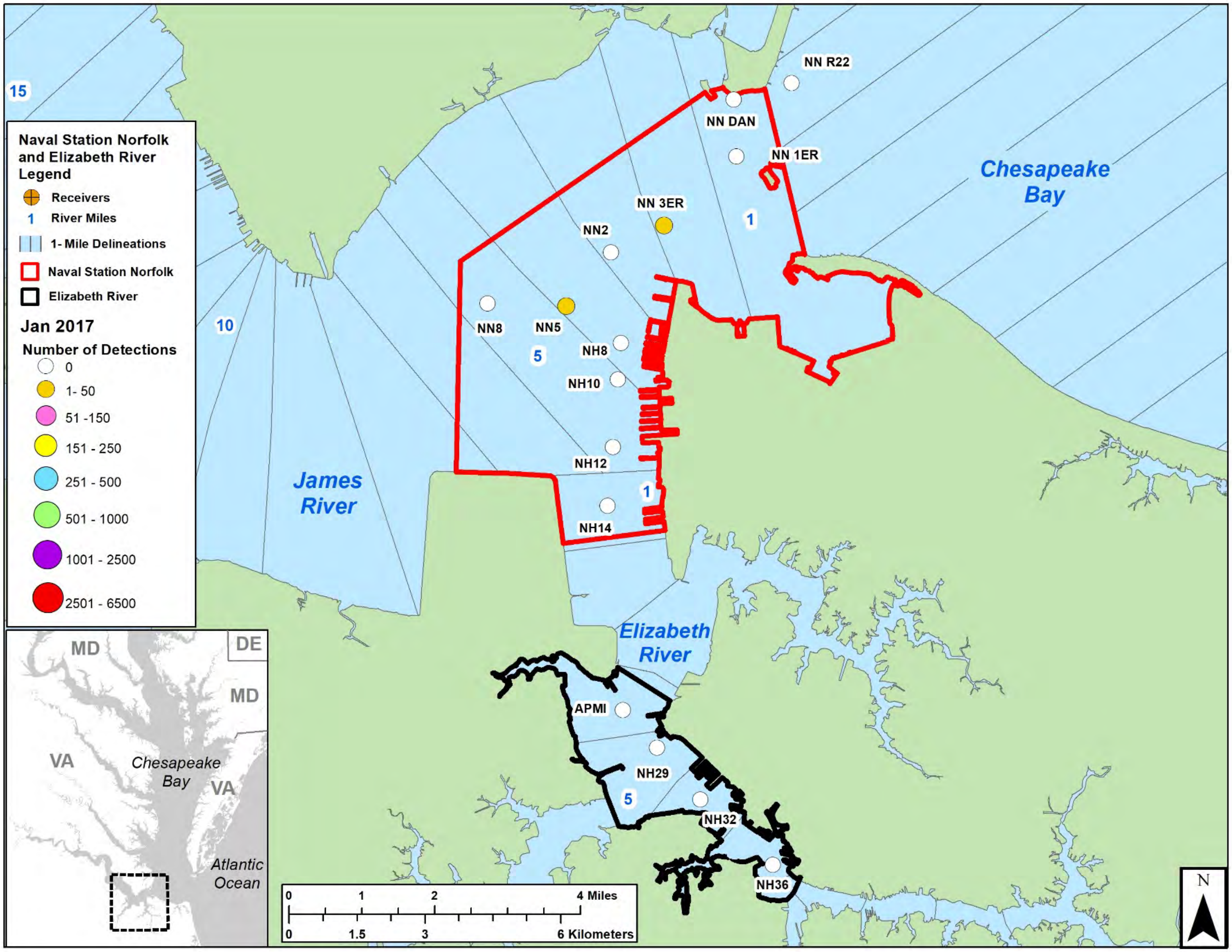

Naval Station Norfolk and Elizabeth River Legend
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1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Jan 2017
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James River
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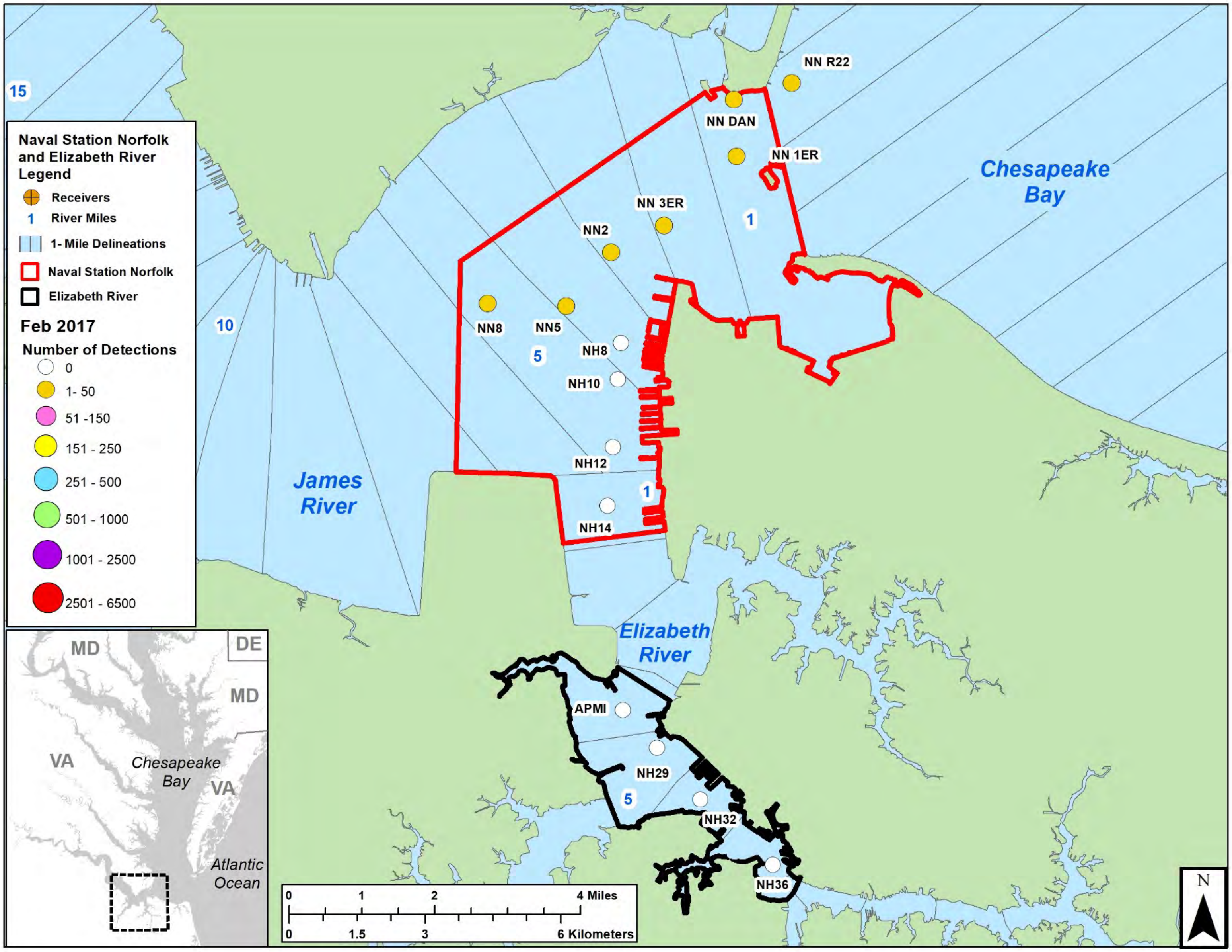
Naval Station Norfolk and Elizabeth River Legend
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Naval Station Norfolk
Elizabeth River
Feb 2017
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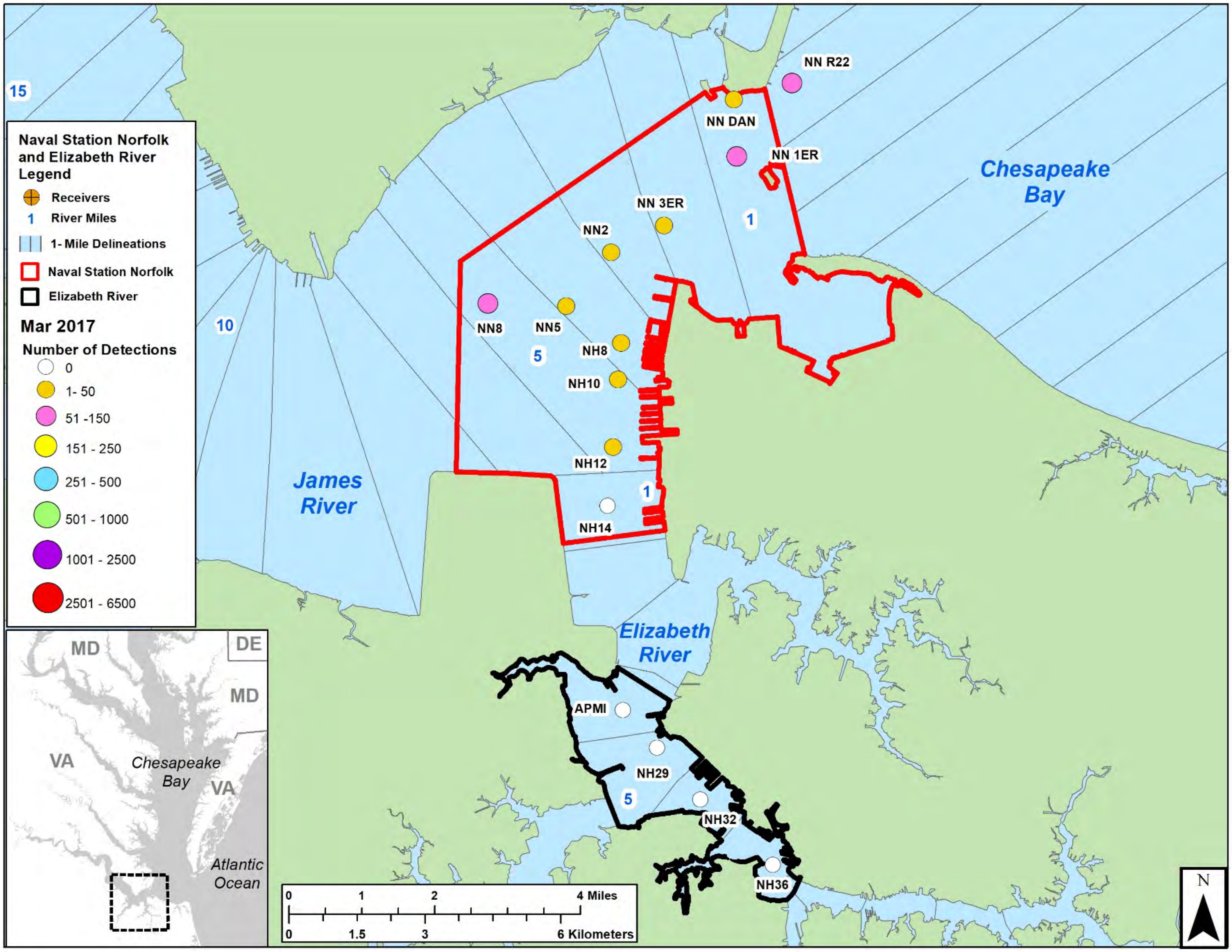
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Elizabeth River
Mar 2017
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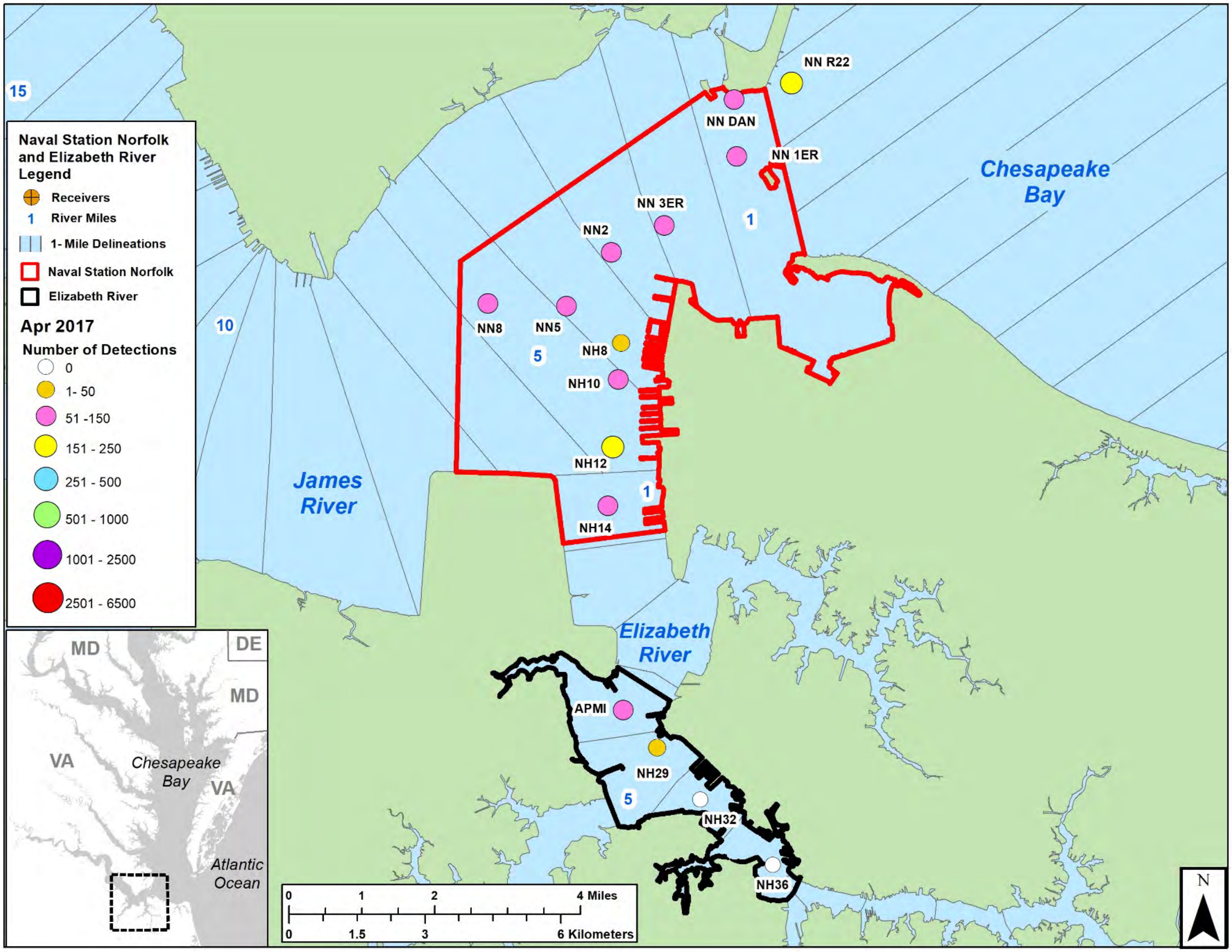
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Naval Station Norfolk and Elizabeth River Legend
Receivers
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Naval Station Norfolk
Elizabeth River
Apr 2017
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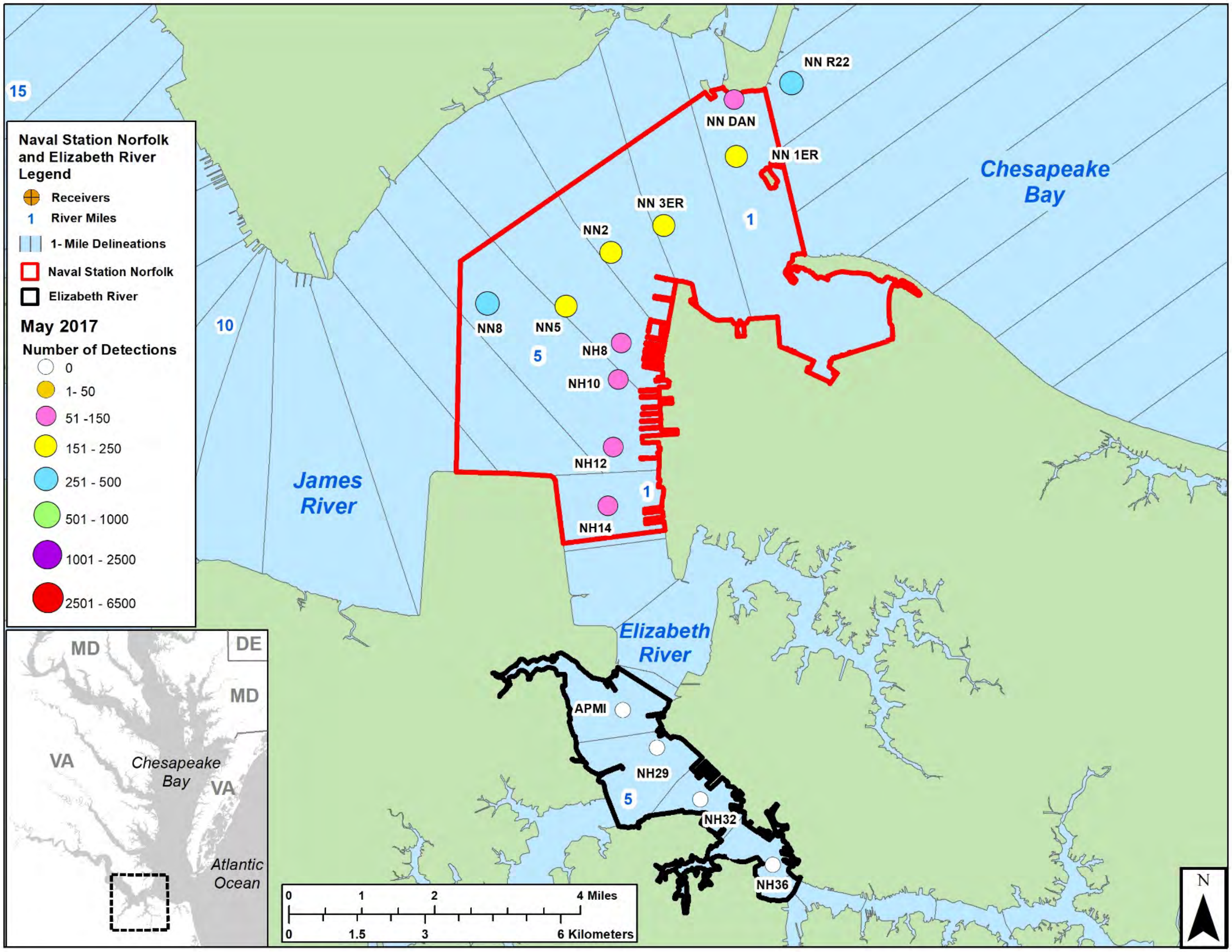
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Naval Station Norfolk and Elizabeth River Legend
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Naval Station Norfolk
Elizabeth River
May 2017
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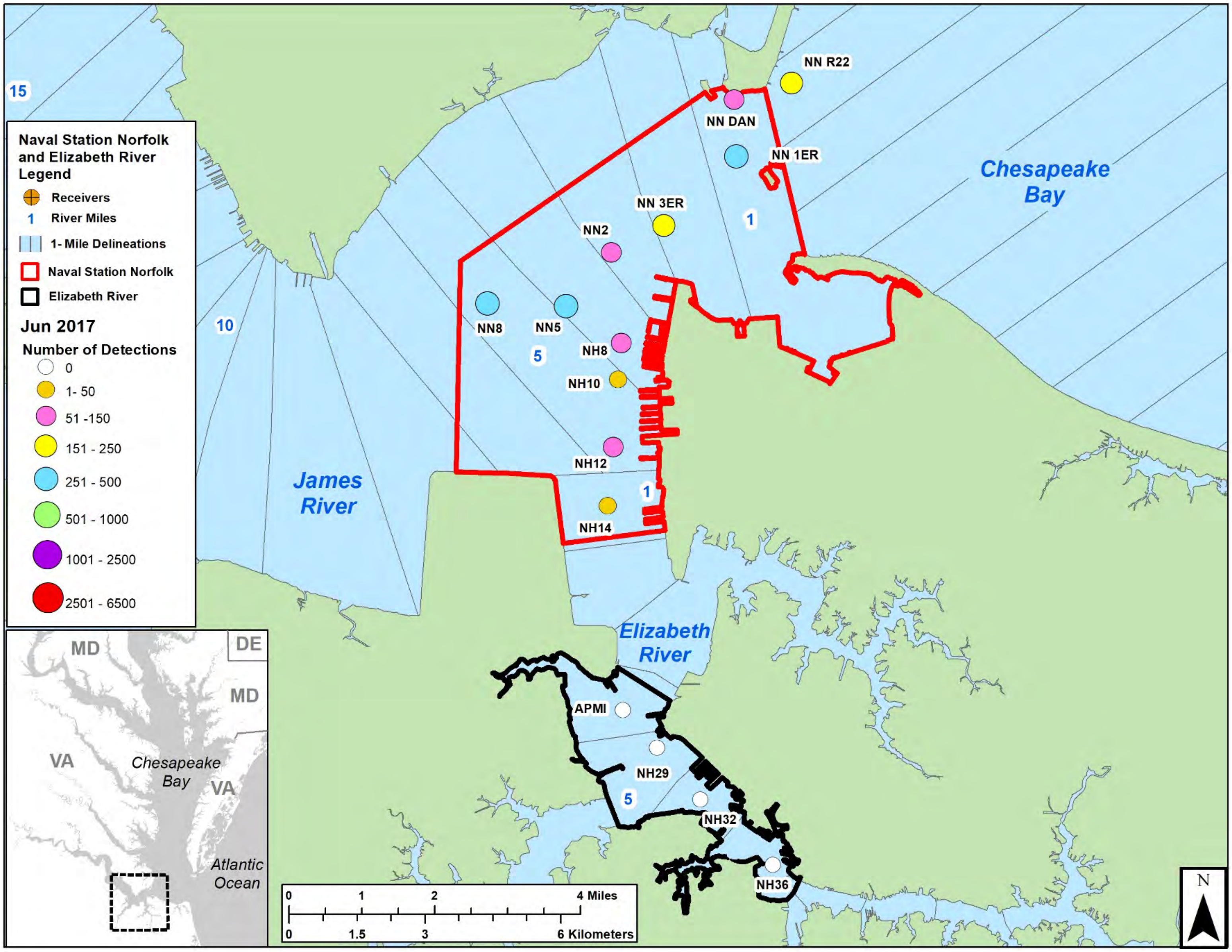
Naval Station Norfolk and Elizabeth River Legend
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1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Jun 2017
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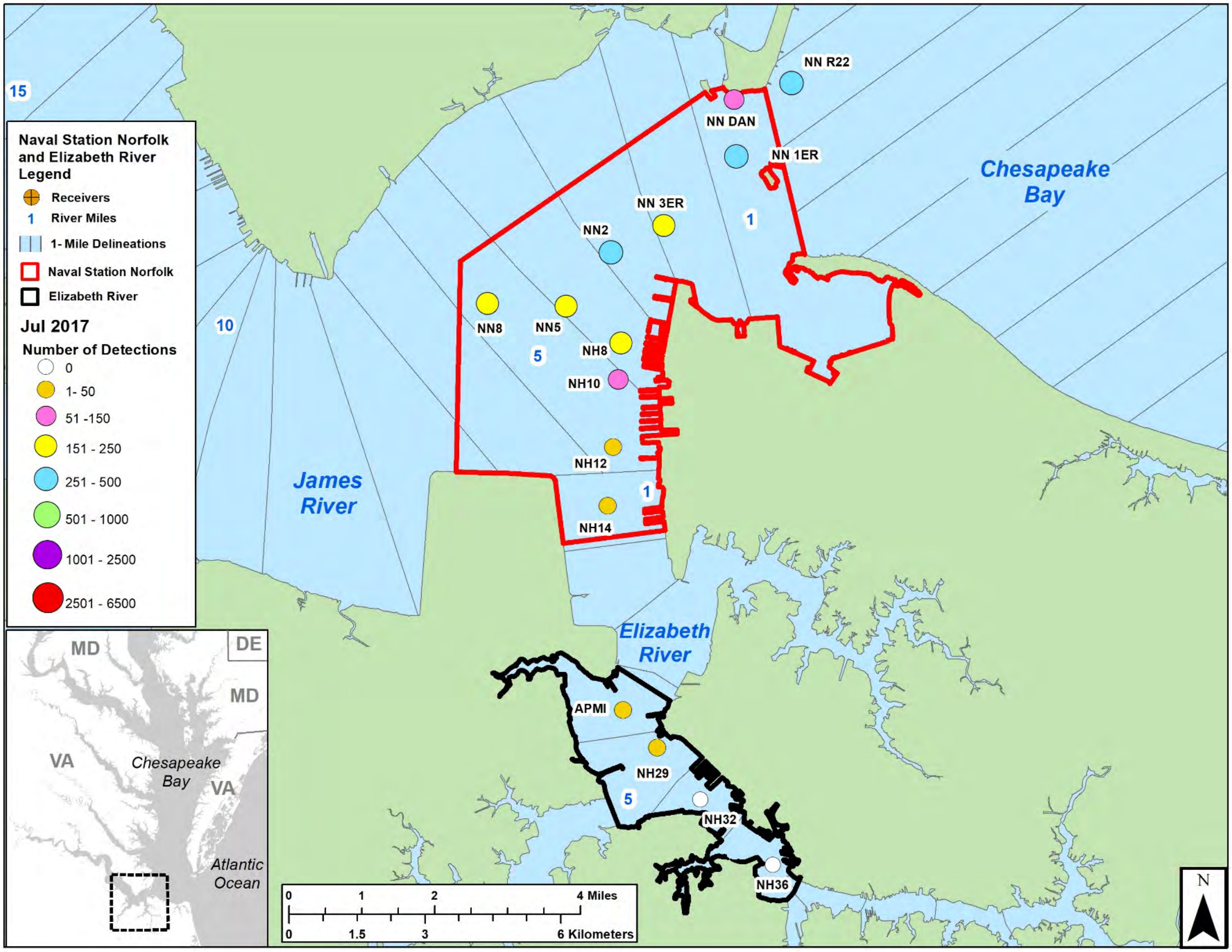
Naval Station Norfolk and Elizabeth River Legend
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Naval Station Norfolk
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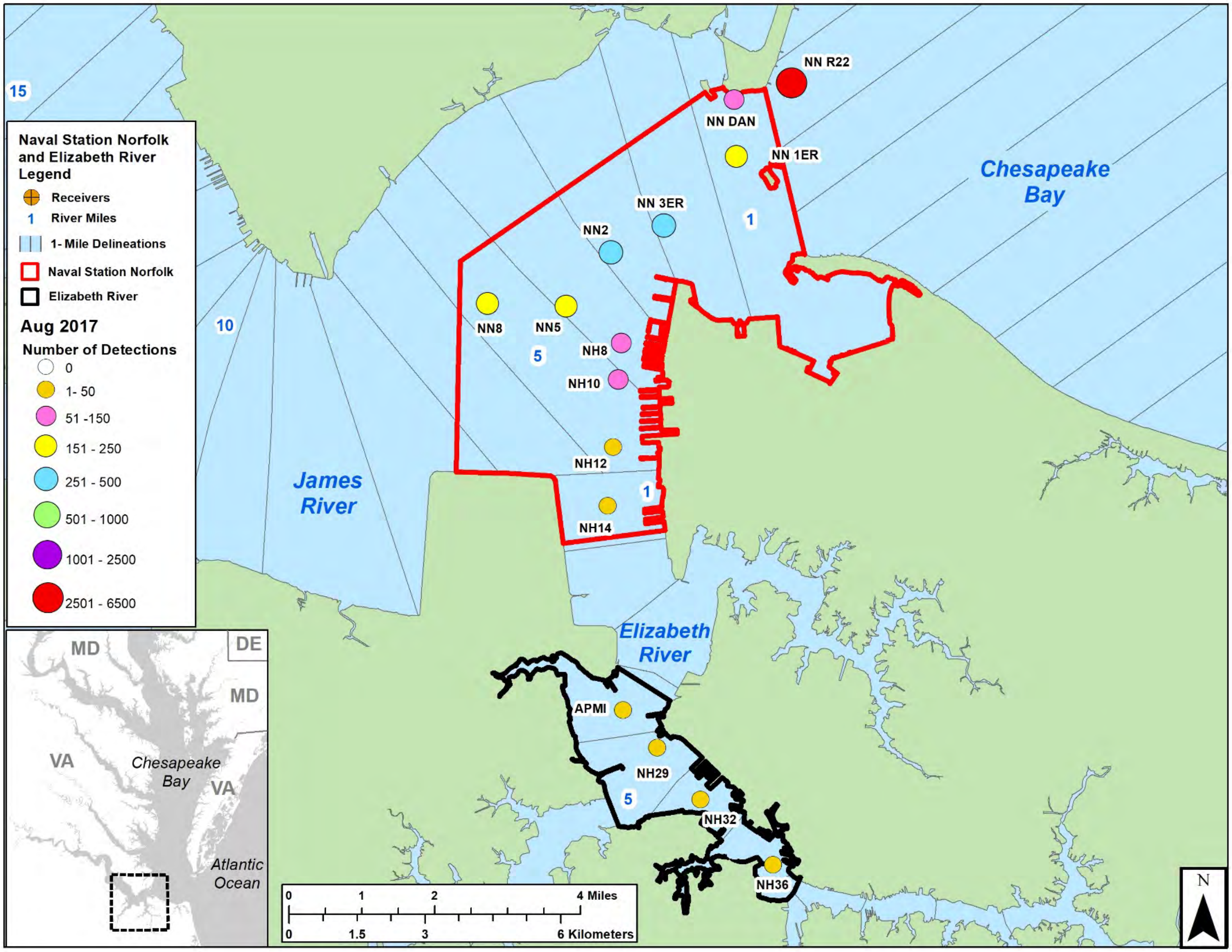
Naval Station Norfolk and Elizabeth River Legend
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River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Aug 2017
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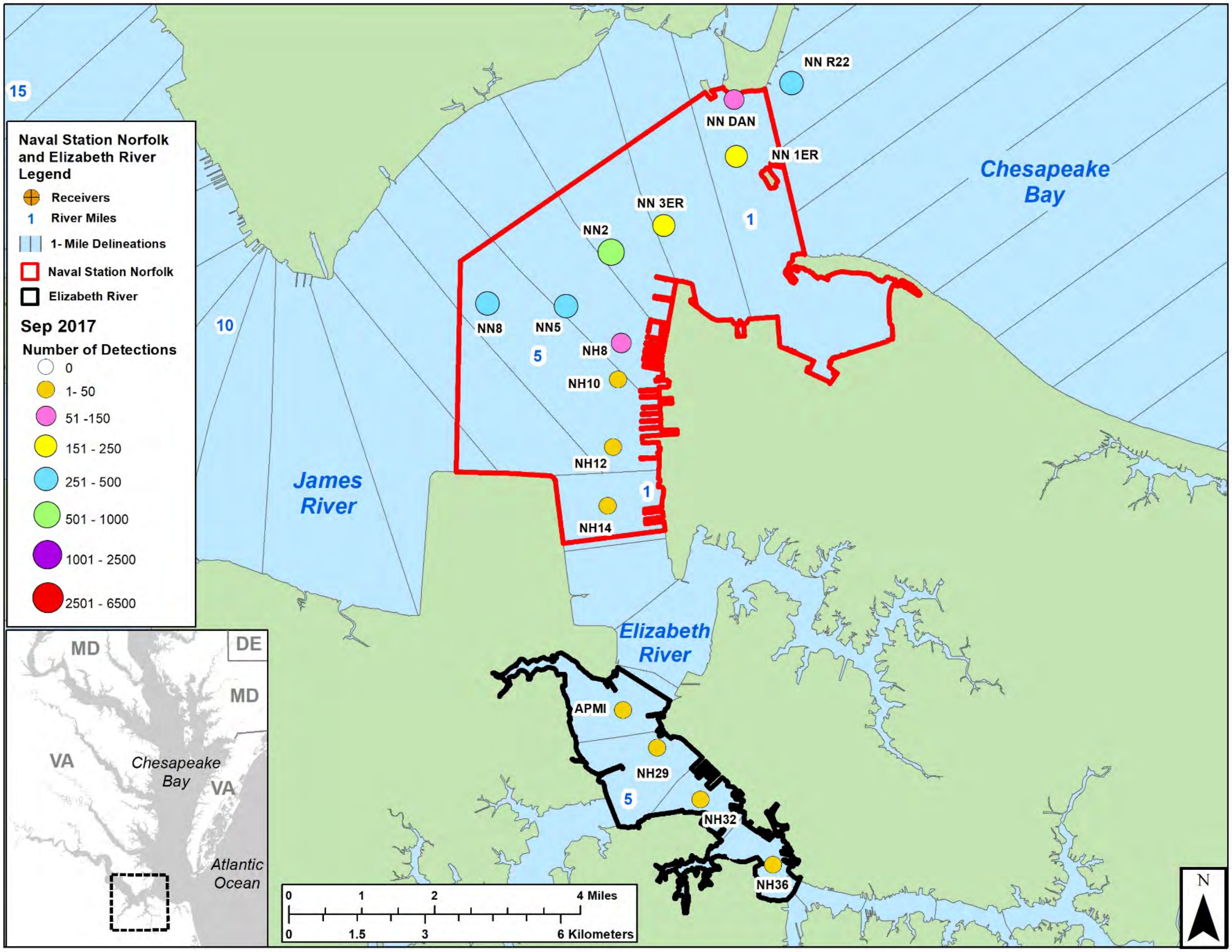
Naval Station Norfolk and Elizabeth River Legend
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1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Sep 2017
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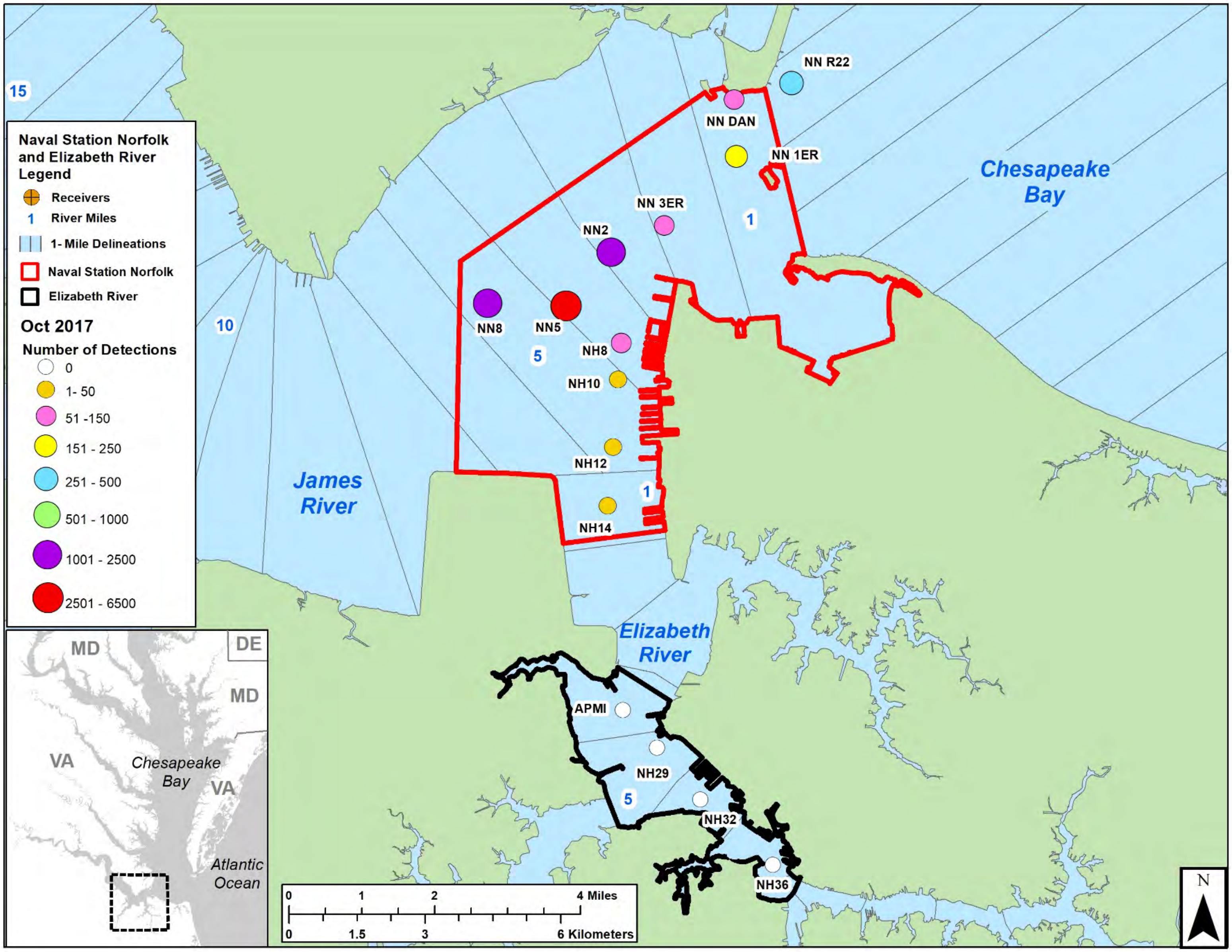
Naval Station Norfolk and Elizabeth River Legend
Receivers
River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Oct 2017
Number of Detections
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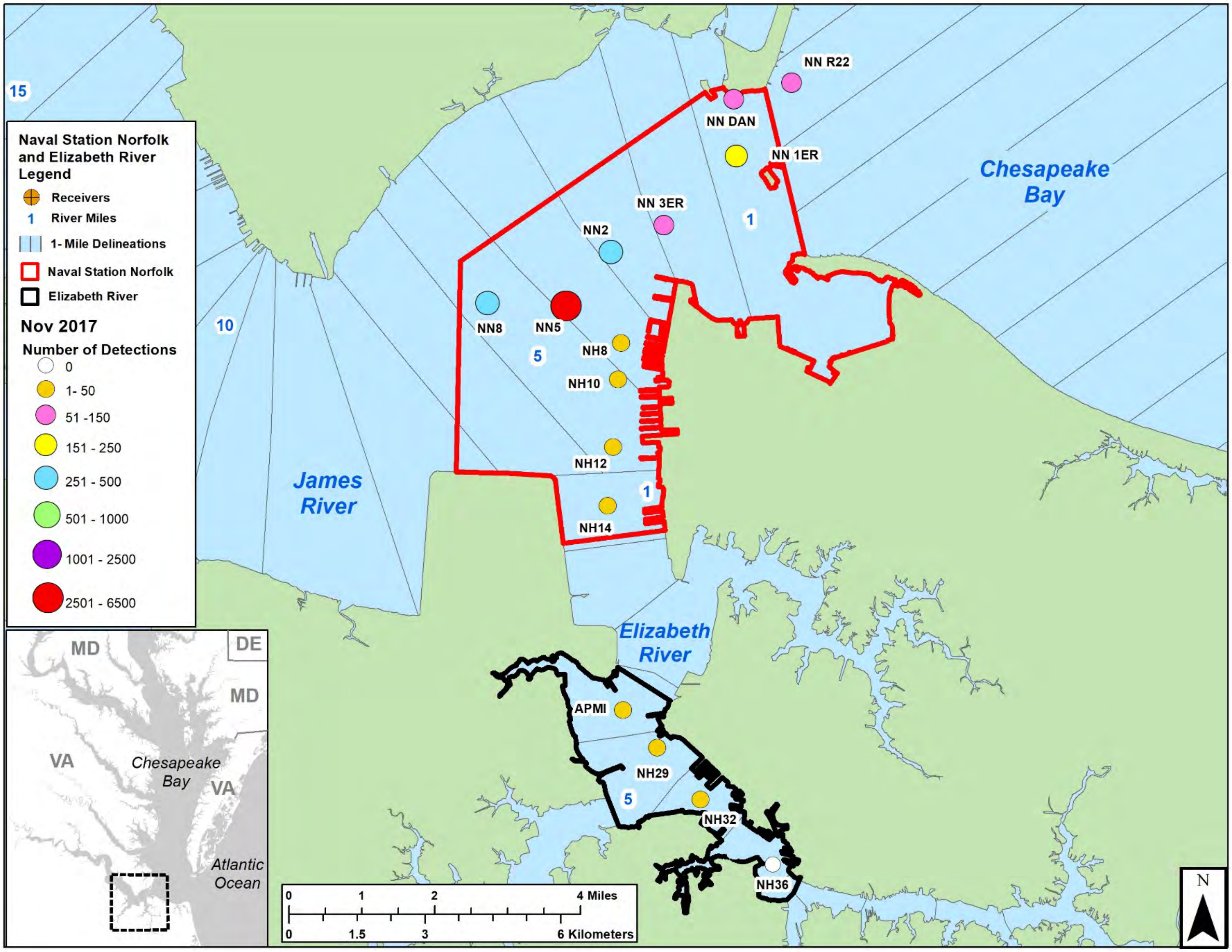
Naval Station Norfolk and Elizabeth River Legend
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Naval Station Norfolk
Elizabeth River
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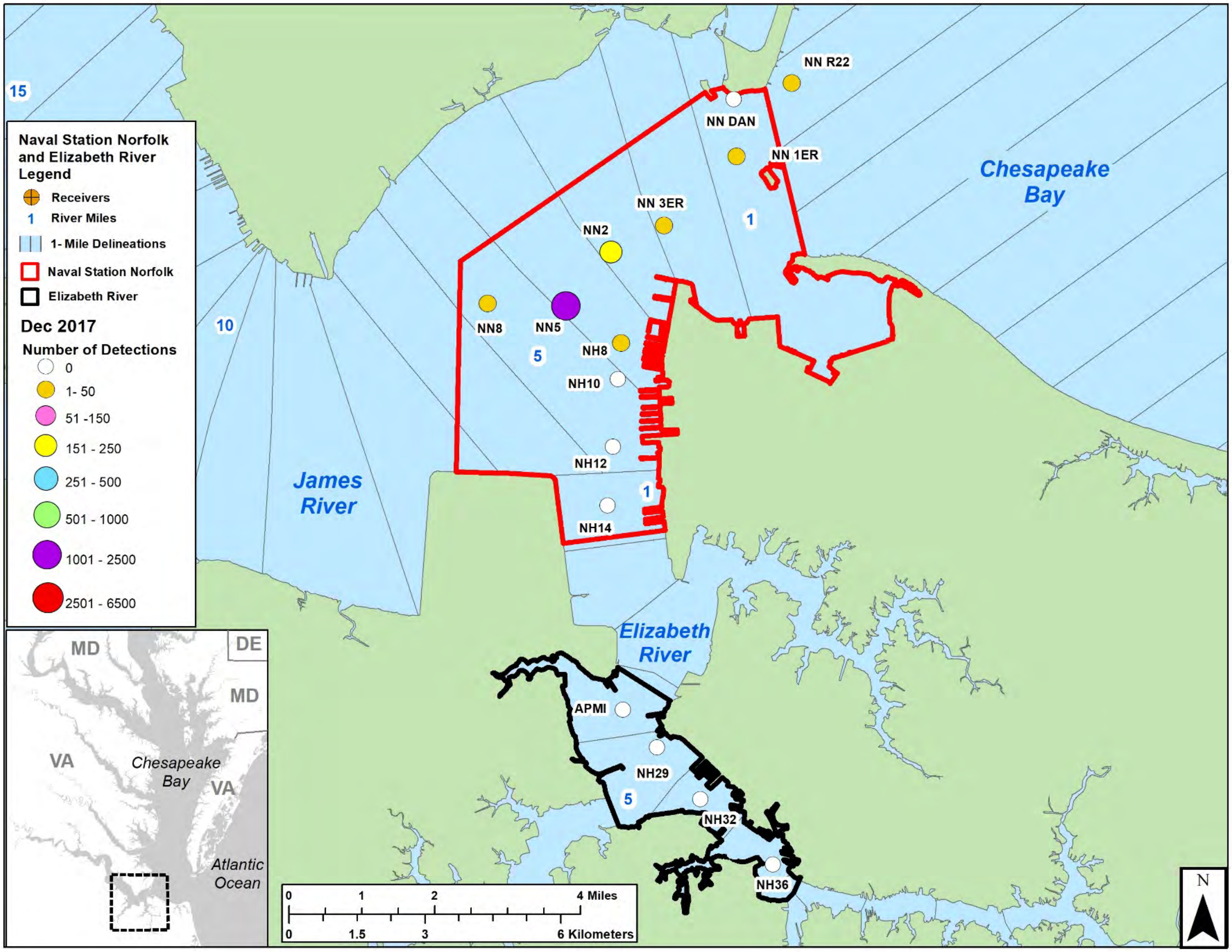
Naval Station Norfolk and Elizabeth River Legend
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River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Dec 2017
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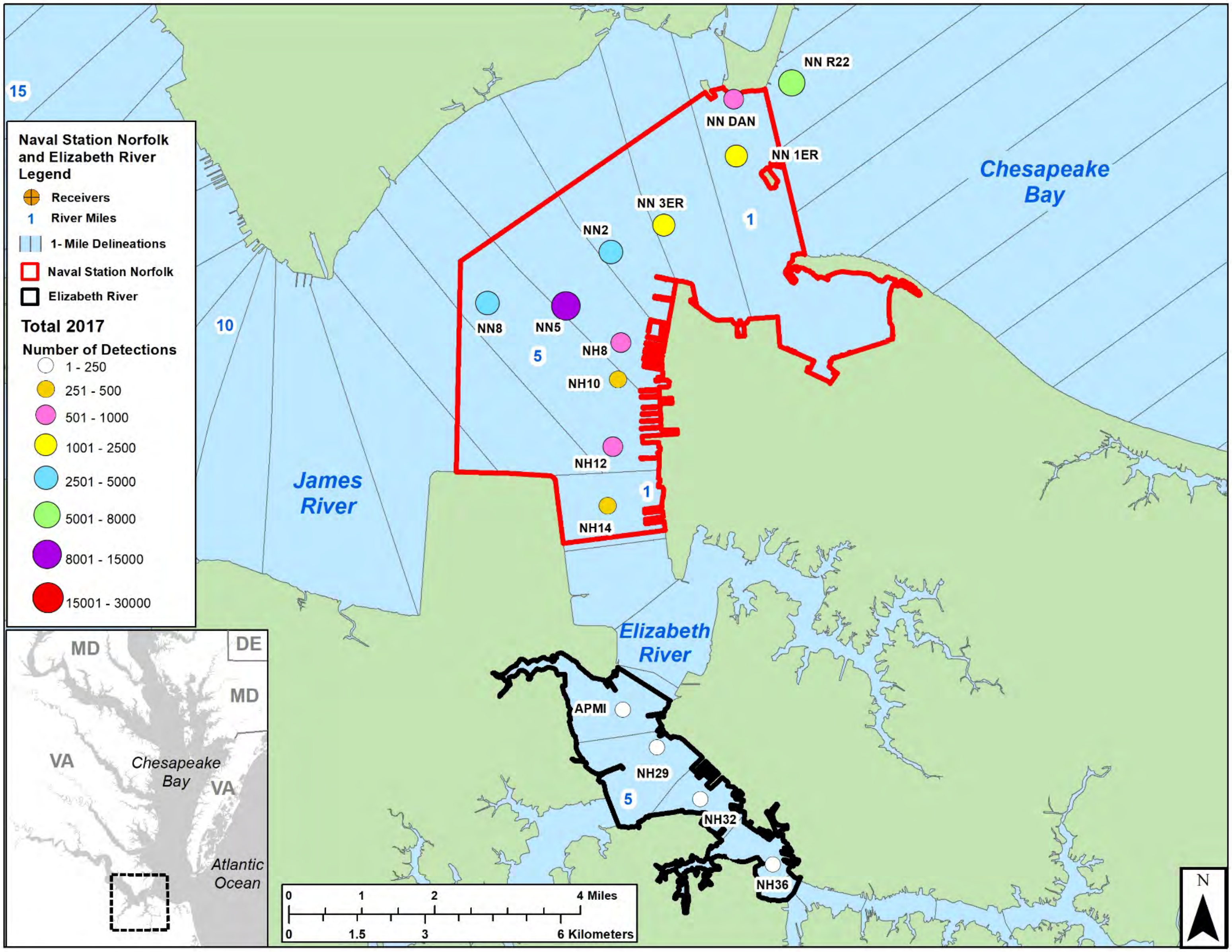
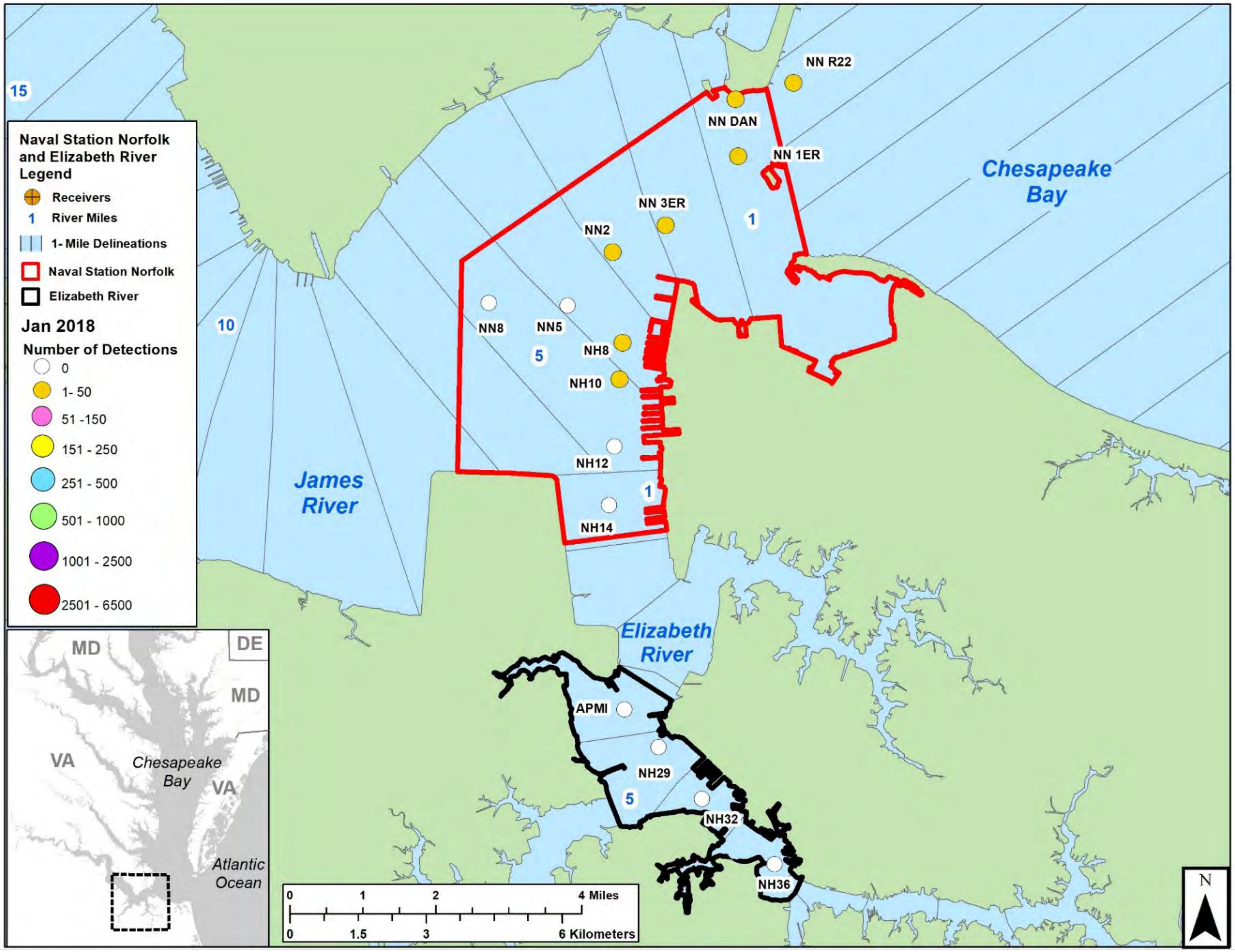
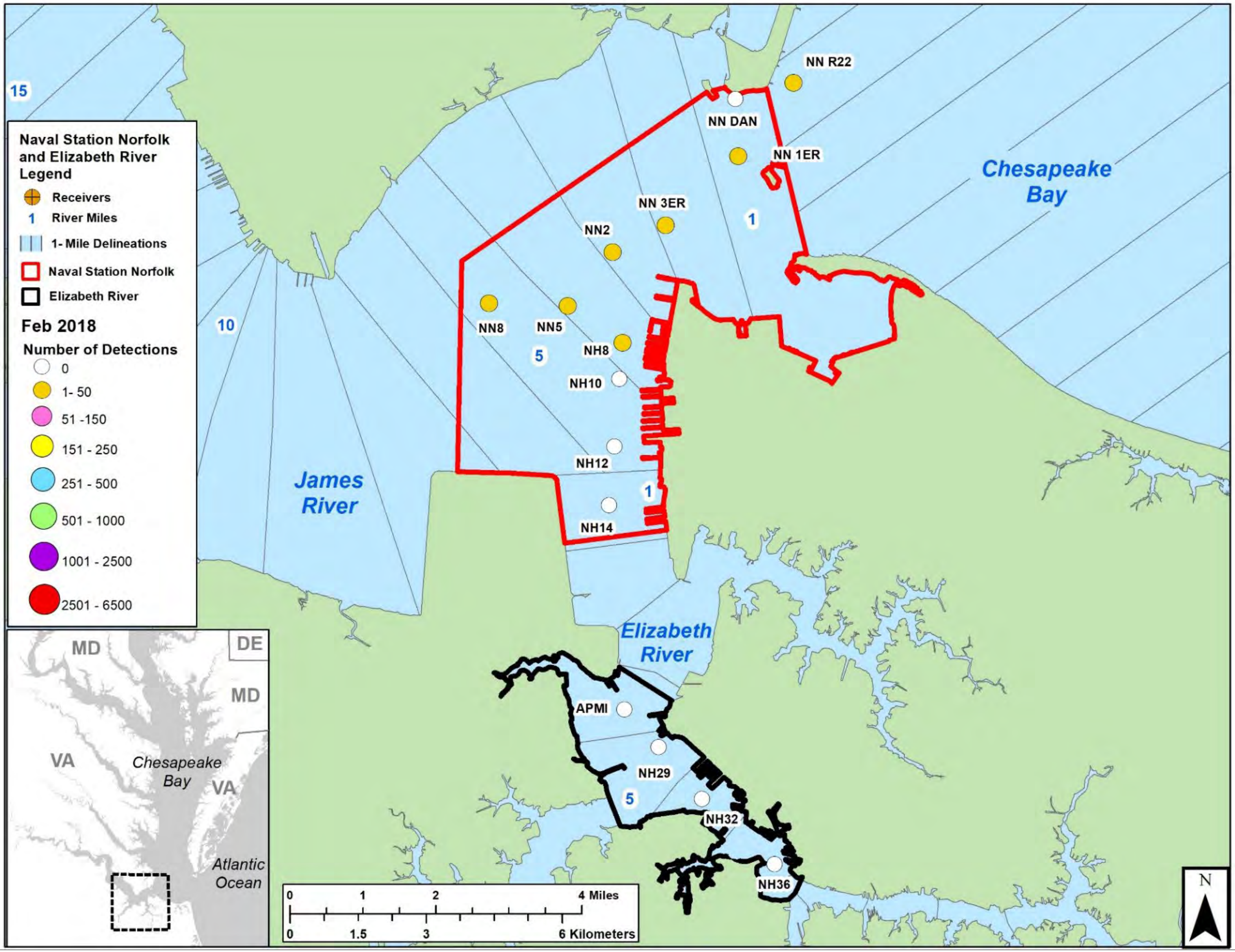
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
Chesapeake Bay
James River
Elizabeth River
APMI
NH29
NH32
NH36
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N


Naval Station Norfolk and Elizabeth River Legend
Receivers
River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Total 2017
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N


Naval Station Norfolk and Elizabeth River Legend
Receivers
River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Jan 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
James River
Chesapeake Bay
Elizabeth River
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N


Naval Station Norfolk and Elizabeth River Legend
Receivers
River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Feb 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
Chesapeake Bay
James River
Elizabeth River
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
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APMI
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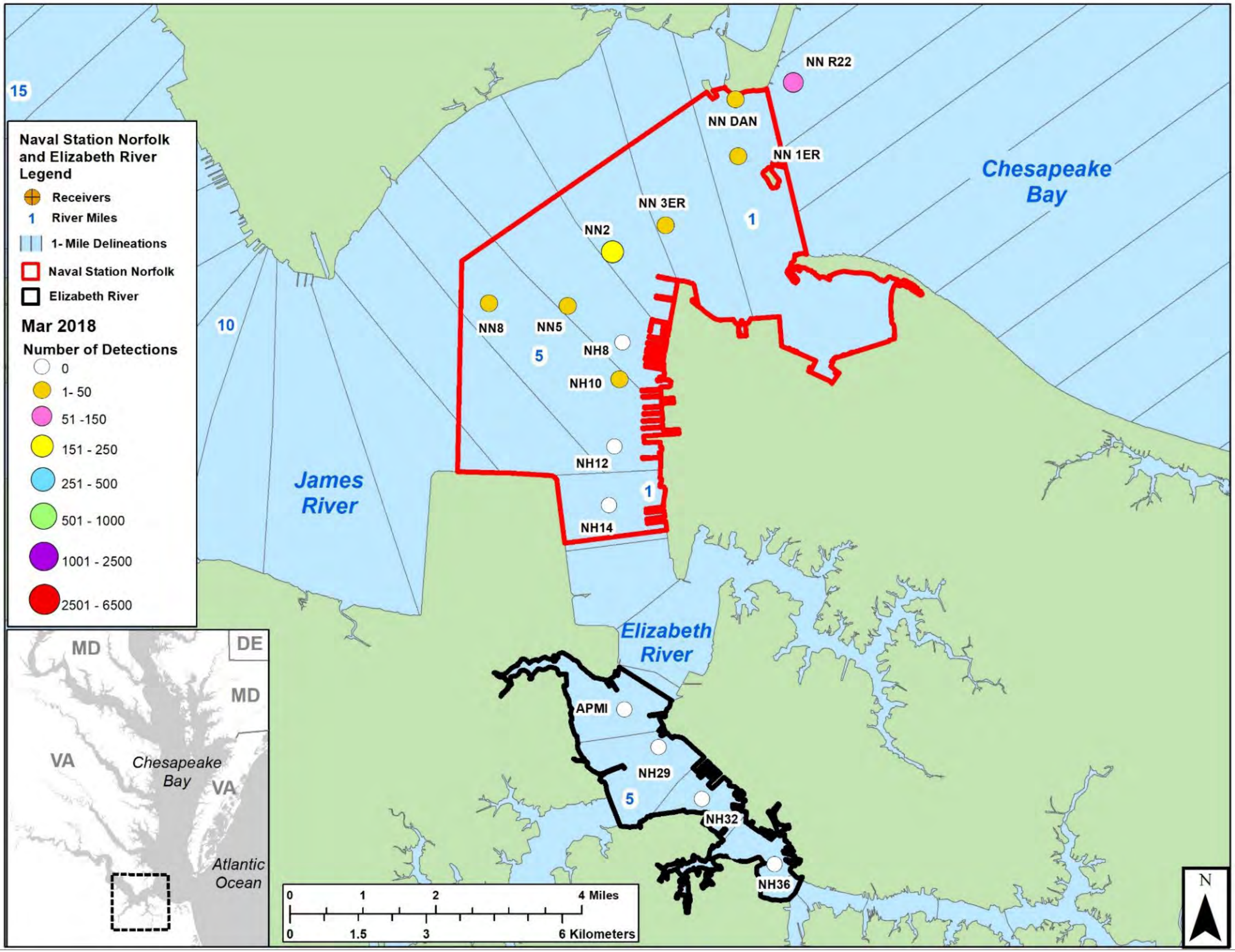
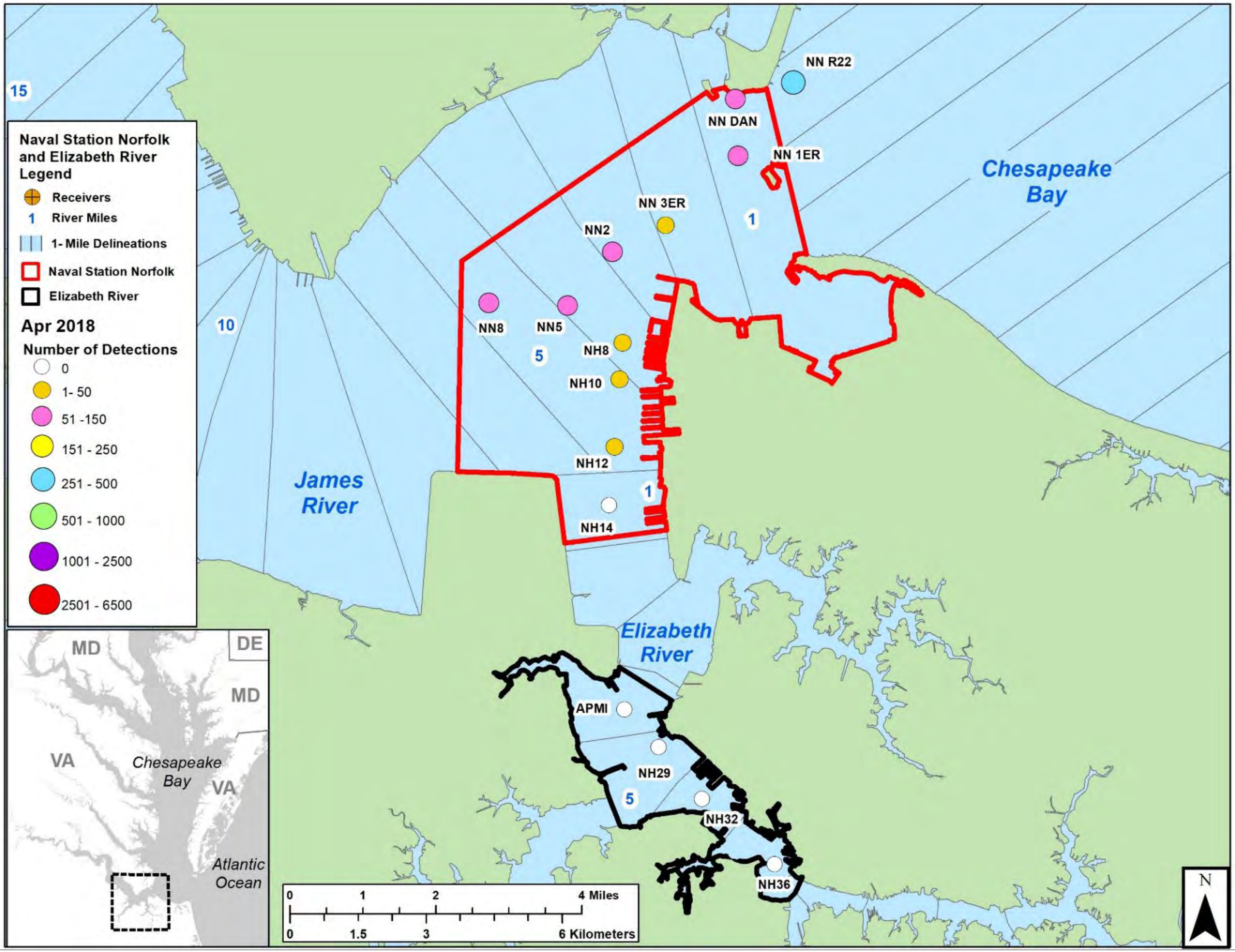
NH32
NH36
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N


Naval Station Norfolk and Elizabeth River Legend
Receivers
River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Mar 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N


Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Apr 2018
Number of Detections
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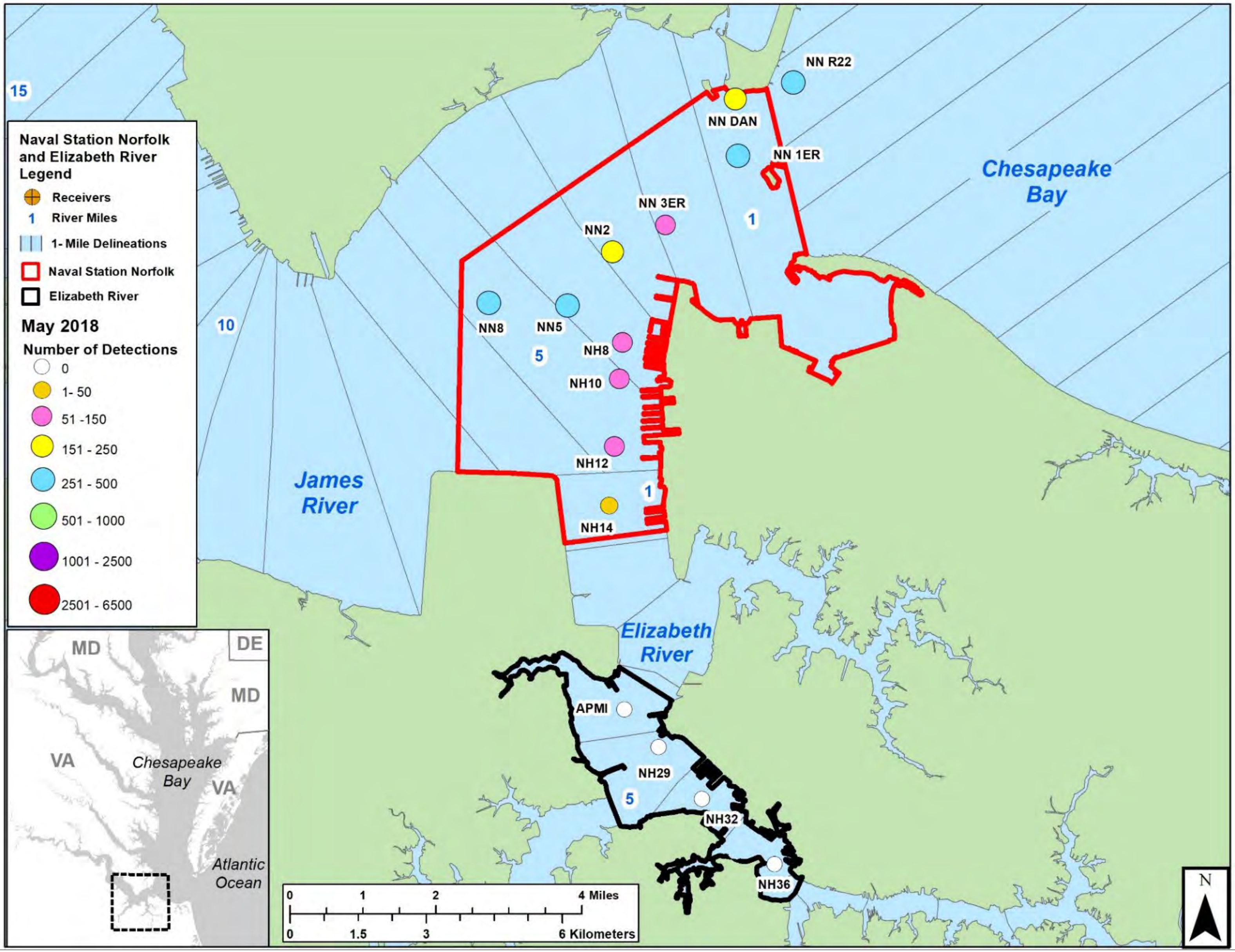
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N


Naval Station Norfolk and Elizabeth River Legend
Receivers
River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
May 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
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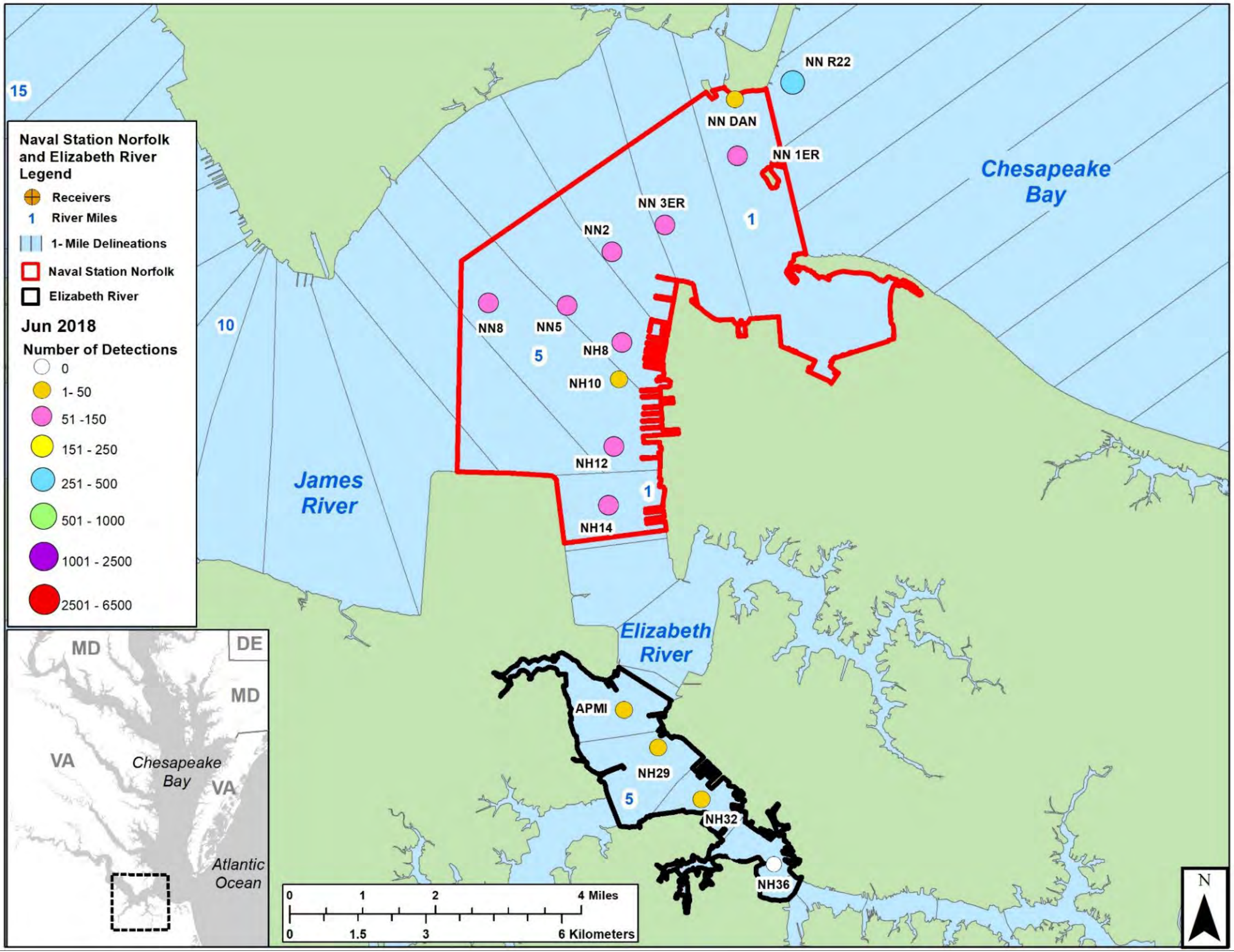
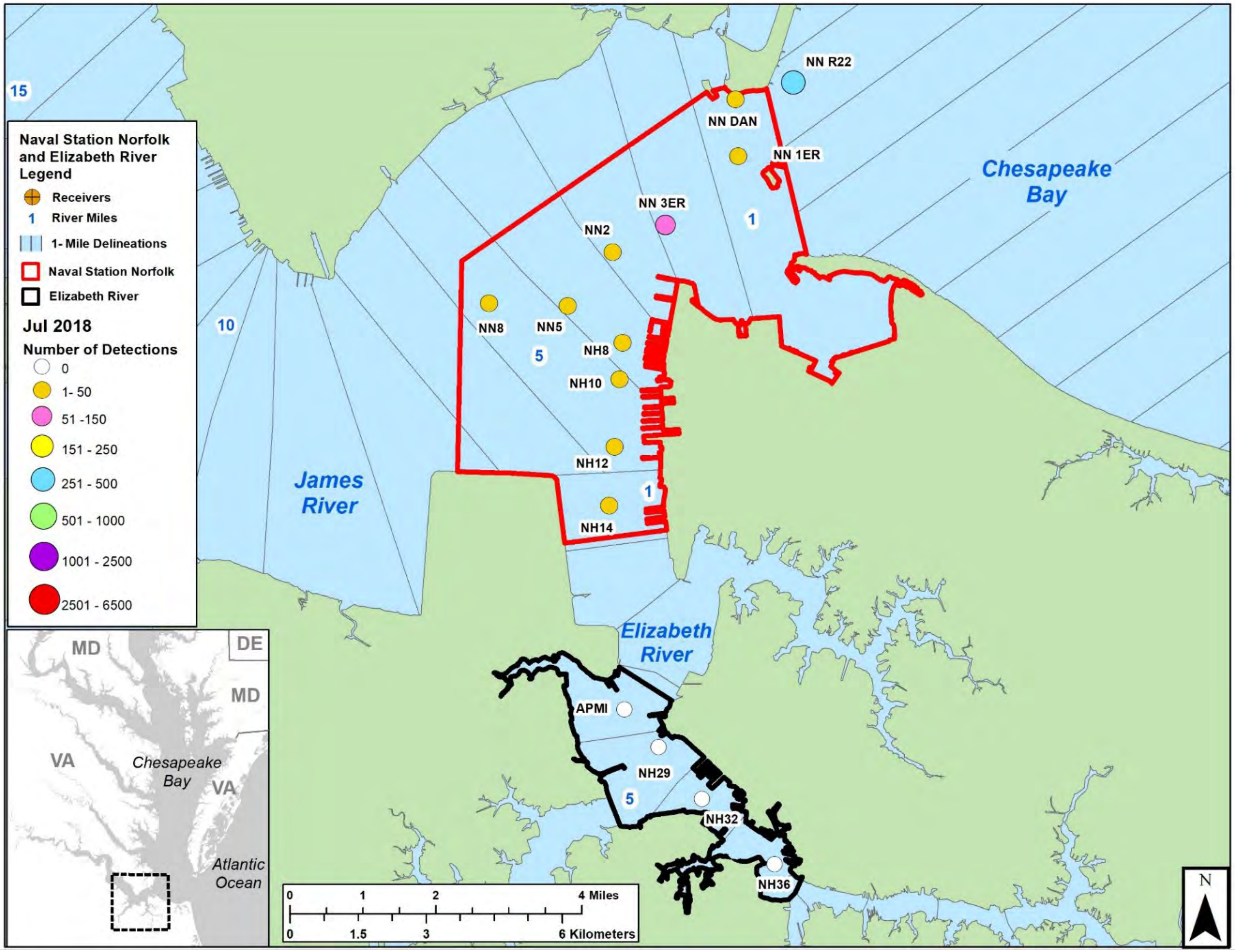
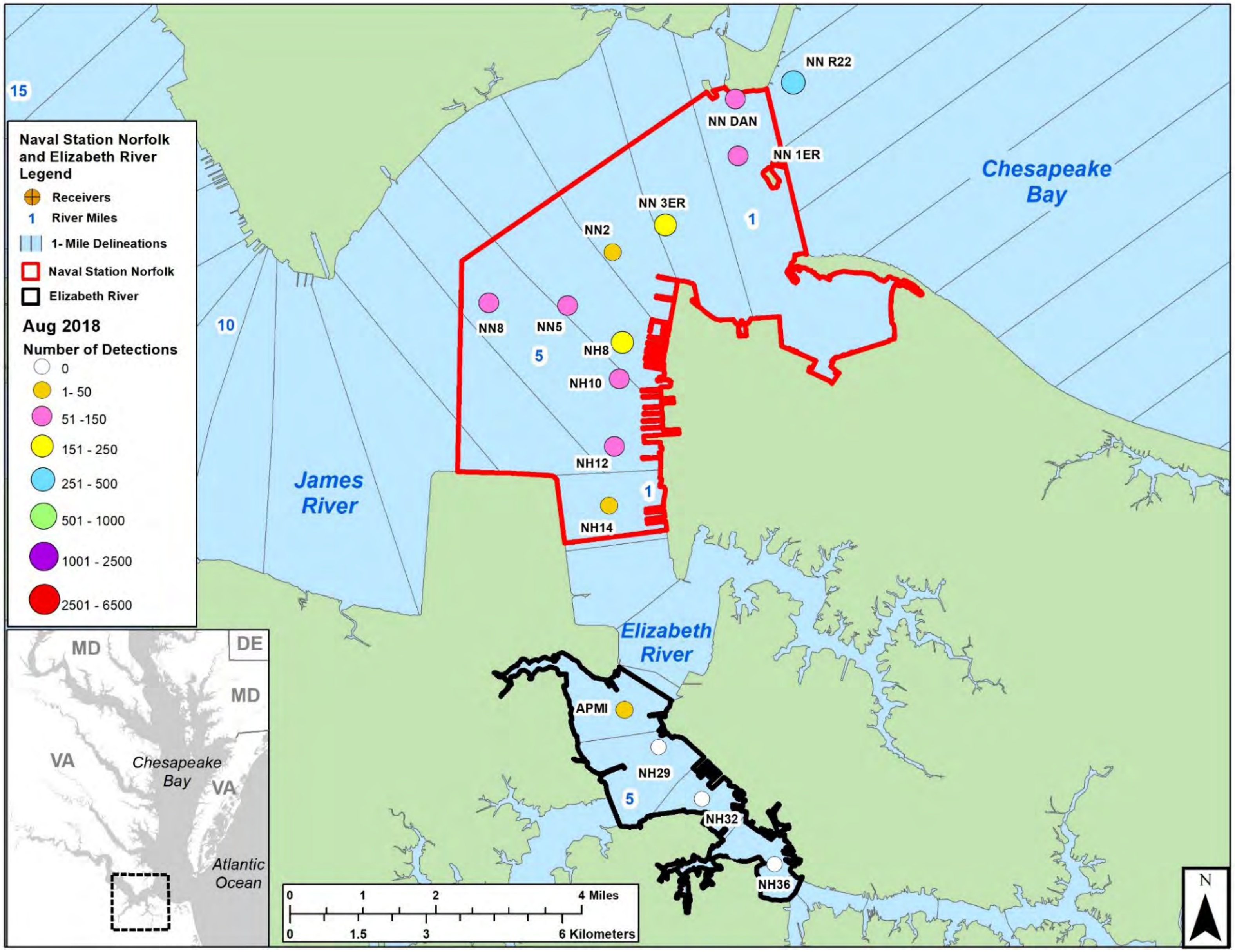
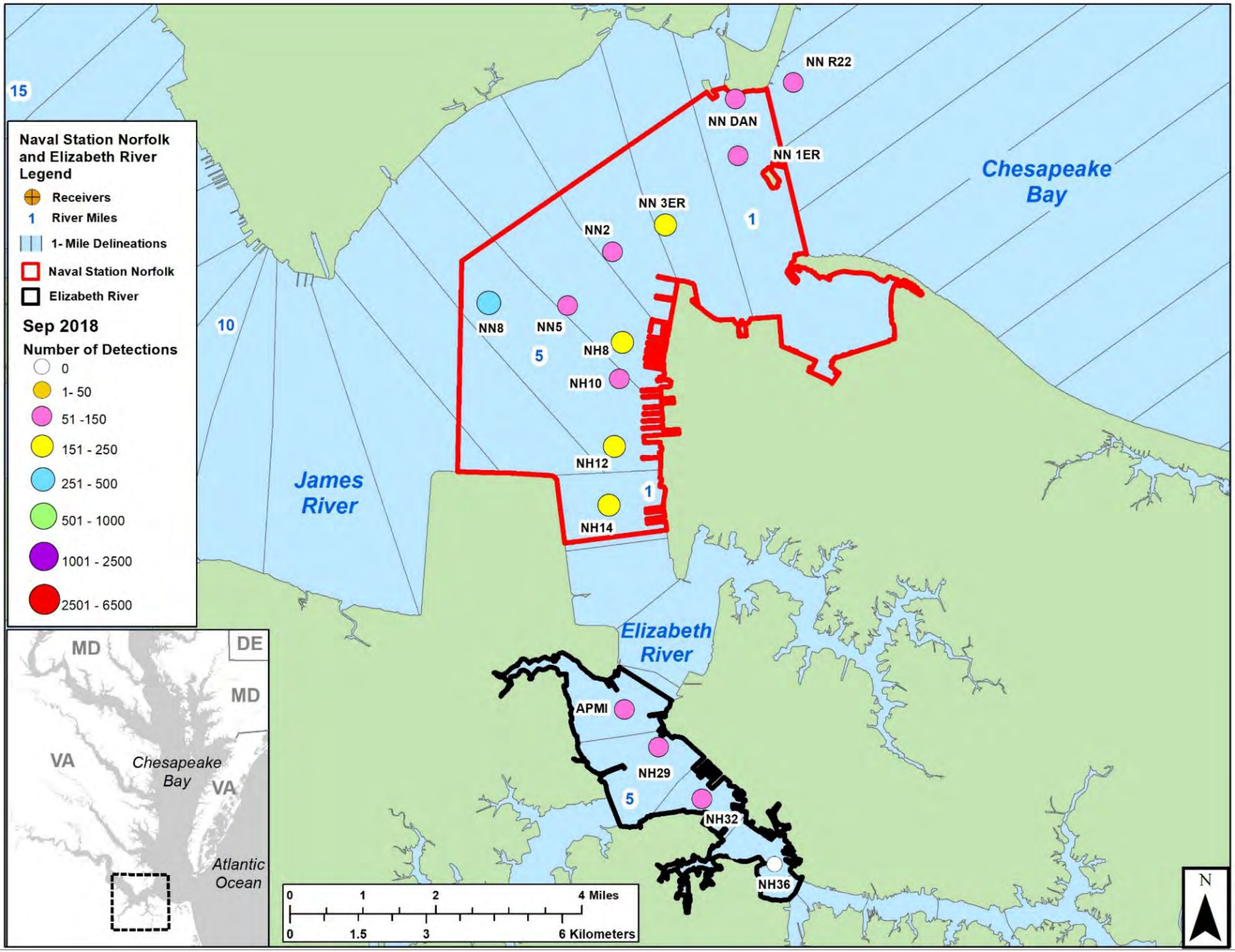
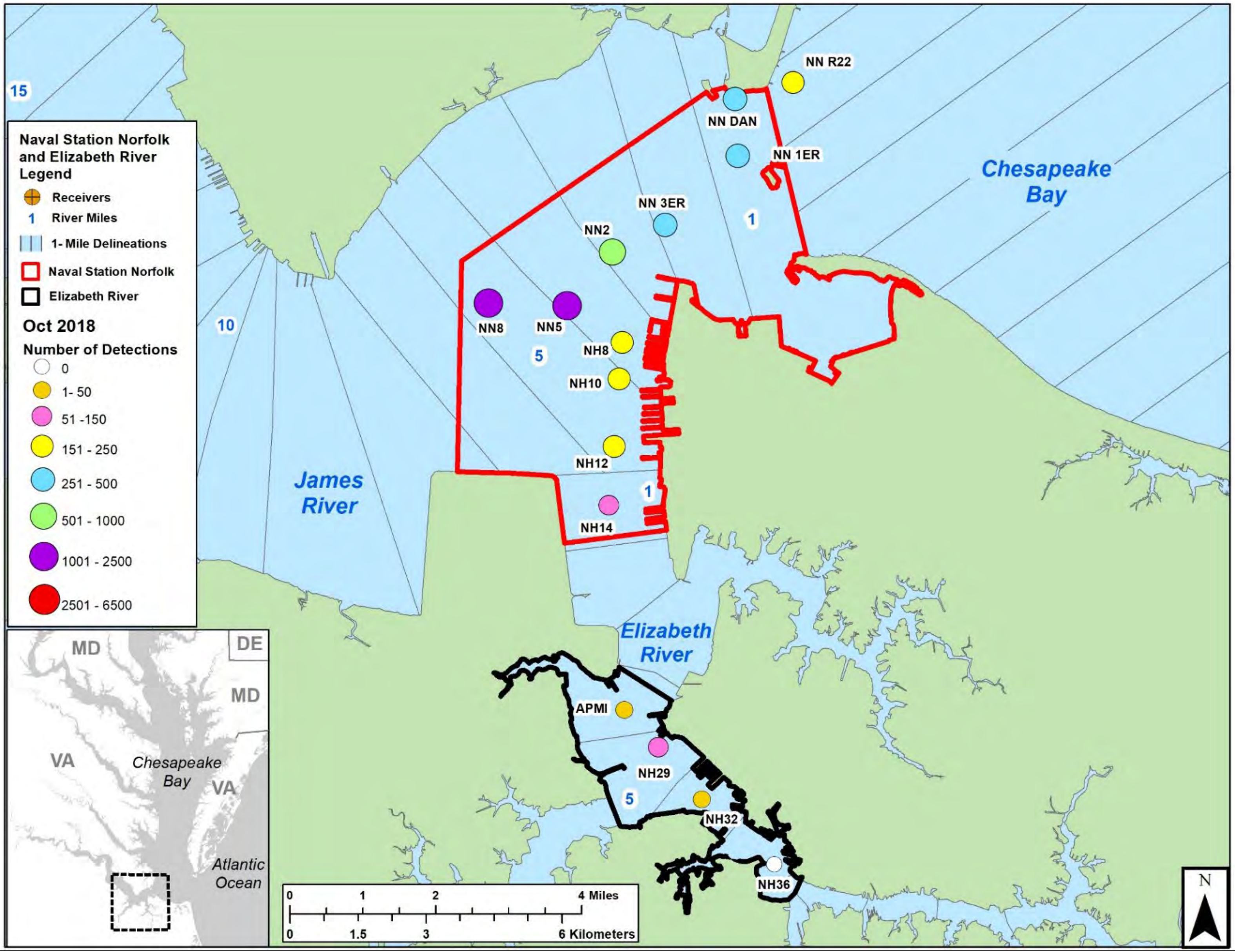
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

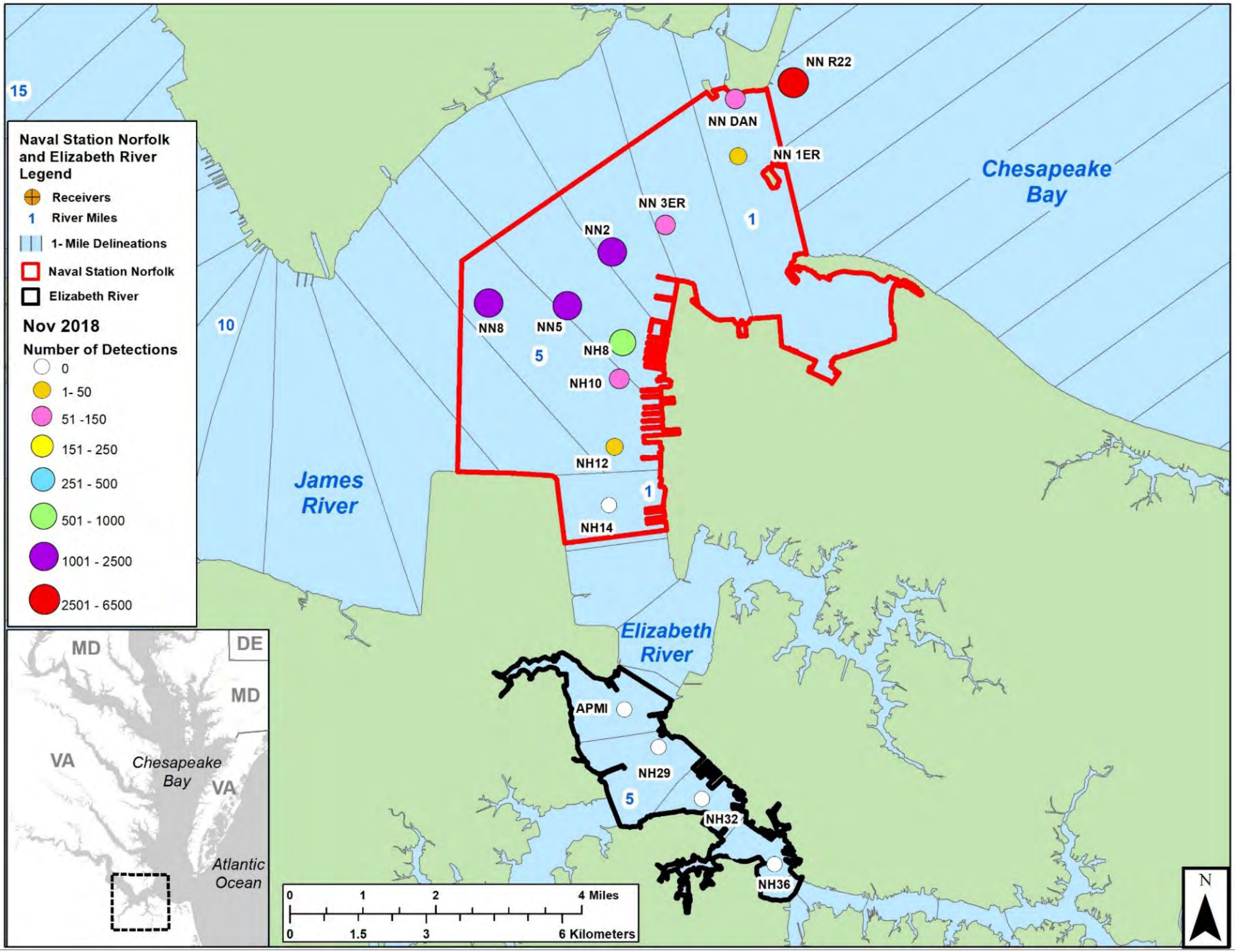

Naval Station Norfolk and Elizabeth River Legend
Receivers
River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Jun 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N


Naval Station Norfolk and Elizabeth River Legend
Receivers
River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Jul 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

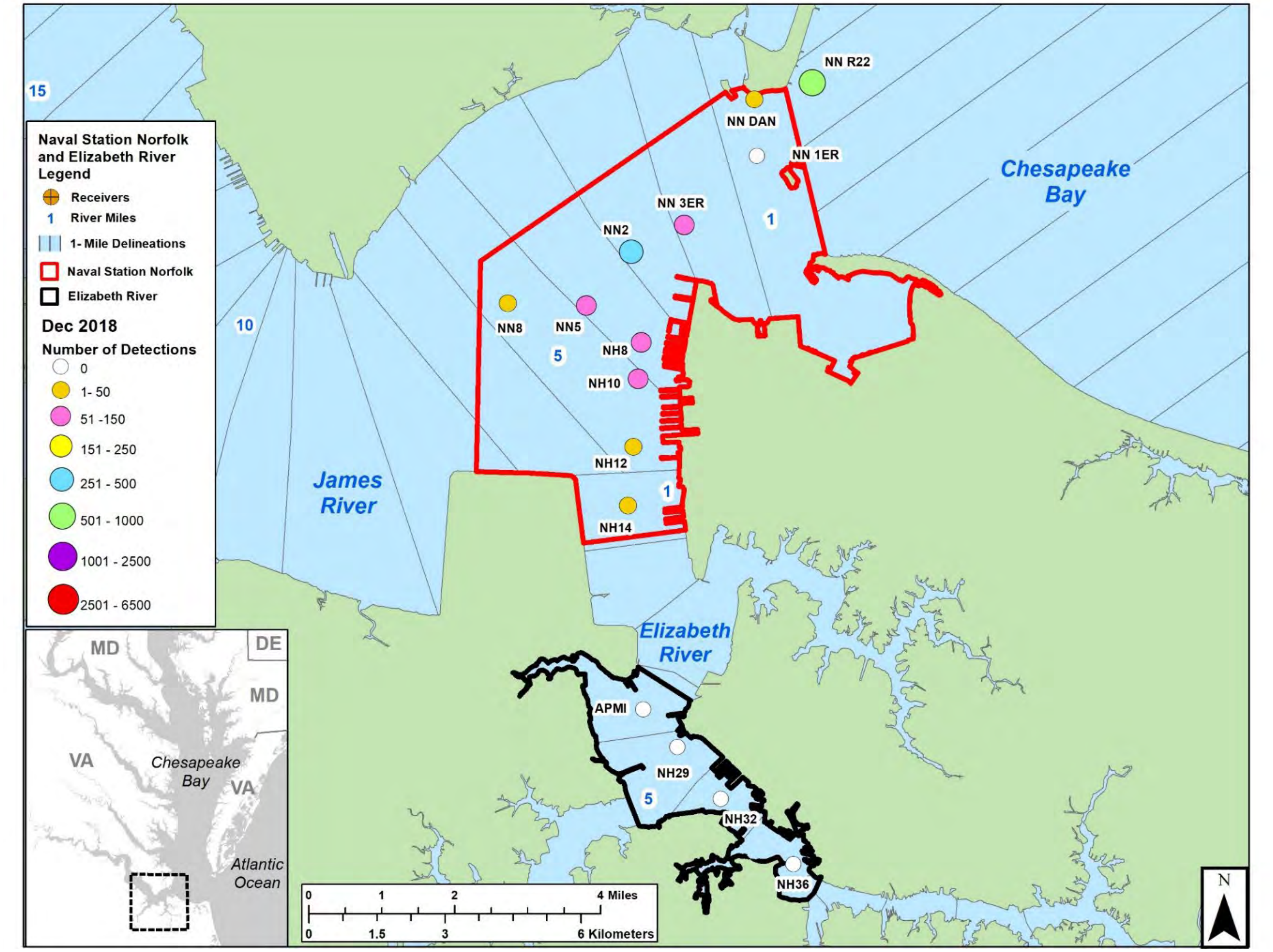

Naval Station Norfolk and Elizabeth River Legend
Receivers
River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Aug 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
15
10
5
1
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

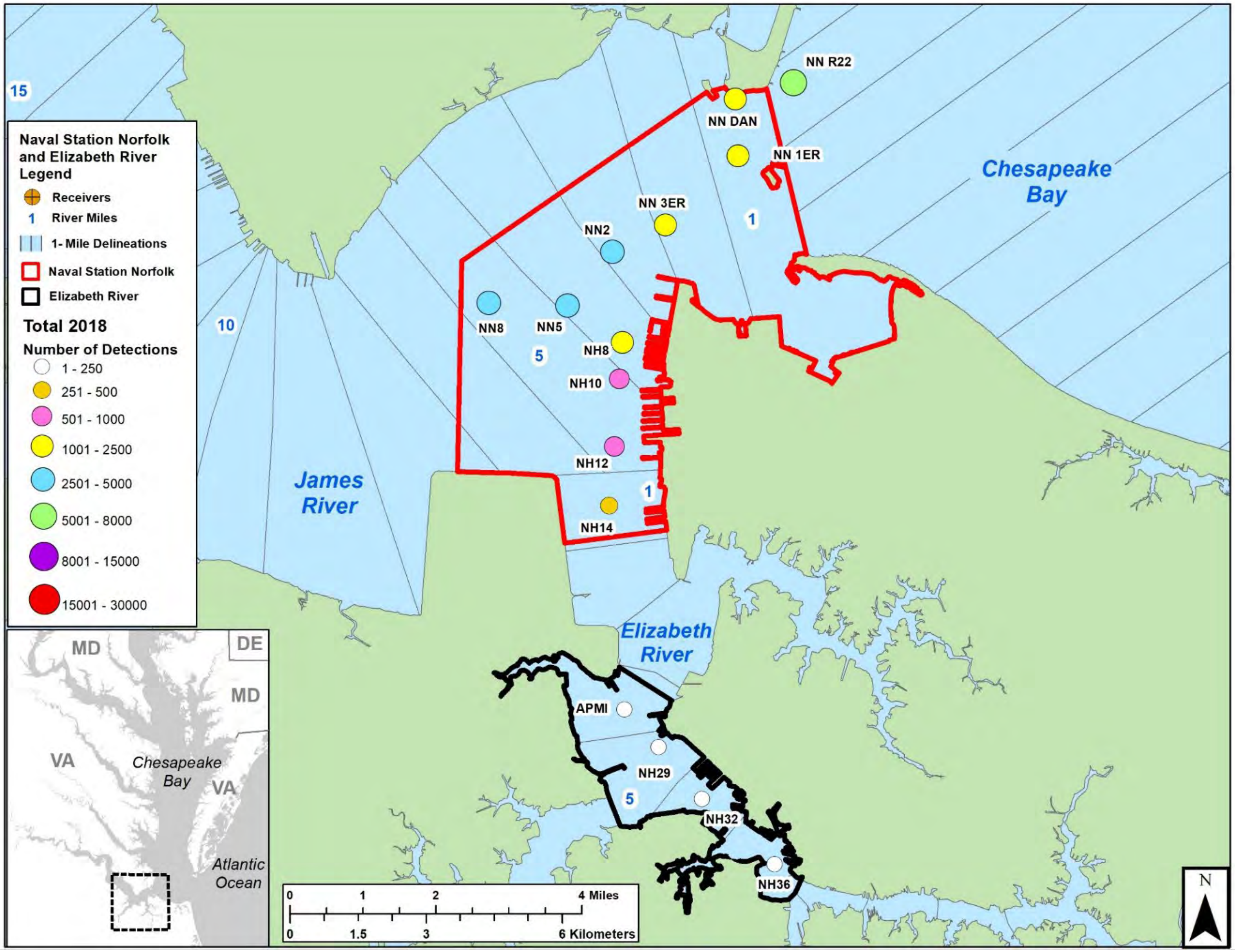

Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Sep 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

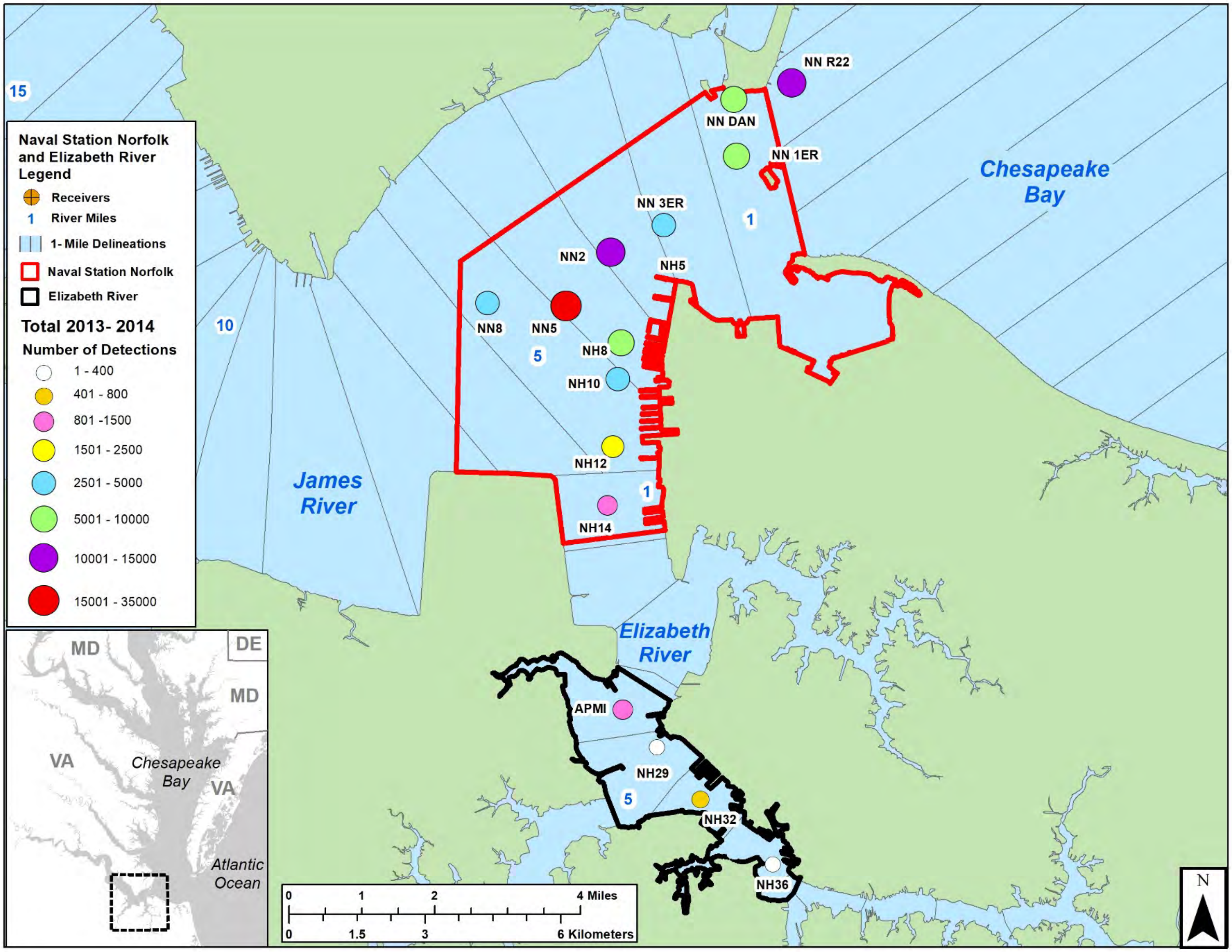

Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Oct 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
Chesapeake Bay
James River
Elizabeth River
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

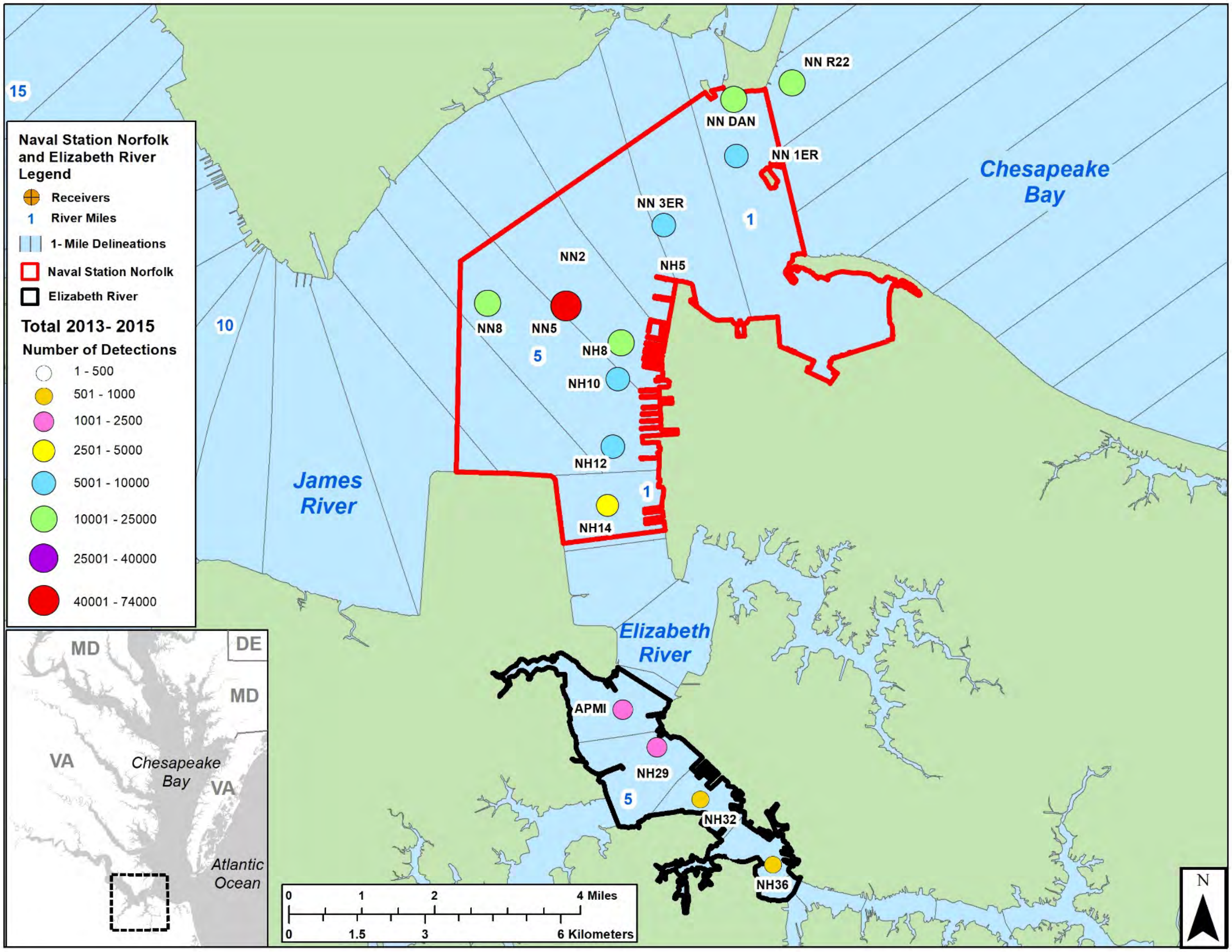


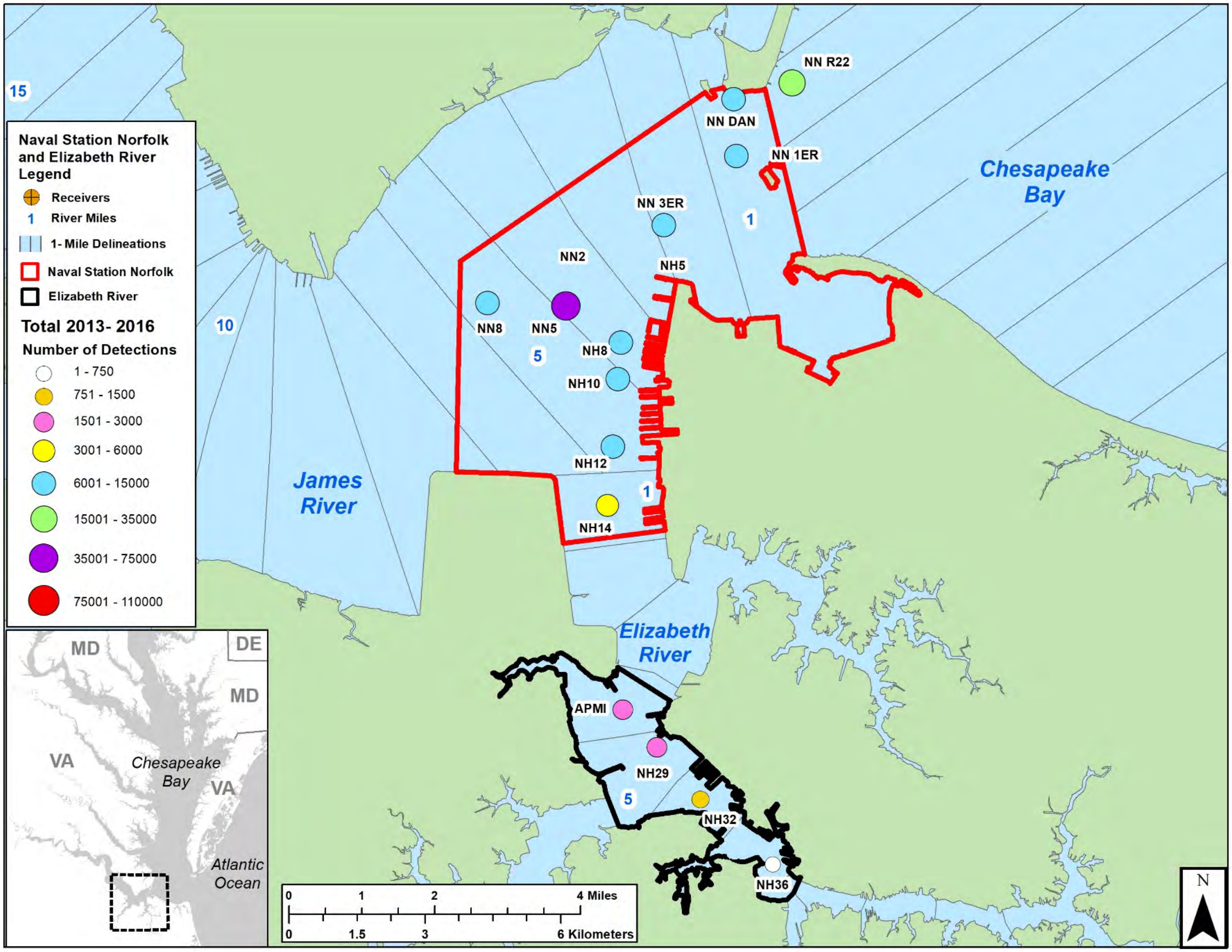
Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Nov 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Chesapeake Bay
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

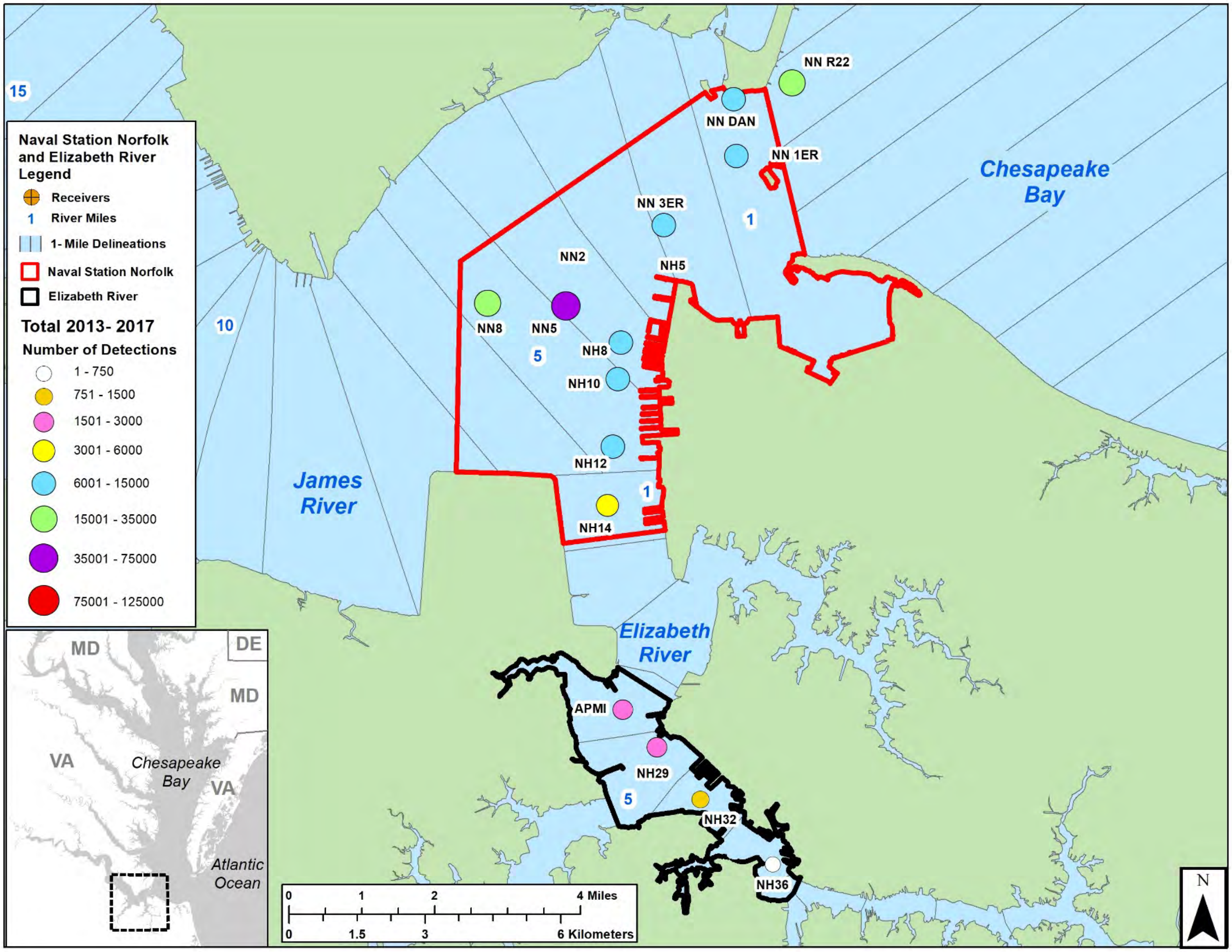

Naval Station Norfolk and Elizabeth River Legend
Receivers
River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Dec 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

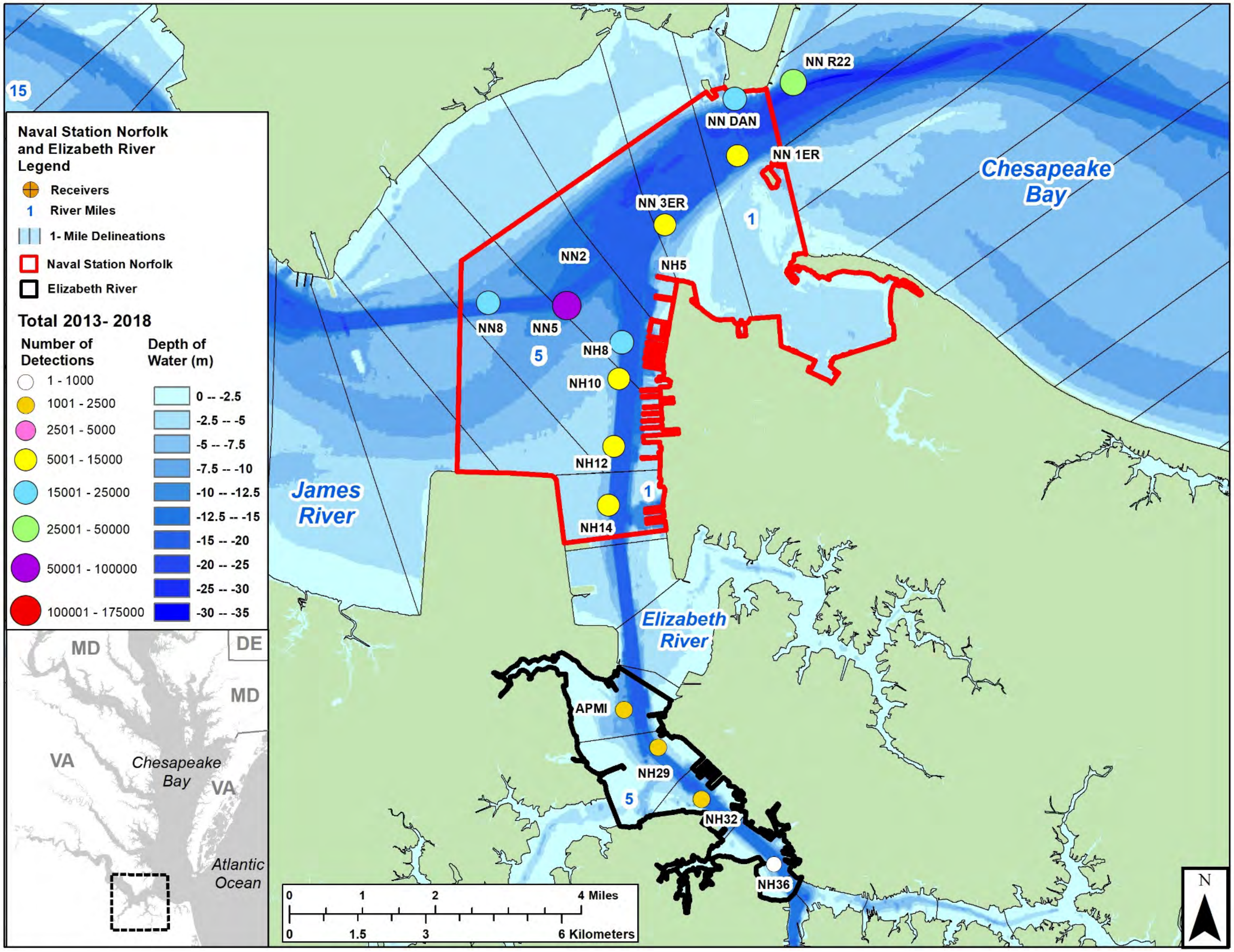

Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Total 2018
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

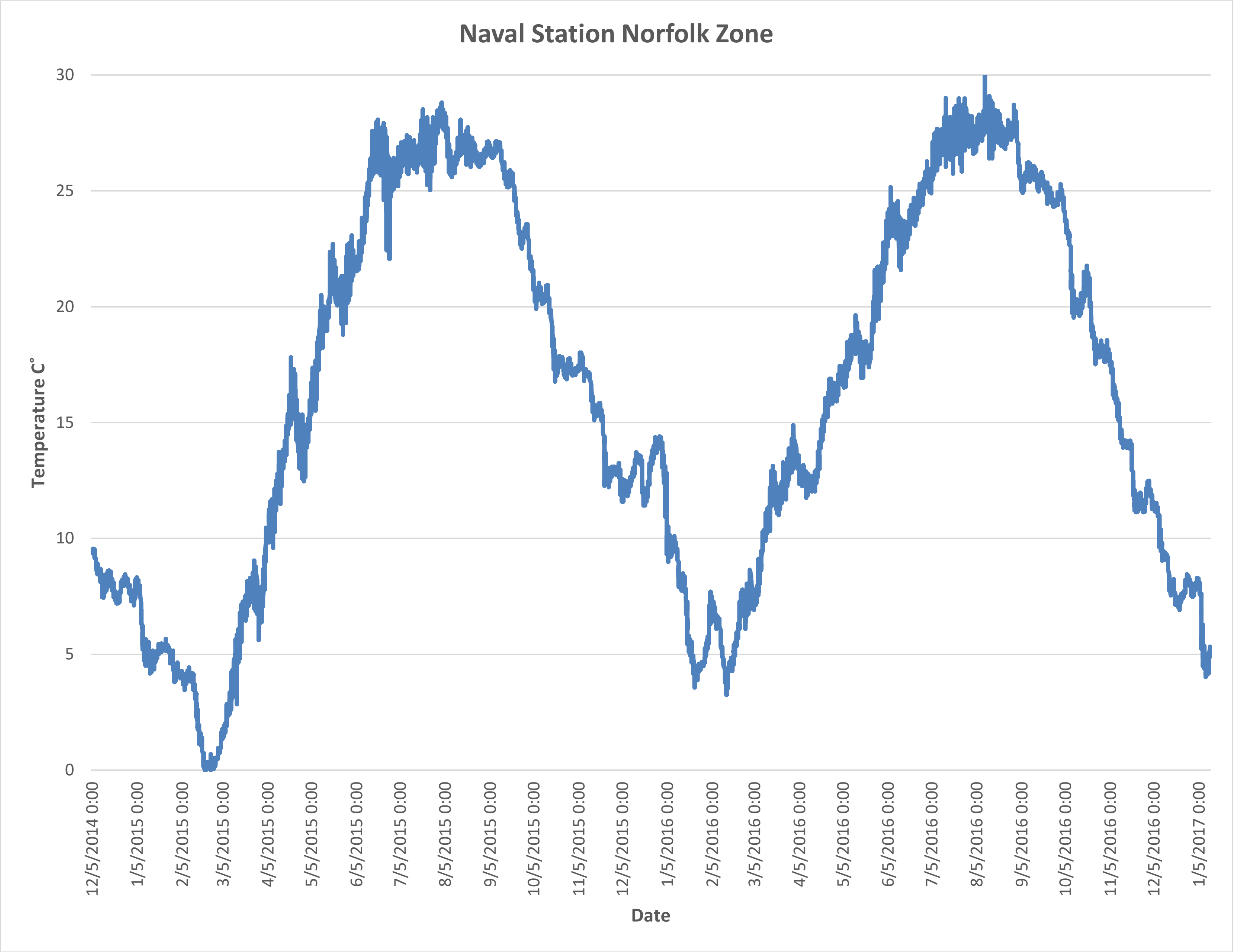

Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Total 2013- 2014
Number of Detections
1 - 400
401 - 800
801 -1500
1501 - 2500
2501 - 5000
5001 - 10000
10001 - 15000
15001 - 35000
15
10
5
1
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Chesapeake Bay
James River
Elizabeth River
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0
1
2
4 Miles
0
1.5
3
6 Kilometers
N


Naval Station Norfolk and Elizabeth River Legend
Receivers
River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Total 2013- 2015
Number of Detections
1 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 10000
10001 - 25000
25001 - 40000
40001 - 74000
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
15
10
5
1
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

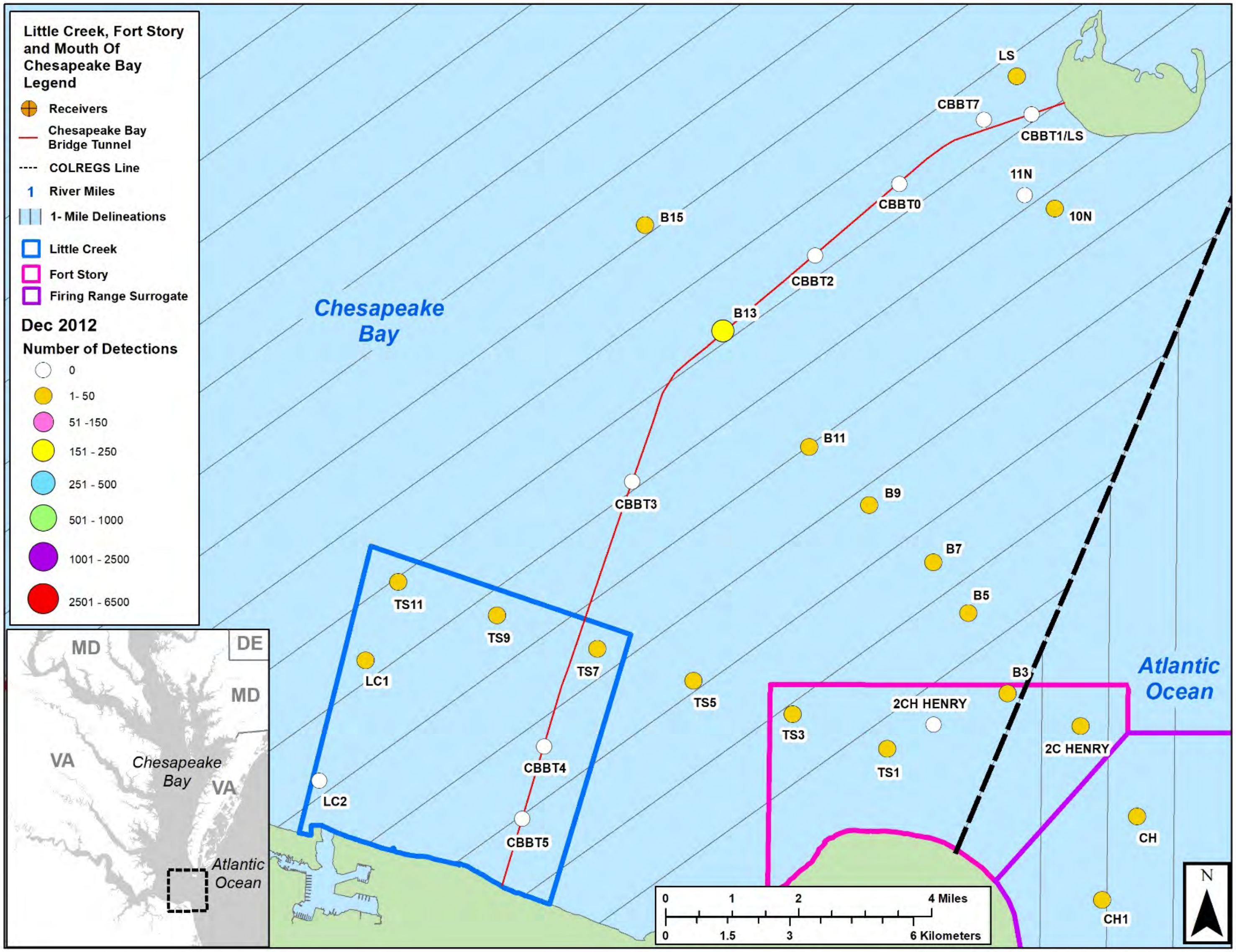

Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Total 2013- 2016
Number of Detections
1 - 750
751 - 1500
1501 - 3000
3001 - 6000
6001 - 15000
15001 - 35000
35001 - 75000
75001 - 110000
15
10
5
1
James River
Chesapeake Bay
Elizabeth River
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

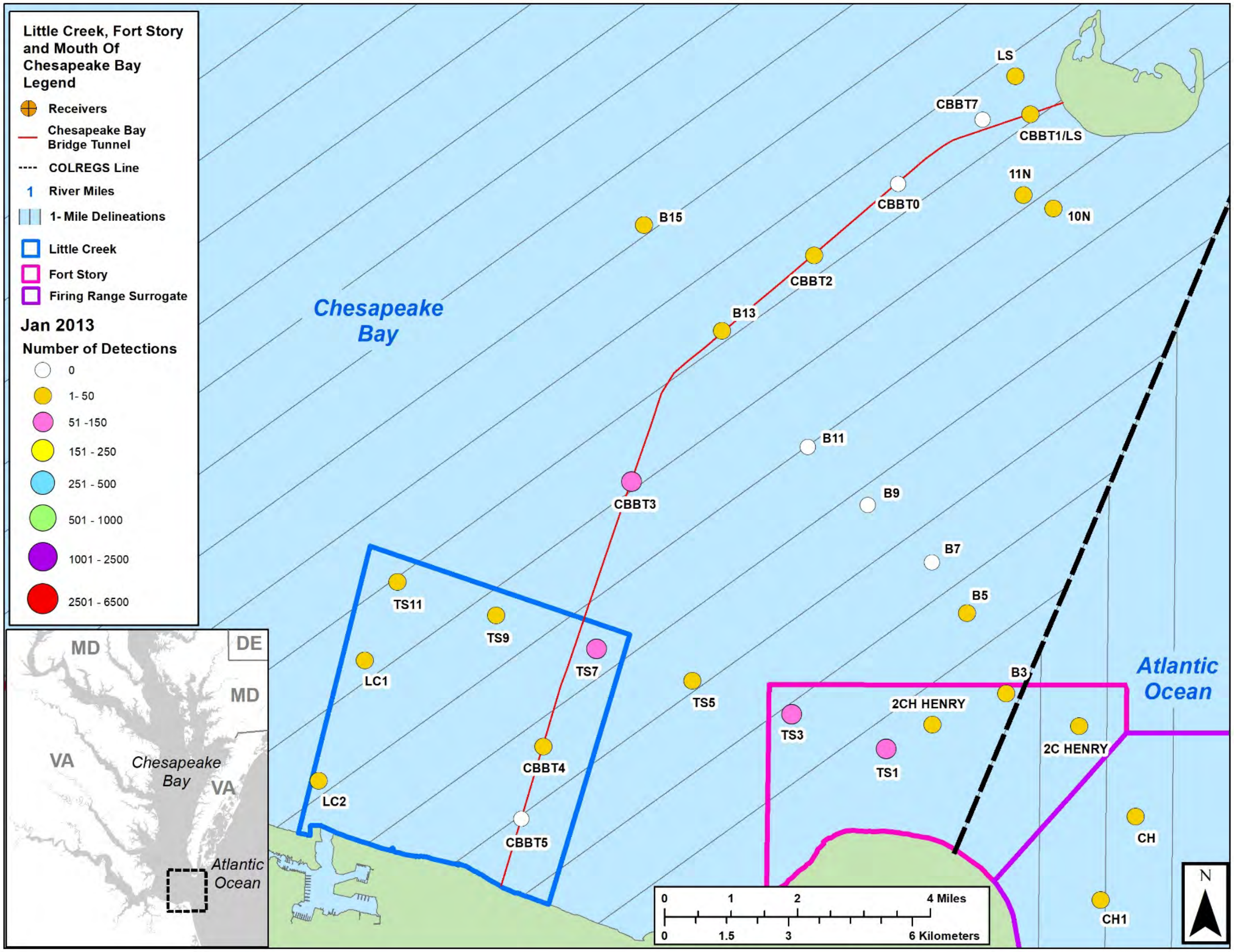

Naval Station Norfolk and Elizabeth River Legend
Receivers
River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Total 2013- 2017
Number of Detections
1 - 750
751 - 1500
1501 - 3000
3001 - 6000
6001 - 15000
15001 - 35000
35001 - 75000
75001 - 125000
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
15
10
5
1
Chesapeake Bay
James River
Elizabeth River
MD
DE
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

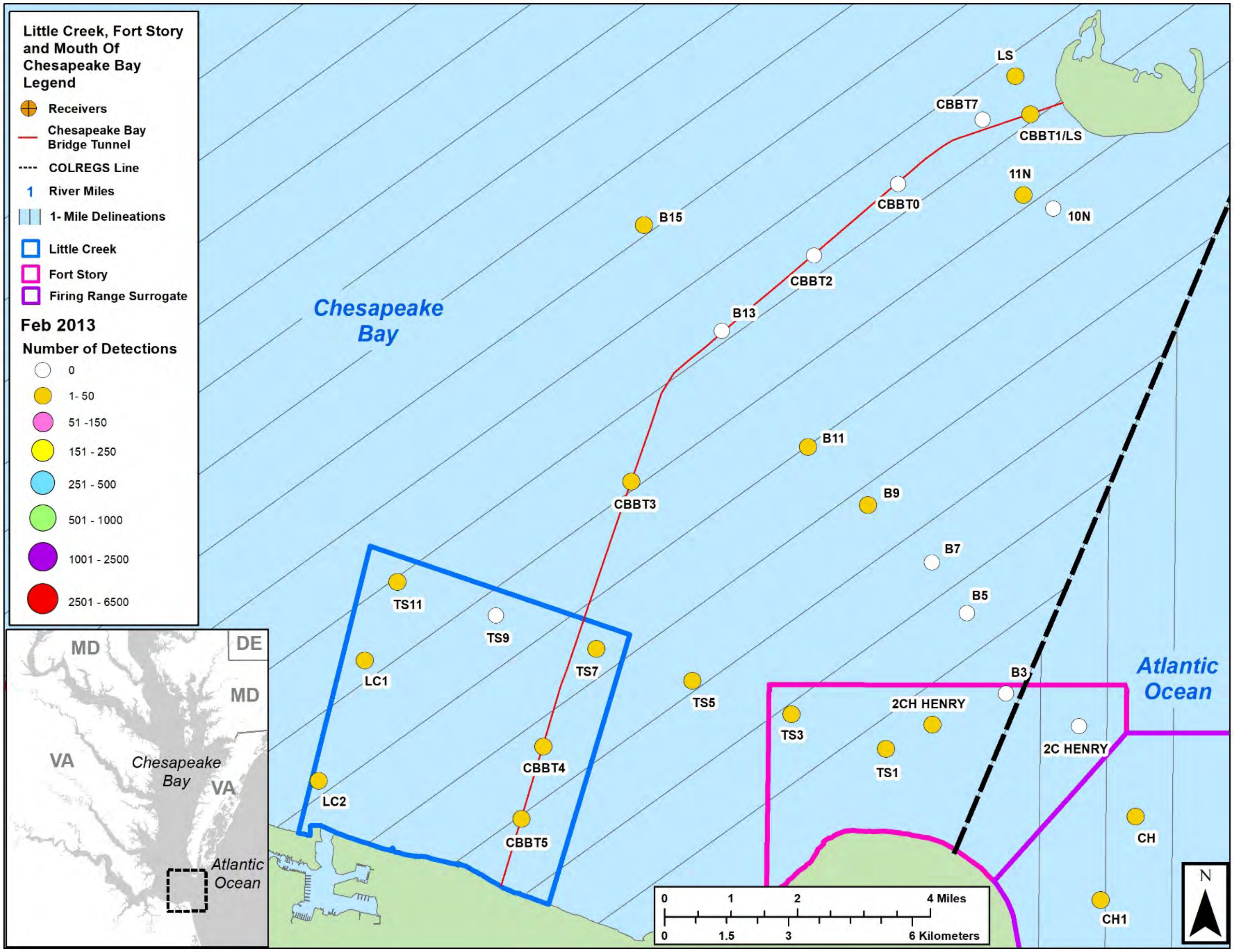

Naval Station Norfolk and Elizabeth River Legend
Receivers
1 River Miles
1- Mile Delineations
Naval Station Norfolk
Elizabeth River
Total 2013- 2018
Number of Detections
1 - 1000
1001 - 2500
2501 - 5000
5001 - 15000
15001 - 25000
25001 - 50000
50001 - 100000
100001 - 175000
Depth of Water (m)
0 -- -2.5
-2.5 -- -5
-5 -- -7.5
-7.5 -- -10
-10 -- -12.5
-12.5 -- -15
-15 -- -20
-20 -- -25
-25 -- -30
-30 -- -35
15
NN R22
NN DAN
NN 1ER
NN 3ER
1
Chesapeake Bay
NN2
NH5
NN8
NN5
5
NH8
NH10
NH12
1
NH14
James River
Elizabeth River
APMI
NH29
5
NH32
NH36
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

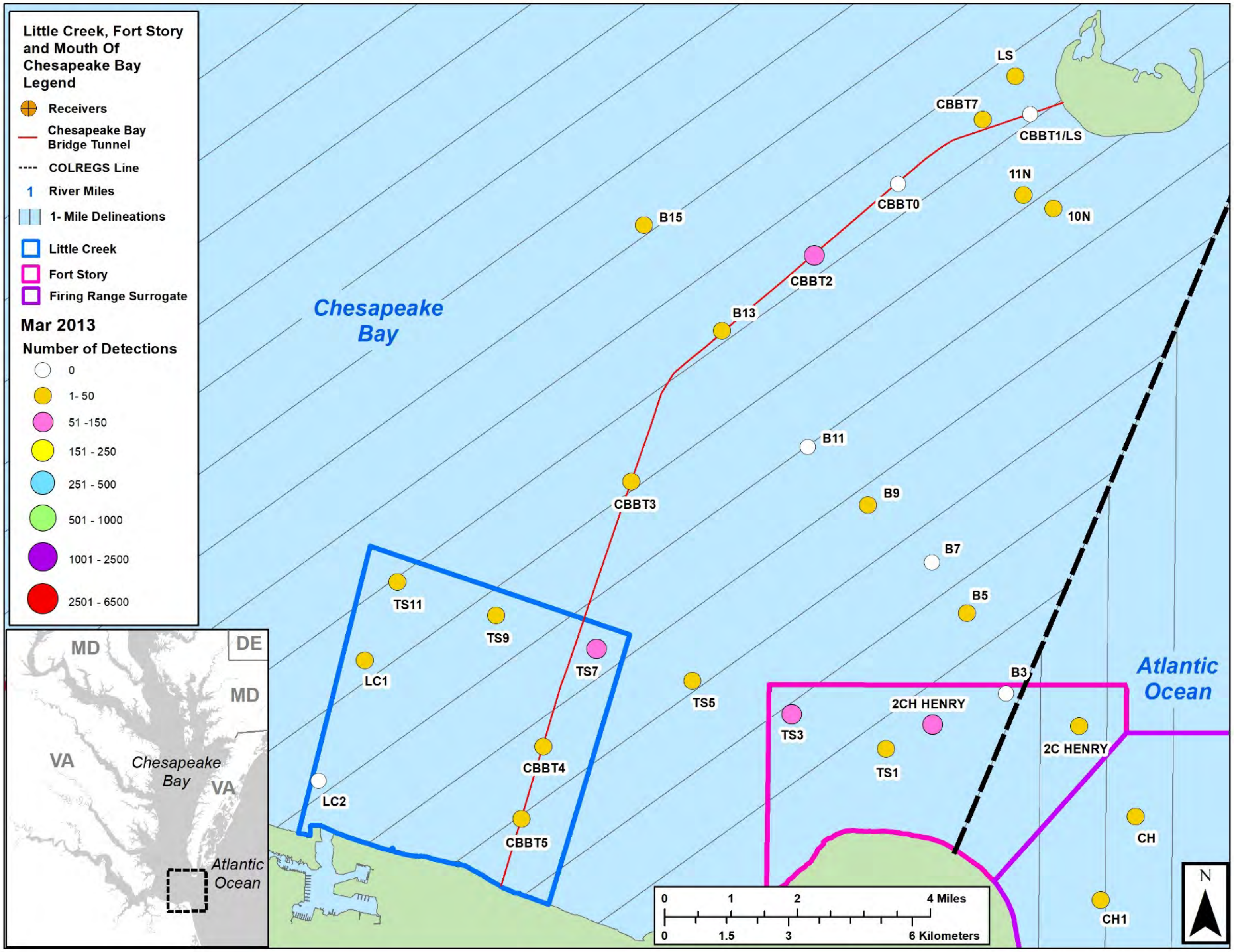

Naval Station Norfolk Zone
Temperature C˚
30
25
20
15
10
5
0
12/5/2014 0:00
1/5/2015 0:00
2/5/2015 0:00
3/5/2015 0:00
4/5/2015 0:00
5/5/2015 0:00
6/5/2015 0:00
7/5/2015 0:00
8/5/2015 0:00
9/5/2015 0:00
10/5/2015 0:00
11/5/2015 0:00
12/5/2015 0:00
1/5/2016 0:00
2/5/2016 0:00
3/5/2016 0:00
4/5/2016 0:00
5/5/2016 0:00
6/5/2016 0:00
7/5/2016 0:00
8/5/2016 0:00
9/5/2016 0:00
10/5/2016 0:00
11/5/2016 0:00
12/5/2016 0:00
1/5/2017 0:00
Date

8.8. Appendix 8.8: Detections of Sonic-tagged Atlantic Sturgeon in the Chesapeake Bay Region (Little Creek Zone and Fort Story Zone), by Month, Year, and Overall




Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Jan 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
11N
10N
CBBT0
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
B3
2CH HENRY
TS3
2C HENRY
TS1
CBBT4
LC2
CBBT5
CH
CH1
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean


Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Feb 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
11N
10N
CBBT0
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
B3
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean


Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Mar 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
11N
10N
CBBT0
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
B3
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
2C HENRY
TS1
CBBT4
LC2
CBBT5
CH
CH1
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N
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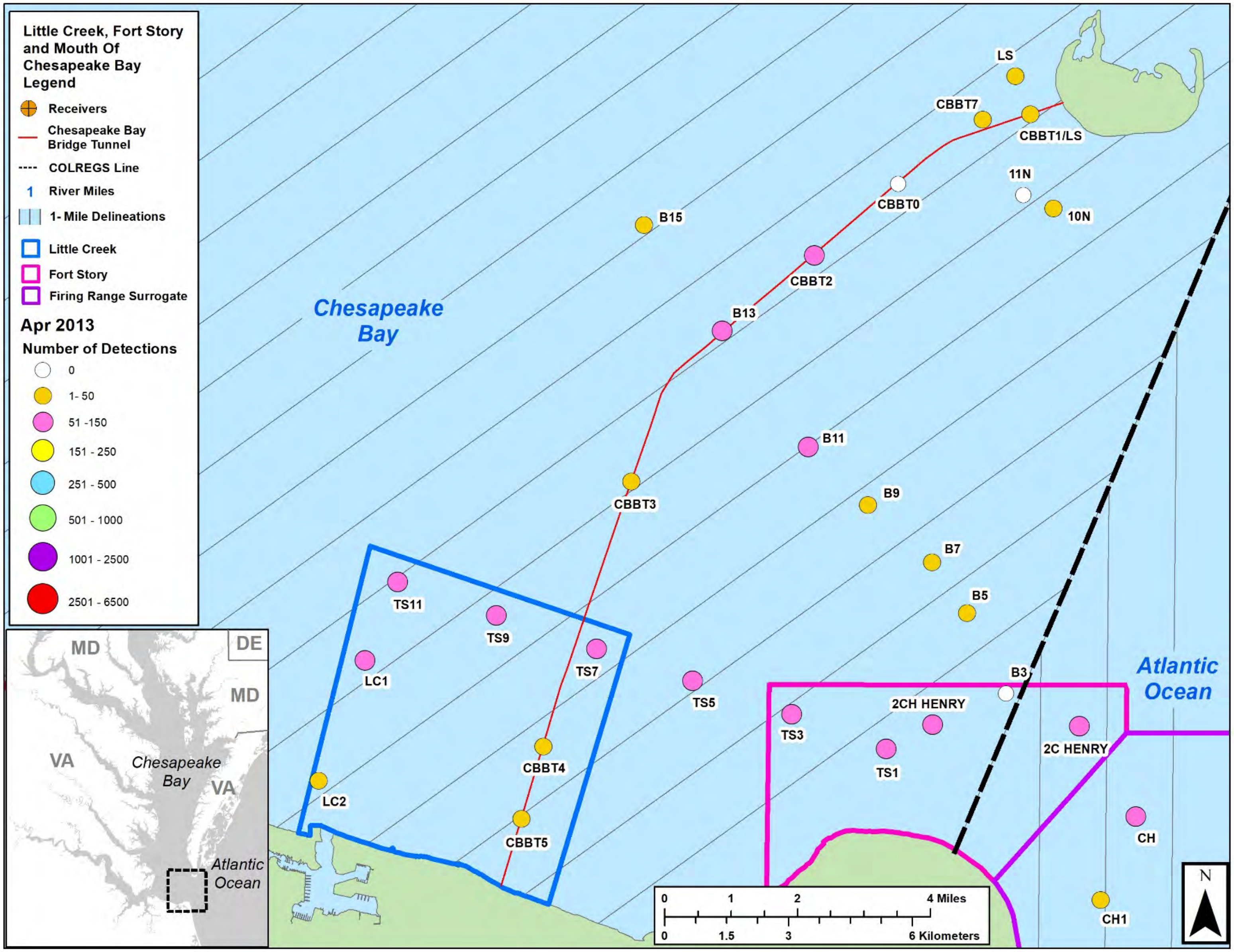
VA
Atlantic Ocean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Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Apr 2013
Number of Detections
0
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51 -150
151 - 250
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501 - 1000
1001 - 2500
2501 - 6500
Chesapeake Bay
Atlantic Ocean
LS
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CBBT1/LS
11N
CBBT0
10N
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2C HENRY
TS1
CBBT4
LC2
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0 1.5 3 6 Kilometers
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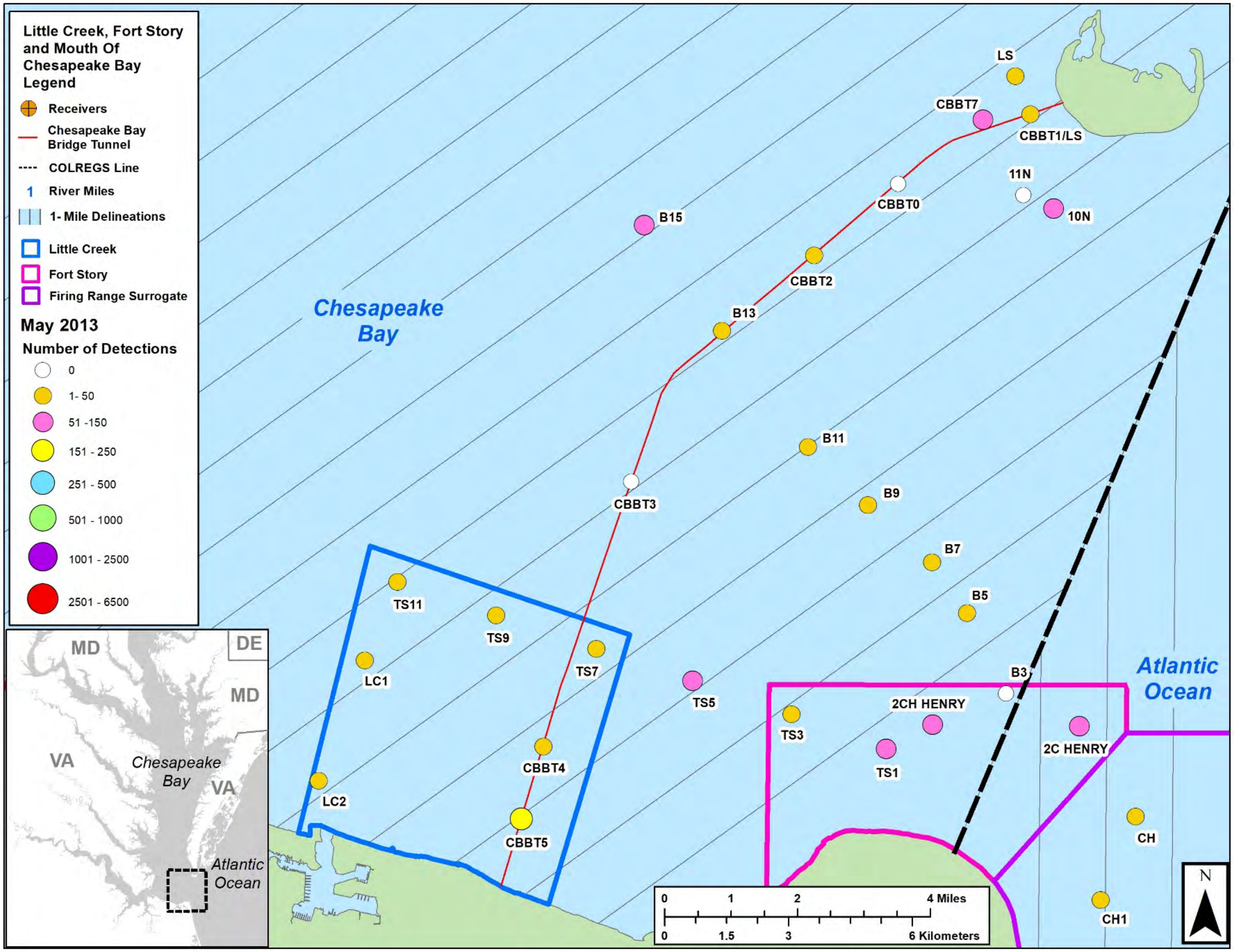
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COLREGS Line
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1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
May 2013
Number of Detections
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Atlantic Ocean
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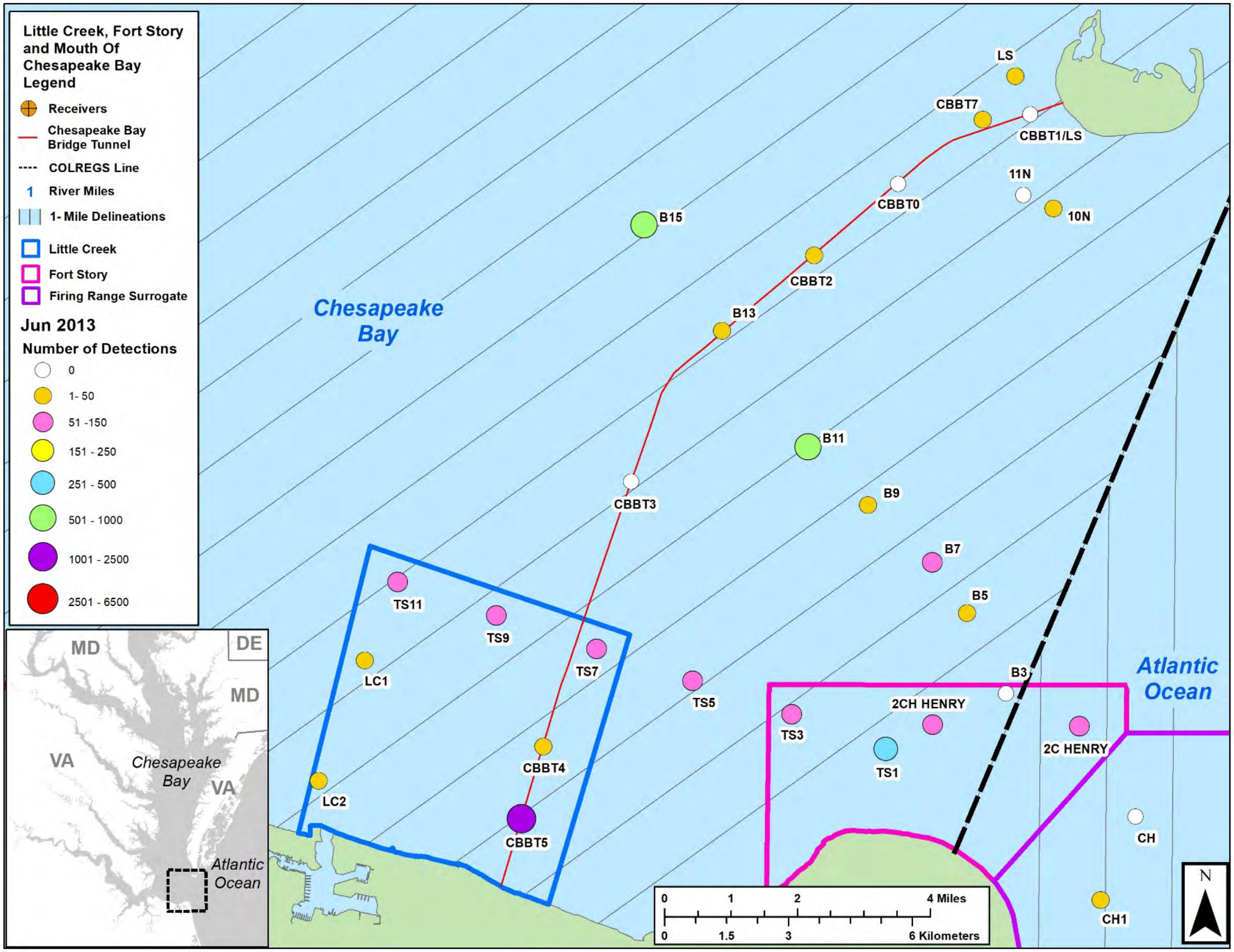
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COLREGS Line
River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Jun 2013
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2501 - 6500
Chesapeake Bay
Atlantic Ocean
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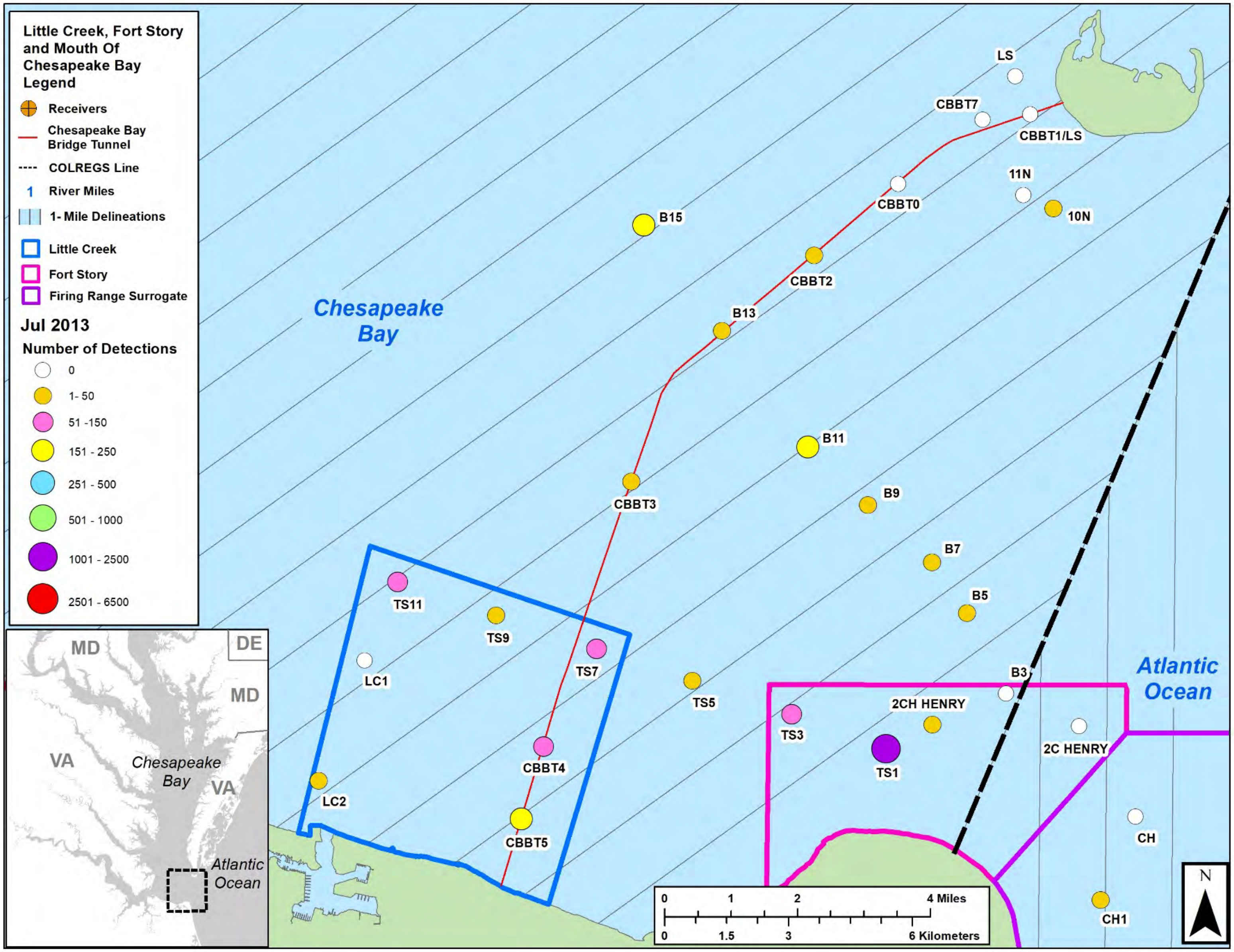
Atlantic Ocean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Little Creek
Fort Story
Firing Range Surrogate
Jul 2013
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Atlantic Ocean
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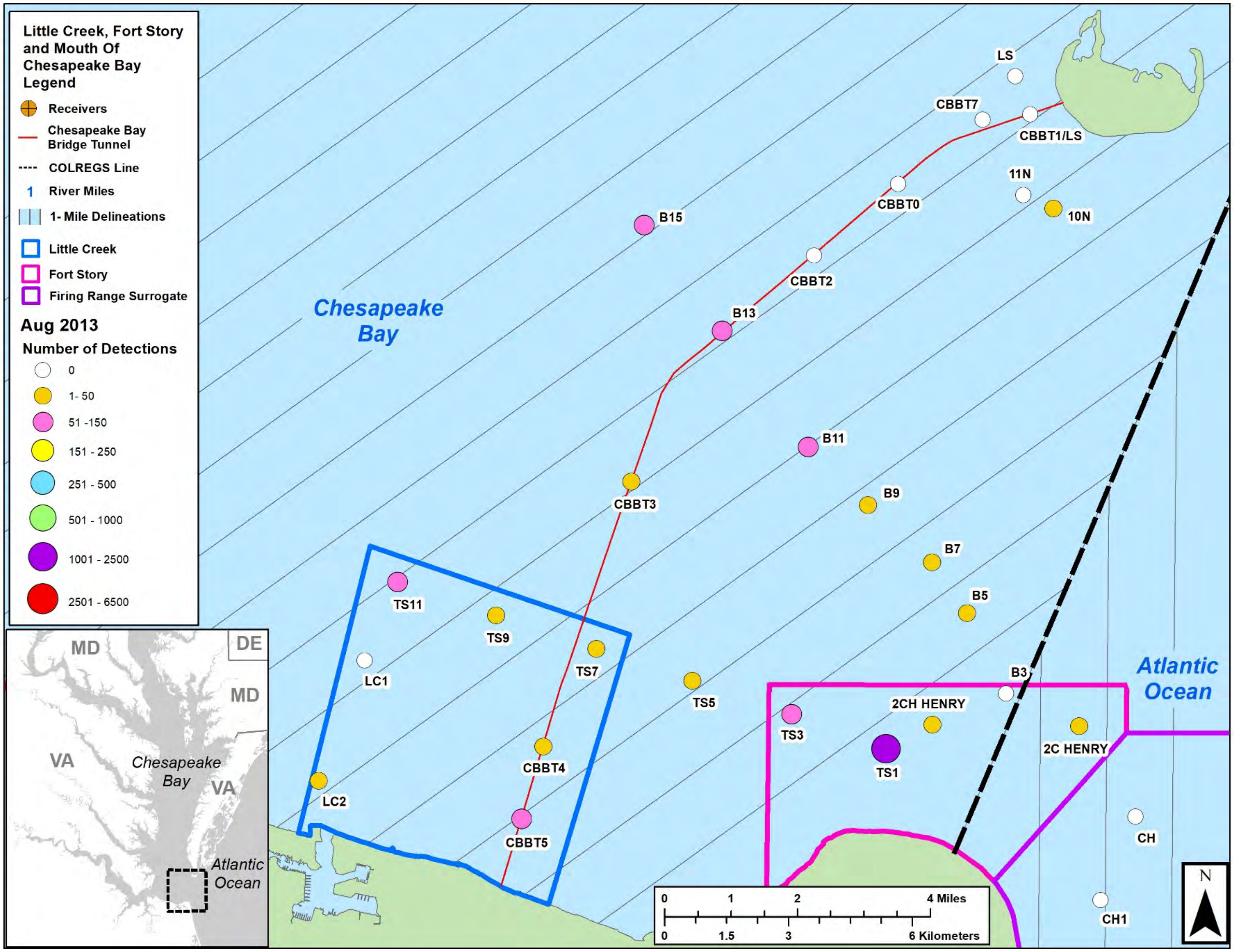
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Chesapeake Bay Bridge Tunnel
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River Miles
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Little Creek
Fort Story
Firing Range Surrogate
Aug 2013
Number of Detections
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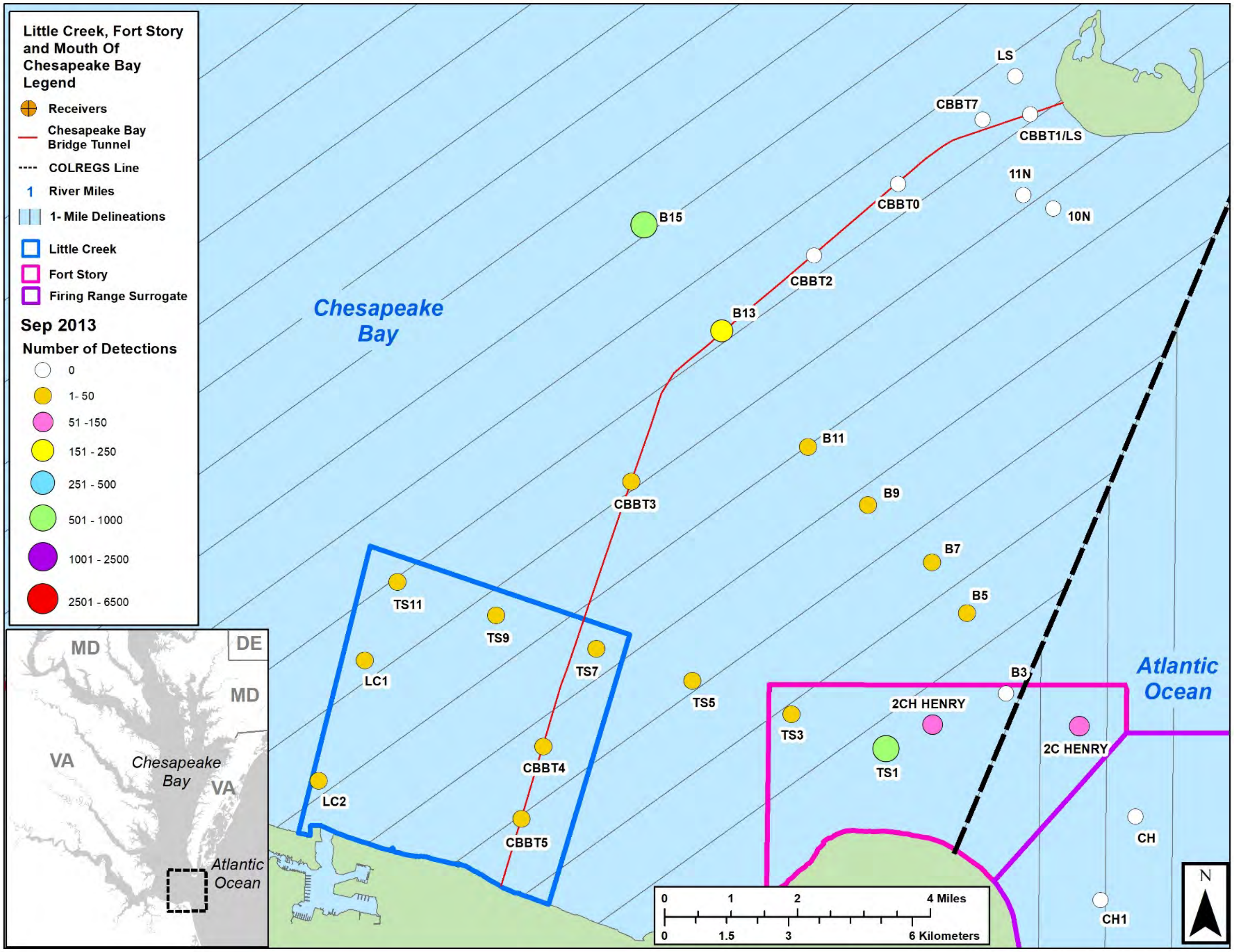
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Chesapeake Bay Bridge Tunnel
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1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Sep 2013
Number of Detections
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Atlantic Ocean
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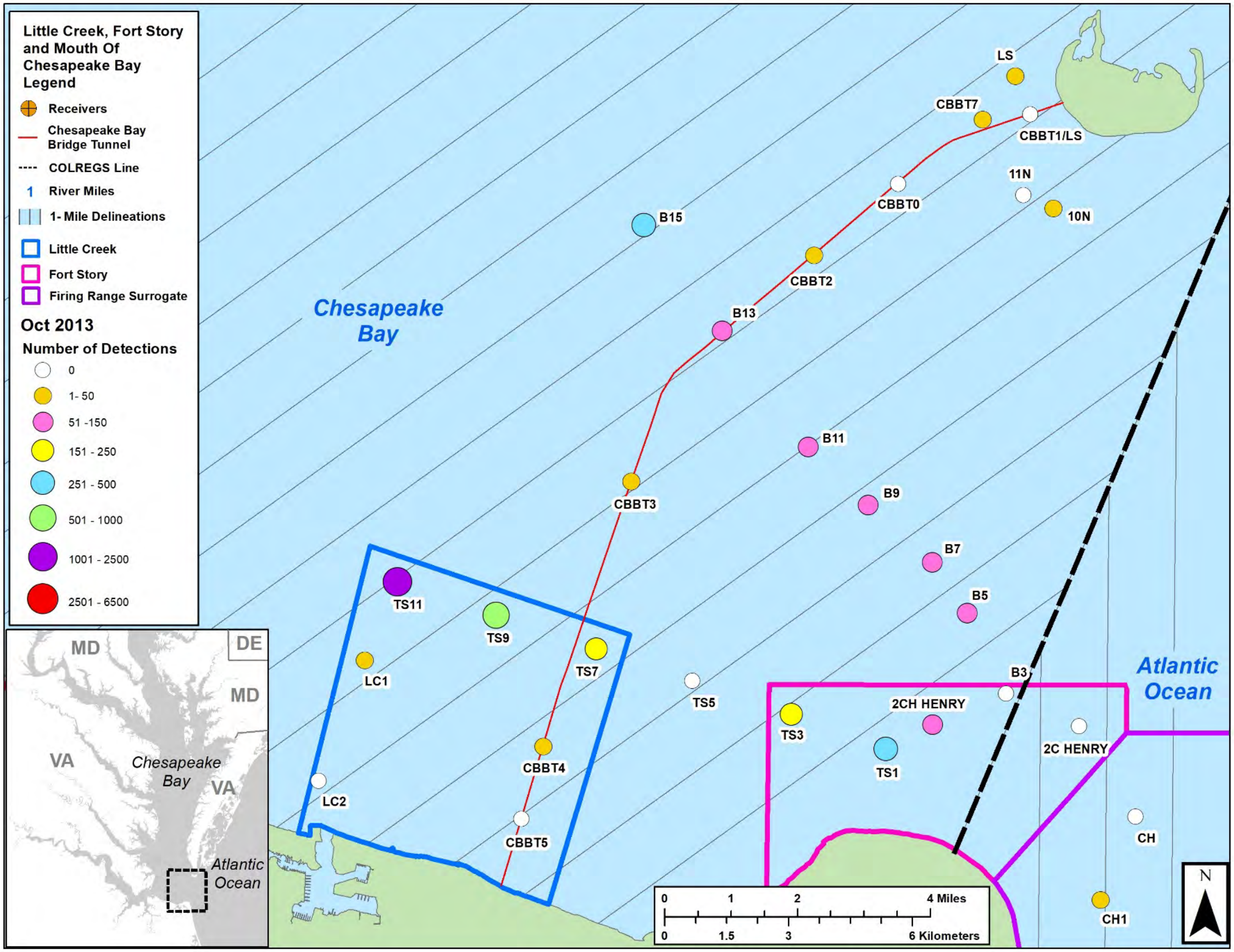
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COLREGS Line
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1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Oct 2013
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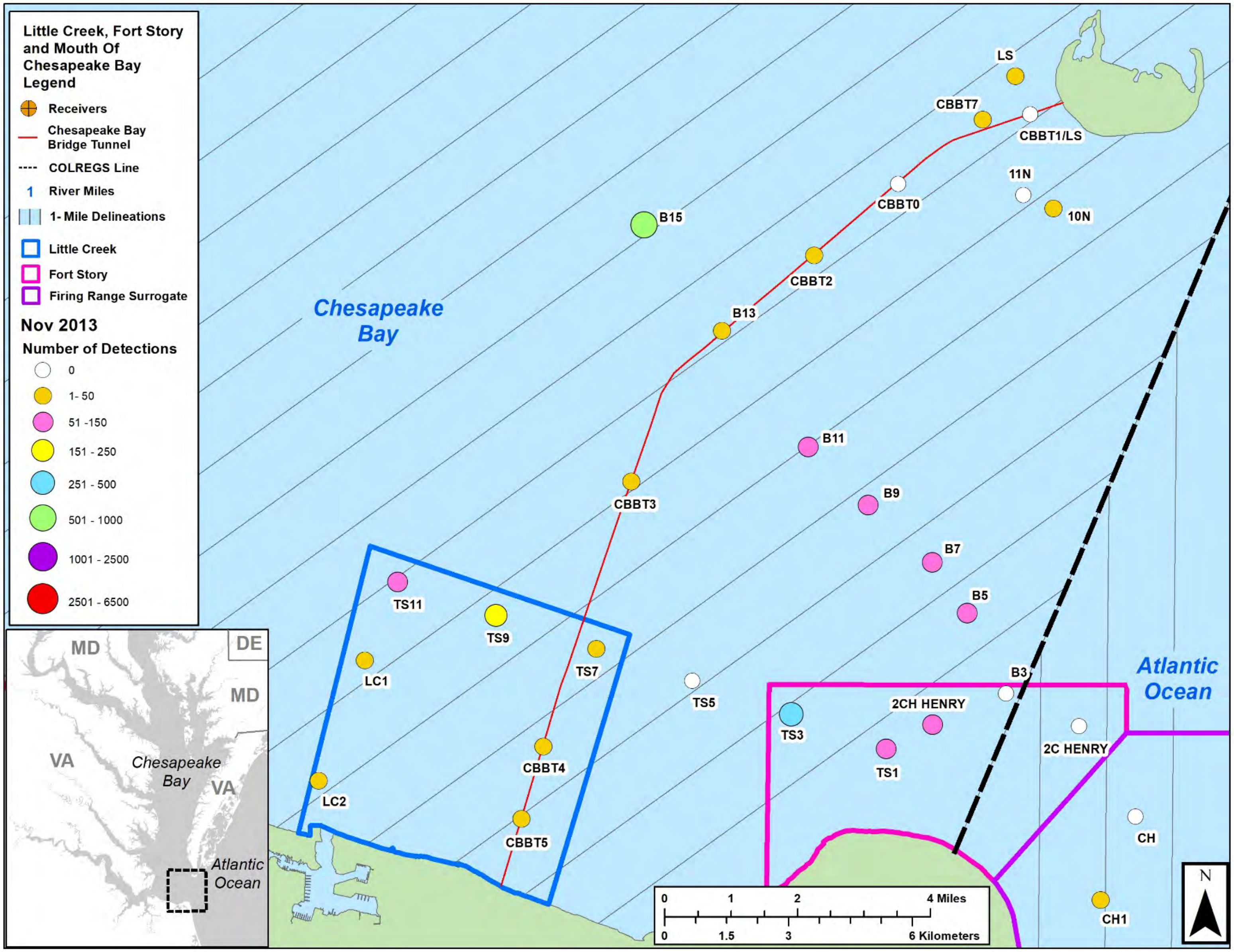
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1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Nov 2013
Number of Detections
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Chesapeake Bay
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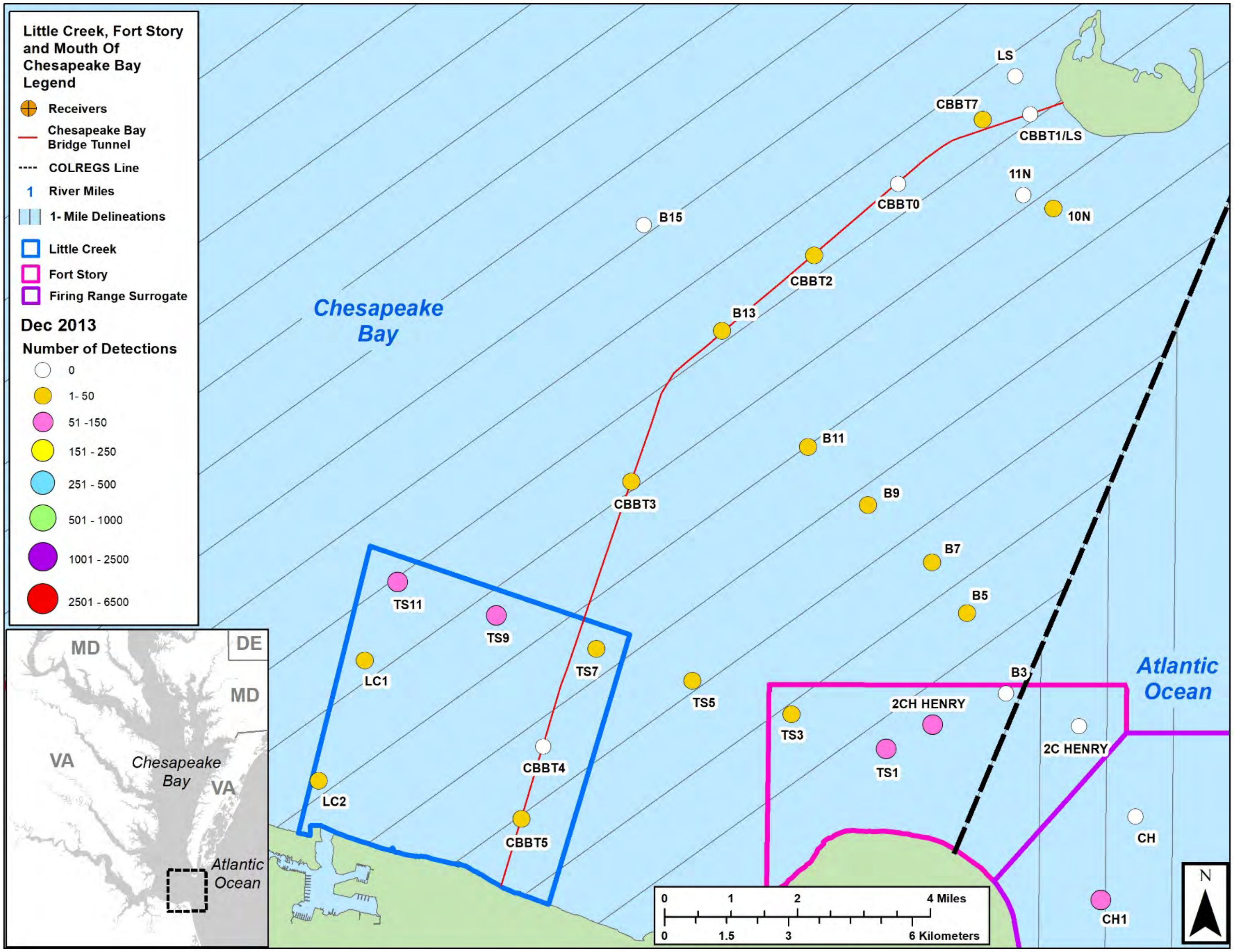
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Fort Story
Firing Range Surrogate
Dec 2013
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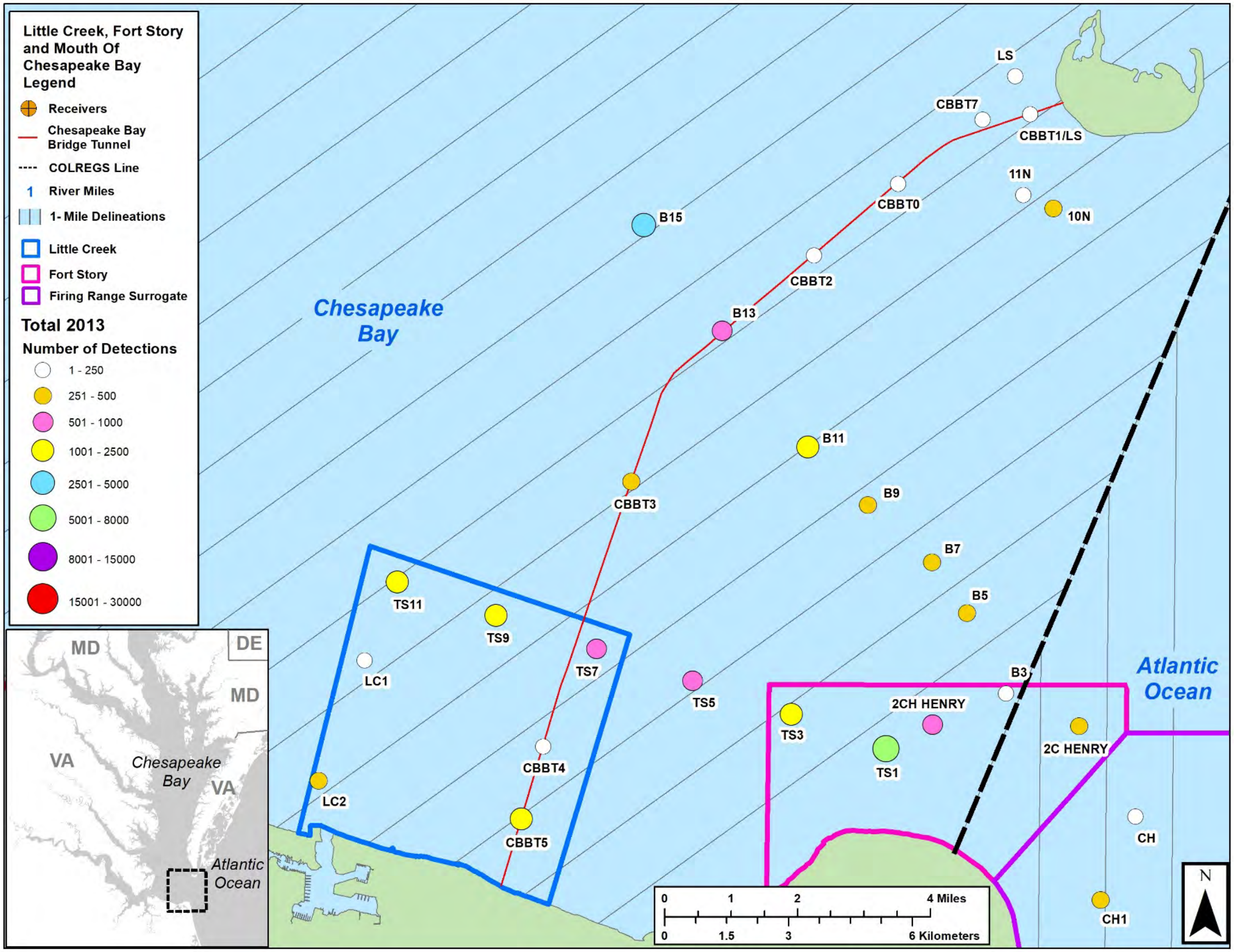
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COLREGS Line
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1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Total 2013
Number of Detections
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Atlantic Ocean
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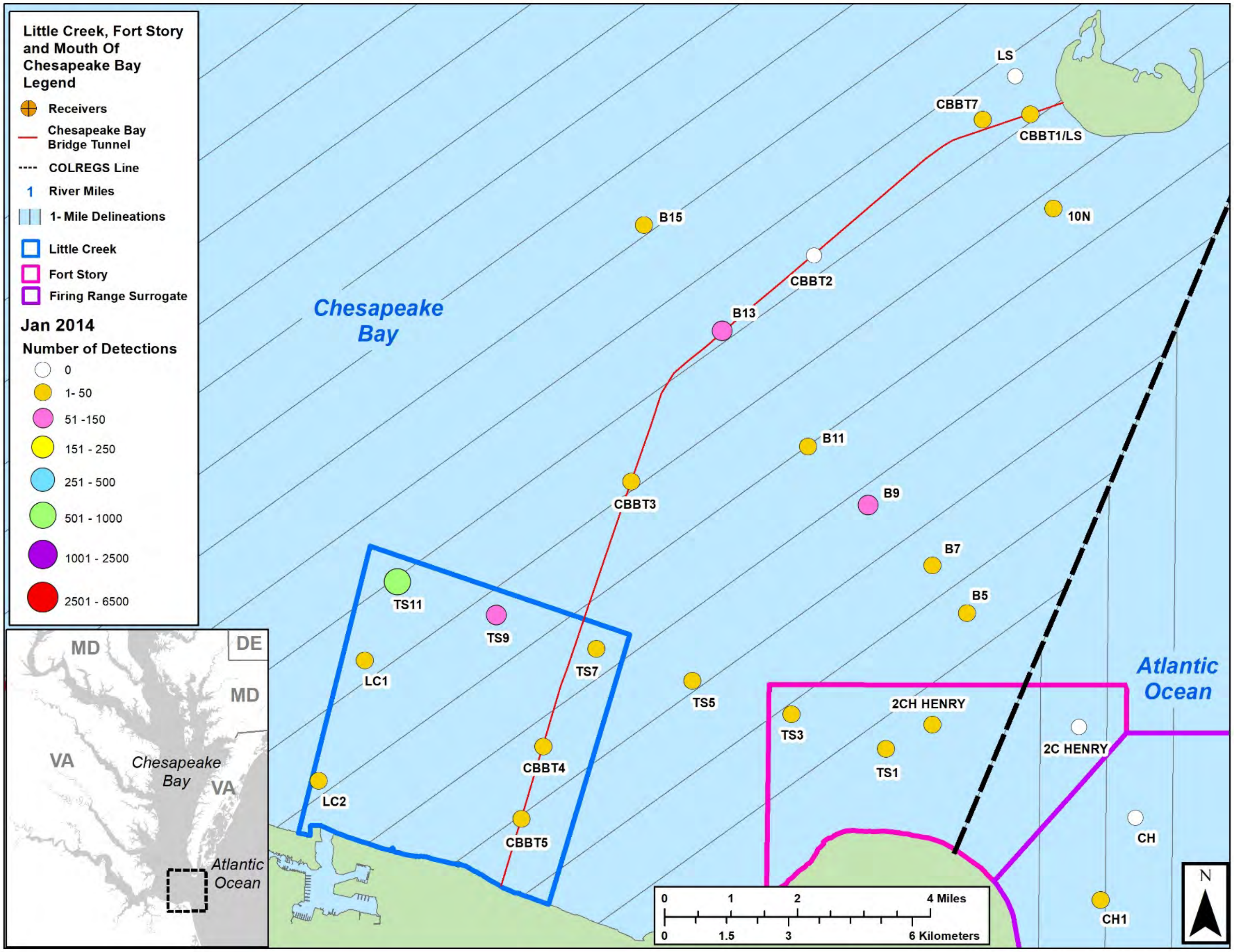
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River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Jan 2014
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Atlantic Ocean
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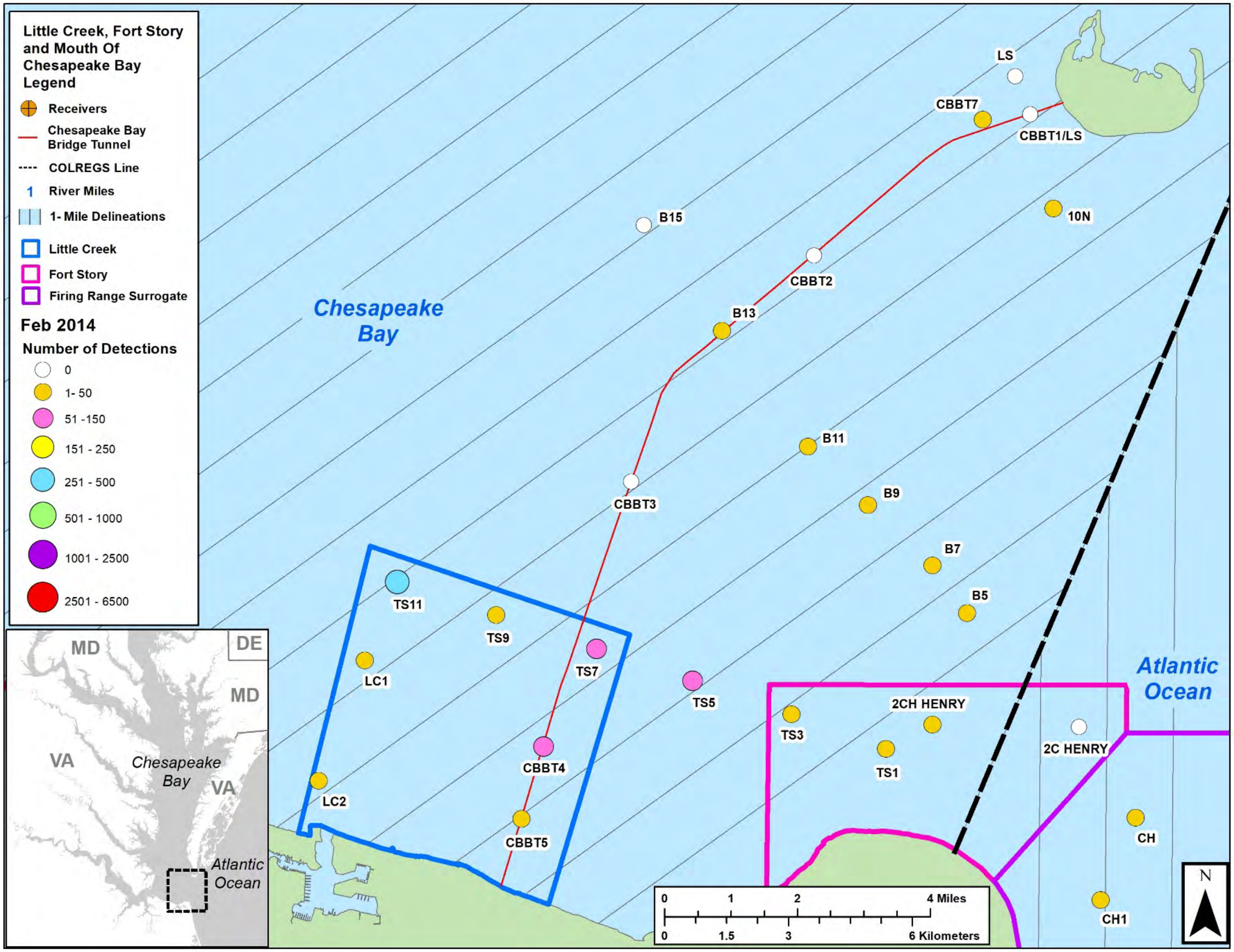
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Firing Range Surrogate
Feb 2014
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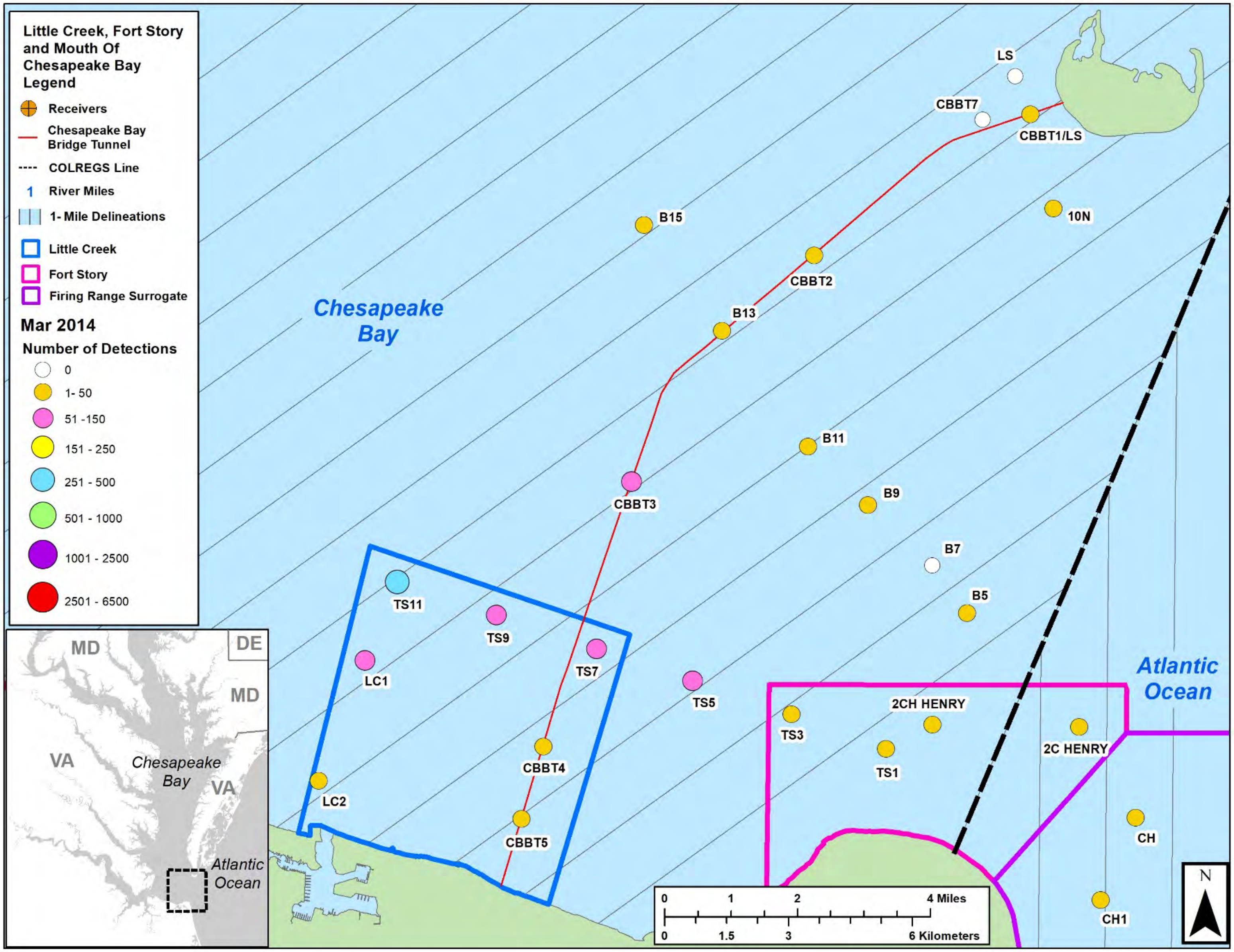
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1- Mile Delineations
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Fort Story
Firing Range Surrogate
Mar 2014
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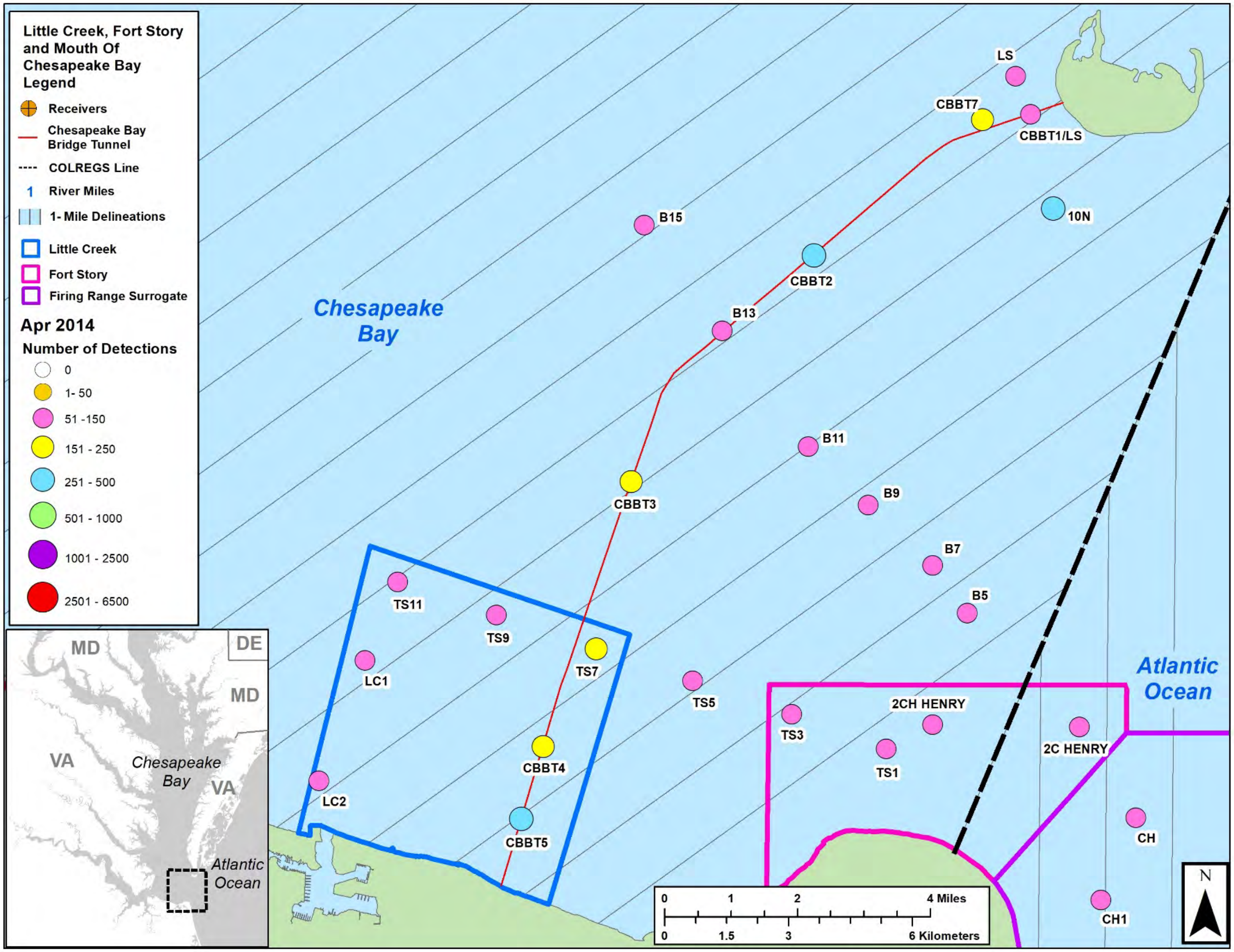
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Fort Story
Firing Range Surrogate
Apr 2014
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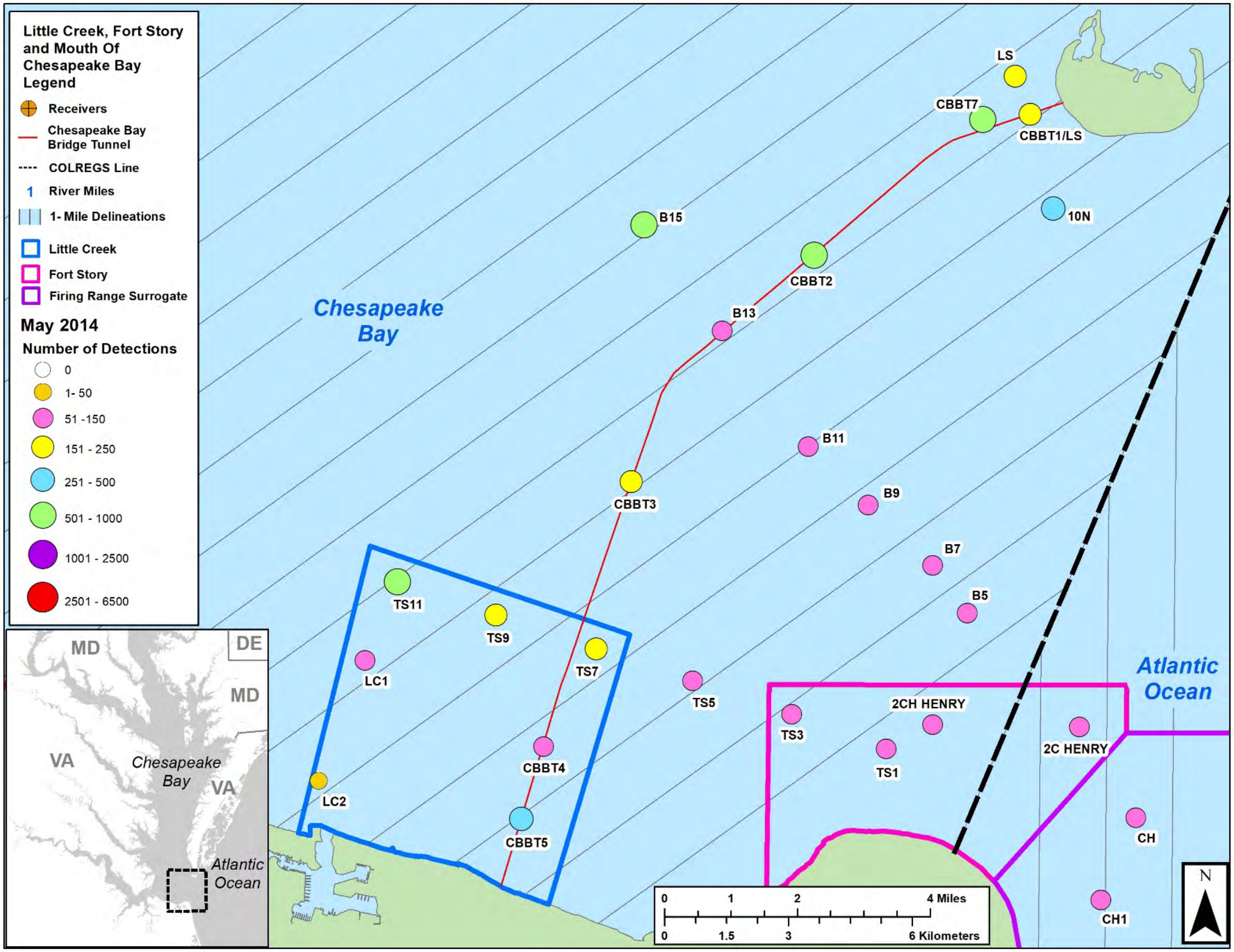
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Chesapeake Bay Bridge Tunnel
COLREGS Line
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1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
May 2014
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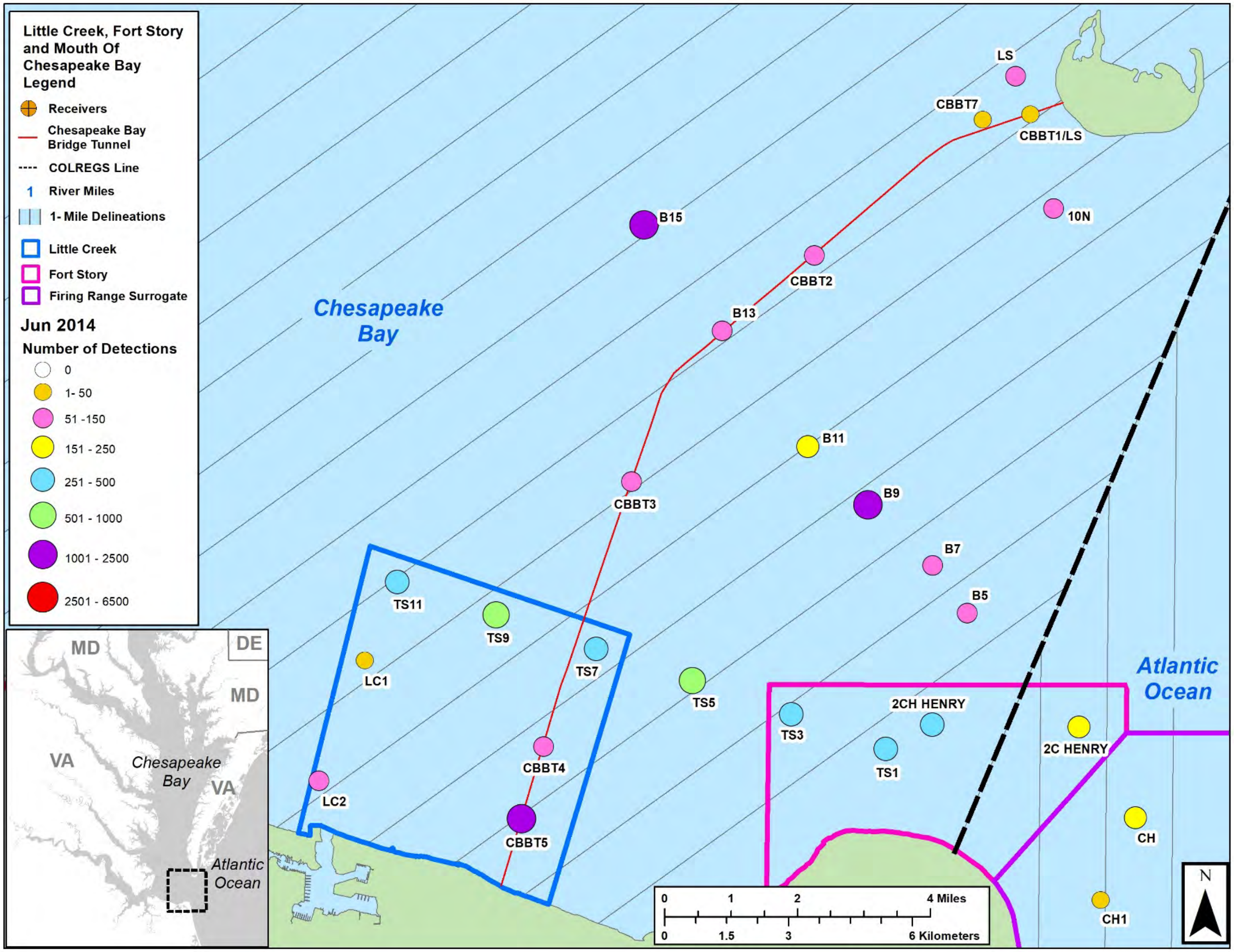
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Receivers
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1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Jun 2014
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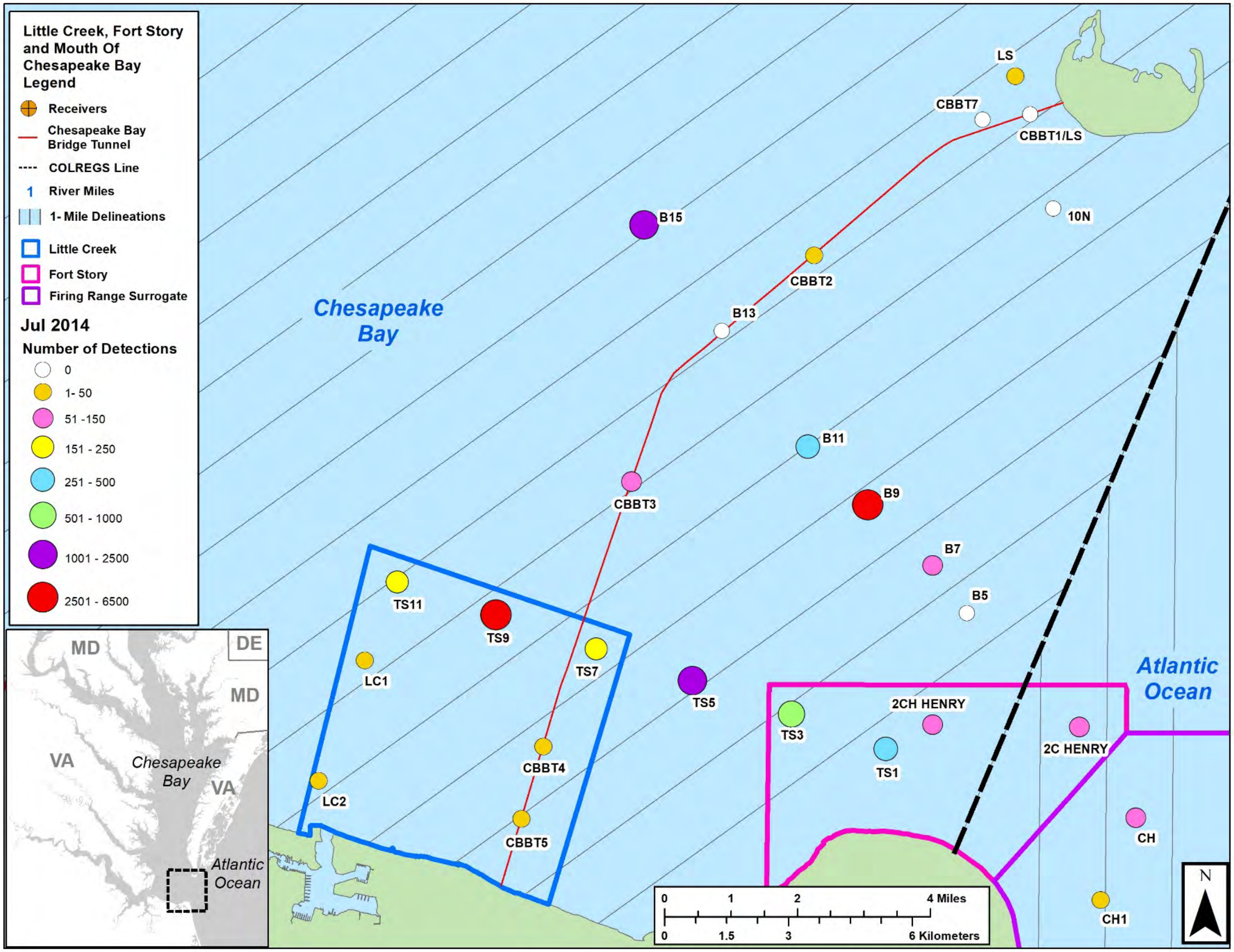
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Little Creek
Fort Story
Firing Range Surrogate
Jul 2014
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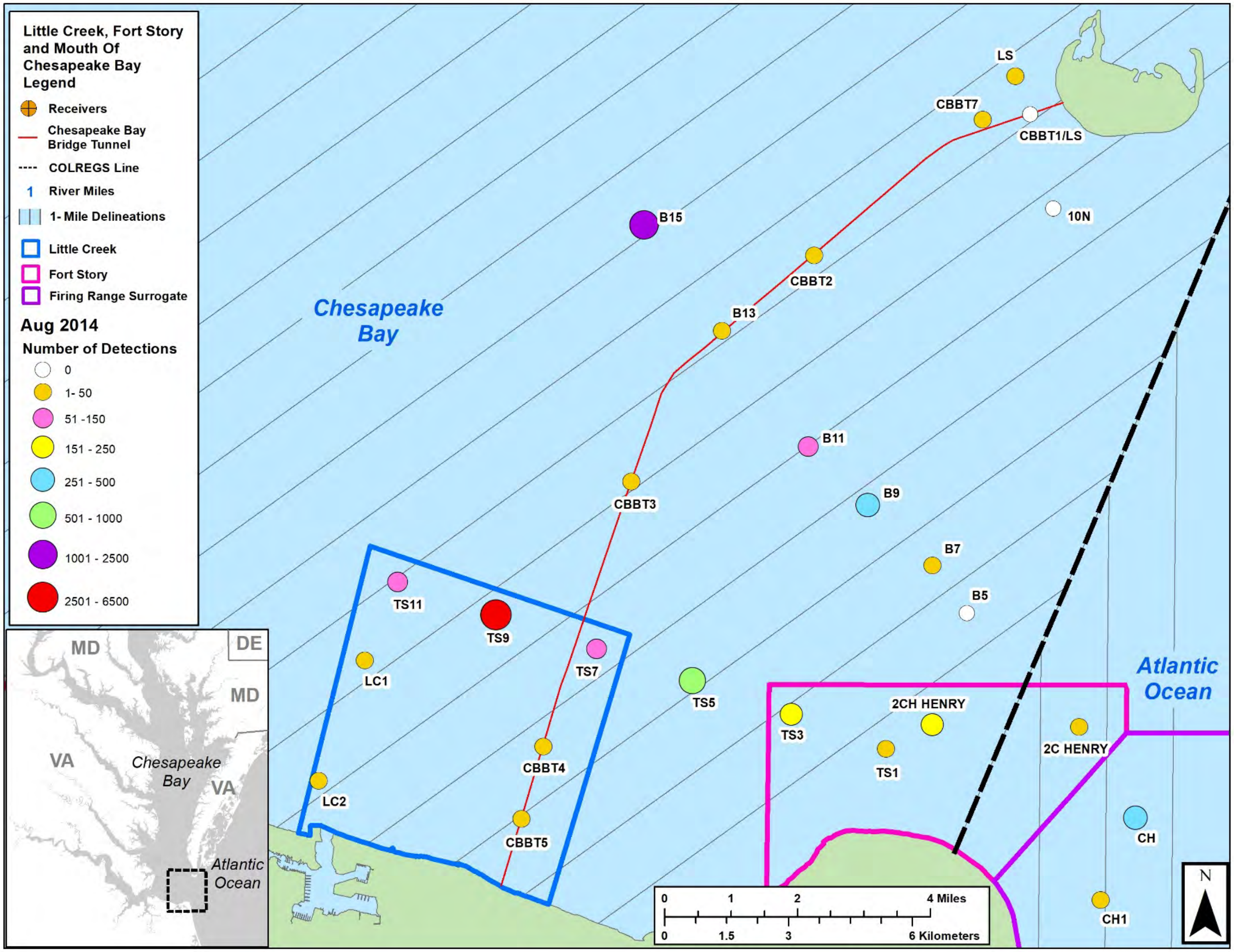
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Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
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1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Aug 2014
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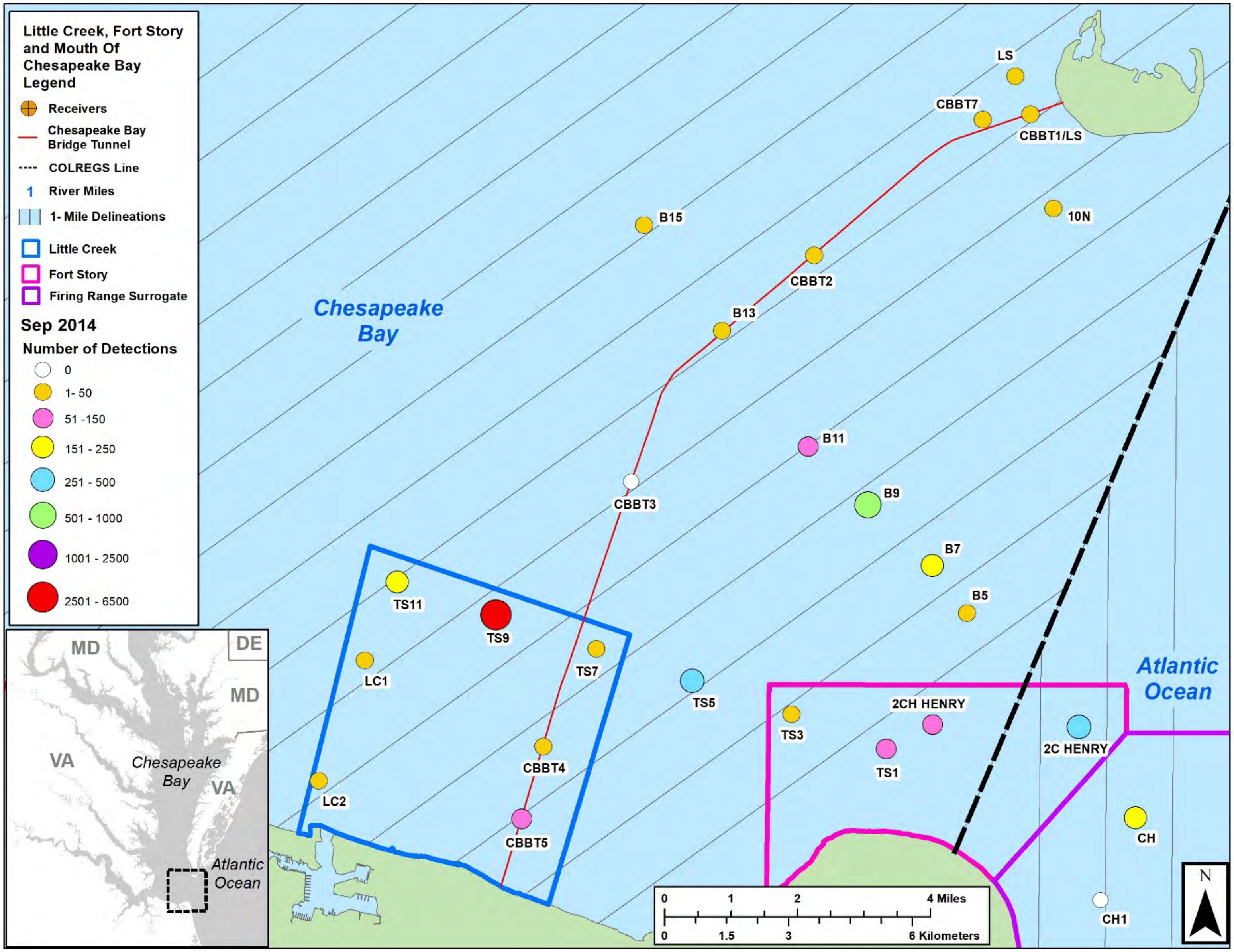
Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
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COLREGS Line
River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Sep 2014
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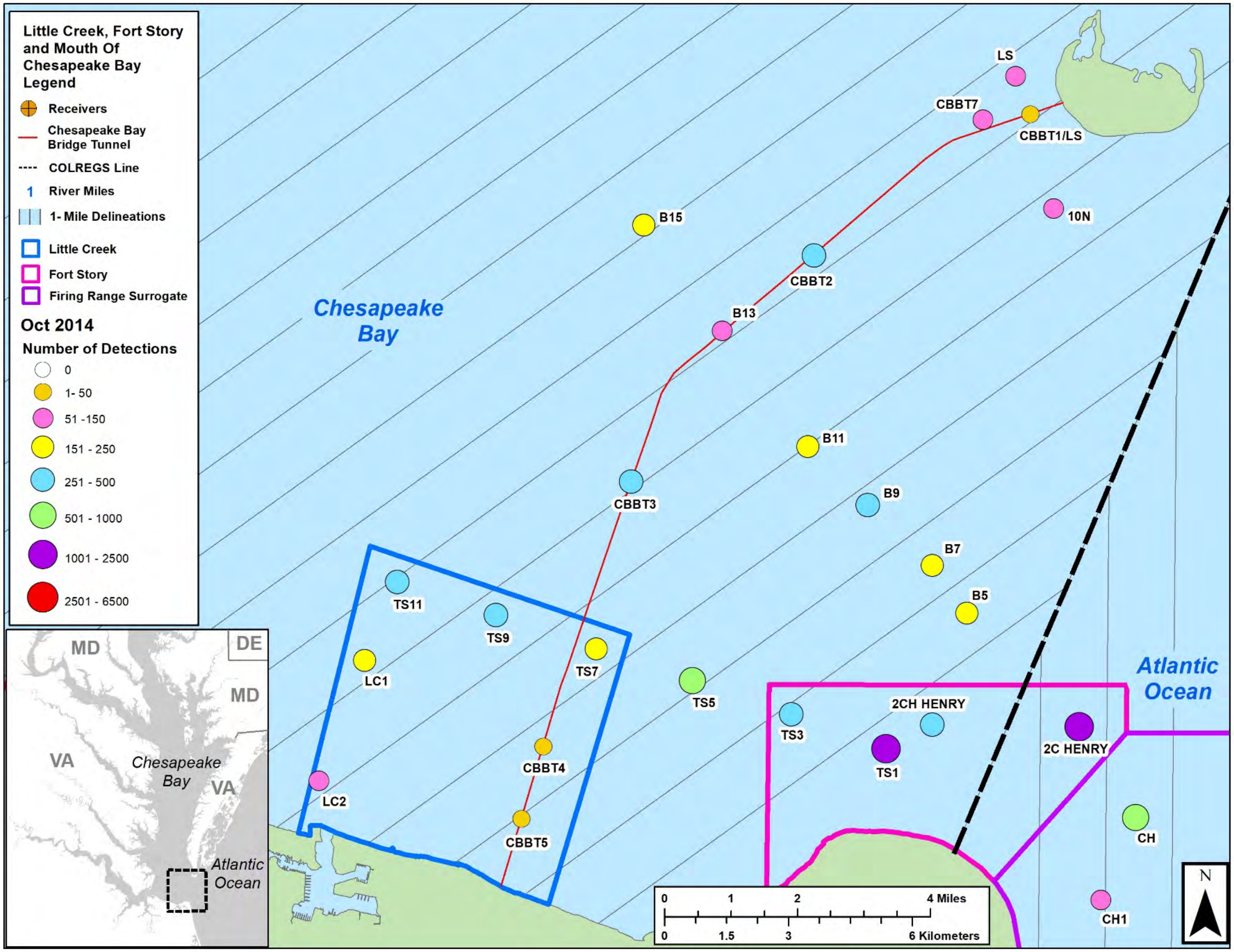
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1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Oct 2014
Number of Detections
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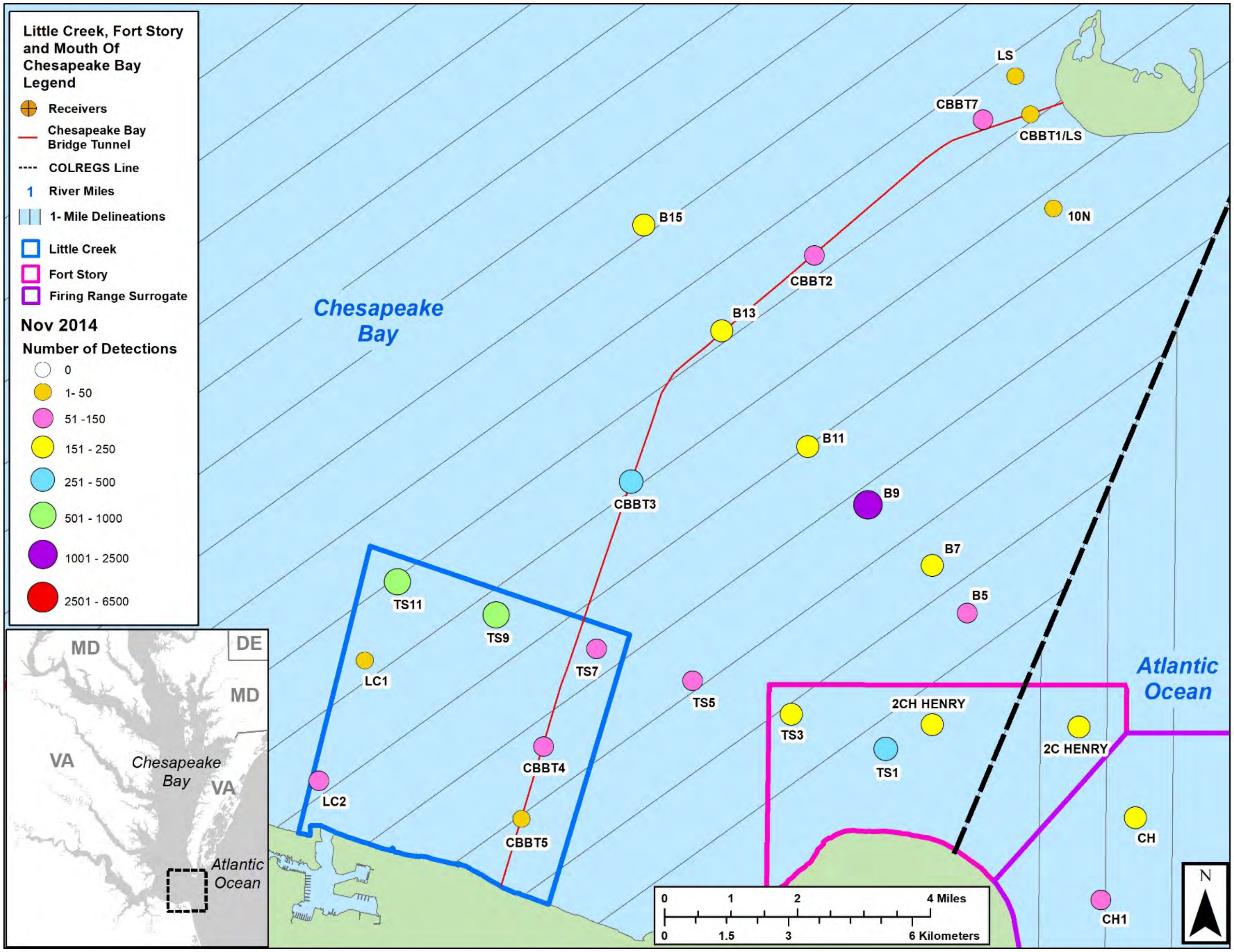
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Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Nov 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10N
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CBBT2
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CBBT3
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TS11
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TS7
LC1
TS5
TS3
2CH HENRY
TS1
2C HENRY
CBBT4
LC2
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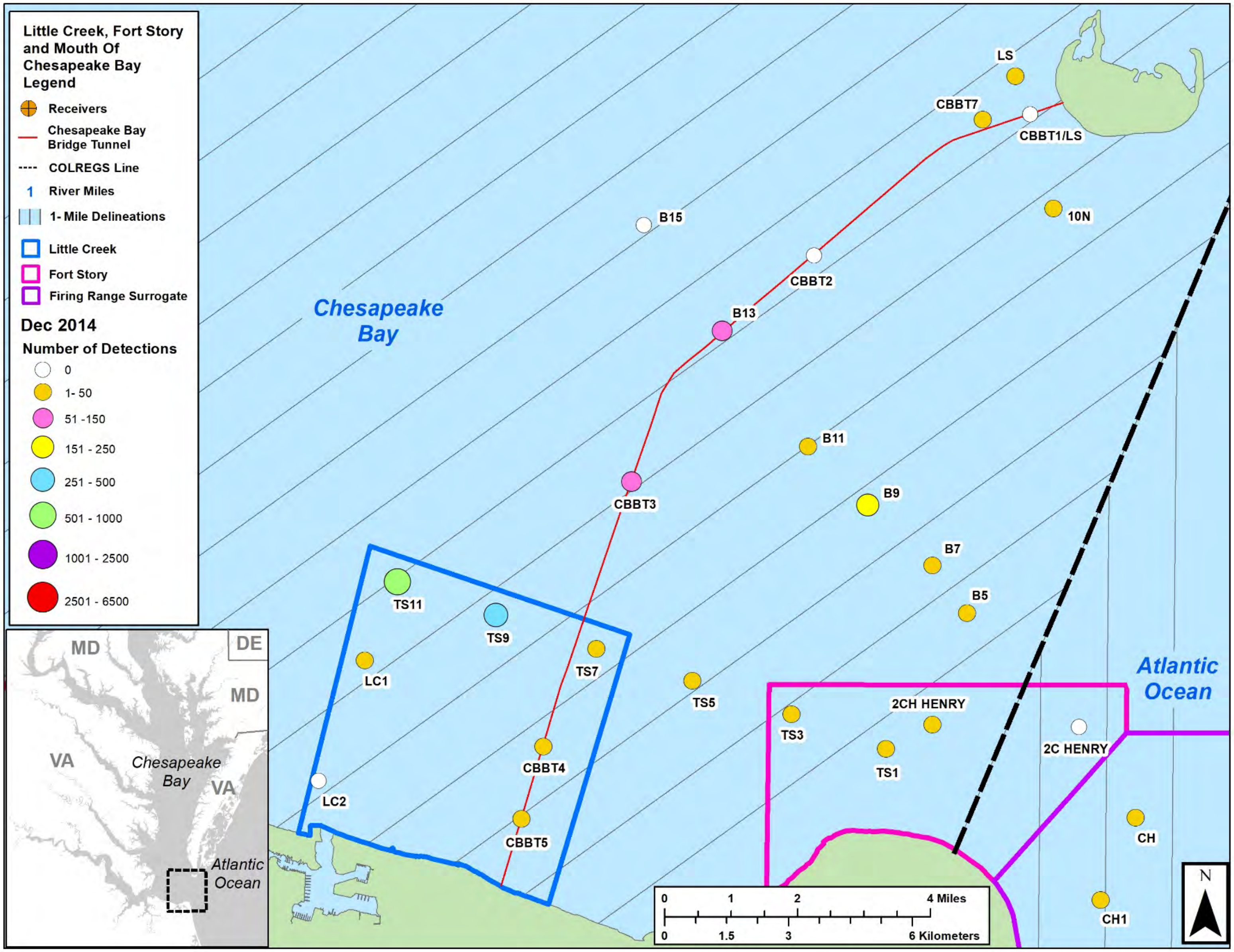
Atlantic Ocean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Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Dec 2014
Number of Detections
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251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chesapeake Bay
Atlantic Ocean
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CBBT1/LS
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TS1
2C HENRY
CBBT4
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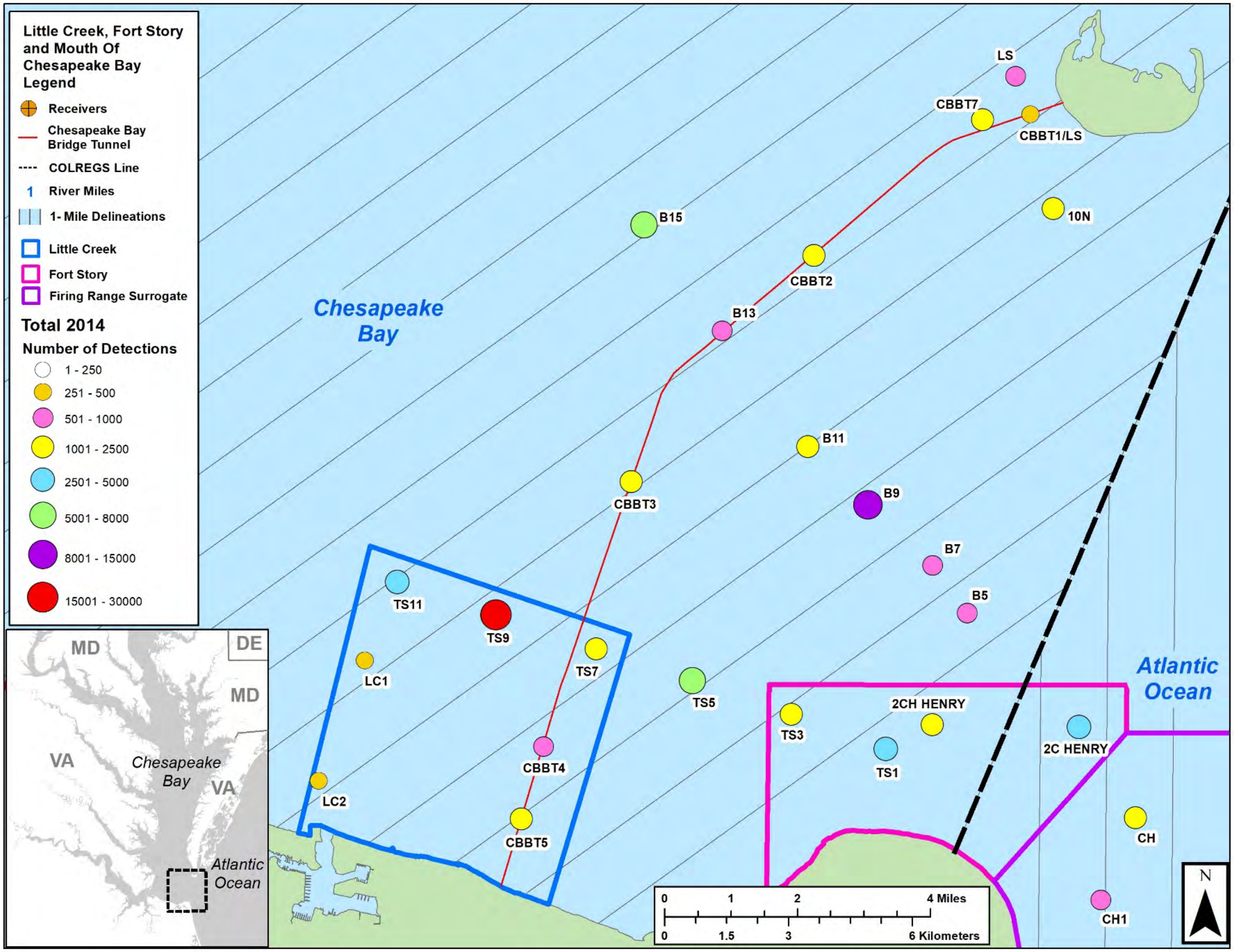
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Receivers
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COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Total 2014
Number of Detections
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1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
Chesapeake Bay
Atlantic Ocean
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2C HENRY
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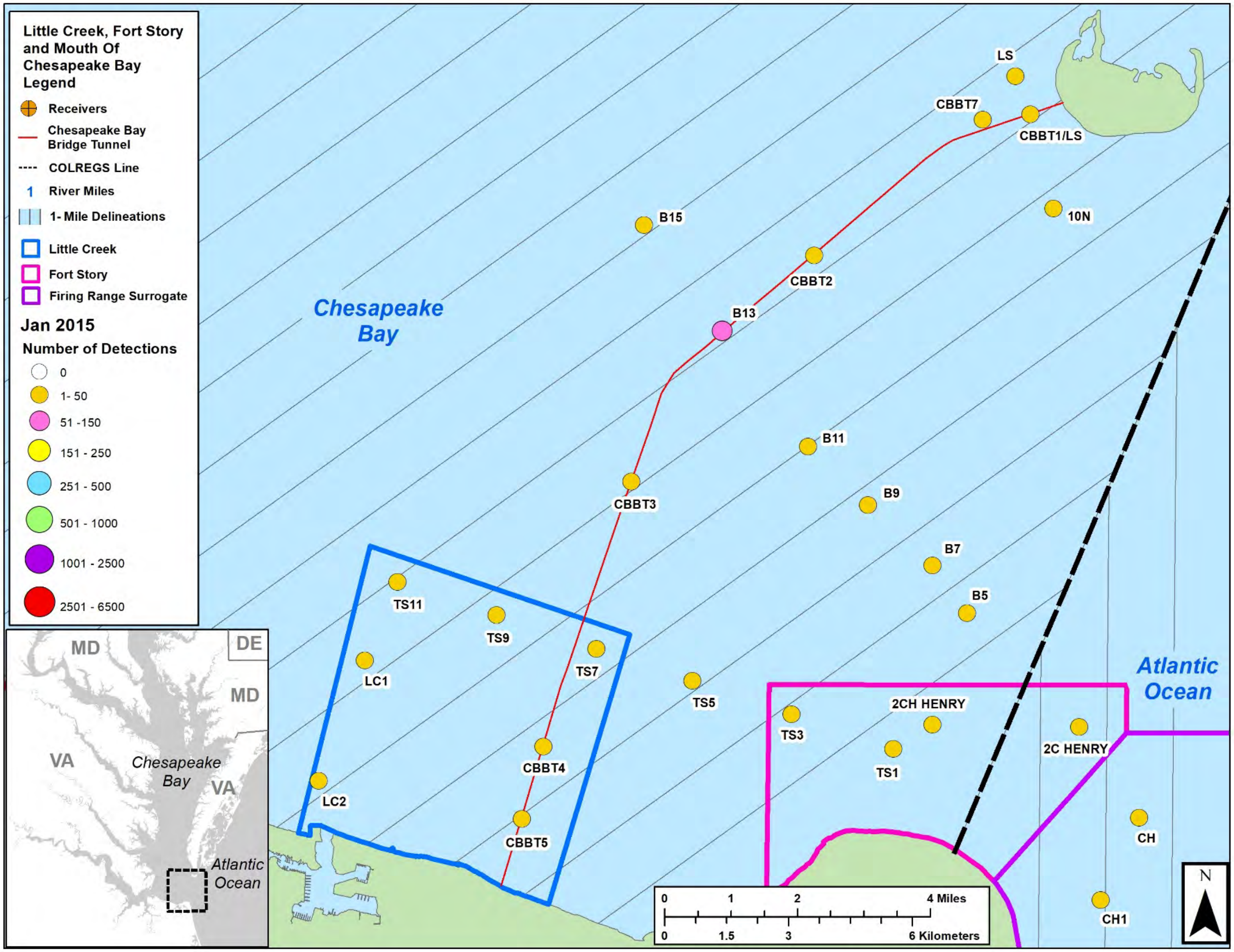
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River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Jan 2015
Number of Detections
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Chesapeake Bay
Atlantic Ocean
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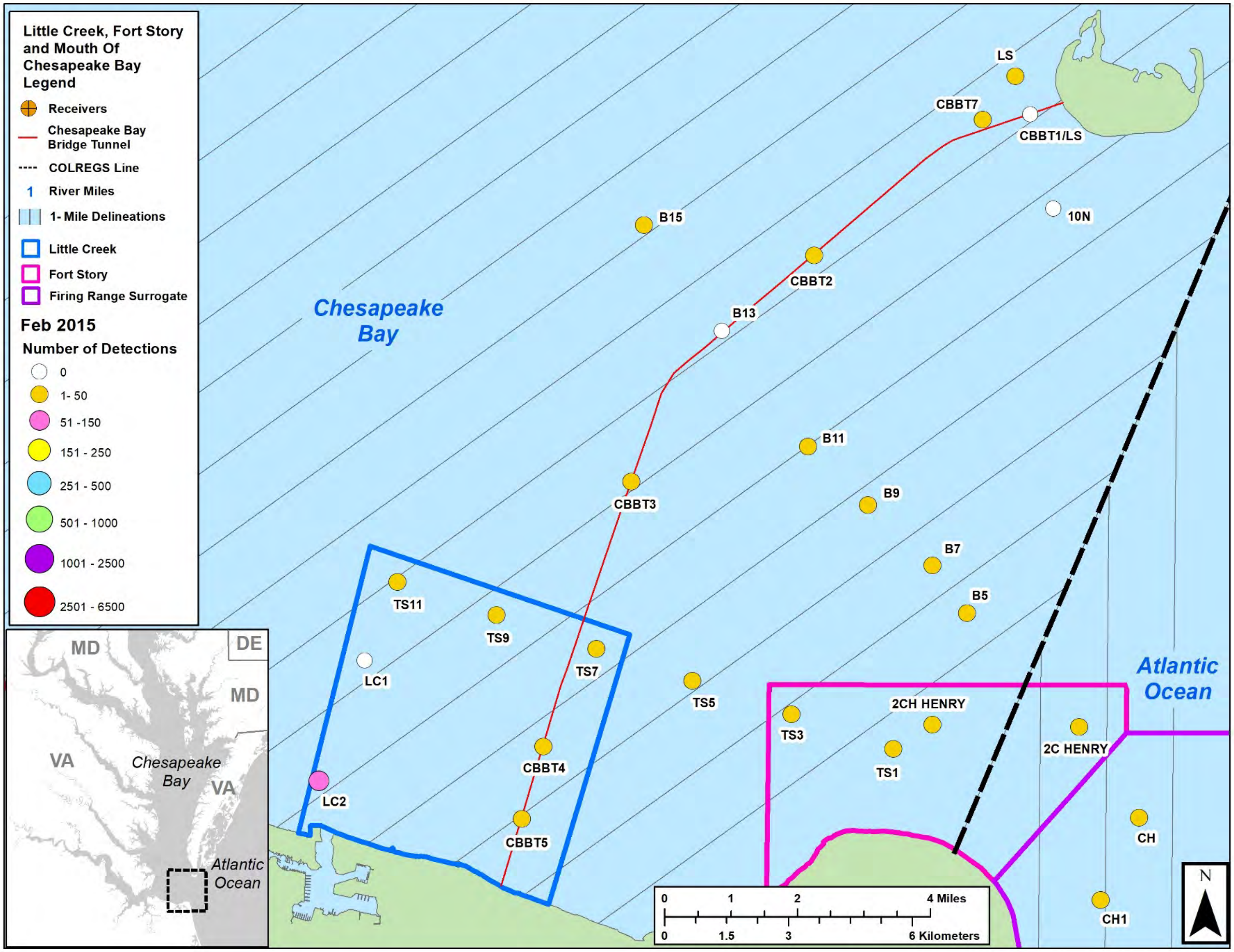
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Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Feb 2015
Number of Detections
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Chesapeake Bay
Atlantic Ocean
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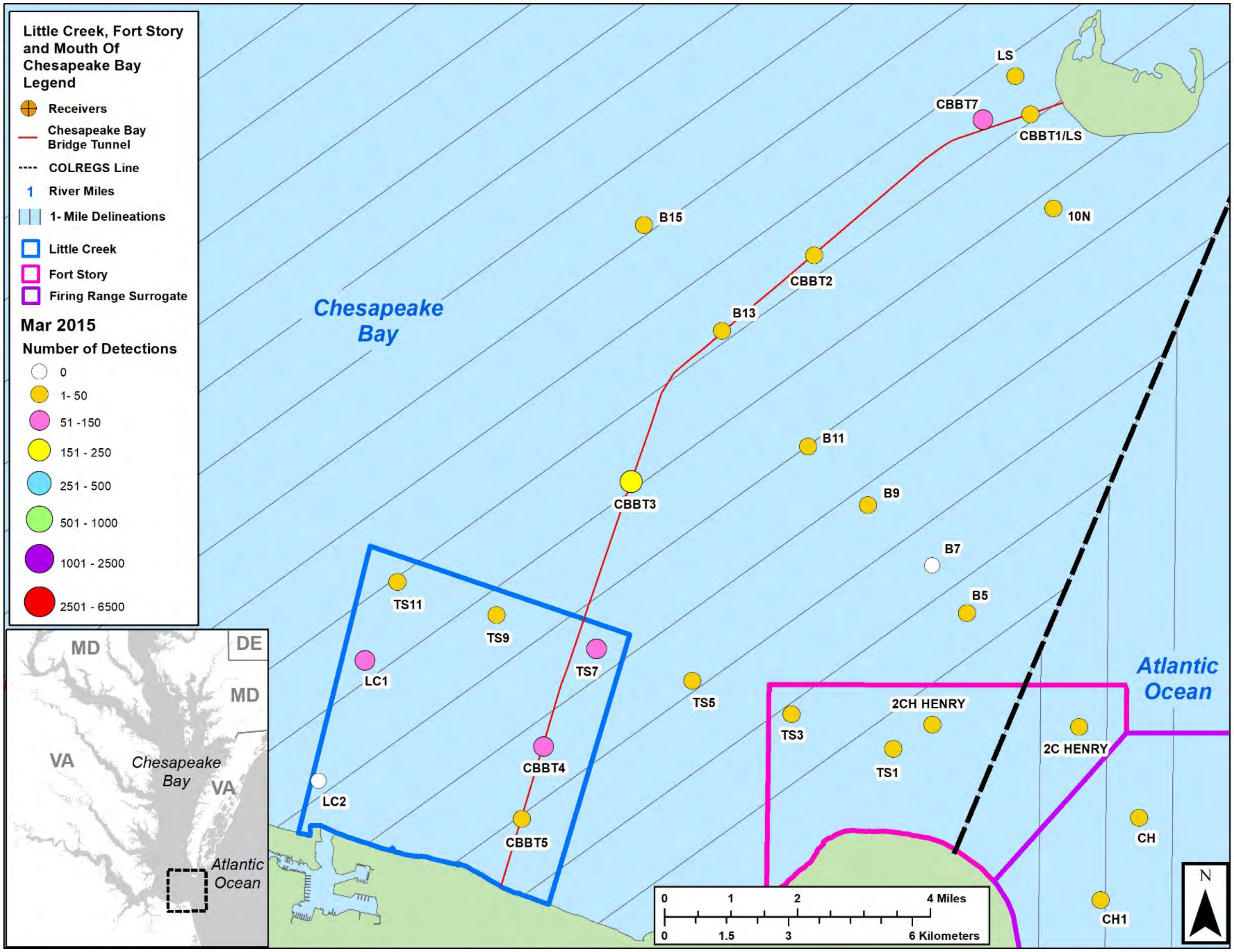
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Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Mar 2015
Number of Detections
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Chesapeake Bay
Atlantic Ocean
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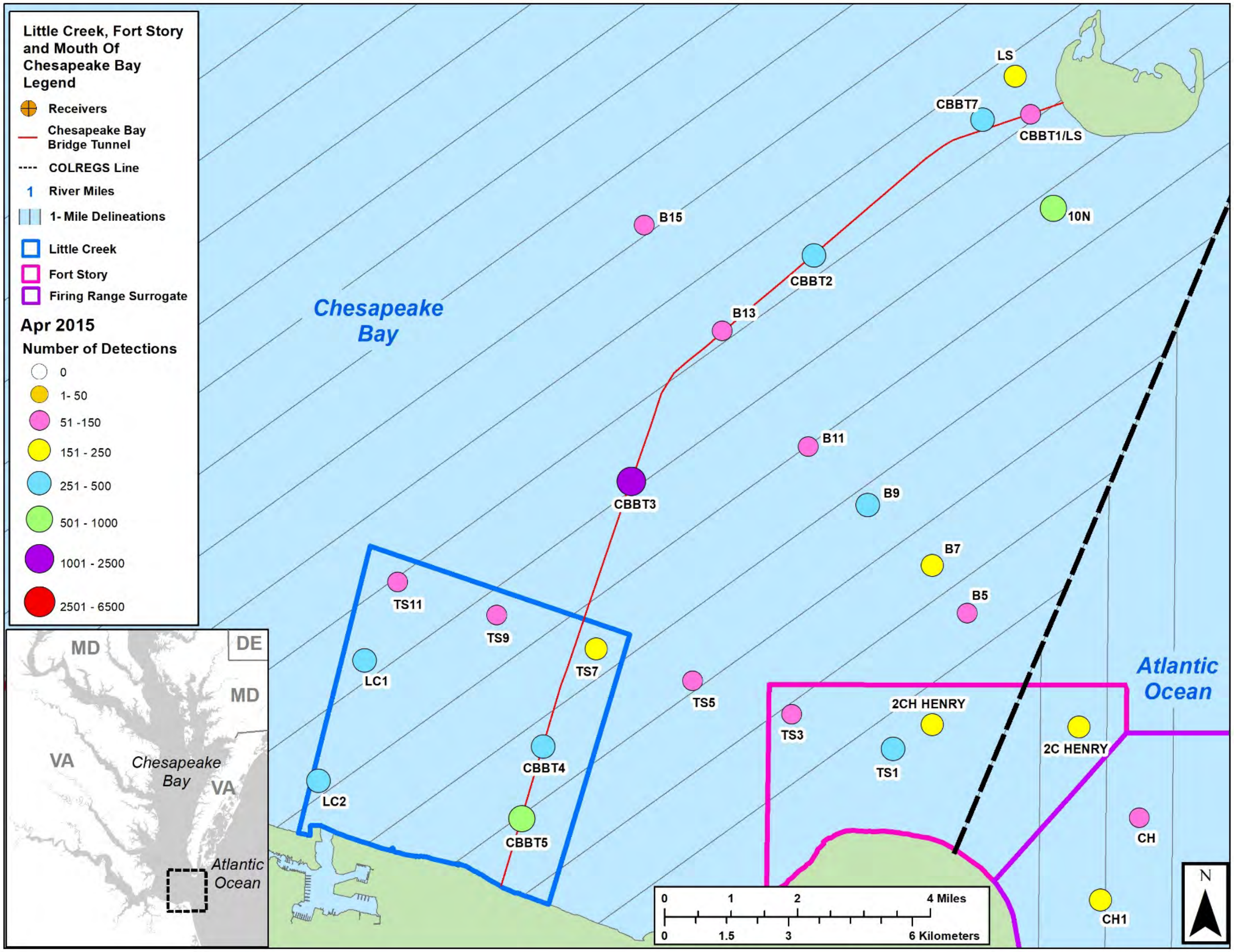
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Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Apr 2015
Number of Detections
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Chesapeake Bay
Atlantic Ocean
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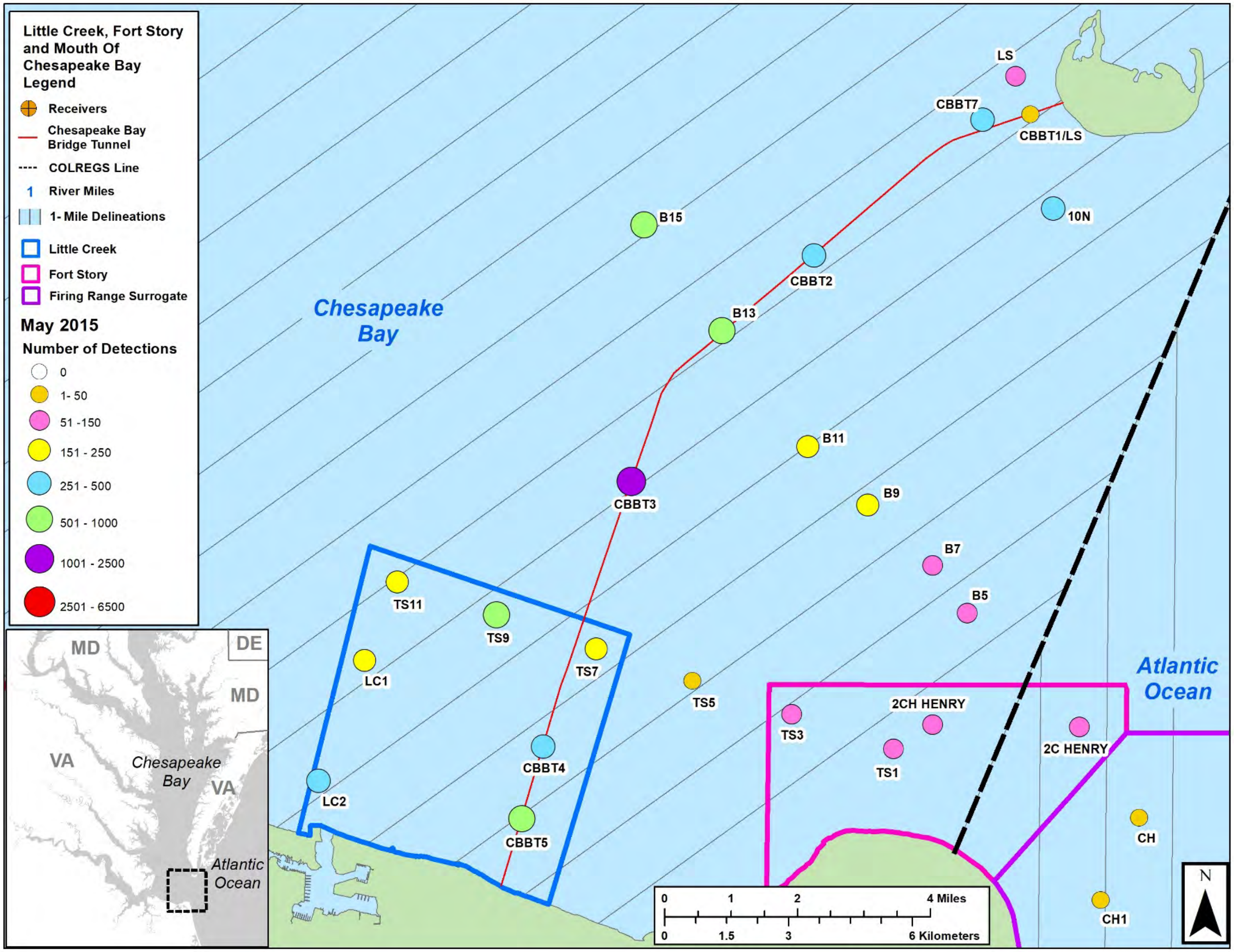
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Chesapeake Bay Bridge Tunnel
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1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
May 2015
Number of Detections
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Chesapeake Bay
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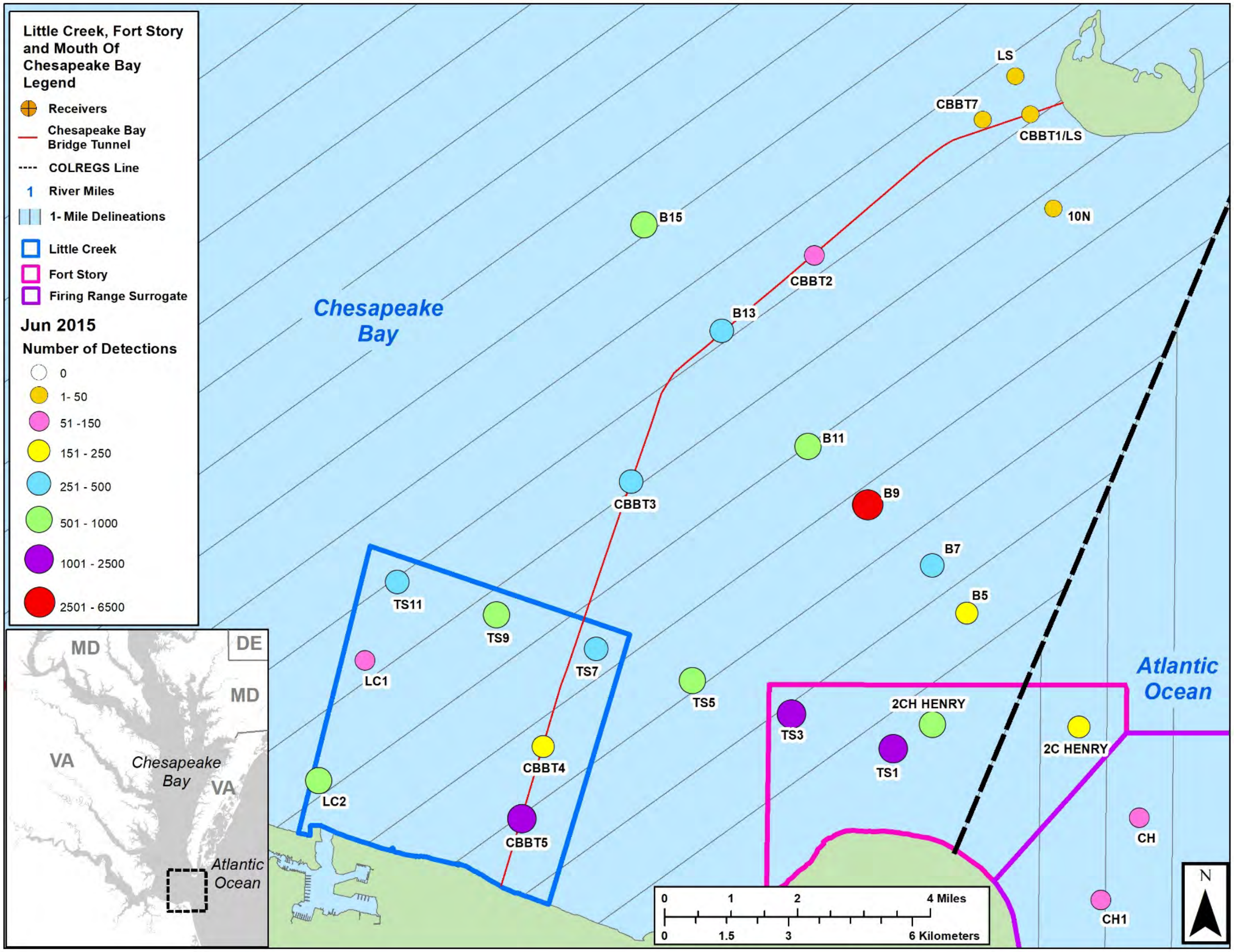
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1- Mile Delineations
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Fort Story
Firing Range Surrogate
Jun 2015
Number of Detections
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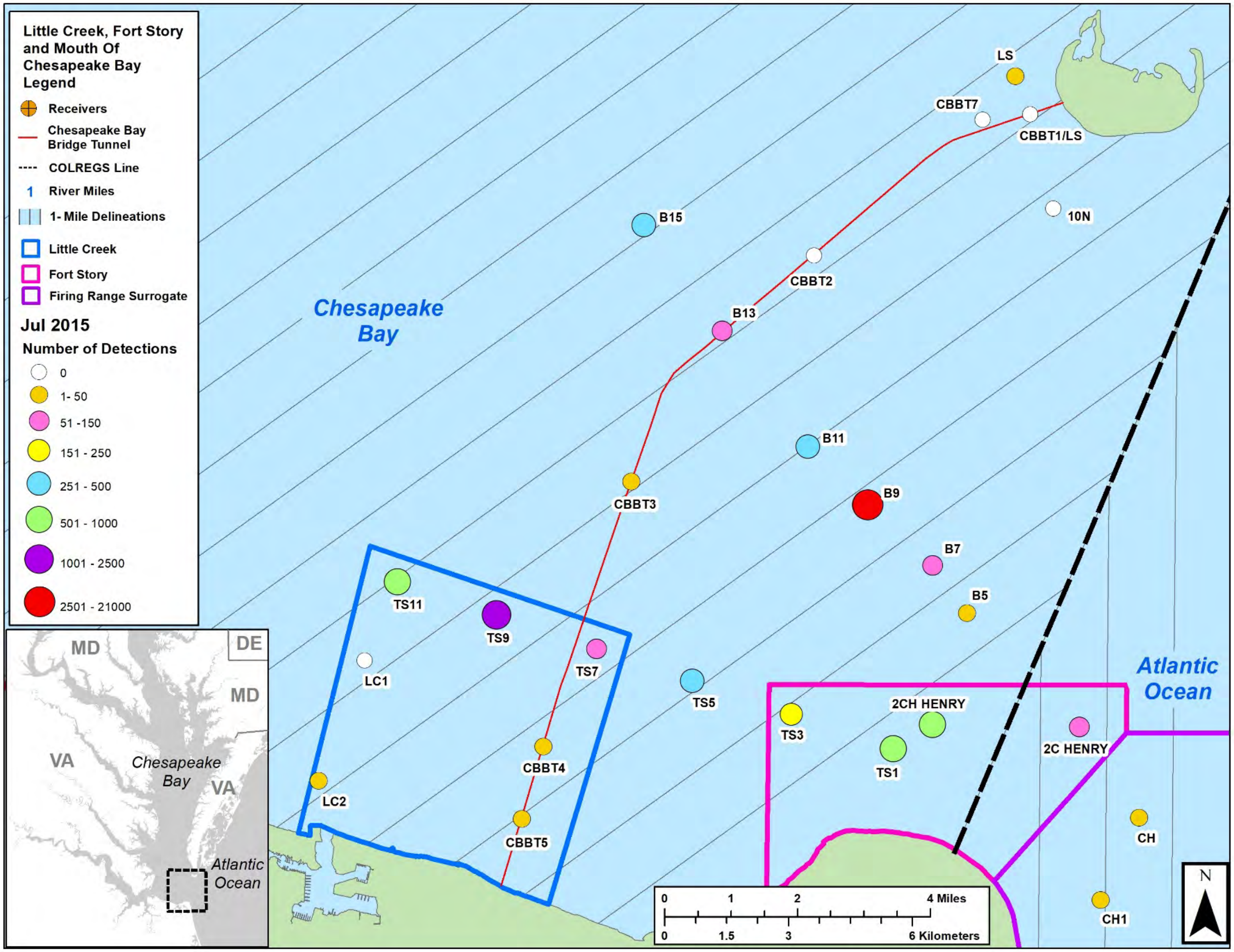
Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
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1- Mile Delineations
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Fort Story
Firing Range Surrogate
Jul 2015
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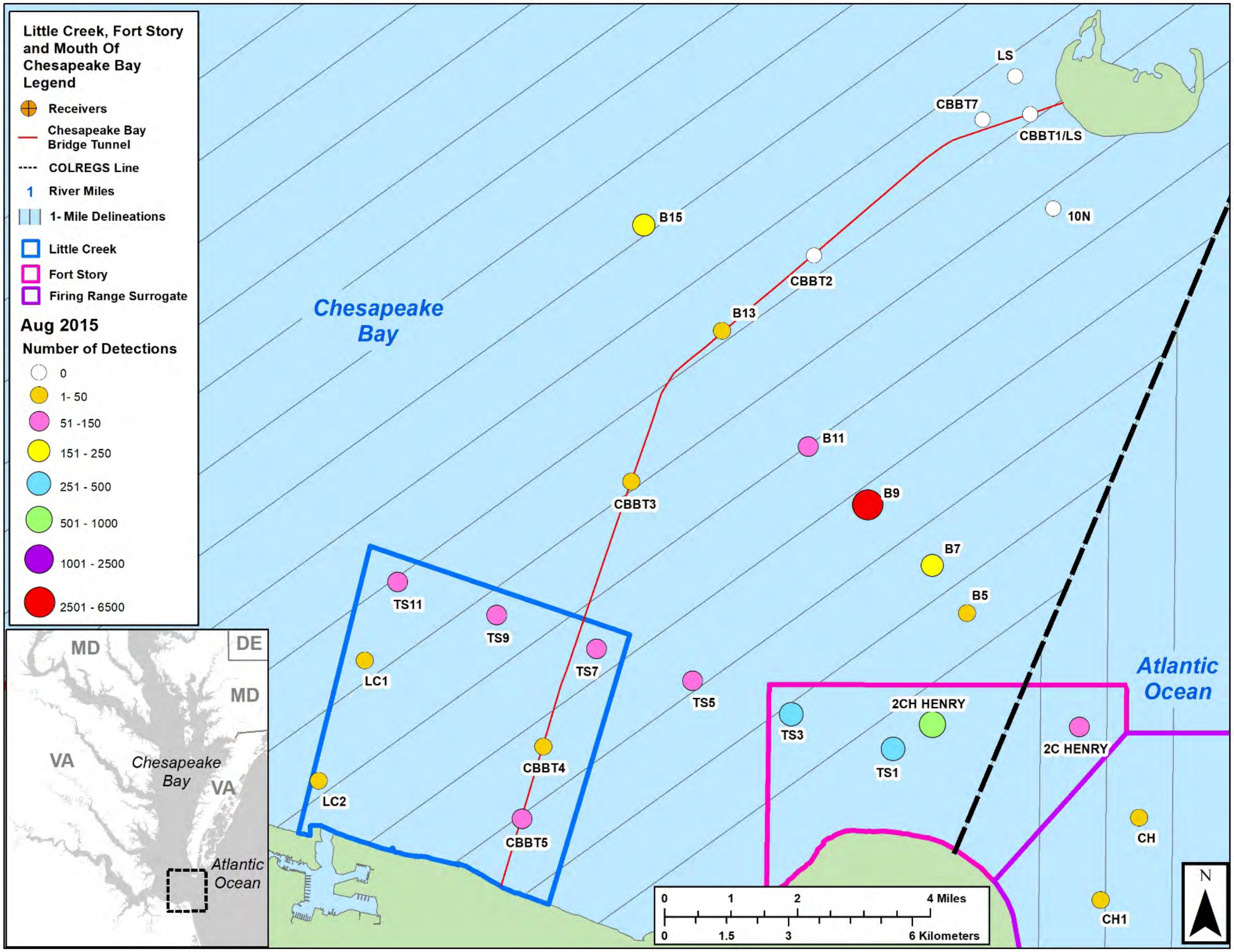
Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
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Chesapeake Bay Bridge Tunnel
COLREGS Line
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1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Aug 2015
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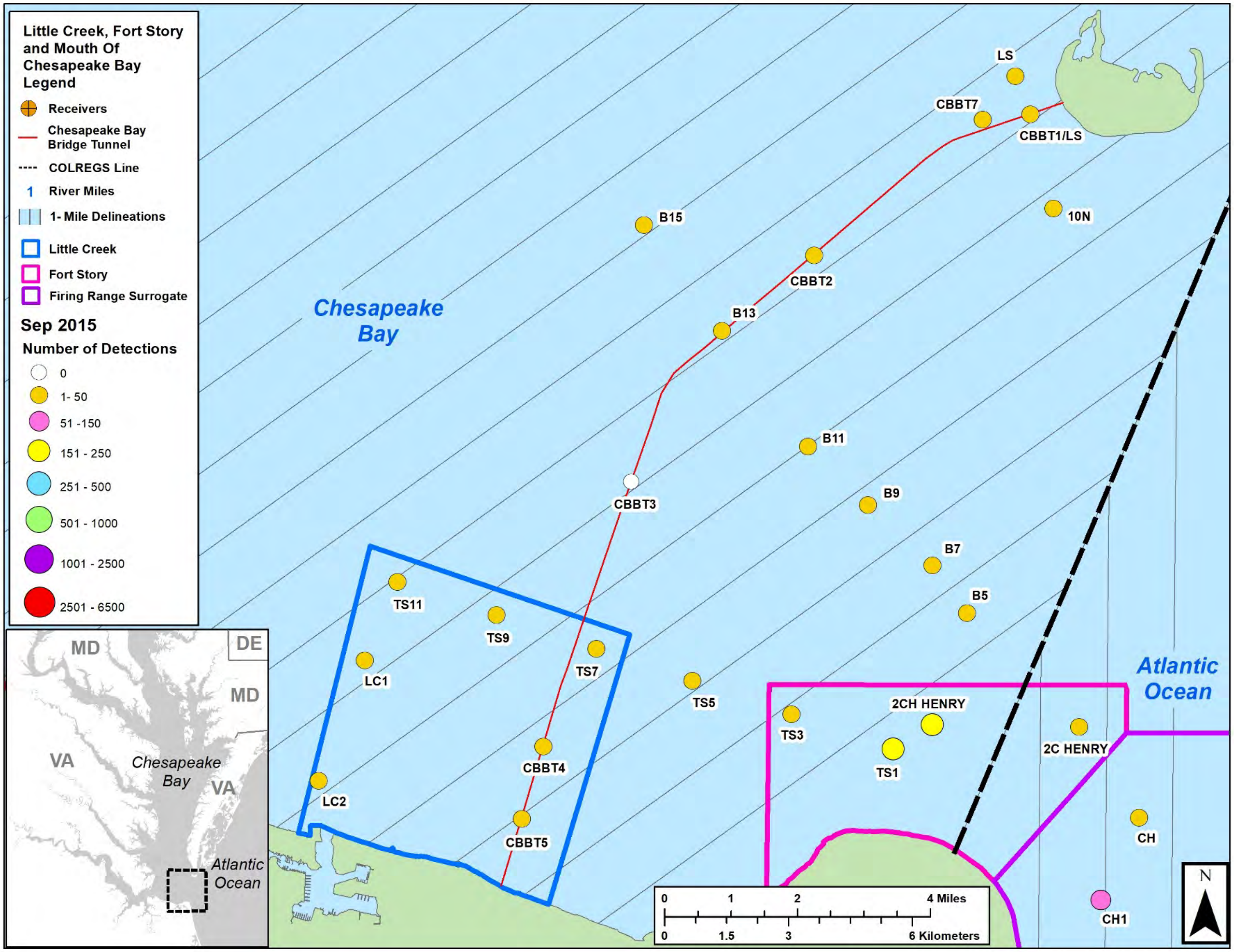
Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
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1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Sep 2015
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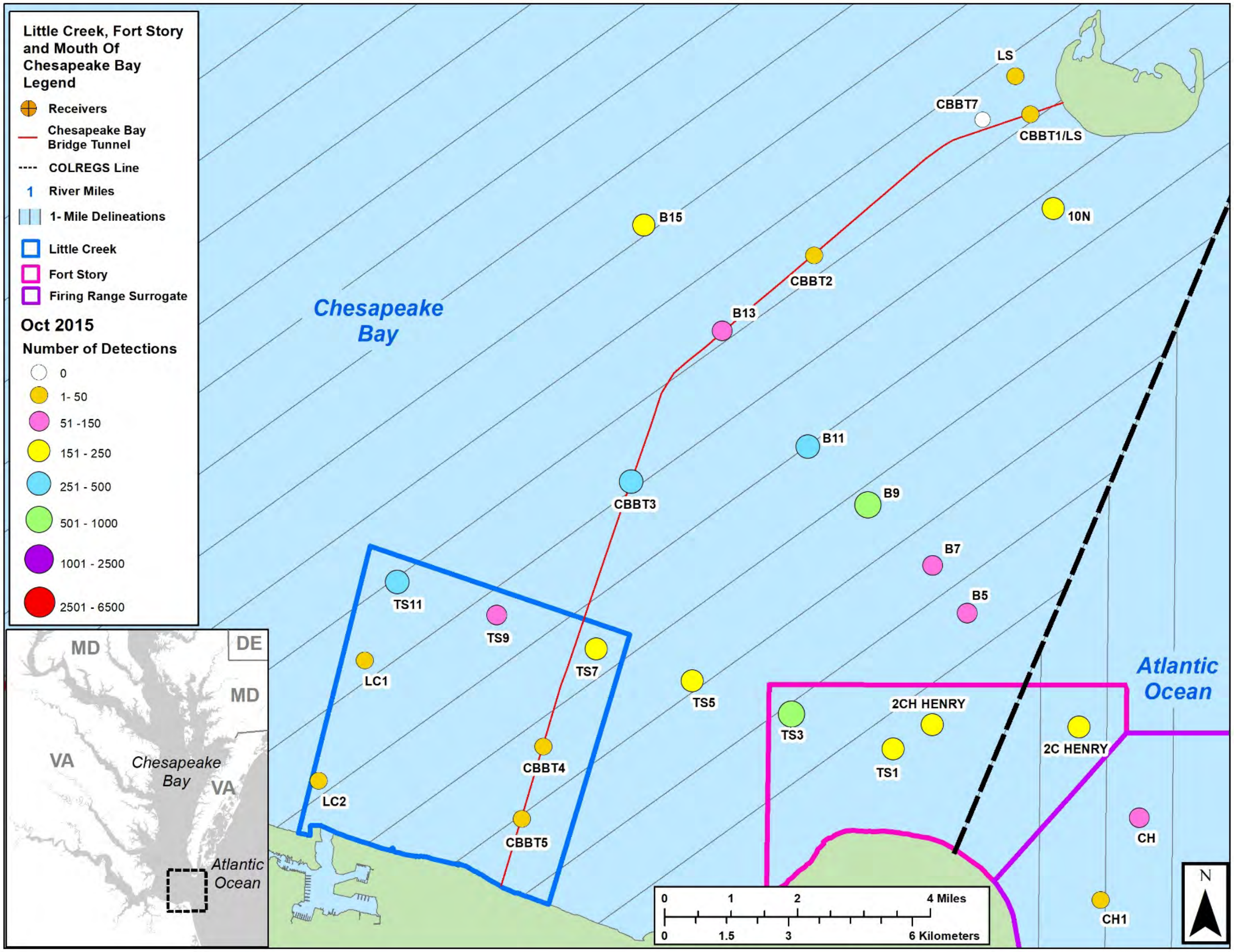
Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
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1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Oct 2015
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Atlantic Ocean
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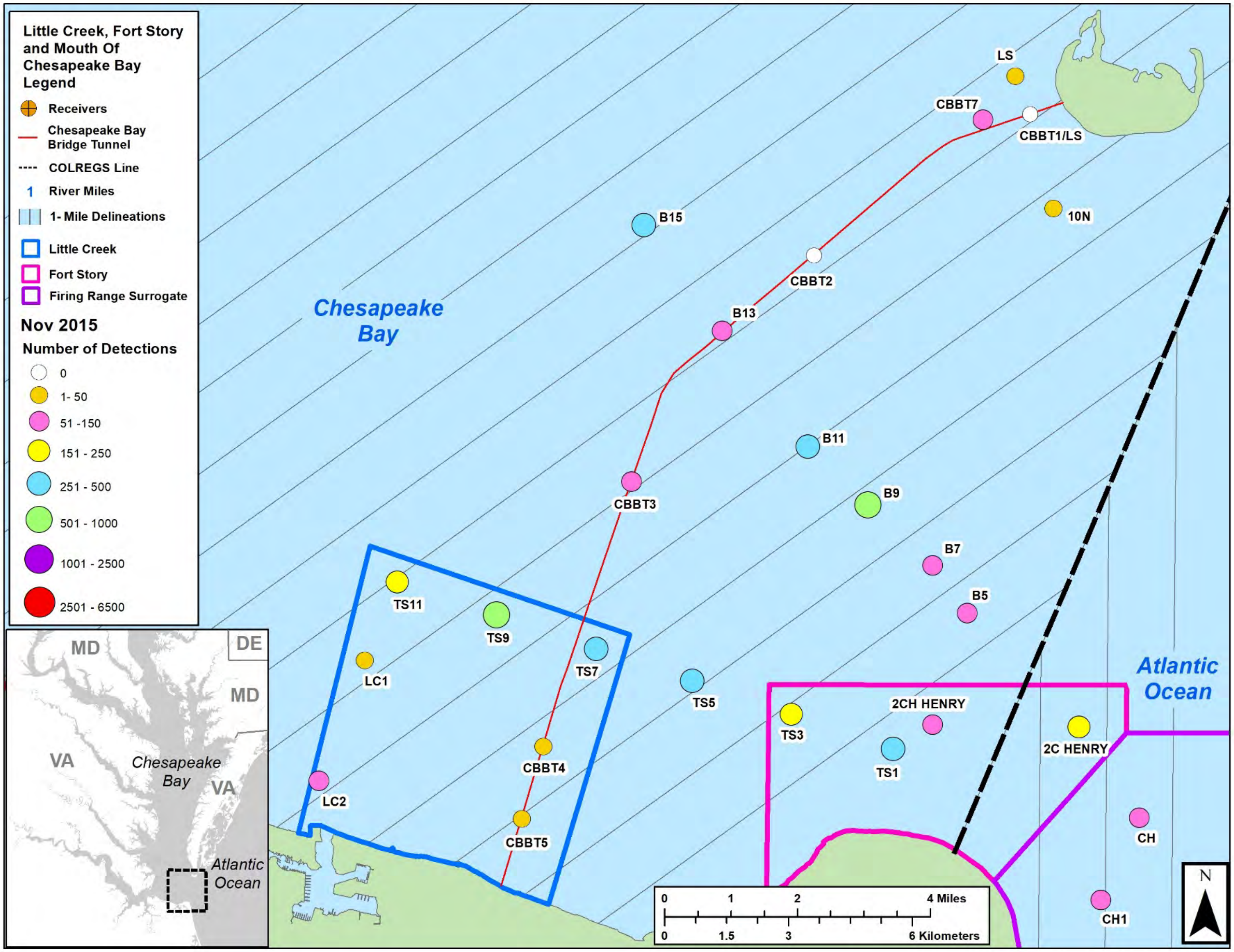
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Little Creek
Fort Story
Firing Range Surrogate
Nov 2015
Number of Detections
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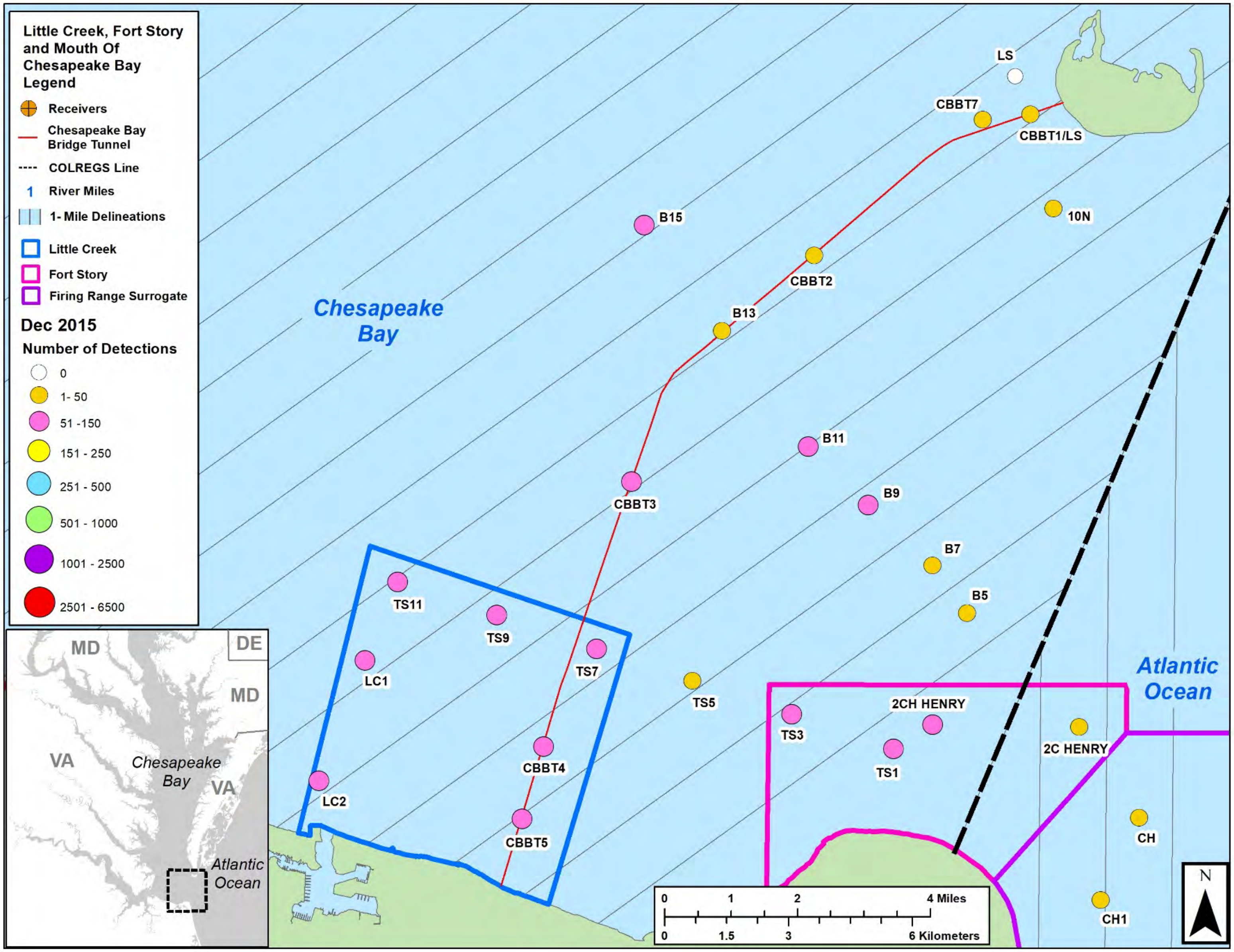
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Receivers
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River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Dec 2015
Number of Detections
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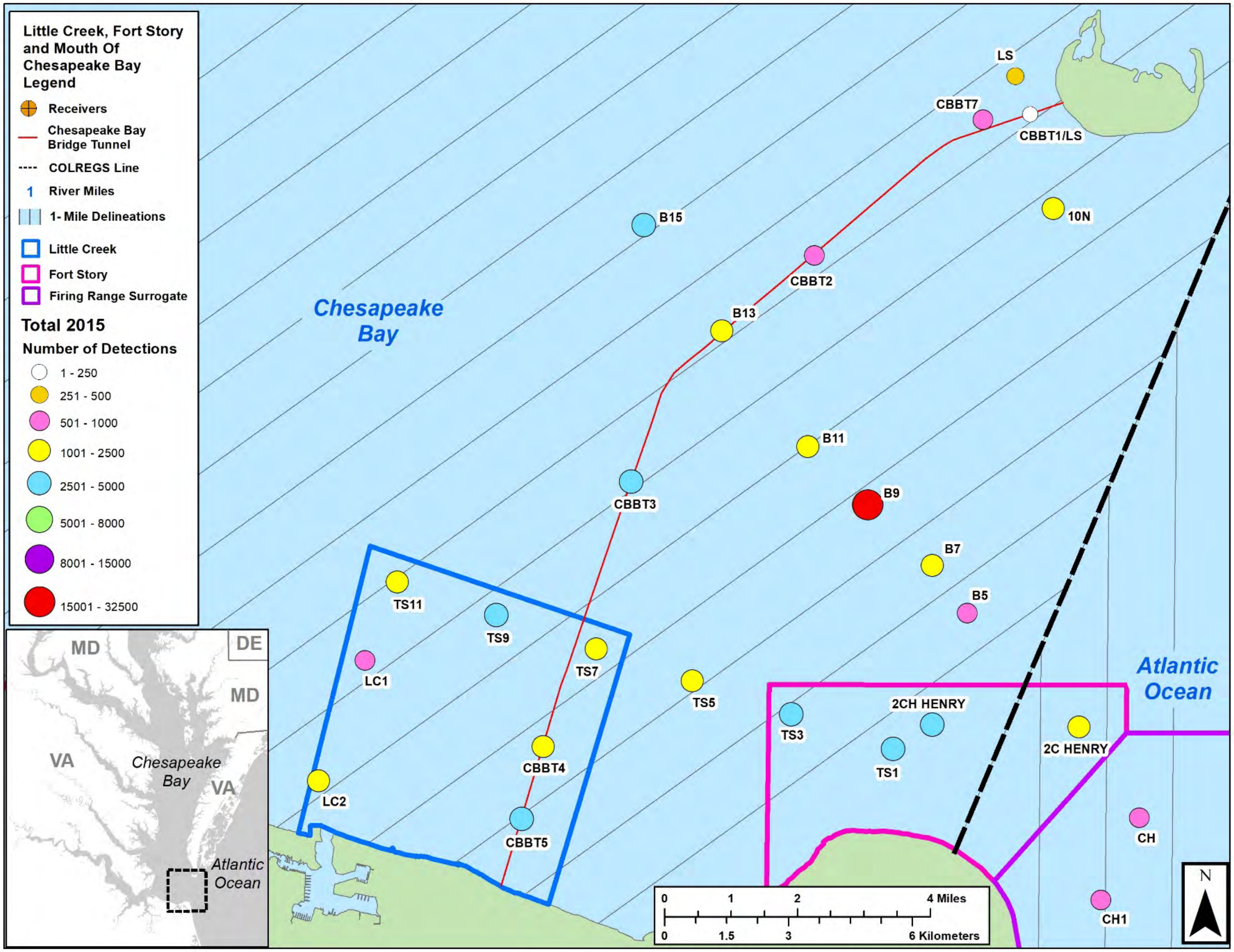
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COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Total 2015
Number of Detections
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2501 - 5000
5001 - 8000
8001 - 15000
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Chesapeake Bay
Atlantic Ocean
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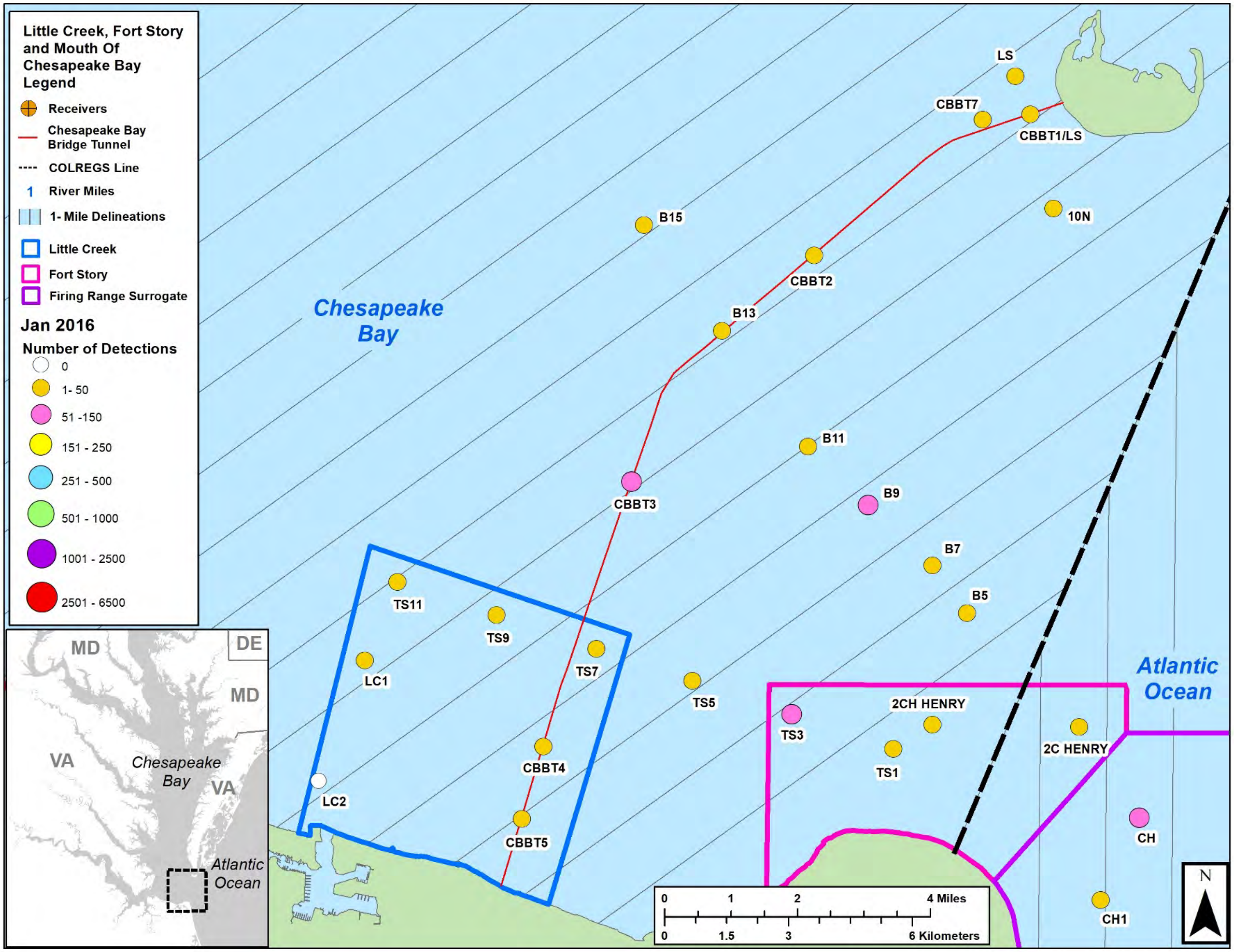
Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
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Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Jan 2016
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Chesapeake Bay
Atlantic Ocean
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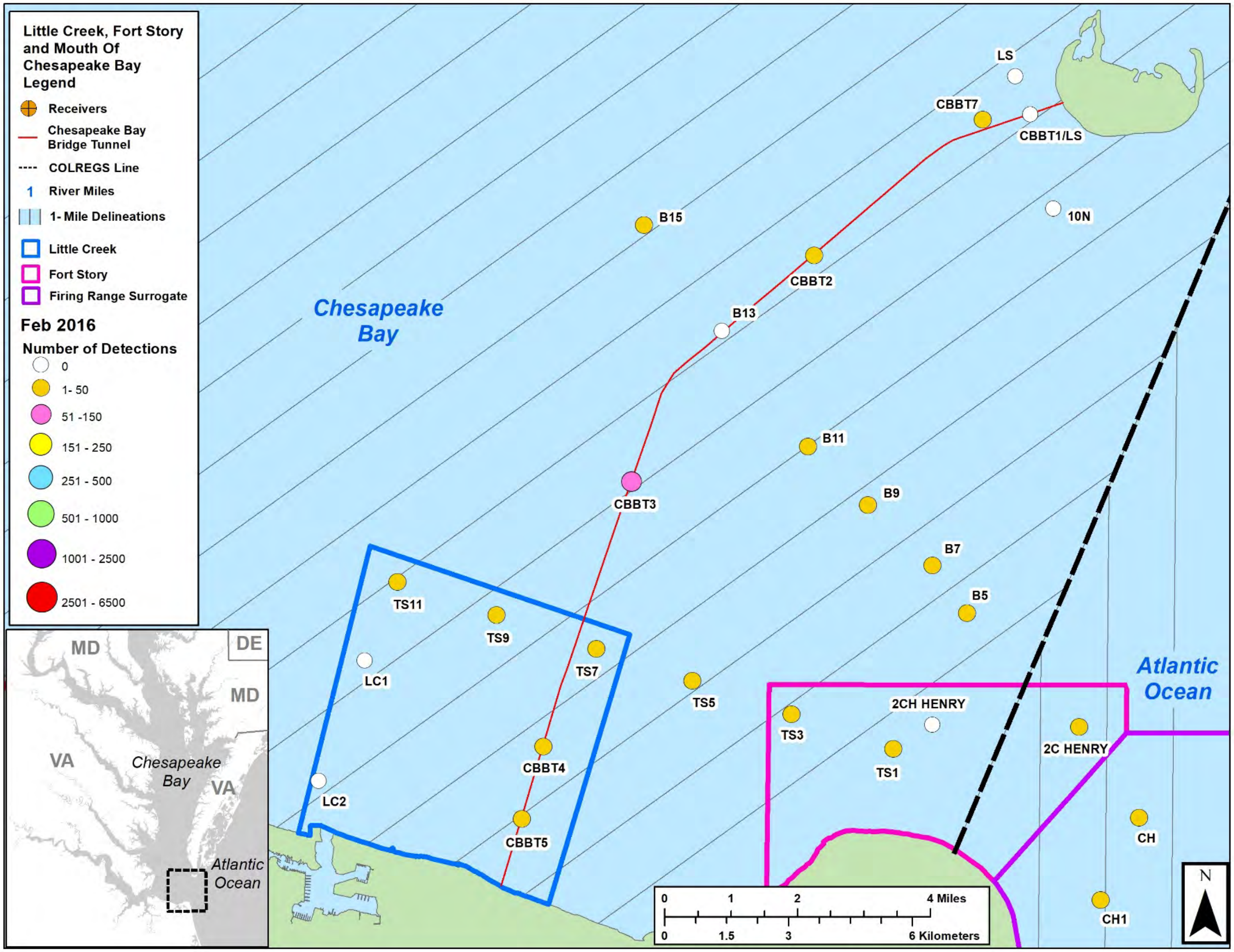
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Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
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Little Creek
Fort Story
Firing Range Surrogate
Feb 2016
Number of Detections
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Chesapeake Bay
Atlantic Ocean
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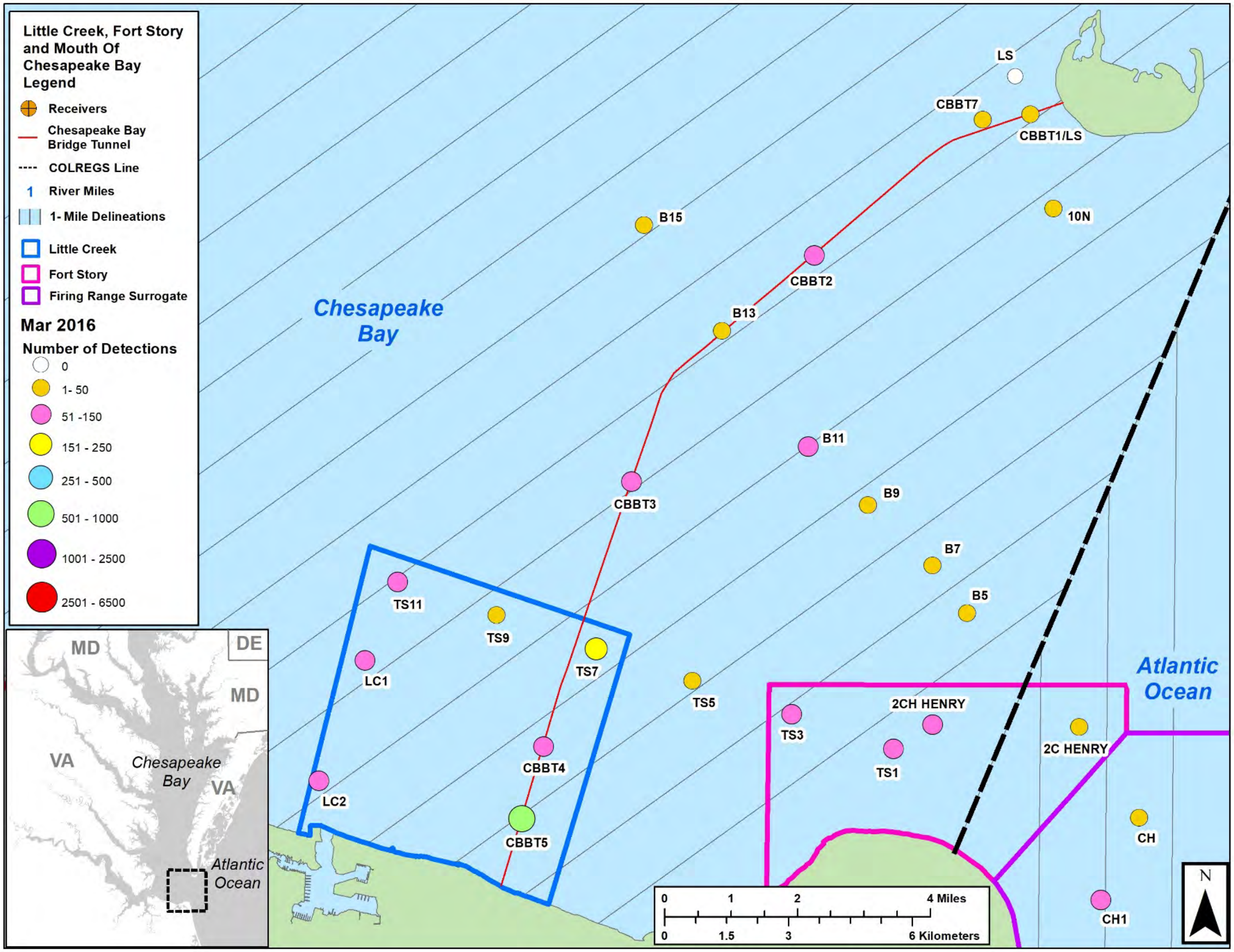
Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Mar 2016
Number of Detections
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151 - 250
251 - 500
501 - 1000
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Chesapeake Bay
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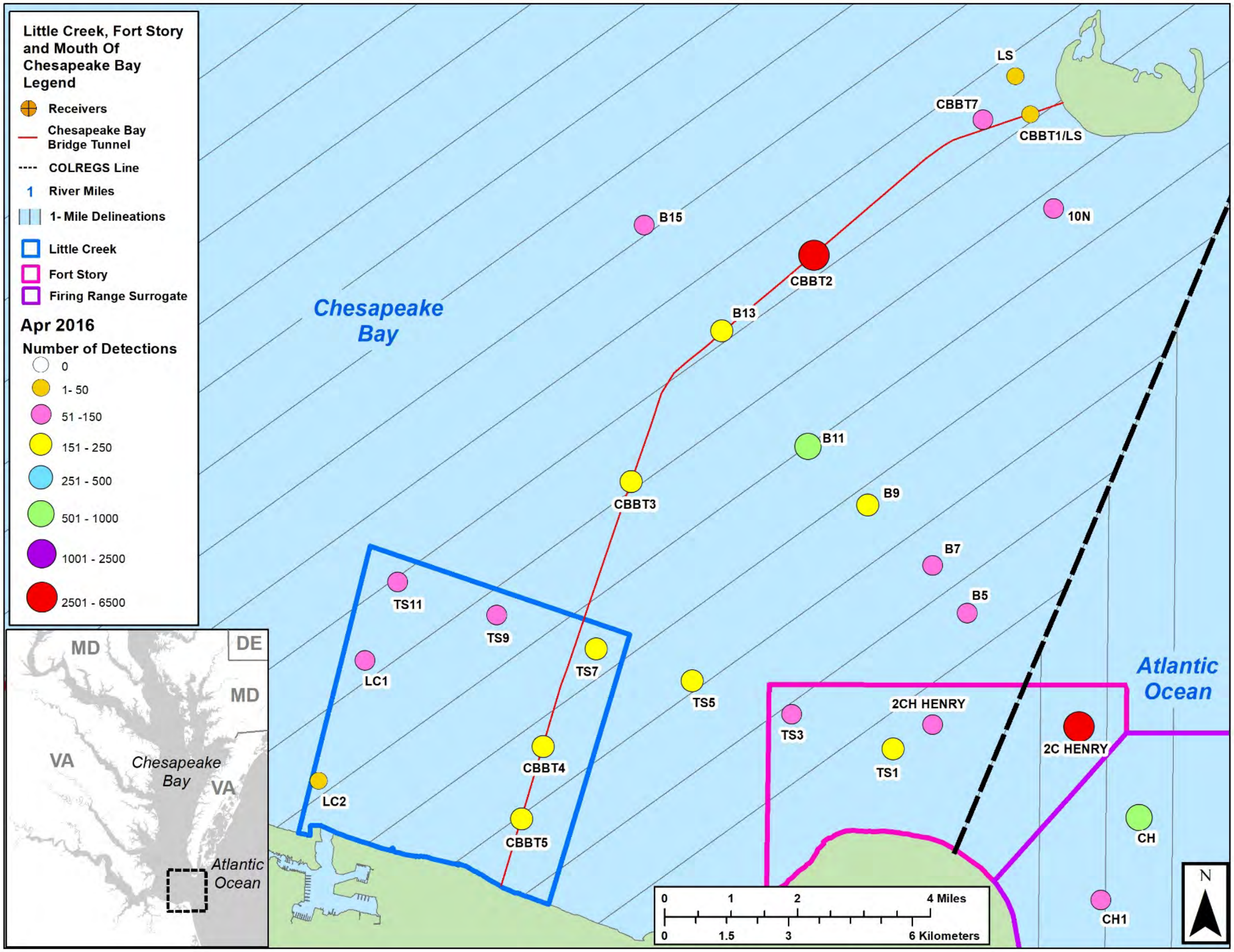
Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Apr 2016
Number of Detections
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151 - 250
251 - 500
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Chesapeake Bay
Atlantic Ocean
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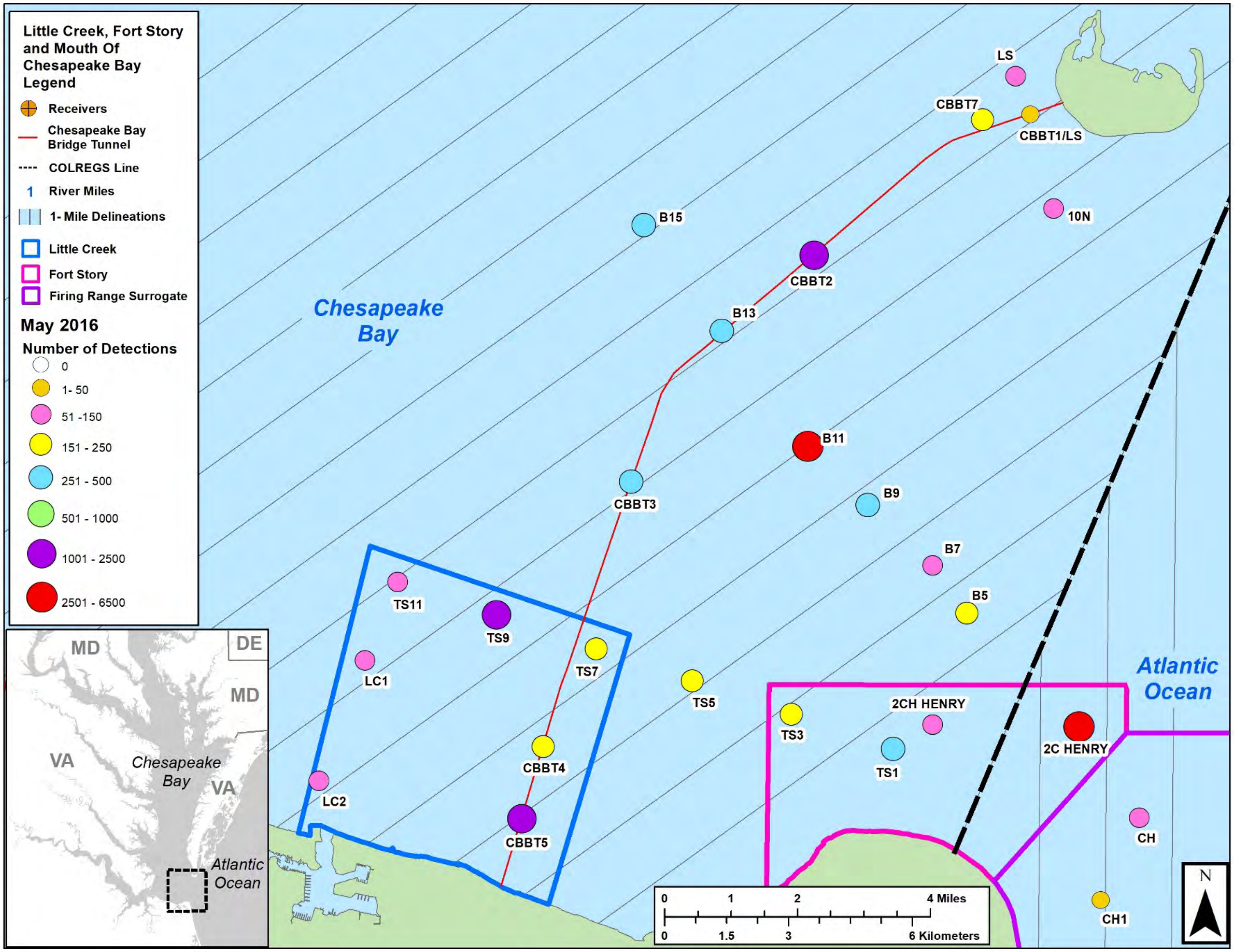
Atlantic Ocean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Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
May 2016
Number of Detections
0
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51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
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CBBT2
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TS11
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LC1
TS5
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2CH HENRY
2C HENRY
TS1
CBBT4
LC2
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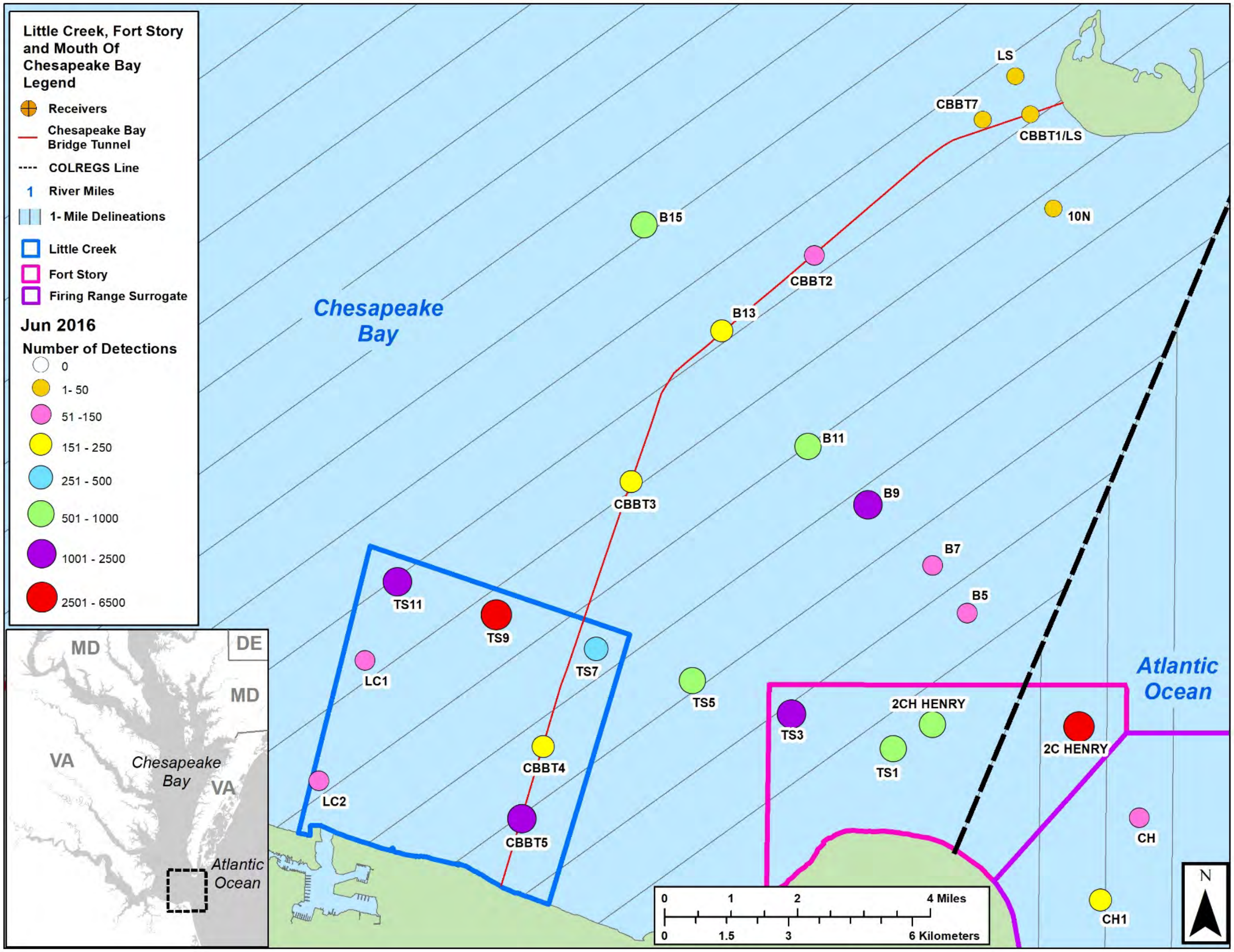
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Receivers
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COLREGS Line
River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Jun 2016
Number of Detections
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Chesapeake Bay
Atlantic Ocean
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LC2
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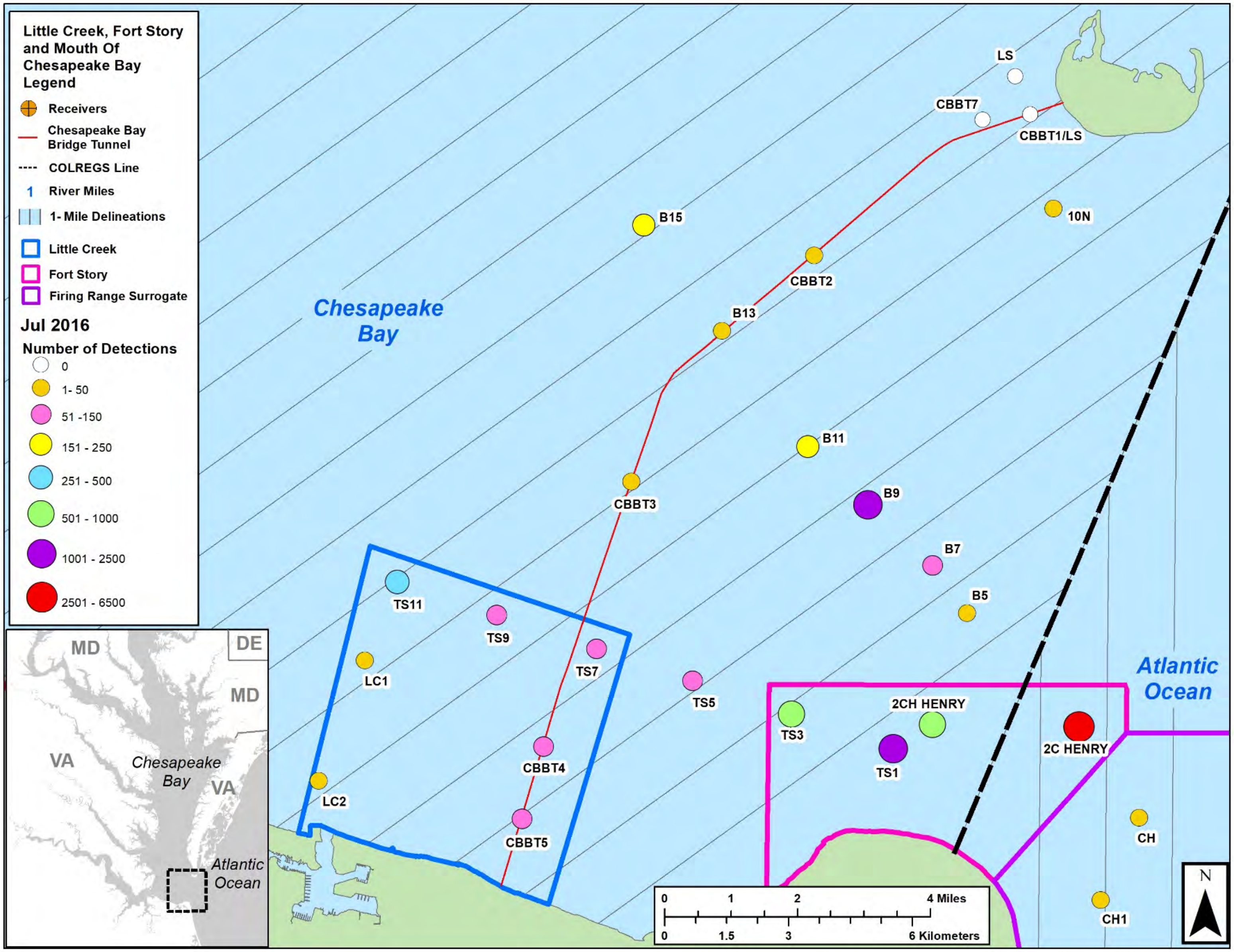
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Little Creek
Fort Story
Firing Range Surrogate
Jul 2016
Number of Detections
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Atlantic Ocean
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LC2
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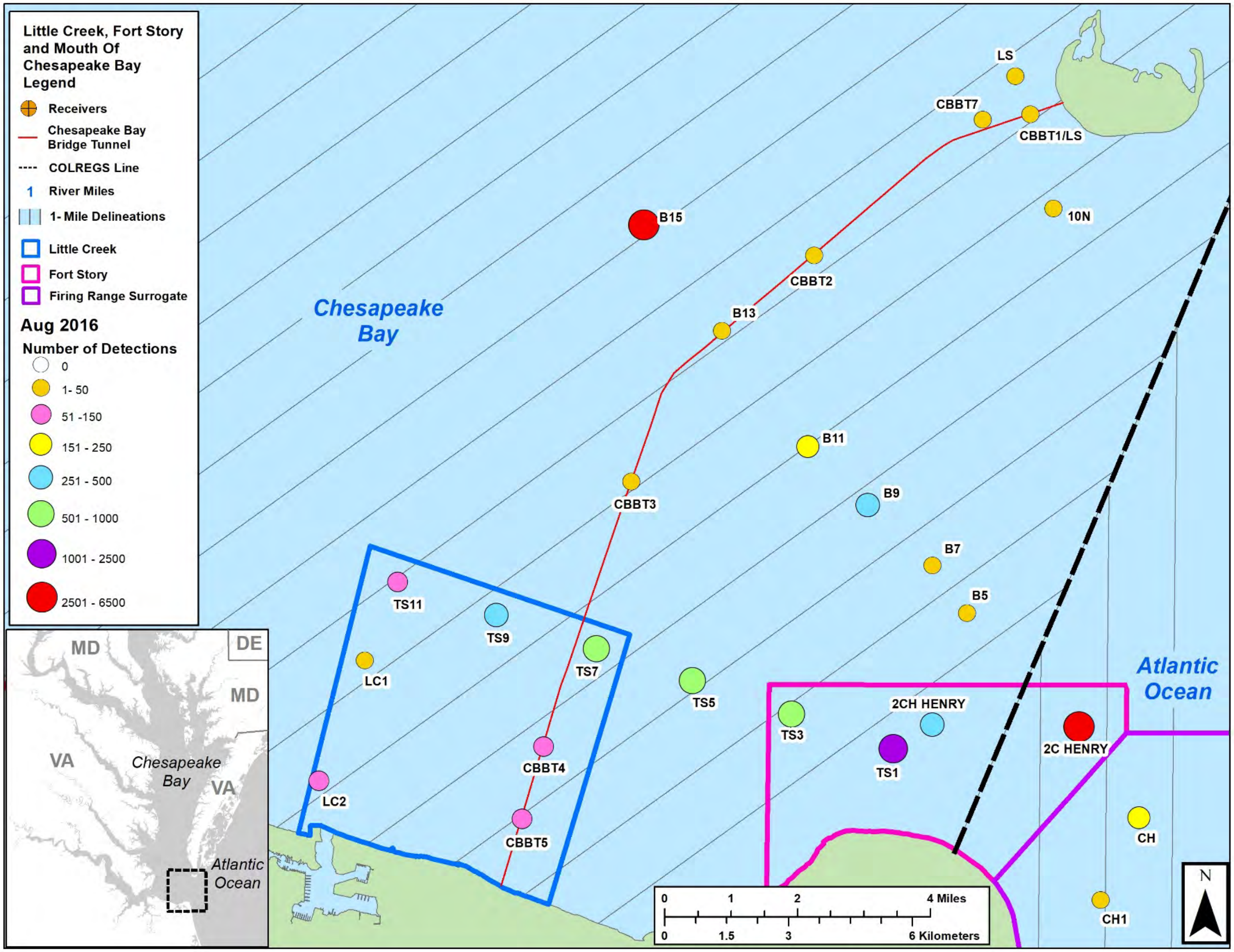
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Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Aug 2016
Number of Detections
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Chesapeake Bay
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Atlantic Ocean
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Atlantic Ocean
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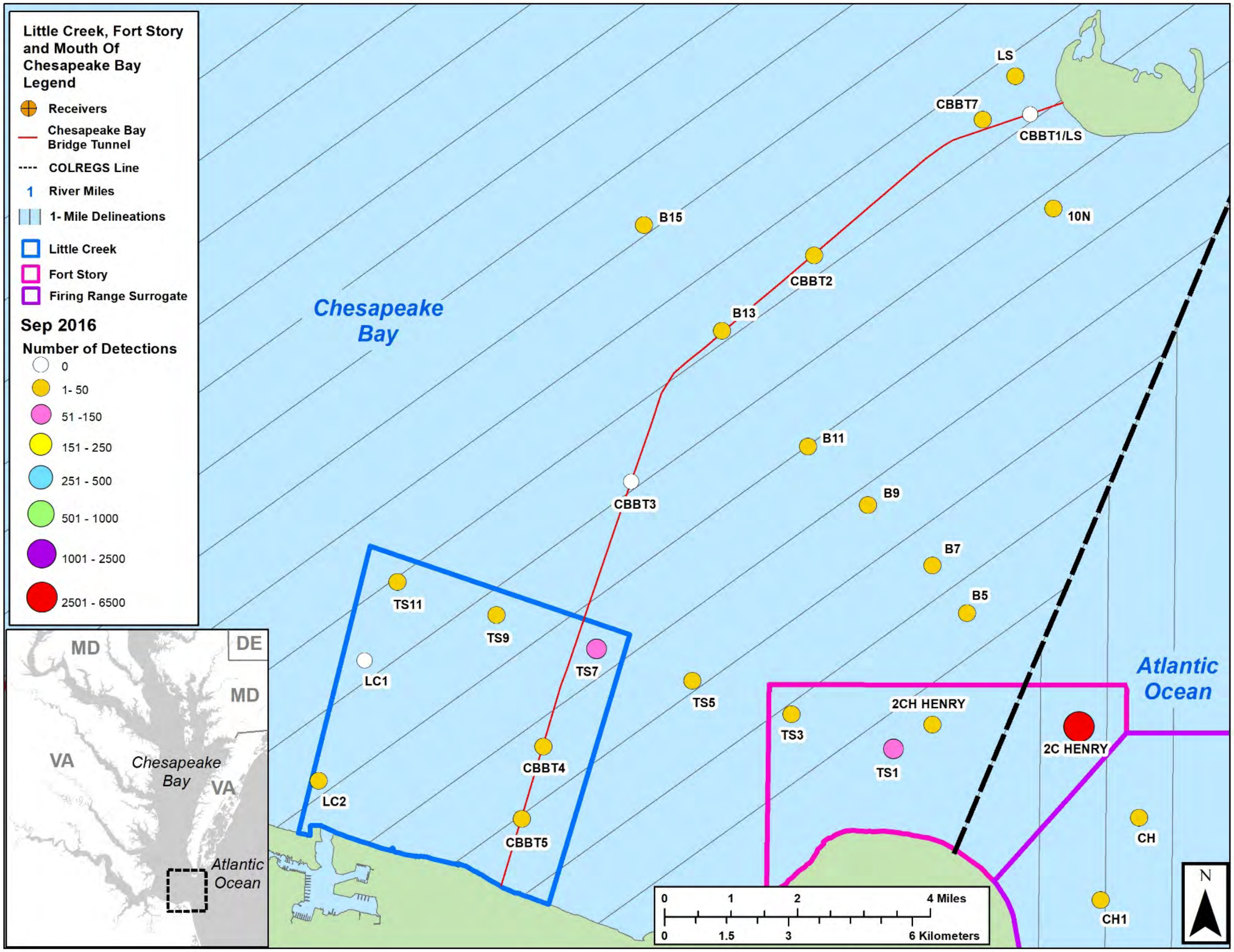
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1- Mile Delineations
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Fort Story
Firing Range Surrogate
Sep 2016
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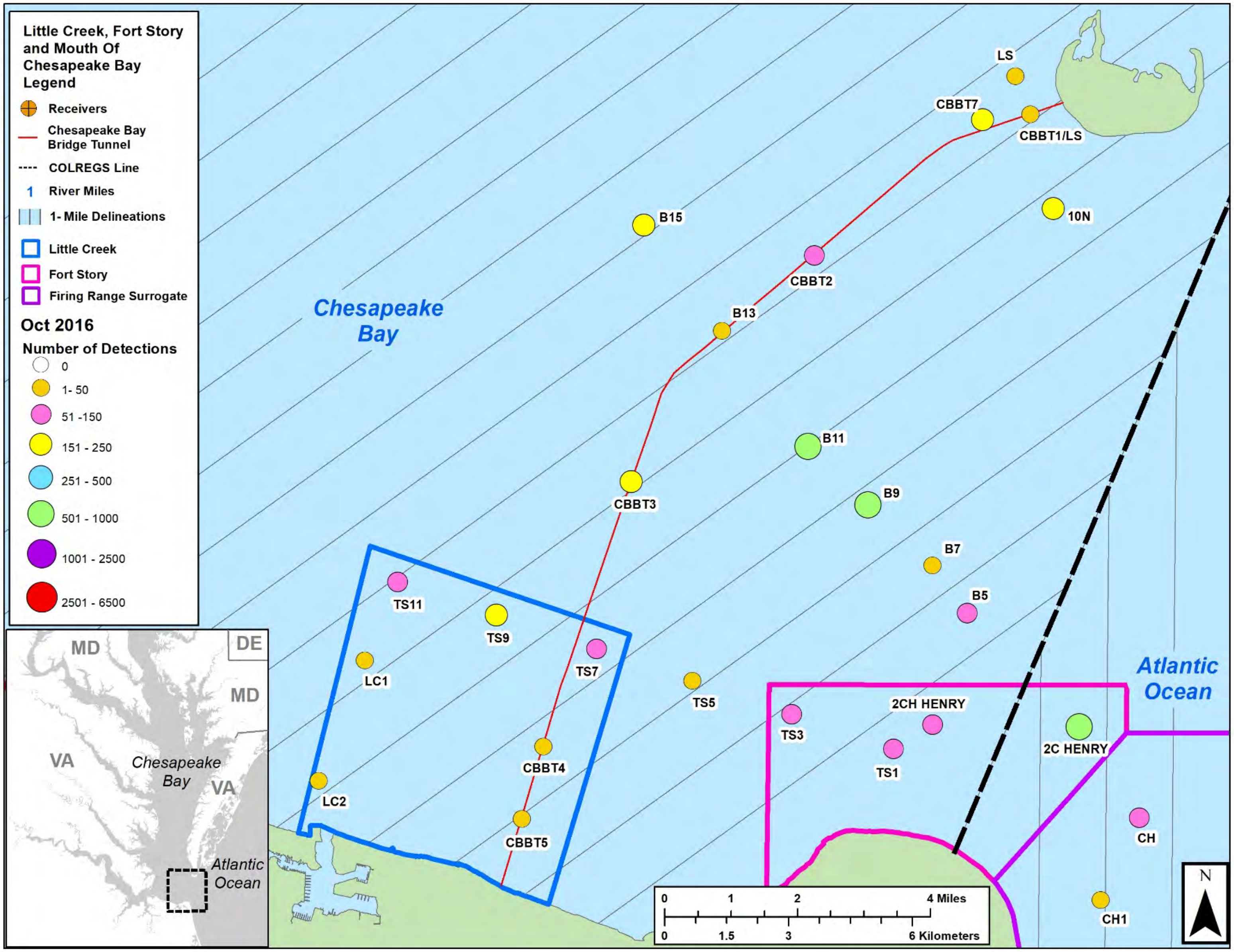
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Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Oct 2016
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Chesapeake Bay
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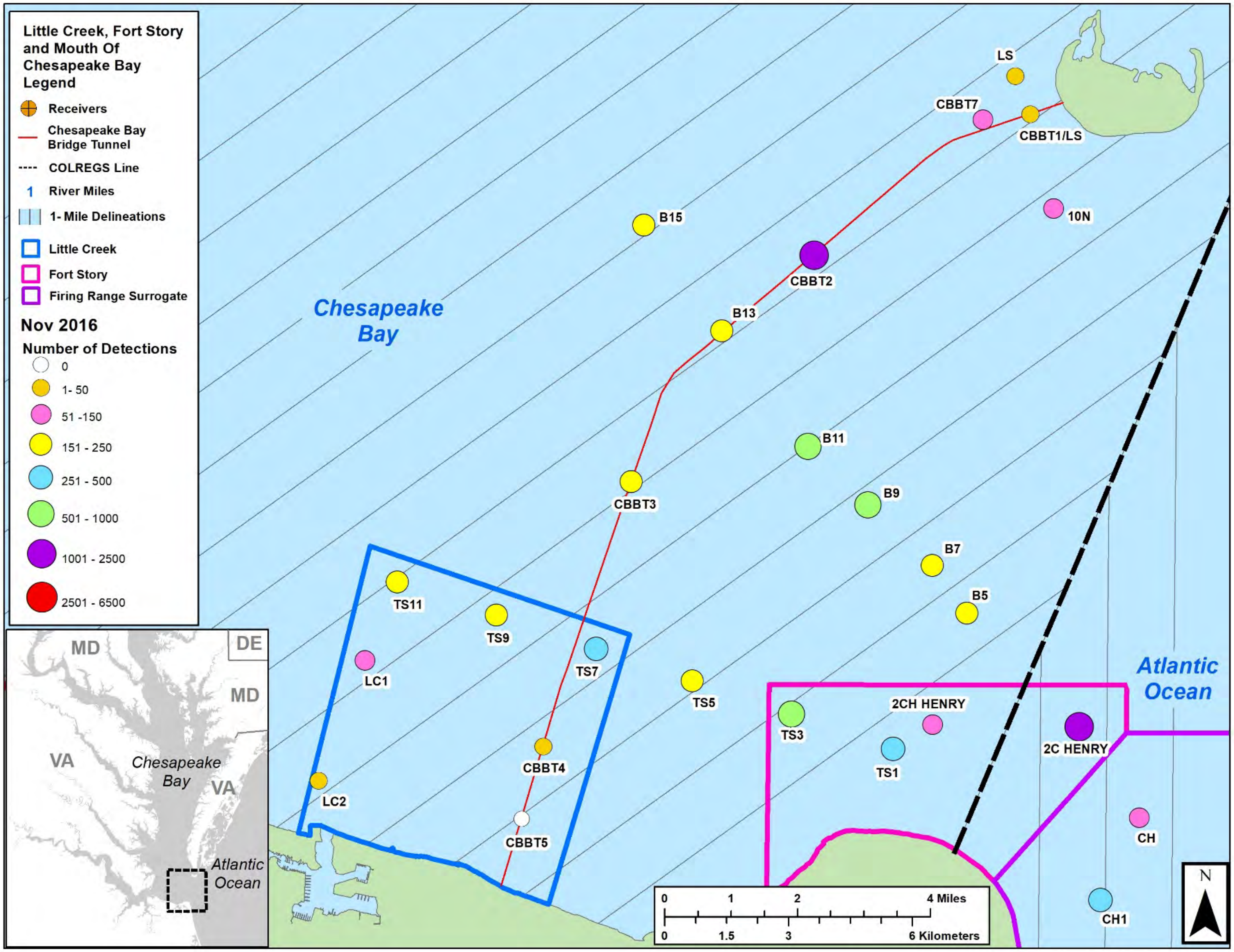
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COLREGS Line
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1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Nov 2016
Number of Detections
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Atlantic Ocean
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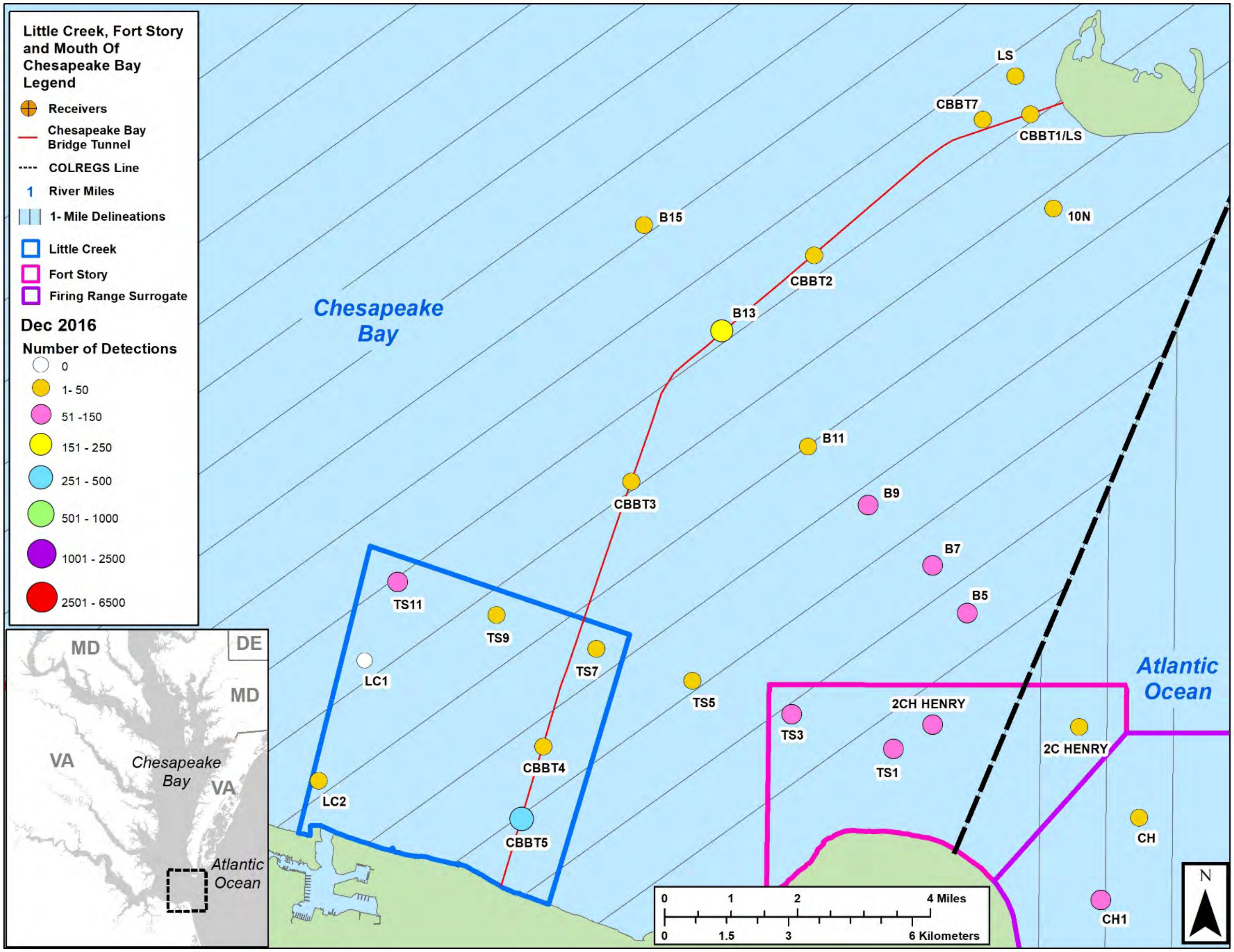
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Fort Story
Firing Range Surrogate
Dec 2016
Number of Detections
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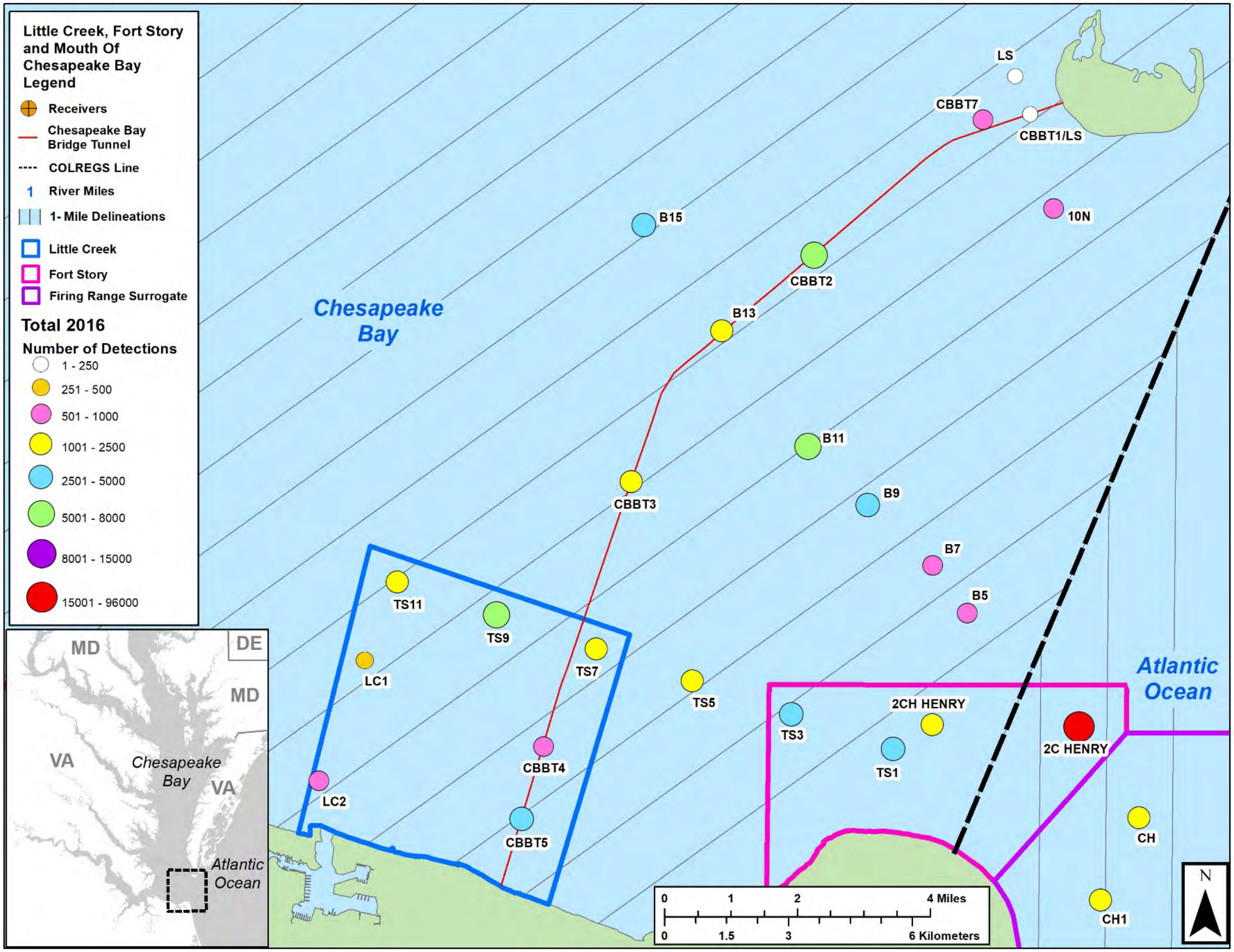
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1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Total 2016
Number of Detections
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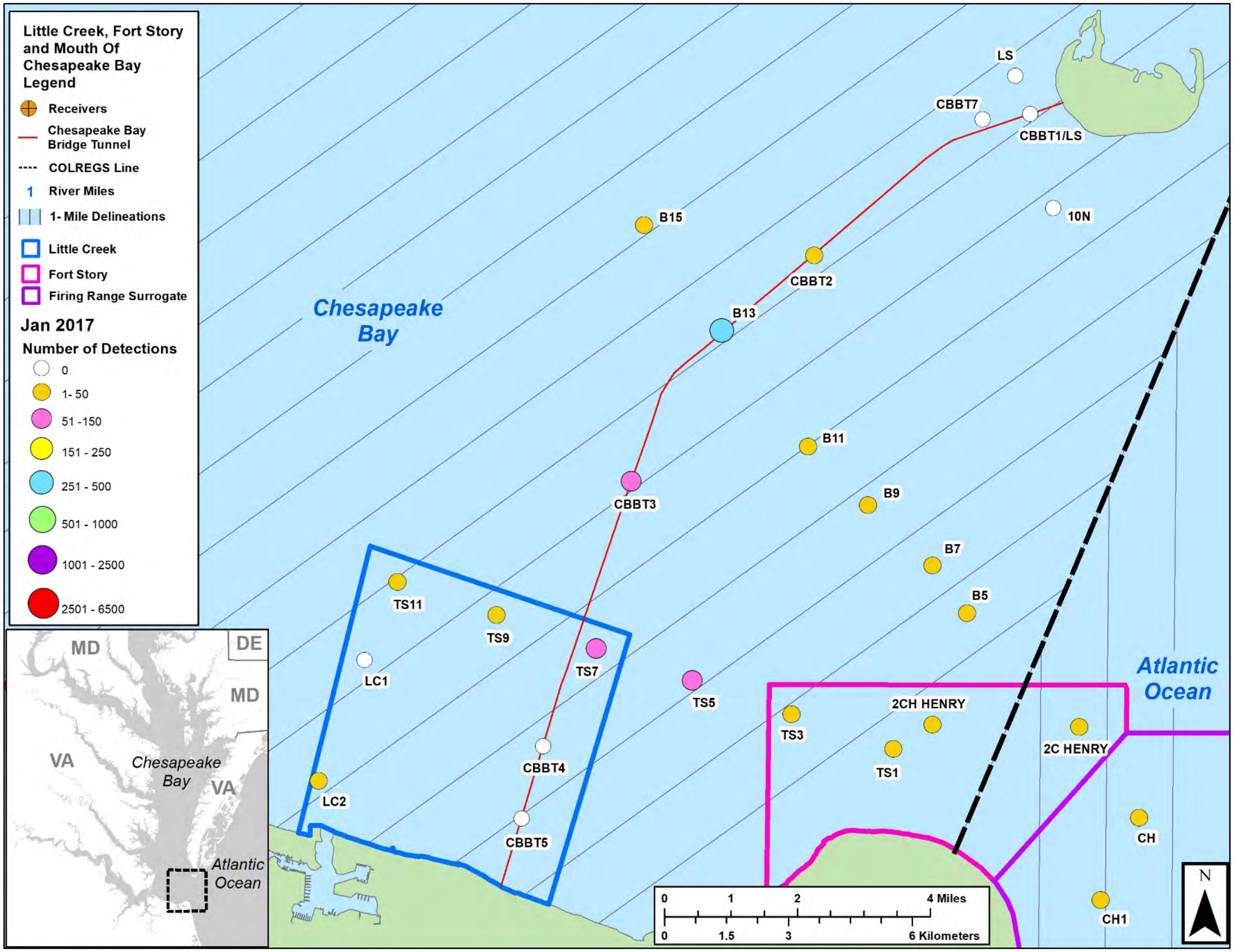
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Chesapeake Bay Bridge Tunnel
COLREGS Line
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1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Jan 2017
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Atlantic Ocean
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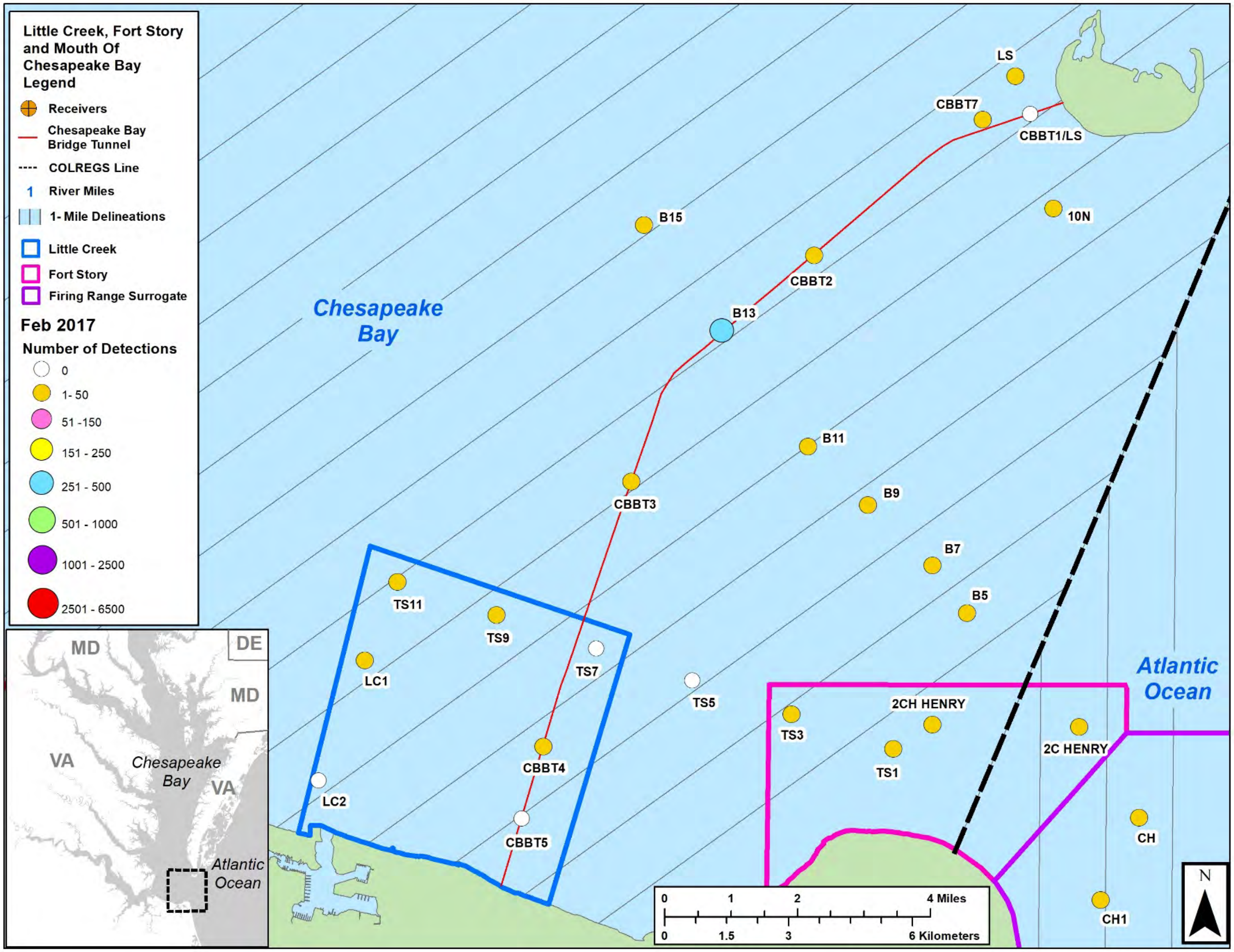
Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
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1- Mile Delineations
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Fort Story
Firing Range Surrogate
Feb 2017
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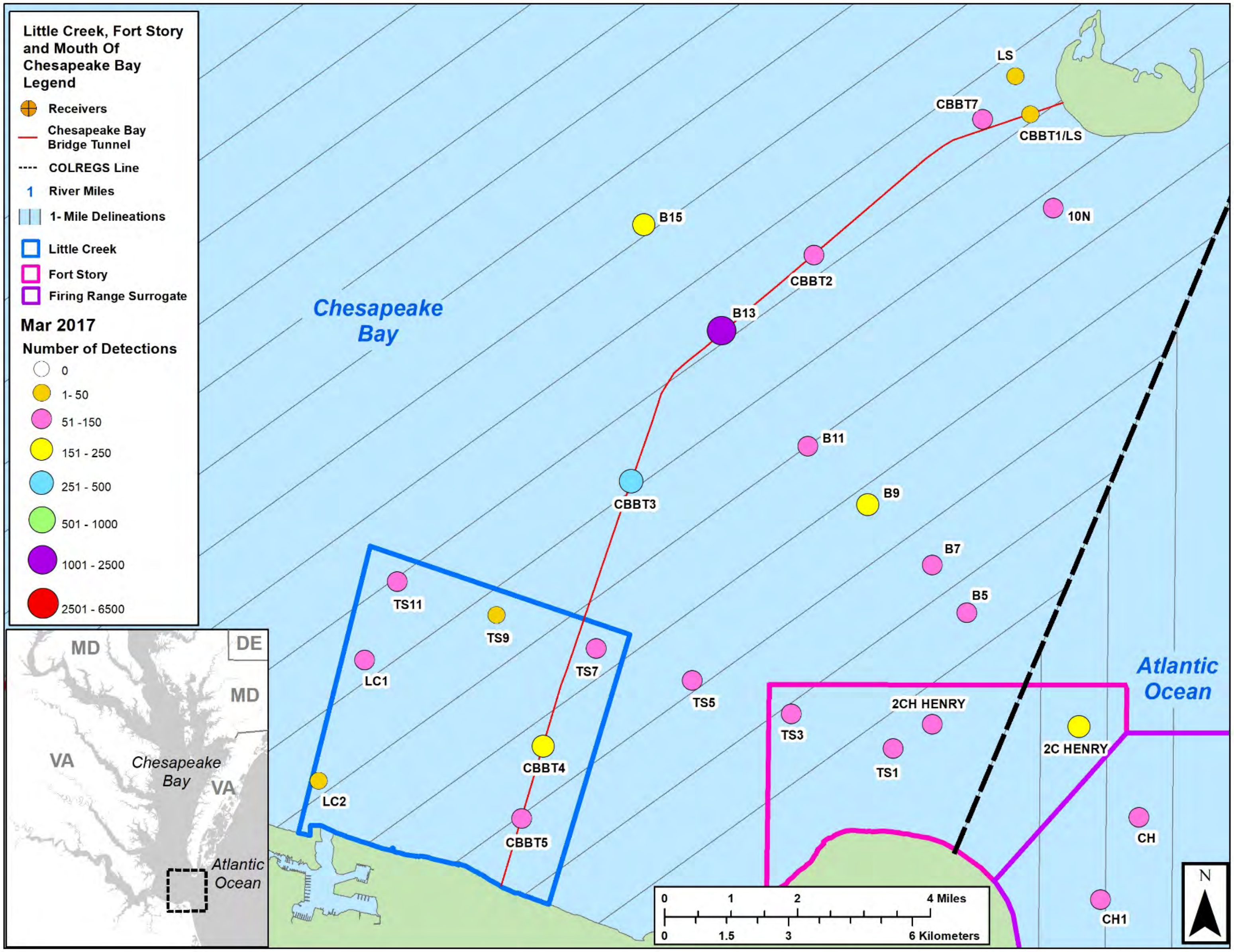
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1- Mile Delineations
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Fort Story
Firing Range Surrogate
Mar 2017
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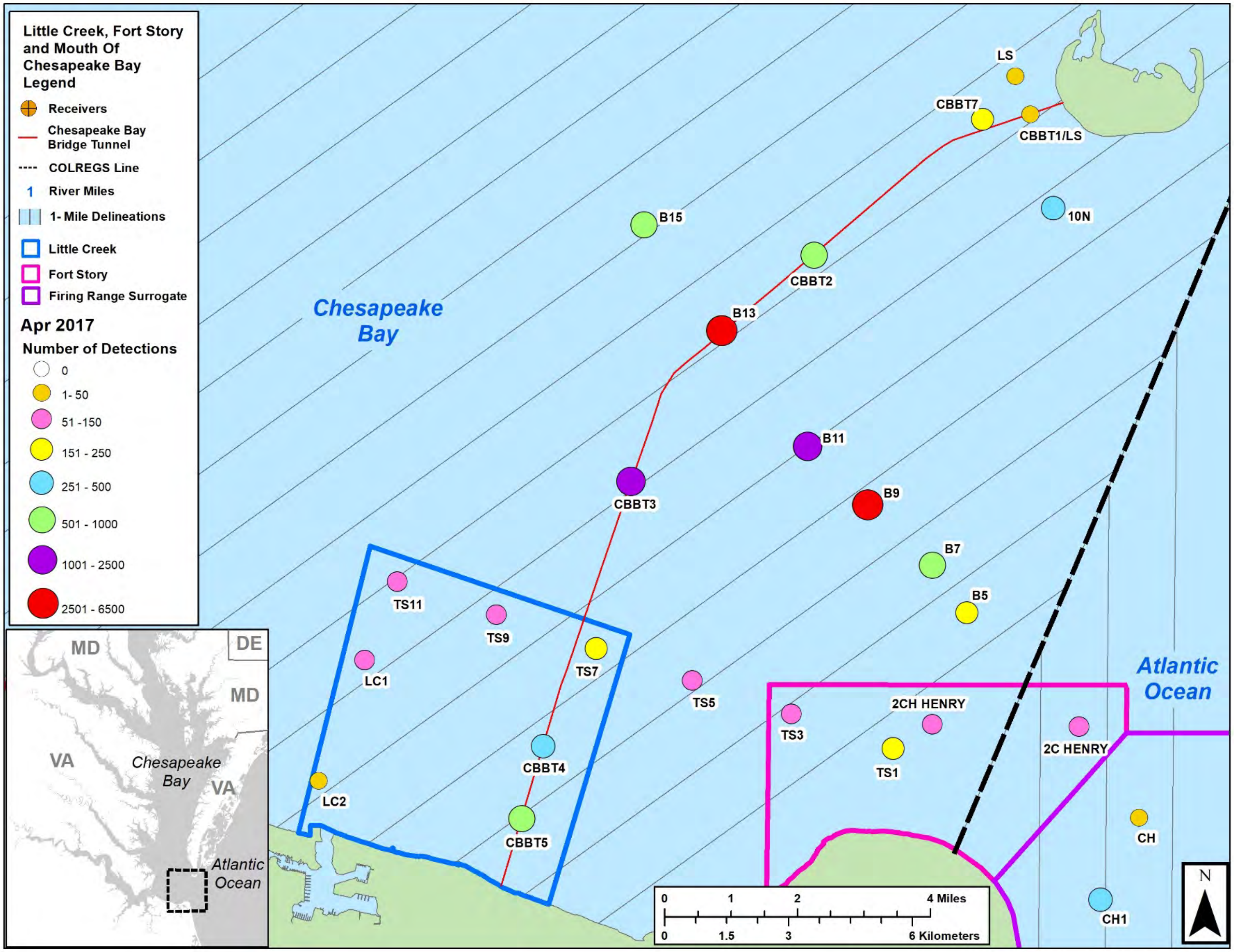
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Fort Story
Firing Range Surrogate
Apr 2017
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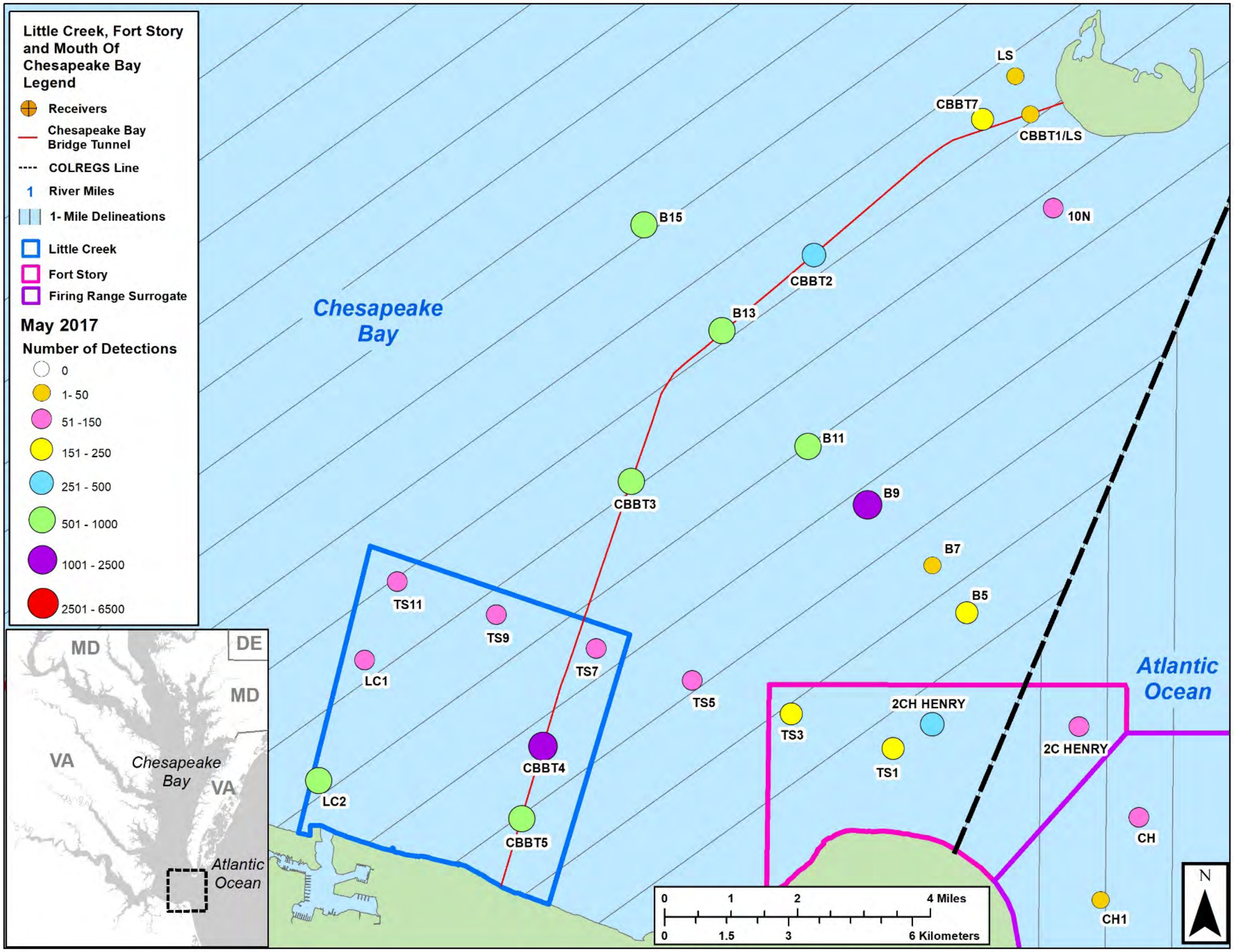
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Little Creek
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May 2017
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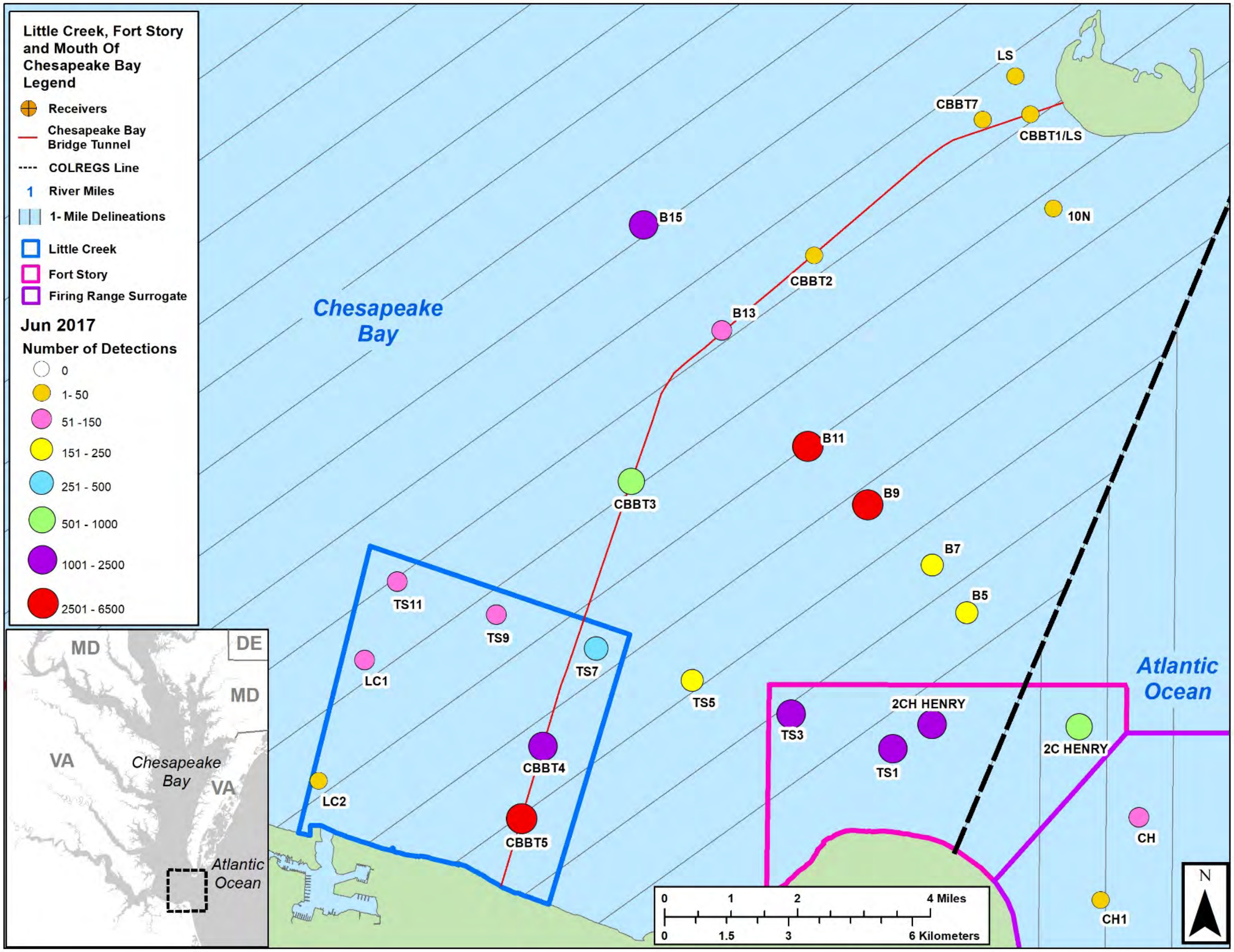
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Chesapeake Bay Bridge Tunnel
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1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Jun 2017
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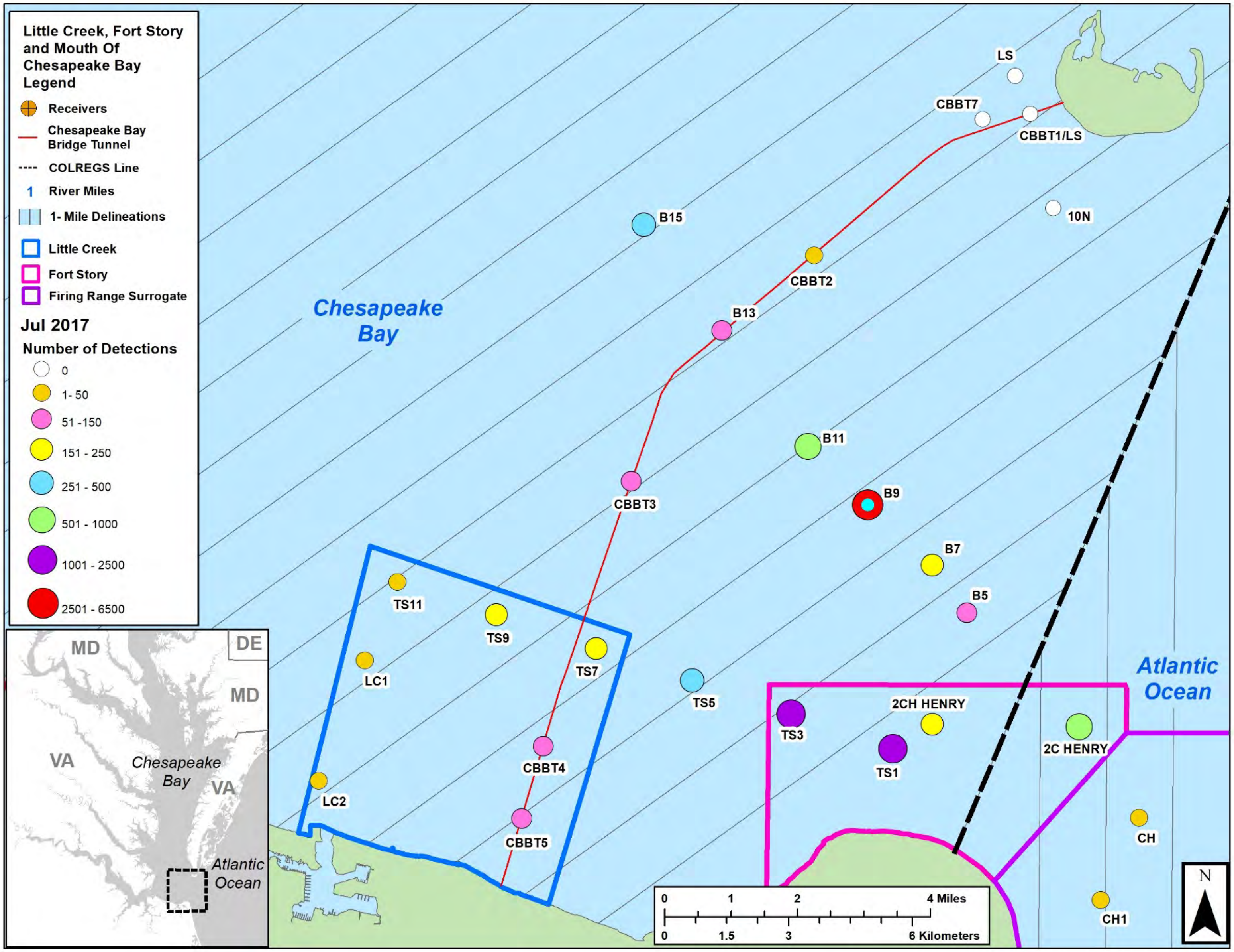
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Jul 2017
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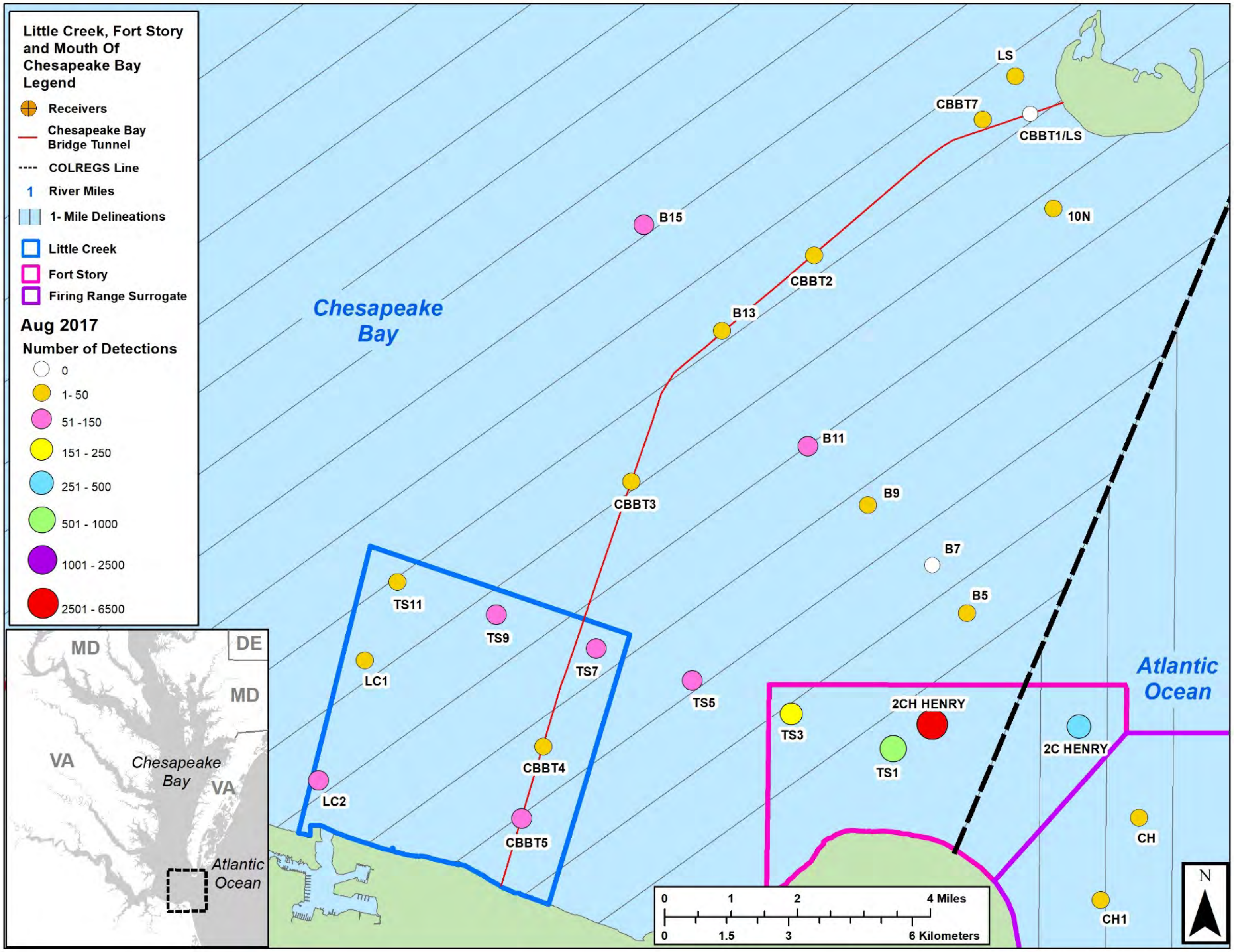
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Fort Story
Firing Range Surrogate
Aug 2017
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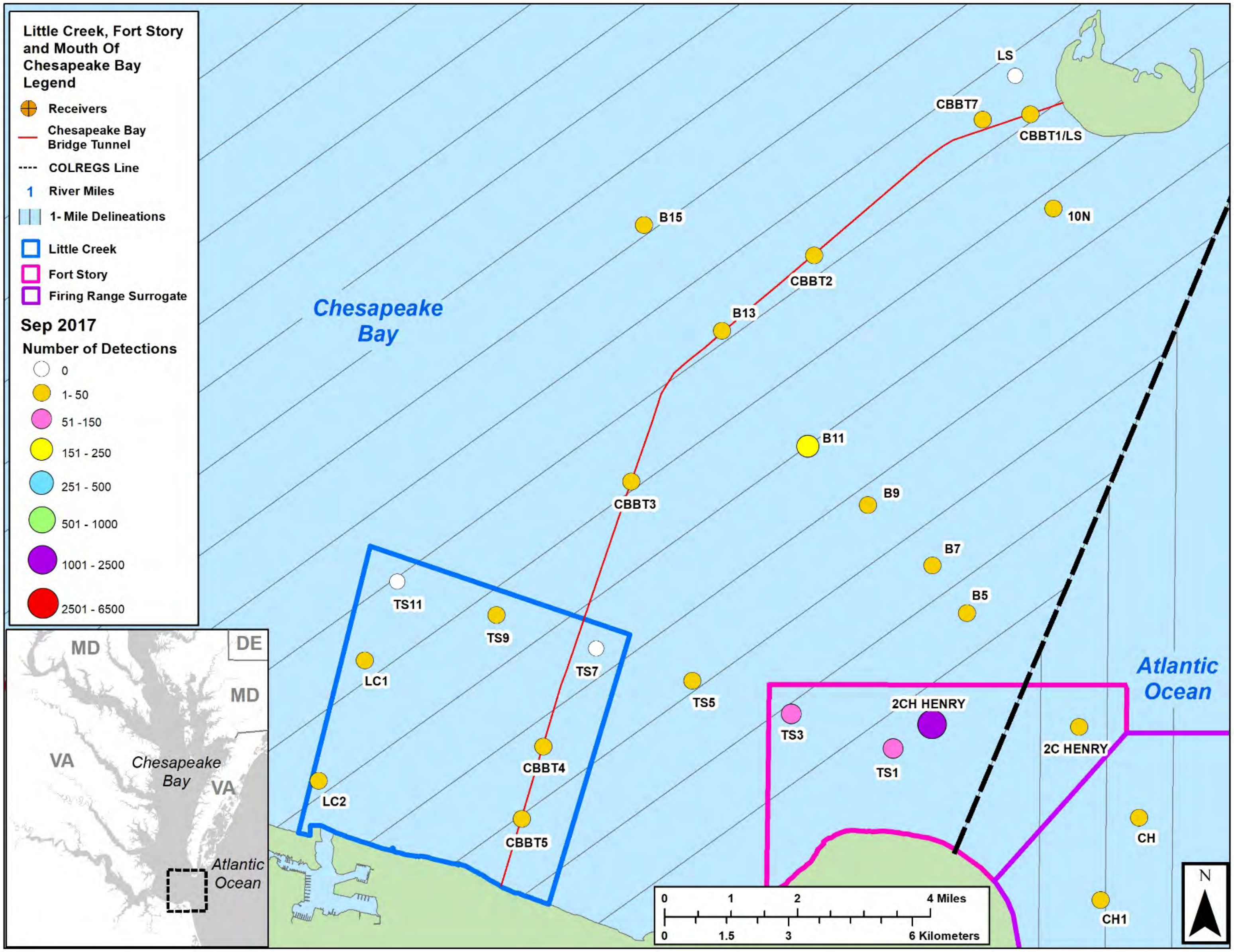
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Little Creek
Fort Story
Firing Range Surrogate
Sep 2017
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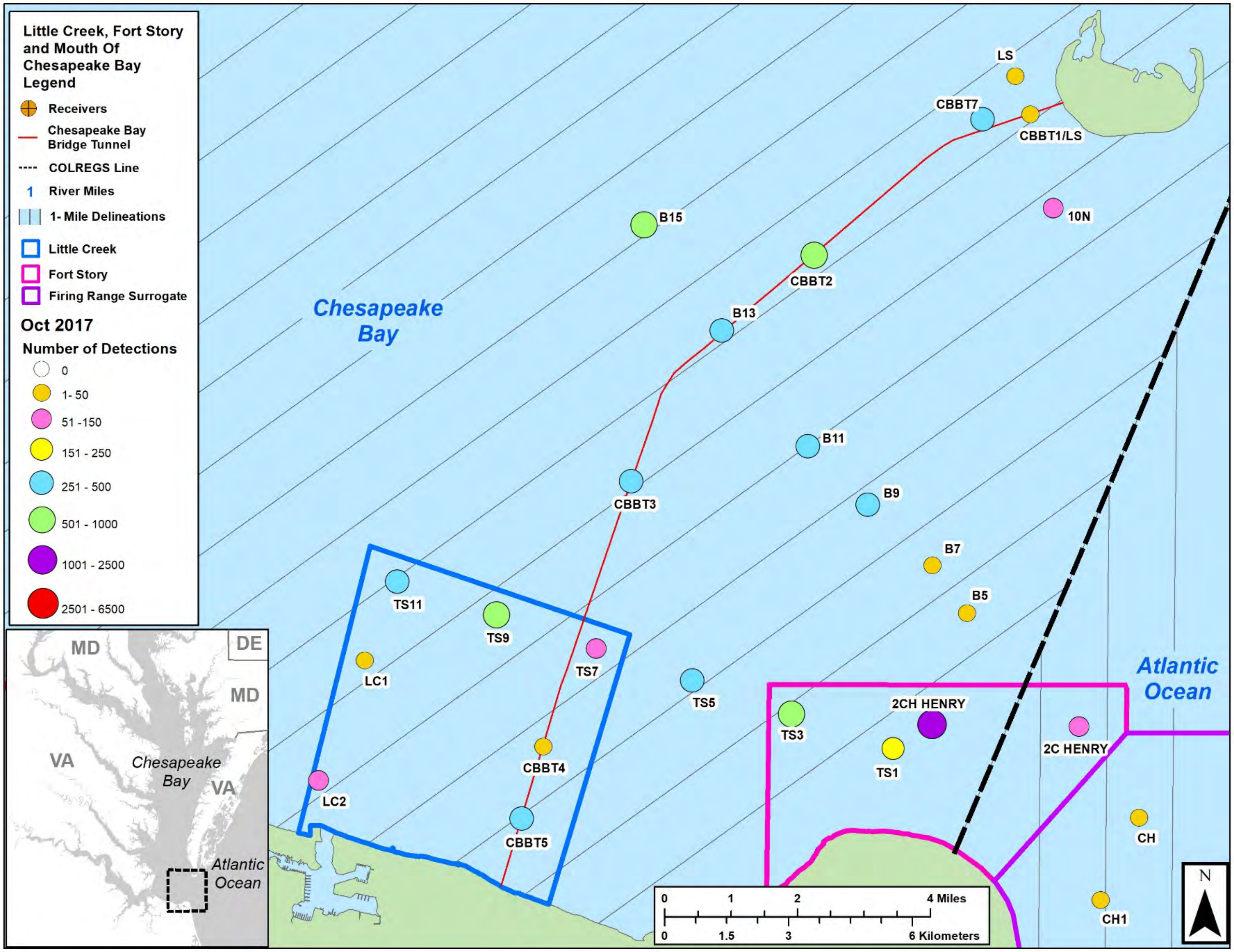
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Little Creek
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Oct 2017
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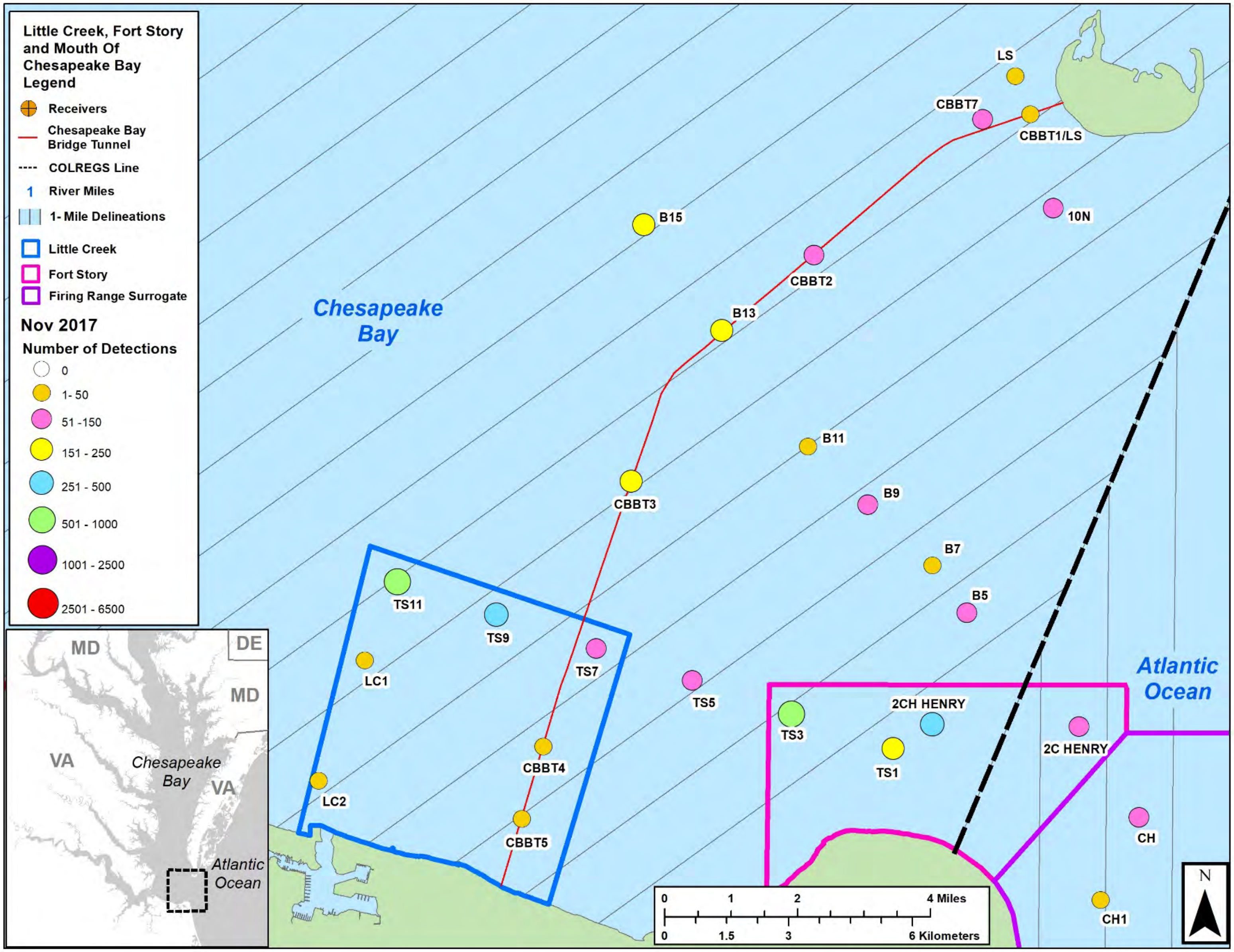
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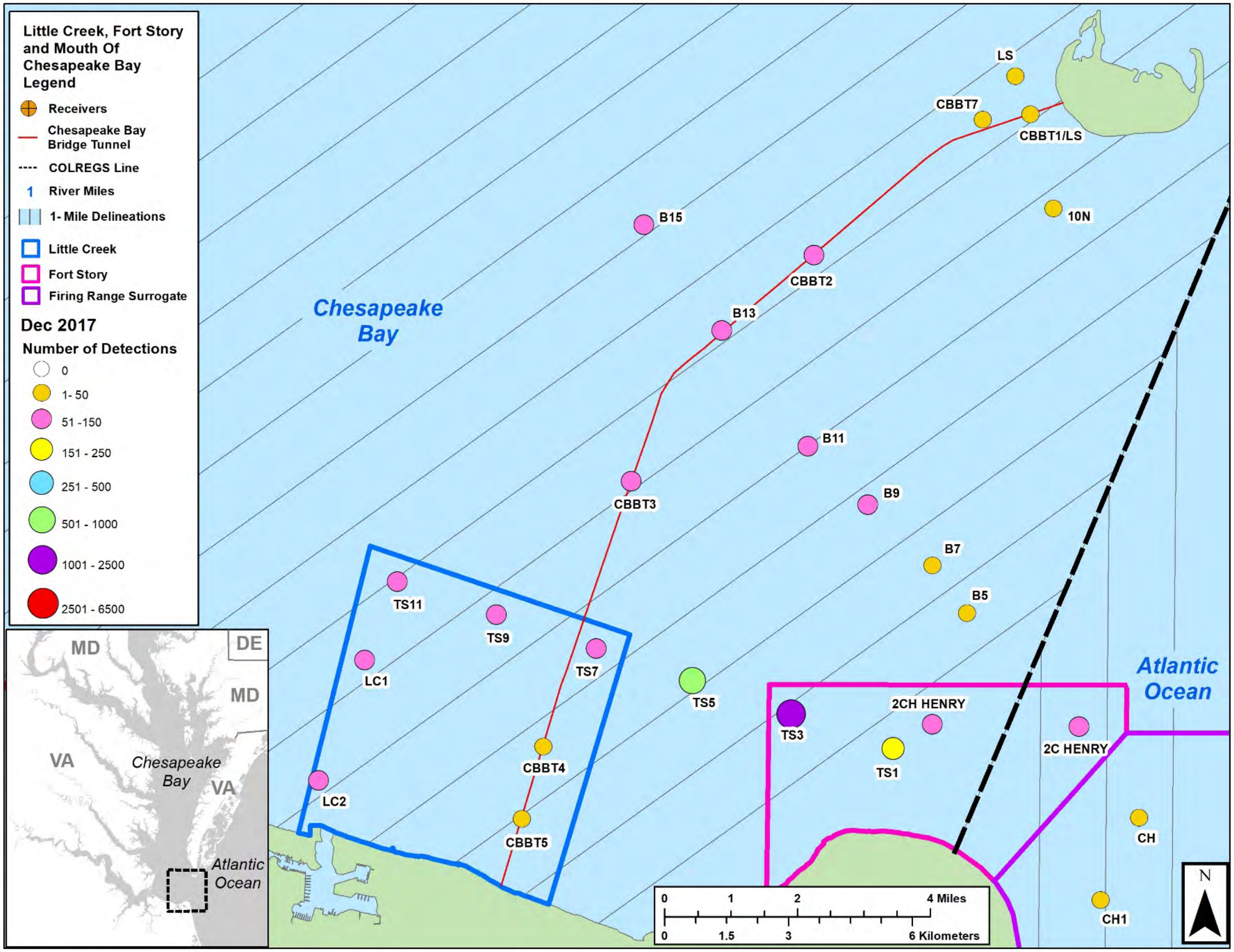
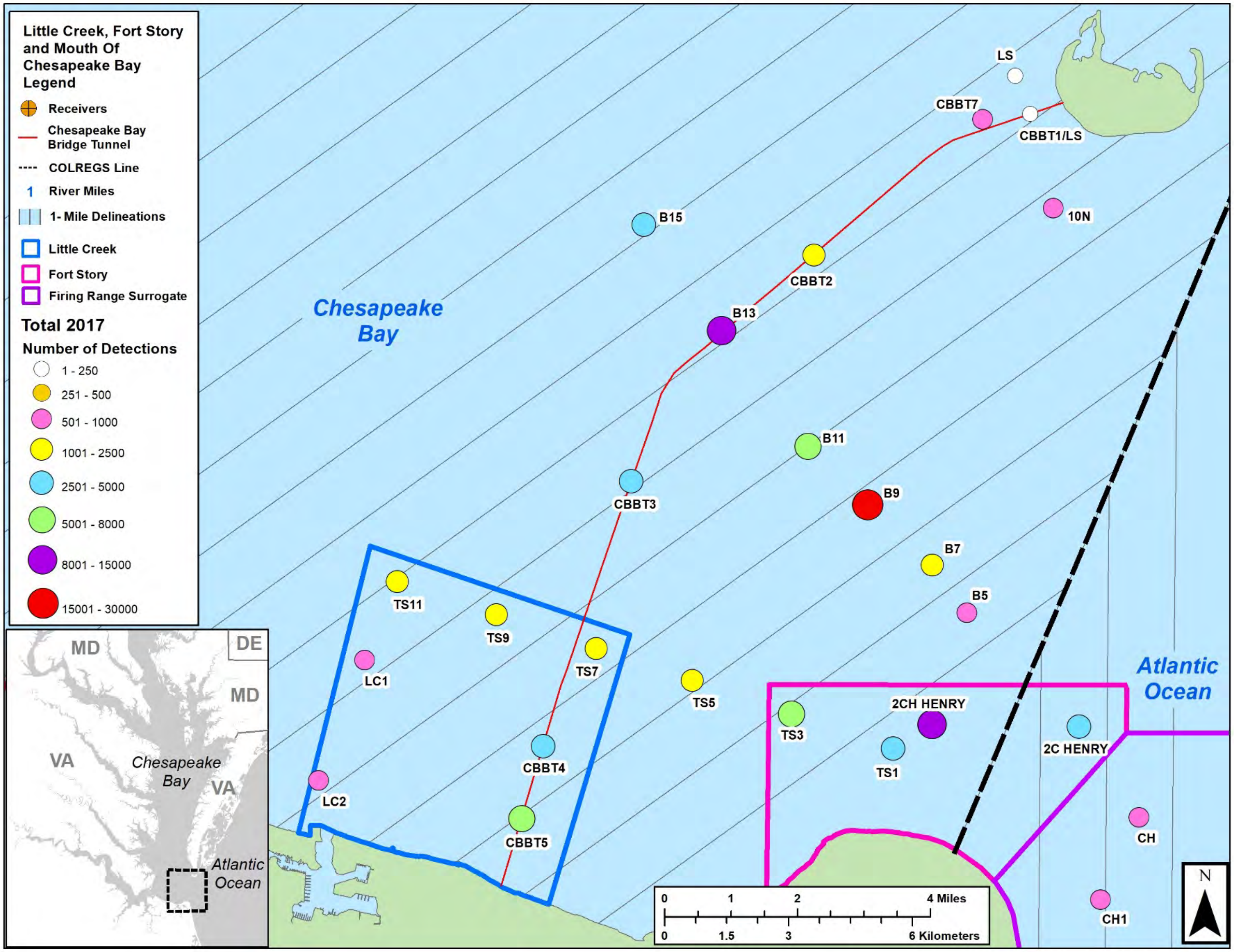
Atlantic Ocean


Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Dec 2017
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean


Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Total 2017
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
0 1 2 4 Miles
0 1.5 3 6 Kilometers
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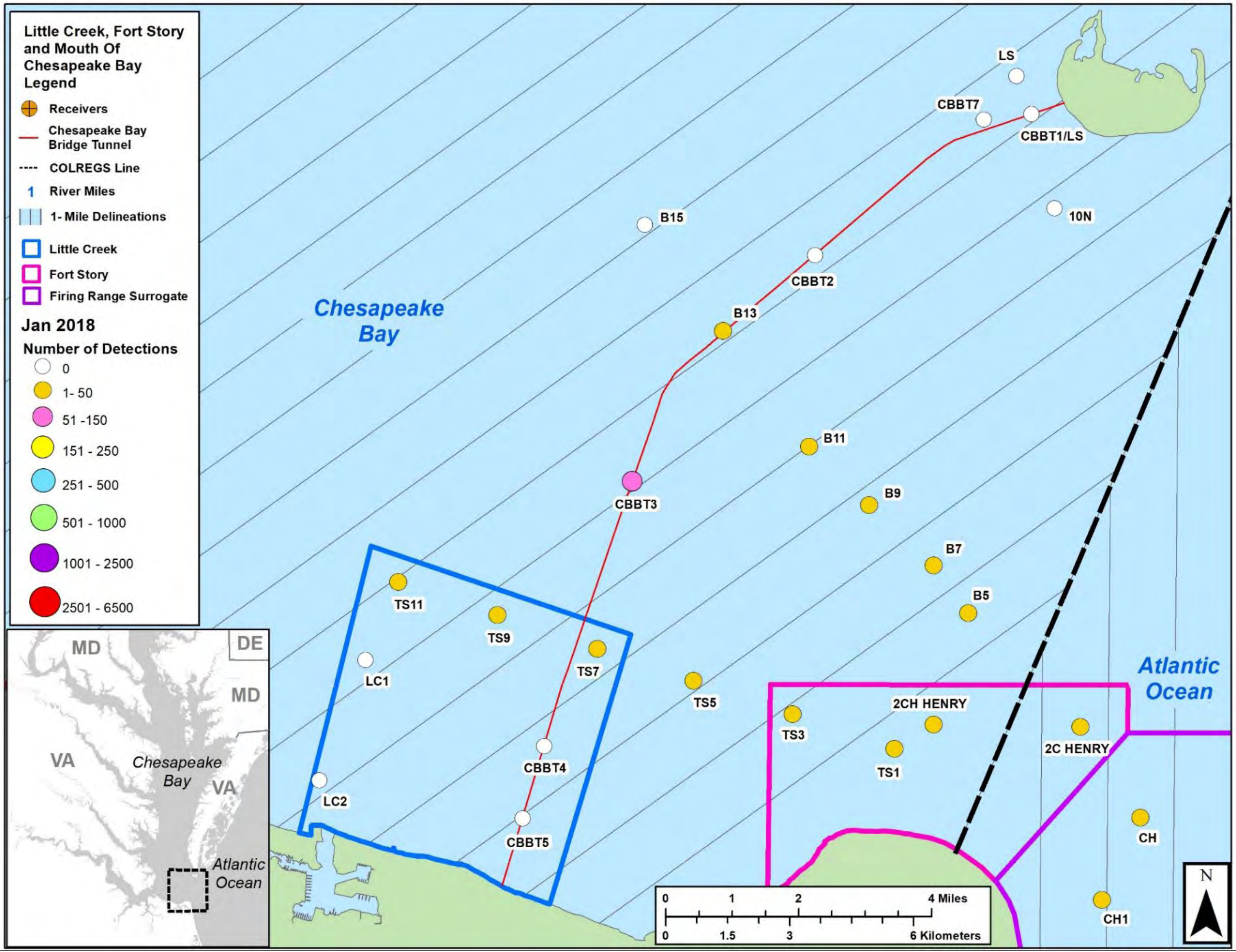
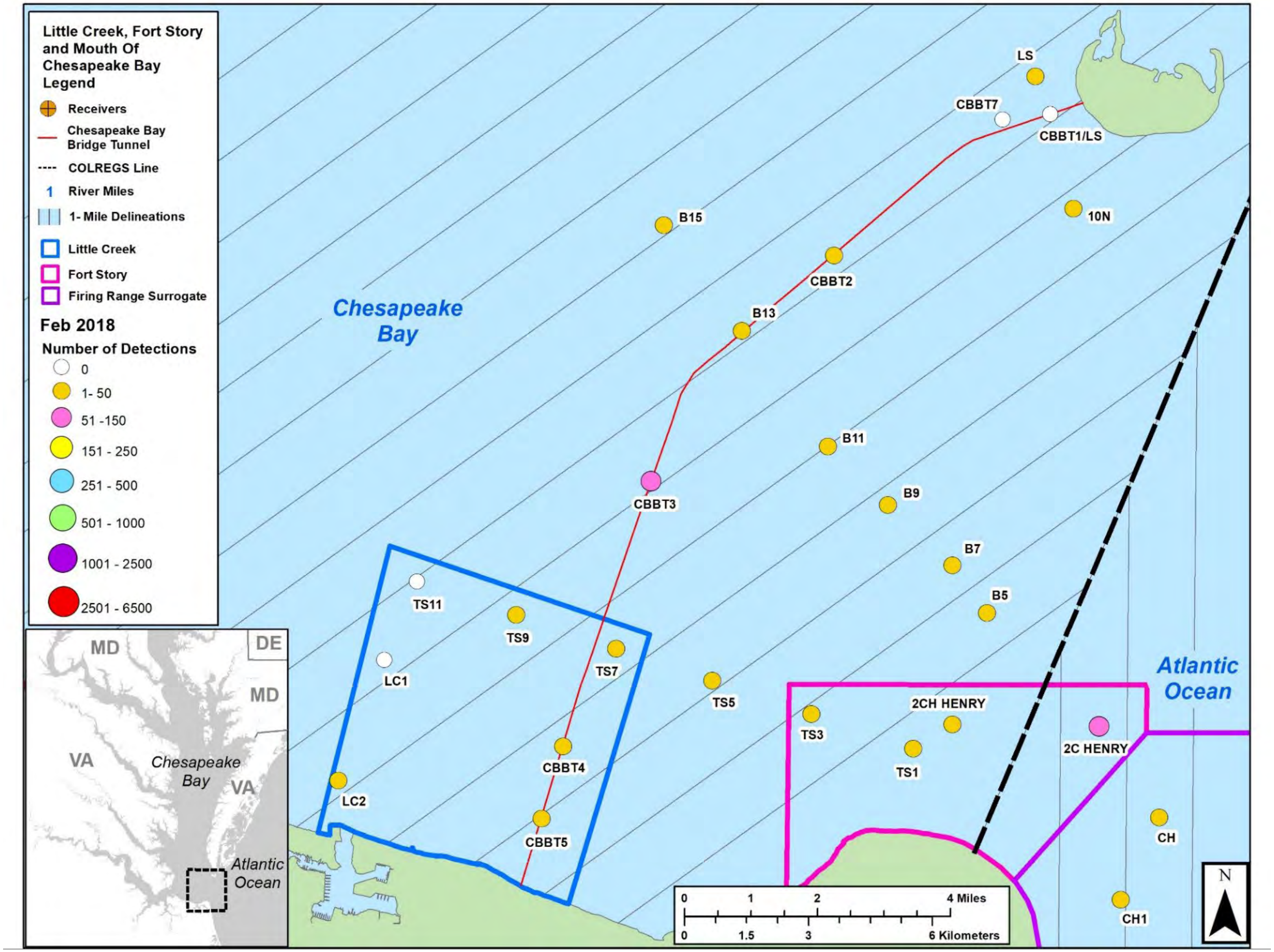
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean


Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Jan 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
2C HENRY
TS1
CBBT4
LC2
CBBT5
CH
CH1
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N


Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Feb 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
TS1
2C HENRY
CBBT4
LC2
CBBT5
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CH1
0 1 2 4 Miles
0 1.5 3 6 Kilometers
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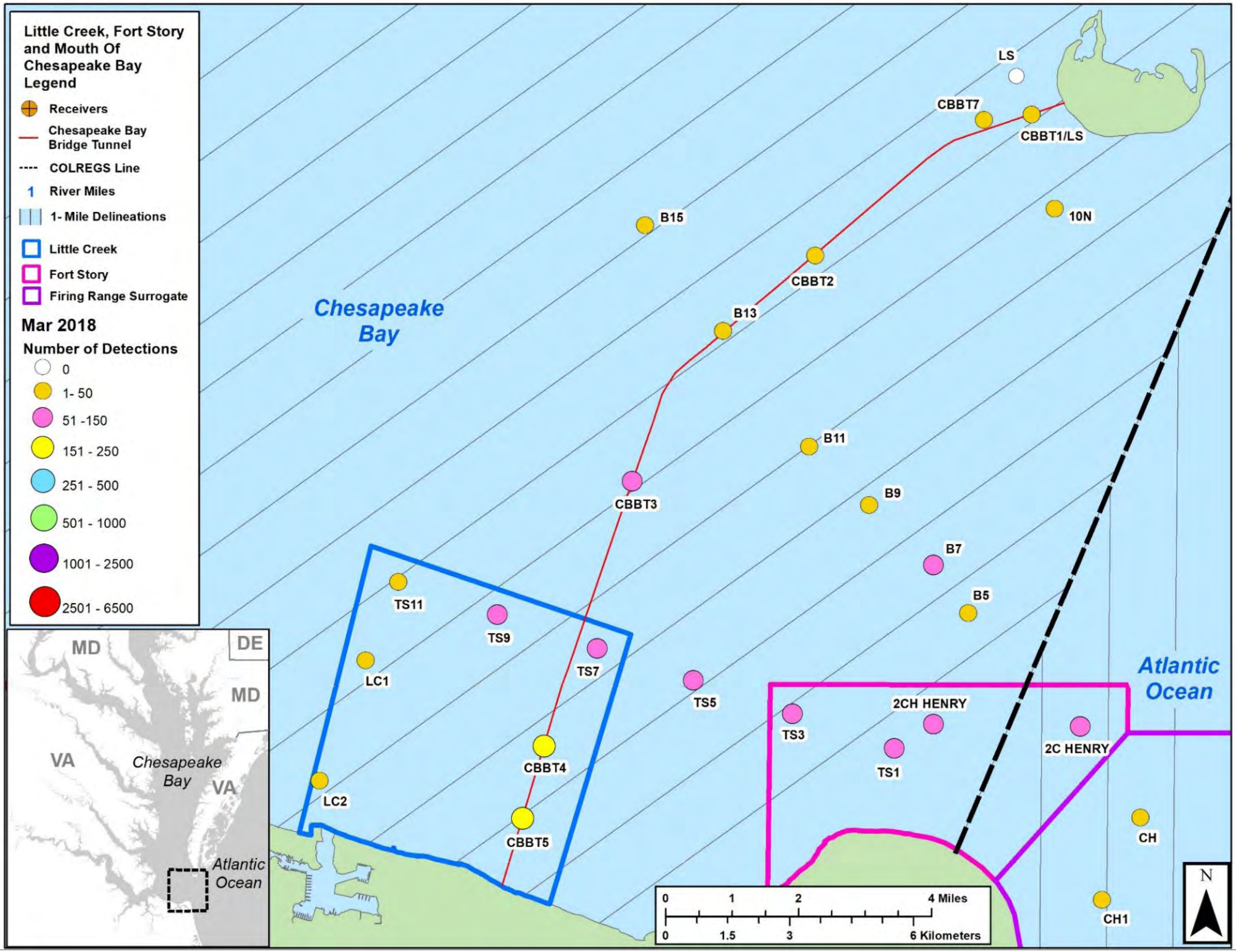
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean


Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Mar 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
TS1
2C HENRY
CBBT4
LC2
CBBT5
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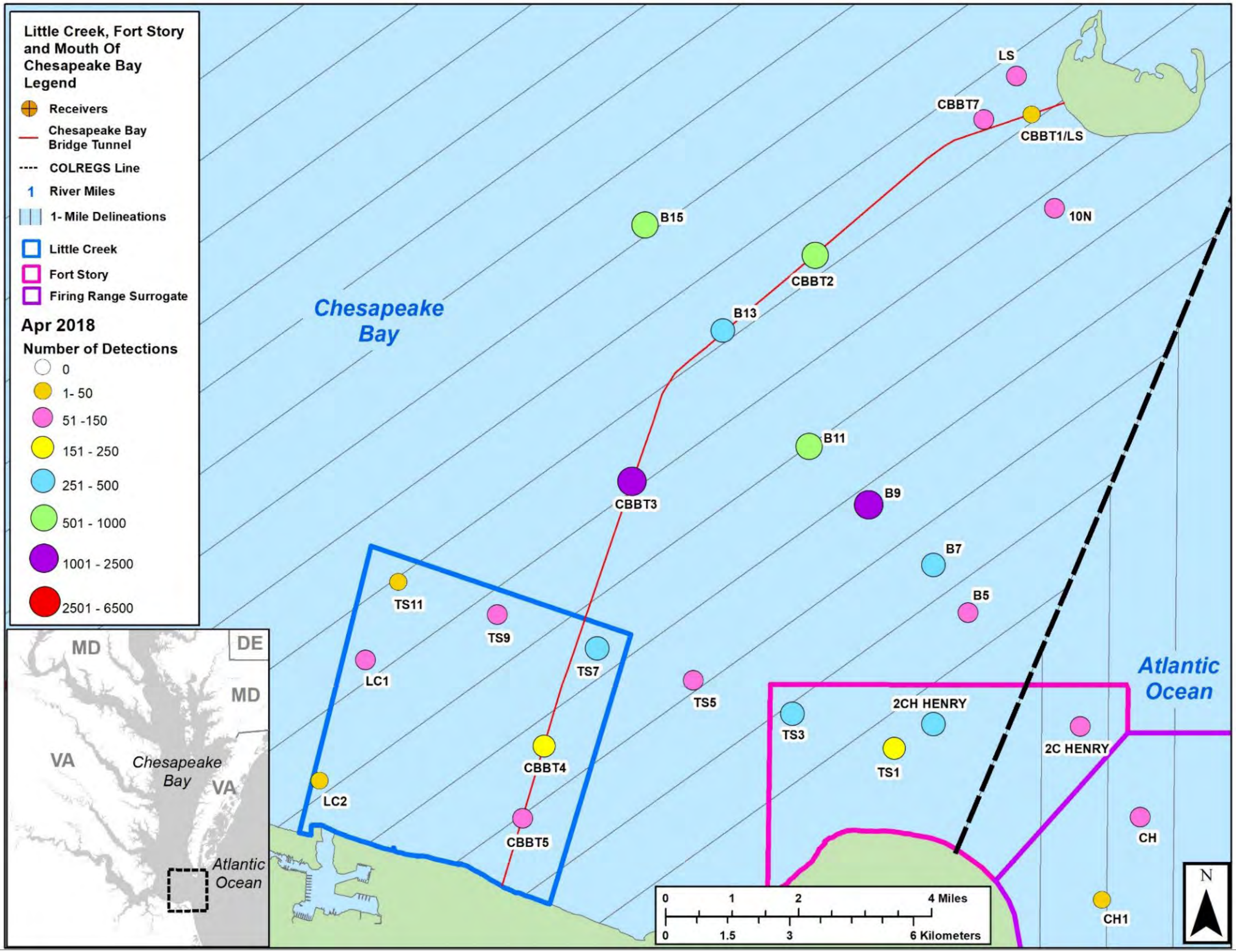
CH1
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean


Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Apr 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
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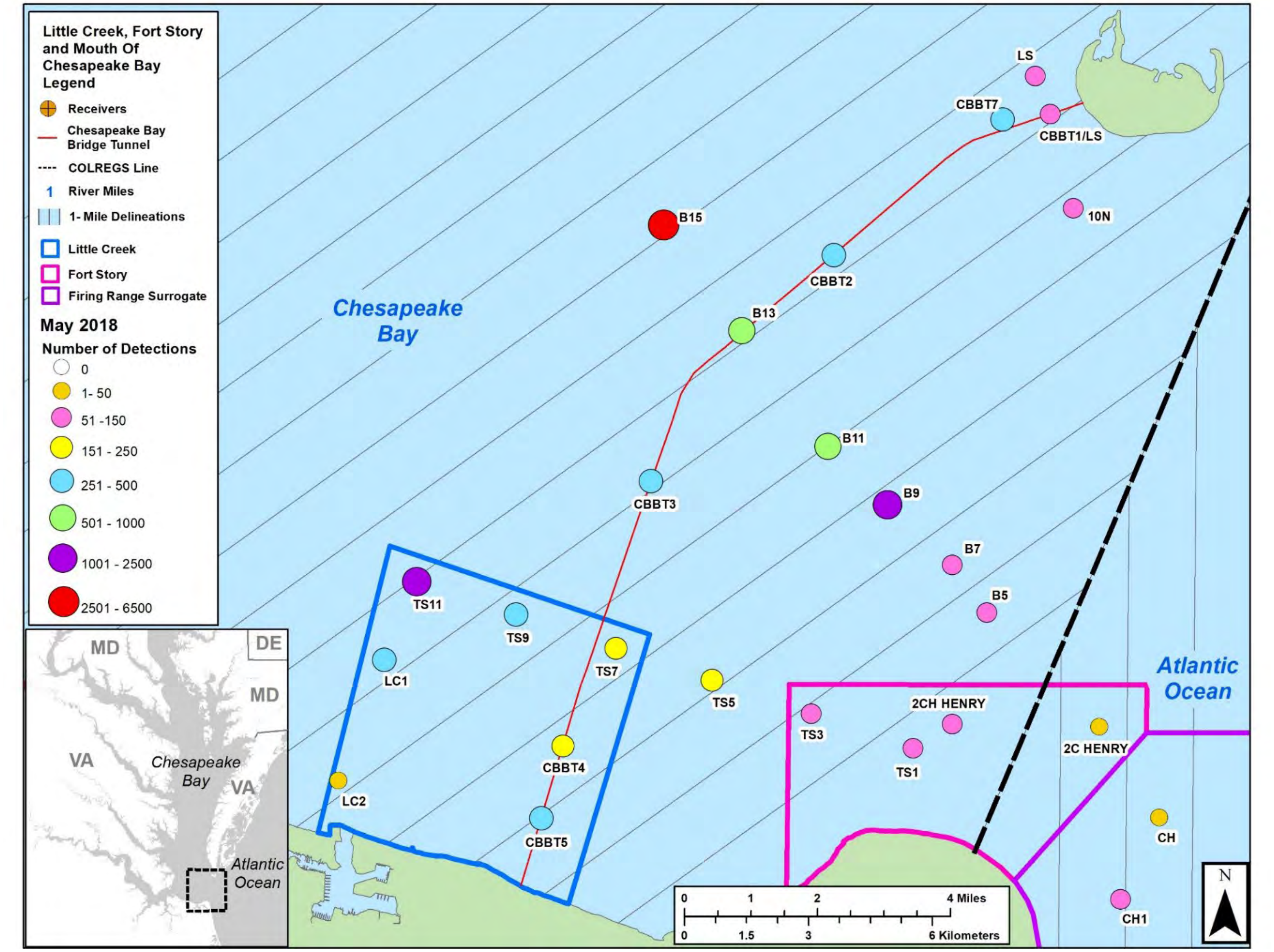
CBBT4
LC2
CBBT5
CH
CH1
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N


Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
May 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
2C HENRY
TS1
CBBT4
LC2
CBBT5
CH
CH1
0 1 2 4 Miles
0 1.5 3 6 Kilometers
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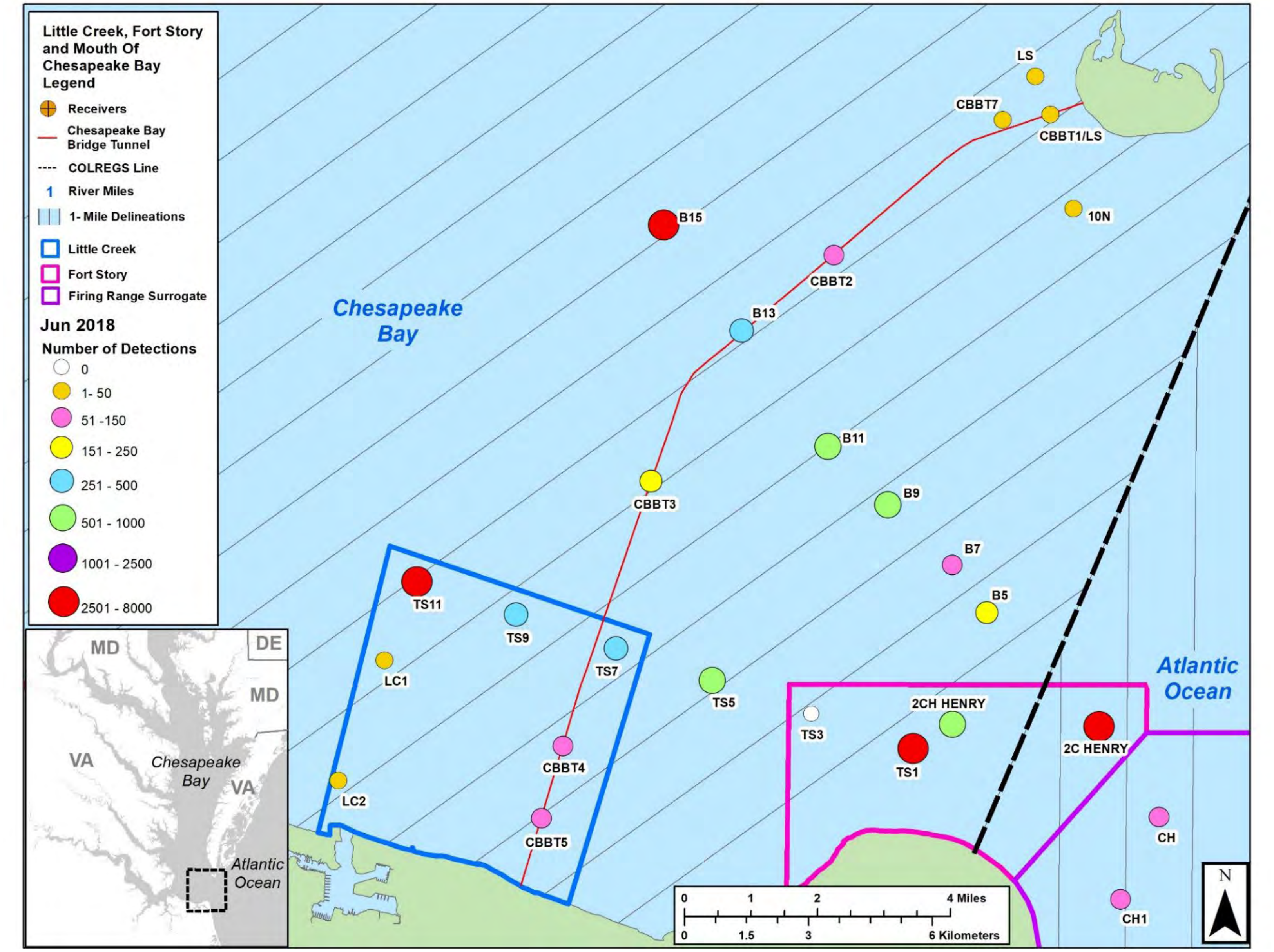
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean


Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Jun 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 8000
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
2C HENRY
TS1
CBBT4
LC2
CBBT5
CH
CH1
0 1 2 4 Miles
0 1.5 3 6 Kilometers
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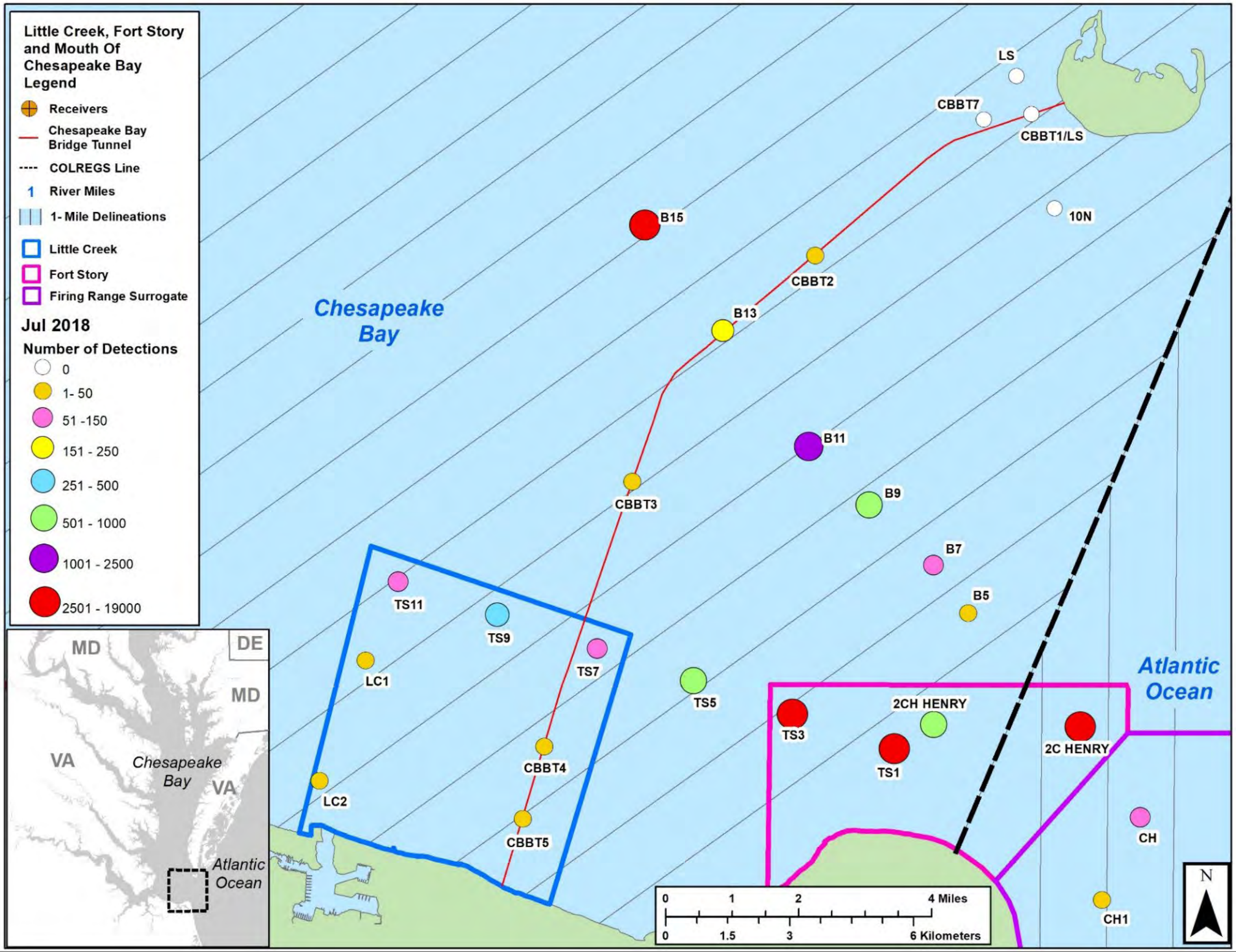
Chesapeake Bay
VA
Atlantic Ocean


Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Jul 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 19000
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N
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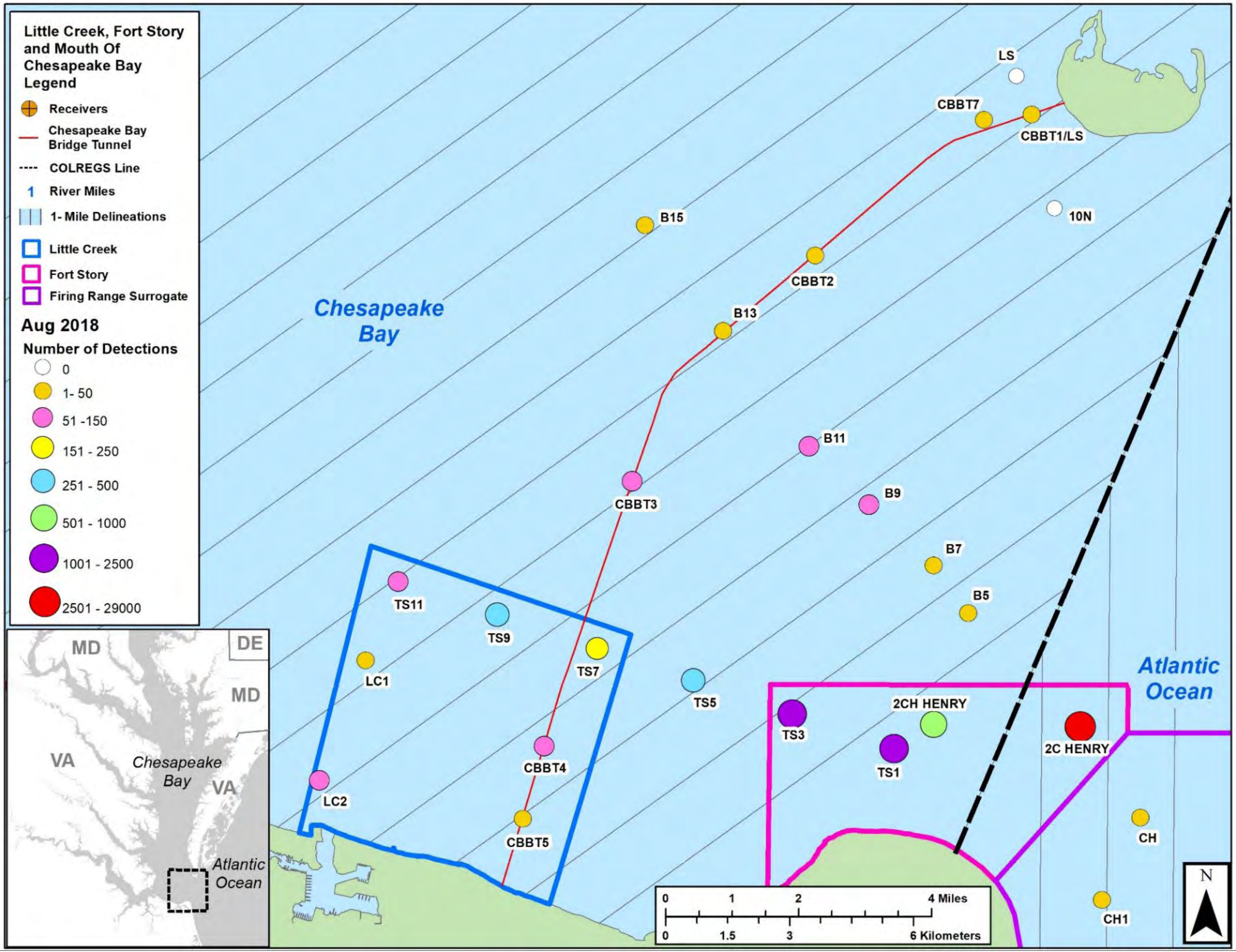
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean


Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Aug 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 29000
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
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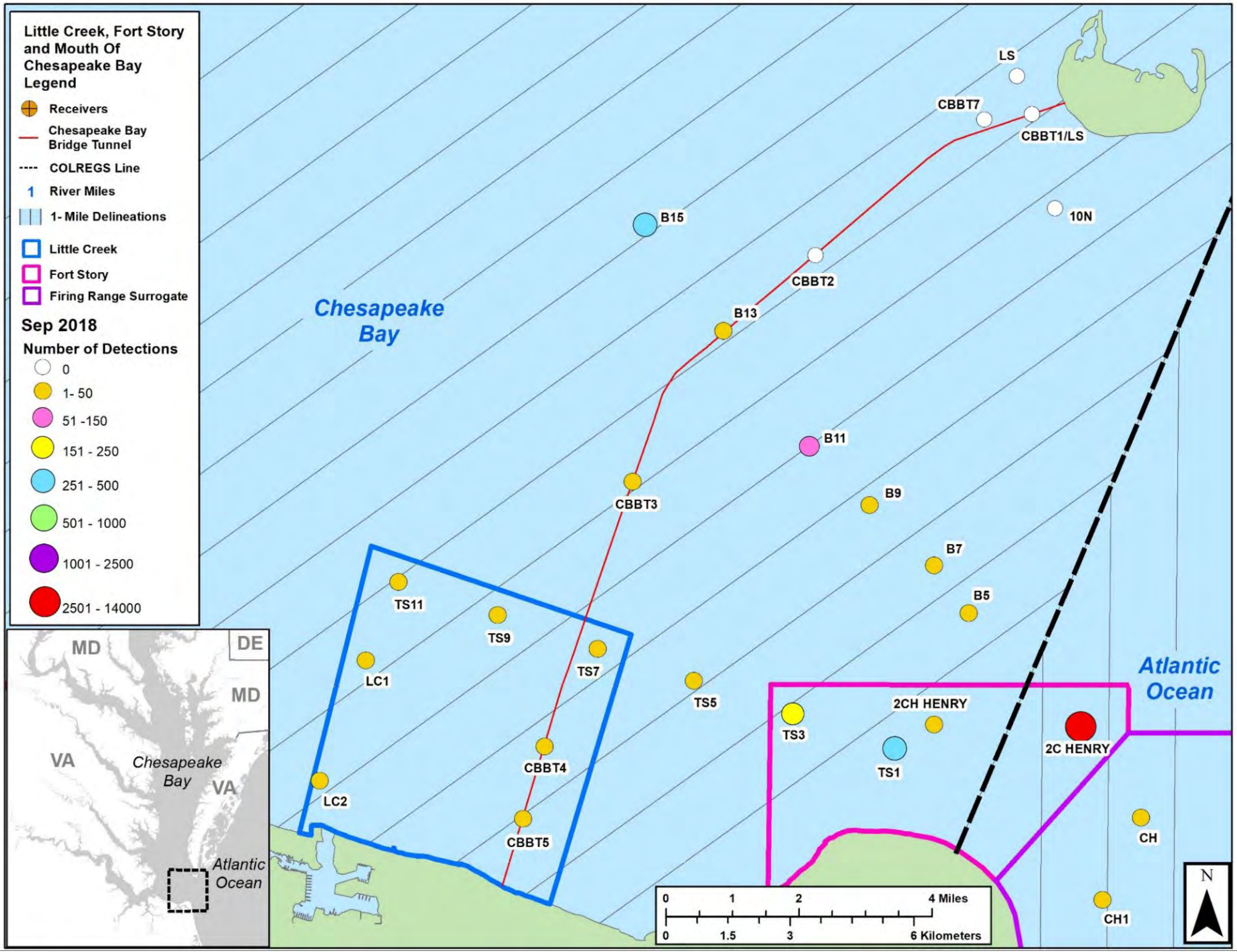
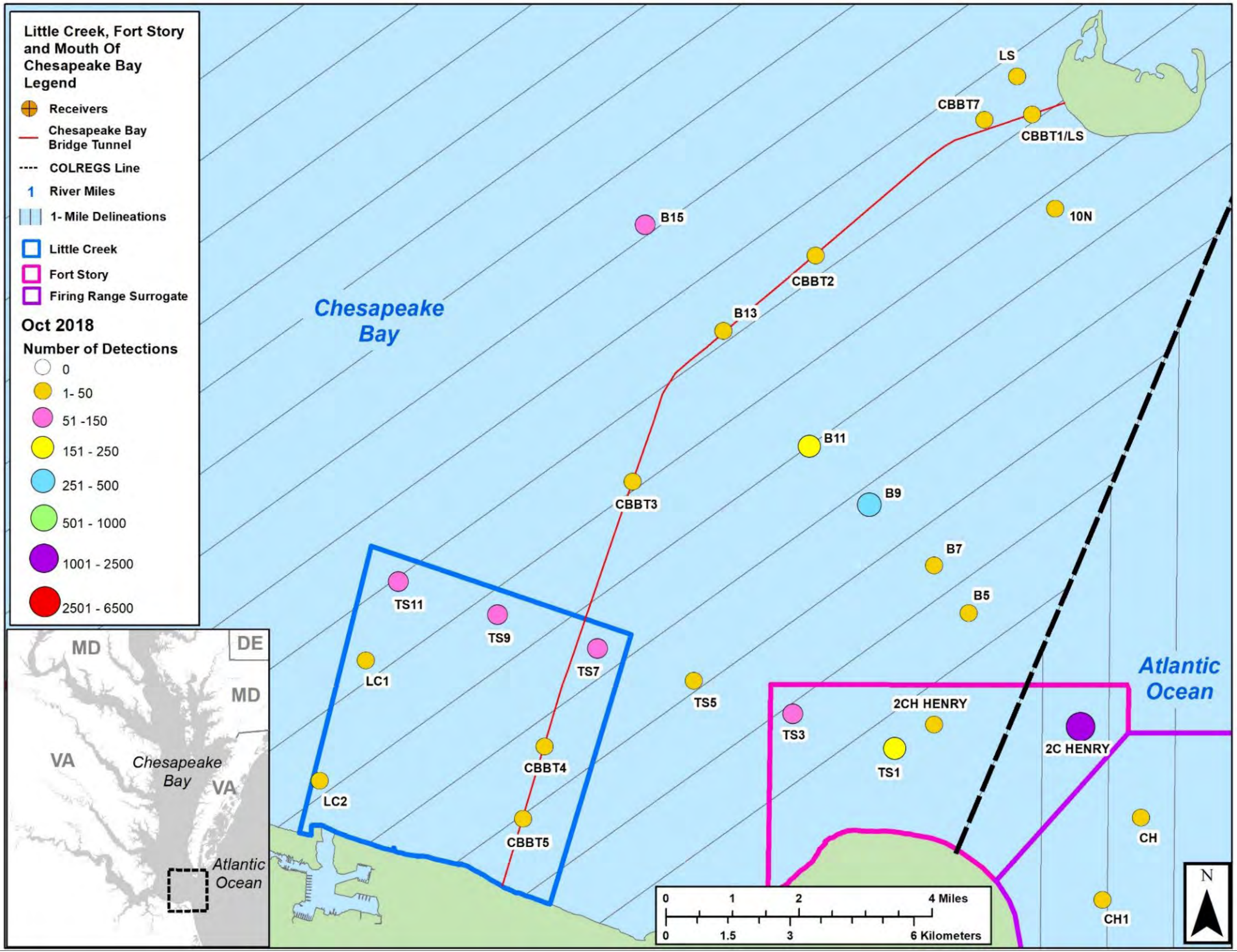
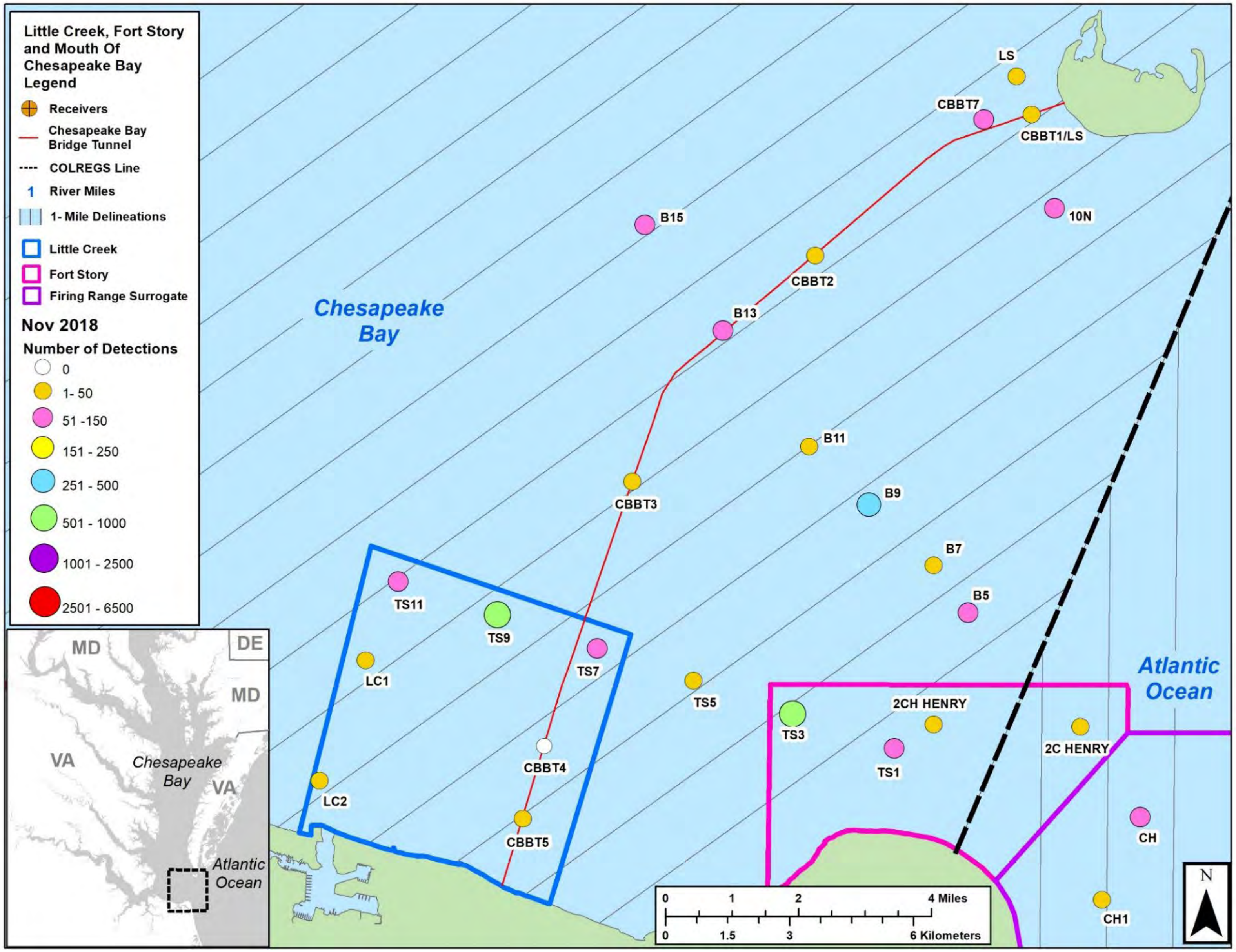
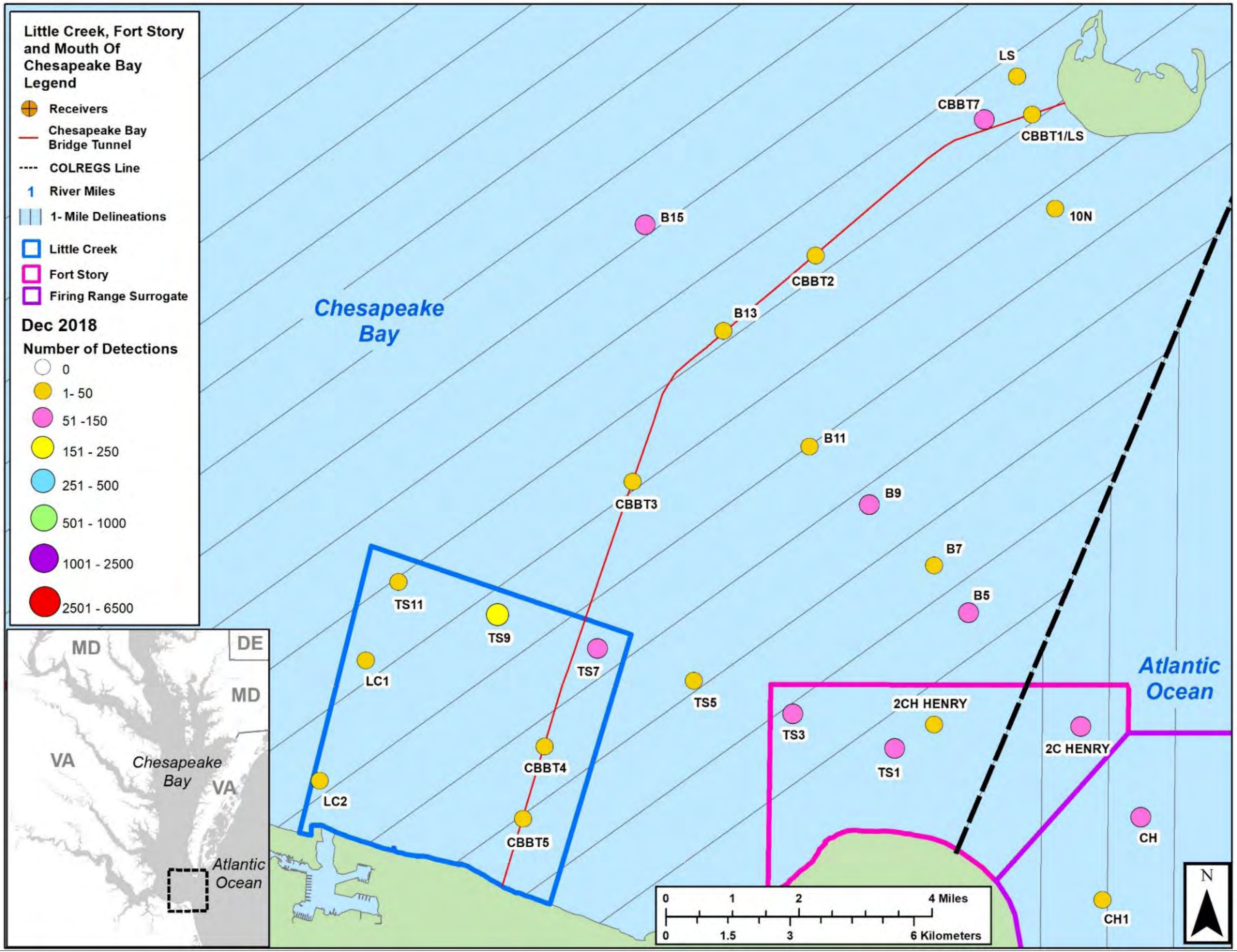
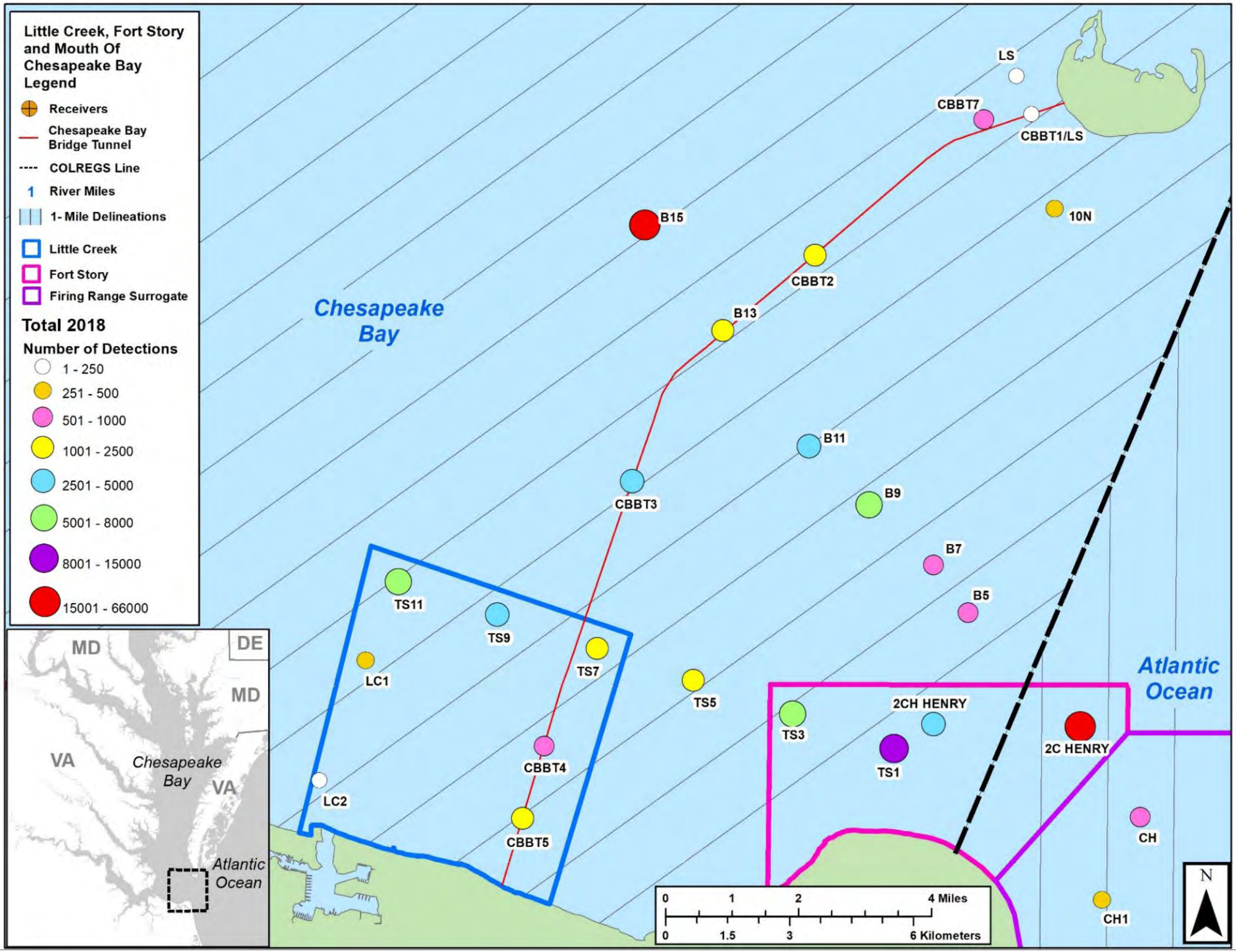
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
2C HENRY
TS1
CBBT4
LC2
CBBT5
CH
CH1
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

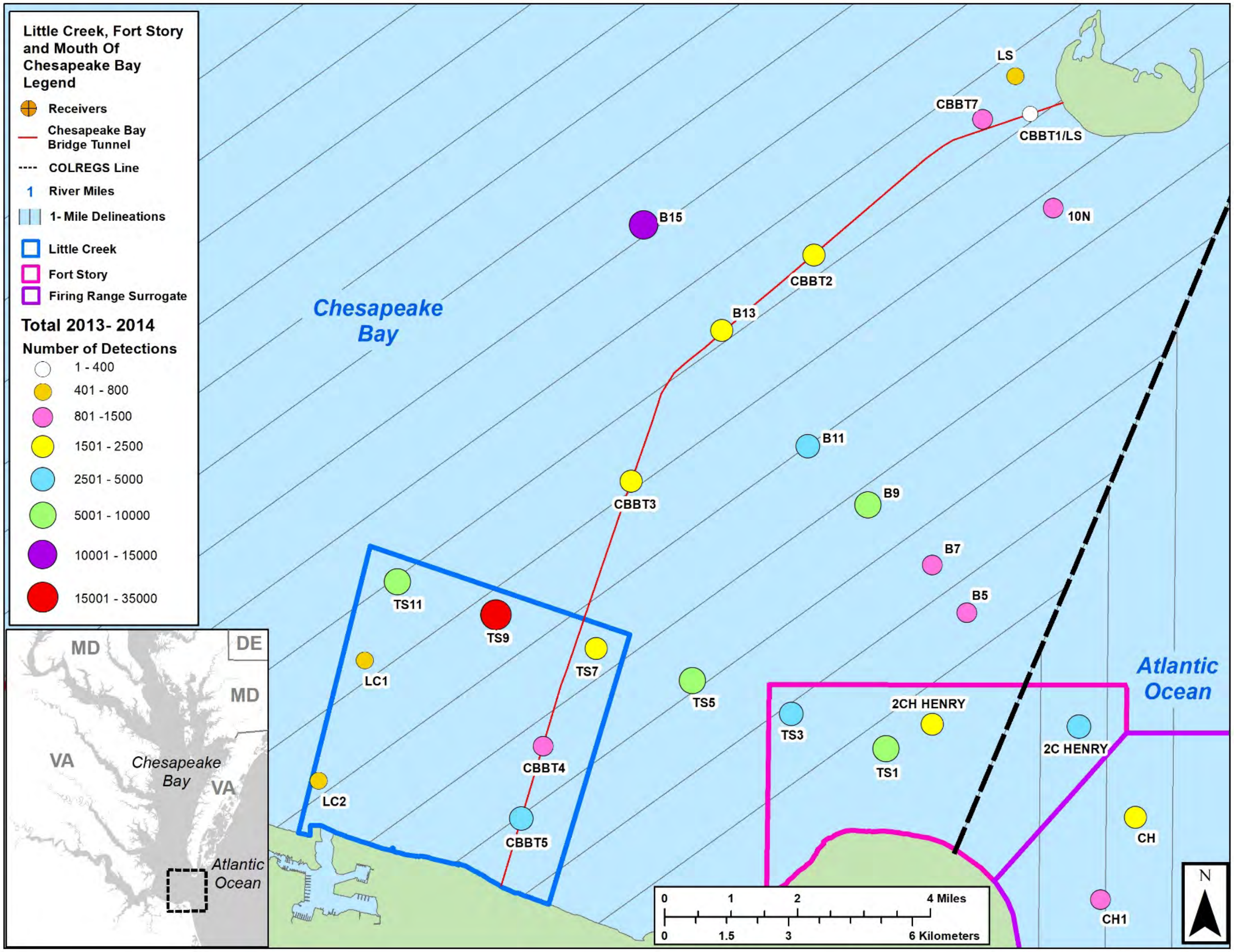

Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Sep 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 14000
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
MD
DE
VA
Chesapeake Bay
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

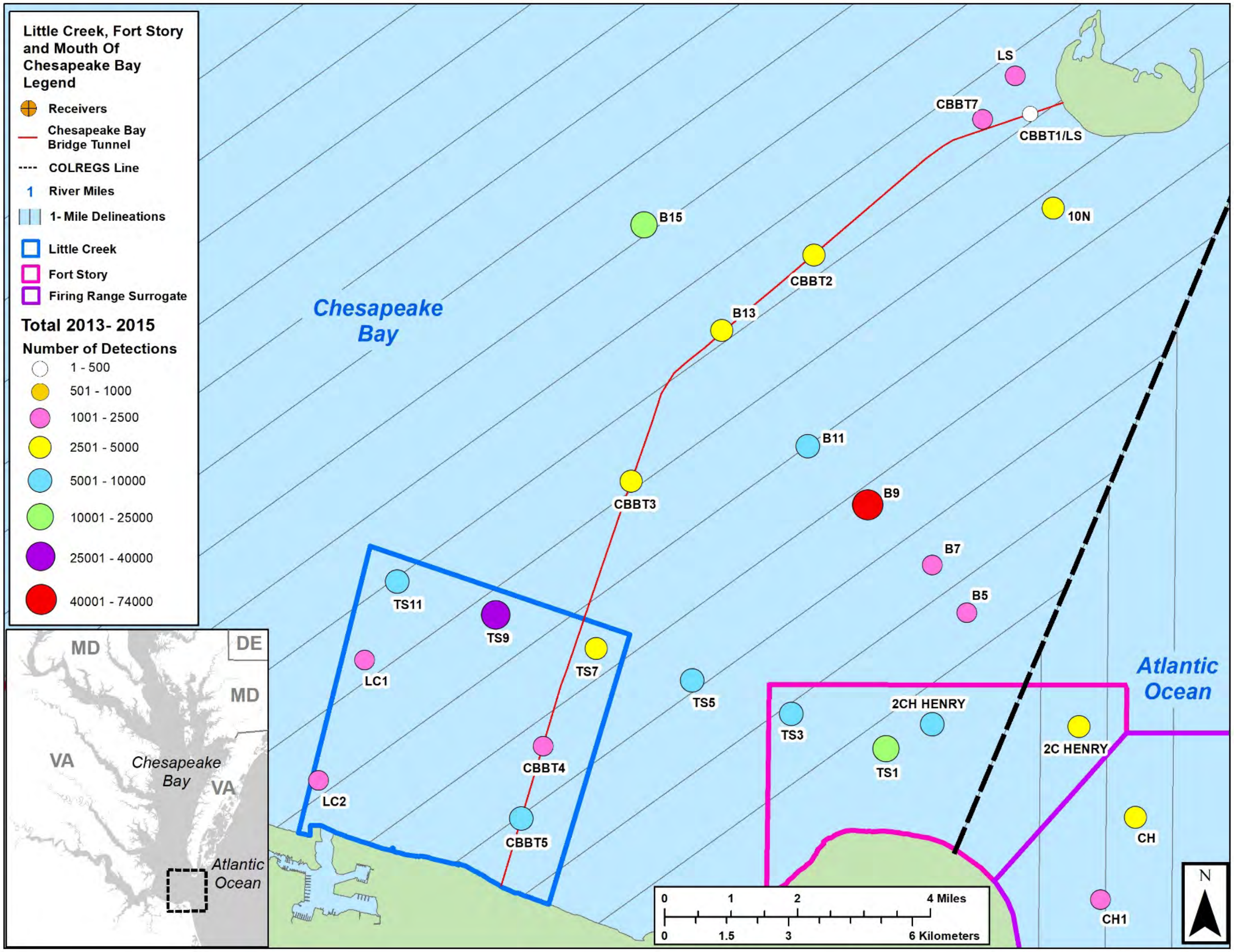

Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Oct 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
2C HENRY
TS1
CBBT4
LC2
CBBT5
CH
CH1
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean

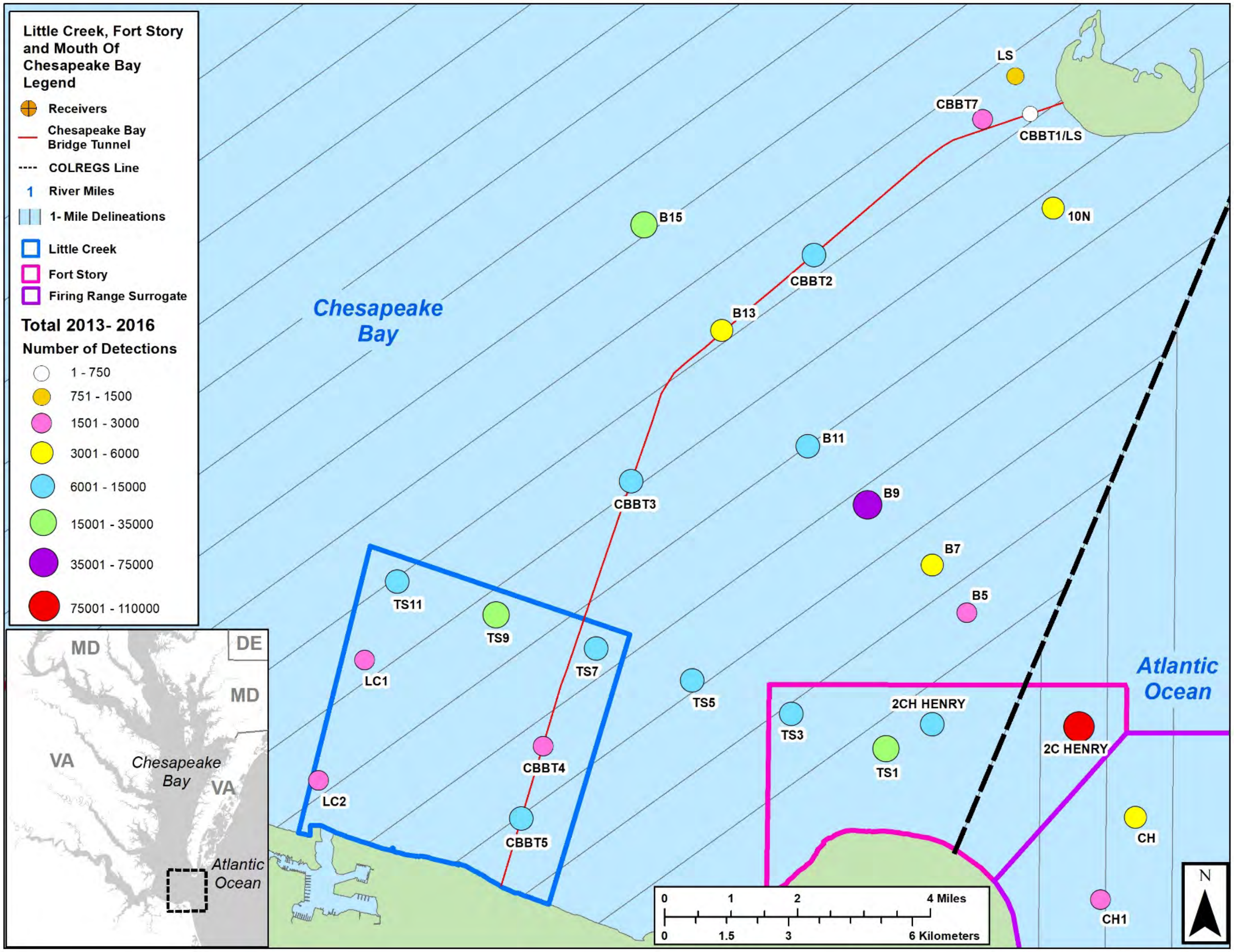

Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Nov 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
2C HENRY
TS1
CBBT4
LC2
CBBT5
CH
CH1
0
1
2
4 Miles
0
1.5
3
6 Kilometers
N

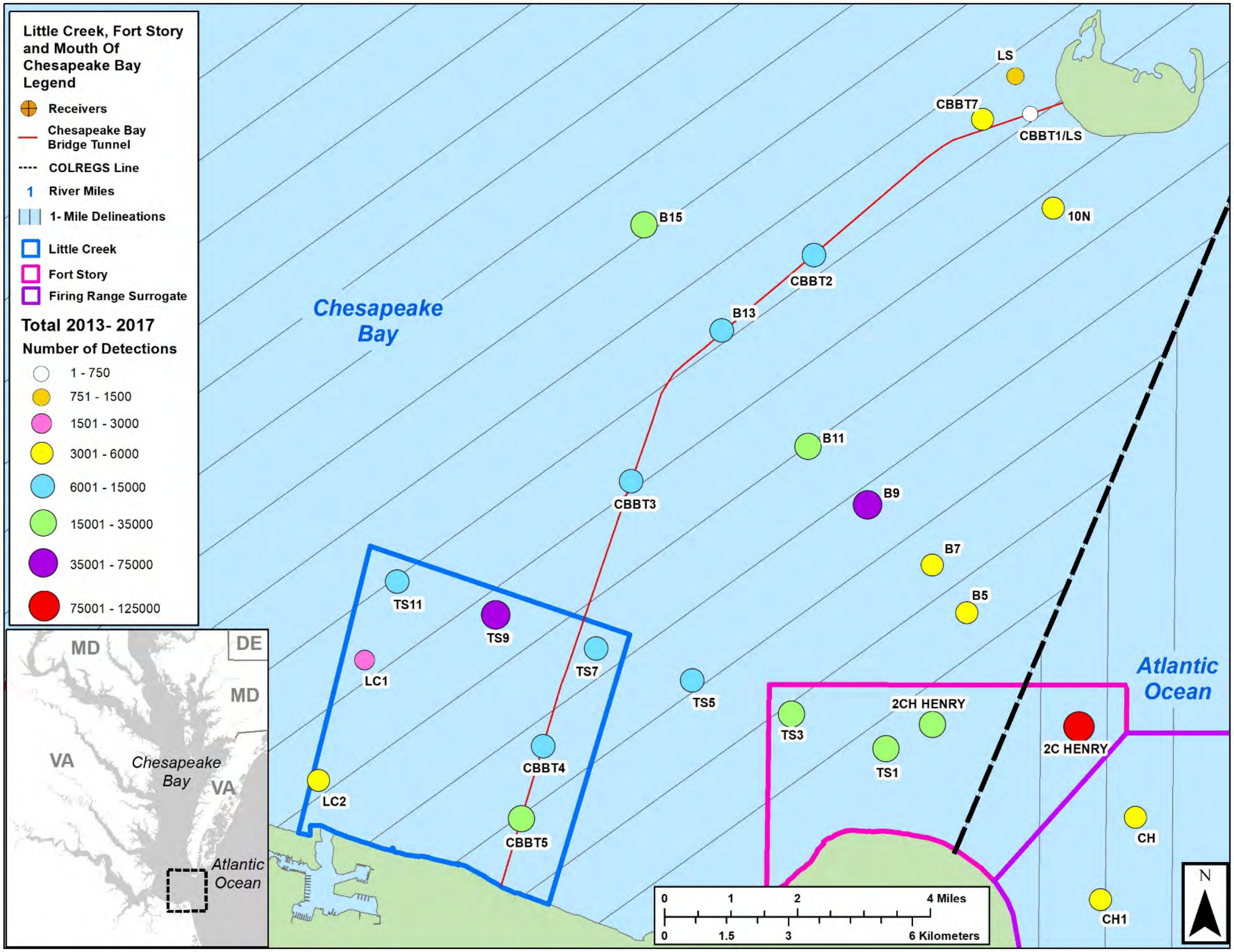

Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Dec 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Chesapeake Bay
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
TS1
2C HENRY
Atlantic Ocean
LC2
CBBT4
CBBT5
CH
CH1
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

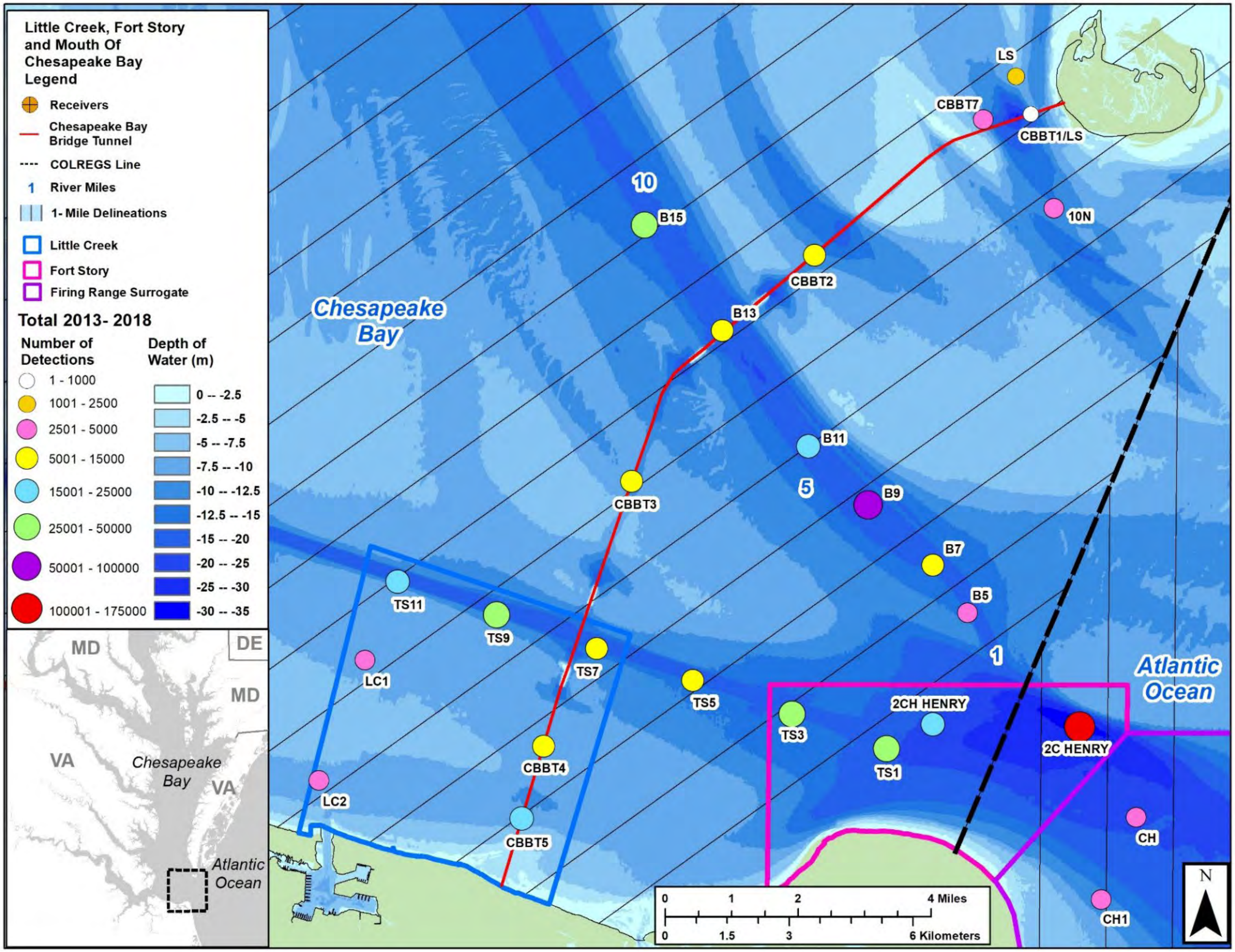

Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Total 2018
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 66000
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
Chesapeake Bay
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
TS1
2C HENRY
Atlantic Ocean
CBBT4
LC2
CBBT5
CH
CH1
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N

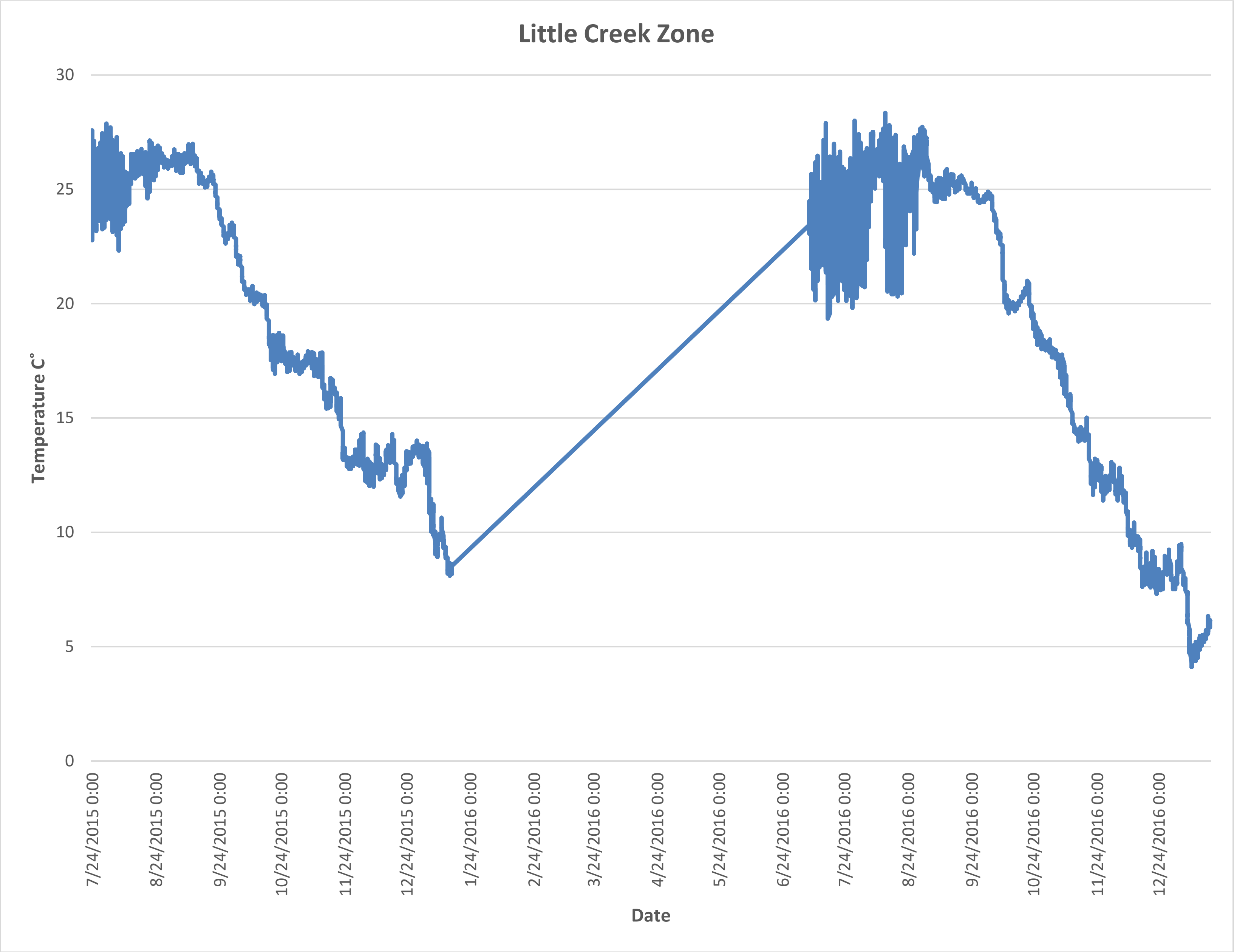

Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Total 2013- 2014
Number of Detections
1 - 400
401 - 800
801 -1500
1501 - 2500
2501 - 5000
5001 - 10000
10001 - 15000
15001 - 35000
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
2C HENRY
TS1
CBBT4
LC2
CBBT5
CH
CH1
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean

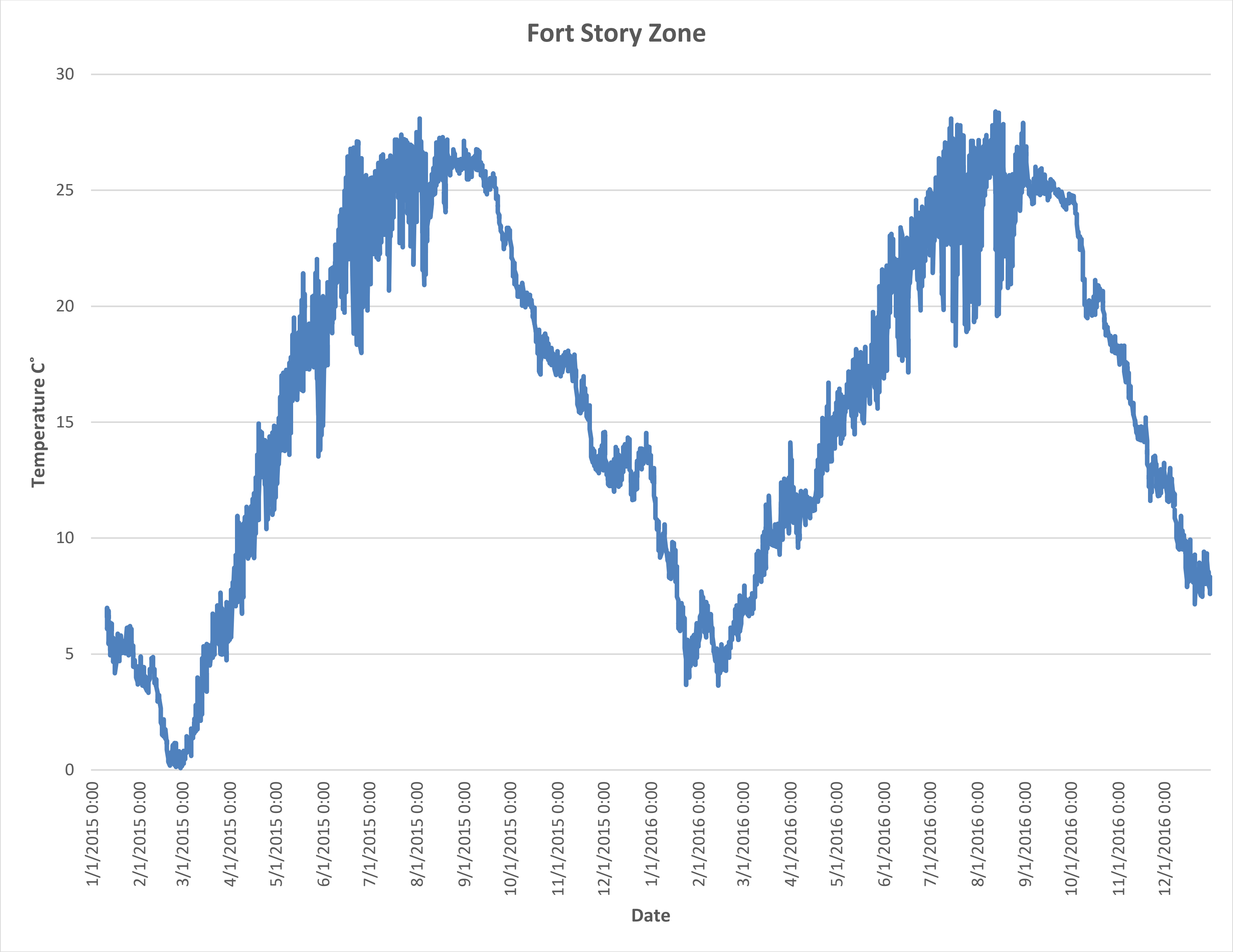

Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Total 2013- 2015
Number of Detections
1 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 10000
10001 - 25000
25001 - 40000
40001 - 74000
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean


Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Total 2013- 2016
Number of Detections
1 - 750
751 - 1500
1501 - 3000
3001 - 6000
6001 - 15000
15001 - 35000
35001 - 75000
75001 - 110000
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
2C HENRY
TS1
CBBT4
LC2
CBBT5
CH
CH1
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N


Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Total 2013- 2017
Number of Detections
1 - 750
751 - 1500
1501 - 3000
3001 - 6000
6001 - 15000
15001 - 35000
35001 - 75000
75001 - 125000
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
2C HENRY
TS3
TS1
CBBT4
LC2
CBBT5
CH
CH1
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N


Little Creek, Fort Story and Mouth Of Chesapeake Bay Legend
Receivers
Chesapeake Bay Bridge Tunnel
COLREGS Line
1 River Miles
1- Mile Delineations
Little Creek
Fort Story
Firing Range Surrogate
Total 2013- 2018
Number of Detections
1 - 1000
1001 - 2500
2501 - 5000
5001 - 15000
15001 - 25000
25001 - 50000
50001 - 100000
100001 - 175000
Depth of Water (m)
0 -- -2.5
-2.5 -- -5
-5 -- -7.5
-7.5 -- -10
-10 -- -12.5
-12.5 -- -15
-15 -- -20
-20 -- -25
-25 -- -30
-30 -- -35
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
Chesapeake Bay
Atlantic Ocean
LS
CBBT7
CBBT1/LS
10
10N
B15
CBBT2
B13
B11
5
B9
CBBT3
B7
B5
1
TS11
TS9
TS7
TS5
LC1
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
0 1 2 4 Miles
0 1.5 3 6 Kilometers
N


Little Creek Zone
Temperature C°
30
25
20
15
10
5
0
7/24/2015 0:00
8/24/2015 0:00
9/24/2015 0:00
10/24/2015 0:00
11/24/2015 0:00
12/24/2015 0:00
1/24/2016 0:00
2/24/2016 0:00
3/24/2016 0:00
4/24/2016 0:00
5/24/2016 0:00
6/24/2016 0:00
7/24/2016 0:00
8/24/2016 0:00
9/24/2016 0:00
10/24/2016 0:00
11/24/2016 0:00
12/24/2016 0:00
Date


Fort Story Zone
Temperature C˚
30
25
20
15
10
5
0
1/1/2015 0:00
2/1/2015 0:00
3/1/2015 0:00
4/1/2015 0:00
5/1/2015 0:00
6/1/2015 0:00
7/1/2015 0:00
8/1/2015 0:00
9/1/2015 0:00
10/1/2015 0:00
11/1/2015 0:00
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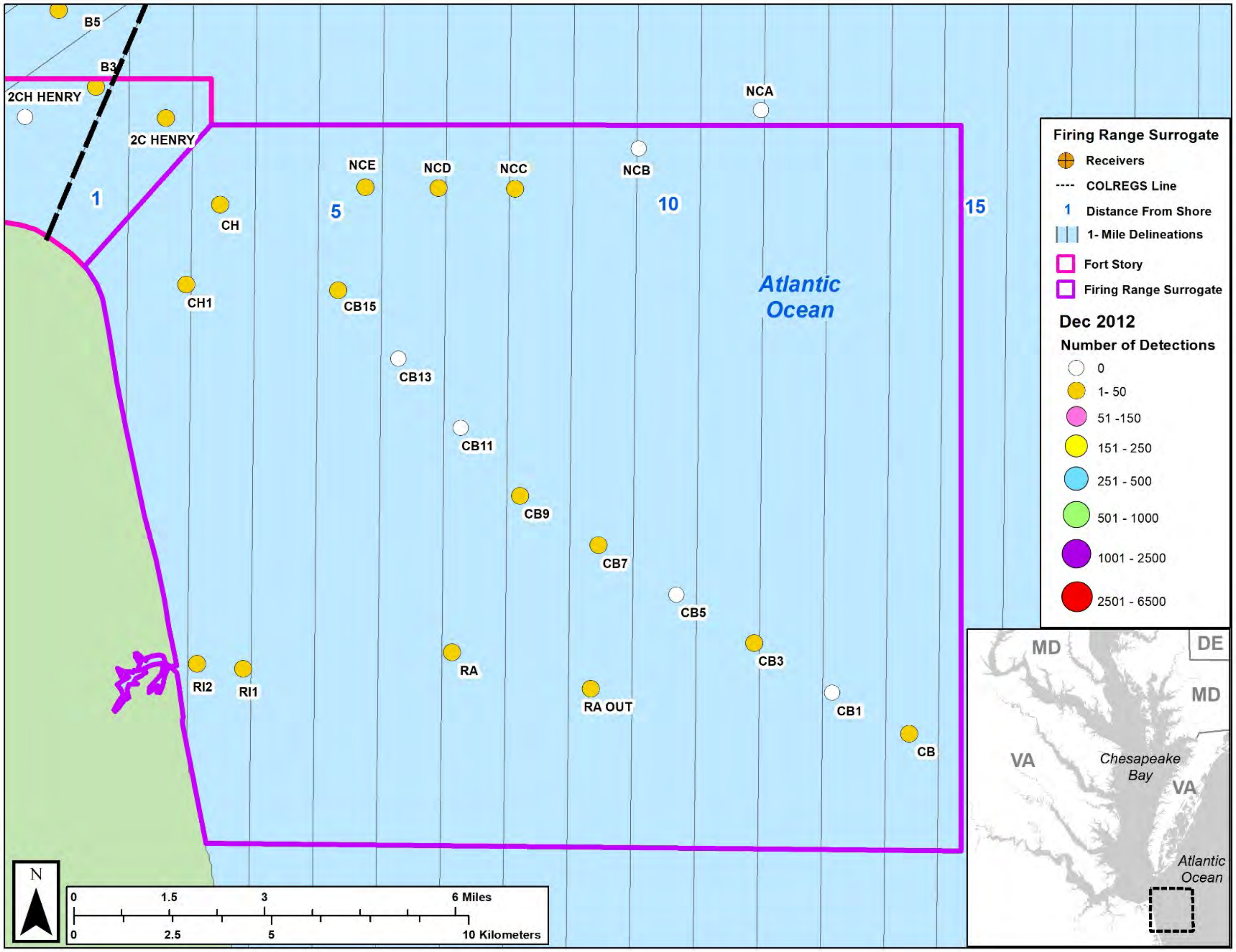
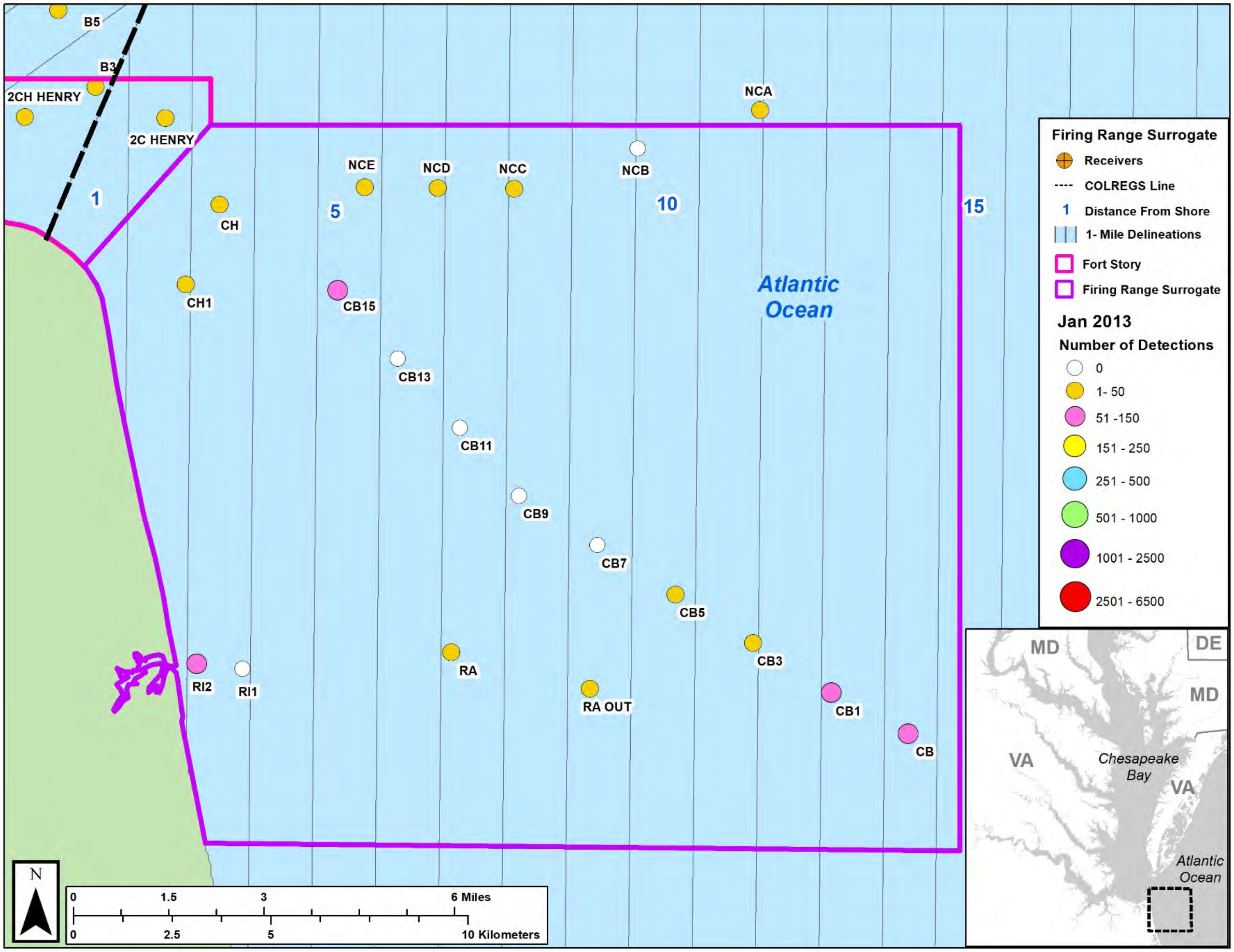
2/1/2016 0:00
3/1/2016 0:00
4/1/2016 0:00
5/1/2016 0:00
6/1/2016 0:00
7/1/2016 0:00
8/1/2016 0:00
9/1/2016 0:00
10/1/2016 0:00
11/1/2016 0:00
12/1/2016 0:00
Date

8.9. Appendix 8.9: Detections of Sonic-tagged Atlantic Sturgeon in the Atlantic Region (Range Sur.), by Month, Year, and Overall

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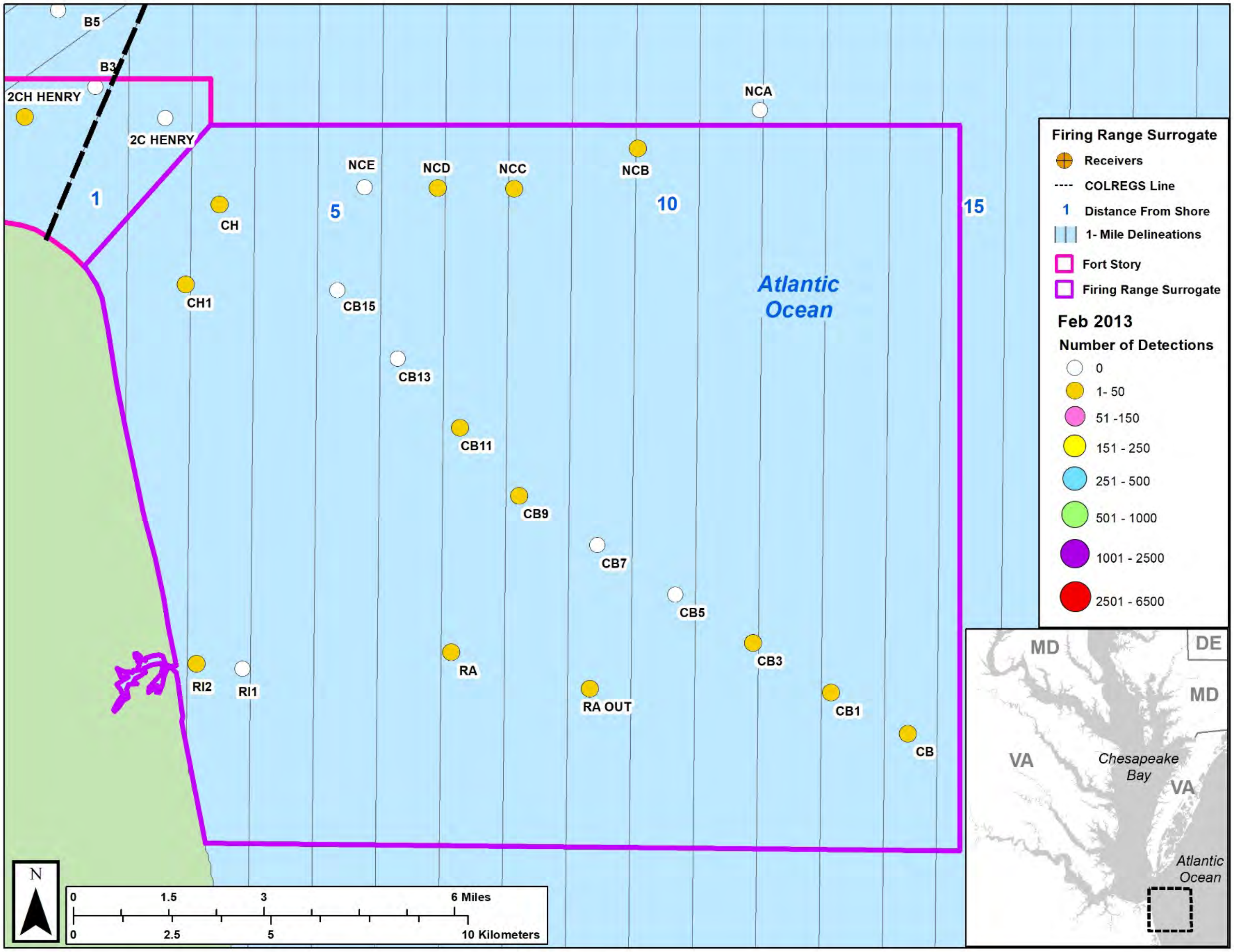
B3
2CH HENRY
2C HENRY
1
5
10
15
NCA
NCE
NCD
NCC
NCB
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Jan 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
N
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers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2C HENRY
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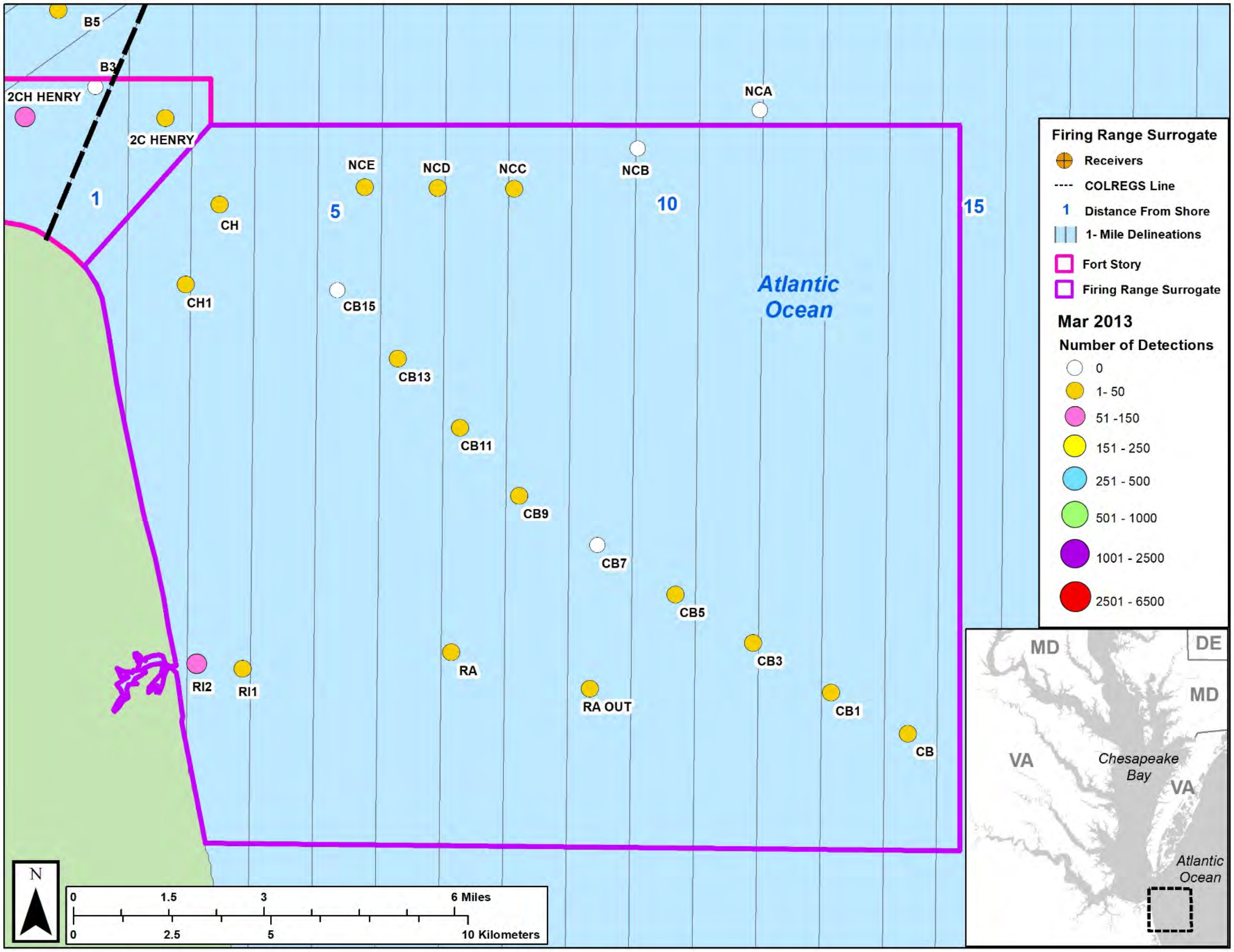
NCE
NCD
NCC
NCB
1
5
10
15
CH
CH1
CB15
Atlantic Ocean
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Feb 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
N
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers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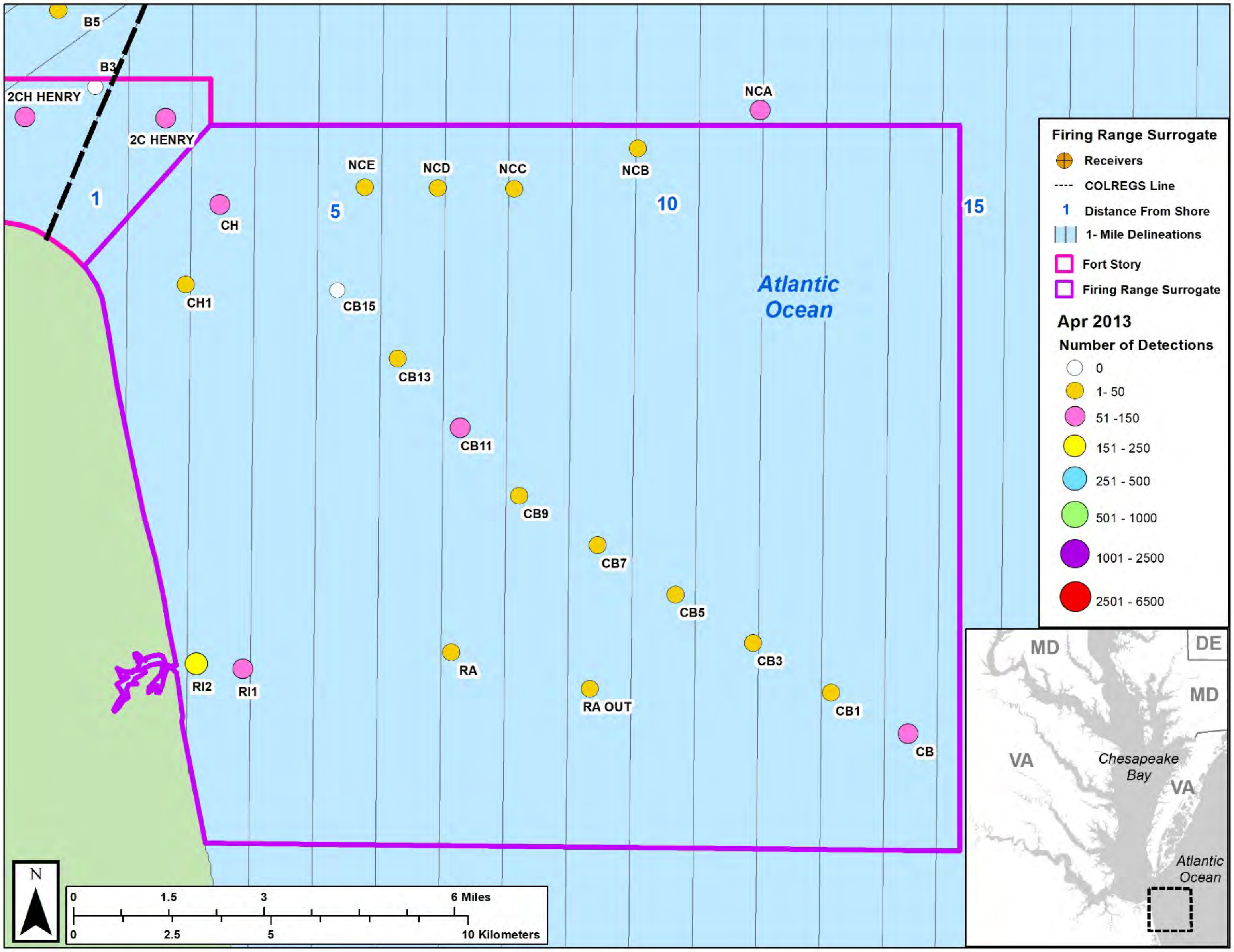
2C HENRY
NCA
NCE
NCD
NCC
NCB
1
5
10
15
CH
CH1
CB15
Atlantic Ocean
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Mar 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
N
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers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2C HENRY
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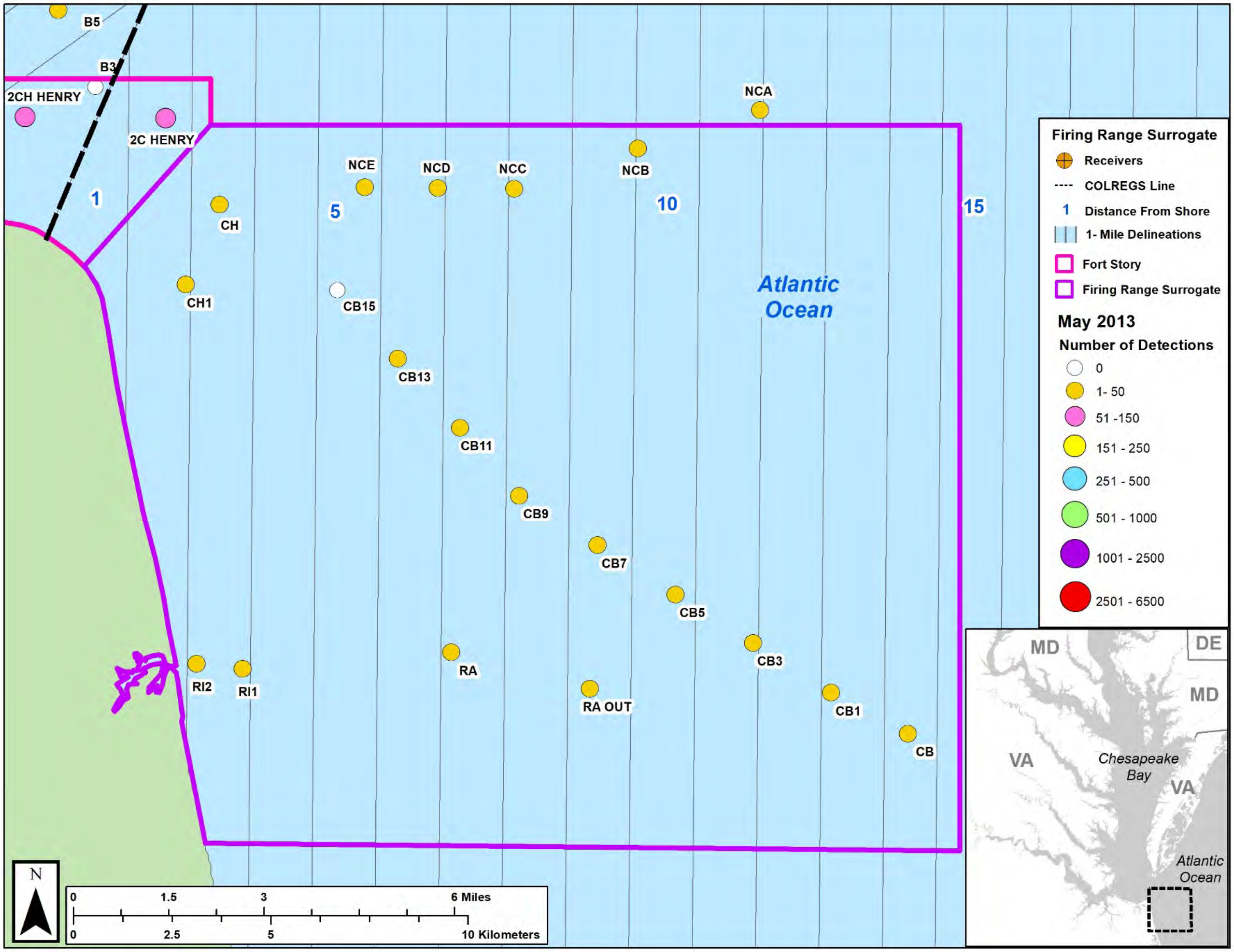
5
10
15
NCA
NCE
NCD
NCC
NCB
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Apr 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
N
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers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2C HENRY
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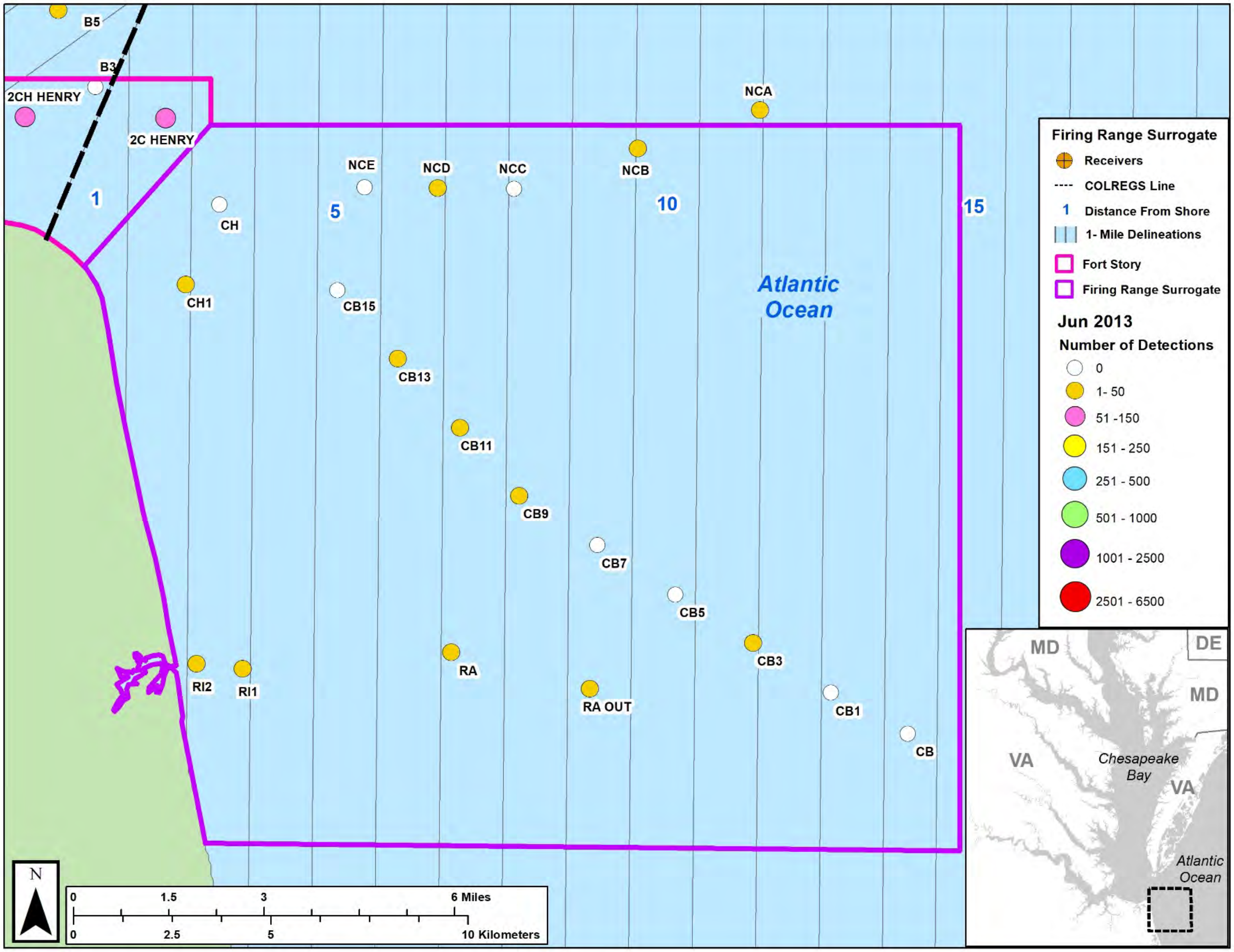
5
10
15
NCA
NCE
NCD
NCC
NCB
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
May 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
N
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers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2C HENRY
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NCE
NCD
NCC
NCB
CH
CH1
CB15
CB13
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CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
1
5
10
15
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Jun 2013
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
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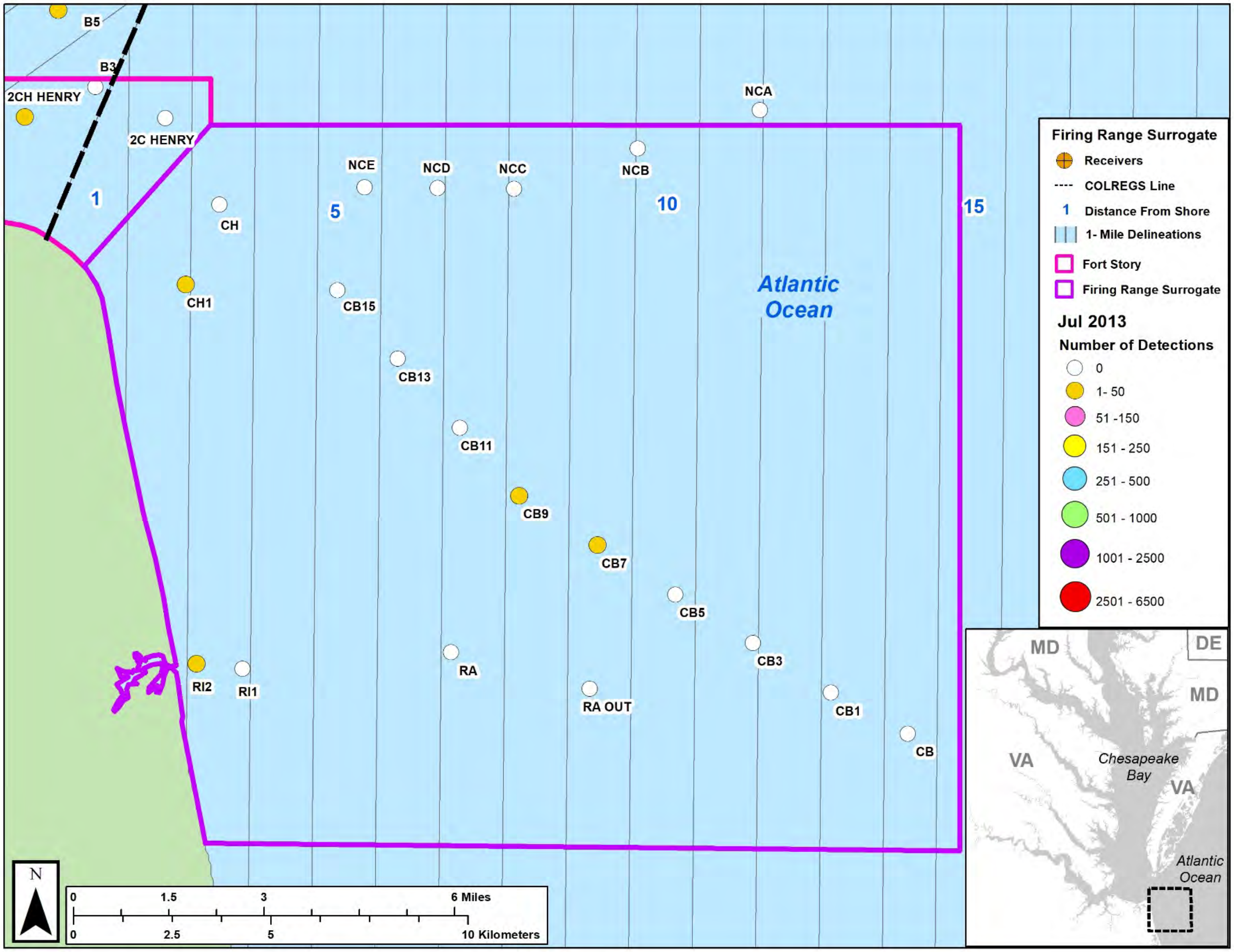
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
N
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers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2C HENRY
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5
10
15
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NCB
NCC
NCD
NCE
CH
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CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Jul 2013
Number of Detections
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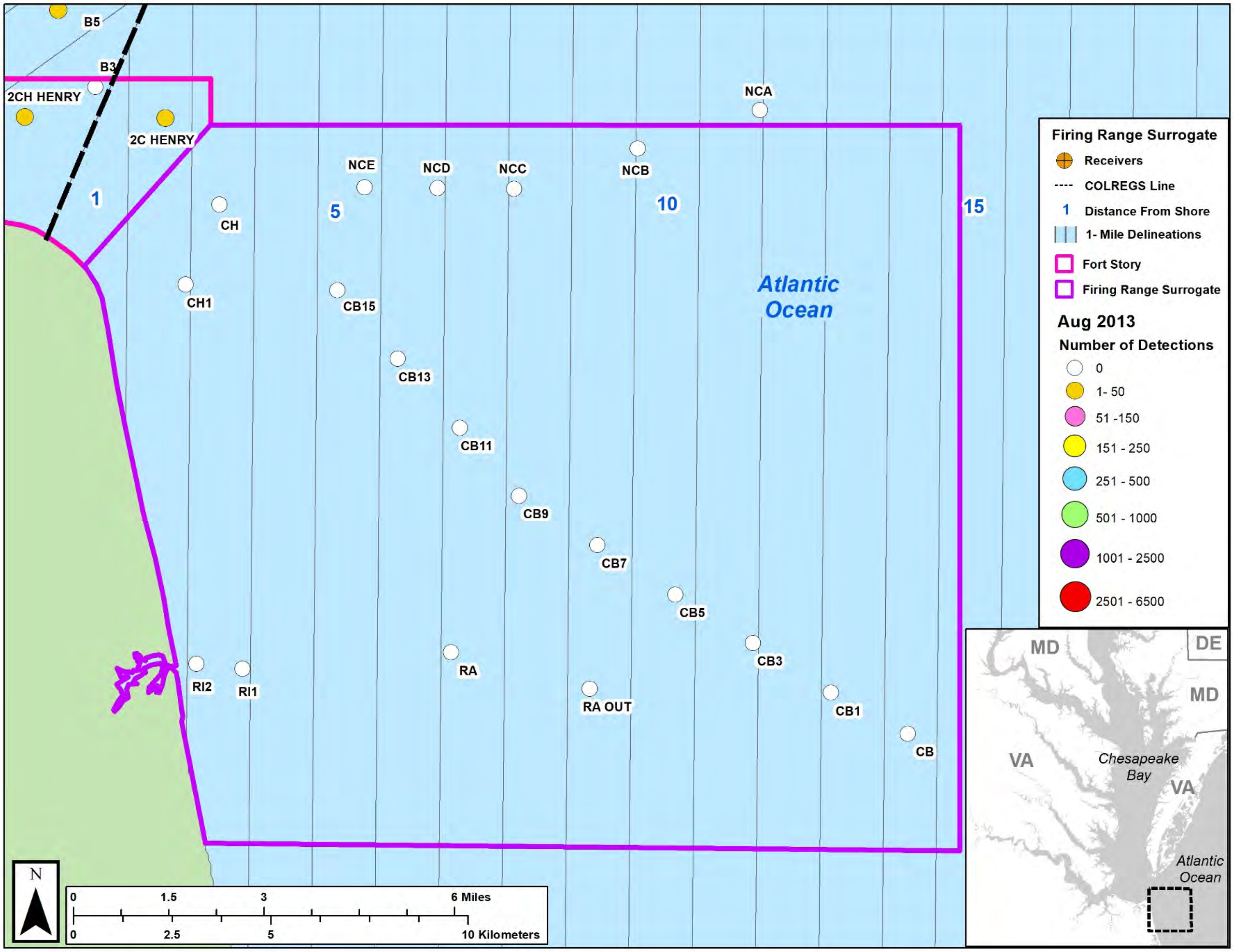
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
N
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers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2C HENRY
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5
10
15
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NCB
NCC
NCD
NCE
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Aug 2013
Number of Detections
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51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
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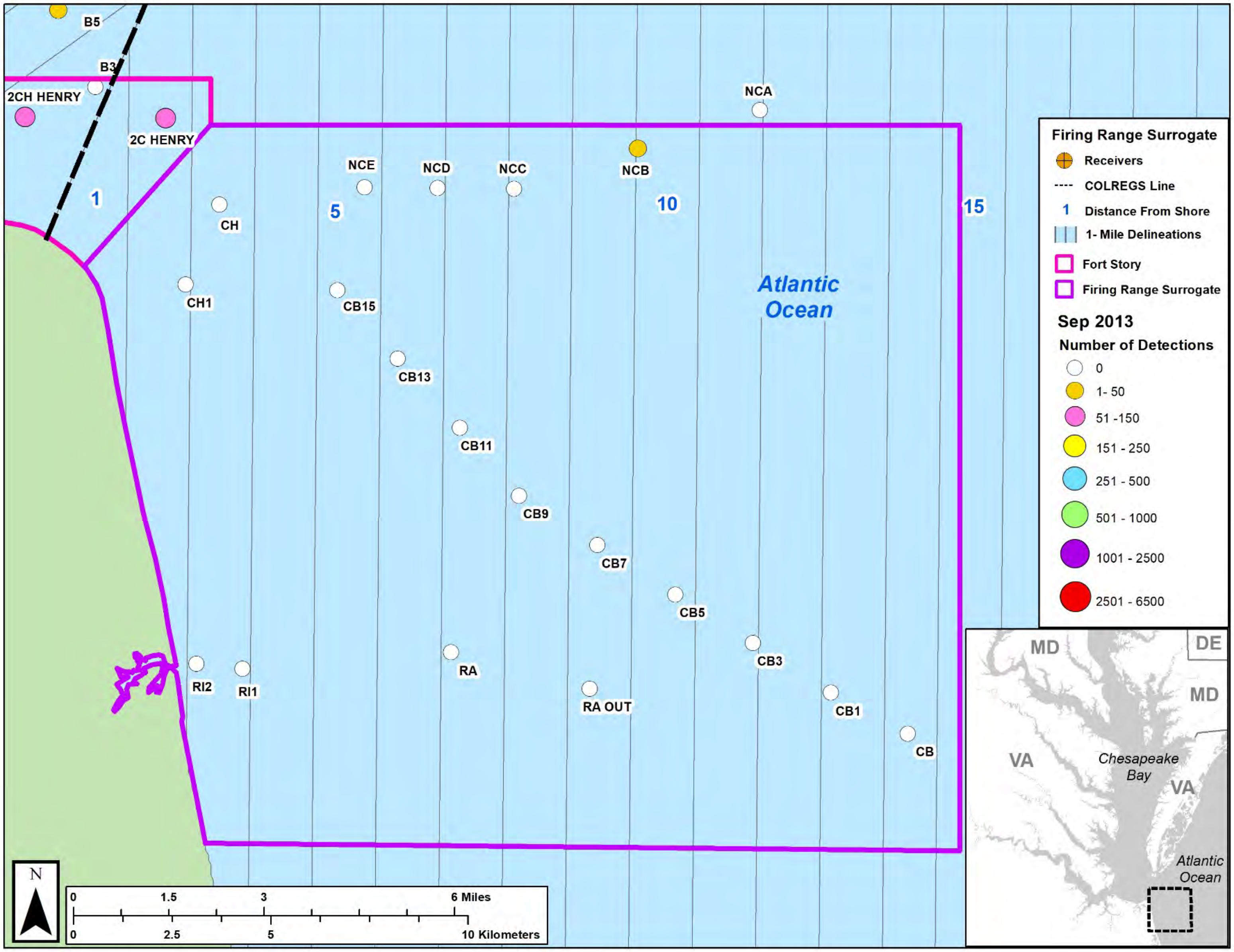
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
N
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers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2C HENRY
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NCE
NCD
NCC
NCB
CH
CH1
CB15
CB13
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CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
1
5
10
15
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Sep 2013
Number of Detections
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151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
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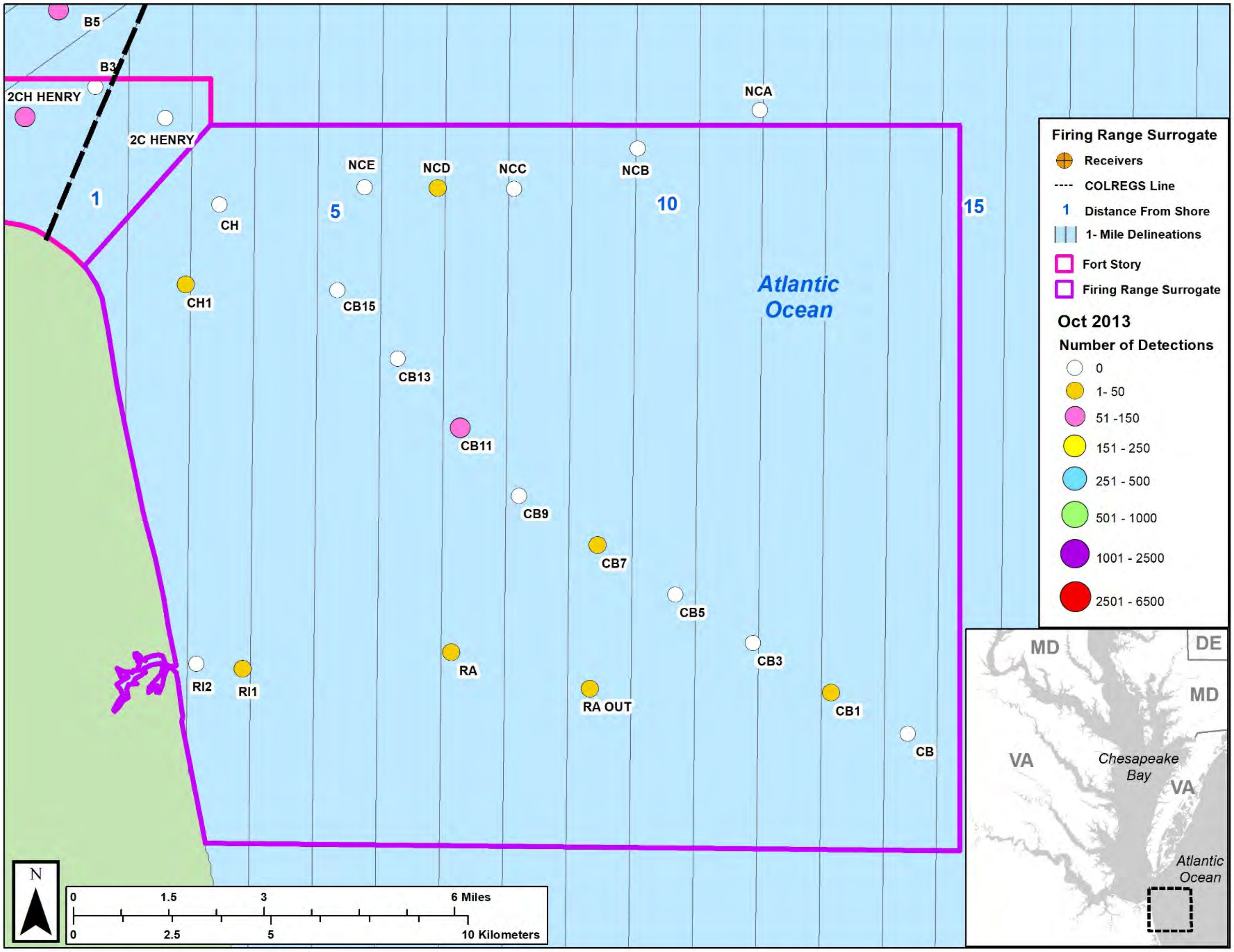
0
2.5
5
10 Kilometers
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean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NCD
NCC
NCB
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
Atlantic Ocean
Firing Range Surrogate
Receivers
---- COLREGS Line
1 Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Oct 2013
Number of Detections
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51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
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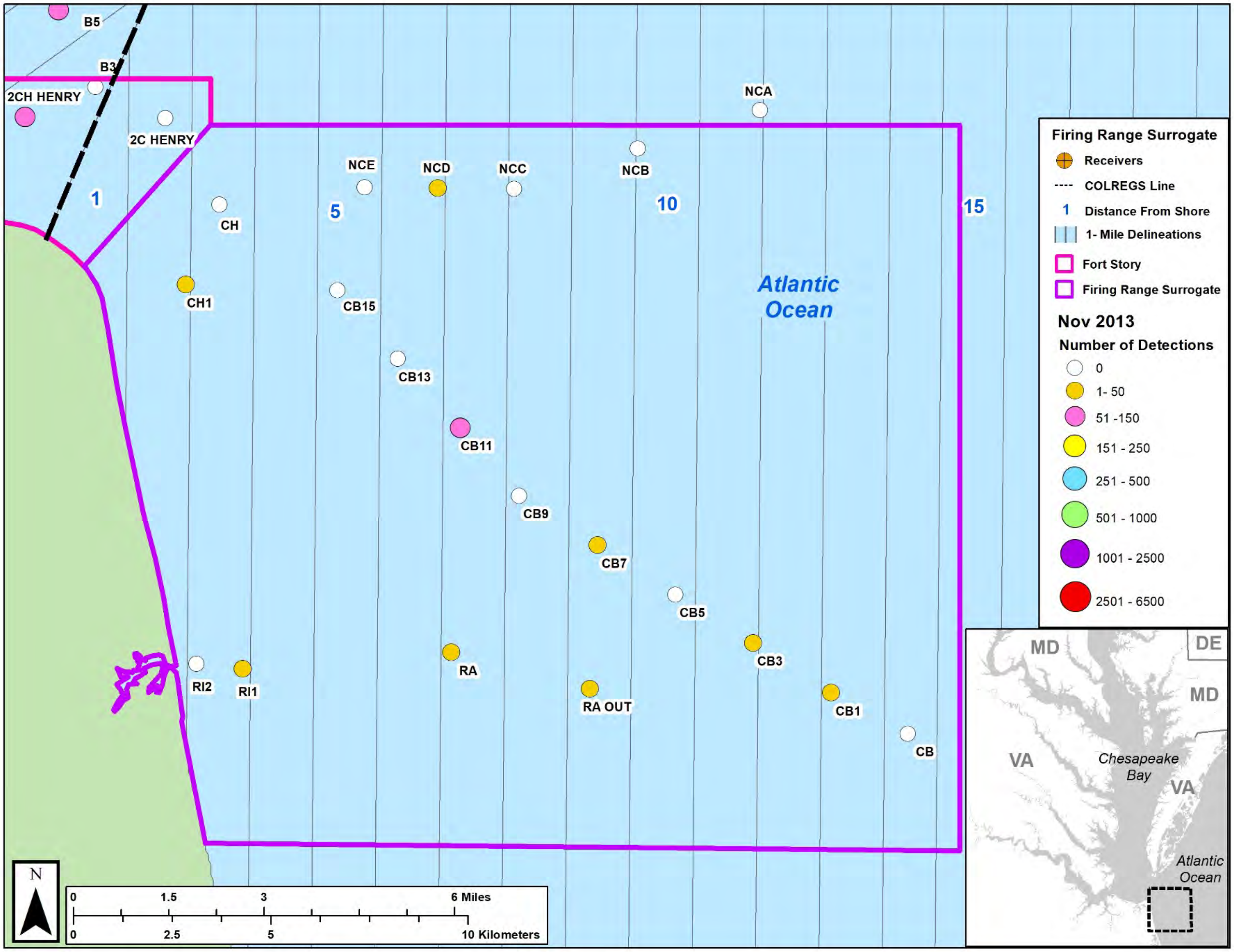
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
N
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers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2C HENRY
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NCD
NCC
NCB
1
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10
15
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Nov 2013
Number of Detections
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51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
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Chesapeake Bay
VA
Atlantic Ocean
N
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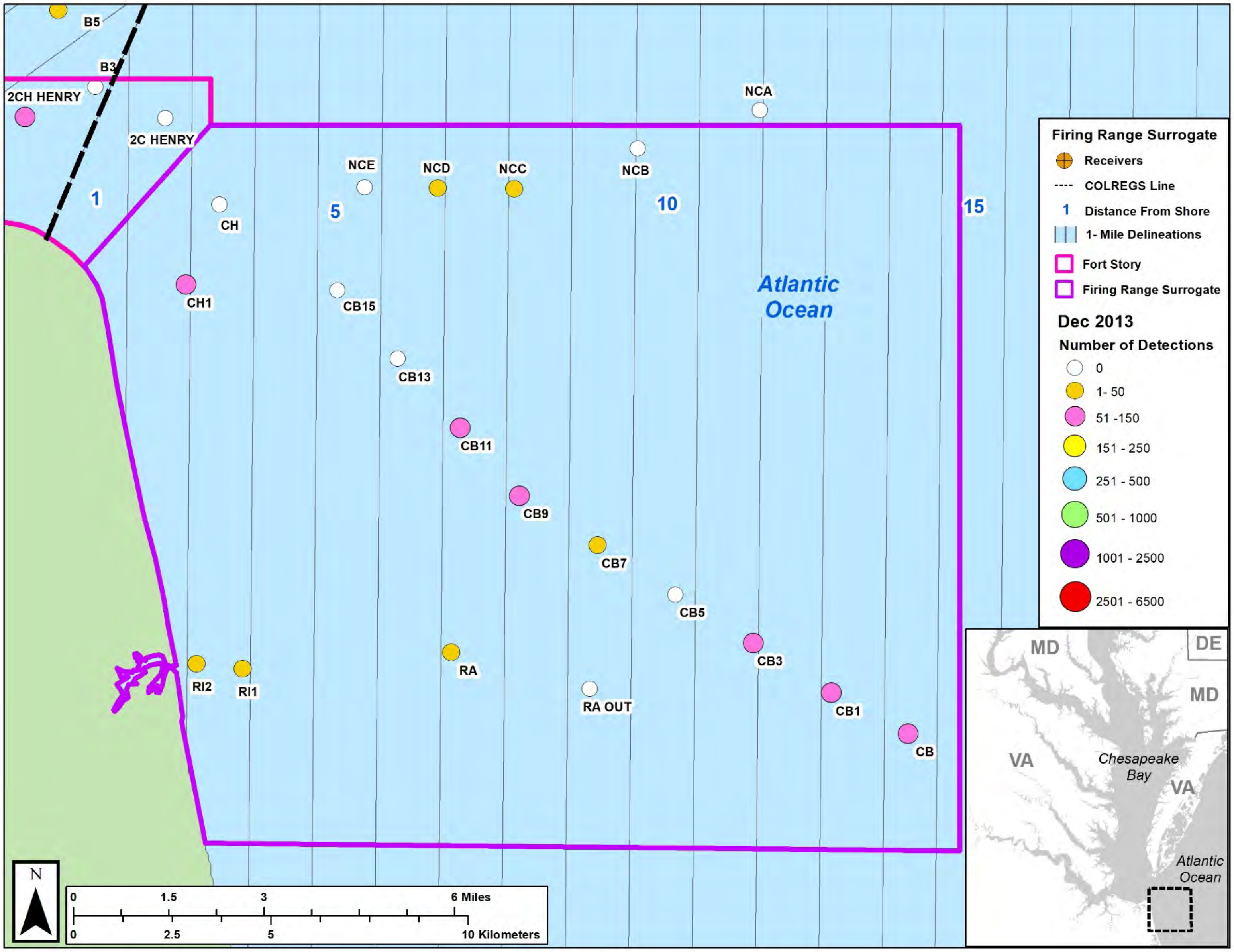
1.5
3
6 Miles
0
2.5
5
10 Kilometers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2C HENRY
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NCE
NCD
NCC
NCB
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5
10
15
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Dec 2013
Number of Detections
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1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
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MD
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Chesapeake Bay
VA
Atlantic Ocean
N
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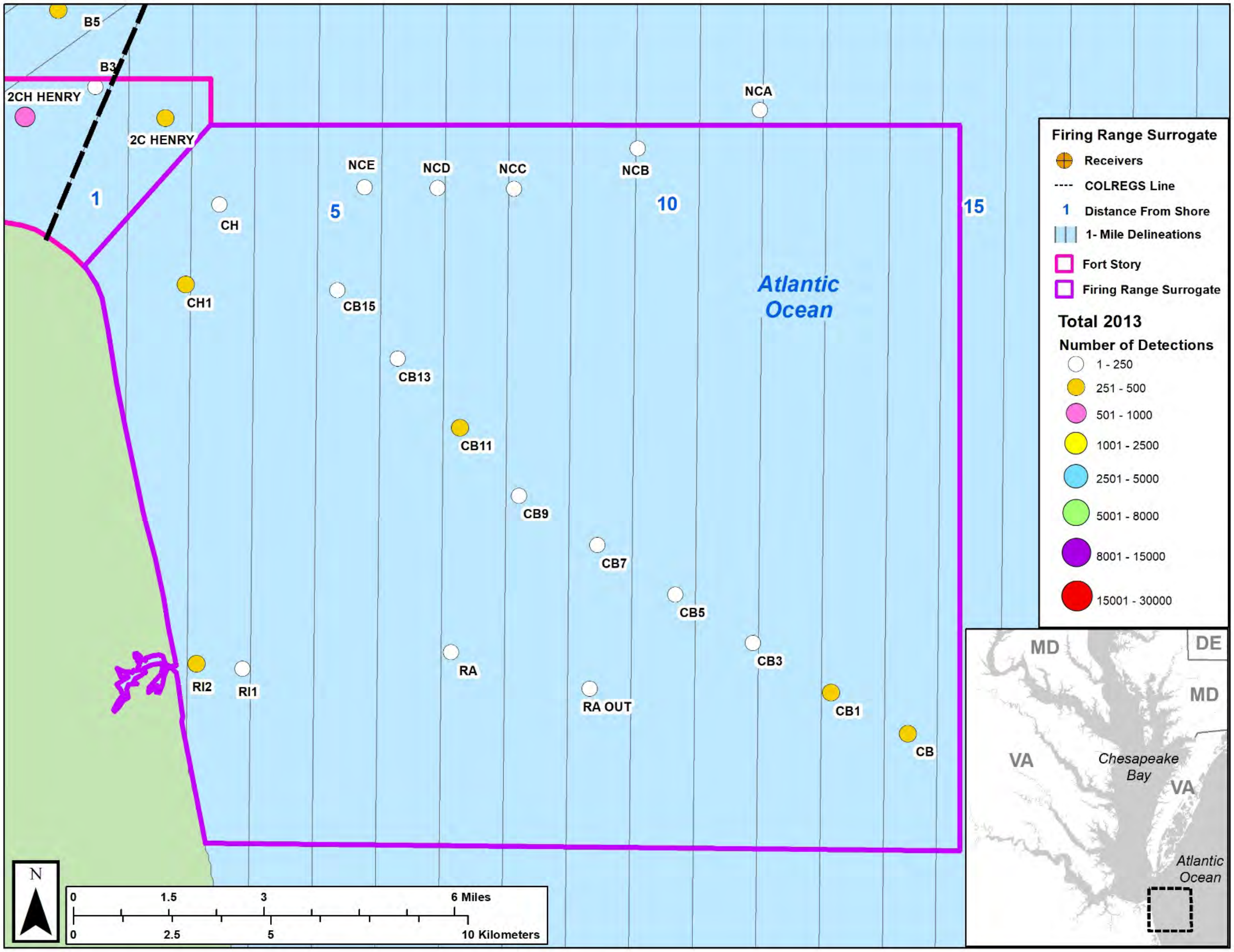
3
6 Miles
0
2.5
5
10 Kilometers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NCB
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10
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CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
1 Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Total 2013
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
MD
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VA
Chesapeake Bay
VA
Atlantic Ocean
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3
6 Miles
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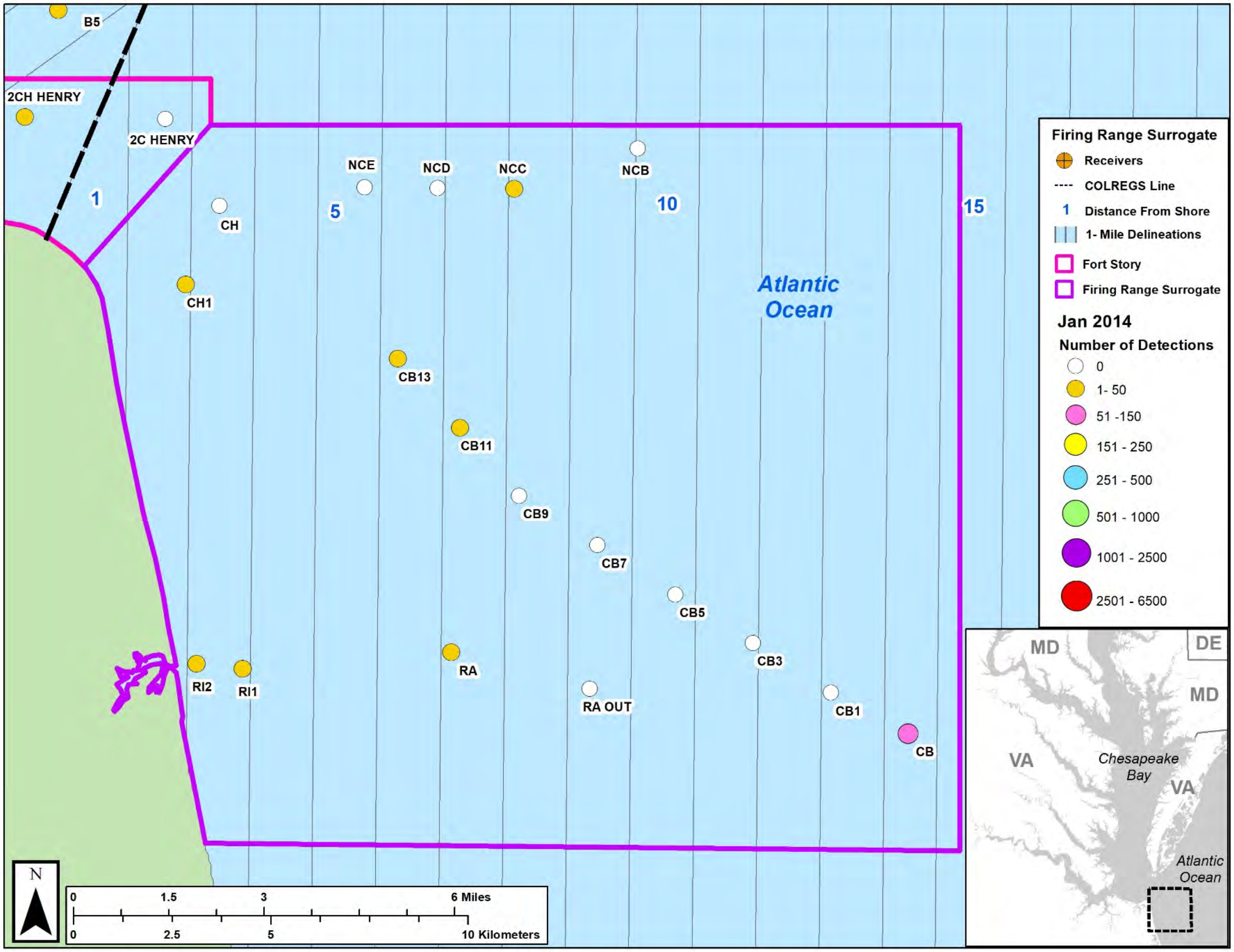
2.5
5
10 Kilometers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2C HENRY
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NCE
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NCB
CH
CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Jan 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
N
0
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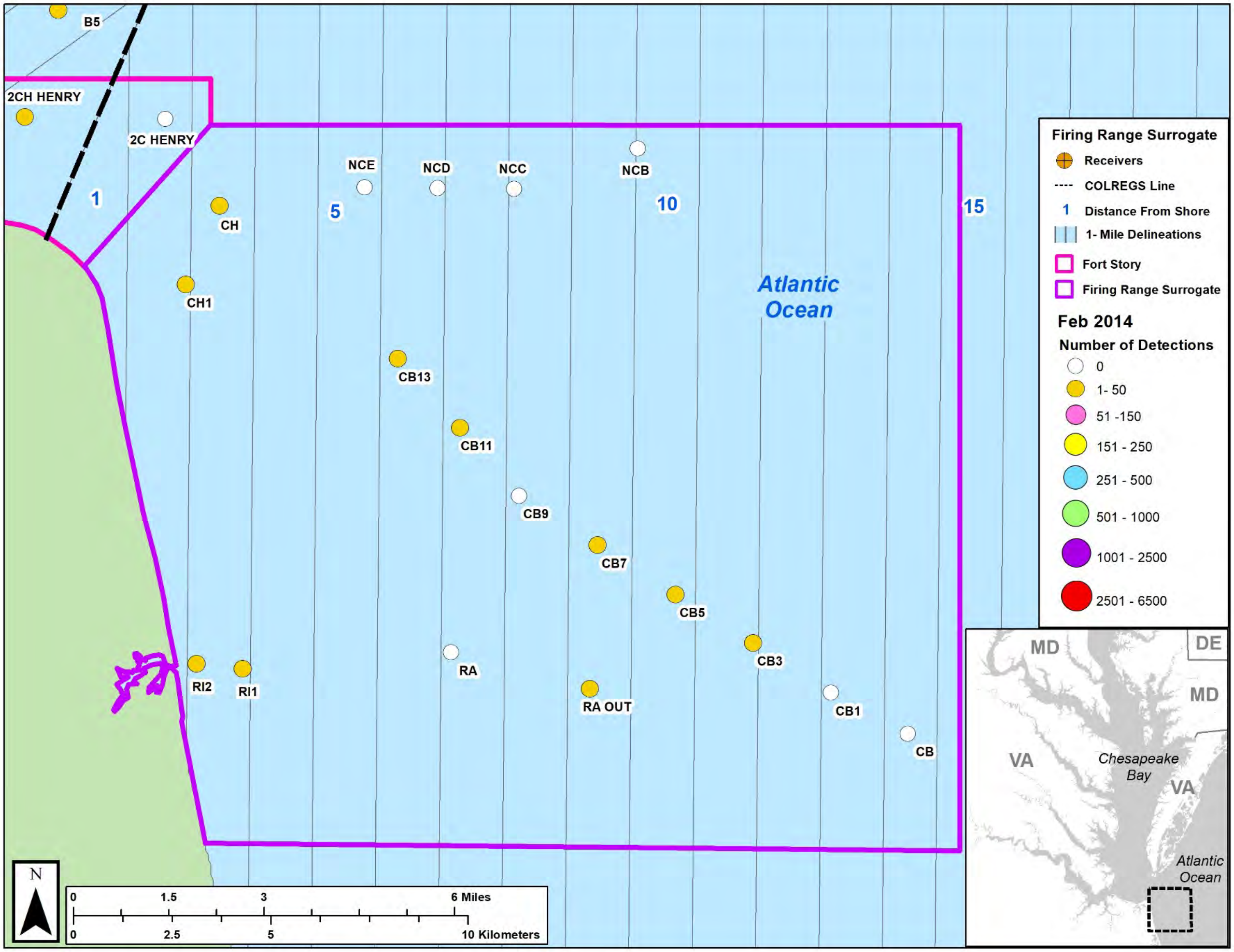
3
6 Miles
0
2.5
5
10 Kilometers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2C HENRY
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10
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NCC
NCB
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CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Feb 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
N
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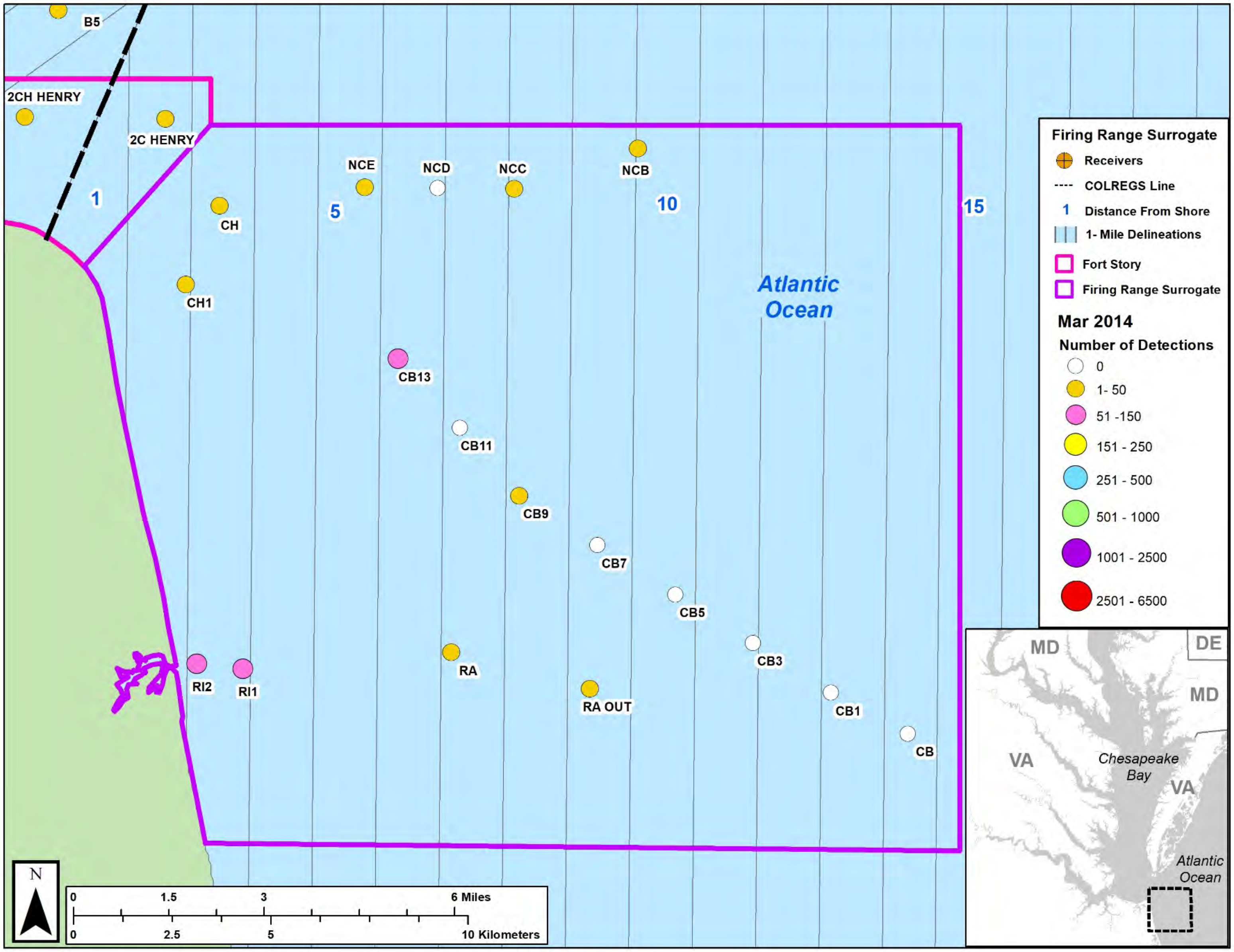
1.5
3
6 Miles
0
2.5
5
10 Kilometers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2C HENRY
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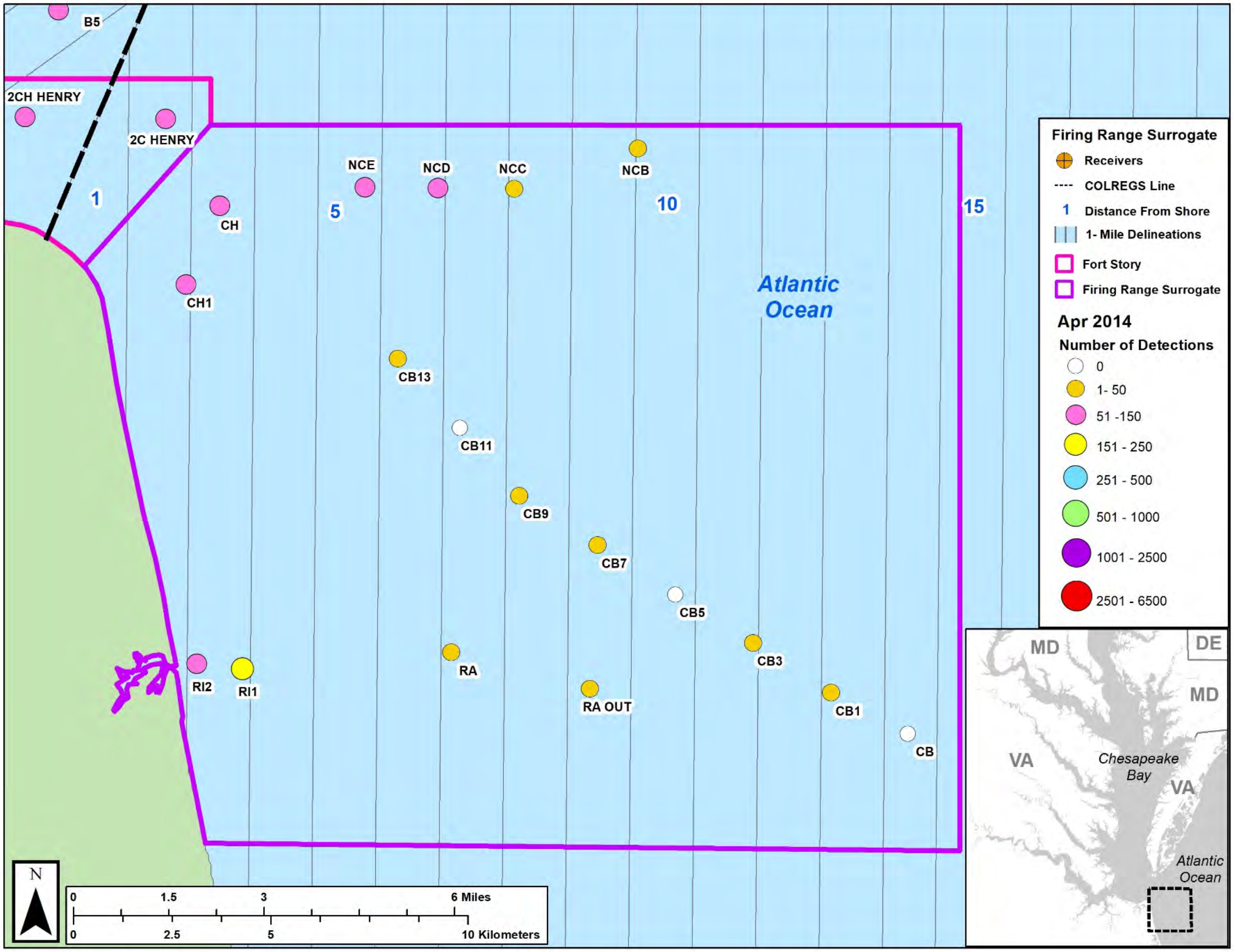
5
10
15
NCE
NCD
NCC
NCB
CH
CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Mar 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
N
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers


B5
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2C HENRY
1
5
10
15
CH
CH1
NCE
NCD
NCC
NCB
Atlantic Ocean
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Apr 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
N
0
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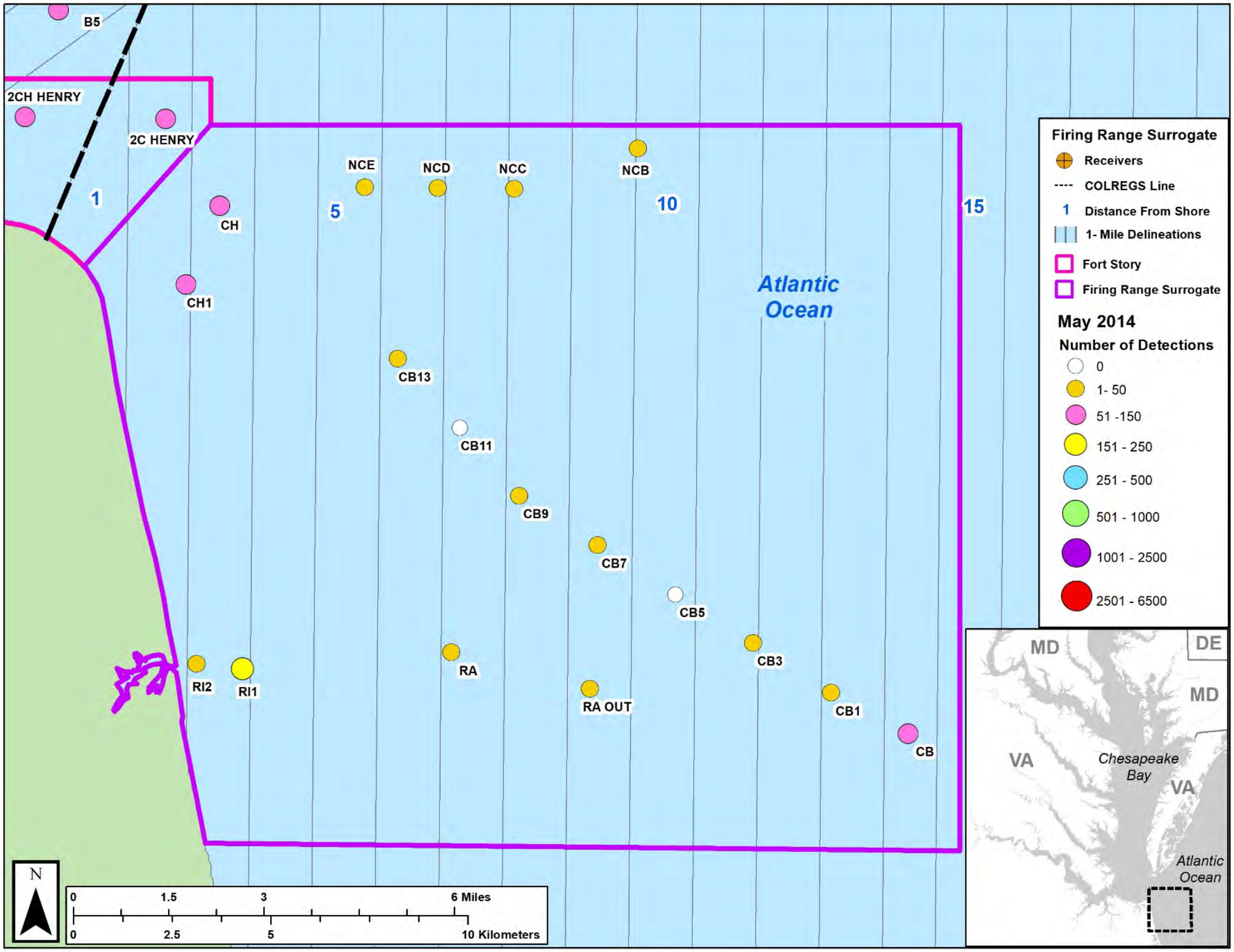
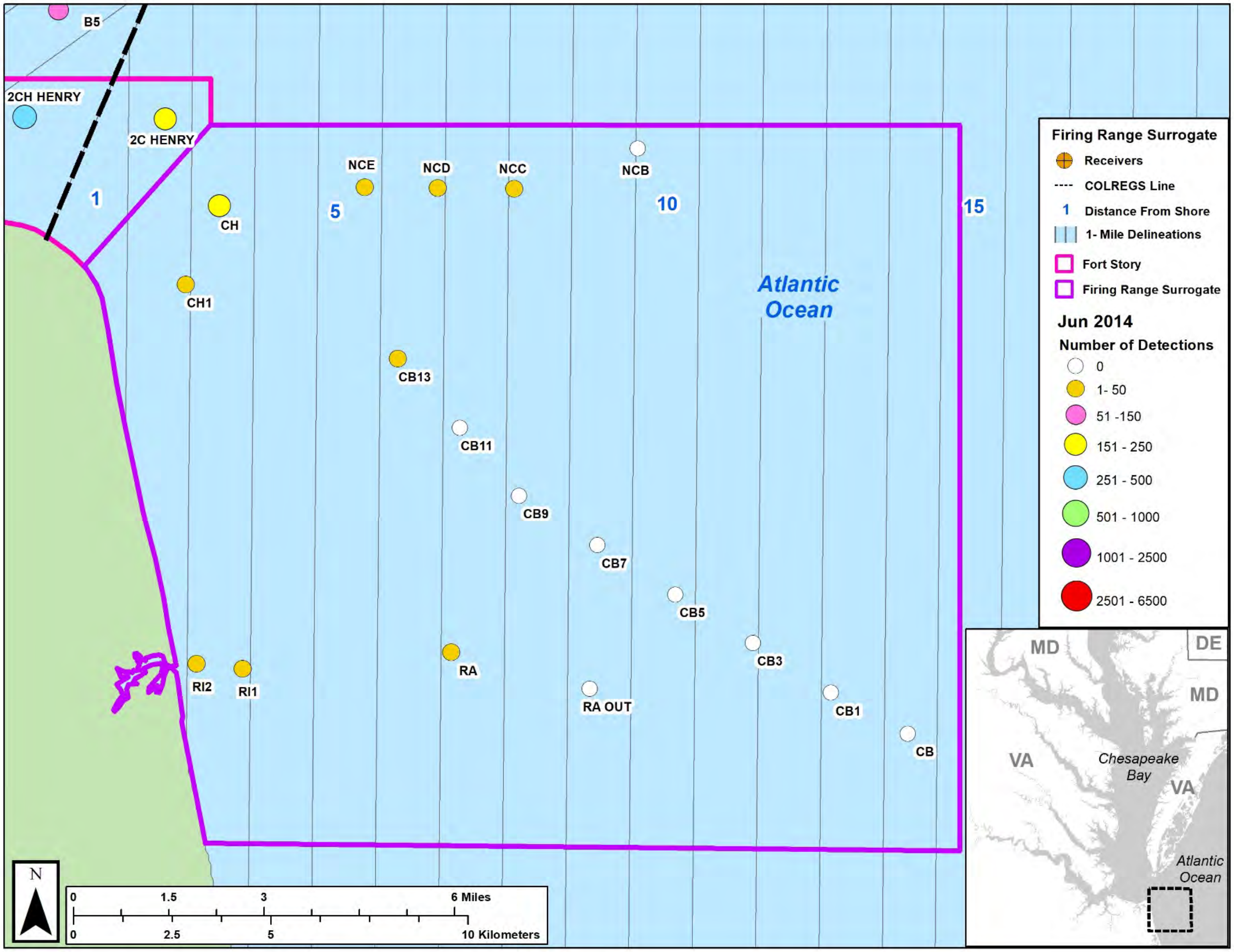
3
6 Miles
0
2.5
5
10 Kilometers


B5
2CH HENRY
2C HENRY
1
CH
CH1
5
NCE
NCD
NCC
NCB
10
15
Atlantic Ocean
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
May 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
N
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers


B5
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2C HENRY
CH
CH1
NCE
NCD
NCC
NCB
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5
10
15
Atlantic Ocean
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Jun 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
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Chesapeake Bay
VA
Atlantic Ocean
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3
6 Miles
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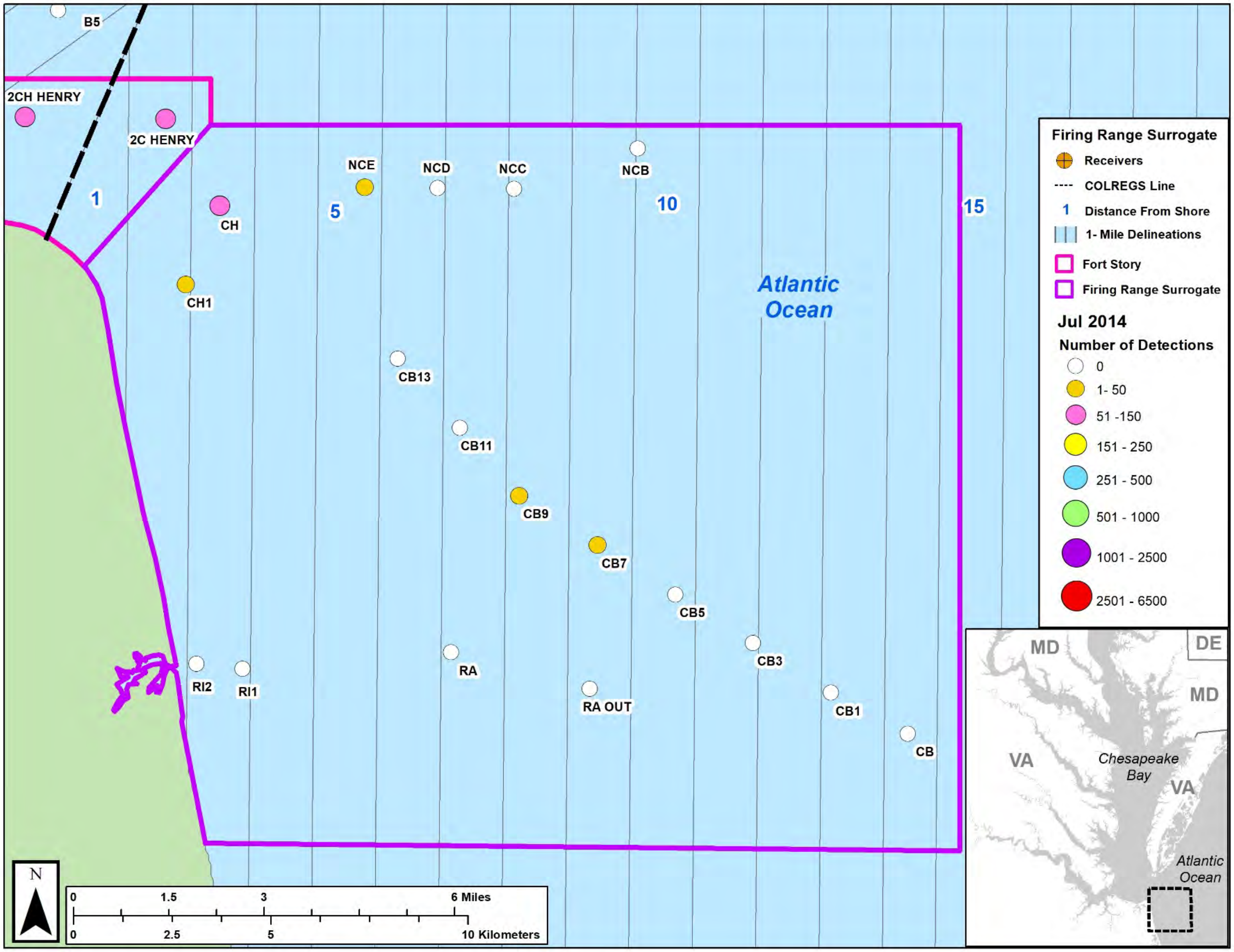
10 Kilometers


B5
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2C HENRY
CH
CH1
NCE
NCD
NCC
NCB
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5
10
15
Atlantic Ocean
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Jul 2014
Number of Detections
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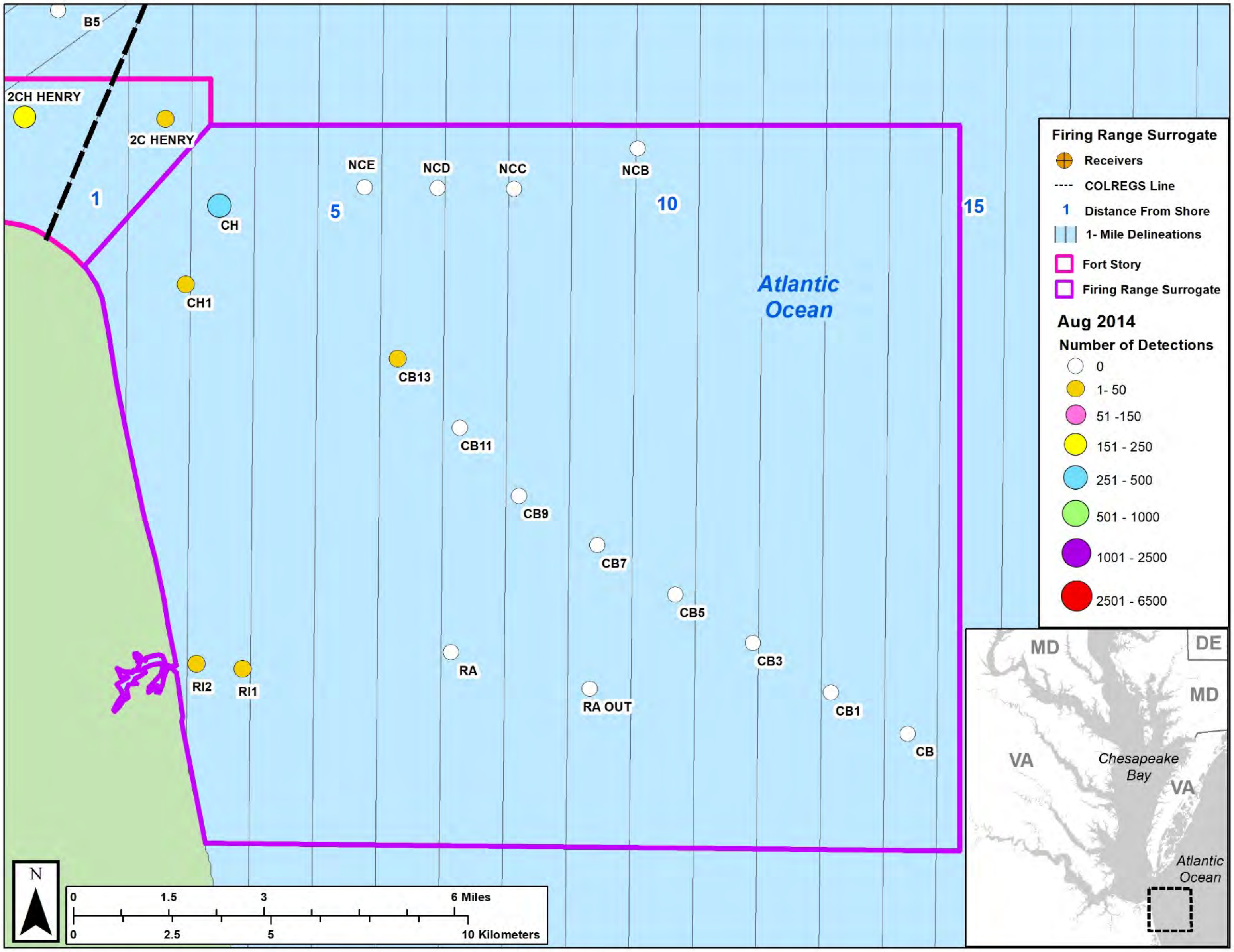
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RA OUT
RI2
RI1
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Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Aug 2014
Number of Detections
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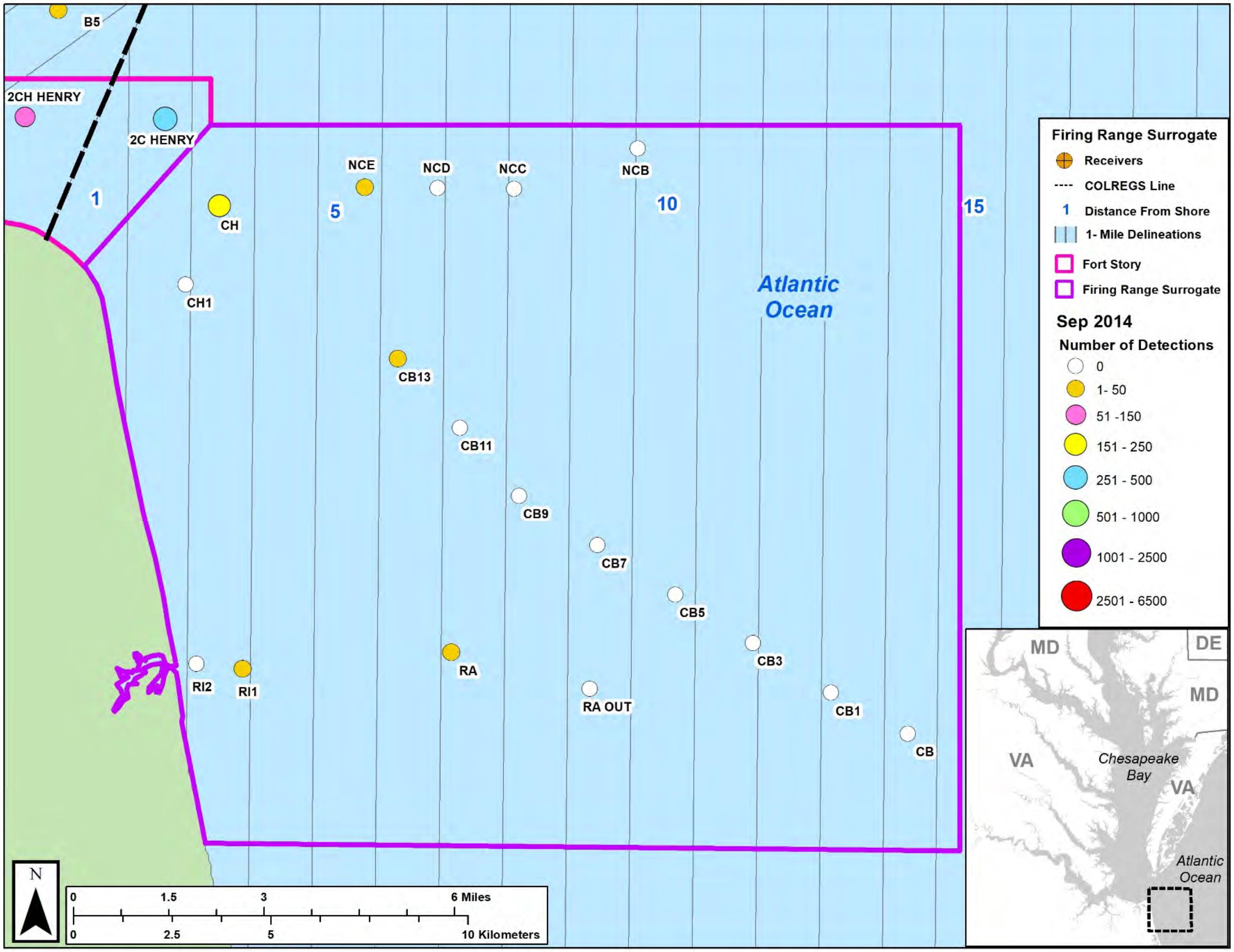
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RI1
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RA OUT
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
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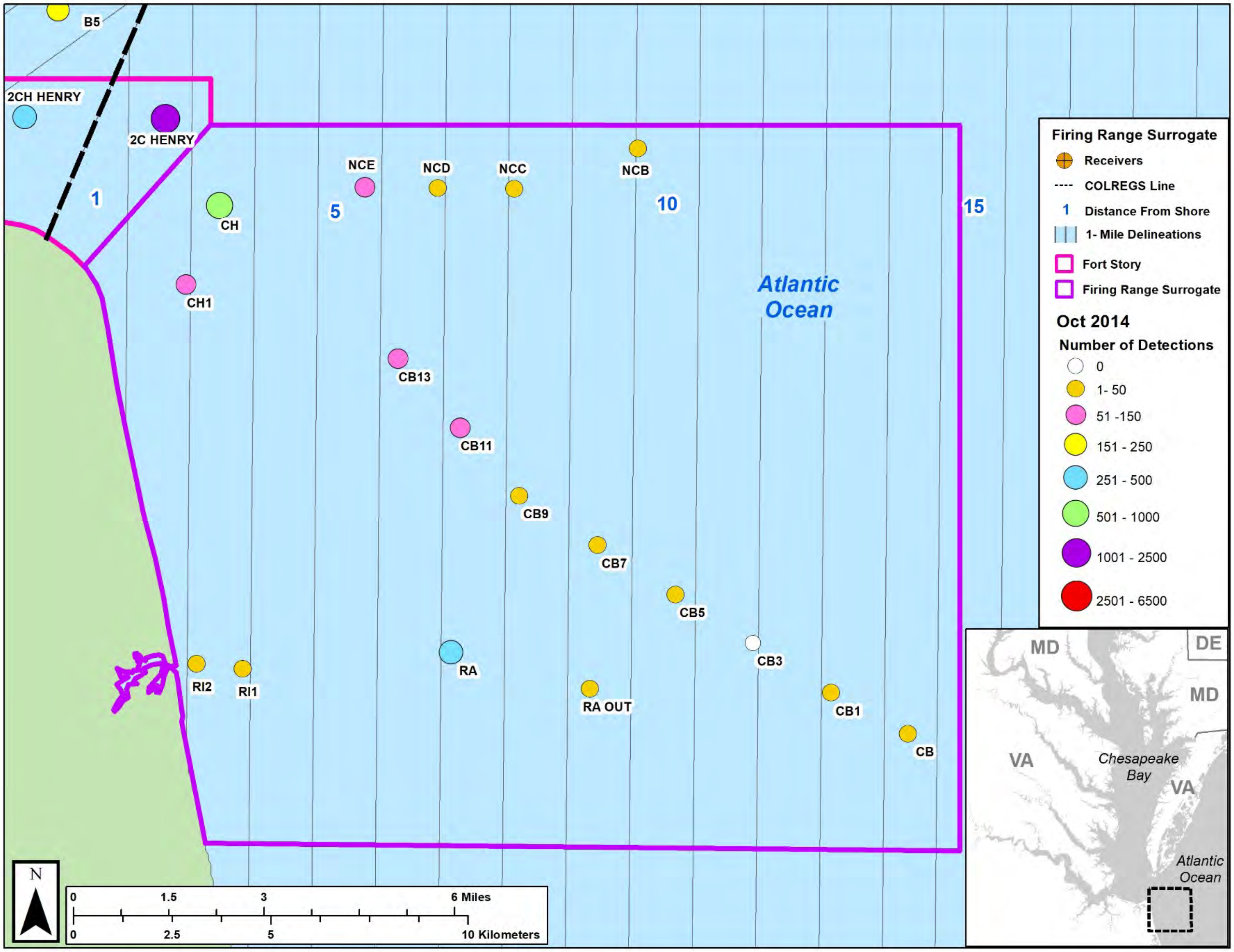
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Distance From Shore
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Firing Range Surrogate
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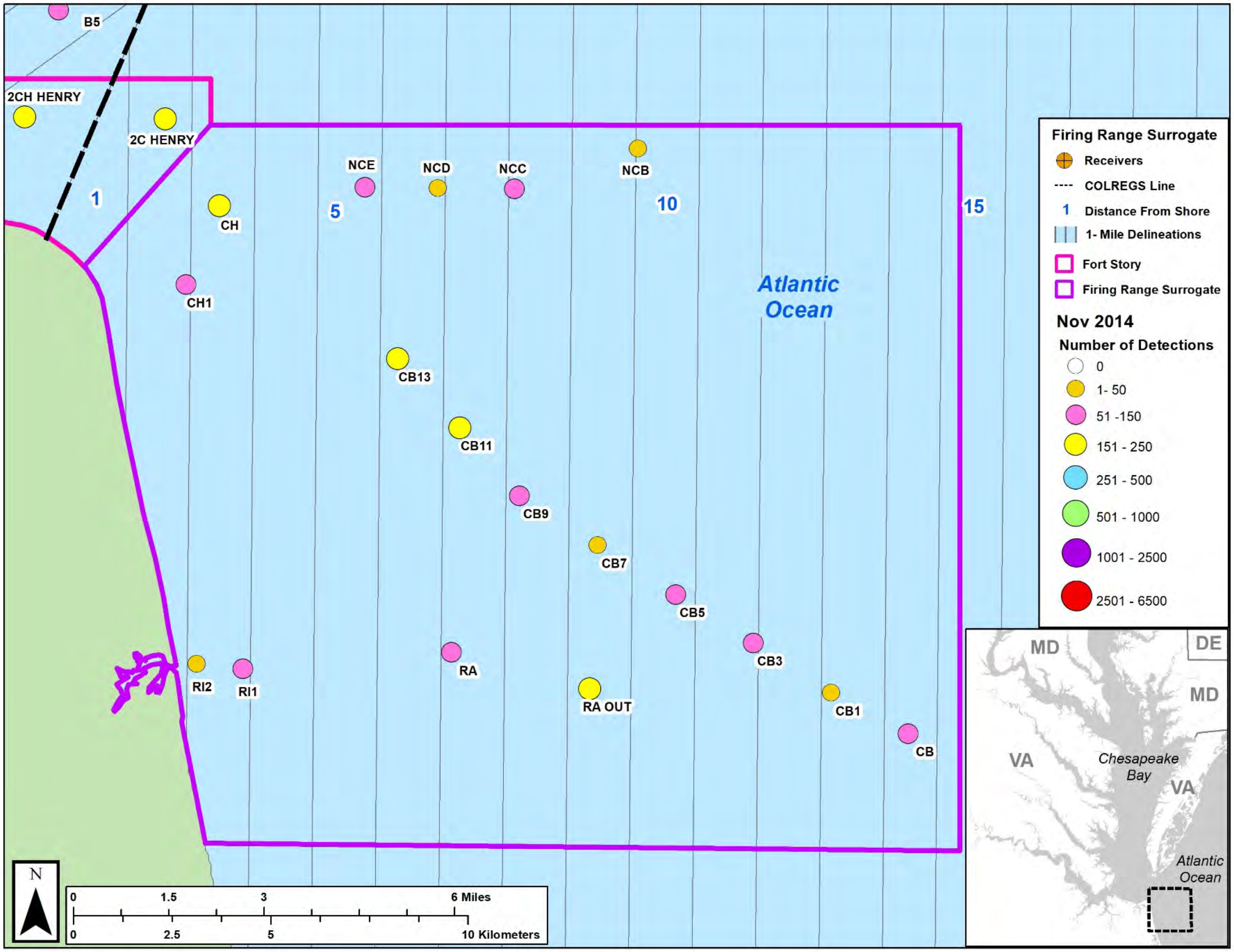
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Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Nov 2014
Number of Detections
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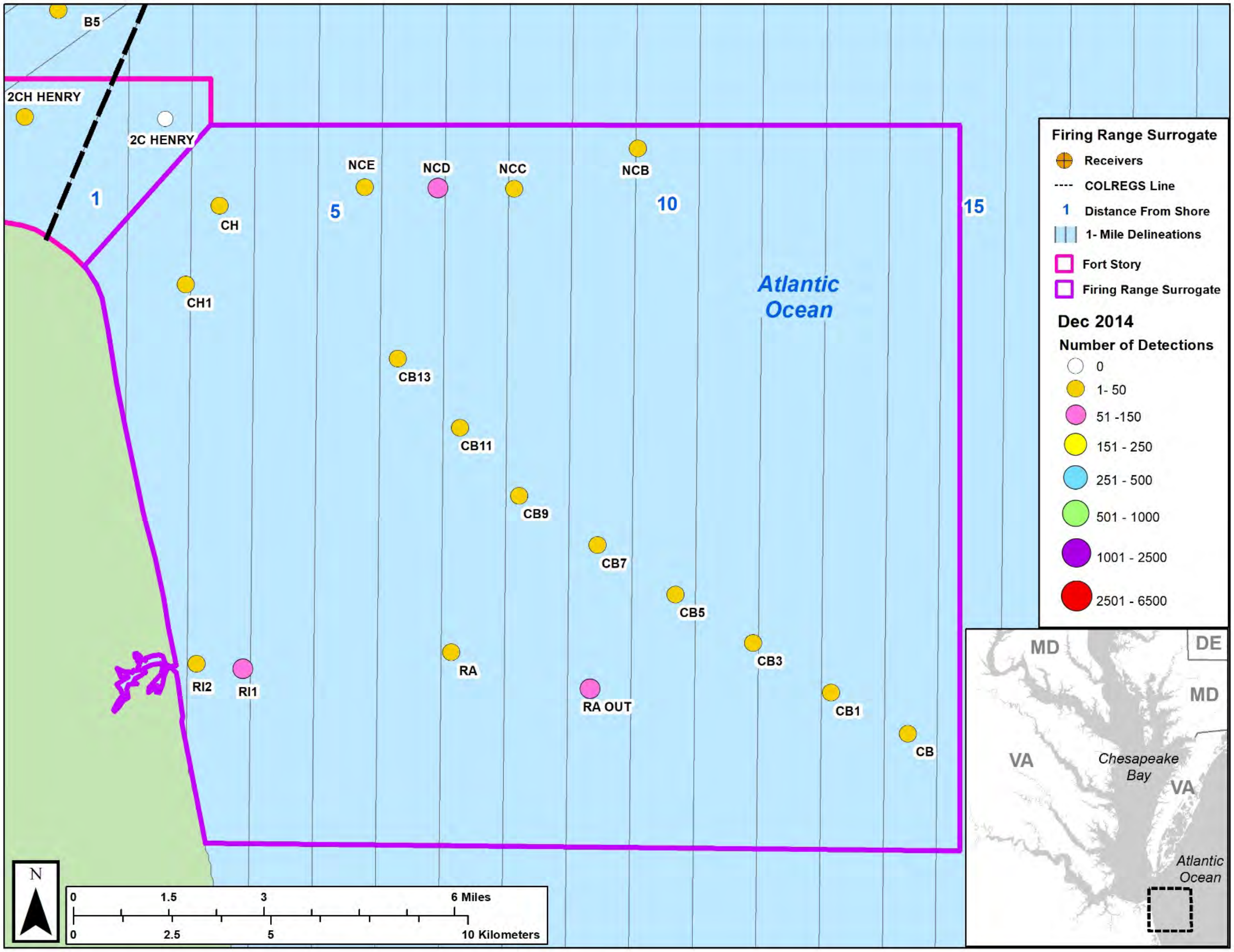
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1- Mile Delineations
Fort Story
Firing Range Surrogate
Dec 2014
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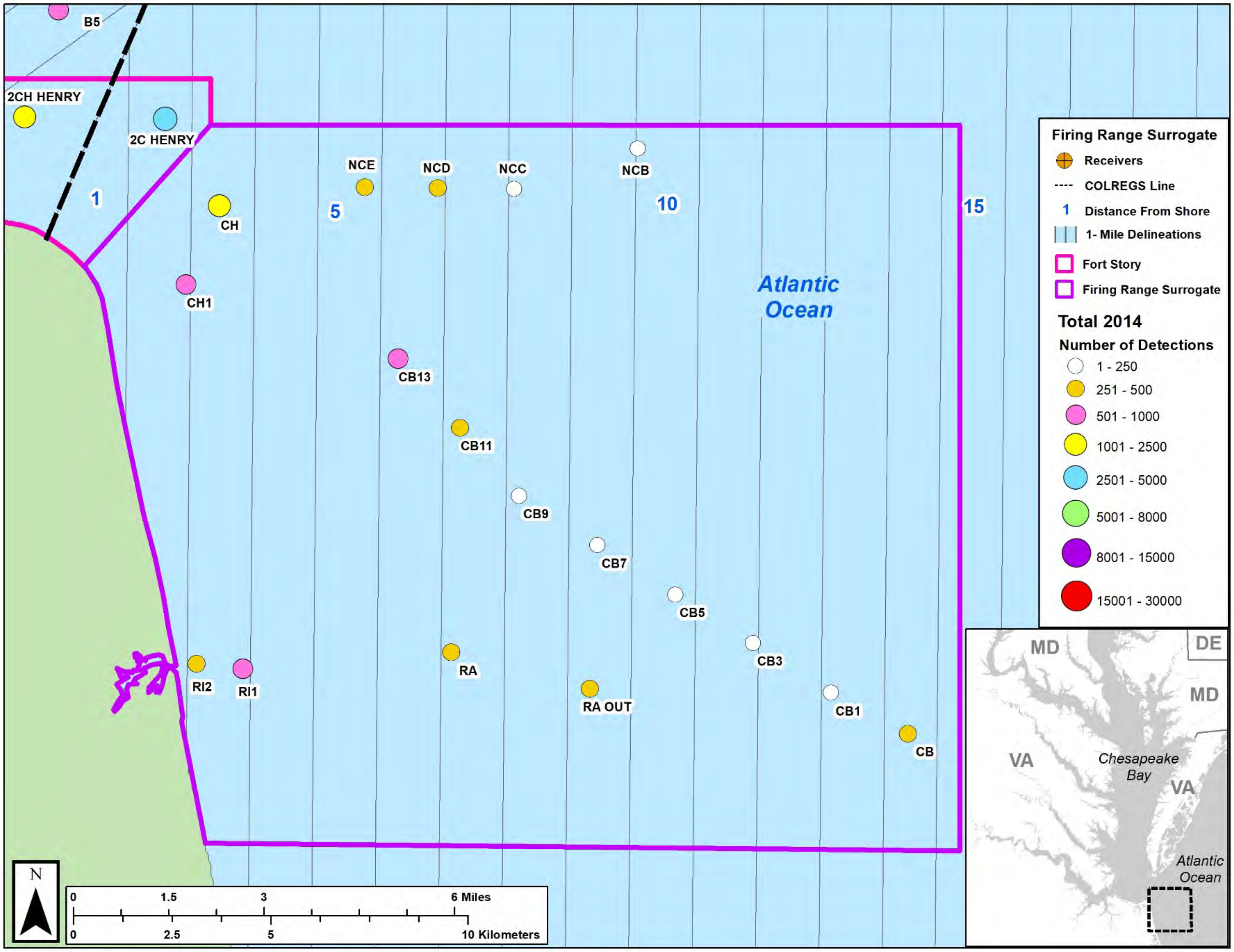
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1- Mile Delineations
Fort Story
Firing Range Surrogate
Total 2014
Number of Detections
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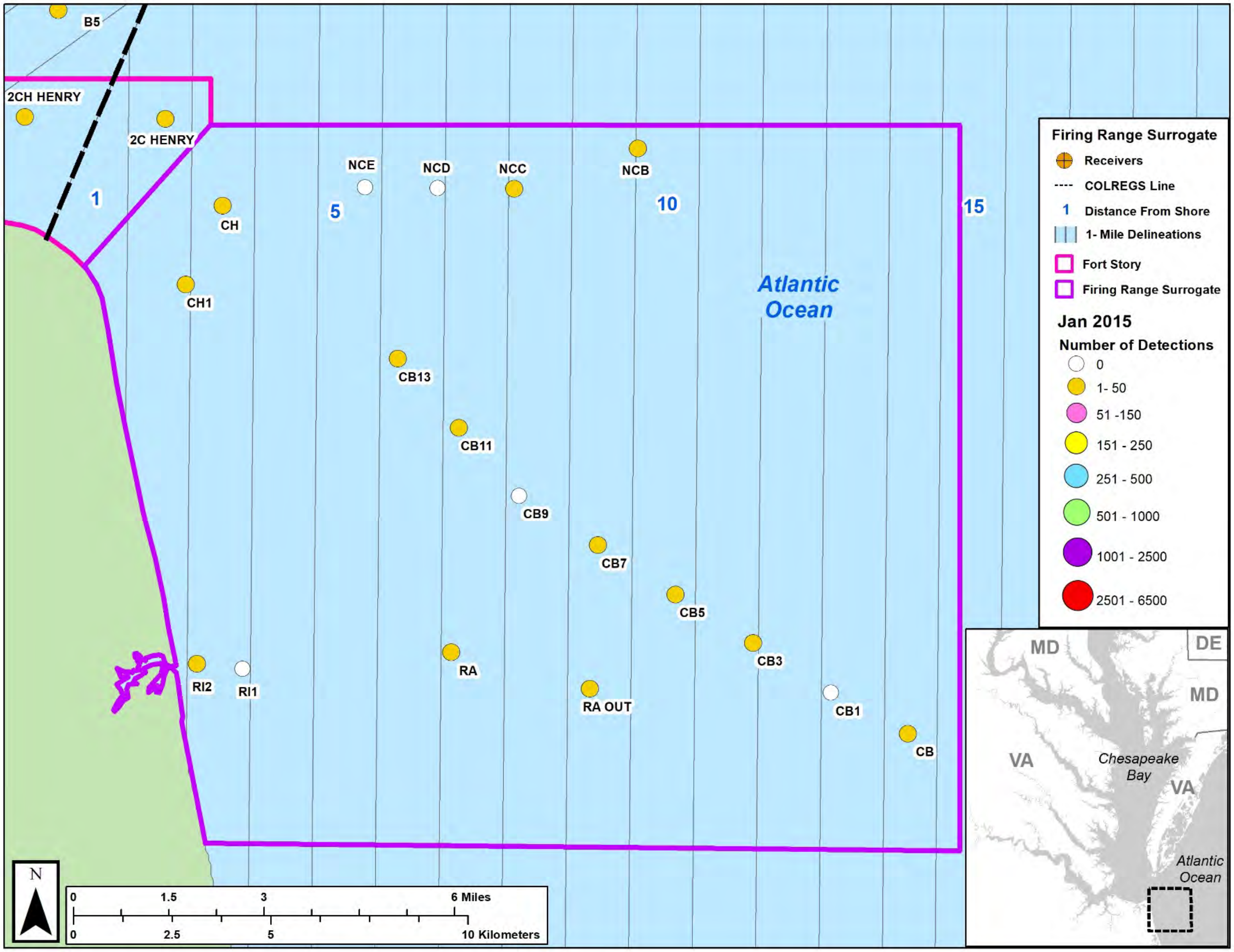
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1- Mile Delineations
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Firing Range Surrogate
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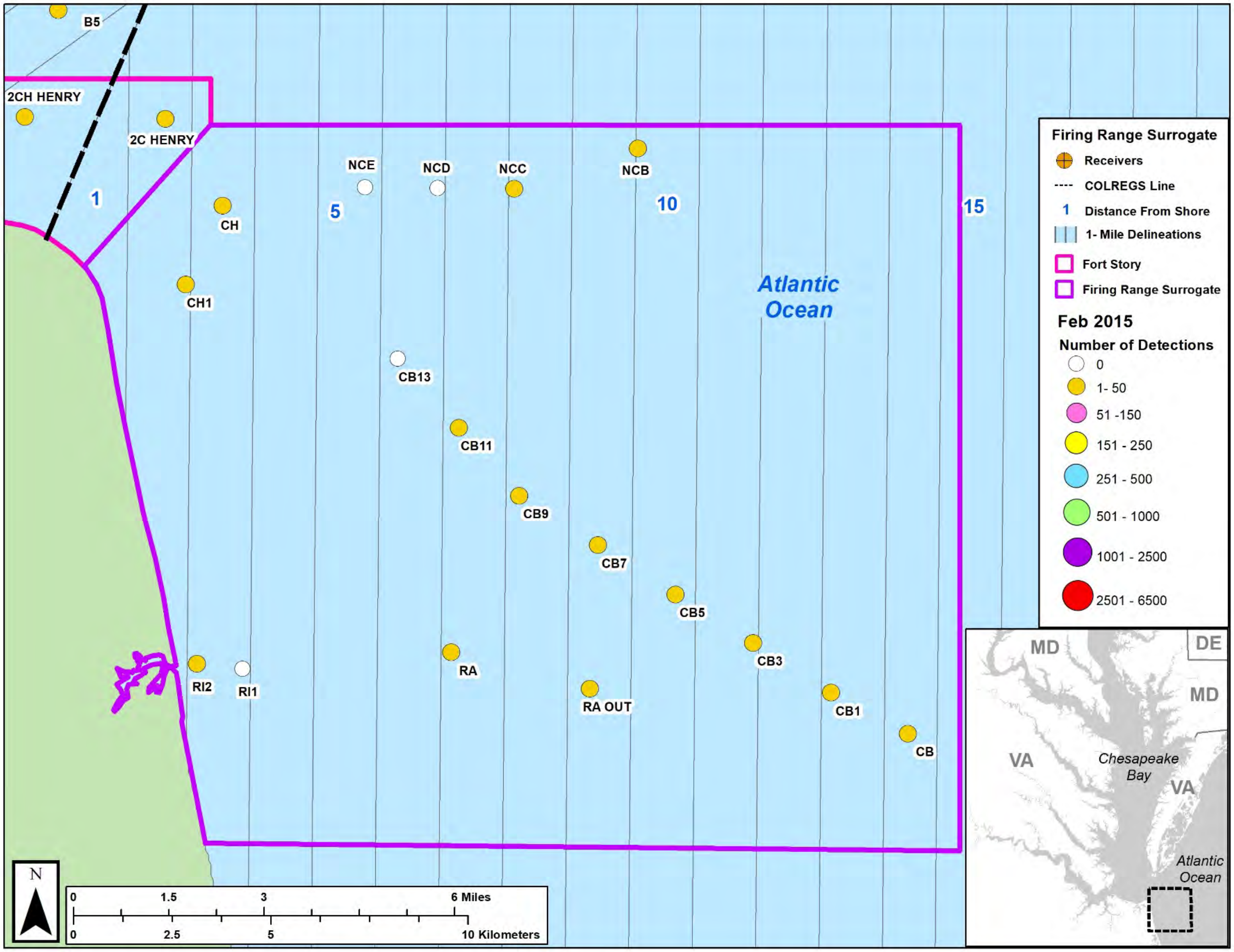
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Firing Range Surrogate
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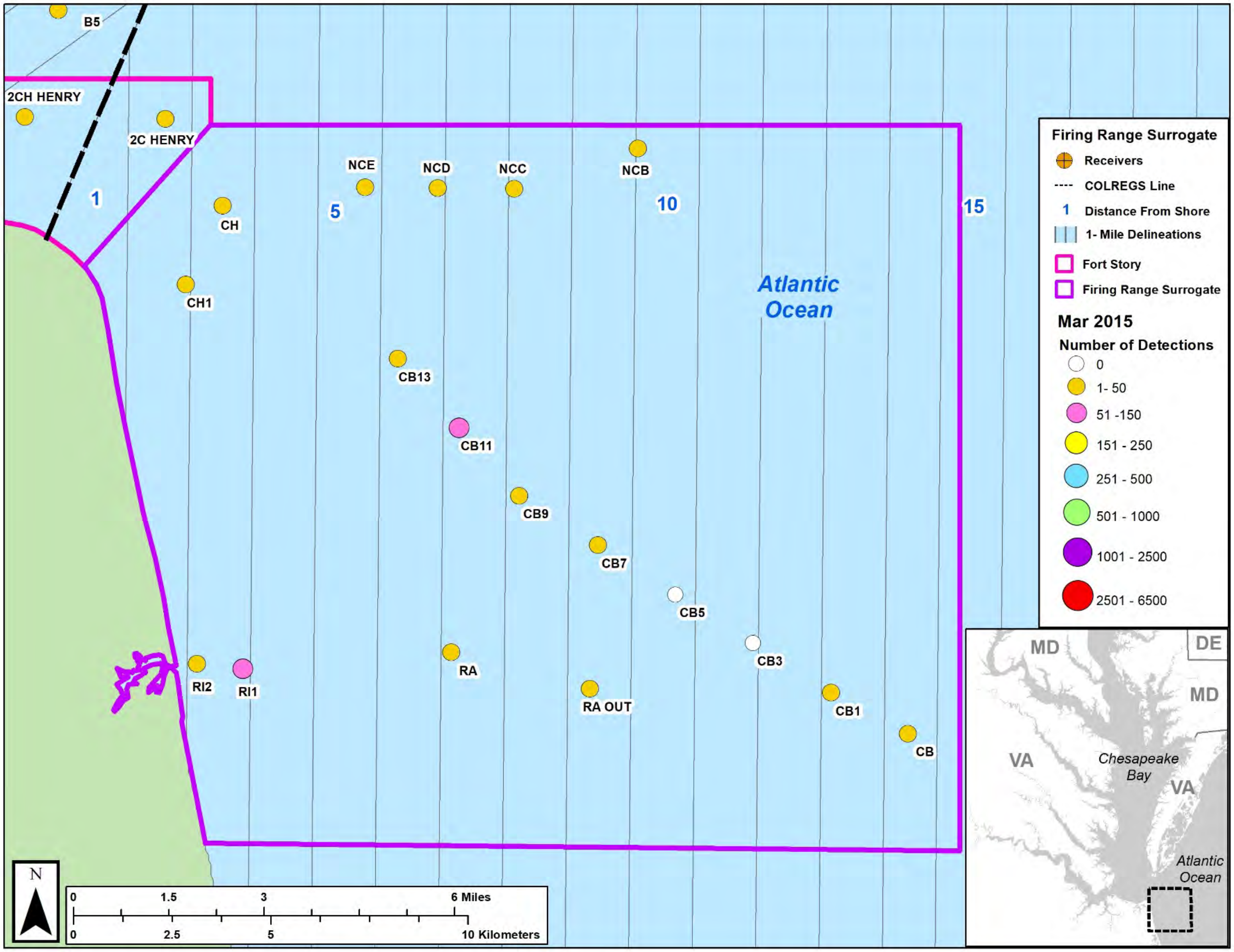
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Firing Range Surrogate
Mar 2015
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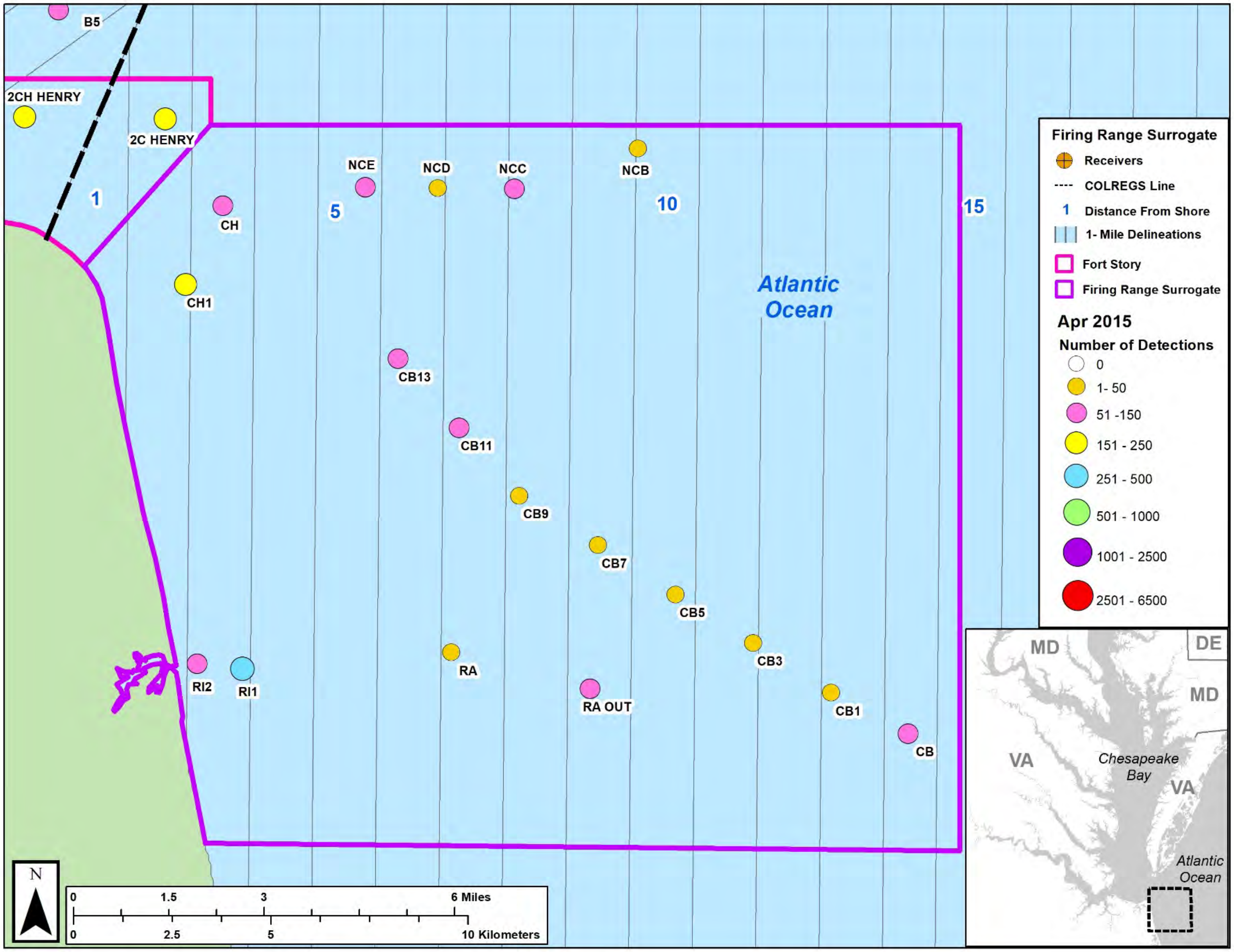
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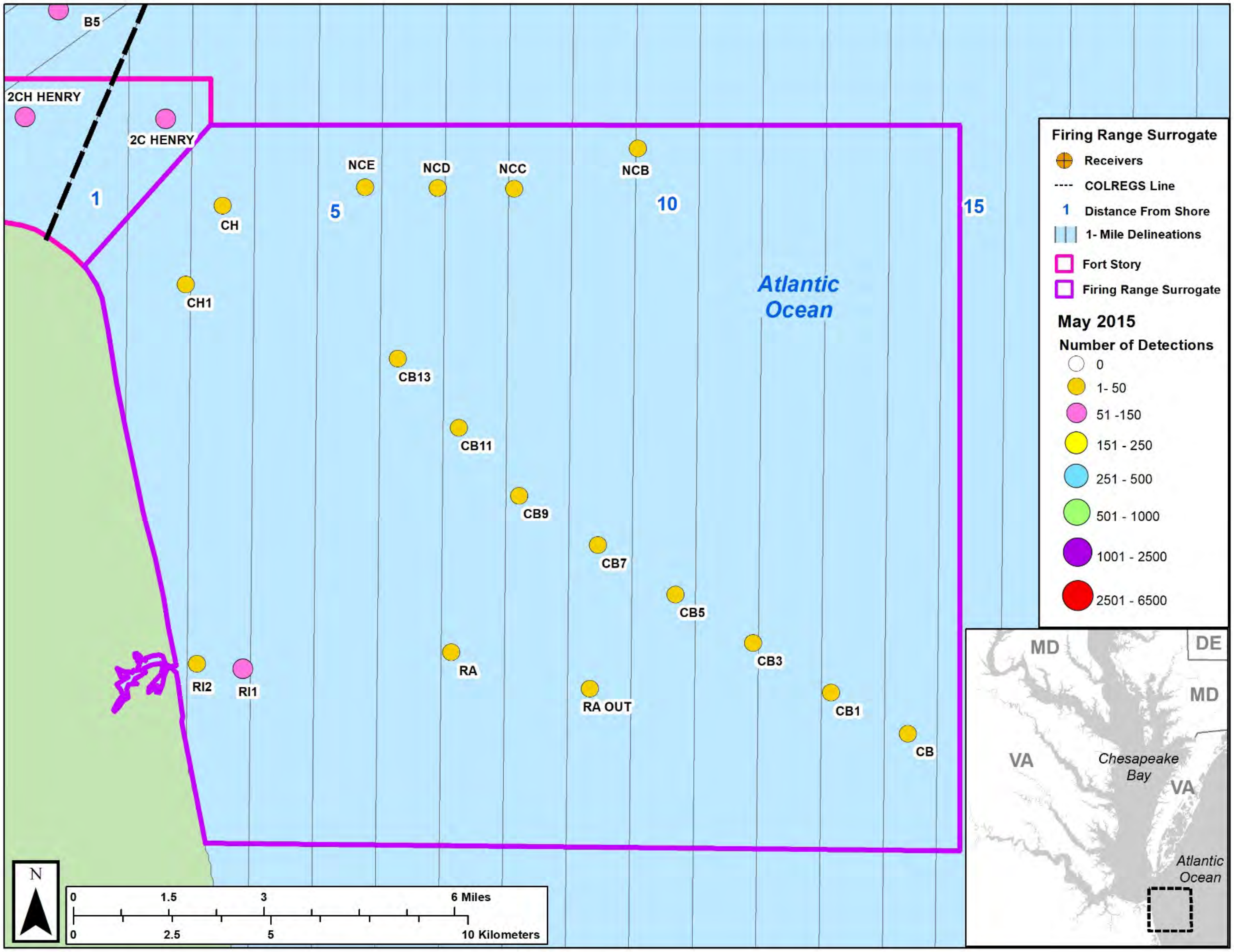
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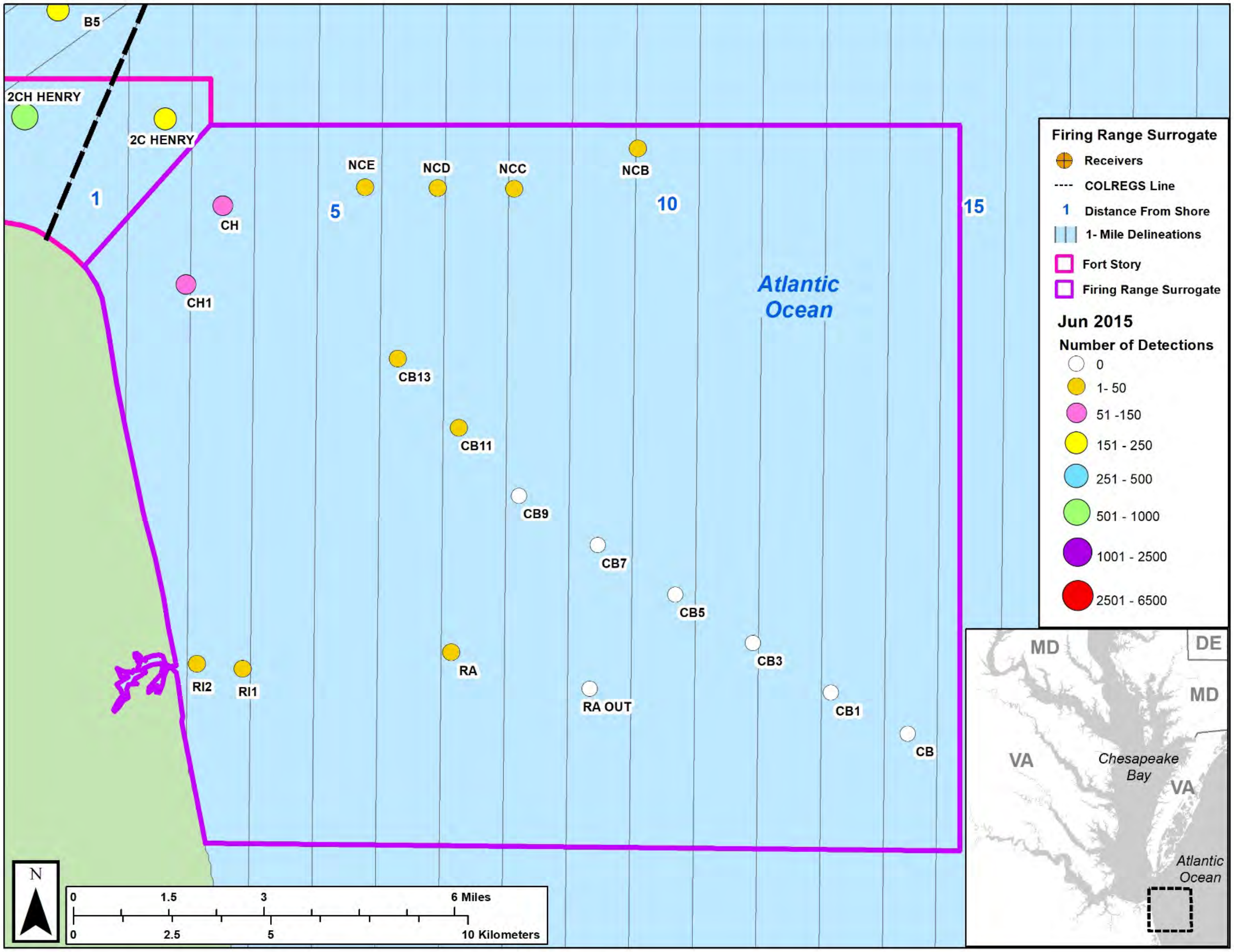
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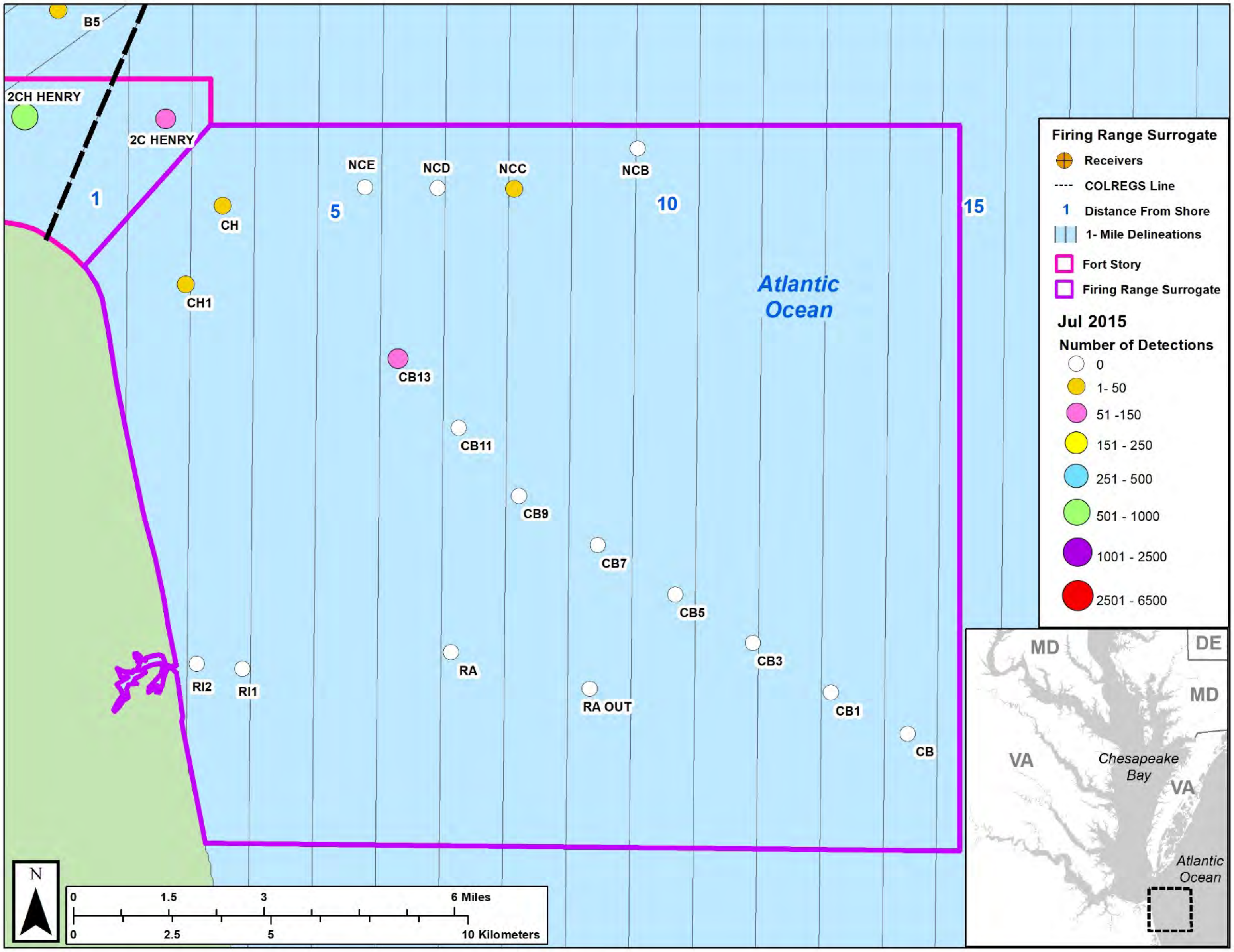
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1- Mile Delineations
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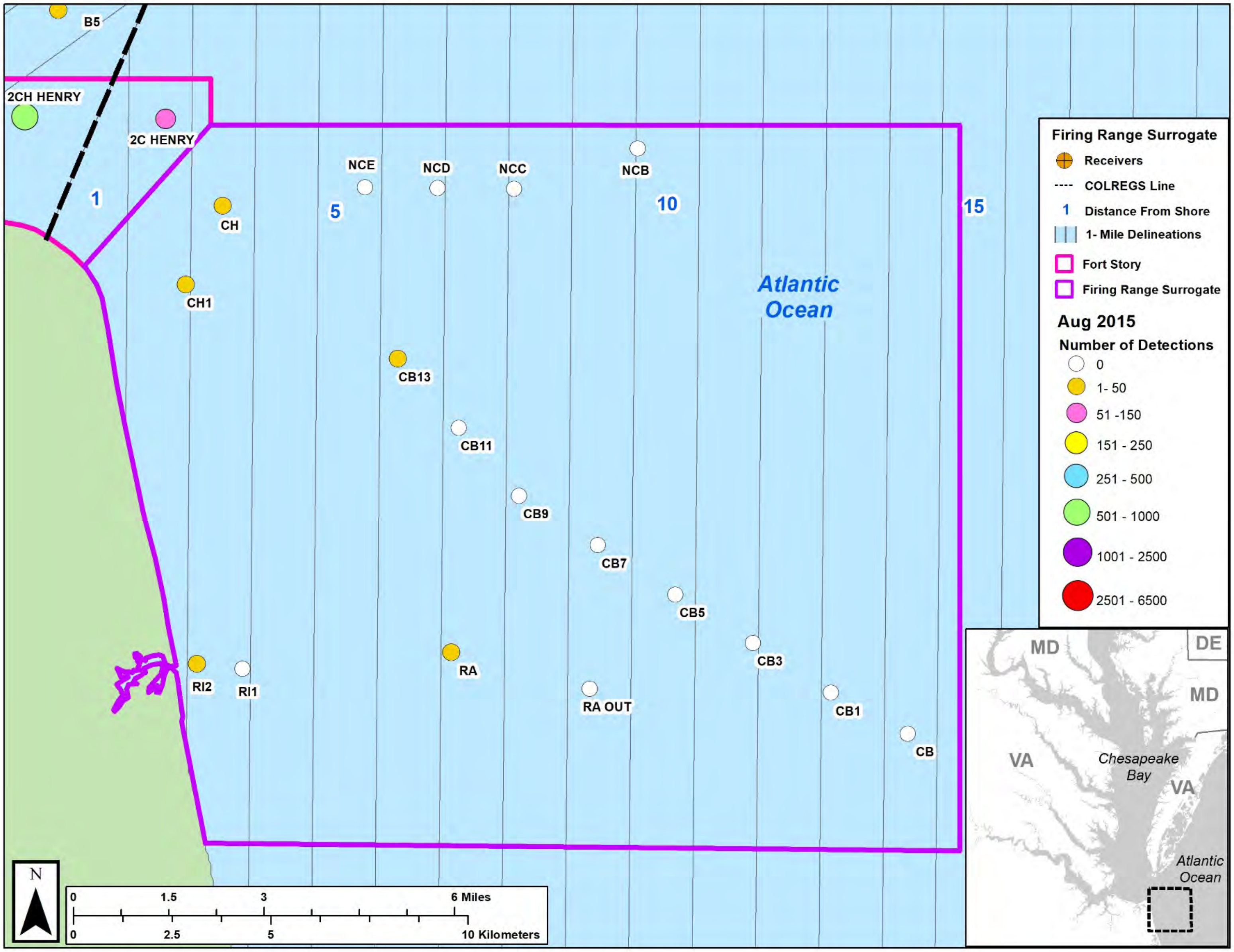
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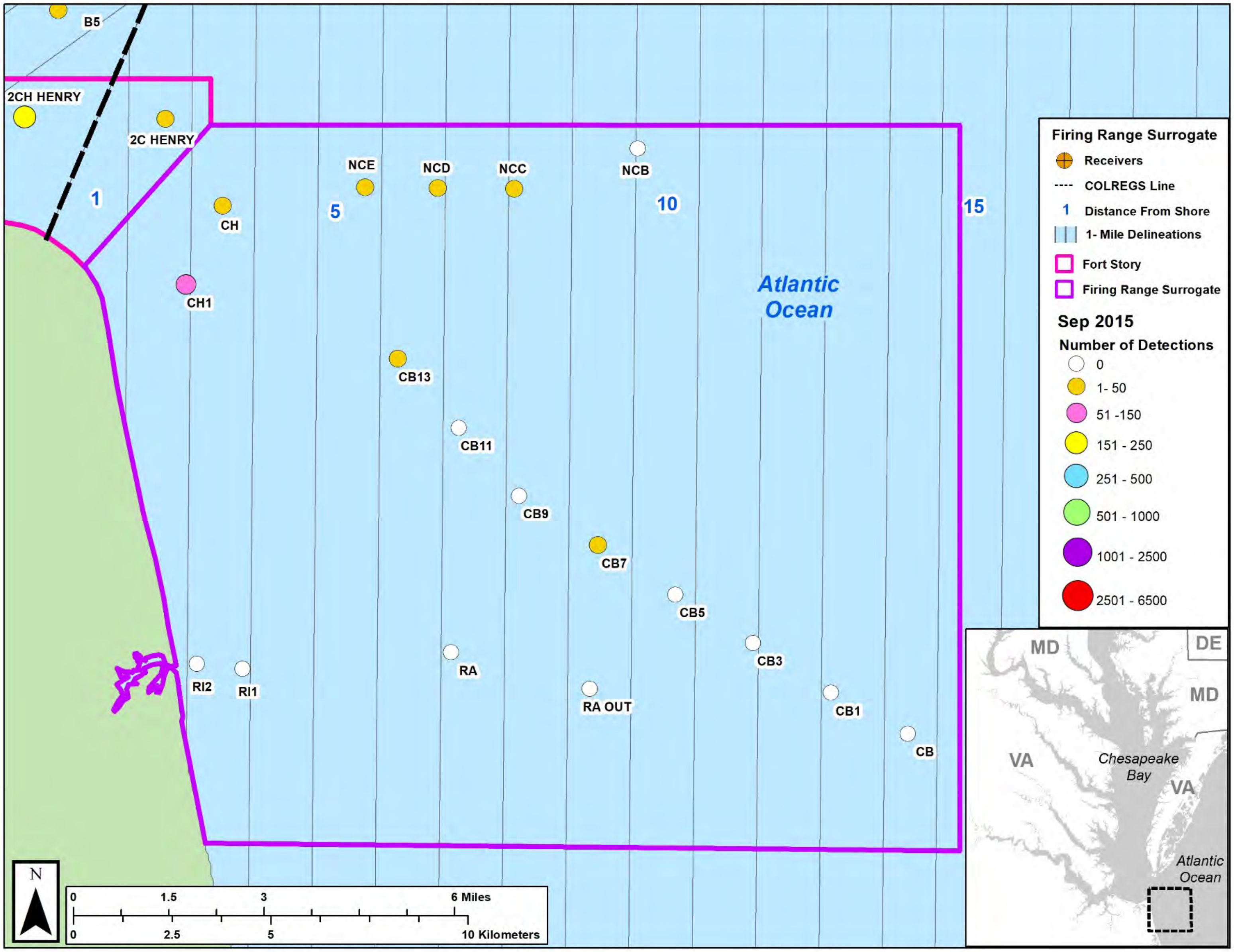
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Distance From Shore
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Fort Story
Firing Range Surrogate
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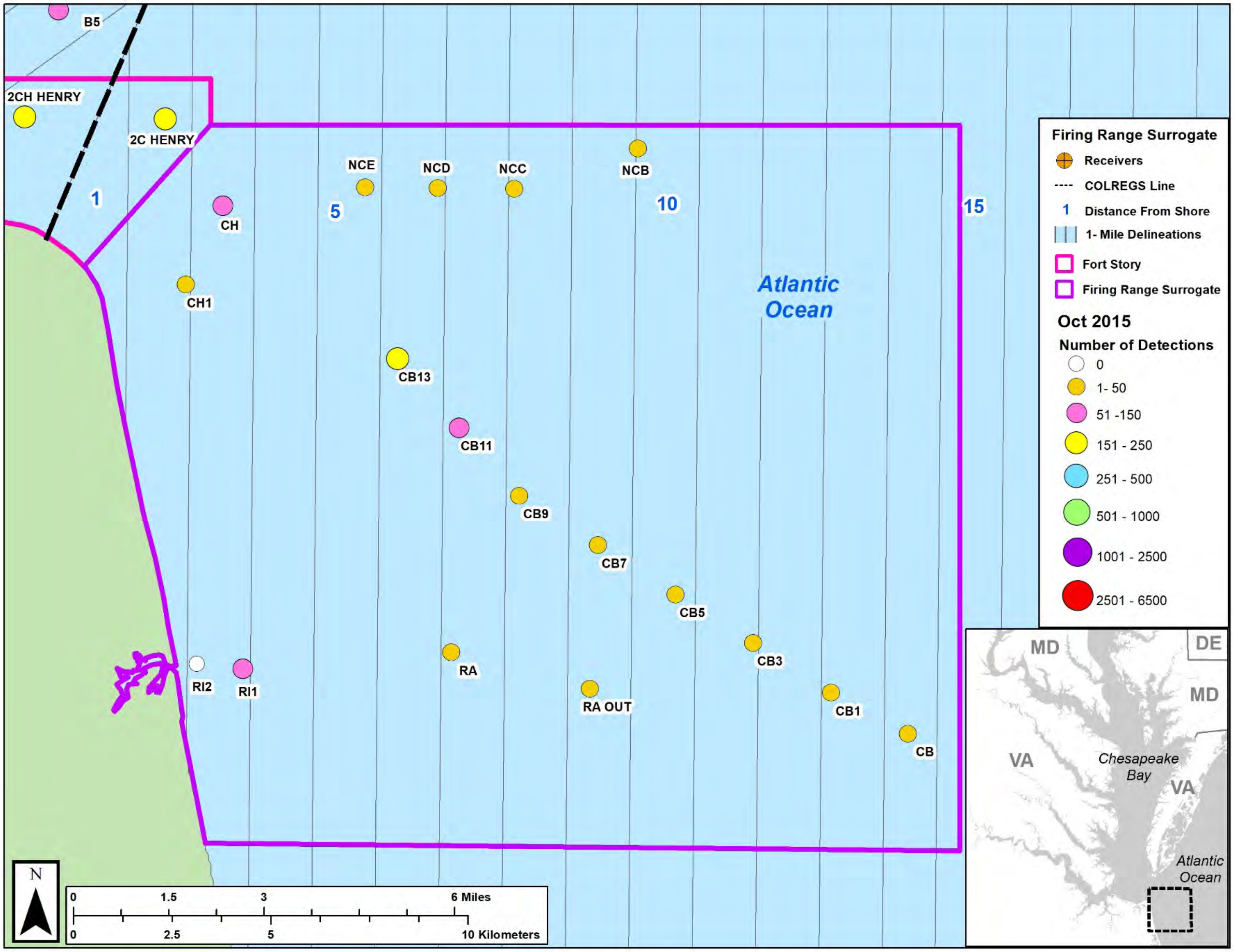
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Distance From Shore
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Fort Story
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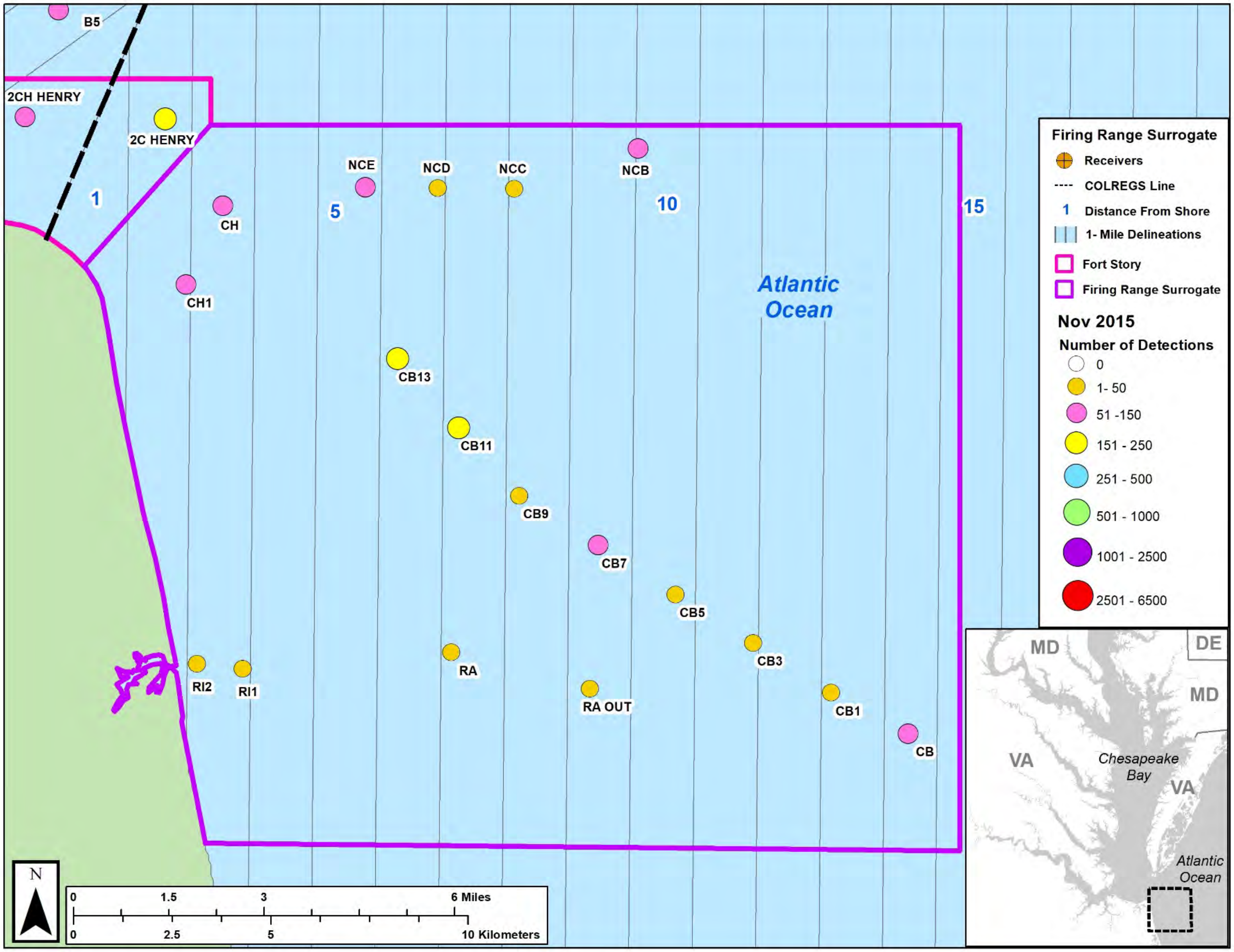
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Fort Story
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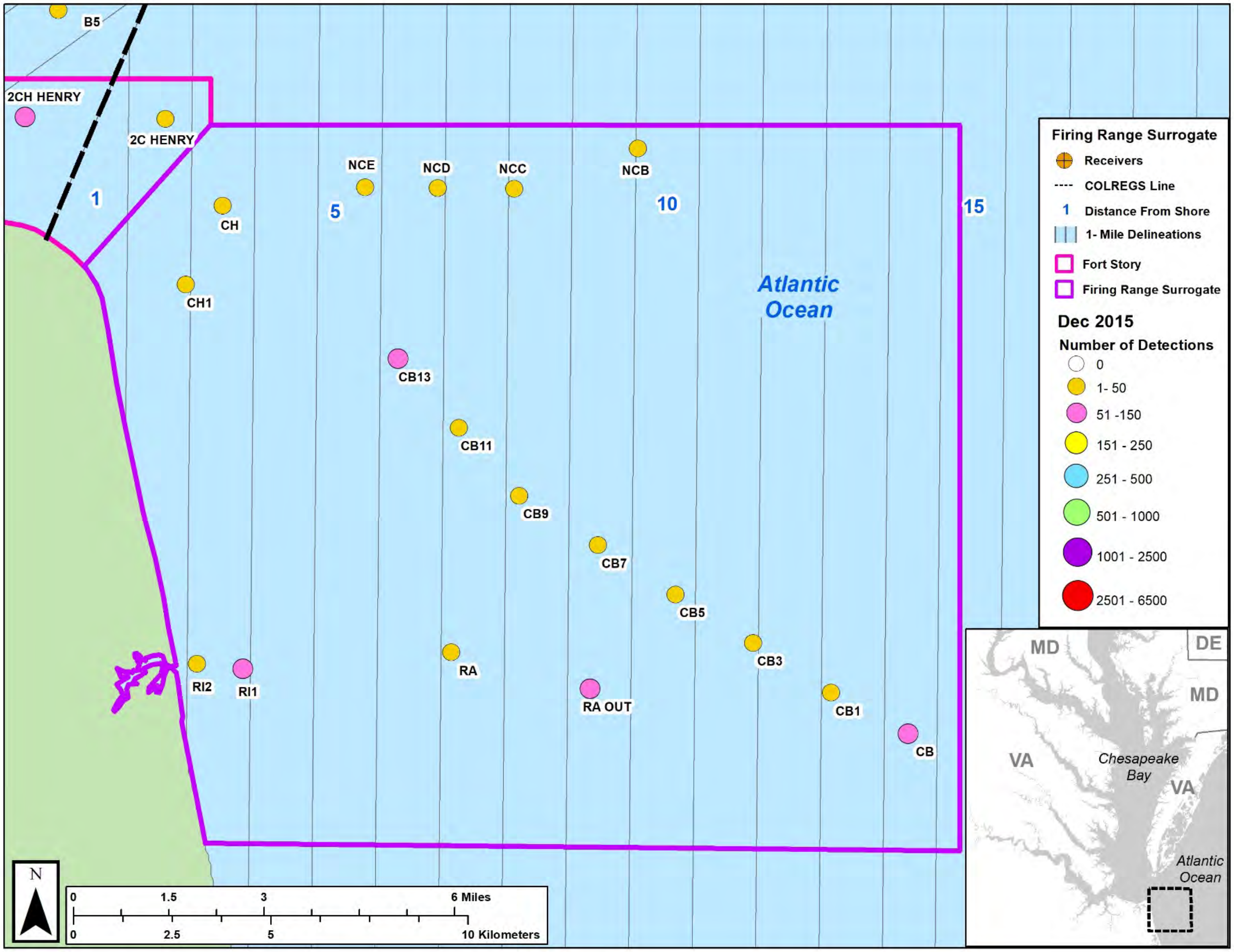
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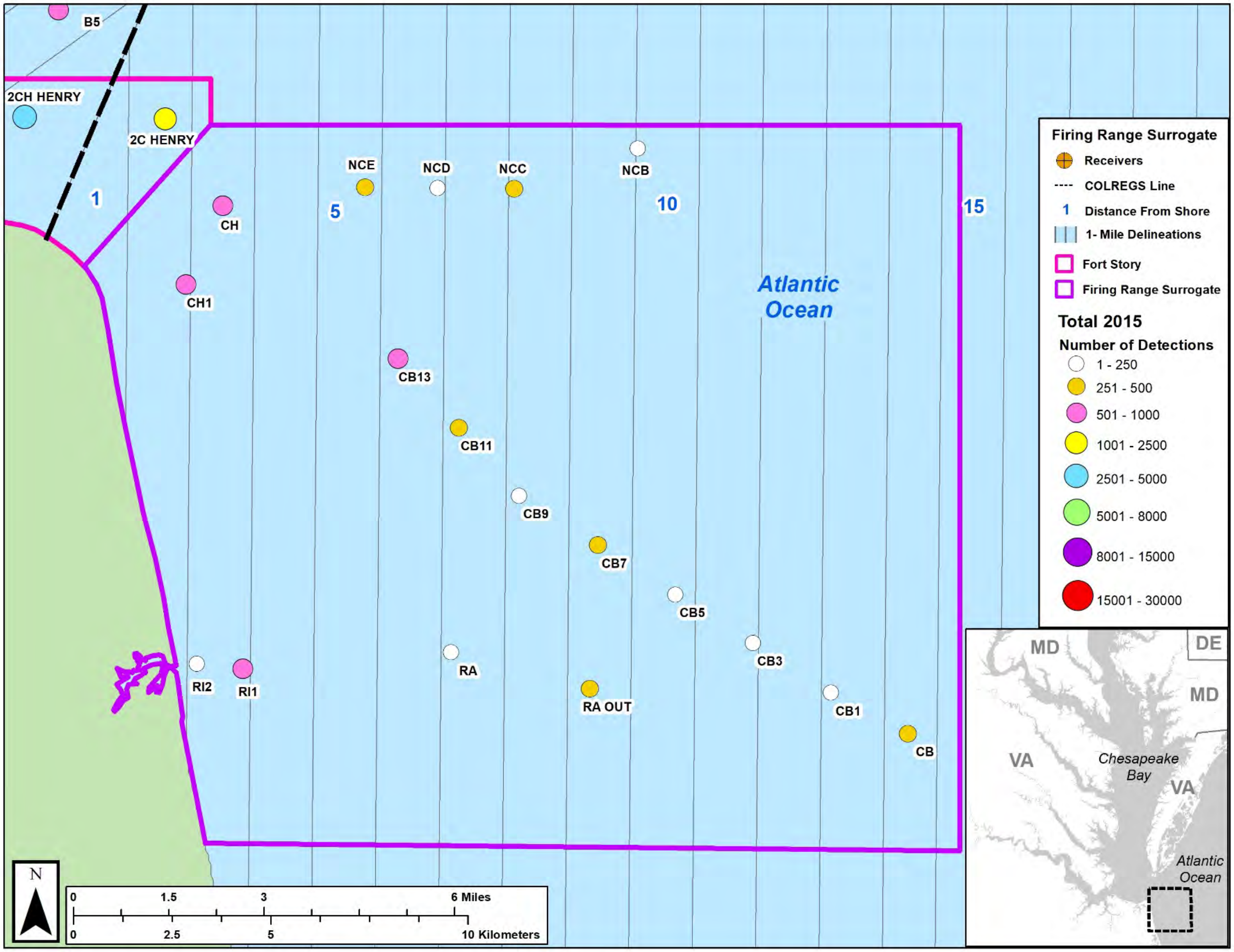
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Firing Range Surrogate
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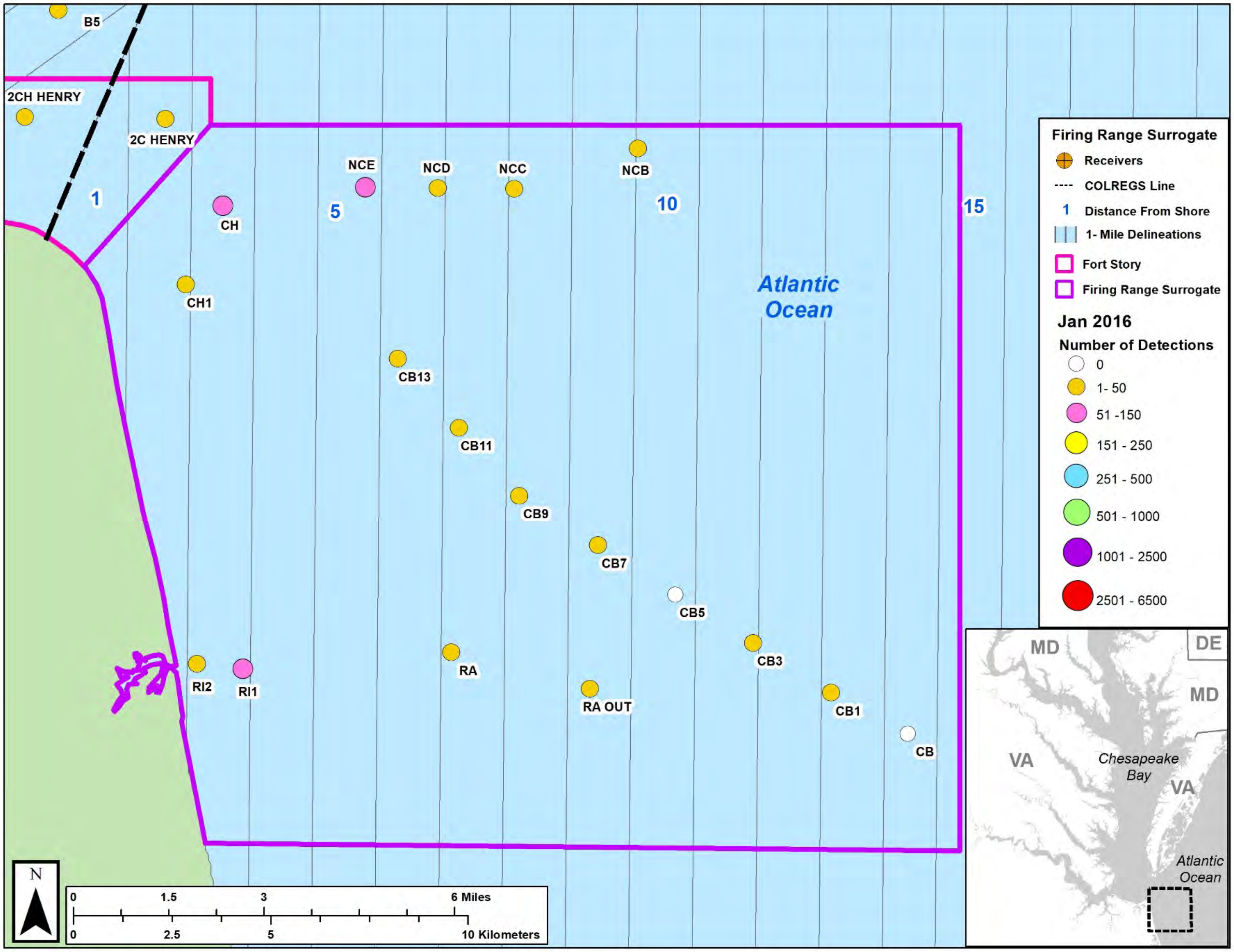
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Firing Range Surrogate
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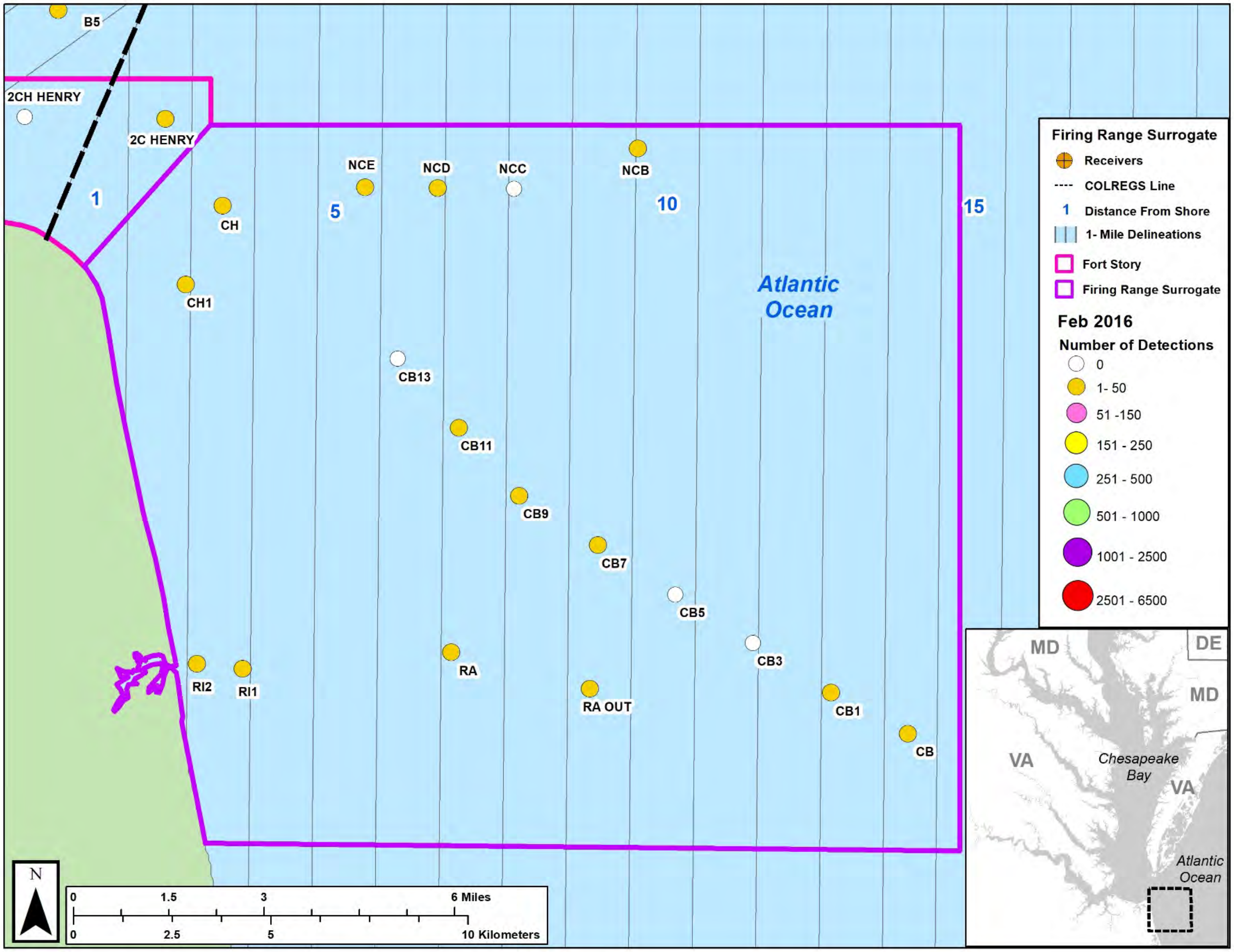
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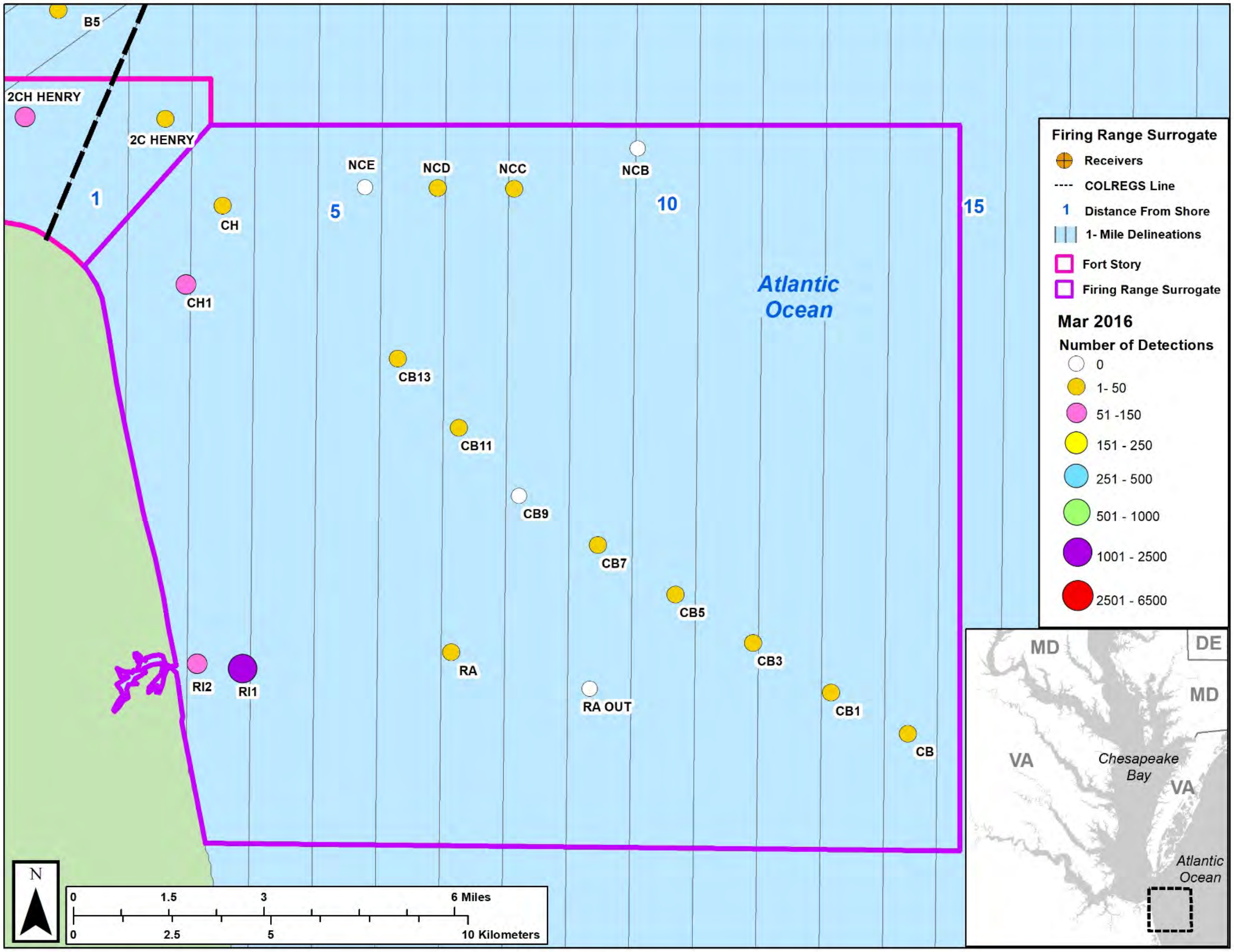
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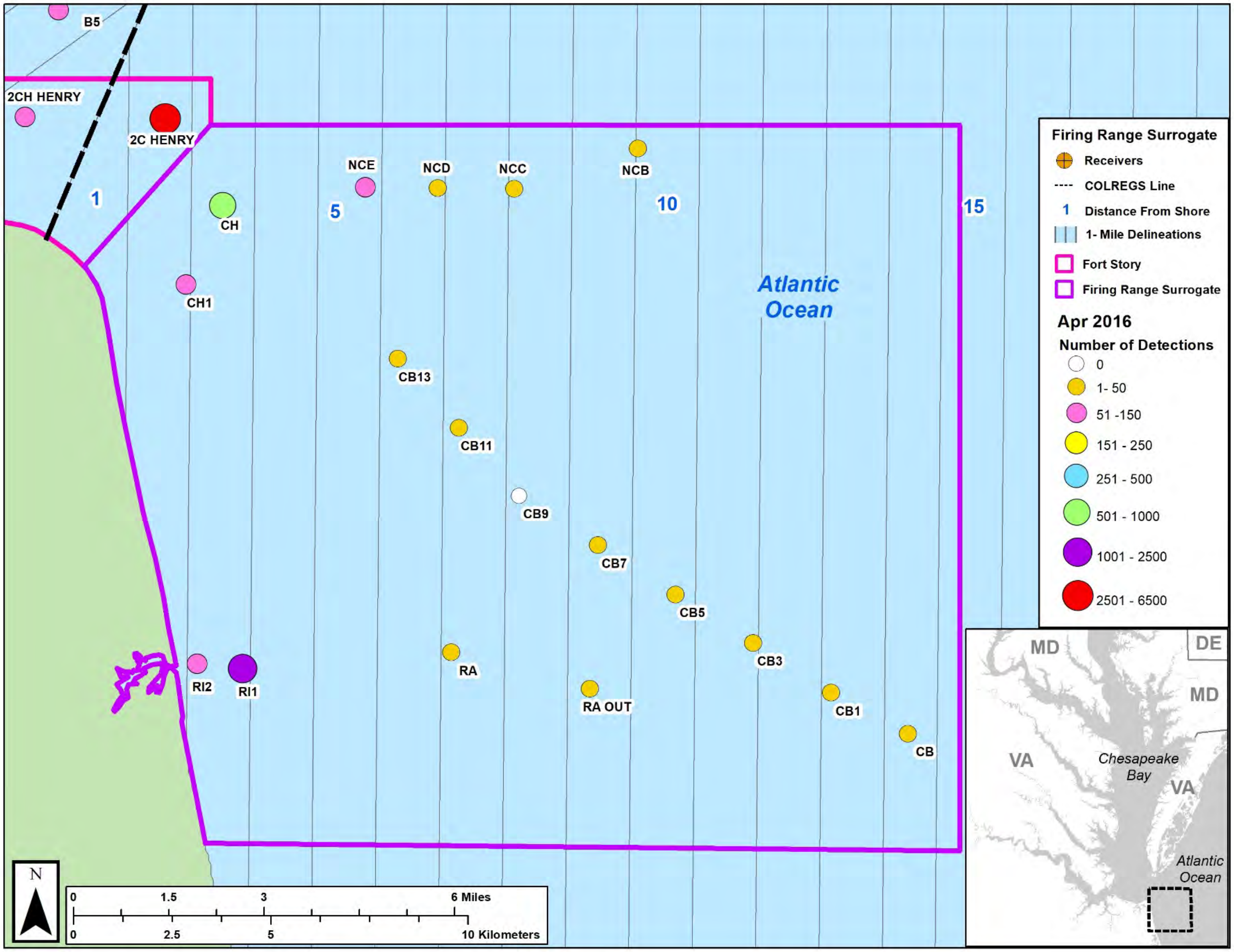
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CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Apr 2016
Number of Detections
0
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51 -150
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251 - 500
501 - 1000
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2501 - 6500
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VA
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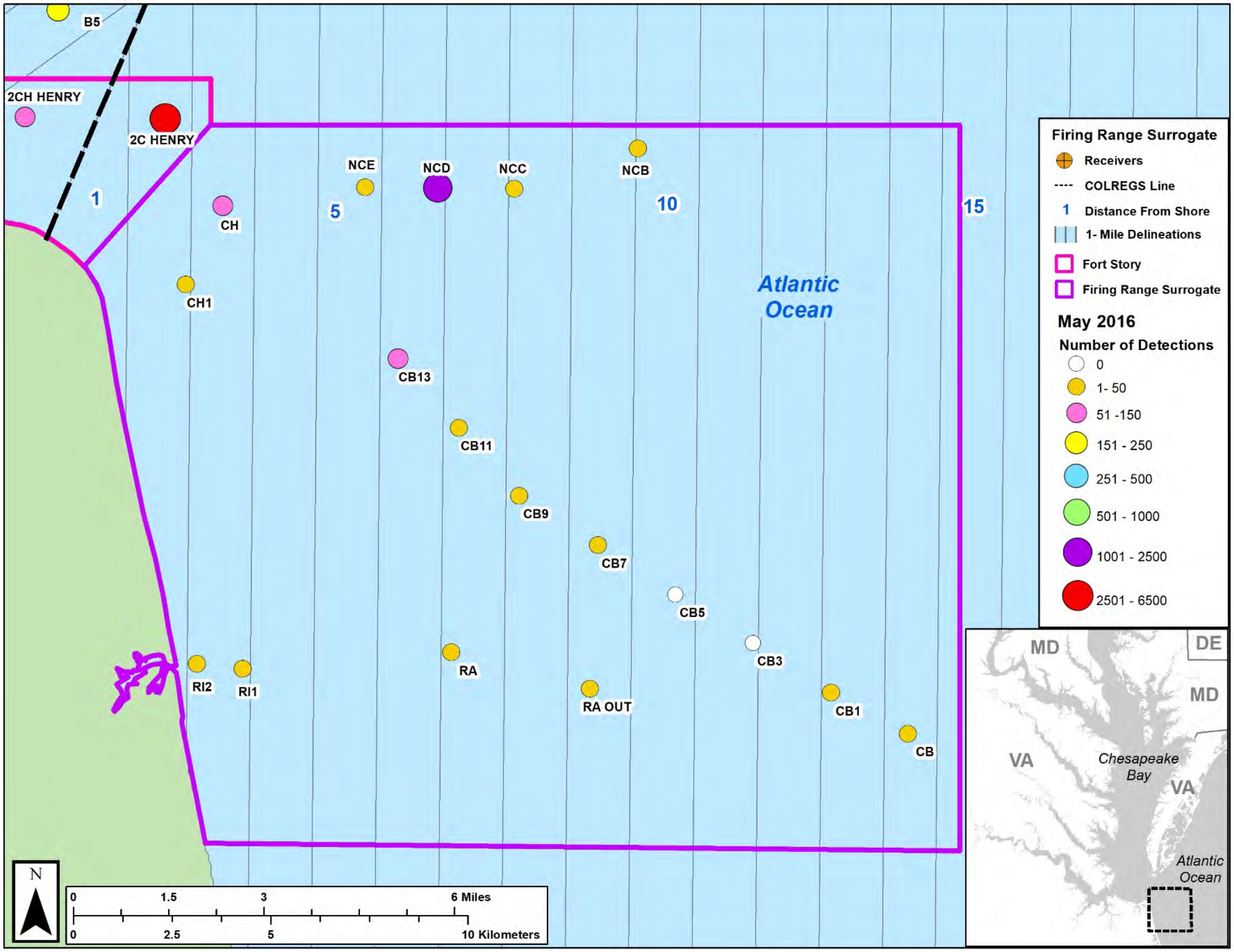
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RI2
RI1
RA
RA OUT
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
May 2016
Number of Detections
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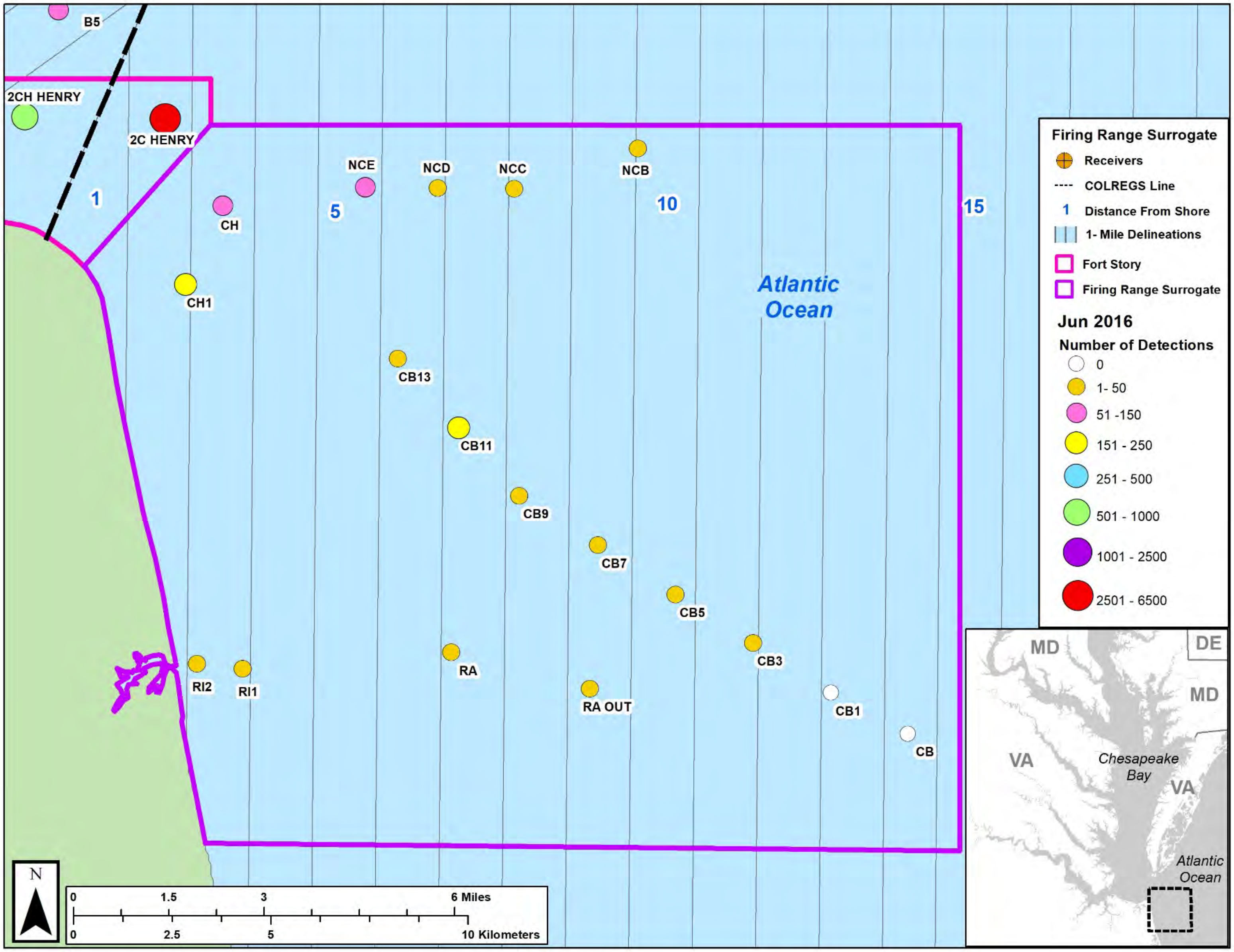
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RA OUT
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Jun 2016
Number of Detections
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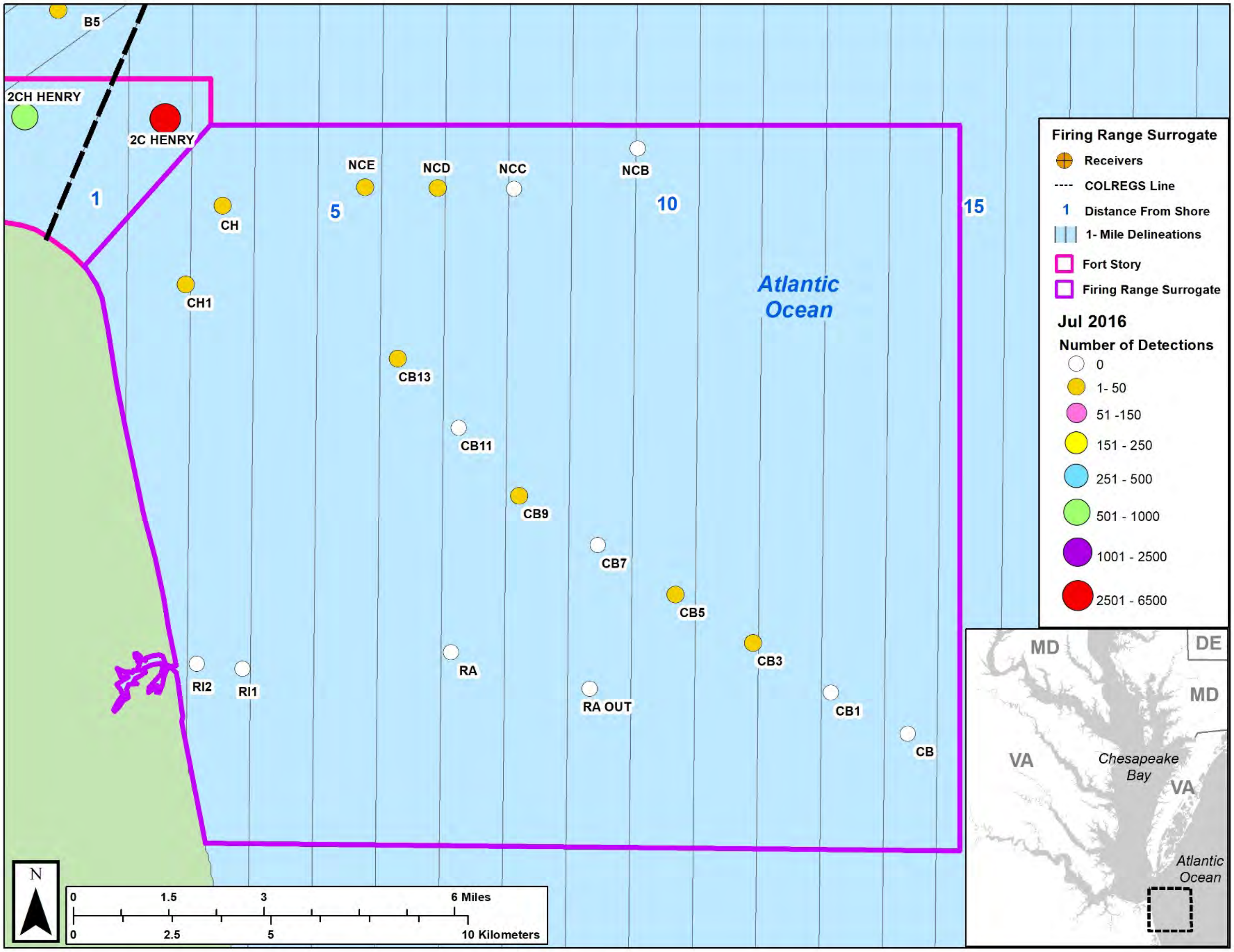
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RI2
RI1
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RA OUT
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Jul 2016
Number of Detections
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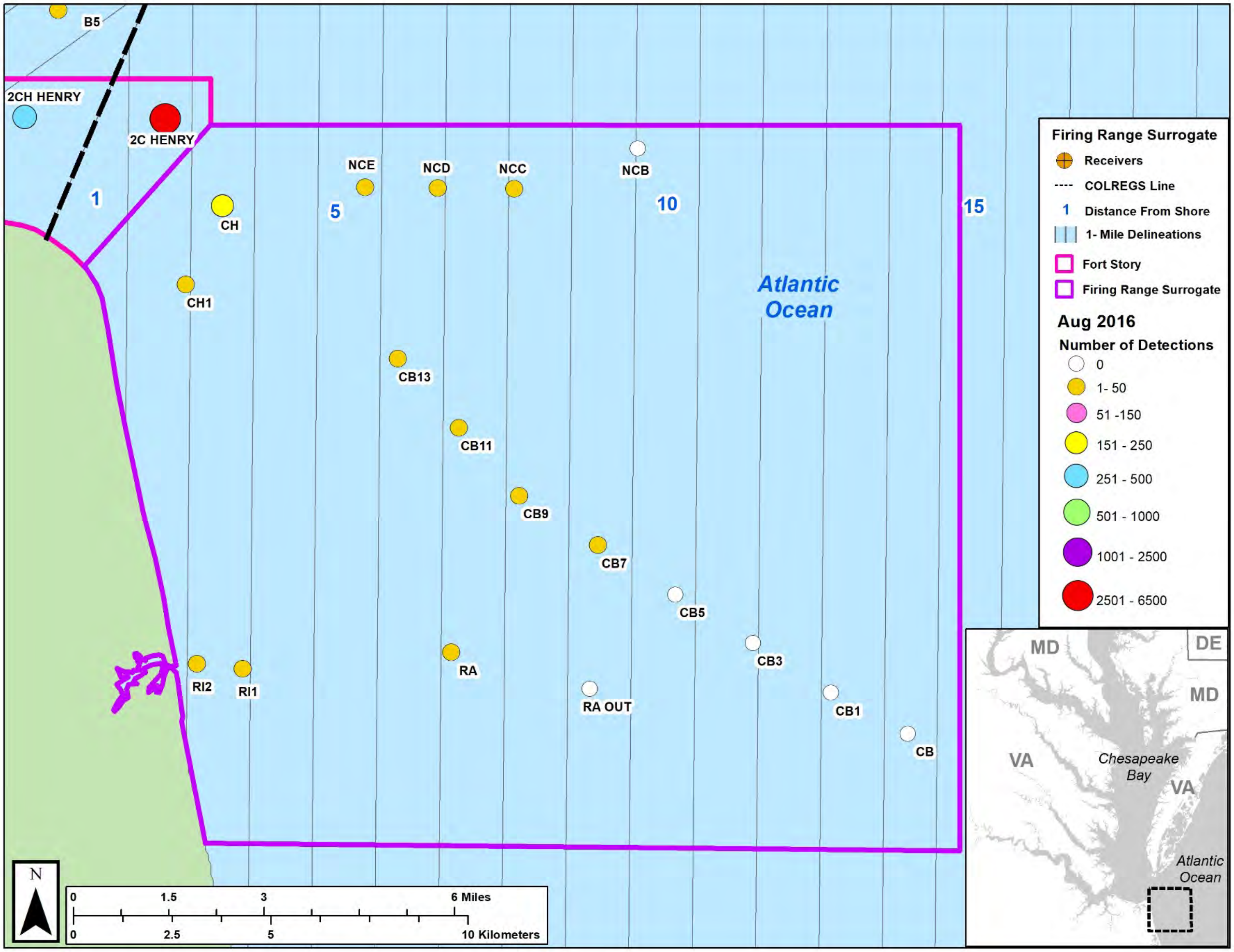
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Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Aug 2016
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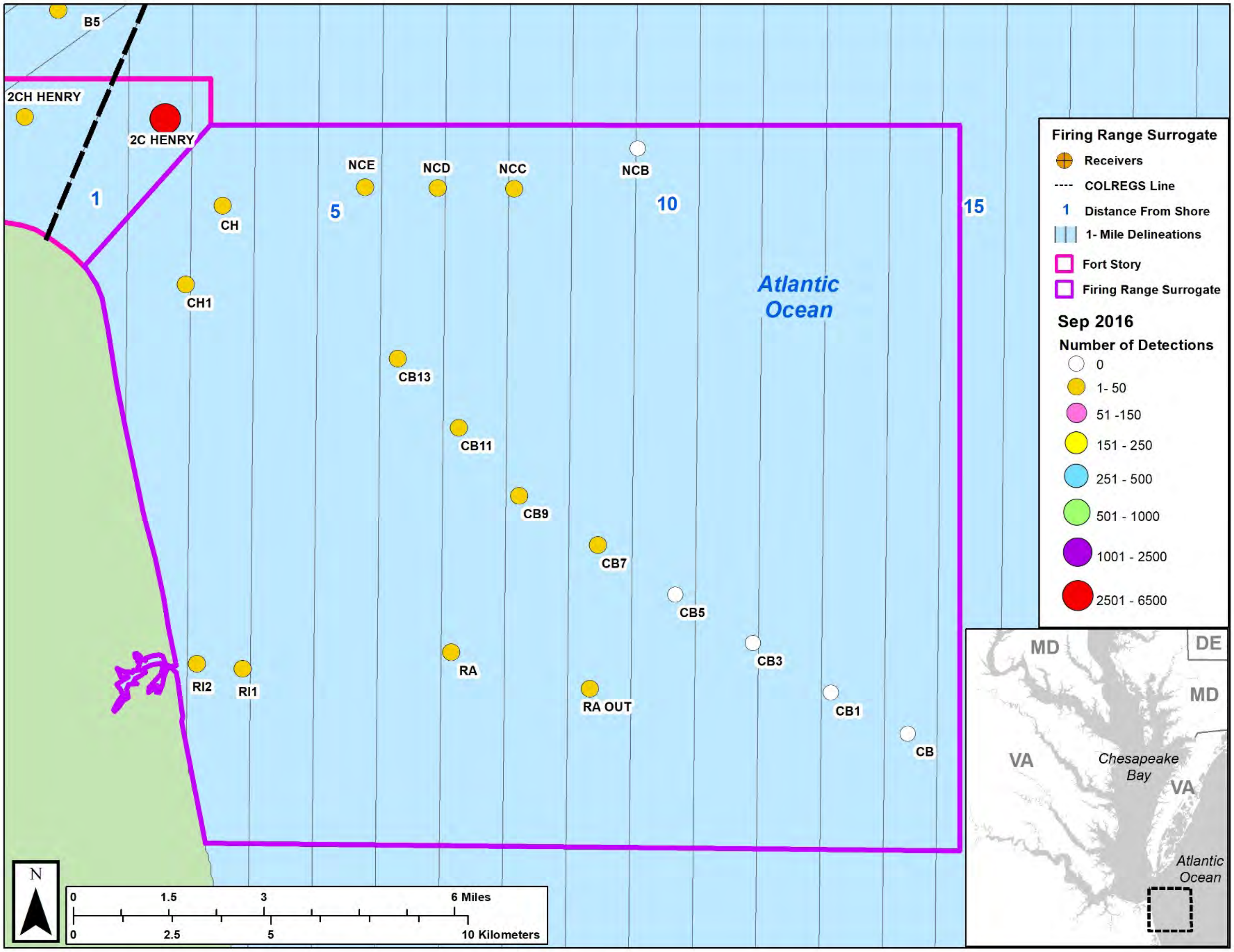
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RA OUT
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Receivers
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Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Sep 2016
Number of Detections
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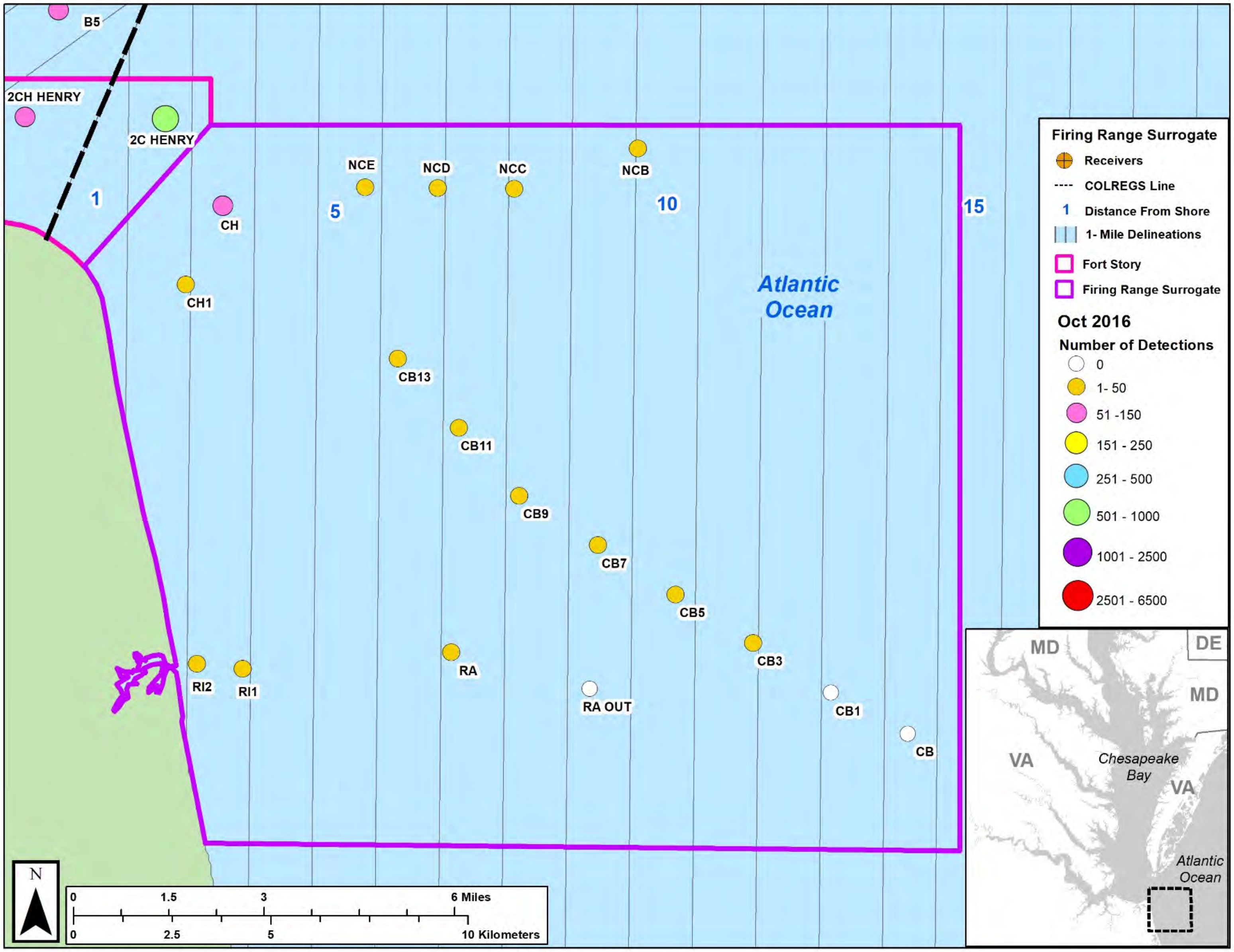
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RA OUT
RI2
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Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
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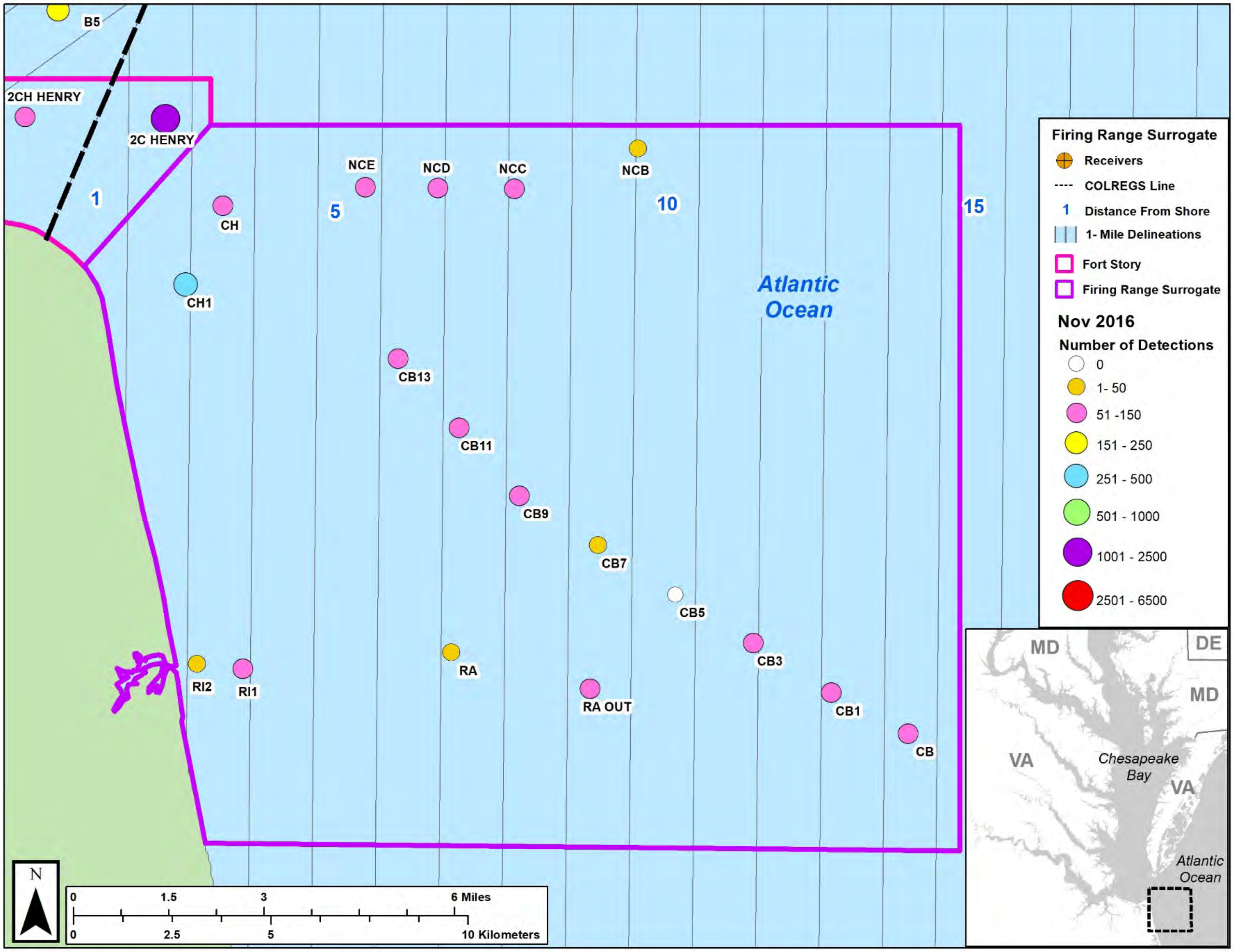
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Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Nov 2016
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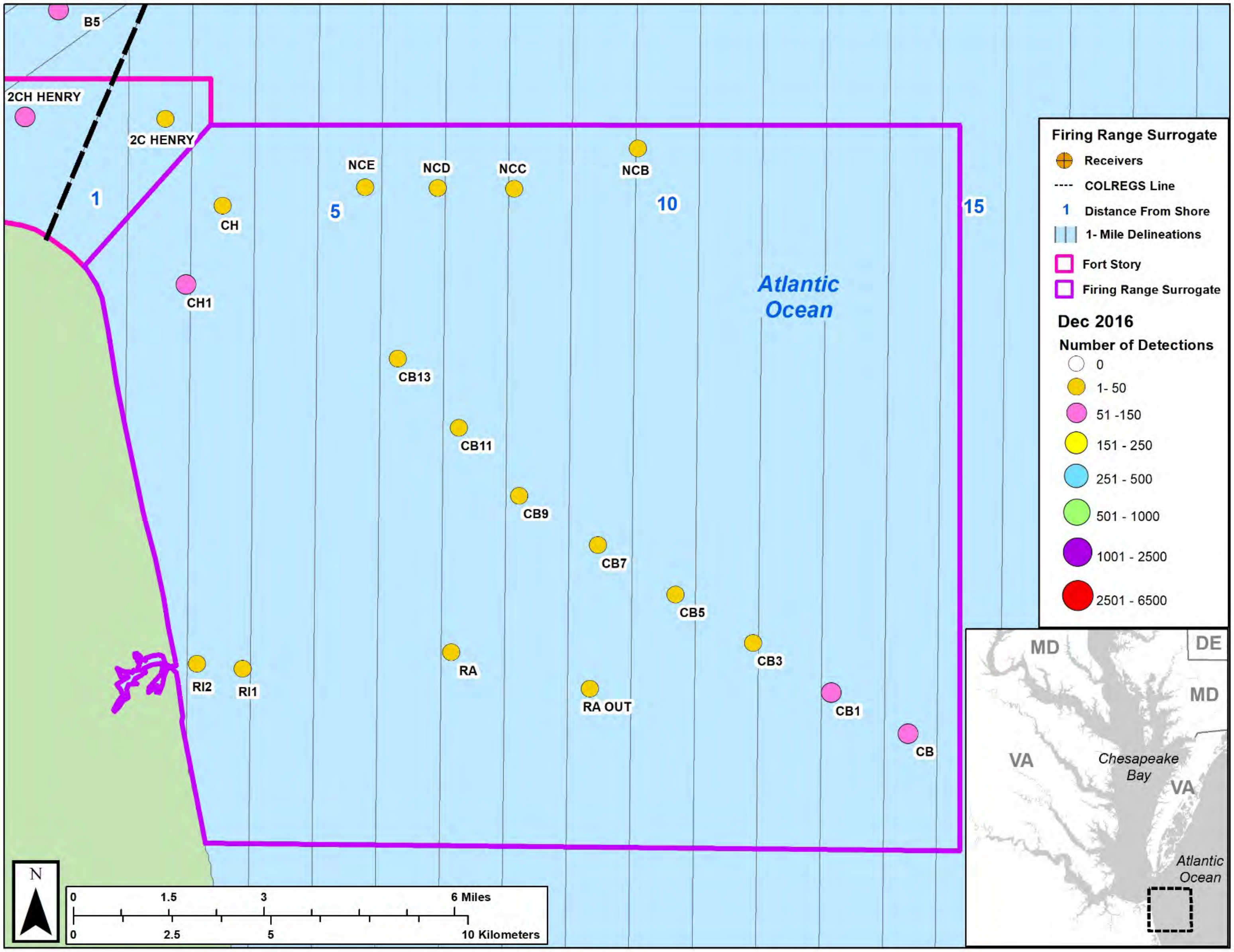
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10 Kilometers
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Dec 2016
Number of Detections
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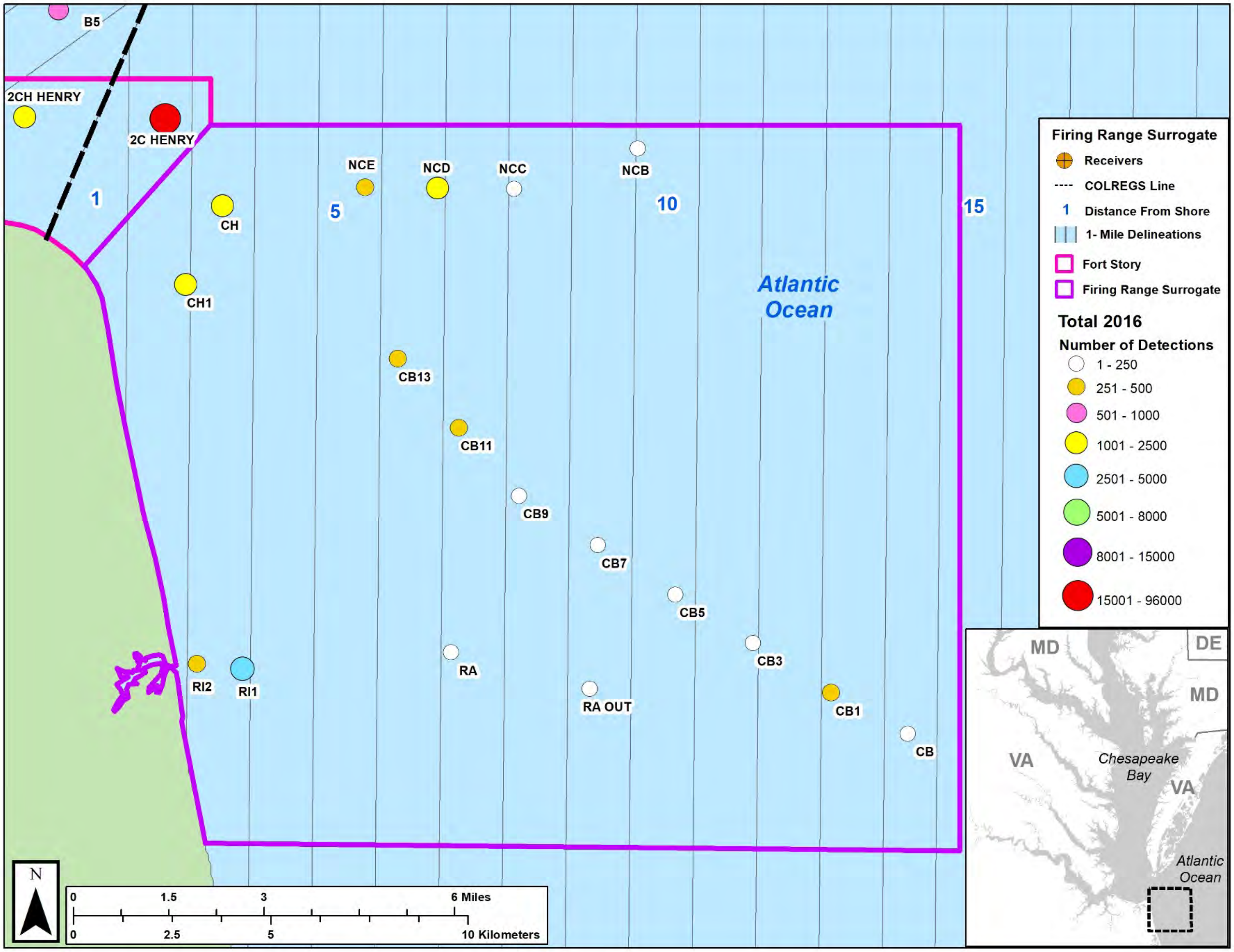
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Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
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Number of Detections
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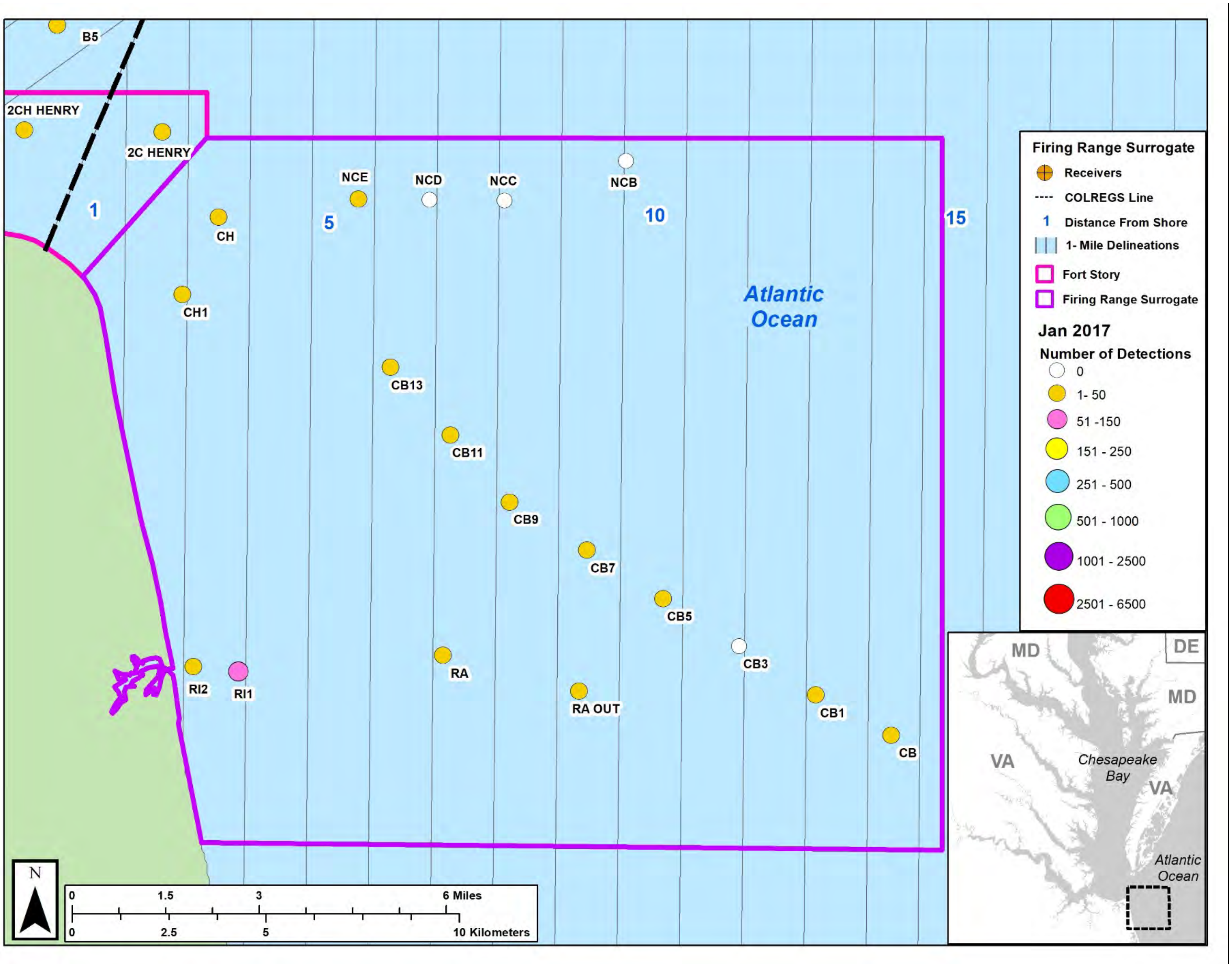
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RA OUT
RI2
RI1
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0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Jan 2017
Number of Detections
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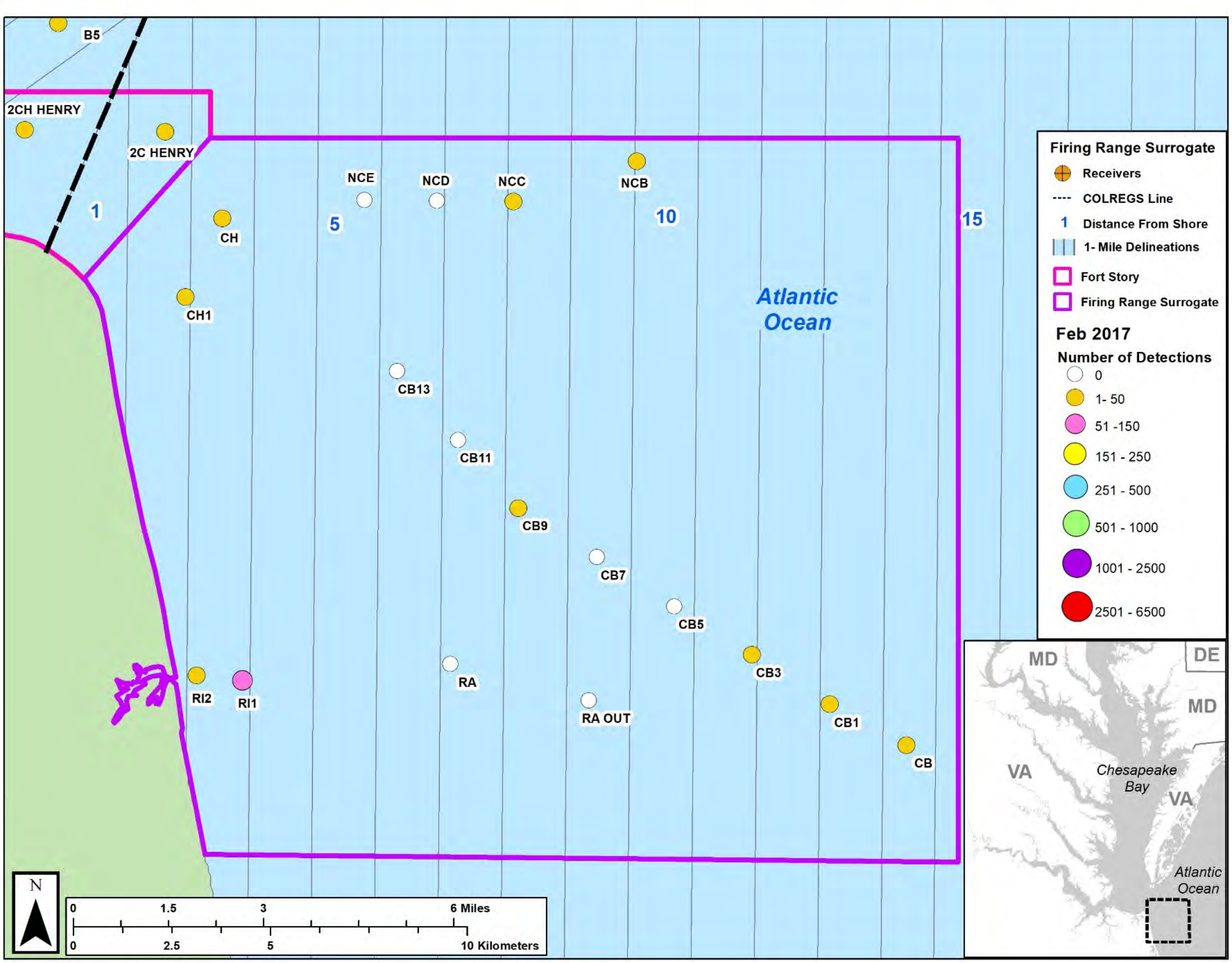
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Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
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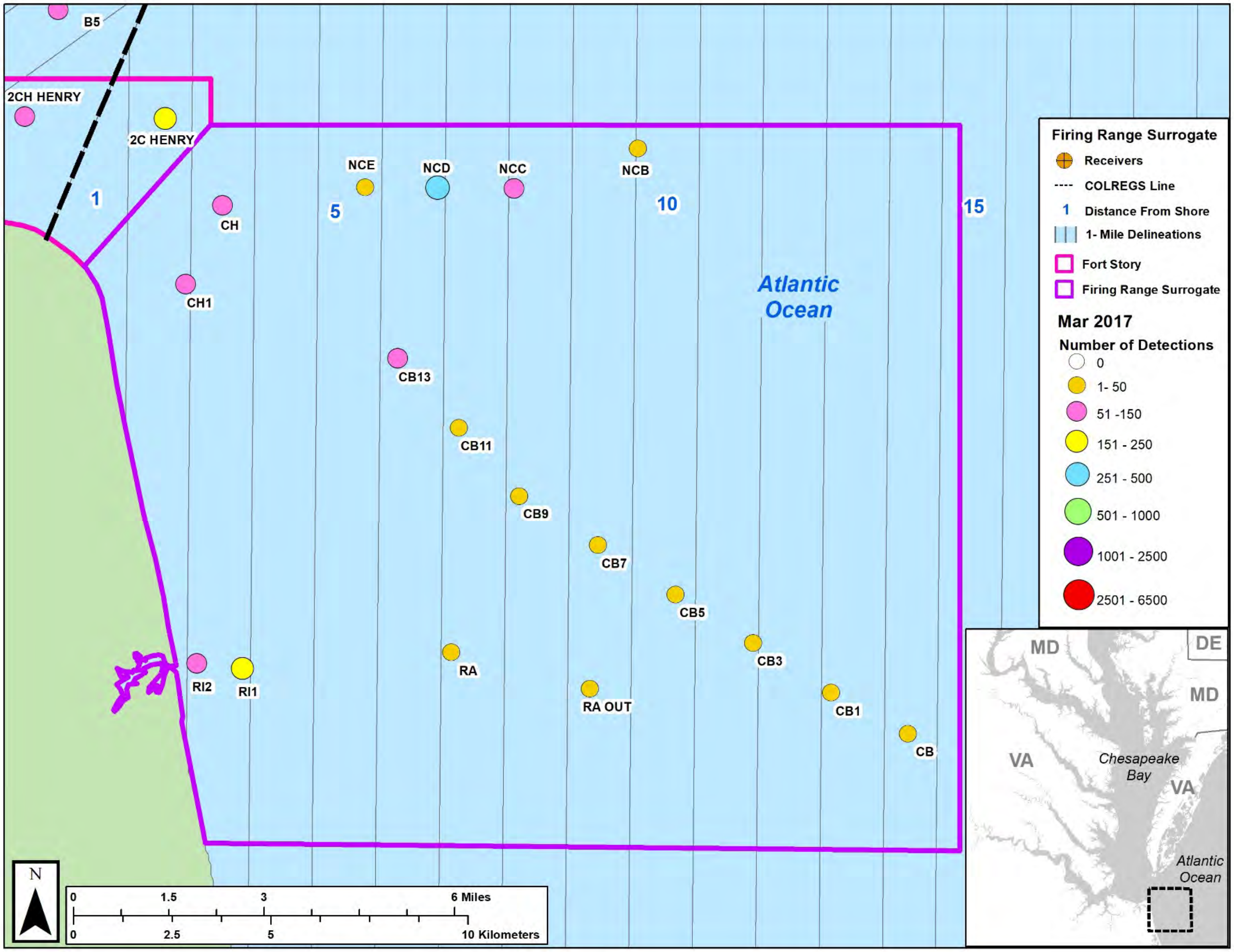
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Receivers
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Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
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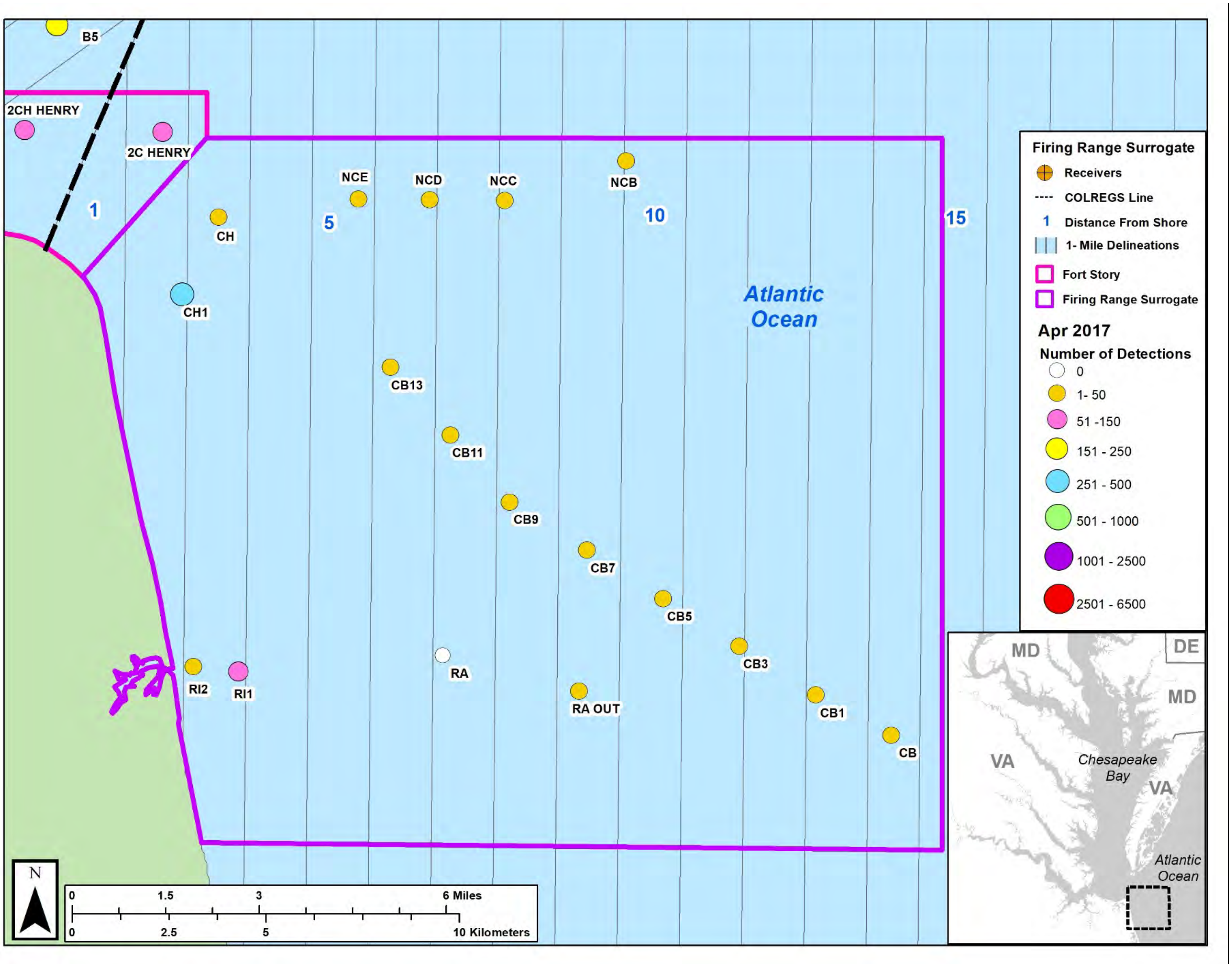
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RI1
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RA OUT
Firing Range Surrogate
Receivers
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1 Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Apr 2017
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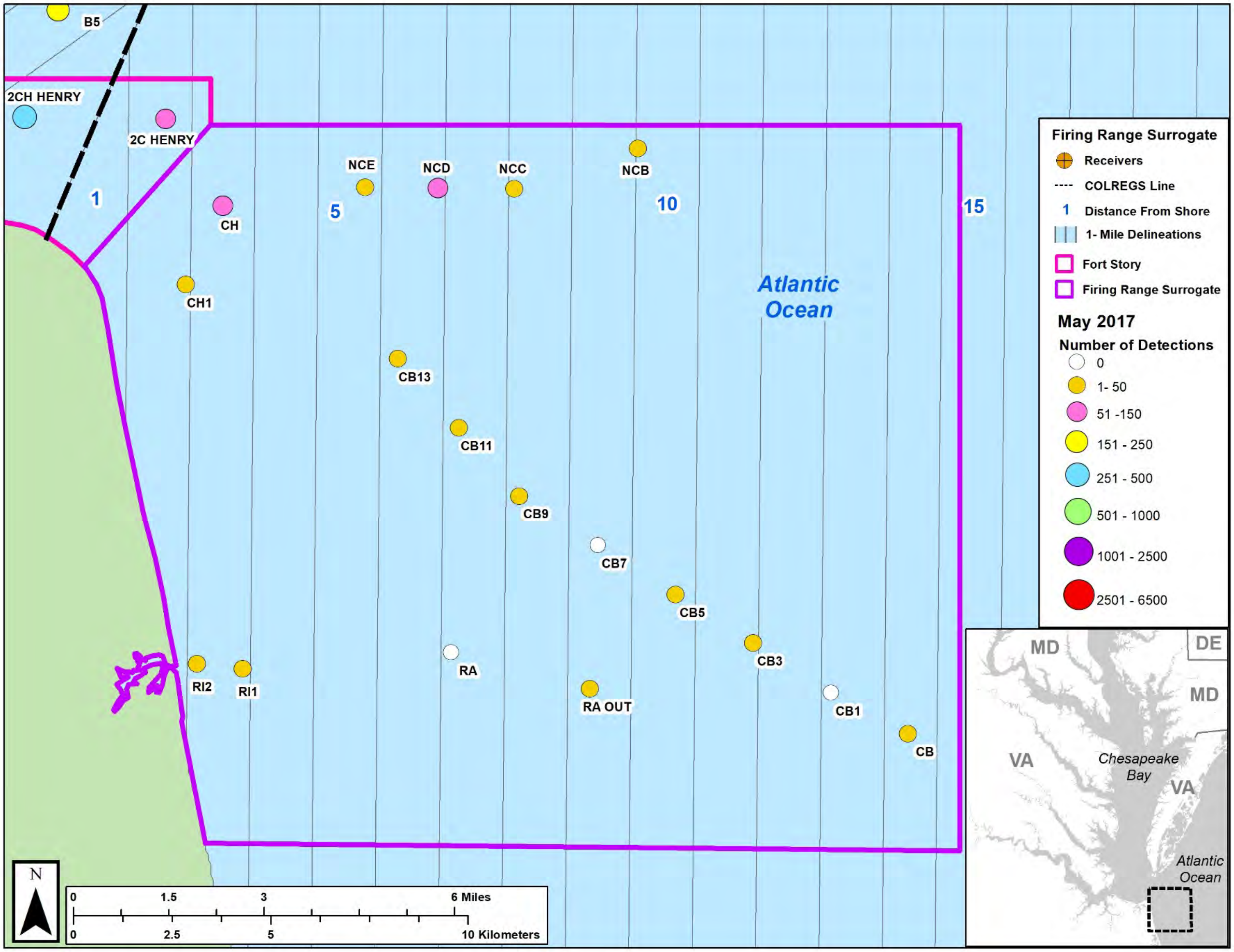
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Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
May 2017
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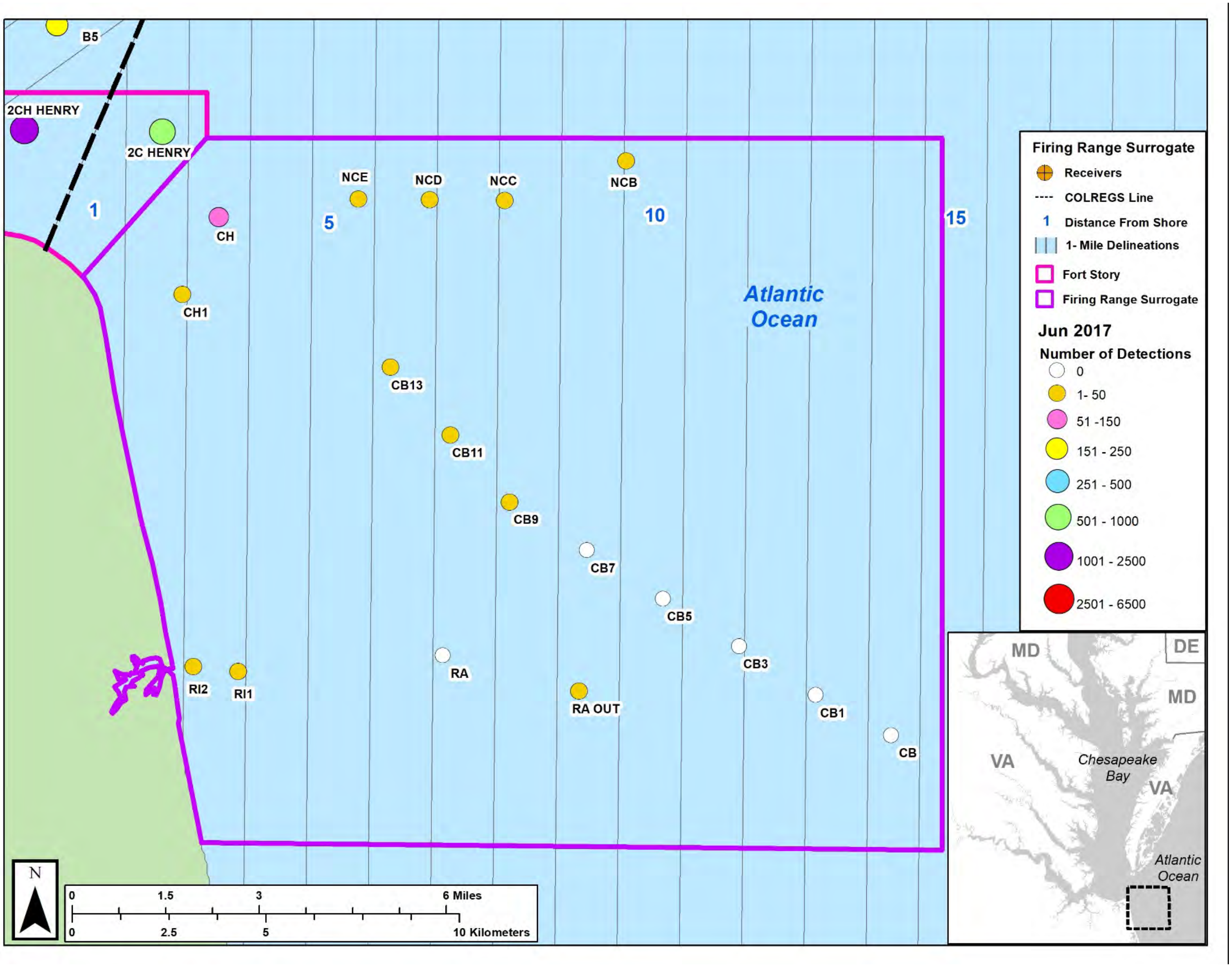
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Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Jun 2017
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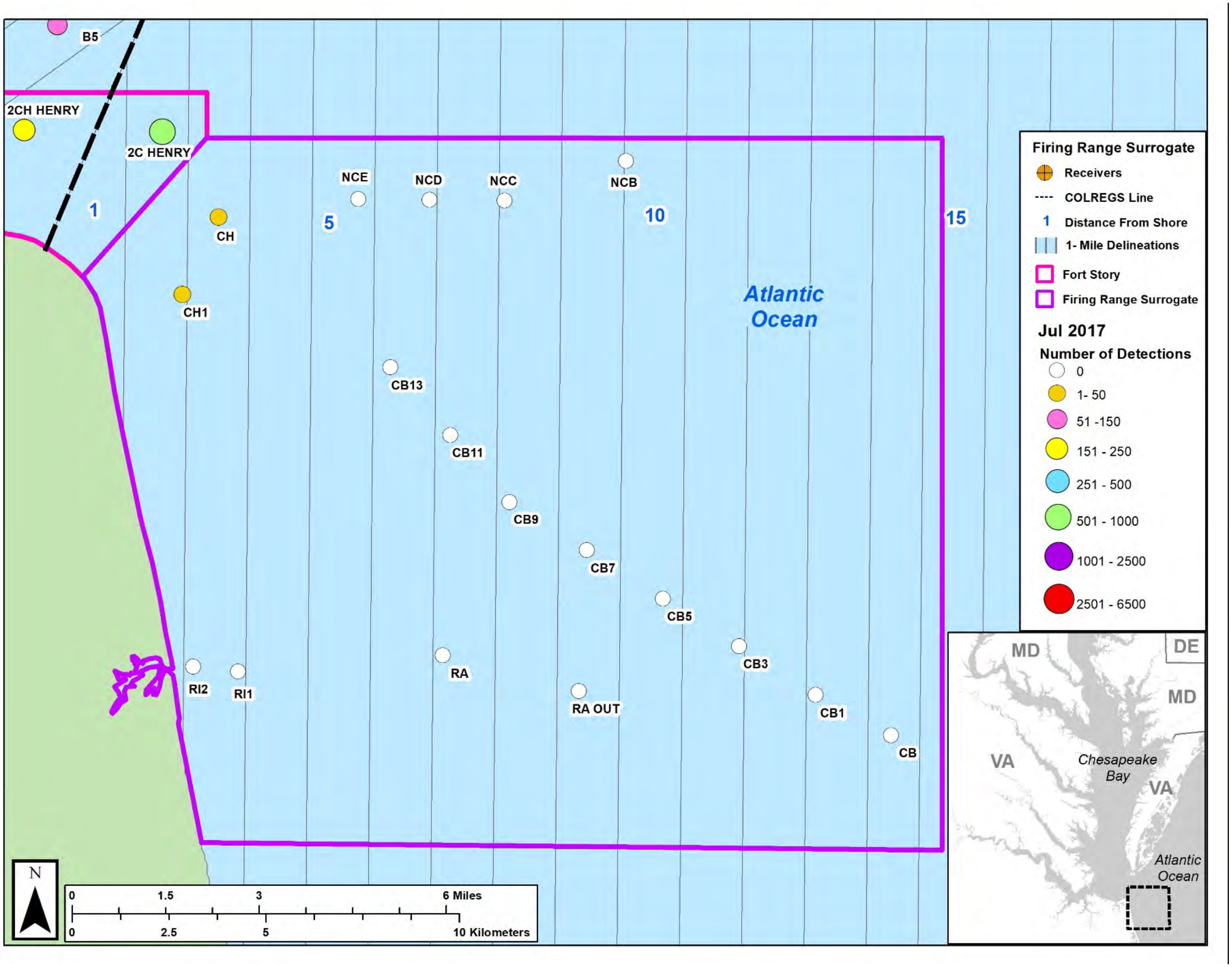
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Receivers
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Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Jul 2017
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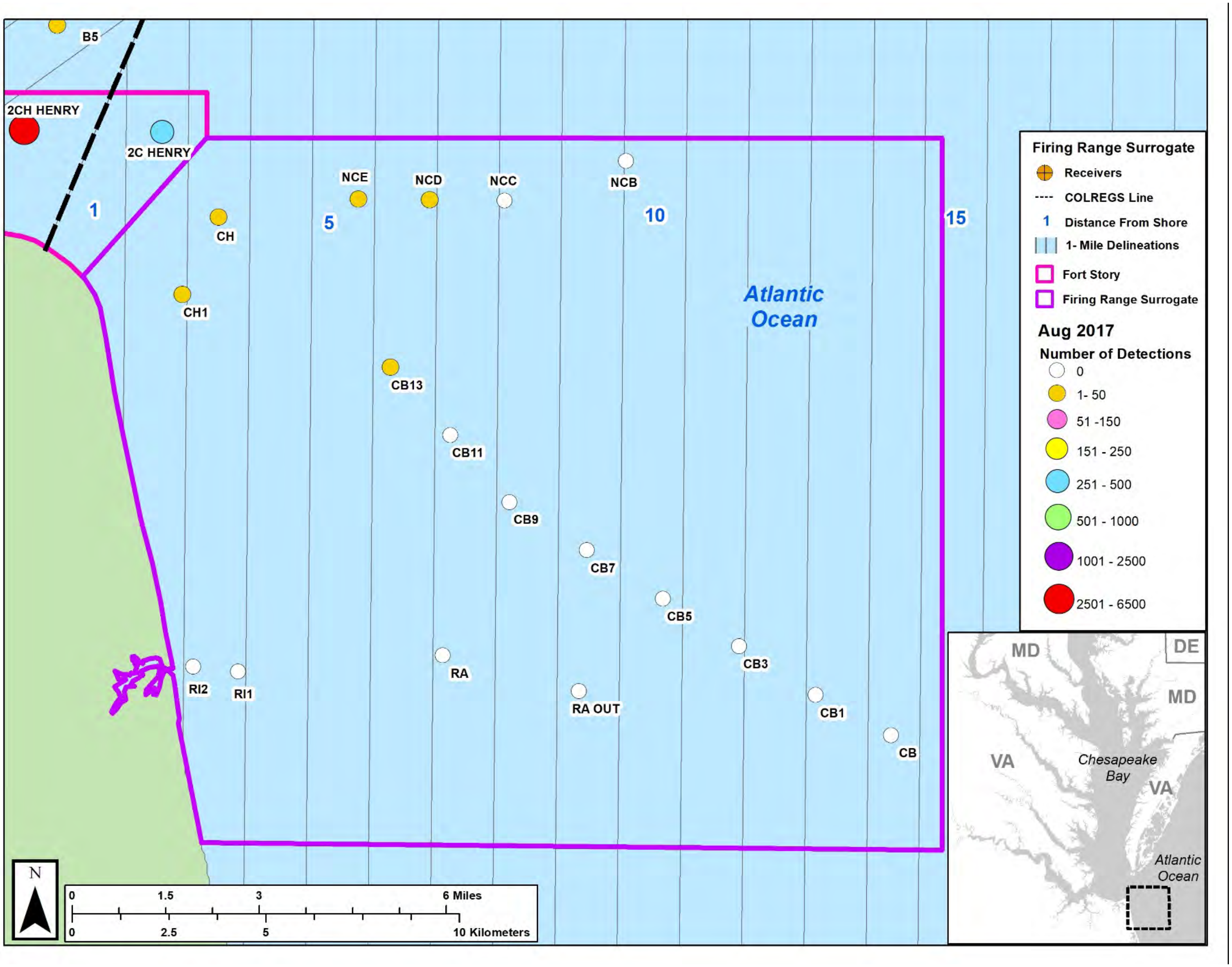
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RI2
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Distance From Shore
1- Mile Delineations
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Firing Range Surrogate
Aug 2017
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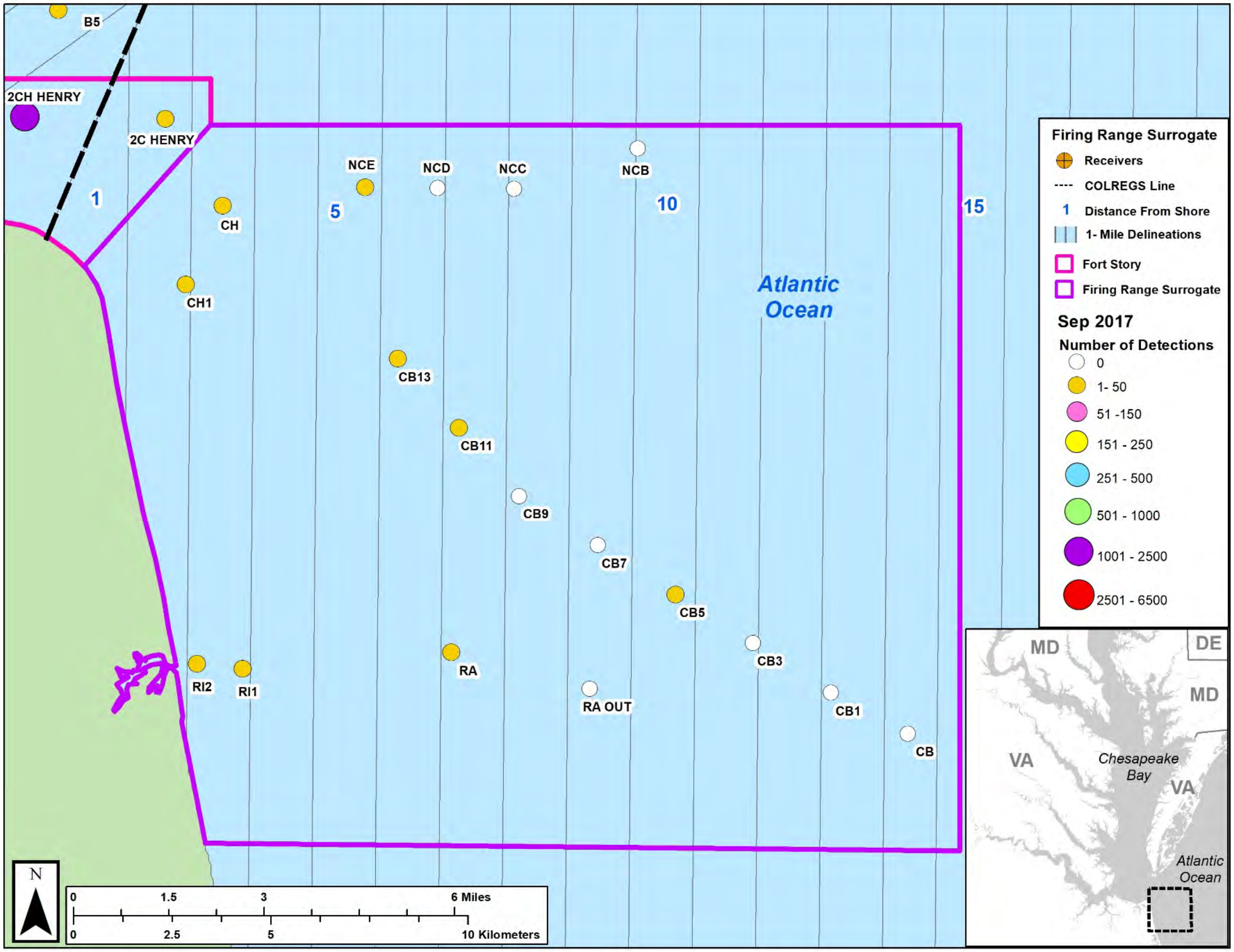
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Receivers
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Distance From Shore
1- Mile Delineations
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Firing Range Surrogate
Sep 2017
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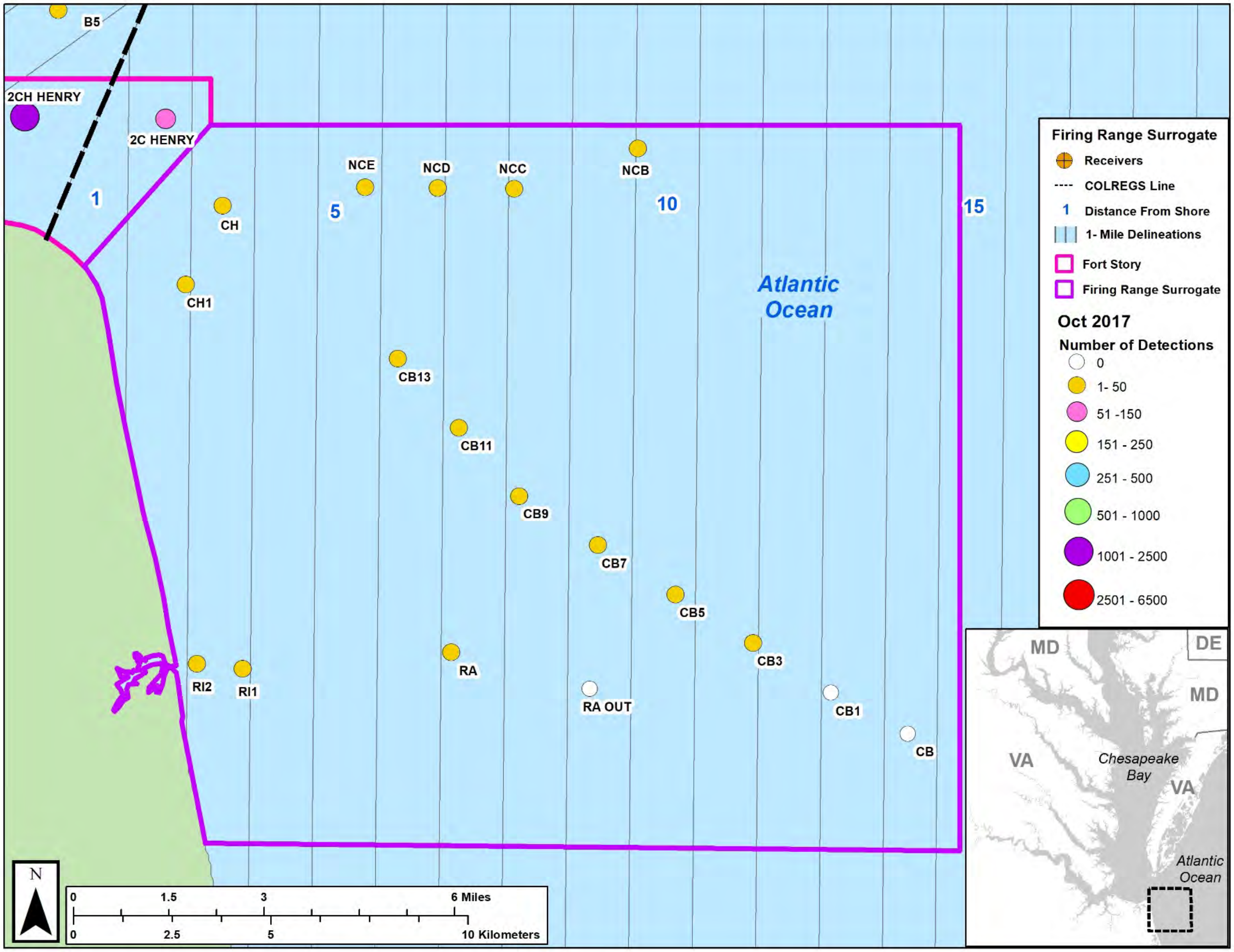
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Receivers
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Distance From Shore
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Fort Story
Firing Range Surrogate
Oct 2017
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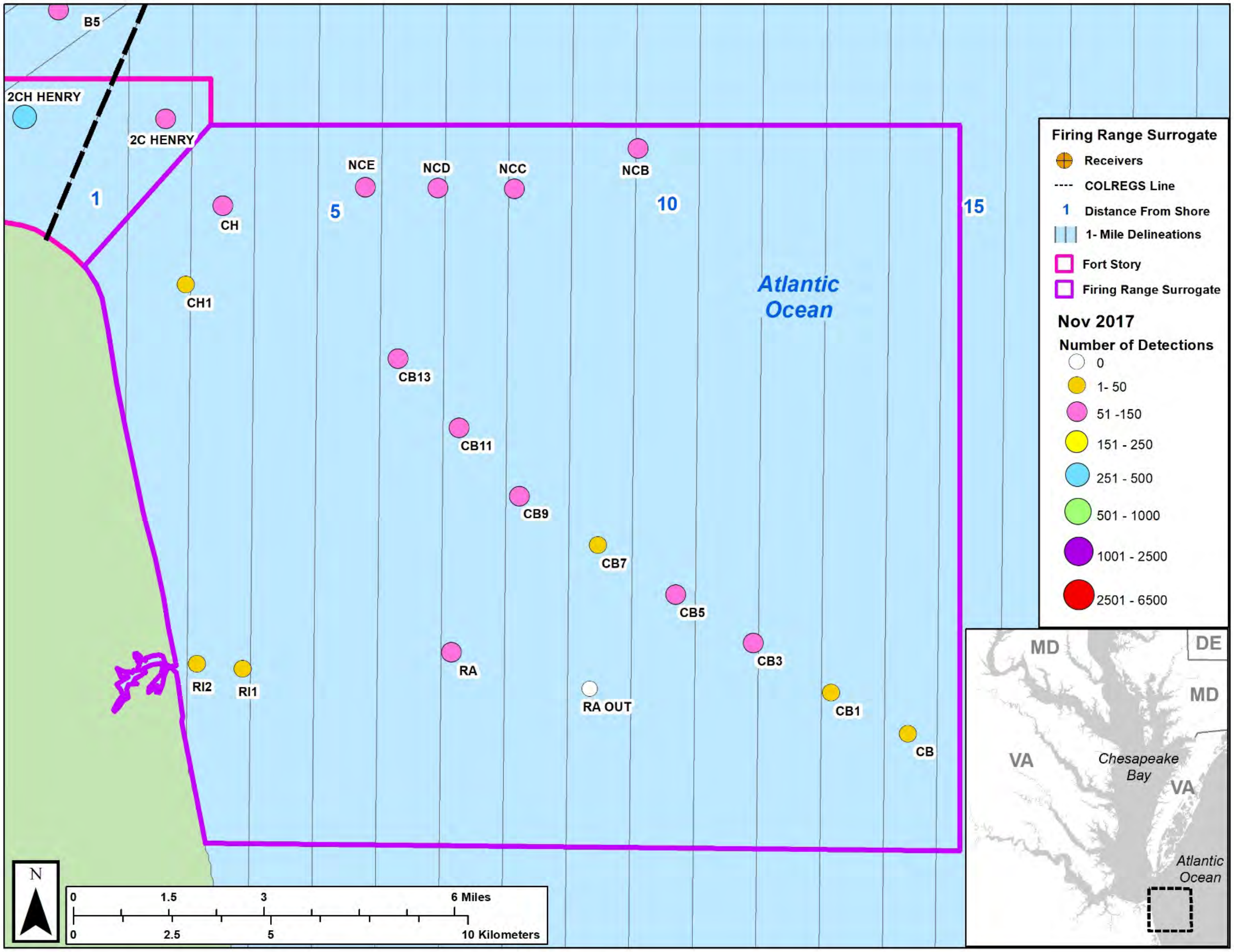
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Firing Range Surrogate
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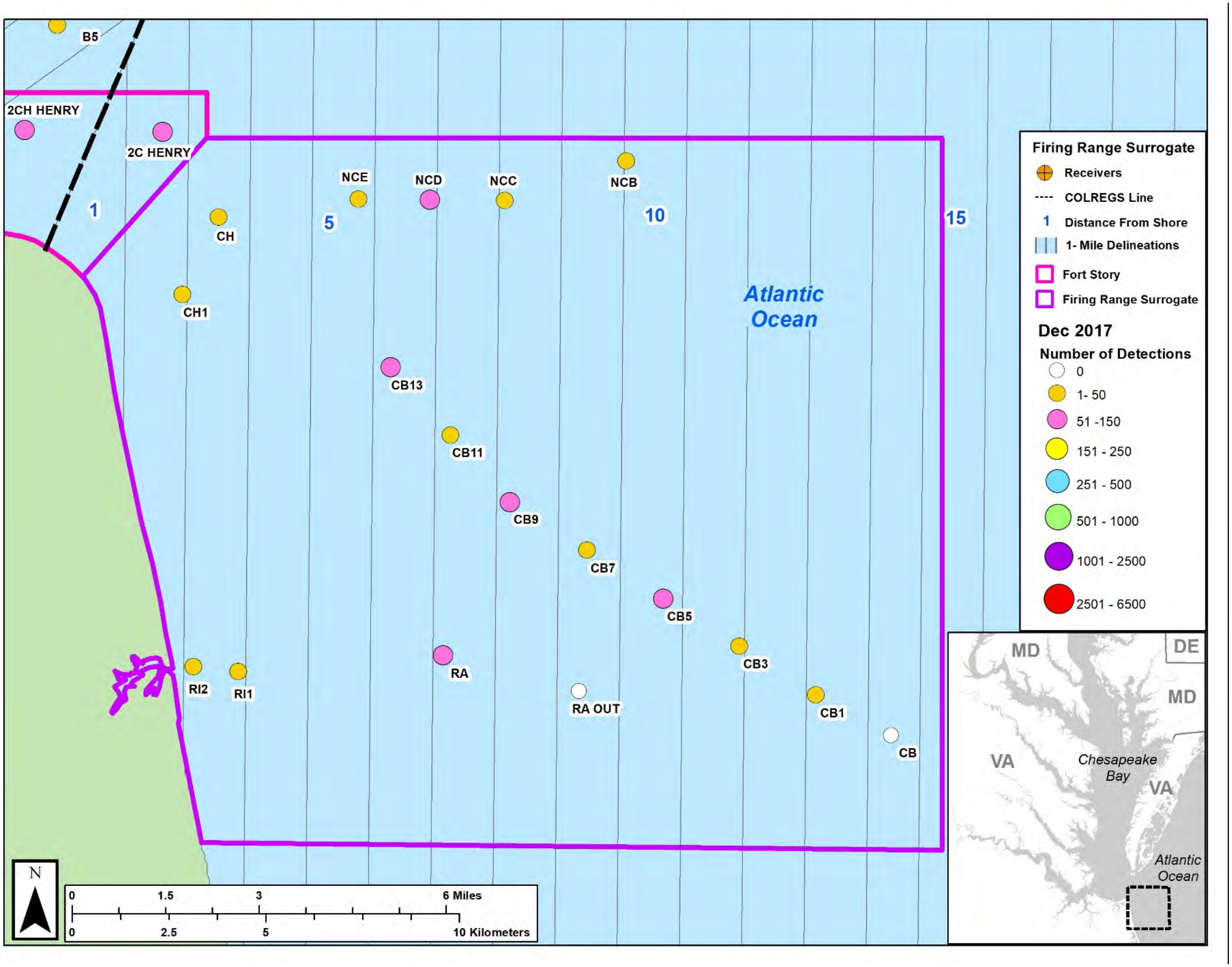
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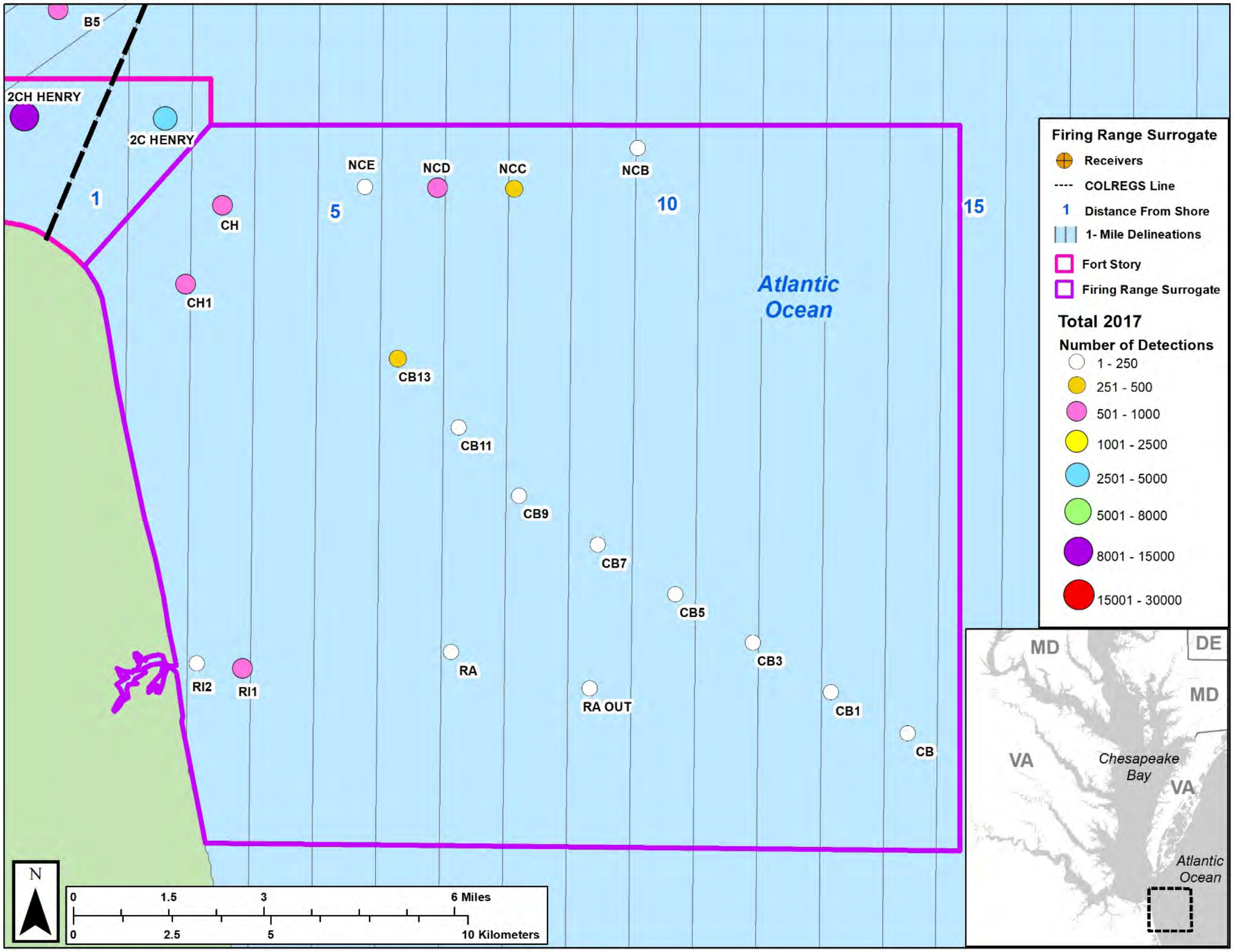
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RI1
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Total 2017
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
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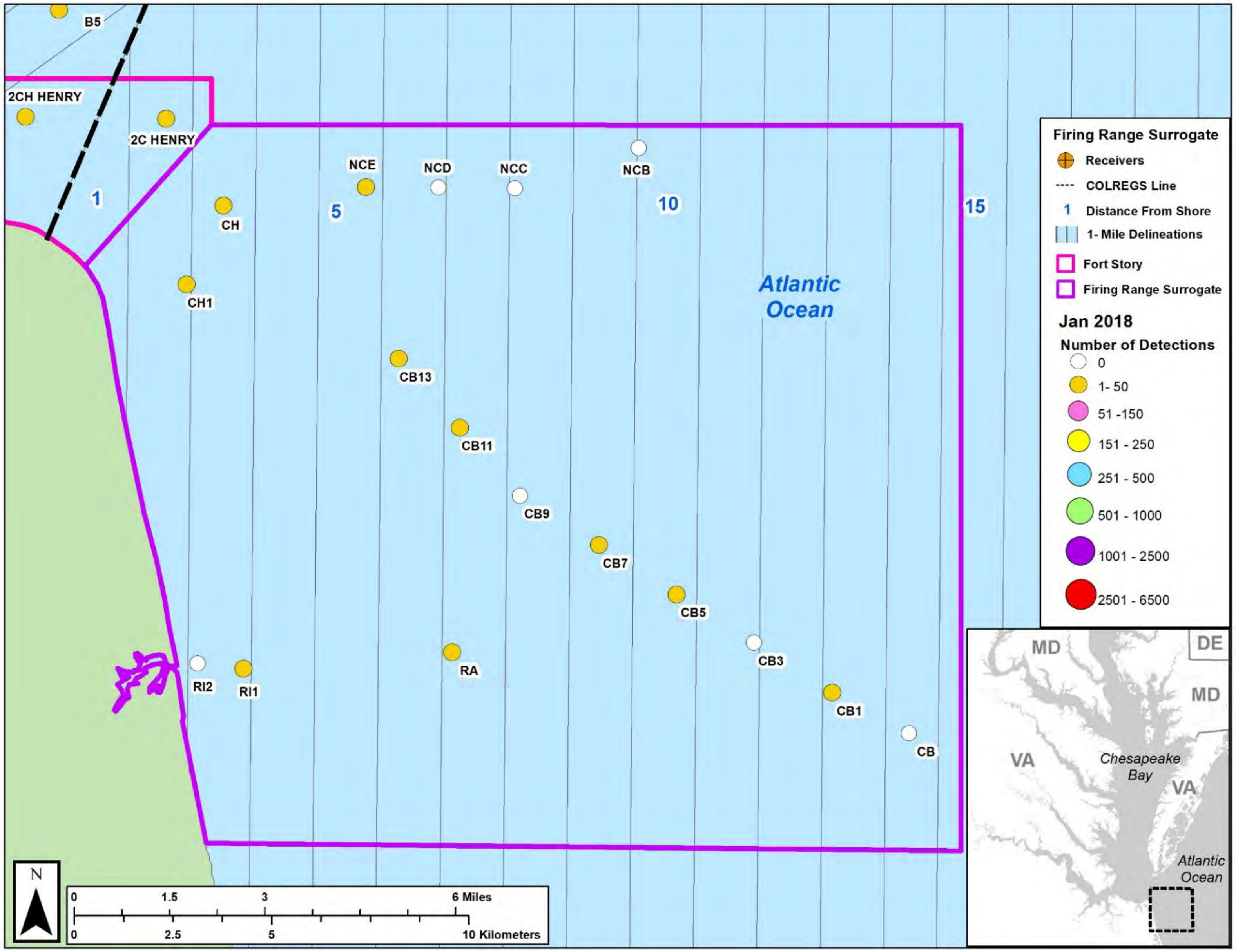
1.5
3
6 Miles
0
2.5
5
10 Kilometers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2C HENRY
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NCB
CH
CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Jan 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
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MD
VA
Chesapeake Bay
VA
Atlantic Ocean
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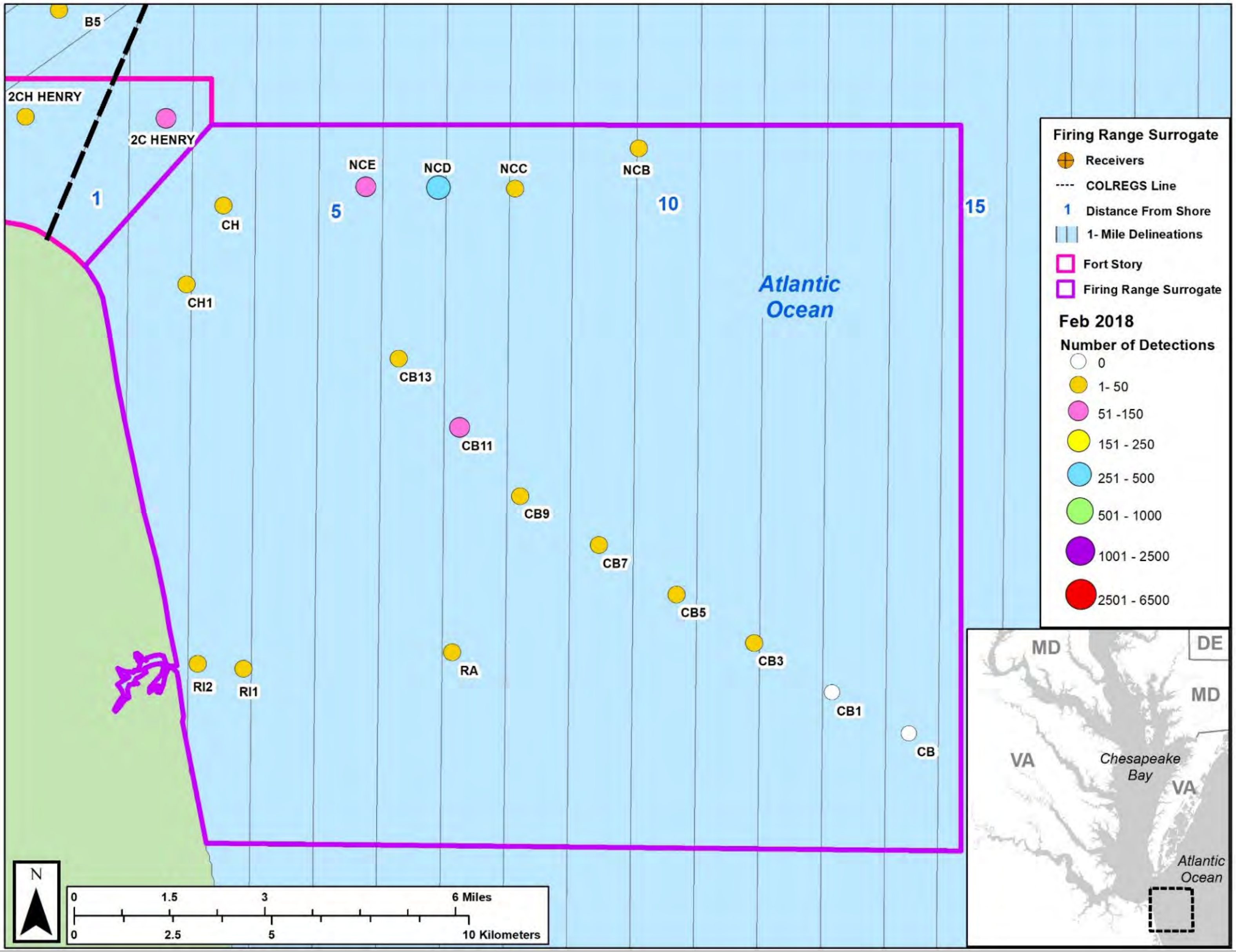
1.5
3
6 Miles
0
2.5
5
10 Kilometers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CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RI2
RI1
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Feb 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
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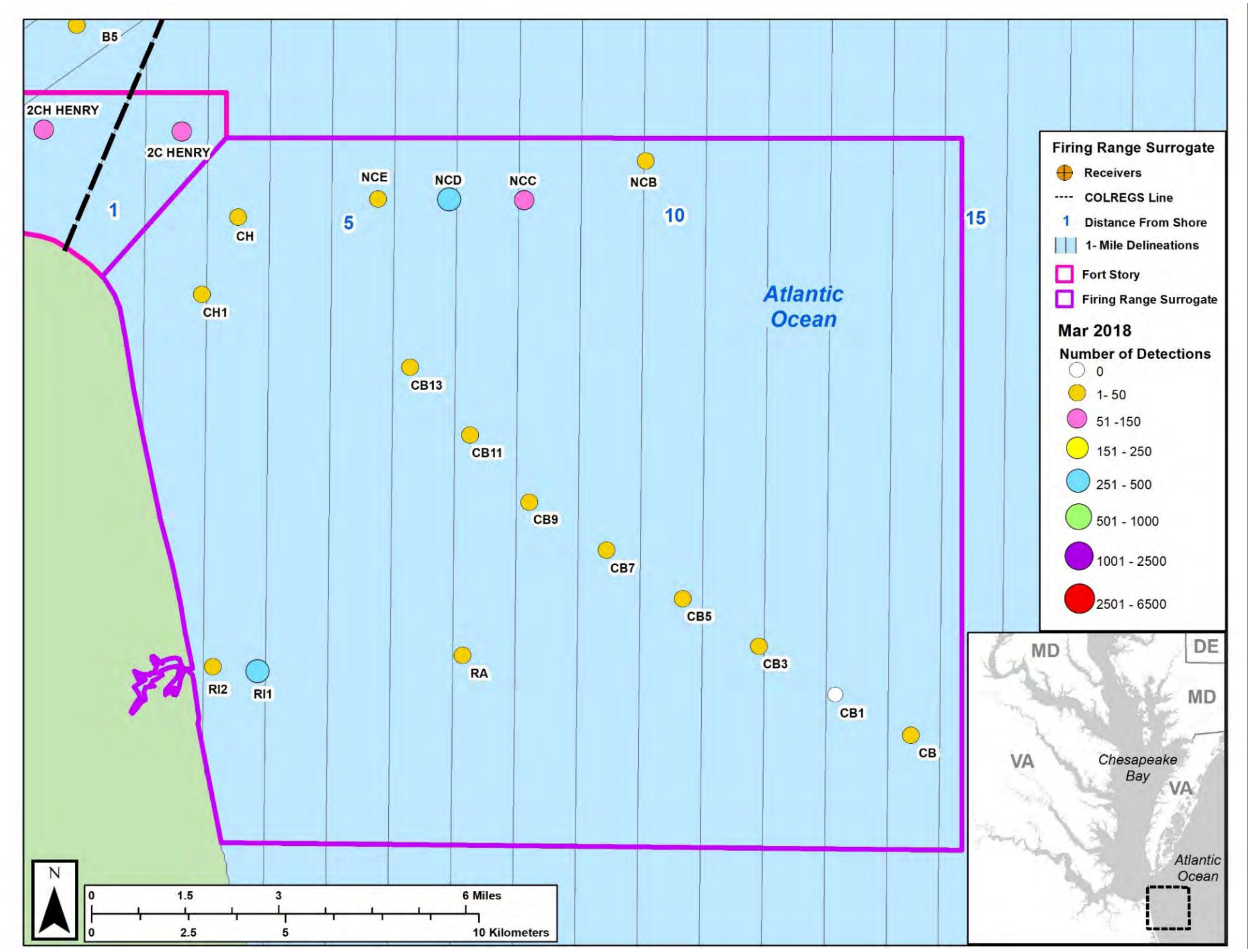
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
N
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers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2C HENRY
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CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RI2
RI1
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Mar 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
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MD
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Chesapeake Bay
VA
Atlantic Ocean
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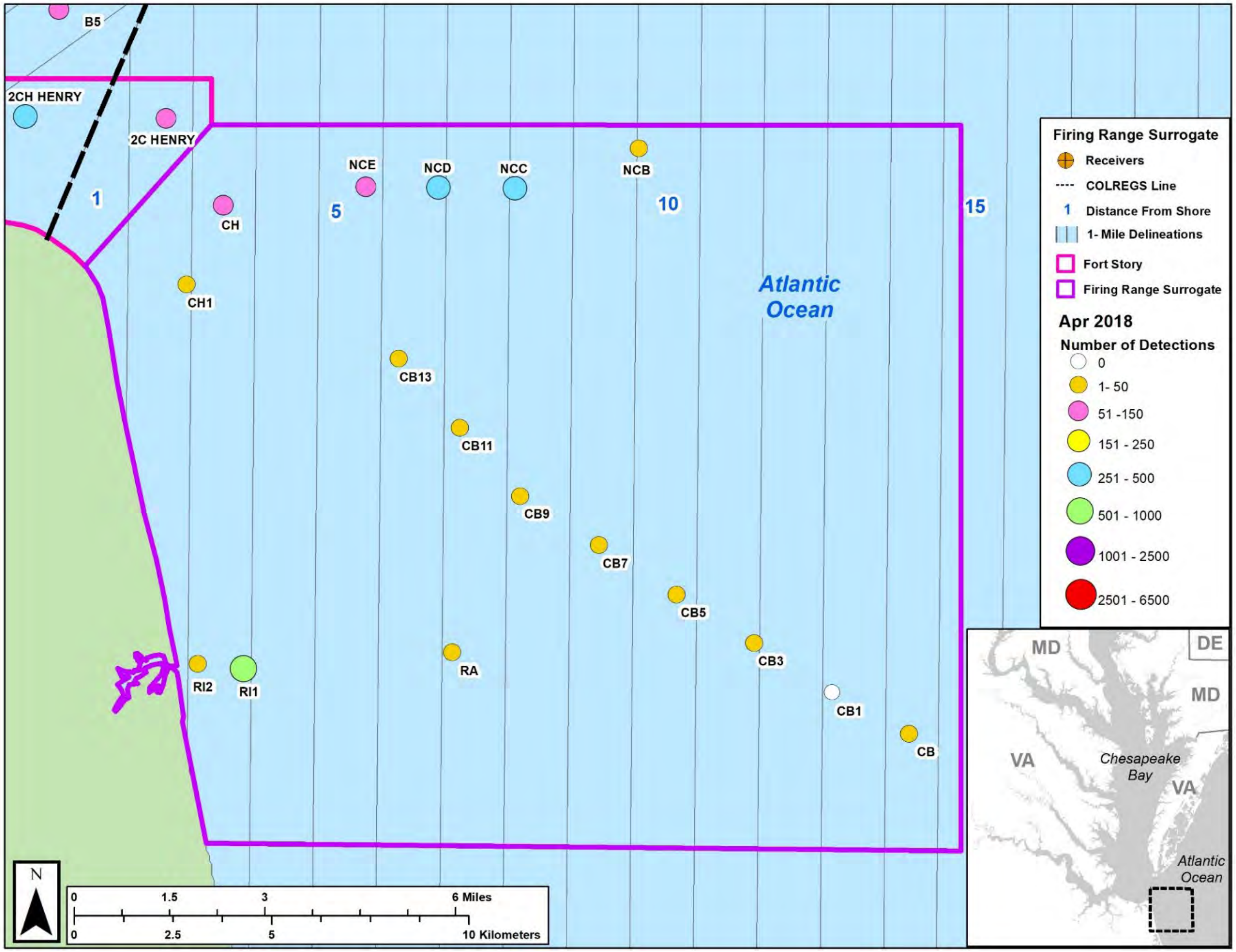
1.5
3
6 Miles
0
2.5
5
10 Kilometers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2C HENRY
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NCC
NCB
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15
CH1
Atlantic Ocean
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RI2
RI1
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Apr 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
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MD
VA
Chesapeake Bay
VA
Atlantic Ocean
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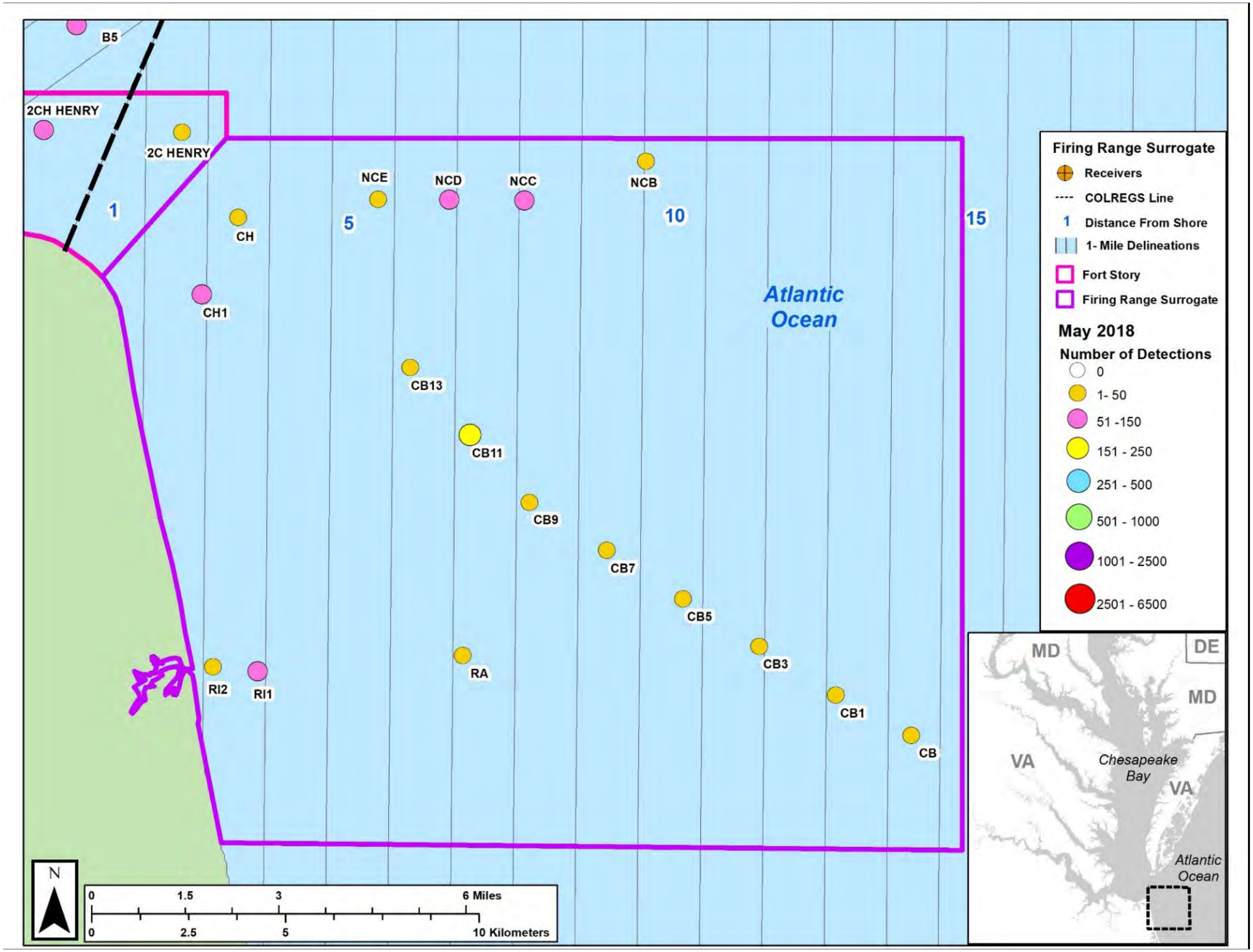
1.5
3
6 Miles
0
2.5
5
10 Kilometers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CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RI2
RI1
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
May 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
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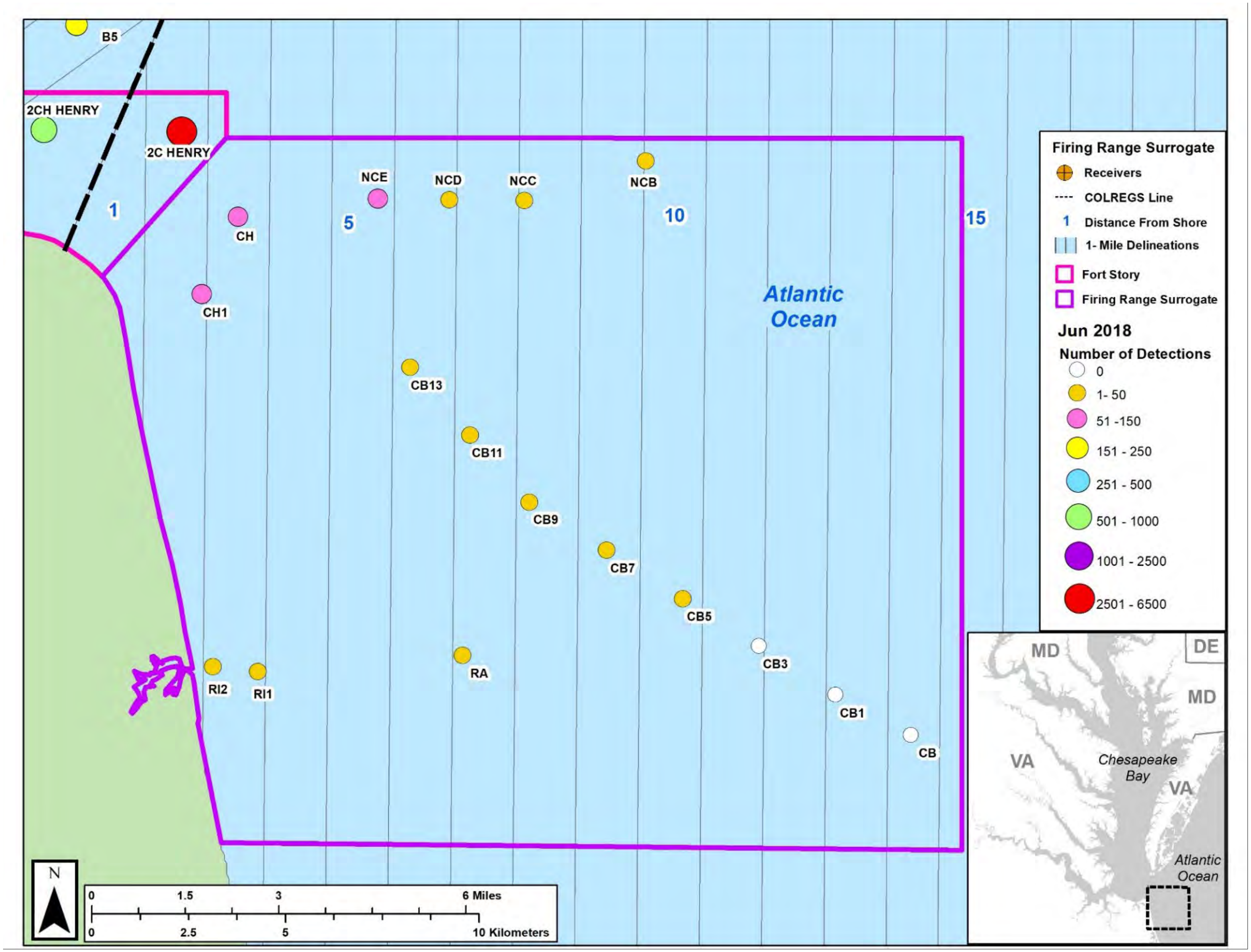
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers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NCB
CH
CH1
1
5
10
15
Atlantic Ocean
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RI2
RI1
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Jun 2018
Number of Detections
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51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
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MD
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Chesapeake Bay
VA
Atlantic Ocean
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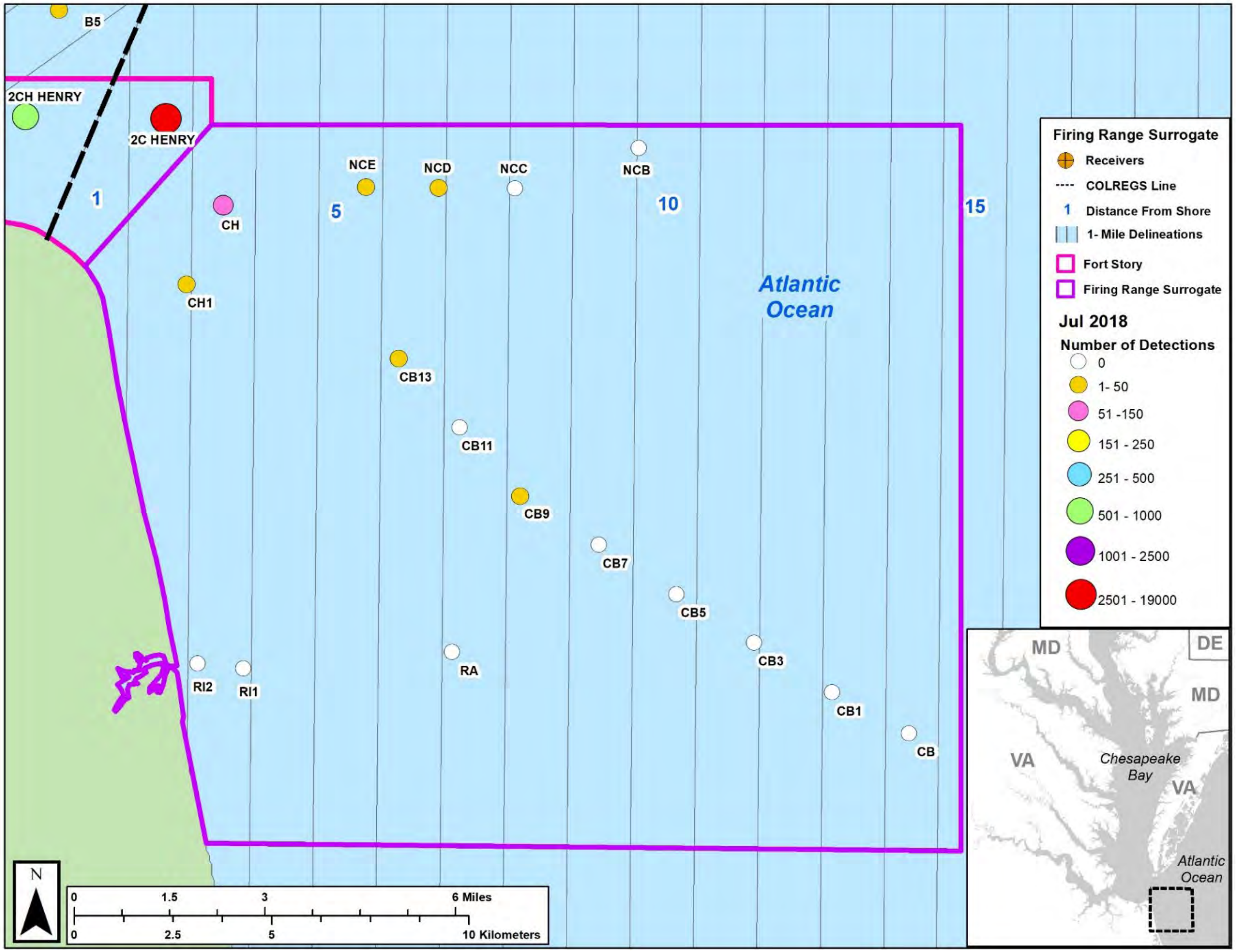
1.5
3
6 Miles
0
2.5
5
10 Kilometers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2C HENRY
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10
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NCE
NCD
NCC
NCB
CH
CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RI2
RI1
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Jul 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 19000
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Chesapeake Bay
VA
Atlantic Ocean
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3
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2.5
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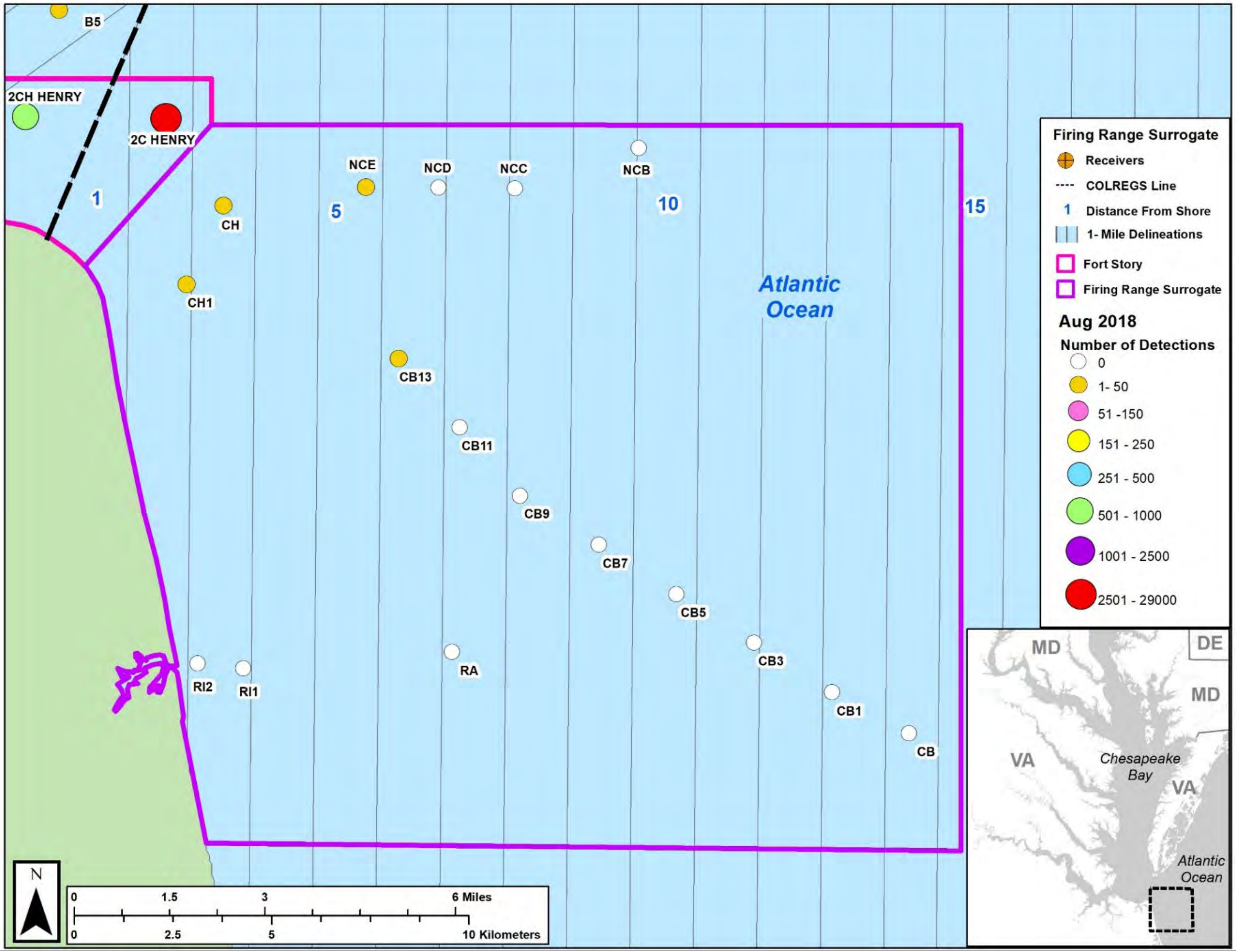
10 Kilometers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NCB
CH
CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RI2
RI1
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Aug 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 29000
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
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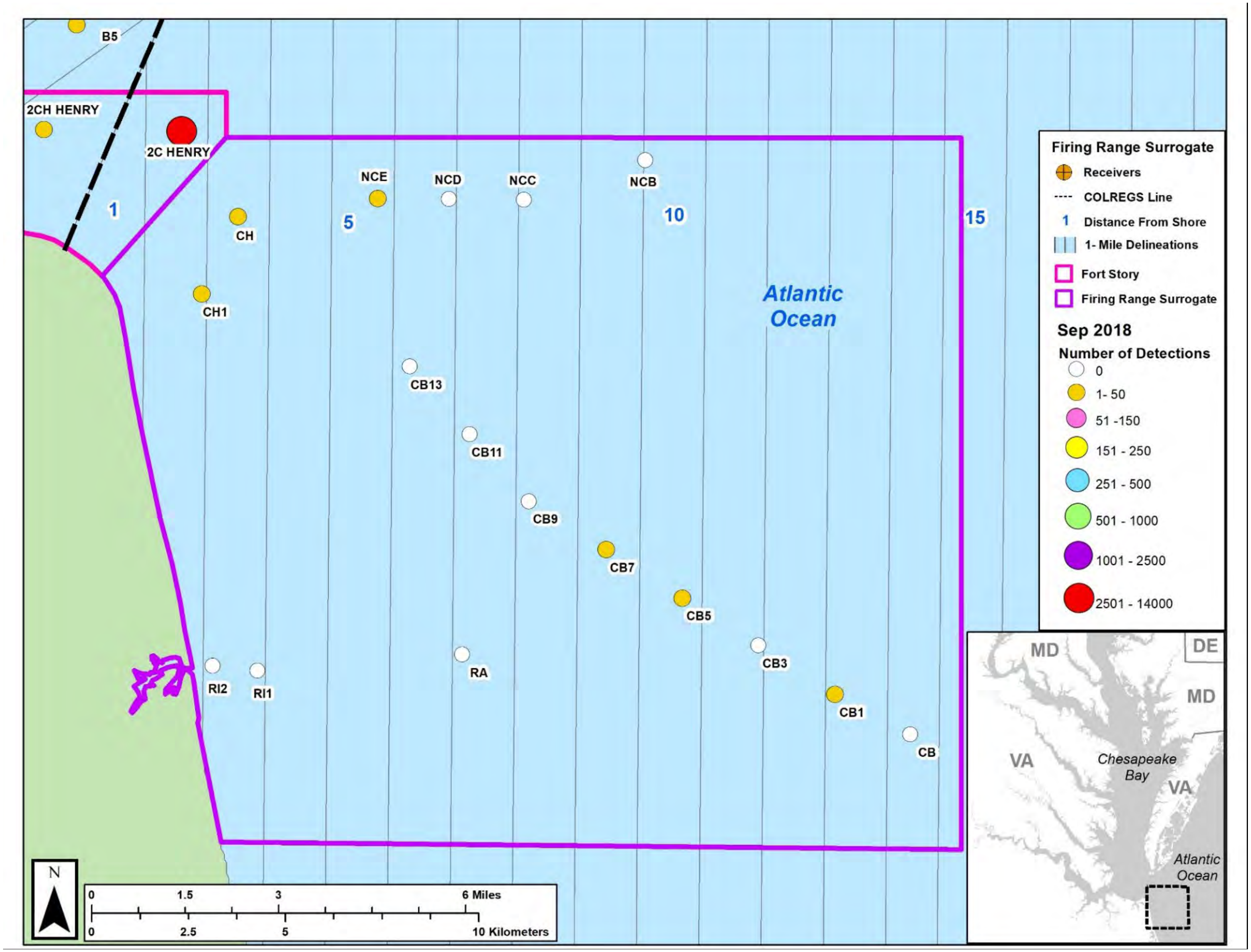
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers


B5
2CH HENRY
2C HENRY
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15
CH
CH1
NCE
NCD
NCC
NCB
Atlantic Ocean
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RI2
RI1
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Sep 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 14000
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DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
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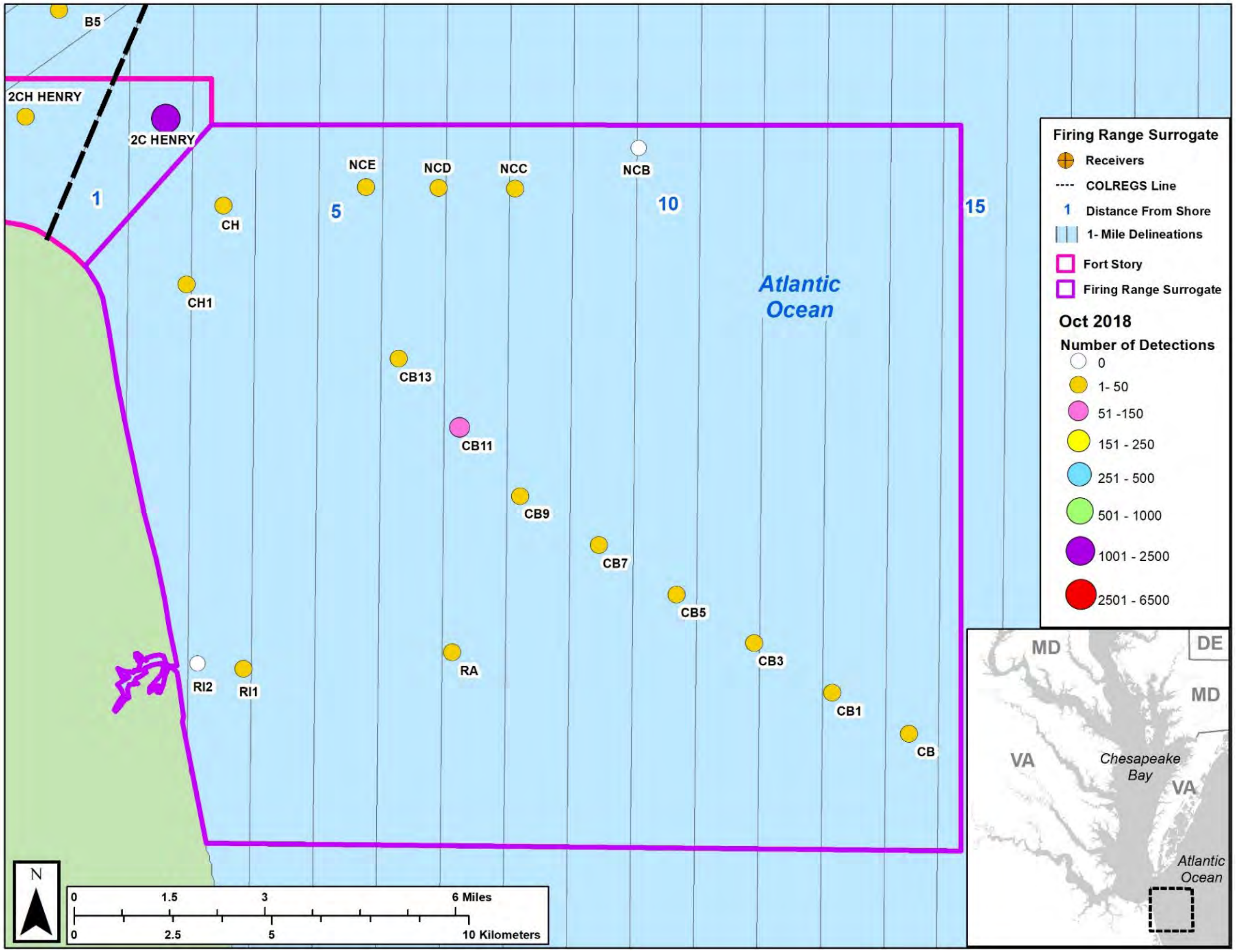
3
6 Miles
0
2.5
5
10 Kilometers


B5
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2C HENRY
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NCD
NCC
NCB
CH
CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RI2
RI1
1
5
10
15
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Oct 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
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MD
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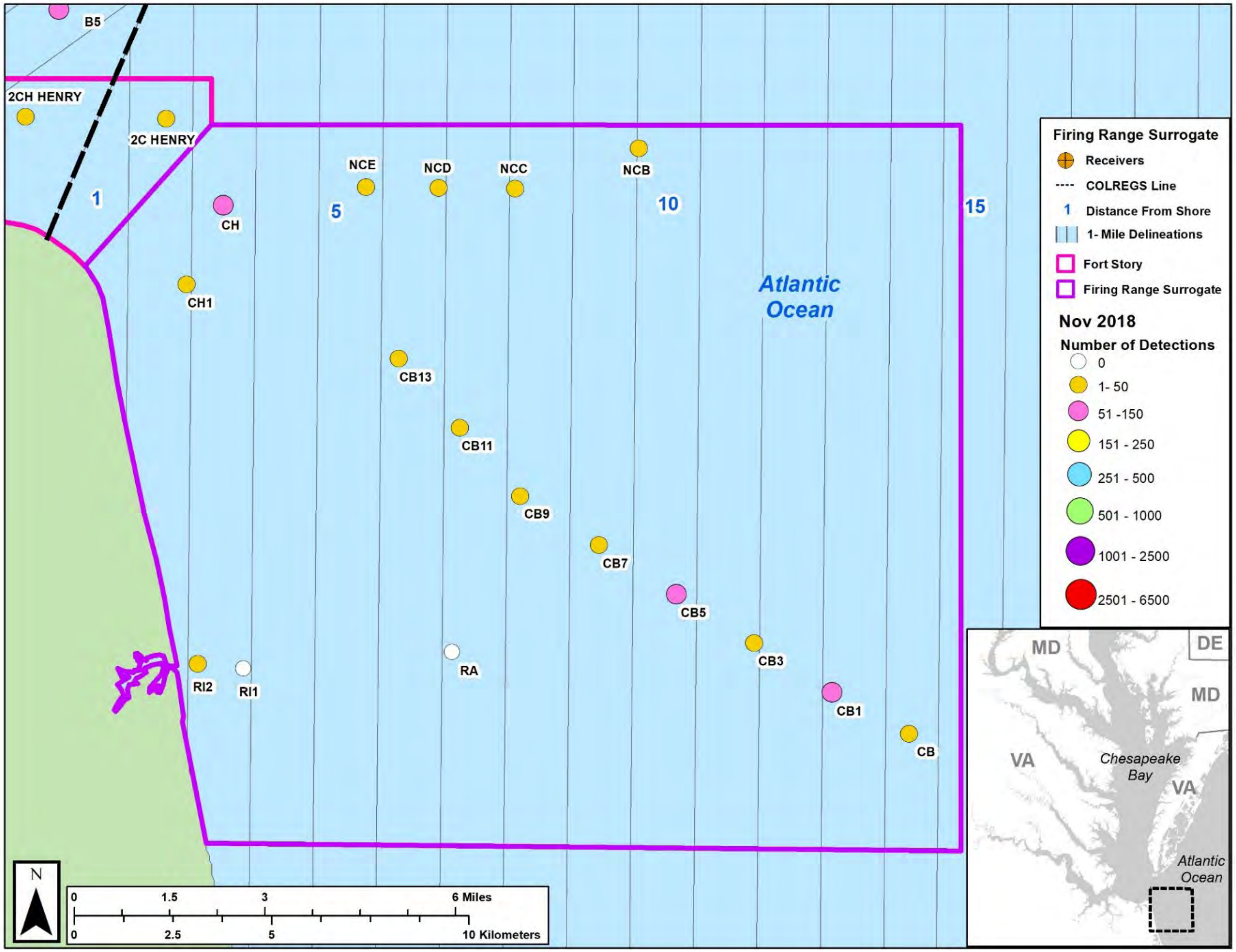
Chesapeake Bay
VA
Atlantic Ocean
N
0 1.5 3 6 Miles
0 2.5 5 10 Kilometers


B5
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2C HENRY
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10
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NCE
NCD
NCC
NCB
CH
CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
1 Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Nov 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
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MD
VA
Chesapeake Bay
VA
Atlantic Ocean
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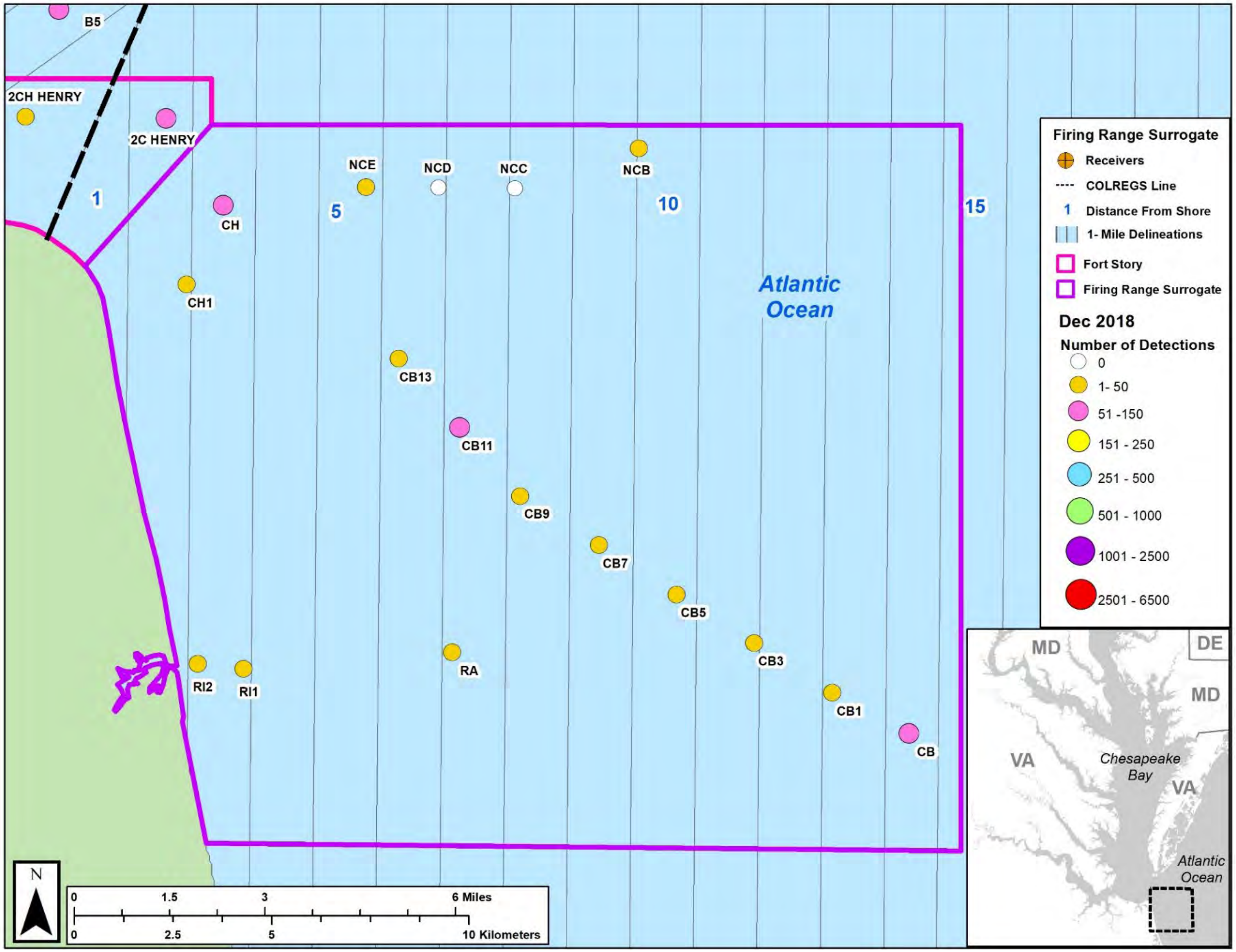
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers


B5
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2C HENRY
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5
10
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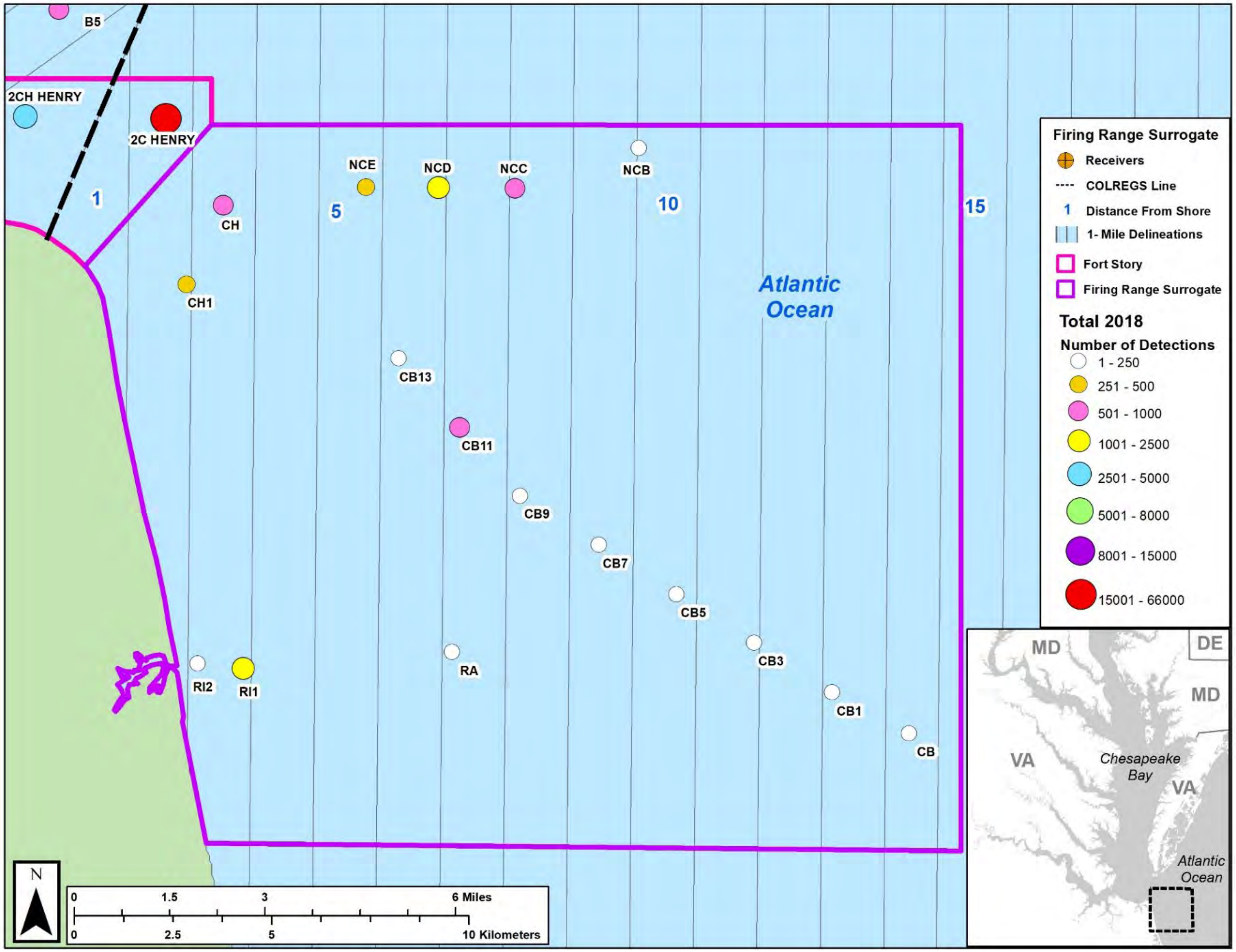
NCD
NCC
NCB
CH
CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RI2
RI1
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Dec 2018
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
N
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers


B5
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2C HENRY
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5
10
15
NCE
NCD
NCC
NCB
CH
CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RI2
RI1
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
1 Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Total 2018
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 66000
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
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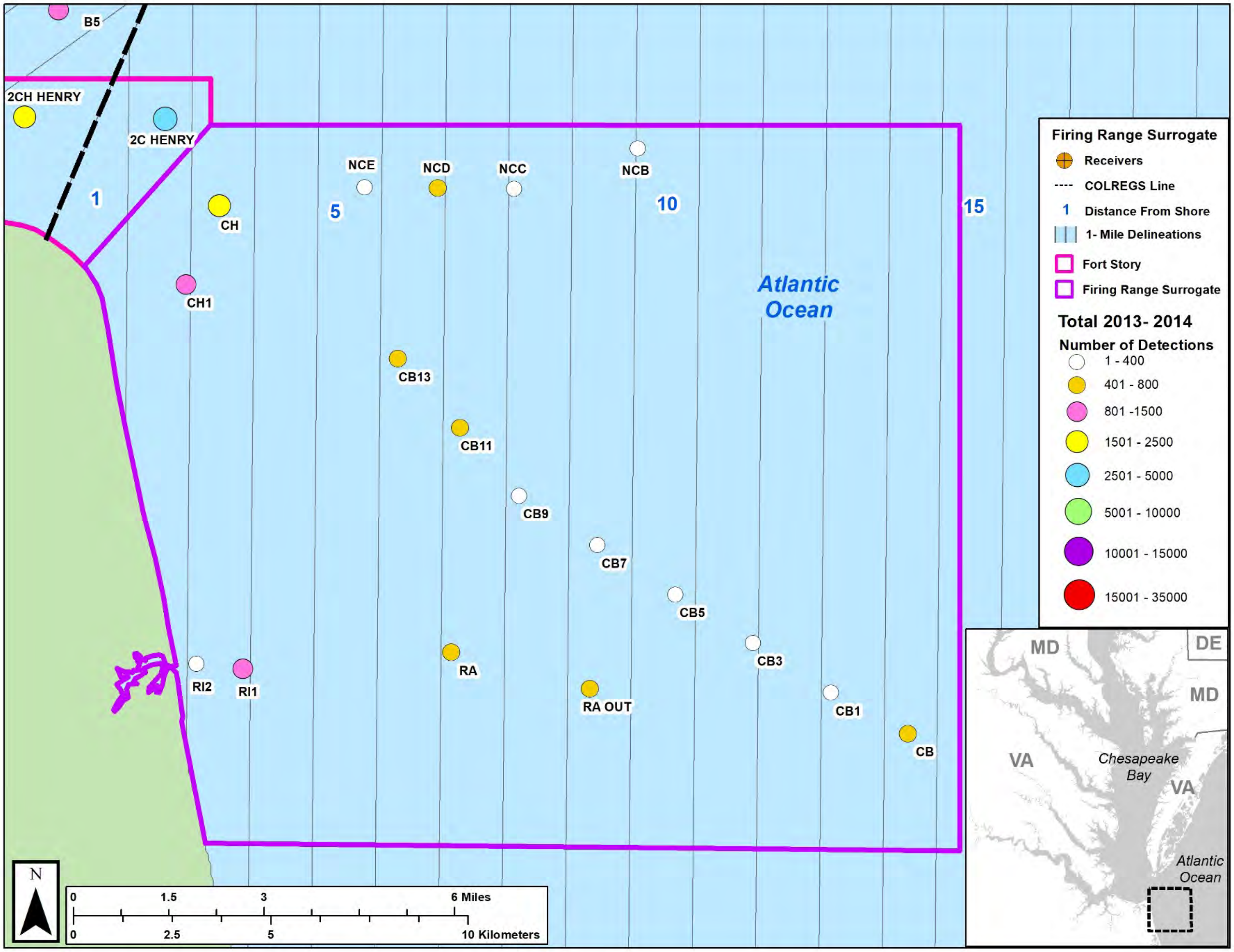
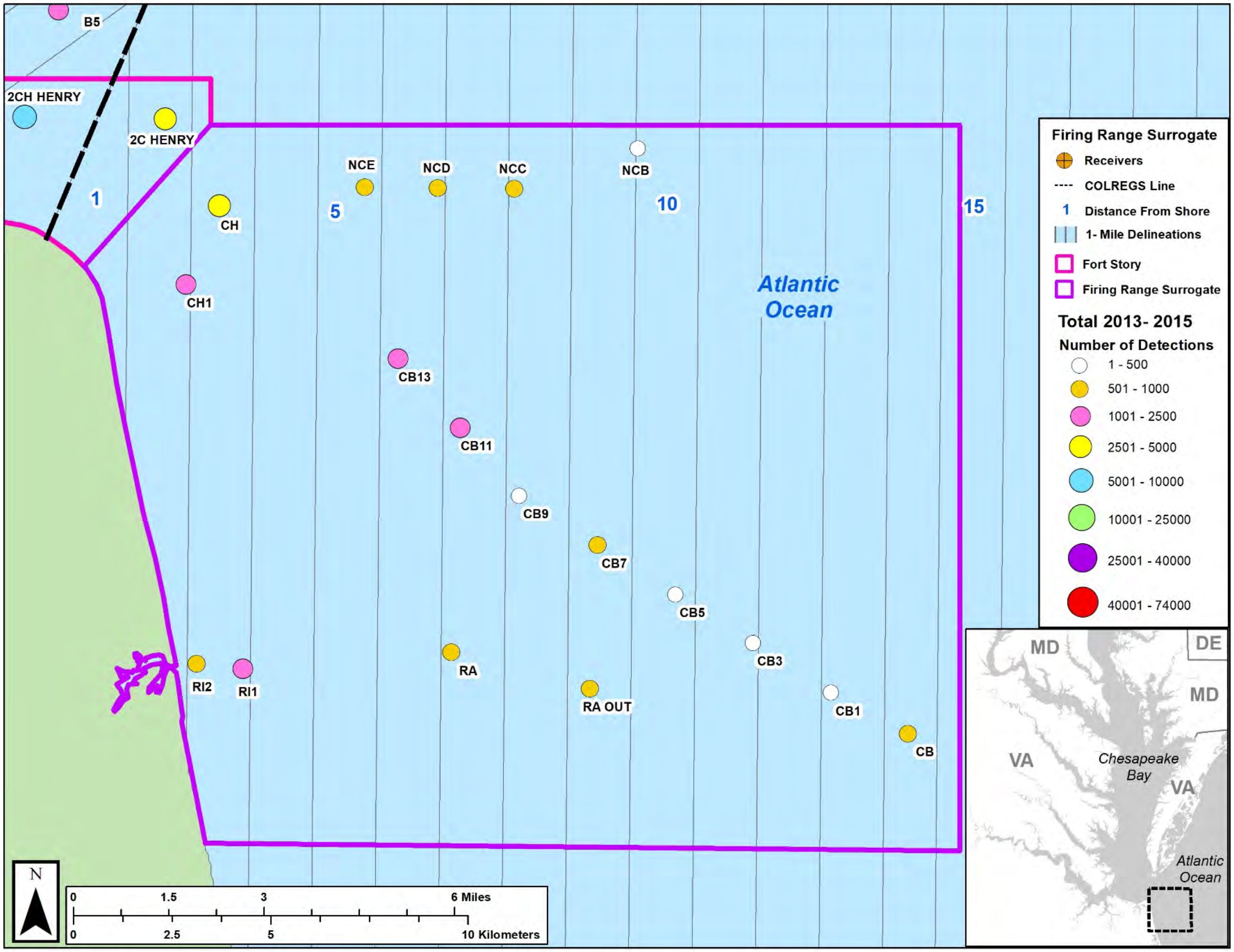
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers


B5
2CH HENRY
2C HENRY
1
5
10
15
NCE
NCD
NCC
NCB
CH
CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Atlantic Ocean
Firing Range Surrogate
Receivers
---- COLREGS Line
1 Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Total 2013- 2014
Number of Detections
1 - 400
401 - 800
801 -1500
1501 - 2500
2501 - 5000
5001 - 10000
10001 - 15000
15001 - 35000
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
N
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers


B5
2CH HENRY
2C HENRY
1
CH
5
NCE
NCD
NCC
NCB
10
15
CH1
Atlantic Ocean
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Total 2013- 2015
Number of Detections
1 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 10000
10001 - 25000
25001 - 40000
40001 - 74000
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
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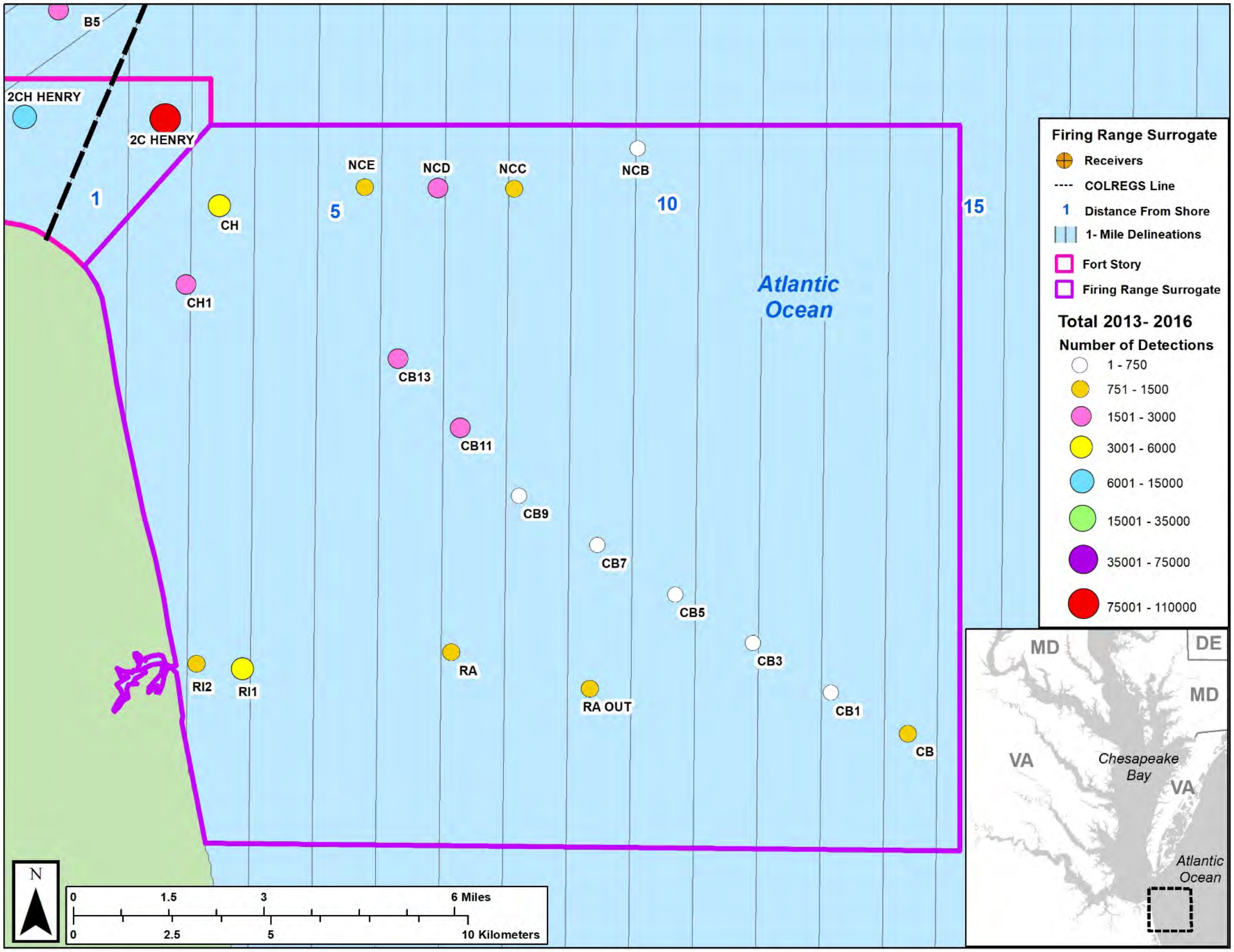
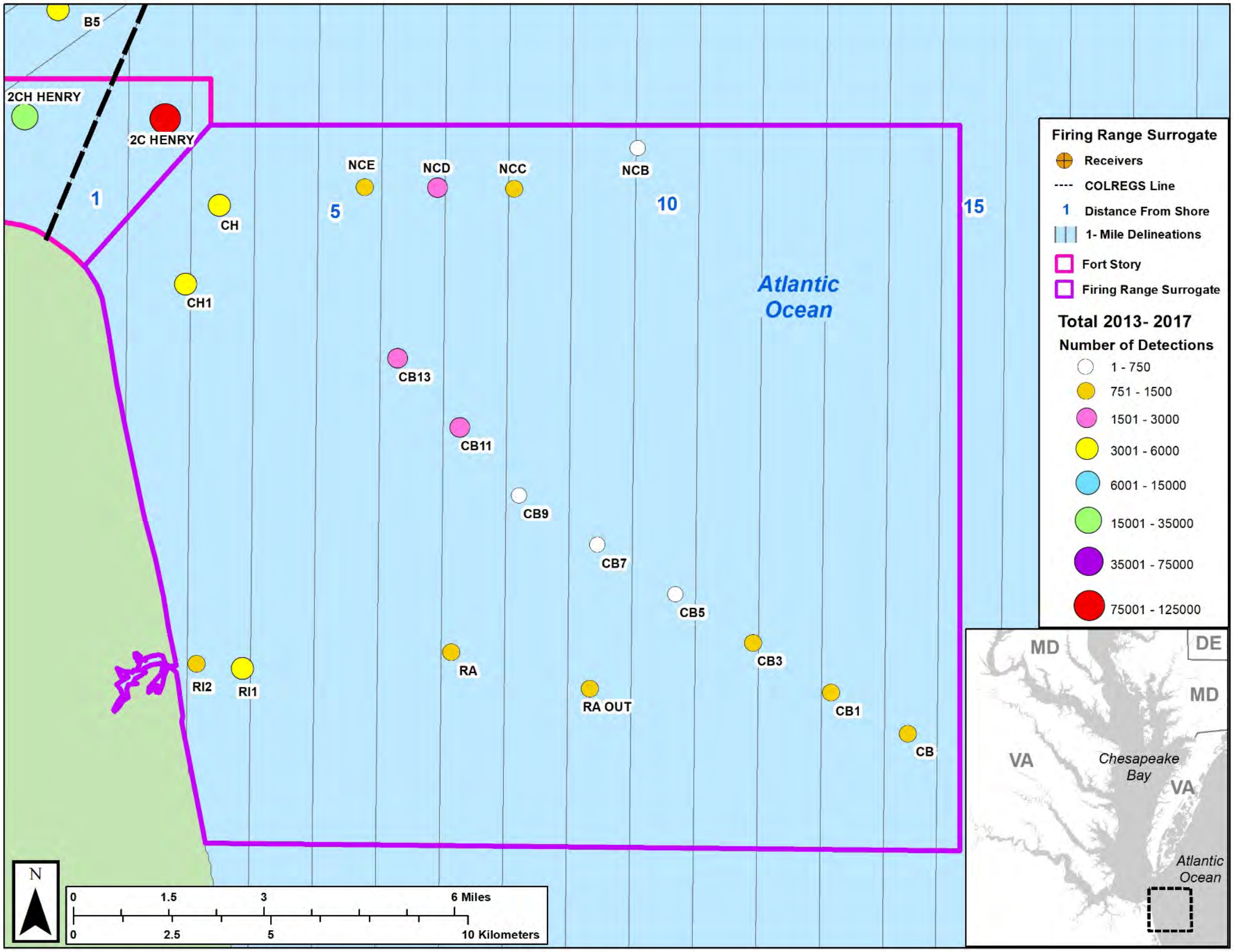
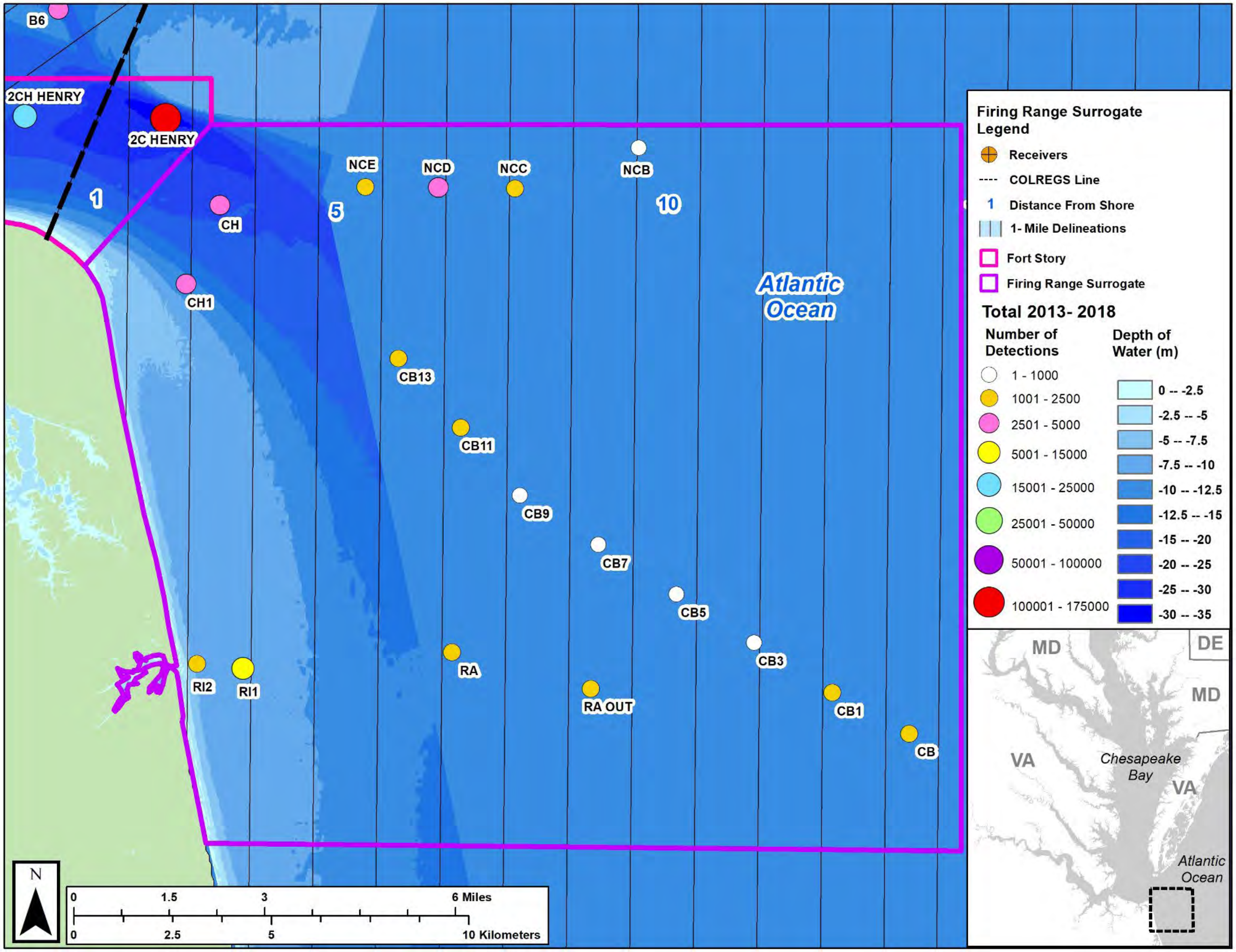
1.5
3
6 Miles
0
2.5
5
10 Kilometers


B5
2CH HENRY
2C HENRY
1
5
10
15
NCE
NCD
NCC
NCB
CH
CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Total 2013- 2016
Number of Detections
1 - 750
751 - 1500
1501 - 3000
3001 - 6000
6001 - 15000
15001 - 35000
35001 - 75000
75001 - 110000
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean
N
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers


B5
2CH HENRY
2C HENRY
1
5
10
15
NCE
NCD
NCC
NCB
CH
CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Atlantic Ocean
Firing Range Surrogate
Receivers
COLREGS Line
Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Total 2013- 2017
Number of Detections
1 - 750
751 - 1500
1501 - 3000
3001 - 6000
6001 - 15000
15001 - 35000
35001 - 75000
75001 - 125000
N
0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean


B6
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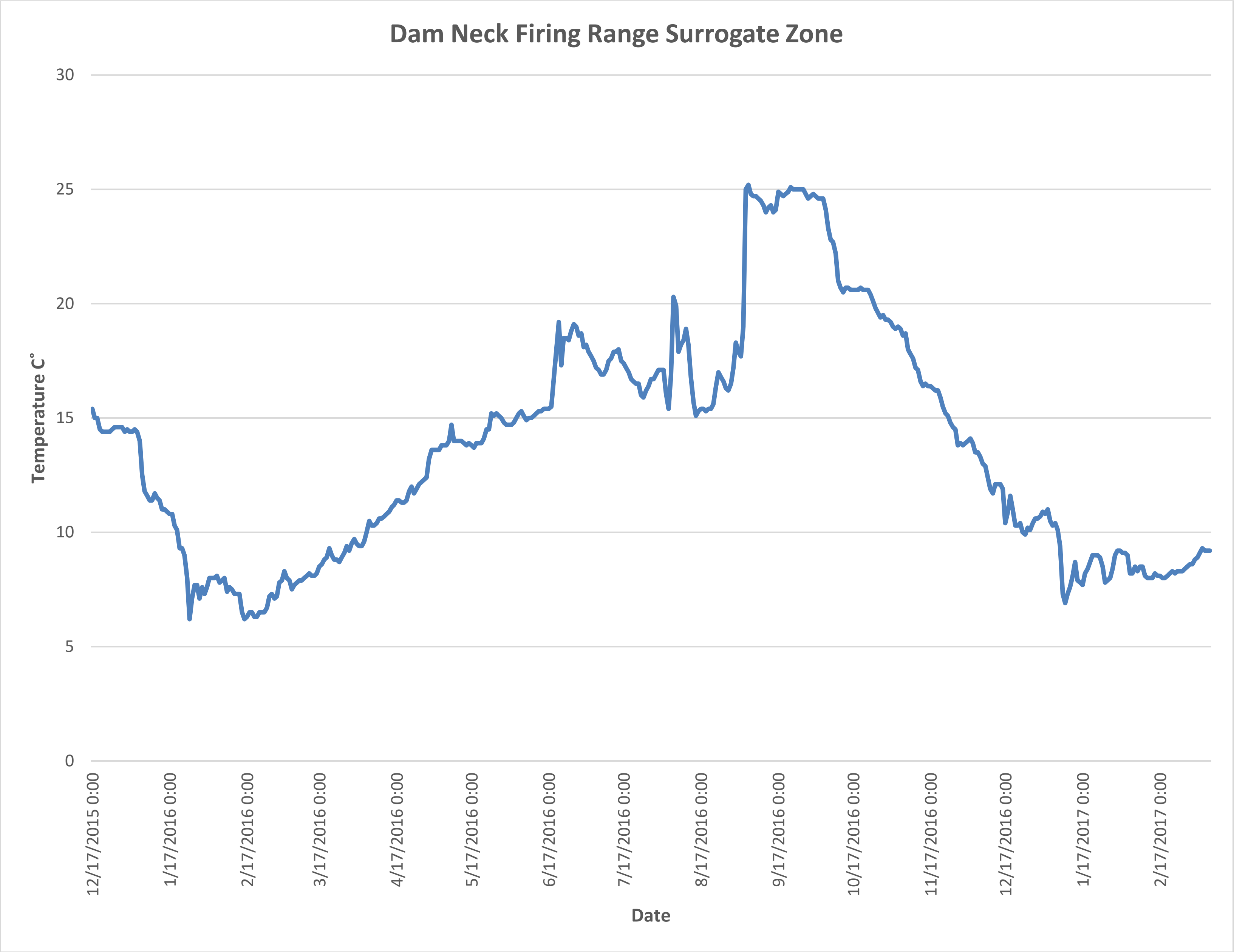
2C HENRY
1
CH
CH1
5
NCE
NCD
NCC
NCB
10
Atlantic Ocean
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RI2
RI1
RA
RA OUT
N
0
1.5
3
6 Miles
0
2.5
5
10 Kilometers
Firing Range Surrogate Legend
Receivers
COLREGS Line
1 Distance From Shore
1- Mile Delineations
Fort Story
Firing Range Surrogate
Total 2013- 2018
Number of Detections
1 - 1000
1001 - 2500
2501 - 5000
5001 - 15000
15001 - 25000
25001 - 50000
50001 - 100000
100001 - 175000
Depth of Water (m)
0 -- -2.5
-2.5 -- -5
-5 -- -7.5
-7.5 -- -10
-10 -- -12.5
-12.5 -- -15
-15 -- -20
-20 -- -25
-25 -- -30
-30 -- -35
MD
DE
MD
VA
Chesapeake Bay
VA
Atlantic Ocean


Dam Neck Firing Range Surrogate Zone
Temperature C˚
30
25
20
15
10
5
0
12/17/2015 0:00
1/17/2016 0:00
2/17/2016 0:00
3/17/2016 0:00
4/17/2016 0:00
5/17/2016 0:00
6/17/2016 0:00
7/17/2016 0:00
8/17/2016 0:00
9/17/2016 0:00
10/17/2016 0:00
11/17/2016 0:00
12/17/2016 0:00
1/17/2017 0:00
2/17/2017 0:00
Date

9. Table Appendices

9.1. Complete Summary of Monitoring for Sonic-tagged Sturgeon, December 2012–January 2018.

Note: Block colors indicate the site's status during a given period: white denotes the site was not monitored; green denotes the receiver was fully functional, yellow indicates that data may be missing, and red denotes that a broken receiver was at the location during some of the monitoring period. The numbers in the data columns are the dates of maintenance. An R following this date denotes that the receiver was retrieved, D denotes deployment, B denotes broken unknown cause, W means that the receiver was wet internally, C indicates clock failure, USCG means that the buoy was replaced by USCG and the receiver was removed and L denotes lost. Abbreviations for sites/regions/zones are: Pam. = Pamunkey; Chick. = Chickahominy; CBBT = Chesapeake Bay Bridge Tunnel; Eliz. = Elizabeth; Ches. = Chesapeake; Matt. = Mattaponi; NW/Ch. = Naval Weapons/Cheatham Annex; NSN = Naval Station Norfolk; Range Sur. = the Dam Neck Naval Firing Range Surrogate.

Receiver Site	Region	Military zone	1st trip 2013	2nd trip 2013	3rd trip 2013	4th trip 2013	5th trip 2013	6th trip 2013	7th trip 2013	8th trip 2013	9th trip 2013	10th trip 2013	11th trip 2013	12th trip 2013	13th trip 2013
CB	Atlantic	Range Sur.	12/4/2012	1/8/2013	2/15/2013	3/15/2013LD	4/8/2013	5/14/2013	6/12/2013	7/29/2013	8/13/2013	9/20/2013	10/2/2013	11/22/2013LD	12/13/2013
CB1	Atlantic	Range Sur.	12/4/2012	1/8/2013LD	2/15/2013	3/15/2013	4/8/2013	5/14/2013	6/12/2013	7/29/2013	8/13/2013	9/20/2013	10/2/2013	11/22/2013	12/13/2013
CB11	Atlantic	Range Sur.	12/4/2012	1/8/2013	2/15/2013	3/15/2013	4/8/2013	5/14/2013	6/12/2013	7/29/2013	8/13/2013	9/20/2013	10/21/2013	11/22/2013	12/13/2013
CB13	Atlantic	Range Sur.	12/4/2012	1/8/2013	2/15/2013	3/15/2013LD	4/30/2013	5/14/2013	6/12/2013	7/29/2013RD	8/13/2013	9/20/2013L, 10/12/2013D	10/21/2013RCD	11/22/2013	12/13/2013RCD
CB15	Atlantic	Range Sur.	12/4/2012	1/8/2013	2/15/2013	3/15/2013L	not deployed								
CB3	Atlantic	Range Sur.	12/4/2012	1/8/2013	2/15/2013	3/15/2013LD	4/8/2013	5/14/2013	6/12/2013	7/29/2013	8/13/2013	9/20/2013	10/2/2013	11/22/2013	12/13/2013
CB5	Atlantic	Range Sur.		1/4/2013	2/15/2013	3/15/2013L	3/15/2013D	4/8/2013	5/14/2013	7/29/2013	8/13/2013	9/20/2013	10/2/2013	11/22/2013	12/13/2013
CB7	Atlantic	Range Sur.	12/4/2012	1/8/2013	2/15/2013L	3/15/2013	4/8/2013D	5/14/2013	6/12/2013	7/29/2013	8/13/2013	9/20/2013	10/21/2013	11/22/2013	12/13/2013
CB9	Atlantic	Range Sur.	12/4/2012	1/8/2013	2/15/2013	3/15/2013	4/8/2013	5/14/2013	6/12/2013	7/29/2013	7/29/2013	9/20/2013	10/21/2013RC	11/22/2013D	12/13/2013
RA	Atlantic	Range Sur.	12/4/2012	1/8/2013	2/15/2013	3/15/2013RD	4/8/2013	5/14/2013	6/12/2013	7/23/2013L	8/27/2013	9/19/2013D	10/21/2013	11/22/2013RCD	12/15/2013
RA outside	Atlantic	Range Sur.	12/4/2012	1/8/2013	2/15/2013	3/15/2013RD	4/8/2013	5/14/2013	6/12/2013	7/23/2013	8/27/2013	9/19/2013	10/21/2013	11/22/2013	12/13/2013
RI1	Atlantic	Range Sur.	1/4/2013	1/8/2013	2/15/2013	3/15/2013R	3/15/2013D	4/8/2013	5/14/2013	6/12/2013	7/23/2013	8/27/2013L	9/19/2013D	10/21/13RWD	12/15/2013RWD
RI2	Atlantic	Range Sur.	12/4/2012	1/8/2013	2/15/2013L	3/15/2013D	4/8/2013	5/14/2013	6/12/2013	7/23/2013L	🟥	9/19/2013D	10/21/2013RWD	11/22/2013	12/15/2013RCD
CH	Atlantic	Range Sur.	12/4/2012	1/8/2013	2/17/2013		4/17/2013	5/15/2013	6/25/2013	7/29/2013L	🟥	🟥	10/22/2013D	11/22/2013RW	🟥
CH1	Atlantic	Range Sur.	12/4/2012	1/4/2013	2/15/2013	3/15/2013	4/17/2013	5/14/2013	6/12/2013	7/29/2013	8/13/2013	9/20/2013L	10/2/2013D	11/22/2013	12/13/2013
NCA	Atlantic		12/4/2012	1/8/2013	2/15/2013	3/15/2013	4/8/2013	5/15/2013	6/25/2013	7/30/2013	Not deployed				
NCB	Atlantic		12/4/2012	1/8/2013	2/15/2013	3/15/2013LD	4/8/2013	5/15/2013	6/25/2013	7/30/2013	8/13/2013	9/5/2013	10/2/2013	11/22/2013LD	12/17/2013
NCC	Atlantic		12/4/2012	1/8/2013	2/15/2013	3/15/2013	4/8/2013	5/15/2013	6/25/2013	7/30/2013	8/13/2013	9/5/2013	10/2/2013	11/22/2013LD	12/17/2013
NCD	Atlantic		12/4/2012	1/8/2013	2/15/2013	3/15/2013LD	4/8/2013	5/15/2013	6/25/2013	7/30/2013	8/13/2013	9/5/2013	9/20/2013RB	10/2/2013D	11/22/2013
NCE	Atlantic		12/4/2012	1/8/2013	2/15/2013	3/15/2013	4/8/2013	5/15/2013	6/25/2013	7/30/2013	8/13/2013	9/5/2013	10/2/2013	11/22/2013LD	12/17/2013
2CH	Ches. Bay	Fort Story	12/4/2012	1/8/2013	2/19/2013	3/15/2013	4/17/2013	5/15/2013	6/24/2013	7/30/2013	8/27/2013	9/20/2013	10/22/2013	11/22/2013	12/17/2013
TS1	Ches. Bay	Fort Story	12/4/2012	1/8/2013	2/19/2013	3/15/2013	4/17/2013	5/15/2013	6/24/2013	7/30/2013	8/27/2013	9/20/2013	10/22/2013	11/25/2013	12/17/2013
TS3	Ches. Bay	Fort Story	12/4/2012	1/8/2013	2/19/2013	3/15/2013	4/17/2013	5/15/2013	6/24/2013	7/30/2013	8/30/2013	9/20/2013	10/22/2013	11/25/2013	12/17/2013
B3	Ches. Bay	Fort Story	12/4/2012	1/8/2013	2/17/2013	3/29/2013L	not deployed								
2C HENRY	Atlantic	Fort Story	12/4/2012	1/8/2013		3/29/2013LD	4/17/2013	5/15/2013	6/18/2013	6/24/2013	7/29/2013	8/27/2013	9/20/2013	10/22/13USCGD	11/22/2013RW
CBBT4	Ches. Bay	Little Creek		1/9/2013	2/19/2013	3/28/2013	4/17/2013	5/15/2013	6/24/2013	7/30/2013	8/30/2013	10/1/2013	10/22/2013	11/25/2013	12/17/2013
CBBT5	Ches. Bay	Little Creek		1/9/2013	2/19/2013	3/28/2013	4/30/2013	5/15/2013	6/24/2013	7/30/2013	8/27/2013	10/1/2013	10/22/2013	11/25/2013	12/17/2013
LC1	Ches. Bay	Little Creek	12/4/2012	1/8/2013	2/19/2013	3/28/2013	4/17/2013	5/15/2013	6/25/2013	7/29/2013	8/27/2013	10/1/2013	10/22/2013	11/25/2013	12/17/2013
LC2	Ches. Bay	Little Creek		1/8/2013	2/19/2013	3/28/2013	4/17/2013	5/15/2013	6/25/2013	7/29/2013	8/27/2013	10/1/2013	10/22/2013	11/25/2013	12/17/2013
TS11	Ches. Bay	Little Creek	12/4/2012	1/8/2013	2/19/2013	3/28/2013	4/17/2013	5/15/2013	6/25/2013	7/29/2013	8/27/2013	10/1/2013	10/22/2013	11/25/2013	12/17/2013
TS7	Ches. Bay	Little Creek	12/4/2012	1/8/2013	2/19/2013	3/28/2013	4/17/2013	5/15/2013	6/25/2013	7/29/2013	8/27/2013	10/1/2013	11/25/2013	12/17/2013	1/14/2014
TS9	Ches. Bay	Little Creek	12/4/2012	1/8/2013	2/19/2013	3/28/2013	4/17/2013	5/15/2013	6/25/2013	7/29/2013	8/27/2013	10/1/2013L	10/22/2013D	11/25/2013	12/17/2013
10N	Ches. Bay		12/4/2012	1/8/2013	2/15/2013	3/29/2013	4/30/2013	5/15/2013	6/24/2013	7/29/2013	8/30/2013	10/1/2013	10/22/2013	11/25/2013	12/17/2013
11N	Ches. Bay		12/4/2012	1/8/2013	2/15/2013	3/29/2013R	not deployed								
CBBT1	Ches. Bay			1/9/2013	2/15/2013	3/29/2013	4/17/2013	5/15/2013	6/24/2013	8/30/2013	10/1/2013	10/22/2013	11/25/2013RBD	12/17/2013	1/14/2014
LS	Ches. Bay			1/8/2013	2/15/2013	3/29/2013	4/17/2013	5/15/2013	6/24/2013L	7/29/2013D	8/2/2013R	9/20/2013D	10/1/2013	11/25/2013	12/17/2013
CBBT2	Ches. Bay			1/9/2013	2/15/2013	3/29/2013	4/17/2013	5/15/2013	6/24/2013	7/30/2013R	🟥	🟥	10/1/2013D	11/25/2013	12/17/2013
CBBT3	Ches. Bay			1/9/2013	2/19/2013	3/28/2013	4/17/2013	5/15/2013	6/24/2013L	7/29/2013D	8/30/2013	10/1/2013	10/22/2013	11/25/2013	12/17/2013
CBBT7	Ches. Bay		not deployed	not deployed	not deployed	3/29/2013	4/17/2013	5/15/2013	6/24/2013	7/29/2013	8/30/2013	10/1/2013	10/22/2013	11/25/2013	12/17/2013
TS5	Ches. Bay		12/4/2012	1/8/2013	2/19/2013	3/15/2013	4/17/2013	5/15/2013	6/25/2013	7/30/2013	8/27/2013	9/20/2013	10/22/2013LD	11/25/2013	12/17/2013
B11	Ches. Bay		12/4/2012	1/8/2013	2/15/2013	3/29/2013L	4/17/2013D	5/15/2013	6/24/2013	7/29/2013	8/27/2013	10/1/2013	10/22/2013	11/25/2013	12/17/2013

Receiver Site	Region	Military zone	1st trip 2013	2nd trip 2013	3rd trip 2013	4th trip 2013	5th trip 2013	6th trip 2013	7th trip 2013	8th trip 2013	9th trip 2013	10th trip 2013	11th trip 2013	12th trip 2013	13th trip 2013
B13	Ches. Bay		12/4/2012	1/8/2013	2/15/2013	3/29/2013LD	4/17/2013	5/15/2013	6/24/2013	7/29/2013	8/27/2013	10/1/2013	10/22/2013	11/25/2013	12/17/2013
B15	Ches. Bay		12/4/2012	1/8/2013	2/15/2013	3/29/2013	4/17/2013	5/15/2013	6/24/2013	7/29/2013	8/27/2013	10/1/2013	10/22/2013	11/25/2013	12/17/2013RD
B5	Ches. Bay		12/4/2012	1/8/2013	2/17/2013	3/29/2013LD	4/17/2013	5/15/2013	6/24/2013	7/29/2013	8/27/2013	10/1/2013	10/22/2013	11/22/2013	12/17/2013
B7	Ches. Bay		12/4/2012	1/8/2013	2/15/2013L	🟥	4/17/2013D	5/15/2013	6/24/2013	7/29/2013	8/30/2013	10/1/2013	10/22/2013	11/22/2013	12/17/2013
B9	Ches. Bay		12/4/2012	1/8/2013	2/15/2013	3/29/2013	4/17/2013	5/15/2013	6/24/2013	7/29/2013	8/27/2013	10/1/2013	10/22/2013	11/22/2013	12/17/2013
NH5	James River	NNB	12/7/2012	1/9/2013	2/12/2013	3/4/2013	4/3/2013	5/13/2013	6/28/2013	7/18/2013	8/21/2013	not deployed			
NN 1ER FWS	James River	NNB	not deployed	not deployed	not deployed	not deployed	4/3/2013	5/13/2013	6/28/2013	7/18/2013	8/21/2013	9/5/2013	10/17/2013	11/6/2013	12/6/2013
NN 3ER NOAA SP	James River	NNB	not deployed	not deployed	not deployed	not deployed	4/3/2013	5/13/2013	6/28/2013	7/18/2013	8/21/2013	9/5/2013	10/17/2013	11/6/2013	12/6/2013
NN DANGER FWS	James River	NNB	not deployed	not deployed	not deployed	not deployed	4/3/2013	5/13/2013	6/28/2013	7/18/2013	8/21/2013	9/5/2013	10/17/2013	11/6/2013	12/6/2013
NN R22 NOAA SP	James River	NNB	not deployed	not deployed	not deployed	not deployed	4/3/2013	5/13/2013	6/28/2013	7/18/2013	8/21/2013	9/5/2013	10/17/2013	11/6/2013	12/6/2013
NN2	James River	NNB	12/7/2012	1/9/2013	2/12/2013	3/4/2013	4/3/2013	5/13/2013	6/28/2013	7/18/2013	8/21/2013	9/5/2013	10/17/2013	11/6/2013	12/6/2013
NN5	James River	NNB	12/7/2012	1/9/2013	2/12/2013	3/4/2013RD	4/3/2013	5/13/2013	6/28/2013	7/18/2013	8/21/2013	9/5/2013L	10/17/2013D	11/6/2013	12/6/2013
NN8	James River	NNB	12/7/2012	1/9/2013	2/12/2013	3/4/2013	4/3/2013	5/13/2013	6/28/2013	7/18/2013	8/21/2013	9/5/2013	10/17/2013	11/6/2013	12/6/2013
NH8	Eliz. River	NNB	12/7/2012	1/9/2013	2/12/2013	3/4/2013	4/3/2013	5/13/2013	6/28/2013	7/18/2013	8/21/2013	9/5/2013	10/17/2013	11/6/2013	12/6/2013
NH10	Eliz. River	NNB	12/7/2012	1/9/2013	2/12/2013	3/4/2013	4/3/2013	5/13/2013	6/28/2013	7/18/2013	8/21/2013	9/5/2013	10/17/2013	11/6/2013	12/6/2013
NH12	Eliz. River	NNB	12/7/2012	1/9/2013	2/12/2013	3/4/2013	4/3/2013	5/13/2013	6/28/2013	7/18/2013	8/21/2013	9/5/2013	10/17/2013	11/6/2013	12/6/2013
NH14	Eliz. River	NNB	12/7/2012	1/9/2013	2/12/2013	3/4/2013	4/3/2013	5/13/2013	6/28/2013	7/18/2013	8/21/2013	9/5/2013	10/17/2013	11/6/2013	12/6/2013
APMI	Eliz. River	Eliz. River	12/7/2012	1/9/2013	2/12/2013	3/4/2013	4/3/2013	5/13/2013	6/28/2013	7/18/2013	8/21/2013	9/5/2013	10/17/2013	11/6/2013	12/6/2013
NH29	Eliz. River	Eliz. River	12/7/2012	1/9/2013	2/12/2013	3/4/2013	4/3/2013	5/13/2013	6/28/2013	7/18/2013	8/21/2013	9/5/2013	10/17/2013	11/6/2013	12/6/2013
NH32	Eliz. River	Eliz. River	12/7/2012	1/9/2013	2/12/2013	3/4/2013	4/3/2013	5/13/2013	6/28/2013	7/18/2013	8/21/2013	9/5/2013	10/17/2013	11/6/2013	12/6/2013
NH36	Eliz. River	Eliz. River	12/7/2012	1/9/2013	2/12/2013	3/4/2013	4/3/2013	5/13/2013	6/28/2013	7/18/2013	8/21/2013	9/5/2013	10/17/2013	11/6/2013	12/6/2013
Y PAGE	York River	NW/Ch.	12/6/2012	1/7/2013	2/11/2013	3/5/2013	4/23/2013	5/8/2013	6/4/2013	7/3/2013	8/8/2013	9/4/2013	10/8/2013	11/18/2013	12/4/2013
Y WAT	York River	NW/Ch.	12/7/2012	1/4/2013	1/31/2013	3/13/2013	4/18/2013	5/8/2013	6/4/2013	7/3/2013	8/8/2013	9/4/2013	10/30/2013	11/18/2013	12/4/2013
Y2	York River	NW/Ch.	12/6/2012	1/7/2013	2/11/2013	3/5/2013	4/23/2013	5/8/2013	6/4/2013	7/3/2013	8/8/2013	9/4/2013	10/8/2013	11/18/2013	12/4/2013
Y8	York River	NW/Ch.	12/6/2012	1/7/2013	2/11/2013	3/5/2013	4/23/2013	5/8/2013	6/4/2013	7/3/2013	8/8/2013	9/4/2013	10/30/2013	11/18/2013RD	12/4/2013
Y BELL NOAA	York River			1/7/2013	2/11/2013	3/13/2013	4/23/2013	5/8/2013	6/19/2013	7/3/2013	8/8/2013	9/4/2013	10/8/2013	11/12/2013	12/4/2013
Y12	York River		12/6/2012	1/7/2013	2/11/2013	3/5/2013	4/23/2013	5/8/2013	6/4/2013	7/3/2013	8/8/2013	9/4/2013	10/8/2013	11/12/2013	12/4/2013
Y18 NOAA	York River		12/1/2012	1/7/2013	2/11/2013	3/13/2013	4/23/2013	5/8/2013	6/19/2013	7/3/2013	8/8/2013	9/4/2013	10/8/2013	11/12/2013	12/4/2013
Y20 NOAA	York River				2/11/2013	3/13/2013	4/23/2013	5/8/2013	6/19/2013	7/3/2013	8/8/2013	9/4/2013	10/8/2013	11/12/2013	12/4/2013
Y29 NOAA	York River				2/11/2013	3/13/2013	4/23/2013	5/8/2013	6/19/2013	7/3/2013	8/8/2013	9/4/2013	10/8/2013	11/12/2013	12/4/2013
PAM Johns	Pam. River		1/2/2013	3/6/2013	3/6/2013	4/1/2013	5/7/2013	6/6/2013	7/8/2013	8/1/2013	9/9/2013	10/4/2013	11/5/2013	12/10/2013	1/3/2014
PAM Res.	Pam. River		1/2/2013	2/4/2013	3/7/2013	4/28/2013	5/7/2013	5/31/2013	6/6/2013	7/8/2013	8/1/2013	9/10/2013	10/4/2013	11/5/2013	12/10/2013
PAM Soffin	Pam. River		1/2/2013	2/4/2013	3/7/2013	4/1/2013	5/7/2013	6/6/2013	7/8/2013	8/1/2013	9/10/2013	10/4/2013	11/5/2013	12/10/2013	1/3/2014
PAM Williams	Pam. River		1/2/2013	2/4/2013	3/7/2013	4/1/2013	5/7/2013	6/6/2013	7/8/2013	8/1/2013	8/29/2013	9/10/2013	10/4/2013	11/5/2013	12/13/2013
PAM 360	Pam. River											9/10/2013	10/4/2013	11/5/2013	12/10/2013
PAM William upper	Pam. River		seasonal								8/20/2013	9/10/2013	10/4/2013	11/5/2013	12/10/2013
PAM Brick wall	Pam. River		seasonal									9/13/2013	10/4/2013	11/5/2013	12/10/2013

Receiver Site	Region	Military zone	1st trip 2014	2nd trip 2014	3rd trip 2014	4th trip 2014	5th trip 2014	6th trip 2014	7th trip 2014	8th trip 2014	9th trip 2014	10th trip 2014	11th trip 2014	12th trip 2014	1st trip 2015
CB	Atlantic	Range Sur.	1/31/2014RWD	2/20/14RWD	3/12/2014RWD	4/25/2014RWD	5/7/2014	6/18/2014	7/30/2014	9/2/2014LD	10/2/2014	10/21/2014	11/10/2014	12/20/2014	1/11/2015
CB1	Atlantic	Range Sur.	1/31/2014RCD	2/20/14 RCD	3/12/2014RCD	4/25/2014RCD	5/7/2014	6/18/2014	7/30/2014	9/2/2014LD	10/9/2014	10/21/2014	11/10/2014	12/20/2014	1/11/2015
CB11	Atlantic	Range Sur.	1/31/2014	2/20/2014	3/12/2014	buoy gone	buoy gone	6/18/2014D	7/31/2014L	9/2/2014D	10/9/2014	10/21/2014	11/10/2014	12/20/2014	1/11/2015
CB13	Atlantic	Range Sur.	1/31/2013C	2/20/14RCD	3/12/2014	4/25/2014	5/7/2014	6/18/2014	7/31/2014	9/2/2014	10/9/2014	10/21/2014	11/10/2014	12/20/2014	1/11/2015
CB3	Atlantic	Range Sur.	1/31/2014RD	2/20/14RCD	3/12/2014	4/25/2014	5/7/2014	6/18/2014	7/30/2014R USCG D	9/2/2014	10/9/2014LD	10/21/2014	11/10/2014	12/20/2014	1/11/2015
CB5	Atlantic	Range Sur.	1/31/2014RCD	2/20/2014	3/12/2014RWD	4/25/2014RWD	5/7/2014	6/18/2014	7/30/2014	9/2/2014	10/9/2014	10/21/2014	11/10/2014	12/20/2014	1/11/2015
CB7	Atlantic	Range Sur.	1/31/2014RCD	2/20/2014RCD	3/12/14RCD	4/25/2014RCD	5/7/2014	6/18/2014	7/30/2014	9/2/2014	10/9/2014	10/21/2014	11/10/2014	12/20/2014	1/11/2015
CB9	Atlantic	Range Sur.	1/31/2014RCD	2/20/2014	3/12/2014	4/25/2014	5/7/2014	6/18/2014	7/31/2014	9/2/2014	10/9/2014	10/21/2014	11/10/2014	12/20/2014	1/11/2015
RA	Atlantic	Range Sur.	1/26/2014	2/20/2014	not retrievable	4/25/2014	5/7/2014	6/18/2014	7/30/2014R USCG D	9/2/2014	10/9/2014	10/20/2014	11/10/2014	12/28/2014	1/11/2015
RA outside	Atlantic	Range Sur.	1/26/2014RWD	2/20/2014	not retrievable	4/25/2014	5/7/2014	6/18/2014	7/30/2014	9/2/2014	10/9/2014	10/20/2014	11/10/2014	12/28/2014	1/11/2015
RI1	Atlantic	Range Sur.	1/26/2014	2/20/2014	not retrievable	4/25/2014	5/7/2014	6/18/2014	7/30/2014R USCG D	9/2/2014	10/9/2014	10/20/2014	11/10/2014	12/18/2014	1/11/2015
RI2	Atlantic	Range Sur.	1/26/2014RCD	2/20/2014	not retrievable	4/25/2014	5/7/2014	6/18/2014LD	7/30/2014	9/2/2014	10/9/2014	10/20/2014	11/10/2014	12/28/2014LD	1/11/2015
CH	Atlantic	Range Sur.	🟥	2/27/2014	3/12/2014	4/2/2014	5/7/2014	6/18/2014	7/31/2014	9/3/2014	10/9/2014	10/9/2014	11/10/2014	12/15/2014	1/11/2015
CH1	Atlantic	Range Sur.	1/14/2014	2/27/2014	3/12/2014	4/2/2014	5/7/2014	6/18/2014	7/31/2014	9/2/2014	10/9/2014	11/10/2014	12/20/2014	1/11/2015	

Receiver Site	Region	Military zone	1st trip 2014	2nd trip 2014	3rd trip 2014	4th trip 2014	5th trip 2014	6th trip 2014	7th trip 2014	8th trip 2014	9th trip 2014	10th trip 2014	11th trip 2014	12th trip 2014	1st trip 2015
NCB	Atlantic		1/31/2014RCD	2/20/2014RCD	3/12/2014	4/25/2014	5/21/2014	6/19/2014	7/31/2014	9/3/2014	10/9/2014	10/21/2014	11/10/2014	12/20/2014	1/11/2015
NCC	Atlantic		1/31/2014RCD	2/20/2014	3/12/2014	4/25/2014	5/21/2014	6/19/2014	7/31/2014	9/3/2014	10/9/2014	10/21/2014	11/10/2014	12/20/2014	1/11/2015
NCD	Atlantic		1/31/2014	2/20/2014	3/12/2014	4/25/2014	5/21/2014	6/19/2014	7/31/2014	9/3/2014	10/9/2014	10/21/2014	11/10/2014	12/20/2014	1/11/2015
NCE	Atlantic		1/31/2014RWD	2/20/2014	3/12/2014	4/25/2014	5/21/2014	6/19/2014RBD	7/31/2014	9/3/2014	10/9/2014	10/21/2014	11/10/2014	12/20/2014	1/11/2015
2CH	Ches. Bay	Fort Story	1/14/2014	2/27/2014	3/12/2014	4/2/2014	5/21/2014	6/19/2014			10/10/2014	10/21/2014	11/25/2014	12/15/2014	1/11/2015
TS1	Ches. Bay	Fort Story	1/14/2014	2/27/2014	3/12/2014	4/2/2014	5/21/2014	6/18/2014	7/31/2014	9/3/2014	10/3/2014	10/10/2014	11/25/2014	12/15/2014	1/11/2015
TS3	Ches. Bay	Fort Story	1/14/2014	2/27/2014	4/2/2014	4/24/2014	5/7/2014	6/18/2014	7/31/2014	9/3/2014	10/3/2014	10/10/2014	11/25/2014	12/15/2014	1/11/2015
2C HENRY	Atlantic	Fort Story	🟥	2/27/2014D	3/12/2014	4/2/2014	5/7/2014	6/18/2014	7/31/2014	9/3/2014	10/3/2014	10/9/2014	11/10/2014	12/20/2014	1/11/2015
CBBT4	Ches. Bay	Little Creek	1/26/2014	2/27/2014	4/2/2014	4/24/2014	5/21/2014	6/19/2014	7/23/2014	9/2/2014	9/22/2014	10/21/2014	11/25/2014	12/28/2014	1/20/2015
CBBT5	Ches. Bay	Little Creek	1/26/2014	2/27/2014	4/2/2014	4/24/2014	5/21/2014	6/19/2014	7/23/2014	9/2/2014	9/22/2014	10/21/2014LD	11/25/2014	12/28/2014	1/20/2015
LC1	Ches. Bay	Little Creek	1/14/2014	2/27/2014	4/2/2014	4/24/2014	5/21/2014	6/19/2014	7/23/2014	9/2/2014	9/22/2014	10/10/2014	11/25/2014	12/15/2014	1/20/2015
LC2	Ches. Bay	Little Creek	1/14/2014	2/27/2014	4/2/2014	4/24/2014	5/21/2014	6/19/2014	7/23/2014	9/2/2014	9/22/2014	10/10/2014	11/25/2014	12/15/2014	1/20/2015
TS11	Ches. Bay	Little Creek	1/14/2014	2/27/2014	4/2/2014	4/24/2014	5/21/2014	6/19/2014	7/23/2014	9/2/2014	9/22/2014	10/10/2014	11/25/2014	12/15/2014	1/20/2015
TS7	Ches. Bay	Little Creek	1/14/2014	2/27/2014	4/2/2014	4/24/2014	5/21/2014	6/19/2014	7/23/2014	9/2/2014	9/22/2014	10/10/2014	11/25/2014	12/15/2014	1/20/2015
TS9	Ches. Bay	Little Creek	1/14/2014	2/27/2014	4/2/2014	4/24/2014	5/21/2014	6/19/2014	7/23/2014	9/2/2014	9/22/2014	10/10/2014	11/25/2014	12/15/2014	1/20/2015
10N	Ches. Bay		1/14/2014	2/27/2014	4/2/2014	4/24/2014	5/21/2014	6/19/2014	7/23/2014	9/3/2014	10/3/2014	not reachable	11/25/2014	12/15/2014	1/20/2015
CBBT1	Ches. Bay		1/14/2014	2/27/2014	4/2/2014	4/24/2014	5/21/2014	6/19/2014	7/23/2014	9/2/2014		10/3/2014	11/25/2014	12/28/2014	1/20/2015
LS	Ches. Bay		1/14/2014	1/14/2014	2/27/2014	4/24/2014	5/21/2014	6/19/2014	7/23/2014	9/2/2014	not reachable	10/3/2014	11/25/2014	12/28/2014	1/20/2015
CBBT2	Ches. Bay		1/14/2014	2/27/2014	4/2/2014	4/24/2014	5/21/2014	6/19/2014	7/23/2014	9/2/2014		10/3/2014	11/25/2014	12/28/2014	1/20/2015
CBBT3	Ches. Bay		1/14/2014	2/27/2014	4/2/2014	4/24/2014	5/21/2014	6/19/2014	7/23/2014	9/2/2014		10/3/2014	11/25/2014	12/28/2014	1/20/2015
CBBT7	Ches. Bay		1/14/2014	2/27/2014	4/2/2014LD	4/24/2014	5/21/2014	6/19/2014	7/23/2014	9/2/2014		10/3/2014	11/25/2014	12/28/2014	1/20/2015LD
TS5	Ches. Bay		1/26/2014	2/27/2014	4/2/2014	4/24/2014	4/24/2014	5/7/2014	6/18/2014	7/23/2014	9/3/2014	10/10/2014	11/25/2014	12/15/2014	1/11/2015
B11	Ches. Bay		1/14/2014	2/27/2014	4/2/2014	4/24/2014	5/7/2014	6/18/2014	7/23/2014R USCG D	9/2/2014	10/3/2014	10/10/2014	11/25/2014	12/15/2014	1/11/2015
B13	Ches. Bay		1/14/2014	2/27/2014	4/2/2014	4/24/2014	5/21/2014	6/19/2014	7/23/2014R USCG D	9/2/2014	10/3/2014	not reachable	11/25/2014	12/15/2014	1/20/2015
B15	Ches. Bay		1/14/2014	2/27/2014	4/2/2014	4/24/2014	5/21/2014	6/19/2014	7/23/2014	9/2/2014	10/3/2014	not reachable	11/25/2014	12/15/2014	1/20/2015
B5	Ches. Bay		1/14/2014	2/27/2014	4/2/2014	4/24/2014	5/21/2014	6/18/2014	7/31/2014R USCG D	9/3/2014	10/3/2014R USCG D	10/10/2014	11/25/2014	12/15/2014	1/11/2015
B7	Ches. Bay		1/14/2014	2/27/2014RCD	buoy gone in March	4/2/2014D	5/7/2014	6/18/2014	7/31/2014	9/2/2014	10/3/2014	10/10/2014	11/25/2014	12/15/2014	1/11/2015
B9	Ches. Bay		1/14/2014	2/27/2014	4/2/2014	4/24/2014	5/7/2014	6/18/2014	7/31/2014	9/2/2014	10/3/2014	10/10/2014	11/25/2014	12/15/2014	1/11/2015
NN 1ER FWS	James River	NNB	1/9/2014	2/6/2014	3/21/2014	4/14/2014	5/6/2014	6/5/2014	7/29/2014	8/9/2014	9/22/2014	10/17/2014	11/21/2014	12/5/2014	1/16/2015
NN 3ER NOAA SP	James River	NNB	1/9/2014	2/6/2014	3/21/2014	4/14/2014	5/6/2014	6/5/2014	7/29/2014	8/9/2014	9/22/2014	10/17/2014	11/21/2014	12/5/2014	1/16/2015
NN DANGER FWS	James River	NNB	1/9/2014	2/6/2014	3/21/2014	4/14/2014	5/6/2014	6/5/2014	7/29/2014	8/9/2014	9/22/2014	10/17/2014	11/21/2014	12/5/2014	1/16/2015
NN R22 NOAA SP	James River	NNB	1/9/2014	2/6/2014	3/21/2014	4/14/2014	5/6/2014	6/5/2014	7/29/2014	8/9/2014	9/22/2014	10/17/2014	11/21/2014	12/5/2014	1/16/2015
NN2	James River	NNB	1/9/2014	2/6/2014	3/21/2014	4/14/2014	5/6/2014	6/5/2014	7/29/2014	8/9/2014	9/22/2014	10/17/2014	11/21/2014	12/5/2014	1/16/2015
NN5	James River	NNB	1/9/2014	2/6/2014	3/21/2014	4/14/2014	5/6/2014	6/5/2014	7/29/2014	8/9/2014	9/22/2014	10/17/2014	11/21/2014	12/5/2014	1/16/2015
NN8	James River	NNB	1/9/2014	2/6/2014	3/21/2014	4/14/2014	5/6/2014	6/5/2014	7/29/2014	8/9/2014	9/22/2014	10/17/2014	11/21/2014	12/5/2014	1/16/2015
NH8	Eliz. River	NNB	1/9/2014	2/6/2014	3/21/2014	4/14/2014	5/6/2014	6/5/2014	7/29/2014	8/9/2014	9/22/2014	10/17/2014	11/21/2014	12/5/2014	1/16/2015
NH10	Eliz. River	NNB	1/9/2014	2/6/2014	3/21/2014LD	4/14/2014	5/6/2014	6/5/2014	7/29/2014	8/9/2014	9/22/2014	10/17/2014	11/21/2014	12/5/2014	1/16/2015
NH12	Eliz. River	NNB	1/9/2014	2/6/2014	3/21/2014	4/14/2014	5/6/2014	6/5/2014	7/29/2014	8/9/2014	9/22/2014	10/17/2014	11/21/2014	12/5/2014	1/16/2015
NH14	Eliz. River	NNB	1/9/2014	2/6/2014	3/21/2014	4/14/2014	5/6/2014	6/5/2014	7/29/2014	8/9/2014	9/22/2014	10/17/2014	11/21/2014	12/5/2014	1/16/2015
APMI	Eliz. River	Eliz. River	1/9/2014	2/6/2014	3/21/2014	4/14/2014	5/6/2014	6/5/2014	7/29/2014	8/9/2014	9/22/2014	10/17/2014	11/21/2014	12/5/2014	1/16/2015
NH29	Eliz. River	Eliz. River	1/9/2014	2/6/2014	3/21/2014	4/14/2014	5/6/2014	6/5/2014	7/29/2014	8/9/2014	9/22/2014	10/17/2014	11/21/2014	12/5/2014	1/16/2015
NH32	Eliz. River	Eliz. River	1/9/2014	2/6/2014	3/21/2014	4/14/2014	5/6/2014	6/5/2014	7/29/2014	8/9/2014	9/22/2014	10/17/2014	11/21/2014	12/5/2014	1/16/2015
NH36	Eliz. River	Eliz. River	1/9/2014	2/6/2014	3/21/2014	4/14/2014	5/6/2014	6/5/2014	7/29/2014	8/9/2014	9/22/2014	10/17/2014	11/21/2014	12/5/2014	1/16/2015
Y PAGE	York River	NW/Ch.	1/2/2014	2/5/2014	3/11/2014	3/29/2014	5/2/2014	6/3/2014	6/30/2014	8/13/2014	9/10/2014	10/1/2014	11/5/2014	12/3/2014	1/21/2015
Y WAT	York River	NW/Ch.	1/2/2014	2/5/2014	3/11/2014	3/29/2014	5/2/2014	6/3/2014	6/30/2014	8/13/2014	9/10/2014	10/1/2014	11/5/2014	12/3/2014	1/21/2015
Y2	York River	NW/Ch.	1/2/2014	2/5/2014	3/11/2014	3/29/2014	5/2/2014	6/3/2014	6/30/2014	8/13/2014	9/10/2014	10/1/2014	11/5/2014	12/3/2014	1/21/2015
Y8	York River	NW/Ch.	1/2/2014	2/5/2014	3/11/2014	3/29/2014	5/2/2014	6/3/2014	6/30/2014	8/13/2014	9/10/2014	10/1/2014	11/5/2014	12/3/2014	1/21/2015
Y BELL NOAA	York River		1/2/2014	2/5/2014	3/11/2014	3/29/2014	5/2/2014	6/3/2014	6/30/2014	8/13/2014	9/10/2014	10/1/2014	11/5/2014	12/3/2014	1/21/2015
Y12	York River		1/2/2014	2/5/2014	3/11/2014	3/29/2014	5/2/2014	6/3/2014	6/30/2014	8/13/2014	9/10/2014	10/1/2014	11/5/2014	12/3/2014	1/21/2015
Y18 NOAA	York River		1/2/2014	2/5/2014	3/11/2014	3/29/2014	5/2/2014	6/3/2014	6/30/2014	8/13/2014	9/10/2014	10/1/2014	11/5/2014	12/3/2014	1/21/2015
Y20 NOAA	York River		1/2/2014	2/5/2014	3/11/2014	3/29/2014	5/2/2014	6/3/2014	6/30/2014	8/13/2014	9/10/2014	10/1/2014	11/5/2014	12/3/2014	1/21/2015
Y29 NOAA	York River		1/2/2014	2/5/2014	3/11/2014	3/29/2014	5/2/2014	6/3/2014	6/30/2014	8/13/2014	9/10/2014	10/1/2014	11/5/2014	12/3/2014	1/21/2015
PAM Johns	Pam. River		1/3/2014	2/4/2014	3/20/2014	4/10/2014	5/15/2014	6/2/2014	7/26/2014	8/12/2014	9/11/2014	11/7/2014	11/15/2014	12/1/2014	1/6/2015

Receiver Site	Region	Military zone	1st trip 2014	2nd trip 2014	3rd trip 2014	4th trip 2014	5th trip 2014	6th trip 2014	7th trip 2014	8th trip 2014	9th trip 2014	10th trip 2014	11th trip 2014	12th trip 2014	1st trip 2015
PAM Res.	Pam. River		1/3/2014	2/4/2014	3/20/2014	4/10/2014	5/1/2014	6/2/2014	7/26/2014	8/12/2014	9/17/2014	10/6/2014	11/3/2014	12/1/2014	1/6/2015
PAM Soffin	Pam. River		1/3/2014	2/4/2014	3/20/2014	4/10/2014	5/1/2014	6/2/2014	7/26/2014	8/12/2014	9/17/2014	10/6/2014	11/3/2014	12/1/2014	1/6/2015
PAM Williams	Pam. River		not reachable	2/4/2014	3/20/2014	4/10/2014	5/1/2014	6/2/2014	7/26/2014	8/12/2014	9/17/2014	10/6/2014	11/3/2014	12/1/2014	1/6/2015
PAM 360	Pam. River		1/3/2014	2/4/2014	3/20/2014	4/10/2014	5/1/2014	6/2/2014	7/26/2014	8/12/2014	9/17/2014	10/6/2014	11/3/2014	12/1/2014	1/6/2015
PAM top $	Pam. River	new in 2014	seasonal							8/11/2014D	9/11/2014	10/6/2014	11/4/2014		
PAM TOP 1	Pam. River	new in 2014	seasonal						7/26/2014D	8/12/2014	9/11/2014CRD	10/6/2014	11/4/2014		
PAM rootball	Pam. River	new in 2014	seasonal							8/11/2014D	9/11/2014	10/6/2014	11/4/2014		
PAM hickory	Pam. River	new in 2014	seasonal						7/21/2014D	8/12/2014	9/11/2014	10/6/2014	11/4/2014		
PAM farm H2O	Pam. River	new in 2014	seasonal						7/21/201D	8/14/2014	9/11/2014	10/6/2014	11/4/2014		
PAM William upper	Pam. River		seasonal				5/1/2014D	6/2/2014	7/26/2014	8/12/2014	9/17/2014	10/6/2014	11/4/2014		
PAM Lower up William	Pam. River	new in 2014	seasonal						7/26/2014D	8/12/2014	9/11/2014	10/6/2014	11/4/2014		
PAM Fossil Cliff	Pam. River	new in 2014	seasonal						7/26/2014D	8/12/2014	9/11/2014	10/6/2014	11/4/2014		
PAM William lower	Pam. River	new in 2014	seasonal						7/26/2014D	8/12/2014	9/11/2014	10/6/2014	11/4/2014		
PAM L. L. William	Pam. River	new in 2014	seasonal								9/5/2014D	10/6/2014	11/4/2014		
PAM poles	Pam. River	new in 2014	seasonal								9/15/2014D	10/6/2014	11/3/141		
PAM Brick wall	Pam. River		seasonal				5/1/2014D	6/2/2014	7/26/2014	8/12/2014	9/11/2014	10/6/2014	11/4/2014		
Chick. Bridge	Chick. River					3/13/2014	4/11/2014	5/10/2014	6/24/2014	7/31/2014		9/9/2014		12/2/2014	1/29/2015
Chick. Bridge CC side	Chick. River					3/20/2014D	4/11/2014	5/10/2014	6/24/2014	7/31/2014		9/9/2014		12/2/2014	1/29/2015

Receiver Site	Region	Military zone	1st trip 2015	2nd trip 2015	3rd trip 2015	4th trip 2015	5th trip 2015	6th trip 2015	7th trip 2015	8th trip 2015	9th trip 2015	10th trip 2015	11th trip 2015	12th trip 2015	1st trip 2016
CB	Atlantic	Range Sur.	1/11/2015	2/25/2015	3/9/2015	4/28/2015	5/18/2015	6/30/2015	7/23/2015	9/1/2015	9/15/2015	10/12/2015RD	10/21/2015	12/10/2015	1/14/2016
CB1	Atlantic	Range Sur.	1/11/2015	2/25/2015	3/9/2015	4/28/2015	5/18/2015	6/30/2015	7/23/2015	9/1/2015	9/15/2015	10/12/2015RD	12/10/2015	12/16/2015	1/14/2016
CB11	Atlantic	Range Sur.	1/11/2015	2/25/2015	3/9/2015	4/28/2015	5/18/2015	6/30/2015	7/14/2015	7/23/2015	9/1/2015	9/15/2015	10/12/2015	12/10/2015	1/14/2016
CB13	Atlantic	Range Sur.	1/11/2015	2/25/2015	3/9/2015	4/28/2015	5/18/2015	6/30/2015	7/14/2015	7/23/2015	9/1/2015	10/12/2015	10/12/2015	12/10/2015	1/14/2016
CB3	Atlantic	Range Sur.	1/11/2015	2/25/2015	3/9/2015	4/28/2015	5/18/2015	6/30/2015	7/23/2015	9/1/2015	9/15/2015	10/12/2015	12/10/2015	12/16/2015	1/14/2016
CB5	Atlantic	Range Sur.	1/11/2015	2/25/2015	3/9/2015	4/28/2015	5/18/2015	6/30/2015	7/23/2015	9/1/2015	9/15/2015	10/12/2015	10/21/2015	12/10/2015	1/14/2016
CB7	Atlantic	Range Sur.	1/11/2015	2/25/2015	3/9/2015	3/9/2015	4/28/2015	5/18/2015	6/30/2015	7/23/2015	9/1/2015	9/15/2015	10/12/2015	12/10/2015	1/14/2016
CB9	Atlantic	Range Sur.	1/11/2015	2/25/2015	3/9/2015	4/28/2015	5/18/2015	6/30/2015	7/14/2015	7/23/2015	9/1/2015	9/15/2015	10/12/2015	12/10/2015	1/14/2016
RA	Atlantic	Range Sur.	1/11/2015	2/25/2015	3/9/2015	4/28/2015	5/18/2015	6/30/2015	7/23/2015	9/1/2015	9/15/2015	10/12/2015	11/6/2015	12/16/2015	1/4/2016
RA outside	Atlantic	Range Sur.	1/11/2015	2/25/2015	3/9/2015	4/28/2015	5/18/2015RD	6/30/2015	7/23/2015	9/1/2015	9/15/2015	10/12/2015	11/6/2015	12/16/2015	1/4/2016
RI1	Atlantic	Range Sur.	1/11/2015	2/25/2015	3/9/2015	4/28/2015	5/18/2015	6/30/2015	7/23/2015	9/1/2015	9/15/2015	10/12/2015	11/6/2015	12/16/2015	1/4/2016
RI2	Atlantic	Range Sur.	1/11/2015	2/25/2015	3/9/2015	4/28/2015	5/18/2015	6/30/2015	7/23/2015	9/1/2015	9/15/2015	10/12/2015LD	11/6/2015	12/16/2015	1/4/2016
CH	Atlantic	Range Sur.	1/11/2015	2/25/2015	3/9/2015	4/29/2015	5/18/2015	6/30/2015	7/14/2015	8/26/2015	9/15/2015	10/22/2015	11/5/2015	12/2/2015	1/15/2016
CH1	Atlantic	Range Sur.	1/11/2015	2/25/2015	3/9/2015	4/29/2015	5/18/2015	6/30/2015	7/14/2015	8/26/2015	10/12/2015	10/22/2015	11/5/2015	12/10/2015	1/14/2016
NCB	Atlantic		1/11/2015	2/25/2015	3/9/2015	4/28/2015	5/18/2015	6/30/2015	7/14/2015	7/23/2015	9/1/2015	9/15/2015	10/21/2015	12/10/2015	1/14/2016
NCC	Atlantic		1/11/2015	2/25/2015	3/9/2015	4/28/2015	5/18/2015	6/30/2015	7/14/2015	7/23/2015	9/1/2015	9/15/2015	10/12/2015	12/10/2015	1/14/2016
NCD	Atlantic		1/11/2015	2/25/2015	3/9/2015	4/28/2015	5/18/2015	6/30/2015	7/14/2015	7/23/2015	9/1/2015	9/15/2015	10/12/2015	12/2/2015	1/14/2016
NCE	Atlantic		1/11/2015	2/25/2015	3/9/2015	4/28/2015	5/18/2015	6/30/2015	7/14/2015	7/23/2015	9/1/2015	9/15/2015	10/12/2015	12/2/2015	1/14/2016
2CH	Ches. Bay	Fort Story	1/11/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/23/2015RD	8/26/2015	9/15/2015	10/22/2015	11/5/2015	12/2/2015	1/15/2016
TS1	Ches. Bay	Fort Story	1/11/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/23/2015	8/26/2015	9/15/2015	10/22/2015	11/5/2015	12/2/2015	1/15/2016
TS3	Ches. Bay	Fort Story	1/11/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/23/2015	8/26/2015	9/16/2015	10/22/2015	11/5/2015	12/2/2015	1/15/2016
2C HENRY	Atlantic	Fort Story	1/11/2015	2/25/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	6/30/2015	7/14/2015	9/1/2015	9/15/2015	10/22/2015	12/12/2015	1/15/2016
CBBT4	Ches. Bay	Little Creek	1/20/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/25/2015	8/26/2015	9/16/2015	11/5/2015	12/2/2015	12/12/2015	1/15/2016
CBBT5	Ches. Bay	Little Creek	1/20/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/25/2015	8/26/2015	9/16/2015	11/5/2015	12/2/2015	12/12/2015	1/15/2016
LC1	Ches. Bay	Little Creek	1/20/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/25/2015	8/26/2015	9/16/2015	11/5/2015	12/2/2015	12/10/2015	1/15/2016
LC2	Ches. Bay	Little Creek	1/20/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/25/2015	8/26/2015	9/16/2015	11/5/2015	12/2/2015	12/10/2015	1/15/2016
TS7	Ches. Bay	Little Creek	1/20/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/25/2015	8/26/2015	9/16/2015	11/5/2015	12/2/2015	12/10/2015	1/15/2016
TS9	Ches. Bay	Little Creek	1/20/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/25/2015	8/26/2015	9/16/2015	11/5/2015	12/2/2015	12/10/2015	1/15/2016
TS11	Ches. Bay	Little Creek	1/20/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/25/2015	8/26/2015	9/16/2015	11/5/2015	12/2/2015	12/10/2015	1/15/2016
10N	Ches. Bay		1/20/2015	2/4/2015	3/9/2015RD	4/29/2015	5/26/2015	6/18/2015	7/25/2015	8/26/2015	9/16/2015	11/5/2015	12/2/15LD	12/12/15RD	1/15/2016
LS	Ches. Bay		1/20/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/25/2015	8/26/2015	9/16/2015	11/5/2015	12/2/2015	12/12/2015	1/15/2016
CBBT1	Ches. Bay		1/20/2015	2/4/2015	3/9/2015RD	4/29/2015	5/26/2015	6/18/2015	7/25/2015	8/26/2015	9/16/2015	11/5/2015	12/2/2015	12/12/2015	1/15/2016
CBBT2	Ches. Bay		1/20/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/25/2015	8/26/2015	9/16/2015	11/5/2015	12/2/2015LD	12/12/2015	1/15/2016
CBBT3	Ches. Bay		1/20/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/25/2015	8/26/2015LD	9/16/2015	11/5/2015	12/2/2015	12/12/2015	1/15/2016
CBBT7	Ches. Bay		1/20/2015LD	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/25/2015	8/26/2015	9/15/2015	11/5/2015LD	12/2/2015	12/12/2015	1/15/2016
TS5	Ches. Bay		1/11/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/23/2015	8/26/2015	9/16/2015	10/22/2015	11/5/2015	12/2/2015	1/15/2016

Receiver Site	Region	Military zone	1st trip 2015	2nd trip 2015	3rd trip 2015	4th trip 2015	5th trip 2015	6th trip 2015	7th trip 2015	8th trip 2015	9th trip 2015	10th trip 2015	11th trip 2015	12th trip 2015	1st trip 2016
B11	Ches. Bay		1/11/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/23/2015	8/26/2015	9/16/2015	10/22/2015	11/5/2015	12/2/2015	1/15/2016
B13	Ches. Bay		1/20/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/25/2015	8/26/2015	9/16/2015	11/5/2015	12/2/2015	1/15/2016	1/15/2016
B15	Ches. Bay		1/20/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/25/2015	8/26/2015	9/16/2015	10/22/2015	12/2/2015	1/15/2016	1/15/2016
B5	Ches. Bay		1/11/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/23/2015	8/26/2015	9/16/2015	10/22/2015	11/5/2015	12/2/2015	1/15/2016
B7	Ches. Bay		1/11/2015	1/11/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/23/2015	8/26/2015	10/22/2015	11/5/2015	12/2/2015	1/15/2016
B9	Ches. Bay		1/11/2015	2/4/2015	3/9/2015	4/29/2015	5/26/2015	6/18/2015	7/23/2015	8/26/2015	9/16/2015	10/12/2015	11/5/2015	12/2/2015	1/15/2016
NN 1ER FWS	James River	NNB	1/16/2015	2/12/2015	3/25/2015	4/11/2015	5/14/2015	6/10/2015	7/9/2015	8/6/2015	9/29/2015	10/15/2015	11/16/2015	11/30/2015	1/3/2016
NN 3ER NOAA SP	James River	NNB	1/16/2015	2/12/2015	3/25/2015	4/11/2015	5/14/2015	6/10/2015	7/9/2015	8/6/2015	9/29/2015	10/15/2015	11/16/2015	11/30/2015	1/3/2016
NN DANGER FWS	James River	NNB	1/16/2015	2/12/2015	3/25/2015	4/11/2015	5/14/2015	6/10/2015	7/9/2015	8/6/2015	9/29/2015	10/15/2015	11/16/2015	11/30/2015	1/3/2016
NN R22 NOAA SP	James River	NNB	1/16/2015	2/12/2015	3/25/2015	4/11/2015	5/14/2015	6/10/2015	7/9/2015	8/6/2015	9/29/2015	10/15/2015	11/16/2015	11/30/2015	1/3/2016
NN2	James River	NNB	1/16/2015	2/12/2015	3/25/2015	4/11/2015	5/14/2015	6/10/2015	7/9/2015	8/6/2015	9/29/2015	10/15/2015	11/16/2015	11/30/2015	1/3/2016
NN5	James River	NNB	1/16/2015	2/12/2015	3/25/2015	4/11/2015	5/14/2015	6/10/2015	7/9/2015	8/6/2015	9/29/2015	10/15/2015	11/16/2015	11/30/2015	1/3/2016
NN8	James River	NNB	1/16/2015	2/12/2015	3/25/2015	4/11/2015	5/14/2015	6/10/2015	7/9/2015	8/6/2015	9/29/2015	10/15/2015	11/16/2015	11/30/2015	1/3/2016
NH8	Eliz. River	NNB	1/16/2015	2/12/2015	3/25/2015	4/11/2015	5/14/2015	6/10/2015	7/9/2015	8/6/2015	9/29/2015	10/15/2015	11/16/2015	11/30/2015	1/3/2016
NH10	Eliz. River	NNB	1/16/2015	2/12/2015	3/25/2015	4/11/2015	5/14/2015	6/10/2015	7/9/2015	8/6/2015	9/29/2015	10/15/2015	11/16/2015	11/30/2015	1/3/2016
NH12	Eliz. River	NNB	1/16/2015	2/12/2015	3/25/2015	4/11/2015	5/14/2015	6/10/2015	7/9/2015	8/6/2015	9/29/2015	10/15/2015	11/16/2015	11/30/2015	1/3/2016
NH14	Eliz. River	NNB	1/16/2015	2/12/2015	3/25/2015	4/11/2015	5/14/2015	6/10/2015	7/9/2015	8/6/2015	9/29/2015	10/15/2015	11/16/2015	11/30/2015	1/3/2016
NH29	Eliz. River	Eliz. River	1/16/2015	2/12/2015	3/25/2015	4/11/2015	5/14/2015	6/10/2015	7/9/2015	8/6/2015	9/29/2015	10/15/2015	11/16/2015	11/30/2015	1/3/2016
NH32	Eliz. River	Eliz. River	1/16/2015	2/12/2015	3/25/2015	4/11/2015	5/14/2015	6/10/2015	7/9/2015	8/6/2015	9/29/2015	10/15/2015	11/16/2015	11/30/2015	1/3/2016
NH36	Eliz. River	Eliz. River	1/16/2015	2/12/2015	3/25/2015	4/11/2015	5/14/2015	6/10/2015	7/9/2015	8/6/2015	9/29/2015	10/15/2015	11/16/2015	11/30/2015	1/3/2016
APMI	Eliz. River	Eliz. River	1/16/2015	2/12/2015	3/25/2015	4/11/2015	5/14/2015	6/10/2015	7/9/2015	8/6/2015	9/29/2015	10/15/2015	11/16/2015	11/30/2015	1/3/2016
Y PAGE	York River	NW/Ch.	1/21/2015	2/6/2015	3/2/2015	4/13/2015	5/8/2015	6/1/2015	7/8/2015	8/3/2015	9/10/2015	10/9/2015	11/12/2015	11/27/2015	1/6/2016
Y WAT	York River	NW/Ch.	1/21/2015	2/6/2015	3/2/2015	4/13/2015	5/8/2015	6/1/2015	7/8/2015	8/3/2015	9/9/2015	10/9/2015	11/12/2015	11/27/2015	1/6/2016
Y2	York River	NW/Ch.	1/21/2015	2/6/2015	3/2/2015	4/13/2015	5/8/2015	6/1/2015	7/8/2015	8/3/2015	9/9/2015	10/9/2015	11/12/2015	11/27/2015	1/6/2016
Y8	York River	NW/Ch.	1/21/2015RD	2/6/2015	3/2/2015	4/13/2015	5/8/2015	6/1/2015	7/8/2015	8/3/2015	9/9/2015	10/9/2015	11/12/2015	11/27/2015	1/6/2016
Y BELL NOAA	York River		1/21/2015	2/6/2015	3/2/2015	4/13/2015	5/8/2015	6/1/2015	7/8/2015	8/3/2015	9/10/2015	10/9/2015	11/12/2015	11/27/2015	1/6/2016
Y12	York River		1/21/2015	2/6/2015	3/2/2015	4/13/2015	5/8/2015	6/1/2015	7/8/2015	8/3/2015	9/10/2015	10/9/2015	11/12/2015	11/27/2015	1/6/2016
Y18 NOAA	York River		1/21/2015	2/6/2015	3/2/2015	4/13/2015	5/8/2015	6/1/2015	7/8/2015	8/3/2015	9/10/2015	10/9/2015	11/12/2015	11/27/2015	1/6/2016
Y20 NOAA	York River		1/21/2015	2/6/2015	3/2/2015	4/13/2015	5/8/2015	6/1/2015	7/8/2015	8/3/2015	9/10/2015	10/9/2015	11/12/2015	11/27/2015	1/6/2016
Y29 NOAA	York River		1/21/2015	2/6/2015	3/2/2015	4/13/2015	5/8/2015	6/1/2015	7/8/2015	8/3/2015	9/10/2015	10/9/2015	11/12/2015	11/27/2015	1/6/2016
Y35	York River	new in 2015	1/21/2015	2/6/2015	3/2/2015	4/13/2015	5/8/2015	6/1/2015	7/8/2015	8/3/2015	9/10/2015	10/9/2015	11/12/2015	11/27/2015	1/6/2016
PAM Johns	Pam. River		1/6/2015	3/11/2015	4/7/2015	4/16/2015	5/5/2015	6/26/2015	7/1/2015	7/30/2015	8/14/2015	9/2/2015	10/13/2015	11/9/2015	1/2/2016
PAM Res.	Pam. River		1/6/2015	2/1/2015	3/10/2015	4/7/2015	5/5/2015	6/26/2015	7/8/2015	8/14/2015	9/25/2015	10/23/2015	11/2/2015	12/1/2015	1/2/2016
PAM Soffin	Pam. River		1/6/2015	2/1/2015	3/10/2015	4/7/2015	5/5/2015	6/26/2015	7/8/2015	8/14/2015	9/25/2015	10/23/2015	11/2/2015	12/1/2015	1/2/2016
PAM Williams	Pam. River		1/6/2015	2/1/2015	3/10/2015	4/7/2015	5/5/2015	6/26/2015	7/8/2015	8/14/2015	9/25/2015	10/23/2015	11/2/2015	12/1/2015	1/19/2016
PAM 360	Pam. River		1/6/2015	2/1/2015	3/10/2015	4/7/2015	5/5/2015	6/26/2015	7/29/2015	not reachable	9/25/2015	10/23/2015	11/2/2015	12/1/2015	1/2/2016
PAM top $	Pam. River		seasonal					6/8/2015	9/8/2015	10/1/2015	10/28/2015	10/29/2015			
PAM rootball	Pam. River		seasonal					6/8/2015	9/8/2015	10/1/2015	10/28/2015	10/29/2015			
PAM TOP 1	Pam. River		seasonal					6/8/2015	9/8/2015	10/1/2015	10/28/2015	10/29/2015			
PAM hickory	Pam. River		seasonal					6/8/2015	9/8/2015	10/1/2015	10/28/2015	10/29/2015			
PAM farm H2O	Pam. River		seasonal					6/8/2015	9/8/2015	10/1/2015	10/28/2015	10/29/2015			
PAM William upper	Pam. River		seasonal					6/8/2015	7/29/2015	8/11/2015	9/25/2015	10/1/2015	10/1/2015	10/29/2015	
PAM Lower up William	Pam. River		seasonal					6/8/2015	7/29/2015	8/11/2015	9/25/2015	10/1/2015	10/28/2015	10/29/2015	
PAM Fossil Cliff	Pam. River		seasonal					6/8/2015	7/29/2015	8/11/2015	9/25/2015	10/1/2015	10/28/2015	10/29/2015	
PAM William lower	Pam. River		seasonal					6/8/2015	7/29/2015	8/11/2015	9/25/2015	10/1/2015	10/28/2015	10/29/2015	
PAM L. L. William	Pam. River		seasonal					6/8/2015	7/29/2015	8/11/2015	9/25/2015	10/1/2015	10/28/2015	10/29/2015	
PAM 4.5	Pam. River	new in 2015	seasonal					6/11/2015	7/29/2015	8/11/2015	9/25/2015	10/1/2015	10/28/2015	10/29/2015	
PAM poles	Pam. River		seasonal					6/8/2015	7/29/2015	8/11/2015	9/25/2015	10/1/2015	10/28/2015	10/29/2015	
PAM Brick wall	Pam. River		seasonal					6/8/2015	7/29/2015	8/11/2015	9/25/2015	10/1/2015	10/28/2015	10/29/2015	
PAM BBW	Pam. River	new in 2015	seasonal					6/11/2015	7/29/2015	8/11/2015	9/25/2015	10/1/2015	10/28/2015	10/29/2015	
Chick. Bridge	Chick. River		1/29/2015	2/28/2015	3/24/2015	4/7/2015	6/5/2015	7/1/2015	7/28/2015	9/30/2015	10/23/2015	11/3/2015	12/7/2015	1/7/2016	
Chick. Bridge CC side	Chick. River		1/29/2015	2/28/2015	3/24/2015	4/7/2015	6/5/2015	7/1/2015	7/28/2015	9/30/2015	10/23/2015	11/3/2015	12/7/2015	1/7/2016	

Receiver Site	Region	Military zone	1st trip 2016	2nd trip 2016	3rd trip 2016	4th trip 2016	5th trip 2016	6th trip 2016	7th trip 2016	8th trip 2016	9th trip 2016	10th trip 2016	11th trip 2016	12th trip 2016	1st trip 2017
CB	Atlantic	Range Sur.	1/14/2016	2/28/2016	3/8/2016	5/12/2016	5/25/2016	6/15/2016	6/29/2016	8/26/2016	9/27/2016	10/19/2016	11/2/2016	12/21/2016	1/5/2017
CB1	Atlantic	Range Sur.	1/14/2016	2/28/2016	3/8/2016	5/12/2016	5/25/2016	6/15/2016	6/29/2016	8/26/2016	9/27/2016	10/19/2016	11/2/2016	12/21/2016	1/5/2017
CB11	Atlantic	Range Sur.	1/14/2016	2/28/2016	3/8/2016	5/12/2016	5/25/2016	6/15/2016	7/7/2016	8/26/2016	9/27/2016	10/19/2016	11/2/2016	12/21/2016	1/5/2017
CB13	Atlantic	Range Sur.	1/14/2016	2/28/2016	3/8/2016	5/12/2016	5/25/2016	6/15/2016	7/7/2016	8/26/2016	9/27/2016	10/19/2016	11/2/2016	12/21/2016	1/5/2017
CB3	Atlantic	Range Sur.	1/14/2016	2/28/2016	3/8/2016	5/12/2016	5/25/2016	6/15/2016	6/29/2016	8/26/2016	9/27/2016	10/19/2016	11/2/2016	12/21/2016	1/5/2017
CB5	Atlantic	Range Sur.	1/14/2016	2/28/2016	3/8/2016	5/12/2016	5/25/2016	6/15/2016	6/29/2016	8/26/2016	9/27/2016	10/19/2016	11/2/2016	12/21/2016	1/5/2017
CB7	Atlantic	Range Sur.	1/14/2016	2/28/2016	3/8&9/2016	5/12/2016	5/25/2016	6/15/2016	7/7/2016	8/26/2016	9/27/2016	10/19/2016	11/2/2016	12/21/2016	1/5/2017
CB9	Atlantic	Range Sur.	1/14/2016	2/28/2016	3/18/2016	5/12/2016RBD	5/25/2016	6/15/2016	7/7/2016	8/26/2016	9/27/2016	10/19/2016	11/2/2016	12/21/2016	1/5/2017
RA	Atlantic	Range Sur.	1/14/2016	2/28/2016	3/9/2016	5/8/2016	5/25/2016	6/29/2016	not reached	8/26/2016	9/27/2016	10/19/2016	11/2/2016	12/21/2016	1/5/2017
RA outside	Atlantic	Range Sur.	1/14/2016	2/27/2016	3/9/2016	5/8/2016	5/25/2016	6/29/2016	not reached	8/26/2016	9/27/2016	10/19/2016	11/2/2016	12/21/2016	1/5/2017
RI1	Atlantic	Range Sur.	1/14/2016	2/27/2016	3/9/2016	5/8/2016	5/25/2016	6/29/2016	not reached	8/26/2016	9/27/2016	10/19/2016	11/2/2016	12/21/2016	1/5/2017
RI2	Atlantic	Range Sur.	1/14/2016	2/27/2016	3/9/2016	5/8/2016	5/25/2016	6/29/2016	not reached	8/26/2016	9/27/2016	10/19/2016	11/2/2016	12/21/2016	1/5/2017
CH	Atlantic	Range Sur.	1/15/2016	2/28/2016	3/8/2016	4/25/2016	5/9/2016	6/15/2016	7/7/2016	8/26/2016	9/27/2016	10/13/2016	11/2/2016	12/8/2016	1/5/2017
CH1	Atlantic	Range Sur.	1/14/2016	2/28/2016	3/8/2016	4/25/2016	5/9/2016	6/15/2016	7/7/2016	8/26/2016	9/27/2016	10/13/2016	11/2/2016	12/8/2016	1/5/2017
NCB	Atlantic		1/14/2016	2/28/2016	3/8&18/2016	5/12/2016	5/25/2016	6/15/2016	7/7/2016	8/26/2016	9/27/2016	10/19/2016	11/2/2016	12/21/2016	1/5/2017
NCC	Atlantic		1/14/2016	2/28/2016	3/8&18/2016R USCG D	5/12/2016	5/25/2016	6/15/2016	7/7/2016	8/26/2016	9/27/2016	10/19/2016	11/2/2016	12/21/2016	1/5/2017
NCD	Atlantic		1/14/2016	2/28/2016	3/3&18/2016	5/12/2016	5/25/2016	6/15/2016	7/7/2016	8/26/2016	9/27/2016	10/19/2016	11/2/2016	12/21/2016	1/5/2017
NCE	Atlantic		1/14/2016	2/28/2016	3/8/2016	5/12/2016	5/25/2016	6/15/2016	7/7/2016	8/26/2016	9/27/2016	10/19/2016	11/2/2016	12/21/2016	1/5/2017
2CH	Ches. Bay	Fort Story	1/15/2016	2/28/2016	3/8/2016	4/25/2016	5/9/2016	6/9/2016RBD	7/7/2016	8/26/2016	9/27/2016	10/13/2016	11/18/2016	12/8/2016	1/18/2017
TS1	Ches. Bay	Fort Story	1/15/2016	2/28/2016	3/8/2016	4/25/2016	5/9/2016	6/9/2016	7/7/2016	8/5/2016	9/27/2016	10/13/2016	11/18/2016	12/8/2016	1/18/2017
TS3	Ches. Bay	Fort Story	1/15/2016	2/28/2016	3/8/2016	4/25/2016	5/9/2016	6/9/2016	7/7/2016	8/5/2016	9/27/2016	10/13/2016	11/18/2016	12/8/2016	1/18/2017
2C HENRY	Atlantic	Fort Story	1/15/2016	2/28/2016	3/8/2016	4/25/2016	5/9/2016	6/15/2016	7/7/2016	8/26/2016	9/28/2016	10/13/2016	11/2/2016	12/8/2016	1/5/2017
CBBT4	Ches. Bay	Little Creek	1/15/2016	2/29/2016	3/18/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/28/2016	10/13/2016	11/18/2016	12/8/2016	1/18/2017
CBBT5	Ches. Bay	Little Creek	1/15/2016	2/29/2016	3/18/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/28/2016	10/13/2016	11/18/2016	12/8/2016	1/17/2017
LC1	Ches. Bay	Little Creek	1/15/2016	2/29/2016	3/8/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/28/2016	10/13/2016	11/18/2016	12/8/2016	1/18/2017
LC2	Ches. Bay	Little Creek	1/15/2016	2/29/2016	3/18/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/28/2016	10/13/2016	11/18/2016	12/8/2016	1/18/2017
TS7	Ches. Bay	Little Creek	1/15/2016	2/29/2016	3/18/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/28/2016	10/13/2016	11/18/2016	12/8/2016	1/17/2017
TS9	Ches. Bay	Little Creek	1/15/2016	2/29/2016	3/18/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/28/2016	10/13/2016	11/18/2016	12/8/2016	1/17/2017
TS11	Ches. Bay	Little Creek	1/15/2016	2/29/2016R USCG D	3/18/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/28/2016	10/13/2016	11/18/2016	12/8/2016	1/18/2017
10N	Ches. Bay		1/15/2016	2/29/2016	3/18/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/28/2016	10/13/2016	11/18/2016	12/8/2016	1/17/2017
LS	Ches. Bay		1/15/2016	2/29/2016	3/18/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/28/2016	10/13/2016	11/18/2016	12/8/2016	1/18/2017RD
CBBT1	Ches. Bay		1/15/2016	2/29/2016	3/18/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/28/2016	10/13/2016	11/18/2016	12/8/2016	1/18/2017
CBBT2	Ches. Bay		1/15/2016	2/29/2016	3/18/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/28/2016	10/13/2016	11/18/2016	12/8/2016	1/18/2017
CBBT3	Ches. Bay		1/15/2016	2/29/2016	3/18/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/28/2016LD	10/13/2016	11/18/2016	12/8/2016	1/17/2017
CBBT7	Ches. Bay		1/15/2016	2/29/2016	3/18/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/28/2016	10/13/2016	11/18/2016	12/8/2016	1/18/2017
TS5	Ches. Bay		1/15/2016	2/29/2016	3/18/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/28/2016	10/13/2016	11/18/2016	12/8/2016	1/18/2017
B11	Ches. Bay		1/15/2016	2/28/2016	3/8/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/27/2016	10/13/2016	11/18/2016	12/8/2016	1/18/2017
B13	Ches. Bay		1/15/2016	2/29/2016	3/8/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/28/2016	10/13/2016	11/18/2016	12/8/2016	1/17/2017
B15	Ches. Bay		1/15/2016	2/29/2016	3/8/2016	4/25/2016	5/9/2016	6/9/2016	7/7/2016	8/5/2016	9/27/2016	10/13/2016	11/18/2016	12/8/2016	1/17/2017
B5	Ches. Bay		1/15/2016	2/29/2016	3/8/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/27/2016	10/13/2016	11/18/2016	12/8/2016	1/18/2017
B7	Ches. Bay		1/15/2016	2/29/2016	3/8/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/27/2016	10/13/2016	11/18/2016	12/8/2016	1/18/2017
B9	Ches. Bay		1/15/2016	2/29/2016	3/8/2016	4/25/2016	5/9/2016	6/9/2016	7/8/2016	8/5/2016	9/27/2016	10/13/2016	11/18/2016	12/8/2016	1/18/2017
NN 1ER FWS	James River	NNB	1/3/2016	2/17/2016	3/30/2016	4/15/2016	5/20/2016	6/7/2016	7/18/2016	8/18/2016	9/12/2016	10/18/2016	11/15/2016	12/1/2016	1/13/2017
NN 3ER NOAA SP	James River	NNB	1/3/2016	2/17/2016	3/30/2016	4/15/2016	5/20/2016	6/7/2016	7/18/2016	8/18/2016	9/12/2016	10/18/2016	11/15/2016	12/1/2016	1/13/2017
NN DANGER FWS	James River	NNB	1/3/2016	2/17/2016	3/30/2016	4/15/2016	5/20/2016	6/7/2016	7/18/2016	8/18/2016	9/12/2016	10/18/2016	11/15/2016	12/1/2016	1/13/2017
NN R22 NOAA SP	James River	NNB	1/3/2016	2/17/2016	3/30/2016	4/15/2016	5/20/2016	6/7/2016	7/18/2016	8/18/2016	9/12/2016	10/18/2016	11/15/2016	12/1/2016	1/13/2017
NN2	James River	NNB	1/3/2016	2/17/2016	3/30/2016	4/15/2016	5/20/2016	6/7/2016	7/18/2016	8/18/2016	9/12/2016	10/18/2016	11/15/2016	12/1/2016	1/13/2017
NN5	James River	NNB	1/3/2016	2/17/2016	3/30/2016	4/15/2016	5/20/2016	6/7/2016	7/18/2016	8/18/2016	9/12/2016	10/18/2016	11/15/2016	12/1/2016	1/13/2017
NN8	James River	NNB	1/3/2016	2/17/2016	3/30/2016	4/15/2016	5/20/2016	6/7/2016	7/18/2016	8/18/2016	9/12/2016	10/18/2016	11/15/2016	12/1/2016	1/13/2017
NH8	Eliz. River	NNB	1/3/2016	2/17/2016	3/30/2016	4/15/2016	5/20/2016	6/7/2016	7/18/2016	8/18/2016	9/12/2016	10/18/2016	11/15/2016	12/1/2016	1/13/2017
NH10	Eliz. River	NNB	1/3/2016	2/17/2016	3/30/2016	4/15/2016	5/20/2016	6/7/2016	7/18/2016	8/18/2016	9/12/2016	10/18/2016	11/15/2016	12/1/2016	1/13/2017
NH12	Eliz. River	NNB	1/3/2016	2/17/2016	3/30/2016	4/15/2016	5/20/2016	6/7/2016	7/18/2016	8/18/2016	9/12/2016	10/18/2016	11/15/2016	12/1/2016	1/13/2017
NH14	Eliz. River	NNB	1/3/2016	2/17/2016	3/30/2016	4/15/2016	5/20/2016	6/7/2016	7/18/2016	8/18/2016	9/12/2016	10/18/2016	11/15/2016	12/1/2016	1/13/2017
NH29	Eliz. River	Eliz. River	1/3/2016	2/17/2016	3/30/2016	4/15/2016	5/20/2016	6/7/2016	7/18/2016	8/18/2016	9/12/2016	10/18/2016	11/15/2016	12/1/2016	1/13/2017

Receiver Site	Region	Military zone	1st trip 2016	2nd trip 2016	3rd trip 2016	4th trip 2016	5th trip 2016	6th trip 2016	7th trip 2016	8th trip 2016	9th trip 2016	10th trip 2016	11th trip 2016	12th trip 2016	1st trip 2017
NH32	Eliz. River	Eliz. River	1/3/2016	2/17/2016	3/30/2016	4/15/2016	5/20/2016	6/7/2016	7/18/2016	8/18/2016	9/12/2016	10/18/2016	11/15/2016	12/1/2016	1/13/2017
NH36	Eliz. River	Eliz. River	1/3/2016	2/17/2016	3/30/2016	4/15/2016	5/20/2016	6/7/2016	7/18/2016	8/18/2016	9/12/2016	10/18/2016	11/15/2016	12/1/2016	1/13/2017
APMI	Eliz. River	Eliz. River	1/3/2016	2/17/2016	3/30/2016	4/15/2016	5/20/2016	6/7/2016	7/18/2016	8/18/2016	9/12/2016	10/18/2016	11/15/2016	12/1/2016	1/13/2017
Y PAGE/Y6	York River	NW/Ch.	1/6/2016	2/2/2016	3/3/2016	4/14/2016	5/19/2016	6/3/2016	6/30/2016	8/3/2016	8/31/2016	10/12/2016	L USN collision	12/2/2016	1/4/2017
Y WAT	York River	NW/Ch.	1/6/2016	2/2/2016	3/3/2016	4/14/2016	5/19/2016	6/3/2016	6/30/2016	8/3/2016	8/31/2016	10/12/2016	11/16/2016	12/2/2016	1/4/2017
Y2	York River	NW/Ch.	1/6/2016	2/2/2016	3/3/2016	4/14/2016	5/19/2016	6/3/2016	6/30/2016	8/3/2016	8/31/2016	10/12/2016	11/16/2016	12/2/2016	1/4/2017
Y8	York River	NW/Ch.	1/6/2016	2/2/2016	3/3/2016	4/14/2016	5/19/2016	6/3/2016	6/30/2016	8/3/2016	8/31/2016	10/12/2016	11/16/2016	12/2/2016	1/4/2017
Y BELL NOAA	York River		1/6/2016	2/2/2016	3/3/2016	4/14/2016	5/19/2016	6/3/2016	6/30/2016	8/3/2016	8/31/2016	10/12/2016	11/16/2016	12/2/2016	1/4/2017
Y12	York River		1/6/2016	2/2/2016	3/3/2016	4/14/2016	5/19/2016	6/3/2016	6/30/2016	8/3/2016	8/31/2016	10/12/2016	11/16/2016	12/2/2016	1/4/2017
Y18 NOAA	York River		1/6/2016	2/2/2016	3/3/2016	4/14/2016	5/19/2016	6/3/2016	6/30/2016	8/3/2016	8/31/2016	10/12/2016	11/16/2016	12/2/2016	1/4/2017
Y20 NOAA	York River		1/6/2016	2/2/2016	3/3/2016	4/14/2016	5/19/2016	6/3/2016	6/30/2016	8/3/2016	8/31/2016	10/12/2016	11/16/2016	12/2/2016	1/4/2017
Y29 NOAA	York River		1/6/2016	2/2/2016	3/3/2016	4/14/2016	5/19/2016	6/3/2016	6/30/2016	8/3/2016	8/31/2016	10/12/2016	11/16/2016	12/2/2016	1/4/2017
Y35	York River	new in 2015	1/6/2016	2/2/2016	3/3/2016	4/14/2016	5/19/2016	6/3/2016	6/30/2016	8/3/2016	8/31/2016	10/12/2016	11/16/2016	12/2/2016	1/4/2017
PAM Johns/neighbor	Pam. River		1/2/2016	2/3/2016	3/27/2016	4/23/2016	5/2/2016	6/2/2016	7/6/2016	8/24/2016	not available	10/31/2016	11/28/2016	12/30/2016	1/12/2017
PAM Res.	Pam. River		1/2/2016	2/3/2016	3/27/2016	4/23/2016	5/2/2016	6/2/2016	7/15/2016	8/24/2016	9/15/2016	10/4/2016	10/31/2016	11/28/2016	1/2/2017
PAM Soffin	Pam. River		1/2/2016	2/3/2016	3/27/2016	4/23/2016	5/2/2016	6/2/2016	7/15/2016	8/24/2016	9/15/2016	10/4/2016	10/31/2016	11/28/2016	1/2/2017
PAM Williams	Pam. River		1/2/2016	2/3/2016	3/27/2016	4/23/2016	5/2/2016	6/2/2016	7/15/2016	8/24/2016	9/15/2016	10/4/2016	10/31/2016	11/28/2016	1/2/2017
PAM 360	Pam. River		1/2/2016	2/3/2016	3/27/2016	4/23/2016	5/2/2016	6/2/2016	7/15/2016	8/24/2016	9/15/2016	10/4/2016	10/31/2016	11/28/2016	1/2/2017
PAM top $	Pam. River		seasonal					6/14/2016			9/15/2016	10/24/2016			
PAM rootball	Pam. River		seasonal					6/13/2016			9/15/2016	10/24/2016			
PAM TOP 1	Pam. River		seasonal					6/13/2016			9/15/2016	10/24/2016			
PAM hickory	Pam. River		seasonal					6/13/2016			9/15/2016	10/24/2016			
PAM farm H2O	Pam. River		seasonal					6/13/2016				10/24/2016			
PAM William upper	Pam. River		seasonal					6/13/2016	7/15/2016		9/29/2016	10/24/2016			
PAM Lower up William	Pam. River		seasonal					6/13/2016			9/29/2016	10/24/2016			
PAM Fossil Cliff	Pam. River		seasonal					6/13/2016				10/24/2016			
PAM William lower	Pam. River		seasonal					6/13/2016				10/24/2016			
PAM L. L. William	Pam. River		seasonal					6/13/2016			9/15/2016	10/24/2016			
PAM 4.5	Pam. River	new in 2015	seasonal					6/13/2016				10/24/2016			
PAM poles	Pam. River		seasonal					6/13/2016				10/24/2016			
PAM Brick wall	Pam. River		seasonal					6/13/2016	9/15/2016	10/24/2016		10/24/2016			
PAM BBW	Pam. River	new in 2015	seasonal					6/13/2016			9/15/2016	10/24/2016			
PAM Shady Hole	Pam. River	new in 2016	seasonal					6/14/2016				10/24/2016			
PAM Powerlines	Pam. River	new in 2016	seasonal					6/14/2016			9/15/2016	10/24/2016			
PAM Glens	Pam. River	new in 2016	seasonal							8/30/2016		11/7/2016			
PAM 21	Pam. River	new in 2016	seasonal						7/15/2016			10/24/2016			
PAM 27	Pam. River	new in 2016	seasonal						7/15/2016			10/24/2016			
PAM duck blind	Pam. River	new in 2016	seasonal							8/30/2016		11/7/2016			
PAM 30	Pam. River	new in 2016	seasonal						7/15/2016			10/24/2016			
PAM Leaning Hickory	Pam. River	new in 2016	seasonal							8/30/2016		11/7/2016			
PAM Boathouse	Pam. River	new in 2016	seasonal					7/15/2016	10/24/2016			10/24/2016			
Chick. Bridge	Chick. River		1/7/2016	2/8/2016	3/31/2016	4/13/2016		6/28/2016		8/29/2016	9/30/2016	10/25/2016	11/1/2016	12/28/2016	1/19/2017
Chick. Bridge CC side	Chick. River		1/7/2016	2/8/2016	3/31/2016	4/13/2016		6/28/2016		8/29/2016	9/30/2016	10/25/2016	11/1/2016	12/28/2016	1/19/2017
Walls	Matt. River	new in 2016	seasonal								9/26/2016		11/7/2016		
Mike's Branch	Matt. River	new in 2016	seasonal								9/26/2016		11/7/2016		
Above Whitehall	Matt. River	new in 2016	seasonal						7/5/2016				11/7/2016		
White Oak Landing	Matt. River	new in 2016	seasonal								9/26/2016		11/7/2016		

Receiver Site	Region	Military zone	1st trip 2017	2nd trip 2017	3rd trip 2017	4th trip 2017	5th trip 2017	6th trip 2017	7th trip 2017	8th trip 2017	9th trip 2017	10th trip 2017	11th trip 2017	12th trip 2017	1st trip 2018
CB	Atlantic	Range Sur.	1/5/2017	2/6/2017	3/9/2017	4/28/2017	5/16/2017	6/27/2017	7/18/2017	8/11/2017	10/10/2017	11/2/2017	11/21/2017	12/7/2017	1/22/2018
CB1	Atlantic	Range Sur.	1/5/2017	2/6/2017	3/9/2017	4/28/2017	5/16/2017	6/27/2017	7/18/2017	8/11/2017	10/10/2017	11/2/2011	11/21/2017	12/7/2017	1/22/2018
CB11	Atlantic	Range Sur.	1/5/2017	2/6/2017	3/9/2017	4/28/2017	5/16/2017	6/27/2017	7/18/2017	8/11/2017R USCG D	10/10/2017	11/2/2017	11/21/2017	12/7/2017	1/22/2018
CB13	Atlantic	Range Sur.	1/5/2017	2/6/2017	3/9/2017	4/28/2017	5/16/2017	6/27/2017	7/18/2017	8/11/2017	10/10/2017	11/2/2017	11/21/2017	12/7/2017	1/22/2018
CB3	Atlantic	Range Sur.	1/5/2017	2/6/2017	3/9/2017	4/28/2017RD	5/16/2017	6/27/2017	7/18/2017	8/11/2017R USCG D	10/10/2017	11/2/2017	11/21/2017	12/7/2017	1/22/2018
CB5	Atlantic	Range Sur.	1/5/2017	2/6/2017	3/9/2017	4/28/2017	5/16/2017	6/27/2017	7/18/2017	8/11/2017R USCG D	10/10/2017	11/2/2017	11/21/2017	12/7/2017	1/22/2018
CB7	Atlantic	Range Sur.	1/5/2017	2/6/2017	3/9/2017	4/28/2017	5/16/2017	6/27/2017	7/18/2017	8/11/2017	10/10/2017	11/2/2017	11/21/2017	12/7/2017	1/22/2018RD
CB9	Atlantic	Range Sur.	1/5/2017	2/6/2017	3/9/2017	4/28/2017	5/16/2017	6/27/2017	7/18/2017	8/11/2017	10/10/2017	11/2/2017	11/21/2017	12/7/2017	1/22/2018
RA	Atlantic	Range Sur.	1/5/2017	2/6/2017	3/9/2017	5/3/2017	5/16/2017	6/27/2017	7/18/2017	8/11/2017R USCG D	10/10/2017	11/1/2017	11/21/2017	12/17/2017	1/22/2018
RA outside	Atlantic	Range Sur.	1/5/2017	2/6/2017	3/9/2017	5/3/2017	5/16/2017	6/27/2017	7/18/2017	8/11/2017R USCG D	Buoy removed				
RI1	Atlantic	Range Sur.	1/5/2017	2/6/2017	3/9/2017	5/3/2017	5/16/2017	6/27/2017	7/18/2017	8/11/2017	10/10/2017	11/1/2017	11/21/2017	12/17/2017	1/22/2018
RI2	Atlantic	Range Sur.	1/5/2017	2/6/2017	3/9/2017	5/3/2017	5/16/2017	6/27/2017	7/18/2017	8/11/2017	10/10/2017	11/1/2017	11/21/2017	12/17/2017	1/22/2018
CH	Atlantic	Range Sur.	1/5/2017	2/6/2017	3/9/2017	4/28/2017	5/16/2017	6/26/2017	7/18/2017	8/11/2017	10/10/2017	11/2/2017	11/21/2017	11/28/2017 & 12/7/2017	1/11/2018
CH1	Atlantic	Range Sur.	1/5/2017	2/6/2017	3/9/2017	4/28/2017	5/16/2017	6/26/2017	7/18/2017	8/11/2017R USCG D	10/10/2017	11/2/2017	11/21/2017	11/28/2017 & 12/7/2017	1/11/2018
NCB	Atlantic		1/5/2017	2/6/2017	3/9/2017	4/28/2017	5/16/2017	6/26/2017	7/18/2017	8/11/2017R USCG D	10/10/2017	11/2/2017	11/21/2017	12/7/2017	1/22/2018
NCC	Atlantic		1/5/2017	2/6/2017	3/9/2017	4/28/2017	5/16/2017	6/26/2017	7/18/2017	8/17/2017	10/10/2017	11/2/2017	11/21/2017	12/7/2017	1/22/2018
NCD	Atlantic		1/5/2017	2/6/2017	3/9/2017	4/28/2017	5/16/2017	6/26/2017	7/18/2017	8/11/2017R USCG D	10/10/2017	11/2/2017	11/21/2017	12/7/2017	1/22/2018
NCE	Atlantic		1/5/2017	2/6/2017	3/9/2017	4/28/2017	5/16/2017	6/26/2017	7/18/2017	8/11/2017R USCG D	10/10/2017	11/2/2017	11/21/2017	12/7/2017	1/22/2018
2CH	Ches. Bay	Fort Story	1/18/2017	2/21/2017	3/17/2017	4/28/2017	5/17/2017	6/26/2017	7/20/2017	8/17/2017		11/2/2017	11/21/2017		1/11/2018
TS1	Ches. Bay	Fort Story	1/18/2017	2/21/2017	3/17/2017	5/3/2017	5/17/2017	6/26/2017	7/20/2017	8/17/2017	10/11/2017	11/2/2017	11/21/2017	11/28/2017	1/11/2018
TS3	Ches. Bay	Fort Story	1/18/2017	2/21/2017	3/17/2017	5/3/2017	5/17/2017	6/26/2017	7/20/2017	8/17/2017	10/11/2017	11/2/2017	11/28/2017	12/7/2017	1/11/2018
2C HENRY	Atlantic	Fort Story	1/5/2017	2/6/2017	3/9/2017	4/28/2017	5/16/2017	6/26/2017	7/18/2017	8/11/2017	10/10/2017	11/2/2017	11/21/2017	11/28/2017	1/11/2018
CBBT4	Ches. Bay	Little Creek	1/18/2017	2/6/2017	3/17/2017	4/28/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017	10/11/2017	11/2/2017	11/28/2017	12/7/2017	1/11/2018
CBBT5	Ches. Bay	Little Creek	1/17/2017	2/6/2017	3/17/2017	4/28/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017	10/11/2017	11/2/2017	11/28/2017	12/7/2017	1/11/2018
LC1	Ches. Bay	Little Creek	1/18/2017	2/21/2017	3/17/2017	5/3/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017	10/10/2017	11/2/2017	11/28/2017	12/7/2017	1/11/2018
LC2	Ches. Bay	Little Creek	1/18/2017	2/21/2017	3/17/2017	5/3/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017	10/10/2017	11/2/2017	11/28/2017	12/7/2017	1/11/2018
TS7	Ches. Bay	Little Creek	1/17/2017	2/21/2017	3/17/2017	5/3/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017	10/10/2017	10/11/2017 11/2/2017	11/28/2017	12/7/2017	1/11/2018
TS9	Ches. Bay	Little Creek	1/17/2017	2/21/2017	3/17/2017	5/3/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017	10/10/2017	10/11/2017 11/2/2017	11/28/2017	12/7/2017	1/11/2018
TS11	Ches. Bay	Little Creek	1/18/2017	2/21/2017	3/17/2017	5/3/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017	10/10/2017	10/11/2017RD 11/2/2017	11/28/2017RD	12/7/2017	1/11/2018
10N	Ches. Bay		1/17/2017	2/6/2017	3/17/2017	4/28/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017	10/11/2017	11/2/2017		12/7/2017	1/11/2018
LS	Ches. Bay		1/18/2017RD	2/6/2017	3/17/2017	4/28/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017	10/11/2017	11/2/2017	11/28/2017	12/7/2017	1/11/2018
CBBT1	Ches. Bay		1/18/2017	2/6/2017	3/17/2017	4/28/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017	10/11/2017	11/2/2017	11/28/2017	12/7/2017	1/11/2018
CBBT2	Ches. Bay		1/18/2017	2/6/2017	3/17/2017	4/28/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017	10/11/2017	11/2/2017	11/28/2017	12/7/2017	1/11/2018
CBBT3	Ches. Bay		1/17/2017	2/6/2017	3/17/2017	4/28/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017	10/11/2017	11/2/2017	11/28/2017	12/7/2017	1/11/2018
CBBT7	Ches. Bay		1/18/2017	2/6/2017	3/17/2017	4/28/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017	10/11/2017	11/2/2017	11/28/2017	12/7/2017	1/11/2018
TS5	Ches. Bay		1/18/2017	2/21/2017	3/17/2017	5/3/2017	5/17/2017	6/26/2017	7/20/2017	8/17/2017	10/11/2017	11/2/2017	11/28/2017	12/7/2017	1/11/2018
B11	Ches. Bay		1/18/2017	2/21/2017	3/17/2017	5/3/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017	10/11/2017	11/2/2017	11/28/2017	12/7/2017	1/11/2018
B13	Ches. Bay		1/17/2017	2/21/2017	3/17/2017	4/28/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017	10/11/2017	11/2/2017	11/28/2017	12/7/2017	1/11/2018
B15	Ches. Bay		1/17/2017	2/21/2017	3/9/2017	4/28/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017	10/11/2017	11/2/2017	11/28/2017	12/7/2017	1/11/2018
B5	Ches. Bay		1/18/2017	2/21/2017	3/17/2017	5/3/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017	10/11/2017	11/2/2017	11/28/2017		1/11/2018
B7	Ches. Bay		1/18/2017	2/21/2017	3/17/2017	5/3/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017	10/11/2017	11/2/2017	11/28/2017		1/11/2018
B9	Ches. Bay		1/18/2017	2/21/2017	3/17/2017	5/3/2017	5/17/2017	6/26/2017	7/20/2017	8/25/2017R USCGD	10/11/2017	11/2/2017	11/28/2017	12/7/2017	1/11/2018
NN 1ER FWS	James River	NNB	1/13/2017	2/2/2017	3/22/2017	4/21/2017	5/22/2017	6/6/2017	7/11/2017	7/27/2017	9/8/2017	10/2/2017	10/25/2017	12/13/2017	1/11/2018

Receiver Site	Region	Military zone	1st trip 2017	2nd trip 2017	3rd trip 2017	4th trip 2017	5th trip 2017	6th trip 2017	7th trip 2017	8th trip 2017	9th trip 2017	10th trip 2017	11th trip 2017	12th trip 2017	1st trip 2018
NN 3ER NOAA SP	James River	NNB	1/13/2017	2/2/2017	3/22/2017	4/21/2017	5/22/2017	6/6/2017	7/11/2017	7/27/2017	9/8/2017	10/2/2017	10/25/2017	12/15/2017	1/11/2018
NN DANGER FWS	James River	NNB	1/13/2017	2/2/2017	3/22/2017	4/21/2017	5/22/2017	6/6/2017	7/11/2017	7/27/2017	9/8/2017	10/2/2017	10/25/2017	12/13/2017	1/11/2018
NN R22 NOAA SP	James River	NNB	1/13/2017	2/2/2017	3/22/2017	4/21/2017	5/22/2017	6/6/2017	7/11/2017	7/27/2017	9/8/2017	10/2/2017	10/25/2017	12/13/2017	1/11/2018
NN2	James River	NNB	1/13/2017	2/2/2017	3/22/2017	4/21/2017	5/22/2017	6/6/2017	7/11/2017	7/27/2017	9/8/2017	10/2/2017	10/25/2017	12/15/2017	1/11/2018
NN5	James River	NNB	1/13/2017	2/2/2017	3/22/2017	4/21/2017	5/22/2017	6/6/2017	7/11/2017	7/27/2017	9/8/2017	10/2/2017	10/25/2017	12/15/2017	1/11/2018
NN8	James River	NNB	1/13/2017	2/2/2017	3/22/2017	4/21/2017	5/22/2017	6/6/2017	7/11/2017	7/27/2017	9/8/2017	10/2/2017	10/25/2017	12/15/2017	1/11/2018
NH8	Eliz. River	NNB	1/13/2017	2/2/2017	3/22/2017	4/21/2017	5/22/2017	6/6/2017	7/11/2017	7/27/2017	9/8/2017	10/2/2017	10/25/2017	12/15/2017	1/11/2018
NH10	Eliz. River	NNB	1/13/2017	2/2/2017	3/22/2017	4/21/2017	5/22/2017	6/6/2017	7/11/2017	7/27/2017	9/8/2017	10/2/2017	10/25/2017	12/15/2017	1/11/2018
NH12	Eliz. River	NNB	1/13/2017	2/2/2017	3/22/2017	4/21/2017	5/22/2017	6/6/2017	7/11/2017	7/27/2017	9/8/2017	10/2/2017	10/25/2017RD	12/15/2017	1/11/2018
NH14	Eliz. River	NNB	1/13/2017	2/2/2017	3/22/2017	4/21/2017	5/22/2017	6/6/2017	7/11/2017	7/27/2017	9/8/2017	10/2/2017	10/25/2017	12/15/2017	1/11/2018
NH29	Eliz. River	Eliz. River	1/13/2017	2/2/2017	3/22/2017	4/21/2017	5/22/2017	6/6/2017	7/11/2017	7/27/2017	9/8/2017	10/2/2017	10/25/2017	12/15/2017	1/11/2018
NH32	Eliz. River	Eliz. River	1/13/2017	2/2/2017	3/22/2017	4/21/2017	5/22/2017	6/6/2017	7/11/2017	7/27/2017	9/8/2017	10/2/2017	10/25/2017	12/15/2017	1/11/2018
NH36	Eliz. River	Eliz. River	1/13/2017	2/2/2017	3/22/2017	4/21/2017	5/22/2017	6/6/2017	7/11/2017	7/27/2017	9/8/2017	10/2/2017	10/25/2017	12/15/2017	1/11/2018
APMI	Eliz. River	Eliz. River	1/13/2017	2/2/2017	3/22/2017	4/21/2017	5/22/2017	6/6/2017	7/11/2017	7/27/2017	9/8/2017	10/2/2017	10/25/2017	12/15/2017	1/11/2018
Y PAGE/Y6	York River	NW/Ch.	1/4/2017	2/1/2017	3/6/2017	4/11/2017	5/15/2017	6/1/2017	7/7/2017	8/1/2017	9/11/2017	10/18/2017	10/31/2017	12/11/2017	1/23/2018
Y WAT	York River	NW/Ch.	1/4/2017	2/1/2017	3/6/2017	4/11/2017	5/15/2017	6/1/2017	7/7/2017	8/1/2017	9/11/2017	10/18/2017	10/31/2017	12/11/2017	1/23/2018
Y2	York River	NW/Ch.	1/4/2017	2/1/2017	3/6/2017	4/11/2017	5/15/2017	6/1/2017	7/7/2017	8/1/2017	9/11/2017	10/18/2017	10/31/2017	12/11/2017	1/23/2018
Y8	York River	NW/Ch.	1/4/2017	2/1/2017	3/6/2017	4/11/2017	5/15/2017	6/1/2017	7/7/2017	8/1/2017	9/11/2017	10/18/2017	10/31/2017	12/11/2017	1/23/2018
Y BELL NOAA	York River		1/4/2017	2/1/2017	3/6/2017	4/11/2017	5/15/2017	6/1/2017	7/7/2017	8/1/2017	9/11/2017	10/18/2017	11/12/2017	12/11/2017	1/23/2018
Y12	York River		1/4/2017	2/1/2017	3/6/2017	4/11/2017	5/15/2017	6/1/2017	7/7/2017	8/1/2017	9/11/2017	10/18/2017	11/12/2017	12/11/2017	1/23/2018
Y18 NOAA	York River		1/4/2017	2/1/2017	3/6/2017	4/11/2017	5/15/2017	6/1/2017	7/7/2017	8/1/2017	9/11/2017	10/18/2017	11/12/2017	12/11/2017	1/23/2018
Y20 NOAA	York River		1/4/2017	2/1/2017	3/6/2017	4/11/2017	5/15/2017	6/1/2017	7/7/2017	8/1/2017	9/11/2017	10/18/2017	11/12/2017	12/11/2017	1/23/2018
Y29 NOAA	York River		1/4/2017	2/1/2017	3/6/2017	4/11/2017	5/15/2017	6/1/2017	7/7/2017	8/1/2017	9/11/2017	10/18/2017	11/12/2017	12/11/2017	1/23/2018
Y35	York River	new in 2015	1/4/2017	2/1/2017	3/6/2017	4/11/2017	5/15/2017	6/1/2017	7/7/2017	8/1/2017	9/11/2017	10/18/2017	11/12/2017	12/11/2017	1/11/2018
PAM Johns/neighbor	Pam. River		1/2/2017	2/24/2017	3/1/2017	4/4/2017	4/26/2017	6/2/2017	7/26/2017	No date given	9/29/2017	10/30/2017	11/13/2017	12/4/2017	1/19/2018
PAM Res.	Pam. River		1/2/2017	2/24/2017	3/1/2017	4/4/2017	4/26/2017	6/2/2017	7/26/2017	8/28/2017	9/12/2017	10/30/2017	11/13/2017	12/4/2017	1/19/2018
PAM Soffin	Pam. River		1/2/2017	2/24/2017	3/1/2017	4/4/2017	4/26/2017	6/2/2017	7/26/2017	8/28/2017	9/12/2017	10/30/2017	11/13/2017	12/4/2017	1/19/2018
PAM Williams	Pam. River		1/2/2017	2/24/2017	3/1/2017	4/4/2017	4/26/2017	6/2/2017	7/26/2017	8/18/2017	9/12/2017	10/30/2017	11/13/2017	12/4/2017	1/19/2018
PAM 360	Pam. River		1/2/2017	2/24/2017	3/1/2017	4/4/2017	4/26/2017	6/2/2017	7/26/2017	8/28/2017	9/12/2017		11/13/2017	12/4/2017	1/19/2018
PAM top $	Pam. River		seasonal					6/2/2017D			9/21/2017		11/13/2017R		
PAM rootball	Pam. River		seasonal					6/2/2017D					11/13/2017R		
PAM TOP 1	Pam. River		seasonal					6/2/2017D			9/21/2017		11/13/2017R		
PAM hickory	Pam. River		seasonal					6/2/2017D			9/21/2017		11/13/2017R		
PAM farm H2O	Pam. River		seasonal					6/2/2017D					11/13/2017R		
PAM William upper	Pam. River		seasonal					6/2/2017D			9/21/2017		11/13/2017R		
PAM Lower up William	Pam. River		seasonal					6/2/2017D			9/21/2017		11/13/2017R		
PAM Fossil Cliff	Pam. River		seasonal					6/2/2017D					11/13/2017R		
PAM William lower	Pam. River		seasonal					6/2/2017D					11/13/2017R		
PAM L. L. William	Pam. River		seasonal					6/2/2017D					11/13/2017R		
PAM 4.5	Pam. River	new in 2015	seasonal					6/2/2017D					11/13/2017R		
PAM poles	Pam. River		seasonal					6/2/2017D					11/13/2017R		
PAM Brick wall	Pam. River		seasonal					6/2/2017D					11/13/2017R		
PAM BBW	Pam. River	new in 2015	seasonal					6/2/2017D					11/13/2017R		
PAM Shady Hole	Pam. River	new in 2016	seasonal					6/2/2017D					11/13/2017R		
PAM Powerlines	Pam. River	new in 2016	seasonal					6/2/2017D			9/21/2017		11/13/2017R		
PAM Glens	Pam. River	new in 2016	seasonal					6/2/2017D					11/13/2017R		
PAM 21	Pam. River	new in 2016	seasonal					6/2/2017D			9/21/2017		11/13/2017R		
PAM 27	Pam. River	new in 2016	seasonal					6/2/2017D			9/21/2017		11/13/2017R		
PAM duck blind	Pam. River	new in 2016	seasonal					6/2/2017D					11/13/2017R		
PAM 30	Pam. River	new in 2016	seasonal					6/2/2017D			9/21/2017		11/13/2017R		
PAM Leaning Hickory	Pam. River	new in 2016	seasonal					6/2/2017D					11/13/2017R		
PAM Boathouse	Pam. River	new in 2016	seasonal					6/2/2017D					11/13/2017R		
Chick. Bridge	Chick. River		1/19/2017	2/8/2017	3/30/2017	4/30/2017	5/30/2017LD	7/3/17	7/29/2017	8/22/2017		10/9/17	11/30/2017		1/12/2018
Chick. Bridge CC side	Chick. River		1/19/2017	2/8/2017	3/30/2017	4/30/2017	5/30/2017	7/3/17	7/29/2017	8/22/2017		10/9/17	11/30/2017		1/12/2018
Walls	Matt. River	new in 2016	seasonal					6/2/2017D			9/12/2017		11/13/2017R		
Mike's Branch	Matt. River	new in 2016	seasonal					6/2/2017D			9/12/2017		11/15/2017R		

Receiver Site	Region	Military zone	1st trip 2017	2nd trip 2017	3rd trip 2017	4th trip 2017	5th trip 2017	6th trip 2017	7th trip 2017	8th trip 2017	9th trip 2017	10th trip 2017	11th trip 2017	12th trip 2017	1st trip 2018
Above Whitehall	Matt. River	new in 2016	seasonal					6/2/2017D			9/12/2017		11/15/2017R		
White Oak Landing	Matt. River	new in 2016	seasonal					6/2/2017D					11/15/2017R		
301	Matt. River	new in 2017	seasonal								8/30/2017D	10/5/2017R			
Walkerton	Matt. River	new in 2017	seasonal								8/30/2017D				
Hanging Birch	Rapp. River	new in 2017	seasonal								9/19/2017D	10/5/2017R			
Belvedere Rock	Rapp. River	new in 2017	seasonal								9/19/2017D	10/5/2017R			
Rapp. 35	Rapp. River	new in 2017	seasonal								9/20/2017D	10/5/2017R			

Receiver Site	Region	Military zone	1st trip 2018	2nd trip 2018	3rd trip 2018	4th trip 2018	5th trip 2018	6th trip 2018	7th trip 2018	8th trip 2018	9th trip 2018	10th trip 2018	11th trip 2018	12th trip 2018	1st trip 2019
CB	Atlantic	Range Sur.	1/22/2018	2/28/2018 RD	4/11/2018	5/1/2018	5/11/2018	6/25/2018	7/29/2018	8/9/2018	9/6/2018	10/30/2018	11/30/2018	12/7/2018	2/27/2019 RD
CB1	Atlantic	Range Sur.	1/22/2018	2/28/2018	4/11/2018	5/1/2018 RD	5/11/2018	6/25/2018	7/29/2018	8/9/2018	9/6/2018	10/30/2018	11/30/2018	12/7/2018	1/18/2019
CB11	Atlantic	Range Sur.	1/22/2018	2/28/2018	4/11/2018	5/1/2018	5/11/2018	6/25/2018	7/29/2018	8/9/2018	9/6/2018	10/30/2018	11/30/2018	12/7/2018	1/18/2019
CB13	Atlantic	Range Sur.	1/22/2018	2/28/2018	4/11/2018	5/1/2018	5/11/2018	6/25/2018	7/29/2018	8/9/2018	9/6/2018	10/30/2018	11/30/2018	12/7/2018	1/18/2019
CB3	Atlantic	Range Sur.	1/22/2018	2/28/2018	4/11/2018	5/1/2018	5/11/2018	6/25/2018	7/29/2018	8/9/2018	9/6/2018	10/30/2018	11/30/2018	12/7/2018	1/18/2019
CB5	Atlantic	Range Sur.	1/22/2018	2/28/2018	4/11/2018	5/1/2018	5/11/2018	6/25/2018	7/29/2018	8/9/2018	9/6/2018	10/30/2018	11/30/2018	12/7/2018	1/18/2019
CB7	Atlantic	Range Sur.	1/22/2018RD	2/28/2018	4/11/2018	5/1/2018	5/11/2018	6/25/2018	7/29/2018	8/9/2018	9/6/2018	10/30/2018	11/30/2018	12/7/2018	1/18/2019
CB9	Atlantic	Range Sur.	1/22/2018	2/28/2018	4/11/2018	5/1/2018	5/11/2018	6/25/2018	7/29/2018	8/9/2018	9/6/2018	10/30/2018	11/30/2018	12/7/2018	1/18/2019
RA	Atlantic	Range Sur.	1/22/2018	2/28/2018	4/11/2018	5/1/2018		6/25/2018	7/29/2018	8/9/2018	9/6/2018	10/15/2018	12/3/2018	12/13/2018	1/18/2019
RA outside	Atlantic	Range Sur.													
RI1	Atlantic	Range Sur.	1/22/2018	2/28/2018	4/11/2018		6/14/2018	6/25/2018	7/29/2018	8/9/2018	9/6/2018	10/15/2018	12/3/2018	12/13/2018	1/18/2019
RI2	Atlantic	Range Sur.	1/22/2018	2/28/2018	4/11/2018		6/14/2018	6/25/2018	7/29/2018	8/9/2018	9/6/2018	10/15/2018 RBD	12/3/2018	12/13/2018	1/18/2019
CH	Atlantic	Range Sur.	1/11/2018	2/20/2018	4/11/2018	4/16/2018	5/11/2018	7/2/2018	7/14/2018	8/27/2018	9/6/2018	10/30/2018	11/19/2018	12/7/2018	1/17/2019
CH1	Atlantic	Range Sur.	1/11/2018	2/20/2018	4/11/2018	4/16/2018	5/11/2018	6/18/2018	7/14/2018	8/27/2018	9/6/2018	10/30/2018	11/30/2018	12/7/2018	1/17/2019
NCB	Atlantic		1/22/2018	2/28/2018	4/11/2018	5/1/2018	5/11/2018	6/18/2018	7/29/2018	8/9/2018	9/6/2018	11/19/2018	11/30/2018	12/7/2018	1/18/2019
NCC	Atlantic		1/22/2018	2/28/2018	4/11/2018	5/1/2018	5/11/2018	6/18/2018	7/29/2018	8/9/2018	9/6/2018	11/19/2018	11/30/2018	12/7/2018	1/18/2019
NCD	Atlantic		1/22/2018	2/28/2018	4/11/2018	5/1/2018	5/11/2018	6/18/2018	7/29/2018	8/9/2018	9/6/2018	11/19/2018	11/30/2018	12/7/2018	1/18/2019
NCE	Atlantic		1/22/2018	2/28/2018	4/11/2018 RD	5/1/2018	5/11/2018	6/18/2018	7/29/2018	8/9/2018	9/6/2018	11/19/2018	11/30/2018	12/7/2018	1/18/2019
2CH	Ches. Bay	Fort Story	1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/11/2018	7/2/2018	7/14/2018	8/27/2018	9/28/2018	10/30/2018	11/19/2018	12/3/2018	1/17/2019
TS1	Ches. Bay	Fort Story	1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/11/2018	7/2/2018	7/14/2018	8/27/2018	9/28/2018	10/30/2018	11/30/2018	12/3/2018	1/17/2019
TS3	Ches. Bay	Fort Story	1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/11/2018	7/2/2018 RD	7/14/2018	8/27/2018	9/28/2018	10/30/2018	11/30/2018	12/3/2018	1/17/2019
2C HENRY	Atlantic	Fort Story	1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	7/2/2018	7/14/2018	8/27/2018	9/6/2018	10/30/2018	11/19/2018	12/7/2018	1/17/2019
CBBT4	Ches. Bay	Little Creek	1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	6/28/2018	7/14/2018	8/27/2018	10/4/2018	11/30/2018	12/3/2018	12/7/2018	1/17/2019
CBBT5	Ches. Bay	Little Creek	1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	6/28/2018	7/14/2018	8/27/2018	10/4/2018	11/30/2018	12/3/2018		1/17/2019
LC1	Ches. Bay	Little Creek	1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	7/2/2018	7/14/2018	8/27/2018	9/28/2018	10/4/2018		12/7/2018 RBD	1/17/2019
LC2	Ches. Bay	Little Creek	1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	7/2/2018	7/14/2018	8/27/2018	9/28/2018	10/4/2018		12/7/2018	1/17/2019
TS7	Ches. Bay	Little Creek	1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	7/2/2018	7/14/2018	8/27/2018	9/28/2018	10/4/2018	12/3/2018	12/7/2018	1/17/2019
TS9	Ches. Bay	Little Creek	1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	7/2/2018	7/14/2018	8/27/2018	9/28/2018	10/4/2018	12/3/2018	12/7/2018	1/17/2019
TS11	Ches. Bay	Little Creek	1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	7/2/2018	7/14/2018	8/27/2018	9/28/2018	10/4/2018	12/3/2018	12/7/2018	1/17/2019
10N	Ches. Bay		1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	6/28/2018	7/14/2018	8/27/2018	9/28/2018	10/4/2018	11/30/2018	12/3/2018	1/17/2019
LS	Ches. Bay		1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	6/28/2018	7/14/2018	8/27/2018	9/28/2018	10/4/2018	11/30/2018	12/3/2018	1/17/2019
CBBT1	Ches. Bay		1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	6/28/2018	7/14/2018	8/27/2018	10/4/2018	11/30/2018	12/3/2018	12/7/2018	1/17/2019
CBBT2	Ches. Bay		1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	6/28/2018	7/14/2018	8/27/2018	10/4/2018	11/30/2018	12/3/2018	12/7/2018	1/17/2019
CBBT3	Ches. Bay		1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	6/28/2018	7/14/2018	8/27/2018	10/4/2018	11/30/2018	12/3/2018	12/7/2018	1/17/2019
CBBT7	Ches. Bay		1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	6/28/2018	7/14/2018	8/27/2018	10/4/2018	11/30/2018	12/3/2018	12/7/2018	1/17/2019
TS5	Ches. Bay		1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	7/2/2018	7/14/2018	8/27/2018	9/28/2018	10/30/2018	11/19/2018	11/30/2018	1/17/2019
B11	Ches. Bay		1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	6/28/2018	7/14/2018	8/27/2018	9/6/2018	11/30/2018	11/30/2018	12/3/2018	1/17/2019
B13	Ches. Bay		1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	6/28/2018	7/14/2018	8/27/2018	9/28/2018	10/4/2018	11/30/2018	12/3/2018	1/17/2019
B15	Ches. Bay		1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	6/28/2018	7/14/2018	8/27/2018	9/28/2018	10/4/2018	11/30/2018	12/3/2018	1/17/2019
B5	Ches. Bay		1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	7/2/2018	7/14/2018	8/27/2018	9/6/2018	11/19/2018 RD		12/3/2018	1/17/2019
B7	Ches. Bay		1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	7/2/2018	7/14/2018	8/27/2018	9/6/2018	11/30/2018	11/30/2018	12/3/2018	1/17/2019
B9	Ches. Bay		1/11/2018	2/20/2018	4/16/2018	4/26/2018	5/24/2018	6/28/2018	7/14/2018	8/27/2018	9/6/2018	11/30/2018	11/30/2018	12/3/2018	1/17/2019
NN 1ER FWS	James River	NNB	1/11/2018	2/16/2018	3/16/2018	4/5/2018	5/15/2018	6/6/2018	7/10/2018	8/25/2018	10/3/2018	10/19/2018	11/18/2018	12/17/2018	1/28/2018 RBD
NN 3ER NOAA SP	James River	NNB	1/11/2018	2/16/2018	3/16/2018	4/5/2018	5/15/2018	6/6/2018	7/10/2018	8/25/2018	10/3/2018	10/19/2018	11/18/2018	12/17/2018	1/28/2018
NN DANGER FWS	James River	NNB	1/11/2018	2/16/2018	3/16/2018	4/5/2018	5/15/2018	6/6/2018	7/10/2018	8/25/2018	10/3/2018	10/19/2018	11/18/2018	12/17/2018	1/28/2018

Receiver Site	Region	Military zone	1st trip 2018	2nd trip 2018	3rd trip 2018	4th trip 2018	5th trip 2018	6th trip 2018	7th trip 2018	8th trip 2018	9th trip 2018	10th trip 2018	11th trip 2018	12th trip 2018	1st trip 2019
NN R22 NOAA SP	James River	NNB	1/11/2018	2/16/2018	3/16/2018	4/5/2018	5/15/2018	6/6/2018	7/10/2018	8/25/2018	10/3/2018	10/19/2018	11/18/2018	12/17/2018	1/28/2018
NN2	James River	NNB	1/11/2018	2/16/2018	3/16/2018	4/5/2018	5/15/2018	6/6/2018	7/10/2018	8/25/2018	10/3/2018	10/19/2018	11/18/2018	12/17/2018	1/28/2018 RD
NN5	James River	NNB	1/11/2018	2/16/2018	3/16/2018	4/5/2018	5/15/2018	6/6/2018	7/10/2018	8/25/2018	10/3/2018	10/19/2018	11/18/2018	12/17/2018	1/28/2018
NN8	James River	NNB	1/11/2018	2/16/2018	3/16/2018	4/5/2018	5/15/2018	6/6/2018	7/10/2018	8/25/2018	10/3/2018	10/19/2018	11/18/2018	12/17/2018	1/28/2018
NH8	Eliz. River	NNB	1/11/2018	2/16/2018	3/16/2018	4/5/2018	5/15/2018	6/6/2018	7/10/2018	8/25/2018	10/3/2018	10/19/2018	11/18/2018	12/17/2018	1/28/2018
NH10	Eliz. River	NNB	1/11/2018	2/16/2018	dredge on buoy	4/5/2018	5/15/2018	6/6/2018	7/10/2018	8/25/2018	10/3/2018	10/19/2018	11/18/2018	12/17/2018	1/28/2018
NH12	Eliz. River	NNB	1/11/2018	2/16/2018	3/16/2018	4/5/2018	5/15/2018	6/6/2018	7/10/2018	8/25/2018	10/3/2018	10/19/2018	11/18/2018	12/17/2018	1/28/2018
NH14	Eliz. River	NNB	1/11/2018	2/16/2018	3/16/2018	4/5/2018	5/15/2018	6/6/2018	7/10/2018	8/25/2018	10/3/2018	10/19/2018	11/18/2018	12/17/2018	1/28/2018
NH29	Eliz. River	Eliz. River	1/11/2018	2/16/2018	3/16/2018	4/5/2018	5/15/2018	6/6/2018	7/10/2018	8/25/2018	10/3/2018	10/19/2018	11/18/2018	12/17/2018	1/28/2018
NH32	Eliz. River	Eliz. River	1/11/2018	2/16/2018	3/16/2018	4/5/2018	5/15/2018	6/6/2018	7/10/2018	8/25/2018	10/3/2018	10/19/2018	11/18/2018	12/17/2018	1/28/2018
NH36	Eliz. River	Eliz. River	1/11/2018	2/16/2018	3/16/2018	4/5/2018	5/15/2018	6/6/2018	7/10/2018	8/25/2018	10/3/2018	10/19/2018	11/18/2018	12/17/2018 RLD	1/28/2018
APMI	Eliz. River	Eliz. River	1/11/2018	2/16/2018	3/16/2018	4/5/2018	5/15/2018	6/6/2018	7/10/2018	8/25/2018	10/3/2018	10/19/2018	11/18/2018	12/17/2018	1/28/2018
Y PAGE/Y6	York River	NW/Ch.	1/23/2018	2/1/2018	3/14/2018	4/2/2018	5/9/2018	6/4/2018	7/9/2018	8/5/2018	9/7/2018	10/7/2018	11/16/2018	12/6/2018	1/7/2019
Y WAT	York River	NW/Ch.	1/23/2018	2/1/2018	3/14/2018	4/2/2018	5/9/2018	6/4/2018	7/9/2018	8/5/2018	9/7/2018	10/7/2018	11/16/2018	12/6/2018	1/7/2019
Y2	York River	NW/Ch.	1/23/2018	2/1/2018	3/14/2018	4/2/2018	5/9/2018	6/4/2018	7/9/2018	8/5/2018	9/7/2018	10/7/2018	11/16/2018	12/6/2018	1/7/2019
Y8	York River	NW/Ch.	1/23/2018	2/1/2018	3/14/2018	4/2/2018	5/9/2018	6/4/2018	7/9/2018	8/5/2018	9/7/2018	10/7/2018	11/16/2018	12/6/2018	1/7/2019
Y BELL NOAA	York River		1/23/2018	3/5/2018	3/14/2018	4/2/2018	5/9/2018	6/4/2018	7/20/2018	8/5/2018	9/20/2018	10/22/2018 RBD	11/16/2018	12/6/2018	1/7/2019
Y12	York River		1/23/2018	2/1/2018	3/14/2018	4/2/2018	5/9/2018	6/4/2018	7/20/2018	8/5/2018	9/20/2018	10/17/2018	11/16/2018 RD	12/6/2018	1/7/2019
Y16	York River	new in 2015	1/23/2018	2/1/2018	3/14/2018	4/2/2018	5/9/2018	6/4/2018	7/20/2018	8/5/2018	9/20/2018	10/17/2018	11/16/2018	12/6/2018	1/7/2019
Y18 NOAA	York River		1/23/2018	2/1/2018	3/14/2018	4/2/2018	5/9/2018	6/4/2018	7/20/2018	8/5/2018	9/20/2018	10/17/2018	11/16/2018 RD	12/6/2018	1/7/2019
Y20 NOAA	York River		1/23/2018	2/1/2018	3/14/2018	4/2/2018	5/9/2018	6/4/2018	7/20/2018	8/5/2018	9/20/2018	10/17/2018	11/16/2018 RD	12/6/2018	1/7/2019
Y29 NOAA	York River		1/23/2018	3/5/2018	3/14/2018	4/2/2018	5/9/2018	6/4/2018	7/20/2018	8/5/2018	9/20/2018	10/17/2018	11/16/2018	12/6/2018 RD	1/7/2019
Y35	York River	new in 2015	1/11/2018	3/5/2018	3/14/2018	4/2/2018	5/9/2018	6/4/2018	7/20/2018	8/5/2018	9/20/2018	10/17/2018	11/16/2018	12/6/2018	1/7/2019
PAM Johns/neighbor	Pam. River		1/19/2018	2/6/2018	3/5/2018	3/30/2018	5/14/2018	6/12/2018	7/23/2018	8/2/2018	8/29/2018	10/1/2018		11/29/2018	1/1/2019
PAM Res.	Pam. River		1/19/2018	2/6/2018	3/8/2018	3/30/2018	5/14/2018	6/12/2018	7/16/2018	8/1/2018	10/1/2018	10/9/2018		10/22/2018	1/1/2019
PAM Soffin	Pam. River		1/19/2018	2/6/2018	3/8/2018	3/30/2018	5/14/2018	6/12/2018	7/11/2018	8/4/2018 RBD		10/10/2018	10/31/2018	11/29/2018	1/1/2019
PAM Williams	Pam. River		1/19/2018	2/6/2018	3/8/2018	3/30/2018	5/14/2018	6/12/2018	8/2/2018	8/29/2018	9/20/2018		10/22/2018	11/28/2018	1/1/2019
PAM 360	Pam. River		1/19/2018	2/6/2018	3/8/2018	3/30/2018	5/14/2018	6/12/2018	8/2/2018	8/29/2018	9/20/2018	10/22/2018	11/2/2018	11/28/2018	1/1/2018
PAM top $	Pam. River		seasonal					7/11/2018 D					11/2/2018 R		
PAM rootball	Pam. River		seasonal					7/11/2018 D					11/2/2018 R		
PAM TOP 1	Pam. River		seasonal					7/11/2018 D					11/2/2018 R		
PAM hickory	Pam. River		seasonal					7/11/2018 D					11/2/2018 R		
PAM farm H2O	Pam. River		seasonal					7/11/2018 D					11/2/2018 R		
PAM William upper	Pam. River		seasonal					7/11/2018 D					11/2/2018 R		
PAM Lower up William	Pam. River		seasonal					7/11/2018 D					11/2/2018 R		
PAM Fossil Cliff	Pam. River		seasonal					7/11/2018 D					11/2/2018 R		
PAM William lower	Pam. River		seasonal					6/21/2018 D					11/2/2018 R		
PAM L. L. William	Pam. River		seasonal					6/21/2018 D					11/2/2018 R		
PAM 4.5	Pam. River	new in 2015	seasonal					6/21/2018 D					11/2/2018 R		
PAM poles	Pam. River		seasonal					6/21/2018 D					11/2/2018 RB		
PAM Brick wall	Pam. River		seasonal					6/21/2018 D					11/2/2018 R		
PAM BBW	Pam. River	new in 2015	seasonal					6/21/2018 D					11/2/2018 R		
PAM Shady Hole	Pam. River	new in 2016	seasonal					7/11/2018 D					11/2/2018 R		
PAM Powerlines	Pam. River	new in 2016	seasonal					7/11/2018 D					11/2/2018 R		
PAM Glens	Pam. River	new in 2016	seasonal					6/21/2018 D					11/2/2018 R		
PAM 21	Pam. River	new in 2016	seasonal					7/11/2018 D				10/22/2018			
PAM 27	Pam. River	new in 2016	seasonal					7/11/2018 D				10/22/2018R			
PAM duck blind	Pam. River	new in 2016	seasonal					6/21/2018 D					11/2/2018 R		
PAM 30	Pam. River	new in 2016	seasonal					7/11/2018 D				10/22/2018 R			
PAM Leaning Hickory	Pam. River	new in 2016	seasonal					6/21/2018 D					11/2/2018 R		
PAM Boathouse	Pam. River	new in 2016	seasonal					6/21/2018 D					11/2/2018 R		
Chick. Bridge	Chick. River		1/12/2018	2/6/2018	3/20/2018	4/28/2018	5/21/2018		7/13/2018	8/29/2018	9/25/2018	10/9/2018	11/29/2018	12/5/2018	1/1/2018
Chick. Bridge CC side	Chick. River		1/12/2018	2/6/2018	3/20/2018	4/28/2018	5/21/2018		7/13/2018	8/29/2018	9/25/2018	10/9/2018 D	11/29/2018	12/5/2018	1/1/2018
Walls	Matt. River	new in 2016	seasonal					7/23/2018 D							

Receiver Site	Region	Military zone	1st trip 2018	2nd trip 2018	3rd trip 2018	4th trip 2018	5th trip 2018	6th trip 2018	7th trip 2018	8th trip 2018	9th trip 2018	10th trip 2018	11th trip 2018	12th trip 2018	1st trip 2019
Mike's Branch	Matt. River	new in 2016	seasonal					7/23/2018 D	🟩	🟩	🟩	🟩	🟩		
Above Whitehall	Matt. River	new in 2016	seasonal					7/23/2018 D	🟩	🟩	🟩	🟩	🟩		
White Oak Landing	Matt. River	new in 2016	seasonal					7/23/2018 D	🟩	🟩	🟩	🟩	🟩		
301	Matt. River	new in 2017	seasonal								🟩	🟩			
Walkerton	Matt. River	new in 2017	seasonal									🟩			
Hanging Birch	Rapp. River	new in 2017	seasonal								🟩	🟩			
Belvedere Rock	Rapp. River	new in 2017	seasonal								🟩	🟩			
Rapp. 35	Rapp. River	new in 2017	seasonal								🟩	🟩			

9.2. Sonic-tagged Species Detected within the Receiver Array by Year, Showing Numbers of Fish Detected and Total Numbers Of Detections (in parentheses).

Species	2013	2014	2015	2016	2017	2018	Total
Alewife (*Alosa pseudoharengus*)	0	0	0	0	1 (1)	1 (2)	2 (3)
American shad (*Alosa sapidissima*)	0	0	4 (61)	0	2 (6)	0	6 (67)
Atlantic angel shark (*Squatina dumeril*)	0	0	0	0	0	1 (8)	1 (8)
Atlantic bluefin tuna (*Thunnus thynnus*)	0	0	0	1 (1)	3 (15)	0	4 (16)
Atlantic cod (*Gadus morhua*)	0	0	0	0	0	2 (2)	2 (2)
Atlantic stingray (*Dasyatis sabina*)	0	0	0	1 (3)	0	0	1 (3)
Atlantic sturgeon (*Acipenser oxyrhynchus oxyrhynchus*)	401 (77,659)	515 (424,373)	644 (576,558)	594 (566,897)	583 (849,926)	519 (736,034)	1,224 (3,231,447)
Atlantic tarpon (*Megalops atlanticus*)	0	0	0	1 (20)	0	1 (12)	1 (32)
Black drum (*Pogonias cromis*)	2 (17)	2 (647)	2 (11,832)	3 (259)	1 (31)	0	7 (12,786)
Black sea bass (*Centropristis striata*)	0	0	10 (2,109)	2 (46)	0	0	11 (2,155)
Blacktip shark (*Carcharhinus limbatus*)	0	2 (4)	2 (780)	6 (1,240)	15 (650)	11 (273)	30 (2,947)
Blue catfish (*Ictalurus furcatus*)	1 (89)	0	30 (648,292)	20 (103,267)	1 (1,815)	0	31 (753,463)
Blueback herring (*Alosa aestivalis*)	45 (68,183)	0	0	0	1 (1)	0	45 (68,184)
Bull shark (*Carcharhinus leucas*)	3 (17)	3 (10)	2 (10)	1 (4)	2 (13)	1 (2)	5 (56)
Cobia (*Rachycentron canadum*)	0	0	0	1 (94)	18 (1,801)	52 (21,580)	55 (23,475)
Cownose ray (*Rhinoptera bonasus*)	0	27 (1,986)	33 (3,981)	15 (952)	25 (2,160)	11 (470)	67 (9,549)
Dusky shark (*Carcharhinus obscurus*)	0	0	0	0	12 (110)	9 (140)	17 (250)
Finetooth shark (*Carcharhinus isodon*)	0	0	1 (47)	1 (213)	0	1 (9)	2 (269)
Great white shark (*Carcharodon carcharias*)	3 (6)	2 (46)	5 (21)	6 (102)	21 (355)	15 (152)	42 (682)
Green sea turtle (*Chelonia mydas*)	2 (59)	2 (875)	0	0	0	1 (24)	5 (958)
Harbor seal (*Phoca vitulina*)	0	0	0	0	0	5 (586)	5 (586)
Kemp's ridley sea turtle (*Lepidochelys kempii*)	2 (103)	11 (1,098)	13 (7,331)	1 (12,624)	10 (758)	14 (2,094)	49 (24,008)
Loggerhead sea turtle (*Caretta caretta*)	7 (1,692)	8 (2,730)	7 (2,667)	1 (75)	2 (240)	0	23 (7,404)
Roughtail stingray (*Dasyatis centroura*)	0	0	1 (3)	0	0	2 (45)	3 (48)
Sand tiger shark (*Carcharias taurus*)	124 (1,248)	111 (1,447)	98 (21,777)	74 (1,929)	75 (1,314)	58 (795)	236 (28,510)
Sandbar shark (*Carcharhinus plumbeus*)	19 (317)	13 (1,100)	3 (159)	1 (97)	1 (6)	0	24 (1,679)
Shortfin mako (*Isurus oxyrinchus*)	0	0	0	0	1 (4)	0	1 (4)
Shortnose sturgeon (*Acipenser brevirostrum*)	0	0	0	0	0	1 (264)	1 (264)
Smooth dogfish (*Mustelus canis*)	0	0	0	0	2 (26)	1 (3)	2 (29)
Spinner shark (*Carcharhinus brevipinna*)	0	1 (27)	0	0	0	0	1 (27)
Spiny dogfish (*Squalus acanthias*)	0	4 (354)	0	0	4 (600)	1 (159)	8 (1,113)
Spotted seatrout (Cynoscion nebulosus)	0	0	1 (8)	10 (627)	11 (1,595)	3 (68)	20 (2,298)
Striped bass (*Morone saxatilis*)	14 (326)	32 (14,521)	30 (24,549)	62 (3,167)	103 (6,801)	195 (17,531)	303 (66,895)
Tarpon (*Megalops atlanticus*)	0	0	0	1 (1)	1 (5)	0	2 (6)
Tiger shark (*Galeocerdo cuvier*)	0	0	0	1 (5)	1 (2)	0	2 (7)
Winter flounder (*Pseudopleuronectes americanus*)	6 (53)	6 (56)	0	0	3 (4)	0	10 (113)
Winter skate (*Leucoraja ocellate*)	0	2 (140)	1 (260)	0	1 (211)	5 (407)	7 (1,018)

9.3. Researchers who Sonically Tagged Species Detected within the Receiver Array.

Researcher	Organization	Species	# of Fish Detected	# of Detections
Aaron J. Bunch	Virginia Department of Game and Inland Fisheries	Blue catfish	30	753,374
Amanda Higgs	New York Department Environmental Conservation	Atlantic sturgeon	1	98
Andy J. Danylchuk, PhD	Bonefish and Tarpon Trust	Tarpon	2	6
Anne Wright	Virginia Commonwealth University	Atlantic sturgeon	9	36,033
Barbara Block	Stanford University	Atlantic bluefin tuna	4	16
Ben Gahagan	Massachusetts Division of Marine Fisheries	Striped bass	91	18,538
Beth Flowers	Florida Atlantic University-Boca Raton	Blacktip shark	17	193
Bill Hoffman	Massachusetts Division of Marine Fisheries	Atlantic cod	2	2
Bill Post	South Carolina Department of Natural Resources	American shad	2	2
		Atlantic sturgeon	37	12,584
		Shortnose sturgeon	2	2
Bradley Stevens, PhD	University of Maryland, Chesapeake Biological Laboratory	Black sea bass	10	2,154
Bryan Frazier	South Carolina Department of Natural Resources	Blacktip shark	3	367
		Tiger shark	1	5
Caroline Collatos	Coastal Carolina University	Sandbar shark	1	6
Charles P. Stence	Maryland Department of Natural Resources	Atlantic sturgeon	22	114,577
Chris Hager, PhD	Chesapeake Scientific	Atlantic sturgeon	6	298
Chris Hager, PhD/ Carter Watterson	U.S. Department of the Navy	Atlantic sturgeon	90	1,669,332
		Blueback herring	45	68,184
Chuck Bangley, PhD	East Carolina University	Sandbar shark	22	1,576
Danielle Haulsee	University of Delaware	Sand tiger shark	63	999
David Secor, PhD	University of Maryland – Chesapeake Bay Laboratory	Black sea bass	1	1
		Striped bass	99	42,460
Debra Abercrombie	Stony Brook University	Bull shark	4	48
Dewayne Fox, PhD	Delaware State University	Atlantic sturgeon	328	169,088
		Sand tiger shark	86	1,645
		Winter skate	5	618
Doug Peterson, PhD	University of Georgia	Atlantic sturgeon	4	22,670
Elizabeth Fairchild	University of New Hampshire	Winter flounder	8	111
Eric Hilton, PhD	Virginia Institute of Marine Science	Atlantic sturgeon	138	638,994
		Spotted seatrout	1	59
Eric Reyier, PhD	Kennedy Space Center Ecological Program	Black drum	3	1,896
		Finetooth shark	2	269
		Roughtail stingray	1	3
		Spanish mackerel	2	11
		Spinner shark	1	27
Eric Thadey	District of Columbia Fisheries & Wildlife	Striped bass	9	497
Evan Ingram	Stony Brook University	Atlantic sturgeon	31	5,581
		Roughtail stingray	2	45
		Shortfin mako	1	4
Gail Wippelhauser, PhD	Maine Department of Marine Resources	Striped bass	24	713
Gayle Zydlewski, PhD	University of Maine	Atlantic sturgeon	1	10
Greg DeCelles	University of Massachusetts-Dartmouth	Winter flounder	2	2
Greg Skomal, PhD	Massachusetts Division of Marine Fisheries	Sand tiger shark	23	2,133
		Great white shark	40	557
Hal Brundage, PhD	Environmental Research and Consulting, Inc.	Atlantic sturgeon	20	8,777
Gwen Lockhart	U.S. Department of the Navy	Harbor seal	5	586
Holly White	North Carolina Division of Marine Fisheries	American shad	2	6
Ian Park	Delaware Division of Fish and Wildlife	Atlantic sturgeon	10	4,806
		Striped bass	70	4,595
Jake Brownscombe	Bonefish and Tarpon Trust	Atlantic tarpon	1	32
Jake LaBelle	Wildlife Conservation Society	Dusky shark	1	15
		Sand tiger shark	35	22,734
James Sulikowski, PhD	University of New England	Atlantic sturgeon	1	6
Jared Flowers	North Carolina State University	Atlantic sturgeon	3	80
Jason Rock	North Carolina Division of Marine Fisheries	Striped bass	1	5
Jeff Kneebone, PhD	Massachusetts Division of Marine Fisheries	Sand tiger shark	6	362
Joanne Braun McNeill	National Marine Fisheries Service	Loggerhead sea turtle	1	39
Joe Hightower, PhD	North Carolina State University	Striped bass	6	70
Johnny E. Moore	Delaware Division of Fish and Wildlife	American shad	2	59
Joshua K. Raabe	North Carolina State University	Striped bass	1	1
Keith Dunton, PhD	Monmouth University	Atlantic angel shark	1	8
		Atlantic sturgeon	236	73,953
		Dusky shark	1	10
		Sand tiger shark	12	400
		Spiny dogfish	4	759
		Winter skate	2	400
Kellie McCartin	Stony Brook University	Alewife	1	1
Kevin Weng	Virginia Institute of Marine Science	Cobia	13	6,635
Kimberly Durham	Riverhead Foundation for Marine Research and Preservation	Green sea turtle	1	36
		Kemp's ridley sea turtle	3	117
Kristine Edwards	New York State Thruway Authority	Atlantic sturgeon	8	366
Madeline M. Marens	University of North Carolina-Wilmington	Sand tiger shark	5	15
Matt Ajemian, PhD	Florida Atlantic University	Sandbar shark	1	97
Matt Balazik, PhD	Virginia Commonwealth University	Atlantic sturgeon	205	410,739
		Blue catfish	1	89
		Shortnose sturgeon	1	264
Matt Kenworthy	University of North Carolina Chapel Hill	Black drum	4	10,890

Researcher	Organization	Species	# of Fish Detected	# of Detections
Matt Ogburn, PhD	Smithsonian Environmental Research Center	Atlantic Stingray	1	3
		Cownose ray	67	9,549
		Dusky shark	14	203
		Smooth dogfish	2	29
Matt Perkinson, Karl Brenkert	South Carolina Department of Natural Resources	Cobia	2	117
Merry Camhi, PhD	Wildlife Conservation Society	Sand tiger shark	6	222
Micah Kieffer, PhD	U.S. Geological Survey	Atlantic sturgeon	1	104
Michael D. Arendt, PhD	South Carolina Department of Natural Resources	Loggerhead turtle	3	1,915
Michael Bailey	U.S. Fish and Wildlife Service	Alewife	1	2
Michael Loeffler	North Carolina Division of Marine Fisheries	Atlantic sturgeon	18	42,347
Neil Hammerschlag, PhD	Rosenstiel School of Marine and Atmospheric Science, University of Miami	Bull shark	1	8
		Tiger shark	1	2
Pat McGrath	Virginia Institute of Marine Science	Spotted seatrout	19	2,239
Riley Gallagher	North Carolina State University	Cobia	38	16,118
Robert Murphy	Northeastern University	Striped bass	2	16
Roger Rulifson, PhD	East Carolina University	Spiny dogfish	4	354
Stephen Kajiura, PhD	Florida Atlantic University	Blacktip shark	19	2,387
Steve Poland	North Carolina Division of Marine Fisheries	Cobia	2	605
Sue Barco/Carter Watterson	Virginia Aquarium, U.S. Department of the Navy	Green sea turtle	4	922
		Kemp's ridley sea turtle	46	23,891
		Loggerhead sea turtle	19	5,450
Tim Ellis, PhD	North Carolina State University	Speckled trout	1	67
Tobey Curtis	NOAA	Dusky shark	1	1
		White shark	2	66
Tom Savoy, PhD	Connecticut Department Environmental Protection	Atlantic sturgeon	57	21,004