# Operation of the Navy's Telemetry Array in the Lower Chesapeake Bay: 2015 Annual Report

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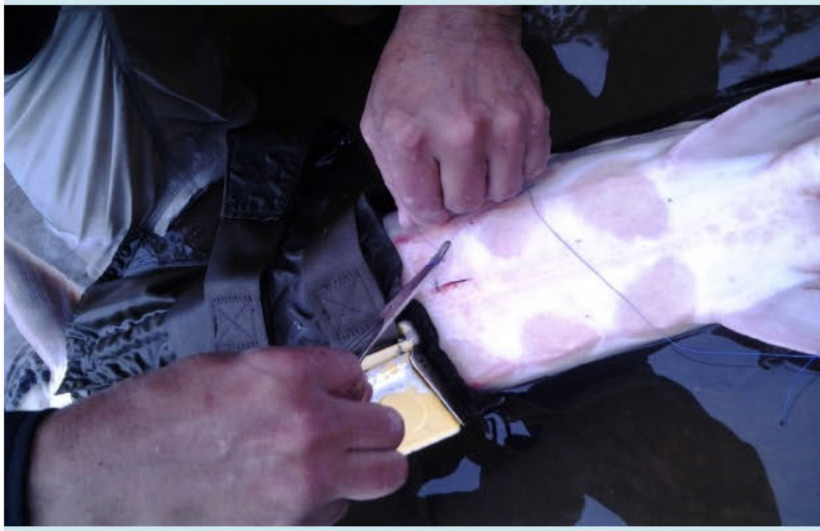


***Prepared by:***

Christian Hager, PhD

Chesapeake Scientific
Williamsburg, VA

***Submitted by:***

Virginia Beach, VA


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# OPERATION OF THE NAVY'S TELEMETRY ARRAY IN THE LOWER CHESAPEAKE BAY

## 2015 ANNUAL REPORT

**Contract # N62470-10-D-3011, Task Order CTO 53**

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*Submitted to:*

**NAVFAC Atlantic**
**Norfolk, Virginia**

*Issued to:*

**HDR Inc.**
**Norfolk Virginia**

*Prepared by:*

**Chesapeake Scientific**
**Williamsburg, Virginia**

**April 2016**

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| CBBT | Chesapeake Bay Bridge-Tunnel |
| DPS | Distinct Population Segments |
| ESA | Endangered Species Act |
| km | kilometer(s) |
| m | meter(s) |
| mm | millimeters(s) |
| Navy | Department of the Navy |
| NEPA | National Environmental Policy Act |
| NMFS | National Marine Fisheries Service |
| NOAA | National Oceanic and Atmospheric Association |
| PIT | Passive Integrated Transponder |
| ppt | parts per thousand |
| USFWS | United States Fish and Wildlife Service |
| USCG | United States Coast Guard |
| VIMS | Virginia Institute of Marine Science |
| YOY | young-of-the-year |

**For regions:**

| | |
|---|---|
| Chick. | Chickahominy River |
| Ches. | Chesapeake Bay |
| Eliz. | Elizabeth River |
| Pam. | Pamunkey River |

**For military zones:**

| | |
|---|---|
| NW/Ch. | Naval Weapons/Cheatham Annex |
| NSN | Naval Station Norfolk |
| Range Sur. | Dam Neck Naval Firing Range Surrogate |

**For political lines:**

| | |
|---|---|
| COLREGS | Collision Regulation Line. The political regulation line that divides inland from coastal waterways as set forth in the International Regulations for the Preventing Collisions at Sea, 1972 is COLREGS. |

# 1. EXECUTIVE SUMMARY

HDR and Chesapeake Scientific were funded by the United States (U.S.) Department of the Navy (Navy), through the U.S. Fleet Forces Command (USFF) and the Commander, Navy Region Mid-Atlantic (CNRMA), to conduct a multi-year tracking study (2013–2015) to examine occupancy patterns of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) within the lower Chesapeake Bay, with an emphasis on zones of military importance. The overarching goal of the study was to define occupancy and migration patterns so that the Navy may conduct a more informed assessment of their activities' potential impacts on Atlantic sturgeon. The objectives of the study were to define migratory pathways, behavior, and periods of residency of the Atlantic sturgeon. The 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. More than 75 VEMCO® VR2W receivers were deployed strategically in arrays to cover military zones, as well as regions of biological significance, within the York River watershed, Hampton Roads, the Elizabeth River, the mouth of the Chesapeake Bay, and nearshore Atlantic waters. The military zones of interest monitored within these regions were the: Naval Weapons Station Yorktown and Cheatham Annex zones (York River region); Naval Station Norfolk and Elizabeth River zones (James River region); and Little Creek and Fort Story zones (Chesapeake Bay region). In addition, a large zone was established just north of the Naval Firing Range off of Dam Neck, referred to as the Dam Neck Naval Firing Range Surrogate zone (Atlantic region) or Naval Firing Range Surrogate zone. From 2013 through 2015, the numbers of sturgeon detected within the Navy array increased from 400 to 637. The percentage of sturgeon detected out of the total number known to be implanted with VEMCO® 69-kilohertz tags also steadily increased from 29 percent to 37 percent, respectively. These sturgeon were originally tagged in Virginia, Maryland, Connecticut, the New York Bight, Delaware, North Carolina, South Carolina, and Georgia. Conversely, sturgeon tagged through this study in the York River drainage were detected in other regions' arrays, with the majority being detected off the South Carolina and Georgia coast in the winter and in the Delaware Bay and the New York Bight during the summer when not returning to the Chesapeake Bay. Fish of varied life stages were recorded dispersed throughout the array. Residence by sturgeon of such diverse ages and origins within Virginia waters demonstrates the importance of the region to the species, and detections of our tagged fish in far-reaching locations highlight the highly migratory character of the species and the need for federal management. Data from adult specimen collection efforts conducted in the Pamunkey River from 2013 to 2015 was used to calculate spawning run population estimates for the river in consecutive years and to estimate the sum adult population. Based on mark-recapture techniques, our most recent analysis estimates the total adult population for the Pamunkey River at 289 fish (95 percent confidence interval = 258–329), a result that suggests the Pamunkey and York rivers contain critical habitat necessary for the survival of the smallest reproducing stock of the species known to be in existence. This hypothesis is supported not only by three years of mark-recapture work but through genetic analysis conducted by Tim King (U.S. Geological Survey), the leading expert on the genetic composition and variability of the species. Due to the Navy's prudent funding of sturgeon research, our tagging and tracking efforts are providing the spatial and temporal data necessary to model the biological attributes of this endangered species including specific migration patterns of the Pamunkey's individual stock. Preliminary tracking data suggest that Pamunkey adults do not randomly migrate through the Chesapeake Bay but select specific pathways and exhibit distinctly seasonal behaviors. Understanding such distributions and behaviors is essential to avoiding negative impacts while continuing the Navy's regional missions.

# 2. INTRODUCTION

The Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) was once abundant throughout the Chesapeake Bay (**Figure 1**) and 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 congruent 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 and was expanded to include all federal waters of the Atlantic Ocean by the National Marine Fisheries Service in 1999. The Atlantic sturgeon (Acipenser oxyrinchus) Chesapeake Bay distinct population segment (DPS) was listed as endangered under the Endangered Species Act on February 12, 2012 (NMFS 2012). Four other DPSs were also identified and named the Gulf of Maine, New York Bight, Carolina and South Atlantic. All but the Gulf of Maine were listed as endangered and the Gulf of Maine was listed as threatened.

**Figure 1. Adult Atlantic sturgeon, Pamunkey River, frontal view. Figure one illustrates an adult sturgeon from the Pamunkey River. At the front of the picture, the large snout with dual spiracles (holes) and a single barbel protruding from under the left side of the snout are visible. Behind the large gill plates, the dorsal and lateral rows of scutes are evident, as is the heterocercal tail.**

The Atlantic sturgeon is anadromous, which means that spawning occurs in fresh water and adults spend most of their lives in marine and estuarine waters. Although a few sturgeon have been taken in deep offshore waters, most are captured near the coast (Vladykov and Greenley 1963). In Virginia, all

scientifically documented catches have occurred in waters less than 20 meters (m) deep (Murdy et al. 1997). For approximately the first year after hatching, Atlantic sturgeon remain within their freshwater nursery habitats and forage for benthic prey (Secor et al. 2000). As they age, their range extends ever further downriver (Van Den Avyle 1984). Some juveniles may reside within native fresh- and brackish-water nurseries for several years (Scott and Crossman 1973), while others exit into the marine environment in their second year. Both behaviors have been recorded in Virginia waters. Congregations of natal fish between ages two and three have been found in the mouth of the York River in the spring (Hager and Musick 2007), which suggests recent downriver emigration. Other juveniles of the same or lesser size have been recorded undertaking marine migrations, indicating that the age at which an individual fish leaves its natal estuary and transitions to its coastal transient life stage varies. Once it transitions, a fish will remain a coastal transient inhabiting various coastal regions, estuaries, and rivers seasonally until maturity (Holland and Yelverton 1973). Fish reach maturity between the ages of seven and twelve, with males maturing earlier than females (Murdy et al. 1997) and maturity is attained more quickly in southern stocks (Vladykov and Greeley 1963). It was once presumed that spawning only occurred in the spring in Virginia waters based on research that had been done in the Hudson River (Murdy et al. 1997). Recent tracking research suggests that spawning occurs in both the spring and fall in the James River (Hager 2011; Balazik et al. 2012) but only in the fall in the Pamunkey River (Hager et al. 2014). Sub-adults close to maturity also occasionally join adults in upriver spawning runs in both the James and Pamunkey rivers (Musick and Hager 2007, Hager 2011) and sub-adults often are found intermixed with adults in regions containing advantageous physical characteristics but no known spawning habitats.

Historically, data on the spatial and temporal details of Atlantic sturgeon occupancy and migration within Virginia have been extremely limited. The knowledge attained and shared among commercial sturgeon fishermen until the fisheries collapsed in the late 1900s was not documented. Later attempts at scientific descriptions of local behavior, residence, and migrations were of limited success due to the apparent scarcity of the species. Technological improvements in marine sonic-tracking equipment have allowed a small sonic transmitter often referred to as a "tag," to be inserted into a fish's body cavity. This technological advance, in conjunction with the initial collaboration of commercial fishermen and the incorporation of their collection techniques into scientific sampling protocols, has greatly expanded our ability to gather data on the species.

The first acoustic receiver array deployed in the Chesapeake Bay to track Atlantic sturgeon was placed in the oligohaline (>0.5-5 ppt) and freshwater portions of the James River by Chris Hager (Virginia Sea Grant, Virginia Institute of Marine Science [VIMS]), and Jack Musick (VIMS) in 2006. Tracking between 2006 and 2012 revealed stark differences between river use by sub-adults and adults (Hager 2011). Some sub-adults resided within the array year-round. Adults made two runs into upriver reaches, one in the spring and one in the late summer (Hager and Musick 2007, Hager 2011). During both residence periods, some adults occupied regions where physical parameters such as salinity, bottom type, dissolved oxygen, and temperature were suitable for spawning (Bushnoe et al. 2005).

In the James River, the first run of adults starts in April, with fish staging in the oligohaline (>0.5-5 ppt) zone prior to immigration into fresh water. By May, some adults have returned down river and others concentrate in the lower freshwater portions of the river near Sturgeon Point. In June, the latter will also return down river. The second run into fresh water starts in late July. Most adults travel much farther upriver on this run and reside within the upper river above Hopewell, within regions identified as suitable spawning grounds. Here they remain from late summer through early fall. Fish were discovered running ripe in this section in 2007 (Hager and Musick 2007) and a large number of detections within the

region from 2006 to 2011 proved that congregations were annually reoccurring (Hager 2011). Through extensive sampling in the proximity of VIMS and the U.S. Army Engineer Research and Development Center receivers that had recorded adult fish, the collection of a female fish with developed eggs confirmed that fall spawning was occurring (Balazik et al. 2012). However, numerous factors suggest that sturgeon are not in this area just to spawn. Firstly, during most of the late summer residence period, water temperatures within these upriver regions (Virginia Estuarine and Coastal Observing System data) are far too warm for spawning (Borodin 1925). Secondly, numerous adults occupy habitats within the James River and its tributaries at this same time that contain no known spawning habitats. Thirdly, these adults are often joined by sub-adults that do not spawn. Finally, and perhaps most revealingly, though all preferred habitats do not contain physical conditions necessary for spawning during late summer, they are similar in their physical water quality attributes, which are known to be bioenergetically beneficial and are recognized as motivating habitat selection by sub-adults of the species (Nitlitscheck 2001). Adult physiology and bioenergetic tolerances remain unclear and are in need of further research.

Tracking of juveniles (sub-adults) in the James River has revealed that this life stage has far less distinct patterns of habitat occupation and migration than those of adults (Hager 2011). Migration patterns are not as well-defined seasonally and habitat use appears to be more dispersed. Though occupation patterns are less defined, tracking and bycatch records suggest that sub-adults likely congregate in winter and summer refuge sites and demonstrate sedentary behavior during extreme temperature conditions (Hager 2011). Juveniles of varied sizes can be found in the James River throughout the year and they are known to use tributaries, river mouths, and channel habitats. Juveniles use these habitats prior to and during their coastal migrant life phase, as evidenced by the large number of natal fish, which were at the time believed to be James River juveniles, found at the mouth of the York River in 2006 (Hager and Musick 2007).

Once juveniles exit their natal rivers, bycatch (Stein et al. 2004), scientific trawl collections (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.'s (2004) examination of federal bycatch records indicated that sturgeon of varied size are most often caught within a narrow range of depths (30–160 feet [10–50 m]) over gravel and sand, and 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 Geographical Information System (GIS) layers to describe catches attained during Cooperative Winter Tagging Cruises. Subsequent scientific cruises (Wilson Laney, U.S. Fish and Wildlife Service [USFWS], personal communication) and transmitter data (Hager 2011) also identified potentially important overwintering grounds in nearshore waters off the Outer Banks of North Carolina. These regions were congruently occupied by individuals of multiple distinct population segments (DPS) and life stages. Tracking showed these overwintering fish of mixed ages making their way north along the coast in the spring, often entering coastal bays and rivers, where sub-adults spread out presumably in search of prey, some adults returned to the James River to spawn, while others continued north along the coast (Hager 2011). Though it has long been recognized that an overall north-to-south and shallow-to-deep coastal migration pattern is evidenced seasonally by juveniles and adults alike (Holland and Yelverton 1973), advances in tracking and genetics are beginning to suggest that offshore migration and occupation patterns are not independent of genetic origin/DPS. While adults and sub-adults collected in the James River believed to be of native origin overwinter off North Carolina (Hager 2011), fish of Pamunkey River origin have been recorded overwintering much farther south off South Carolina and Georgia. If DPS-specific overwintering sites consistently occur then anthropogenic activities within these sites may have DPS-specific impacts.

The Navy has a large presence in Virginia's lower Chesapeake Bay and nearshore Atlantic waters. In order to better understand potential naval impacts and gain additional biological data, receiver arrays were deployed within seven Chesapeake Bay regions: Pamunkey River; York River; Chickahominy River; mouth of the James River; Elizabeth River; lower Chesapeake Bay; and Atlantic Ocean (**Figure 2**). Six zones of military interest occur within these regions, and receivers are strategically deployed within each: the Naval Weapons Station Yorktown/Cheatham Annex zone (York River region); Naval Station Norfolk zone and the Elizabeth River zone (James River region); Little Creek zone and Fort Story zone (Chesapeake Bay region); and Dam Neck Naval Firing Range Surrogate zone (Atlantic region).

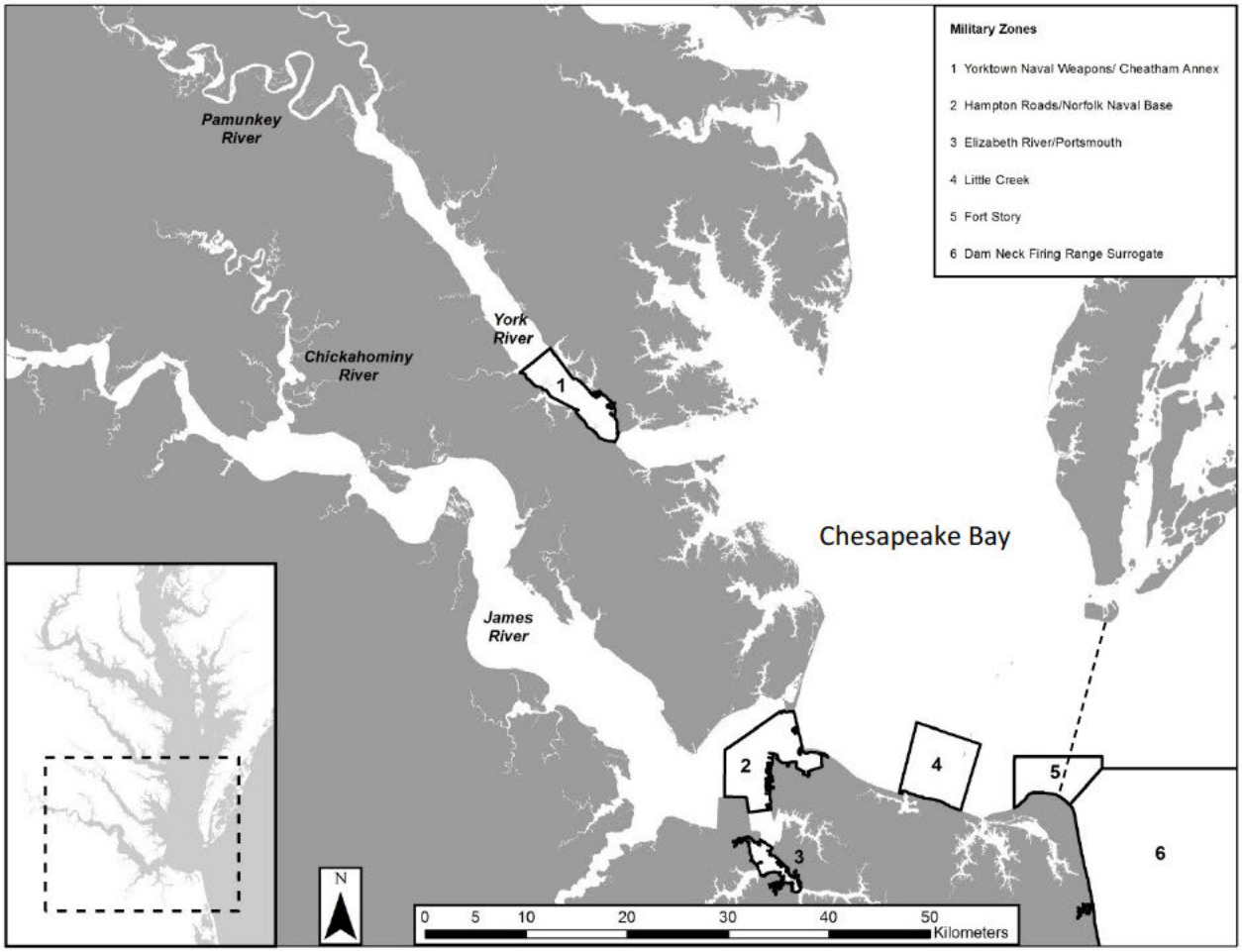


**Figure 2. Geographical location illustrations of the regions in which the arrays were placed, as well as the zones of military interest within these regions. The dashed line at the mouth of the Chesapeake Bay is the U.S. Coast Guard (USCG) COLREGS (Collision Regulations) Line.**

Numerous biological uncertainties surround Atlantic sturgeon within these regions and specifically within these military zones of interest. To describe the potential importance of a specific military zone or activity, one must understand the life stages of the species present, since habitat use characteristics vary temporally and spatially with life stage. For instance, a river site may contain native young-of-the-year (YOY), as well as native and non-native juvenile and adult sturgeon. YOY are residents that depend solely upon their native river's habitats. Juveniles and adults are most often highly mobile within riverine habitats, though they will remain in an area for months at times to benefit from a given habitat's

biological and/or physical attributes, as is the case with adults on the spawning grounds, or sub-adults and adults congregating seasonally in preferred sites. Juveniles and adults found in a bay or open-ocean site have begun to participate in migratory marine behaviors and thus they are considered to be in their highly migratory/transient life stage. Congregations of fish still occur seasonally once this stage is entered, however, as evidenced by coastal overwintering sites and gatherings at the mouth of the Chesapeake Bay during spring and fall migrations.

Due to the location and size of the Naval Station Norfolk zone, all James River native-born fish must pass through the area of the river mouth and Naval Station Norfolk when they transition into their migratory juvenile life stage. Almost nothing is known about how native YOY use the river. YOY may feed within the Norfolk zone prior to this migration, but none have been tagged with transmitters so this hypothesis cannot be substantiated. Native and migratory juveniles likely use the zone for feeding, as some extended residence times by transient juveniles suggest. Adults migrating upriver in the spring and/or fall, potentially to and from the spawning grounds, pass through the zone twice or even four times a year and sometimes linger for unknown reasons. The zone also experiences use by numerous fish of varied ages tagged in distant rivers. Seasonal use of the Elizabeth River by natal and migratory fish is likely augmented due to its close proximity to the mouth of the James. This waterway may also be used as a means of accessing the North Carolina sounds through the Intracoastal Waterway.

When this study began, it was unclear whether the York River contained a reproducing population of sturgeon or not. Although small fish had been collected in the Pamunkey River (a tributary of the York River, located upstream of the Naval Weapons Station Yorktown/Cheatham Annex zone), suggesting that a remnant spawning population persisted (Musick et al. 1994), the National Marine Fisheries Service (NMFS) had thus far not obtained enough data to recognize a reproducing population. Do to our research we now know that a stock of reproducing sturgeon remains in the York River (Hager et al. 2014). In addition, preliminary genetic analysis (Tim King, U.S. Geological Survey, personal communication), an initial population assessment of the spawning run (Kahn et al. 2014), and an unpublished assessment of the total spawning population all suggest that this genetically unique stock is very small. The Yorktown Naval Weapons Station/Cheatham Annex zone is thus of much more importance to the species than previously understood given the newly discovered presence of an additional DPS of Chesapeake origin. These installations' piers extend out to the York River channel and their zones of influence cross it. Required maintenance of the piers related to pile driving and dredging may affect both this crucial habitat and the migration corridor. To understand how important the Naval Weapons Station Yorktown and Cheatham Annex is to sturgeon belonging to the endangered Chesapeake DPS, we first had to establish if reproduction was occurring in the York River system. Once the existence of a York River population was established, tagging efforts were tailored to attain appropriate adult specimens to tag and track, to define habitat use patterns for natal fish, to delineate spawning locations, and to better understand use patterns spatially and temporally within the region and specifically within the military zone.

The Fort Story and Little Creek zones, located strategically on the southern shore of the Chesapeake Bay's entrance along the southern channel, are likely used by the majority of sturgeon entering the Bay. The naval firing range in the Atlantic off of Dam Neck and along Virginia's southern coast is in an important migration corridor for sturgeon and it is as yet unclear if this area also serves as an overwintering ground. In addition to the range being situated just south of the entrance to the Chesapeake Bay, it is north and inshore of deeper waters located off North Carolina's Outer Banks, where fish belonging to numerous coastal stocks have been documented to overwinter (Holland and Yelverton 1973, Hager 2011, Wilson Laney, USFWS, personal communication). Because of limited

deployment options and an interest in reducing interference with range operations, a location extending from the range's northern border and containing similar habitats was selected as a surrogate sampling area.

The overarching objective of this contract 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 Navy interest. All zones contain some 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.

### 2.1 Assumption, Limitations, and Benefits of Using Tracking Data to Delineate Critical Habitats

Fish seek out habitats with characteristics that optimize their bioenergetic budgets (Hager 2004, Niklitschek and Secor 2005). By quantifying and comparing occupancy patterns between sites of known habitat composition, one can delineate preference as long as the observed period of time is sufficient to characterize typical behavior and thus indicate biologically-based habitat selection. If the habitat is continually altered by natural or anthropogenic activities, however, sufficient time is required to identify habitat preference through observations that are not biased by such human impacts. Also in order to minimize bias, the sub-set of fish used as specimens should be randomly collected with respect to the behavior being studied. For example, if all fish sampled are displaying a given behavior or pattern of occupancy when collected, they do not represent an unbiased sample for assessing the behavior or pattern in general. If the goal is to understand how fish use a river, then fish can be collected and released back into that same river but their behavior following release cannot be assumed to be normal for some time due to tagging stress. In fact, it is best and possible now due to advances in the longevity of tag life that behavioral patterns are not used to define normal behavior in the year of tagging.

Tracking data are observation-based and thus offer some advantages. Unlike predictive occupancy models, the factors motivating habitat selection do not have to be understood, weighted, or incorporated appropriately over time and space. By delineating a habitat's importance based on occupancy alone, and operating under the assumption that this indicates preference and thus suitability, prioritization of these regions as important to the species is justifiable without necessarily having to understand what motivates selectivity. 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 just a biased sub-set.

## 3. MATERIALS AND METHODS

### 3.1 Telemetry Equipment

This project's telemetry research used VEMCO® V9, V13 and V16 sonic transmitters (VEMCO, Bedford, Nova Scotia, Canada) operating on a frequency of 69 kilohertz. Selected transmitters were engineered to be used in conjunction with a stationary array of VEMCO® VR2W receivers. Unlike a tag designed for active tracking wherein the researcher follows the specimen, these transmitters were not designed with short-duration transmission intervals or with varied frequencies. Instead, the receivers are stationary and the tagged fish are passively detected as they move within the receivers' reception distance. This sort of tracking approach is thus termed "passive tracking." Every tag transmits a unique identification number upon reception 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 a

receiver's reception range a fish is located and further help describe behavior as it relates to depth distribution.

VEMCO® transmitters (**Figure 3**) are named according to their diameters, thus a V9 is 9 millimeters (mm), a V13 13 mm and V16 is 16 mm. Tags can be engineered to a limited degree to meet a researcher's needs, which are influenced by species morphology and tracking objectives. However, tag size limits performance. A transmitter's battery strength (receptive distance) and longevity are positively correlated with tag size and thus a V9 tag cannot be engineered to perform as a V16. Small tags do have some advantages such as reduced incision size and surgical time and they can be more safely mounted externally.

VEMCO® V9, V13, or V16 transmitters (**Figure 3**) were used in this study. The two most commonly use tags were V13 and V16 tags (V13, 40 mm, 11 grams; V16, 90 mm long, 32 grams in air). The V9s have an expected life of less than a year and thus only provided spawning ground information, V13s are expected to last 779 days, and V16s can last up to 3650 days. Initially, transmitters of varied sizes were selected so that fish of very different sizes could be tagged effectively. Some pressure sensor tags were added to provide additional information on depth of detection but these tags cost more and thus all tags were not ordered with such sensors. Consequently, some adults were implanted with smaller V13 pressure tags, although their body size would have accommodated a V16 because depth data was desired on these particular fish. 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 in consideration of the benefits of requiring smaller incisions, a reduction in surgical time, and thus less stress to the fish. In 2014, two females bearing eggs were equipped with external V13s 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 transmitter's external eye and run back under the dorsal and double crimped with brass on the opposite side.

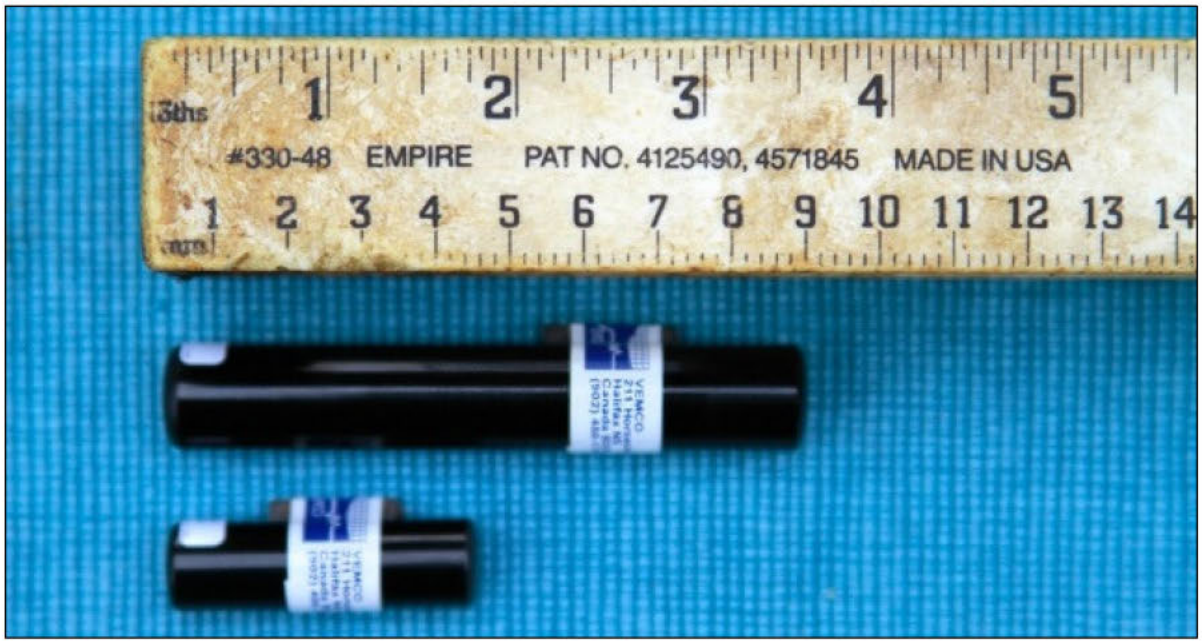


**Figure 3. VEMCO V16 (top) and V13 (below) sonic transmitters.**

## 3.2 Determining Reception Range of Transmitters

Experiments indicate that the reception range of marine sonic transmitters varies under different environmental and biological conditions (Hager 2011, Robydek and Nunley 2012). Reception differences are also influenced by battery size and declining battery strength, which affect signal intensity. Due to the highly varied topography and bottom composition of the numerous receiver sites in this study, especially those in the nearshore Atlantic, reception distances and the effects of location were in need of more rigorous assessment.

In order to provide more detailed, quantitative data, a V7 and a V16 tag were deployed in varied marine environments and conditions. The V7 is the lowest power 69-kilohertz transmitter that has been deployed within the Navy's Chesapeake array, and the V16 is the highest. Since power is positively correlated with receptive distance, these trials have begun to give us the required data to estimate average receptive distances across most of the marine environments monitored.

A VEMCO® V7 transmitter range test tag (transmitting every 10 seconds) was deployed in a local 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 degrees Celsius and the bottom temperature was 5 degrees Celsius with no thermocline. Salinity was 0.2 parts per thousand (ppt) and the lake was calm with winds at 5 miles per hour. The lake was of extremely uniform depth (2.2 m) with a mud bottom. Its minimum width was 100 m and its 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. Luckily, the important 100 percent detection distance at 140 m, the 50 percent range at 210 m, and a good approximation of the 0 percent distance at 320 m were determined (**Figure 4**).

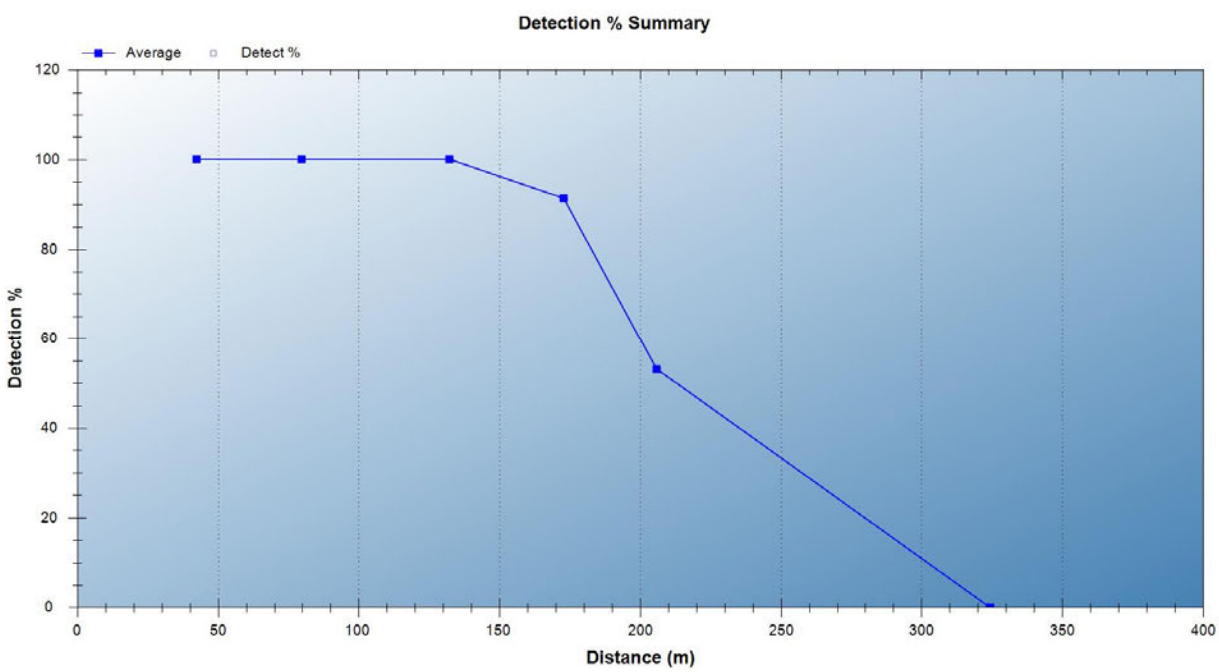


**Figure 4. Percentage of detections at varied distances from a V7 transmitter in a calm lake under ideal conditions.**

A V16 test tag was deployed and tested in situ in the upper Pamunkey's 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 degrees Celsius and the salinity was 0.01 ppt. The river was calm with winds < 10 miles per hour. The river section was relatively 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 in width at its narrowest and approximately 120 m at its widest. Initially, 6 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 determine receptive distance under varied conditions through repetitive trials. The tag was also moved progressively further around a bend in the river to determine whether a tag's transmissions would be refracted or reflected in such a small system and thus result in non-line-of-sight detections. Data were analyzed using VEMCO® distance-testing software. The results for this test were not as clear and thus not as conclusive. They suggest that the 100 percent reception distance can be as great as 600 m, with a calculated distance of 660 m for the 50 percent rate and the zero rate at 720 m. However, receivers that were closer than 600 m did not all receive 100 percent of the detections. In fact, the receiver at a distance of 460 m had very high error bars due to the inconsistent percentage of transmitted signals it detected over time. When the transmitter was relocated and this trial repeated within the same receiver array, the maximum receptive distance was reduced to 350 m.

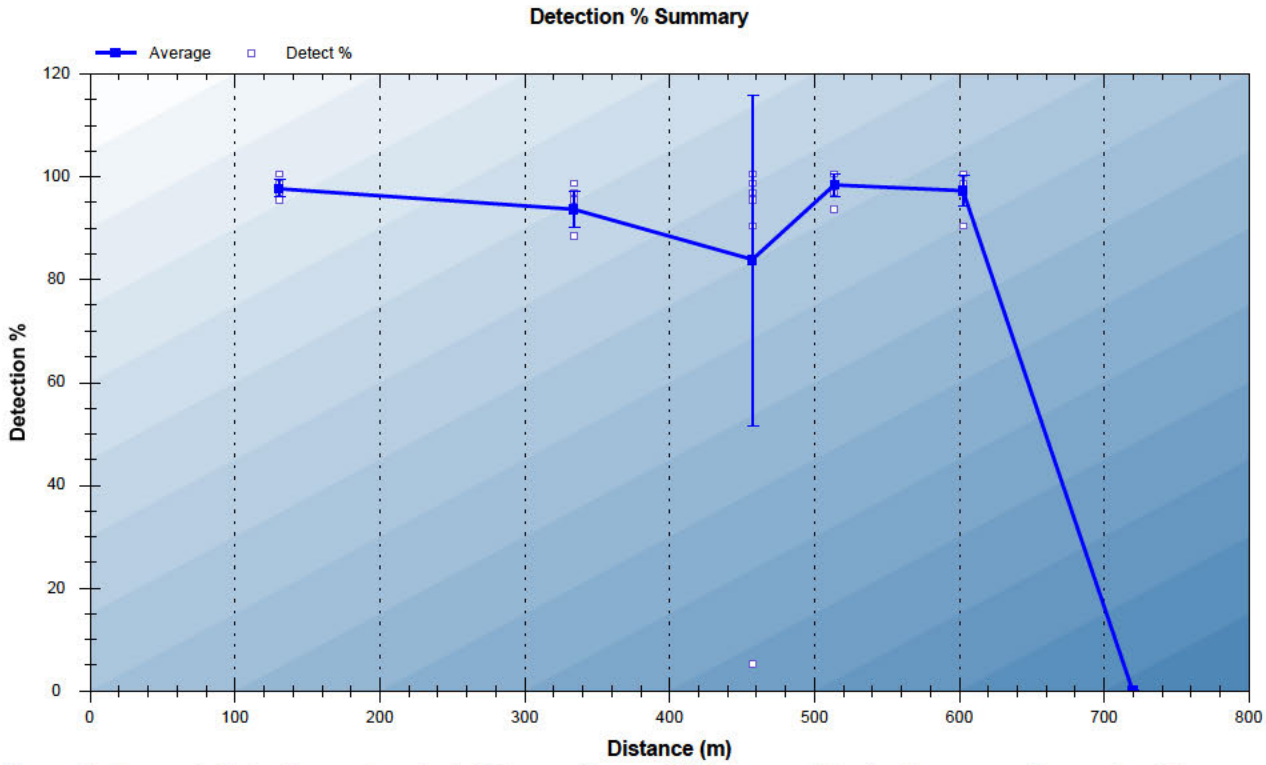


**Figure 5. Percent detections at varied distances from a V16 transmitter in the upper Pamunkey River.**

**The trial was repeated another two times to determine if transmissions could be detected if transmitter and receiver were not within line of sight, and none were detected. Error bars above represent standard error. Large error may indicate environmental or mechanical differences in operation.**

An average reception range was also calculated for a VEMCO® V16 in the James River within its oligohaline (>0.5–5 ppt) and mesohaline (>5–18 ppt) zones based on numerous field tests designed to examine the effect of marine noise and water depth. The Jamestown-Scotland Ferry pier was selected for shallow-water tests due to the presence of ferry noise, the pier's extension across a range of bottom depths, and its location in the middle of the James River's oligohaline (>0.5-5 ppt) 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. No effect from ferry noise was evidenced, but the effect of environmental noise was severe during rough water conditions (breaking waves of 60 to 90 centimeters), when the receiver or transmitter was located in shallow water (< 2 m). Under rough conditions, with the transmitter or receiver placed in shallow water (i.e., 1 to 2 m deep), the reception distance was reduced to 0.2 km. Long-distance reception tests were next conducted in Burwell's Bay in the middle of the James River's mesohaline (>5-18 ppt) zone, where both transient and native fish are found and the majority of sturgeon tagged in the James River have been collected. The maximum reception distance, under calm sea conditions, with transmitter and receiver both in deep water (10 m) was 1.3 kilometer [km]. A distance of 0.7 km was selected as a mean reception distance for a V16 considering its reduced performance in shallow oligohaline (>0.5-5 ppt) water and extended range under calm conditions in deeper mesohaline (>5-18 ppt) water. This measurement is a conservative average between the minimum and maximum distances recorded for a V16 across a range of depths and conditions as observed in the oligohaline (>0.5-5 ppt) and mesohaline (>5-18 ppt) sections of the James River. A slightly reduced average distance was selected due to the shallowness of the majority of riverine habitats and the frequently rough wave/ energy conditions that can occur in these shallows.

The same V16 tag was then tested within the Naval Weapons/Cheatham Annex zone in the York River's polyhaline region (> 18 ppt) in March over a sand (hard) bottom. Again receivers were deployed one meter below the surface and trials were designed to test receptive distances under a number of different tag and transmitter 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. 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 sea 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 reception percentages on some receivers recorded as low as 24.4 percent. Clearly, still more trials are necessary to understand why reception 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 receptive distances. With so many biological and physical variables that can influence receptive distance, the reception will always be an approximation best described as an average. Testing for much longer periods of time may also help to resolve many of the difficulties we are having, according to VEMCO engineers.

## 3.3 Sturgeon Collection and Tagging

Sturgeon of numerous age classes and life stages were tagged in highly varied geographical locations. Sturgeon tagged by our team (**Figure 6**) 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). The Navy array also detected other sturgeon that had been collected and tagged by other researchers, under other federal permits. Prior tracking in the James River demonstrated that recently tagged fish

**Figure 6. Implantation of a V13 transmitter in an adult Atlantic sturgeon in the Pamunkey River.**

often remained near their release site for a significant amount of time, with this resting period positively correlated with holding time (Hager 2011). More recent data on the behavior of fish collected on the spawning grounds suggest that fish often swim down river after tagging, in some cases far enough to enter zones of higher salinity. Here they reside for a short period, generally no more than a week, before returning upriver. When these sites are within an array's receptive area, this behavior artificially enlarges the number of detections that would naturally occur at a given site without the tagging effect. Our fish were not tagged near any zones of military interest thus our detections in these zones are not biased by our tagging efforts.

All surgical, holding, and release methods implemented by our team during this study were tested, proofed, and refined in preceding projects (Hager 2011). When fish were held in these previous studies in pens located in the mesohaline (>5-18 ppt) zone in order to proof surgical techniques, subsequent tracking recorded behavioral and/or habitat-selection alterations. Alterations in behavior were at times so severe that adults abandoned migration runs. In this study, therefore, sturgeon were never moved 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. All fish collected received both a T-bar and PIT tag supplied by the USFWS Virginia Fisheries Coordinator (Albert Spells). A fork-length measurement is also taken since total length can vary greatly due to natural differences in species' morphology and injury, and a caudal fin flesh sample is collected for genetic analysis.

## 3.4 Telemetry Data Collection and Analysis

Receivers were placed on United States 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 Authority, and private landowners, respectively (**Figure 7**). 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 checked monthly for maintenance and data collection. But this number was enlarged seasonally to 89 receivers in order to better describe migration and spawning behaviors in the Pamunkey and York River systems. 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.

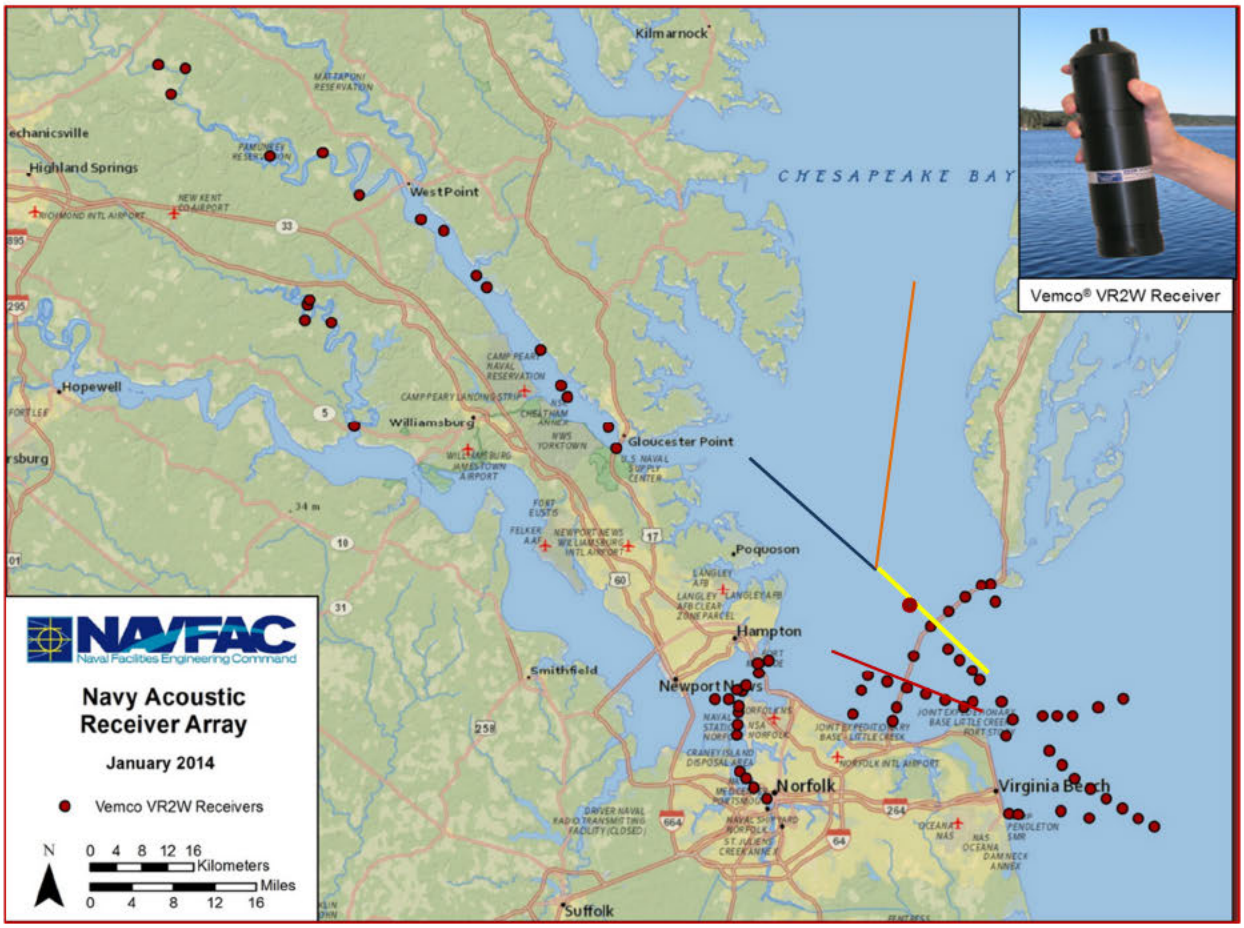


**Figure 7. Map of Navy acoustic receiver locations. Figure 7 illustrates Navy funded receiver sites monitored in 2014. The red line to the south marks the Thimble Shoals Channel to the James River. The yellow line heading northwest is the Baltimore Channel that splits into the York River Channel (blue) and then continues north to Baltimore, MD (orange). The Eastern Shore is clearly visible on the eastern side of the Bay as is the Bay Bridge Tunnel, which is the highway extending across the Bay's entrance from Little Creek to Cape Charles at the Eastern Shore's southern tip.**

# 4. RESULTS

## 4.1 TAGGING

In order to address a scarcity of tracking results in the York River drainage, we targeted Atlantic sturgeon for capture with anchored gillnets in the upper York and Pamunkey rivers during 2012–2015. After obtaining two small fish in 2012 in the York River, we focused tagging efforts on the Pamunkey River in the York River watershed, initially to identify if spawning was occurring. Subsequently, we worked to develop spawning population estimates and improve habitat-occupation data. Collection efforts were concentrated in the late summer and early fall; however, in 2014 and 2015 we also conducted collection activities in the Pamunkey River for several months in the spring but obtained no fish.

During 2012–2013, we captured 18 sturgeon from the York River watershed using gillnets, with 2 recaptures. Sixteen of these fish were tagged with transmitters, including 13 adults and 3 sub-adults (**Table 1**). 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 were tagged in 2013 or 2014 and some fish were recaptured more than once in 2015. Thirty new, never before attained individuals were also collected including 6 confirmed females that were fitted with transmitters.

There are no external anatomically-based methods of identifying the sex of an Atlantic sturgeon. Sex can only be identified by internal examination or the external expression of gametes. In early 2013, the presence of so many adult fish during suitable water temperatures (18–20 degrees Celsius) 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) upon capture; and the rest were unknown. In 2015, of the 101 fish collected 77 were unique fish, of these 11 were female, 37 were male, and 29 were unknown.

**Table 1. Information on each fish tagged through this contract. (* = 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 | Unknown |
| 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 | Unknown |
| 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 | Unknown |
| 8/6/2014 | na - malfunction | 48104 | 1,295 | A69-9002-12732 | Pamunkey | Unknown |
| 8/6/2014 | 900118001181160 | 50752 | 1,607 | A69-9001-27841 | Pamunkey | Unknown |
| 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 | Unknown |
| 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 | M |
| 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 and 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 | Unknown |
| 9/8/2014 | 900118001201948 | 50803 | 1,934 | A69-9002-12750 | Pamunkey | Unknown |
| 9/8/2014 | 985121026865700 | 50804 | 1,810 | A69-9002-12736 | Pamunkey | Unknown |
| 9/8/2014 | 900118001202071 | 50805 | 1,581 | A69-9002-12754 | Pamunkey | Unknown |
| 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 | Unknown |
| 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 | Unknown |
| 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 |

| Date Tagged/ Recaptured | PIT Tag # | T Tag # | Fork Length (mm) | Transmitter # | River | Sex |
|---|---|---|---|---|---|---|
| 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 |
| 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 | A69-9001-26381 | Pamunkey | Male |
| 9/22/2014 | 989001003179745 | 50336 | 1,800 | A69-9001-26380 | 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 | ? | 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 and 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 | Unknown |

| Date Tagged/ Recaptured | PIT Tag # | T Tag # | Fork Length (mm) | Transmitter # | River | Sex |
|---|---|---|---|---|---|---|
| 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 |
| 8/18/2015 | 989001000099053 | 50839 | 1,578 | na | Pamunkey | Unknown |
| 8/19/2015 | 989001000099128 | 50840 | 1,928 | A69-9004-1178 | Pamunkey | Unknown |
| 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 | Unknown |
| 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 | Unknown |
| 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 |

| Date Tagged/ Recaptured | PIT Tag # | T Tag # | Fork Length (mm) | Transmitter # | River | Sex |
|---|---|---|---|---|---|---|
| 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 |
| 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 | Unknown |
| 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 | Unknown |
| 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 | Unknown |
| 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 |

| Date Tagged/ Recaptured | PIT Tag # | T Tag # | Fork Length (mm) | Transmitter # | River | Sex |
|---|---|---|---|---|---|---|
| 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 | Unknown |
| 9/25/2015* | 900118001202200 | 50779 | 1,626 | DEAD TAG - 13589 | Pamunkey | Unknown |
| 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 |
| 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 | Unknown |
| 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 | Unknown |
| 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 |

Key: na = not available.

## 4.2 Array Coverage

Due to loss and breakage, every receiver site did not contain an operational receiver during every day of every month of the study. Gaps in receiver operation may 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 very close proximity to other receivers. These sites were 11n (Chesapeake Region), NH3 (Naval Station Norfolk), B3 (Fort Story), NCA (Atlantic Region), and CB15 (Range Surrogate), which were not monitored in 2014 or 2015. The largest gaps in receiver coverage due to receiver failure or loss occurred in the Atlantic Ocean in the Range Surrogate 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 importance of data gaps within military zones of interest may result in an underestimation of sturgeon occupation due to reduced receiver function. **Table 2** lists receiver site, region, and military zone, if applicable, and describes monitoring by month. It does not include every time a receiver site was maintained due to limited space.

During array operation in 2013, we faced many receiver deployment challenges. Receiver losses (30) expanded with increasing distance from shore. We believe, and in some case have evidence, that losses occurred due to vessel and dredge interactions and extreme equipment stress during unusually large storms. Twelve losses occurred during a single storm event in March 2013, when waves remained very large (2 to 6 m) for weeks. We also suffered from faulty equipment (e.g., shackles) and potentially direct removal by unknown persons in 2013. In one instance, a site on the Chesapeake Bay Bridge-Tunnel (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-centimeter 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 in place of our original copper ones. However, no matter the thickness or type of cable, nothing will prevent all losses. 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. Our communications with USCG were subsequently improved, and we have not had any problems since. Largest losses in data in 2015 were due to damage and wear sustained during a late-season hurricane on 1 October.

**Table 2. Summary of monitoring for sonic-tagged sturgeon, December 2012–January 2016**

**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, and USCG means that the buoy was replaced by USCG and the receiver was removed. Abbreviations for sites/regions/zones are: Pam. = Pamunkey; Chick. = Chickahominy; Eliz. = Elizabeth; Ches. = Chesapeake; NW/Ch. = Naval Weapons/Cheatham Annex; NSN = Naval Station Norfolk; Range Sur. = the surrogate for the Naval Firing Range off Dam Neck.**

| 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 | 9/20/2013LD10/12 | 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 |
| 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 | | | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 (b) (6) | 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 (b) (6) | 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 (b) (6) | 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. (b) (6) 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 | 7/30/2014USCGRD | 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 | 7/30/2014USCGRD | 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 | 7/30/2014USCGRD | 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 | |
| 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 |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 7/23/2014USCGRD | 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 | 7/23/2014USCGRD | 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 | 7/31/2014USCGRD | 9/3/2014 | 10/3/2014USCGRD | 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. (b) (6) | 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 |
| 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. (b) (6) | 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. (b) (6) | 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. 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 | | |

| 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. [redacted] 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 [redacted] | 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 [redacted] lower | Pam. River | new in 2014 | seasonal | | | | | | 7/26/2014D | 8/12/2014 | 9/11/2014 | 10/6/2014 | 11/4/2014 | | |
| Pam. [redacted] | 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 |
| 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 |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| NH5 | 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. (b) (6) | 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. (b) (6) | 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. (b) (6) | 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. (b) (6) 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 (b) (6) | 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 (b) (6) 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 (b) (6) (b) (6) | 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 | |

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Receiver locations were mapped in terms of river mile, bay mile, or offshore distance from the Collision Regulations line (COLREGS) 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 4.2 A**. Coverage by receivers within military zones based on our 0.7-km mean detection range (for a V16 tag) is presented in **Table 3.** Maps denoting estimated receiver reception coverage within each zone of military interest are presented in **Appendix 4.2 B.**

**Table 3. Estimated coverage of receivers within military zones of interest. Perimeters, areas, and percentage of aquatic area covered by the receiver array (based on a 0.7-kilometer estimated reception range) are presented. Receiver coverage was reduced at some sites because a portion of the receiver detection range was occupied by land, therefore, percent coverage reflects aquatic coverage only.**

| Military Zone | Perimeter (m) | 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 | 18,987.3 | 17,990,689.5 | 4,438,136.3 | 24.7 |
| Firing Range Surrogate | 84,761.2 | 375,837,361.0 | 27,698,676.9 | 7.4 |

## 4.3 Transmitter Detection Overview

A total of 889 individual Atlantic sturgeon was detected within the receiver array from December 2012 through December 2015. Data on the number of detections at each receiver will be presented in the appropriate regional and military zone sections. Twenty-four other species with sonic tags were also recorded (**Table 4**); these represent the efforts of 47 (34 through 2014) researchers from 36 (32 through 2014) different organizations (**Table 5)**. The greatest numbers of sturgeon detected from December 2012 until December 2015 were tagged north of the Chesapeake Bay (n=492), followed by those tagged within (n=360), and then those tagged in waters south of the Bay (n=36), which included fish tagged as far south as Georgia.

As the contract requires, ArcGIS® maps denoting the total numbers of detections by month, year, and overall are presented in the appendices. Each region has its own set of maps with its integral military zones. If a map does not appear for a given month, it is because there were no detections, not because the receiver array was not in place. Detection maps/layers can also be combined in the future with layers describing other parameters such as bottom composition, temperature, salinity, and dissolved oxygen—factors known to affect sturgeon distribution (Niklitschek and Secor 2005). And thus layers can be built upon to provide increased insight with regard to why habitats are selected. Results in some regions at this point are meager, but this is common for the first few years of tracking research.

**Table 4. Sonic-tagged species detected within the receiver array. The numbers higlighted in blue for each species are the total number of unique individuals detected and the total at the bottom is the total number of individuals detected.**

| Species/Year | Number of Fish | Number of Detections |
|---|---|---|
| *American shad* | *2* | *59* |
| 2015 | 2 | 59 |
| *Atlantic sturgeon* | *888* | *1,097,157* |
| 2013 | 400 | 77,655 |
| 2014 | 511 | 417,000 |
| 2015 | 637 | 602,502 |
| *Black drum* | *5* | *12,496* |
| 2013 | 2 | 17 |
| 2014 | 2 | 647 |
| 2015 | 2 | 11,832 |
| *Black sea bass* | *9* | *2,108* |
| 2015 | 9 | 2,108 |
| *Blacktip shark* | *8* | *785* |
| 2014 | 4 | 5 |
| 2015 | 4 | 780 |
| *Blue catfish* | *31* | *647,378* |
| 2013 | 1 | 89 |
| 2015 | 30 | 647,289 |
| *Blueback herring* | *45* | *68,183* |
| 2013 | 45 | 68,183 |
| *Bull shark* | *4* | *37* |
| 2013 | 3 | 17 |
| 2014 | 3 | 10 |
| 2015 | 2 | 10 |
| *Cownose ray* | *44* | *5,953* |
| 2014 | 27 | 1,978 |
| 2015 | 32 | 3,975 |
| *Finetooth shark* | *1* | *47* |
| 2015 | 1 | 47 |
| *Green turtle* | *3* | *898* |
| 2013 | 1 | 23 |
| 2014 | 2 | 875 |
| *Horseshoe crab* | *1* | *1* |
| 2013 | 1 | 1 |
| *Kemp's ridley turtle* | *33* | *8,443* |
| 2013 | 2 | 15 |
| 2014 | 19 | 1,098 |
| 2015 | 13 | 7,330 |
| *Loggerhead sea turtle* | *32* | *7,091* |
| 2013 | 13 | 1,693 |
| 2014 | 13 | 2,732 |

| Species/Year | Number of Fish | Number of Detections |
|---|---|---|
| 2015 | 7 | 2,666 |
| *Roughtail stingray* | *1* | *3* |
| 2015 | 1 | 3 |
| *Sand tiger shark* | *185* | *24,482* |
| 2013 | 124 | 1,248 |
| 2014 | 111 | 1,448 |
| 2015 | 98 | 21,786 |
| *Sandbar shark* | *22* | *1,558* |
| 2013 | 19 | 317 |
| 2014 | 13 | 1,082 |
| 2015 | 3 | 159 |
| *Speckled trout* | *1* | *67* |
| 2013 | 1 | 67 |
| *Spinner shark* | *1* | *27* |
| 2014 | 1 | 27 |
| *Spiny dogfish* | *4* | *354* |
| 2013 | 4 | 354 |
| *Striped bass* | *64* | *39,375* |
| 2013 | 14 | 326 |
| 2014 | 32 | 14,521 |
| 2015 | 29 | 24,528 |
| *White shark* | *8* | *73* |
| 2013 | 3 | 6 |
| 2014 | 2 | 46 |
| 2015 | 5 | 21 |
| *Winter flounder* | *7* | *107* |
| 2013 | 6 | 53 |
| 2014 | 6 | 54 |
| *Winter skate* | *2* | *400* |
| 2014 | 2 | 140 |
| 2015 | 1 | 260 |
| **Grand Total** | **1,590** | **1,959,320** |

**Table 5. Researchers who sonically tagged species detected within the receiver array. Researchers in the northeast tagged 492, those in the Chesapeake Bay tagged 360 and those south of the Chespeake Bay tagged 36 sturgeon that were detected.**

| Researcher | Organization | Species | Total |
|---|---|---|---|
| Aaron J. Bunch | Virginia Department of Game and Inland Fisheries | Blue catfish | 30 |
| Amanda Higgs | New York State Department of Environmental Conservation | Atlantic sturgeon | 1 |
| Anne Wright | Virginia Commonwealth University | Atlantic sturgeon | 9 |
| Bill Post | South Carolina Department of Natural Resources | Atlantic sturgeon | 12 |
| Bradley Stevens | University of Maryland Eastern Shore | Black sea bass | 9 |
| Charles P. Stence | Maryland Department of Natural Resources | Atlantic sturgeon | 13 |
| Chris Hager | Chesapeake Scientific | Atlantic sturgeon | 6 |
| Chris Hager/Carter Watterson | Chesapeake Scientific/U.S. Department of the Navy | Atlantic sturgeon | 55 |
| | | Blueback herring | 45 |
| Chuck Bangley | East Carolina University | Sandbar shark | 22 |
| Danielle Haulsee | University of Delaware | Sand tiger shark | 55 |
| David Secor | University of Maryland – Chesapeake Bay Laboratory | Striped bass | 29 |
| Debra Abercrombie | Stony Brook University | Bull shark | 4 |
| Dewayne Fox | Delaware State University | Atlantic sturgeon | 229 |
| | | Horseshoe crab | 1 |
| | | Sand tiger shark | 86 |
| Doug Peterson | University of Georgia | Atlantic sturgeon | 4 |
| Elizabeth Fairchild | University of New Hampshire | Winter flounder | 6 |
| Eric Hilton | Virginia Institute of Marine Science | Atlantic sturgeon | 116 |
| Eric Reyier | Kennedy Space Center Ecological Program | Black drum | 3 |
| | | Finetooth shark | 1 |
| | | Roughtail stingray | 1 |
| | | Spinner shark | 1 |
| Eric Thadey | DC Fisheries & Wildlife | Striped bass | 5 |
| Gail Wippelhauser | Maine Department of Marine Resources | Striped bass | 21 |
| Gayle Zydlewski | University of Maine | Atlantic sturgeon | 1 |
| Greg DeCelles | University of Massachusetts Dartmouth | Winter flounder | 1 |
| Greg Skomal | Massachusetts Marine Fisheries | Sand tiger shark | 21 |
| | | White shark | 8 |
| Hal Brundage | Environmental Research and Consulting, Inc. | Atlantic sturgeon | 14 |
| Ian Park | Delaware Division of Fish and Wildlife | Atlantic sturgeon | 5 |
| | | Striped bass | 1 |
| Jake LaBelle | Wildlife Conservation Society | Sand tiger shark | 14 |
| Jared Flowers | North Carolina State University | Atlantic sturgeon | 3 |
| Jason Rock | North Carolina Division of Marine Fisheries | Striped bass | 1 |
| Jeff Kneebone | Massachusetts Marine Fisheries | Sand tiger shark | 3 |
| Joanne Braun McNeill | National Marine Fisheries Service | Loggerhead turtle | 1 |
| Joe Hightower | North Carolina State University | Striped bass | 3 |
| Johnny E. Moore | Delaware Division of Fish and Wildlife | American shad | 2 |

| Researcher | Organization | Species | Total |
|---|---|---|---|
| Joshua K. Raabe | North Carolina State University | Striped bass | 1 |
| Keith Dunton | Delaware State University | Atlantic sturgeon | 189 |
| | | Winter skate | 2 |
| Kimberly Durham | Riverhead Foundation for Marine Research and Preservation | Kemp's ridley turtle | 2 |
| Kristine Edwards | New York State Thruway Authority | Atlantic sturgeon | 5 |
| Matt Balazik | Virginia Commonwealth University | Atlantic sturgeon | 161 |
| | | Blue catfish | 1 |
| Matt Kenworthy | University of North Carolina Chapel Hill | Black drum | 2 |
| Matt Ogburn | Smithsonian Environmental Research Center | Cownose ray | 44 |
| Merry Camhi | Wildlife Conservation Society | Sand tiger shark | 6 |
| Micah Kieffer | United States Geological Survey | Atlantic sturgeon | 1 |
| Michael Arendt | South Carolina Department of Natural Resources | Loggerhead sea turtle | 1 |
| Michael Loeffler | North Carolina Division of Marine Fisheries | Atlantic sturgeon | 17 |
| Roger Rulifson | East Carolina University | Spiny dogfish | 4 |
| Stephen Kajiura | Florida Atlantic University | Blacktip shark | 4 |
| Sue Barco/Carter Watterson | Virginia Aquarium/U.S. Department of the Navy | Green turtle | 3 |
| | | Kemp's ridley turtle | 22 |
| | | Loggerhead turtle | 19 |
| Tim Ellis | North Carolina State University | Speckled trout | 1 |
| Tom Savoy | Connecticut Department Environmental Protection | Atlantic sturgeon | 47 |

The military zone with the largest average number of detections per receiver (4,434: 6,019 in 2015; 5,011 in 2014; 2,272 in 2013) was the Naval Station Norfolk zone, which was covered by 12 receivers (**Figure 8**). The average number of detections within Little Creek (2,575: 1,996 in 2015; 4,639 in 2014; 1,089 in 2013 on 7 receivers), Fort Story (2,428: 2,850 in 2015; 2,273 in 2014; 2,162 in 2013 on 4 receivers), and the Dam Neck Naval Firing Range Surrogate (396: 399 in 2015; 488 in 2014; 300 in 2013 on 14 receivers) zones were considerably less, with the second largest number of detections being roughly half that recorded within the Naval Station Norfolk zone. The average number of detections per receiver at the Naval Weapons Station Yorktown and Cheatham Annex zone (1,296: 2,125 in 2015; 1,437 in 2014; 245 in 2013 on 4 receivers) increased an order of magnitude in 2014 and increased again in 2015. The Elizabeth River zone (1,102: 568 in 2015; 461 in 2014; 89 in 2013 on 4 receivers) exhibited a similar increase in its rate of detections per receiver.

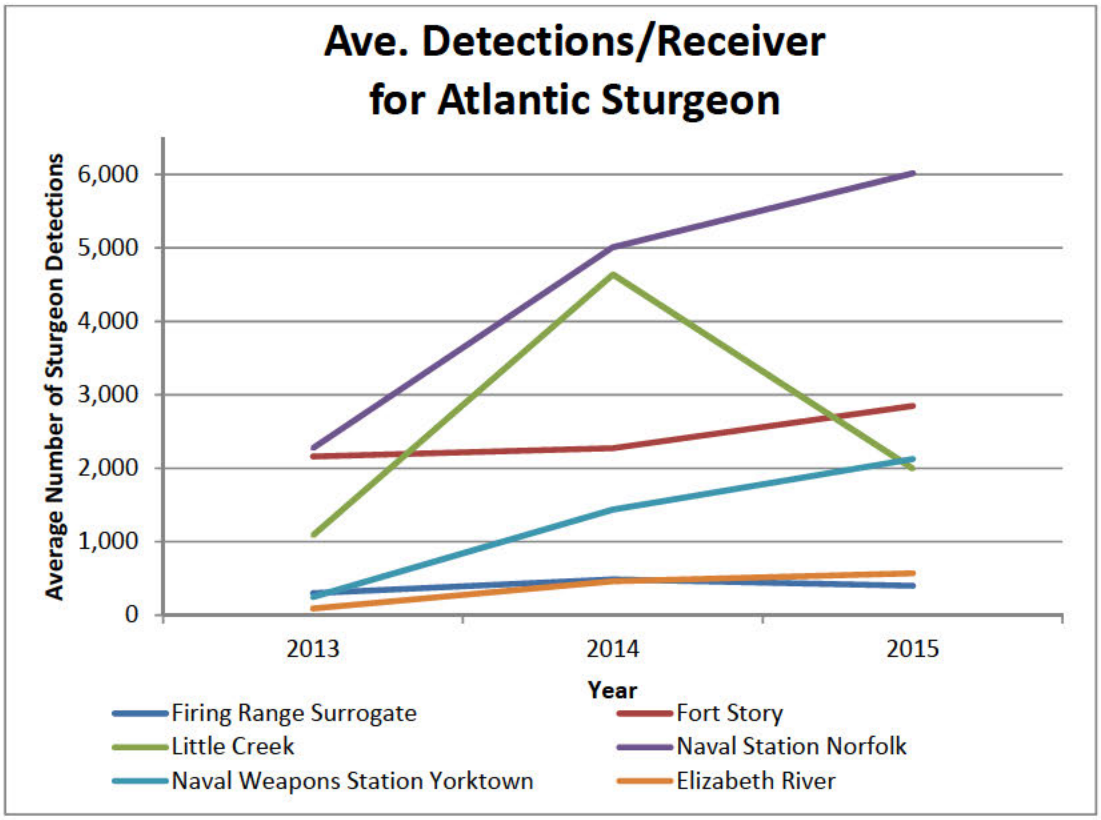


**Figure 8. Figure 8 illustrates the average number of sturgeon detected per receiver within each zone each year. Notice the variation in Little Creek's values that do not consistently correspond to the number of fish detected (Figure 9). This suggests stark differences in interannual behavior.**

The military zone with the largest number of sturgeon detected each year (**Figure 9**) was the Dam Neck Naval Firing Range Surrogate zone (455 in 2015; 352 in 2014; 284 in 2013). The second largest number were detected in the Fort Story zone (276 in 2015; 214 in 2014; 174 in 2013) followed very closely by the Naval Station Norfolk and Little Creek zones which detected nearly identical numbers (256 vs. 256 in 2015; 206 vs 204 in 2014; 157 vs 159 in 2013). The number of sturgeon detected at the Naval Weapons Station Yorktown and Cheatham Annex zone (51 in 2015; 54 in 2014; 15 in 2013) increased annually due to the tagging of new fish and returning fish tagged in preceding years through this study. The Elizabeth River zone (29 in 2015; 22 in 2014; 5 in 2013) also exhibited an increasing rate of detections that were mostly due to upriver tagging efforts in the James River.

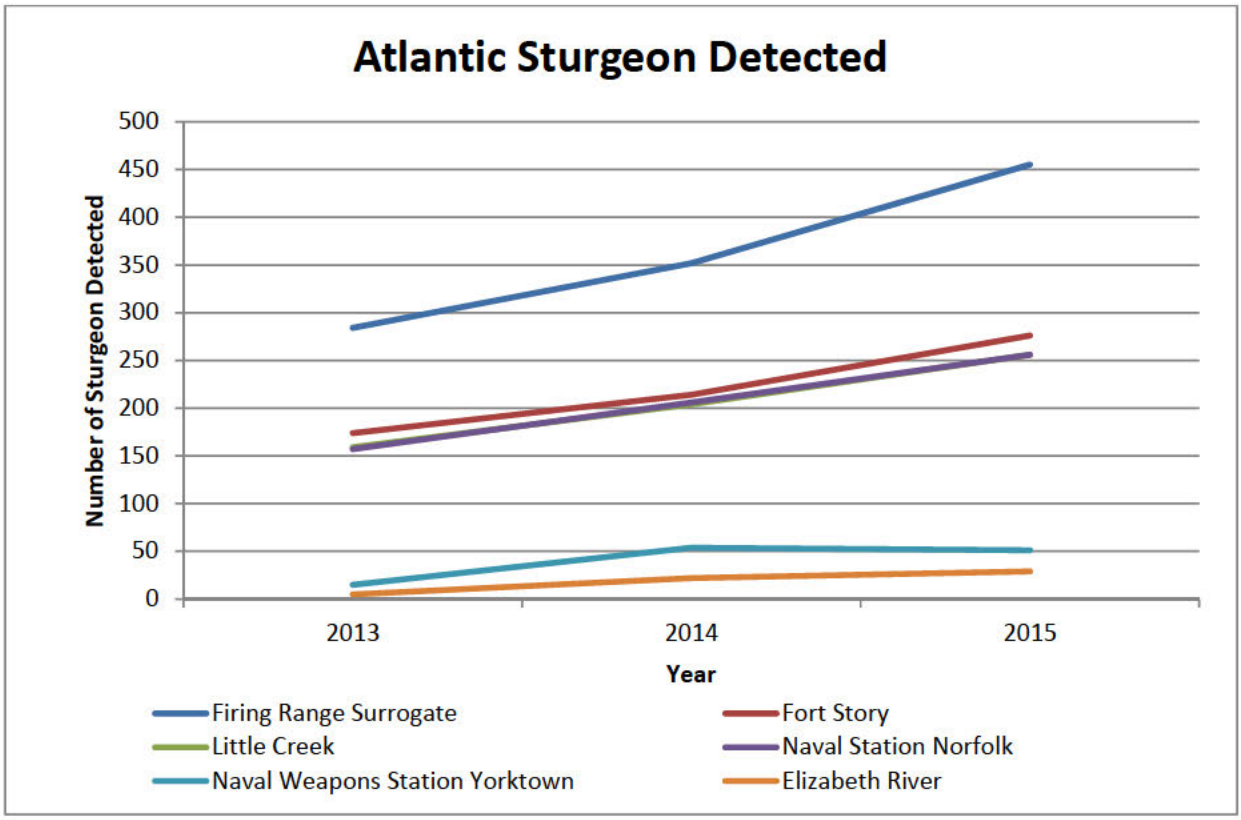


**Figure 9. The number of individual sturgeon detected in each zone in each year appears in Figure 9. Little Creek's values are nearly identical to those of Naval Station Norfolk and thus its green line is not visible below the purple line.**

## 4.4 Results by Region and Military Zone

### 4.4.1 Pamunkey River Region

There were no telemetry results from within the Pamunkey River and very few within the York River watershed prior to our tagging of adult fish in late summer 2013. In 2014 and again in 2015, we continued to tag adults and greatly expanded our receiver array coverage in the Pamunkey River and slightly in the York River in order to attain more precise data on staging and spawning ground locations and migration periods. Old sites were not abandoned and the consistency of spatial monitoring parameters was maintained. Additional stations were placed in regions of interest based on previous reception records. In addition, we directly assisted VIMS in their sub-adult research by providing them with information on sub-adult locations and allowing them to use our tagged fish and receiver array as a means for locating other sub-adults for their tagging efforts.

With our help and a great deal of effort on their own, VIMS tagged ten sub-adults, nine in the lower Pamunkey and one in the lower Mattaponi. However, the only two sub-adults genetically confirmed to be of native origin were the two small fish tagged through our efforts in December of 2012. These left the river shortly after tagging and have not returned but have been detected offshore, on the Eastern Shore and in the Bay. One has not returned to the Bay since 2013 and the other has resided seasonally

in the James River within the Naval Base Norfolk zone. Based upon subsequent detections (2012–2015), sub-adults tagged in the Pamunkey River are highly mobile, which typifies the behavior of sub-adults tagged in other Virginia waters (Hager 2011, Eyler et al 2004). Without genetic analysis, however, there is no way to know if these sub-adults tagged by VIMS are native York River fish, or if in fact they are simply exemplifying the well-documented behavior of highly mobile transient sub-adults and are from other systems (Bain 1997, Savoy and Pacileo 2003). Sub-adults tagged in the James 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 down river in the York have moved up into the Pamunkey in the spring (mid-March) and resided there through November. One sub-adult tagged in the James moved into the Pamunkey where it remained for several months. What does appear consistent thus far is that sub-adults do not often occupy the river's freshwater portion but instead prefer its oligohaline (>0.5-5 ppt) and higher salinity zones (below river mile 23).

We began tagging adult spawners in the Pamunkey River in 2013 and continued in 2014 and 2015. But because tagging can alter behavior (Winter 1983, Sutton and Benson 2003, Hager 2011), it is best if the spatial and temporal aspects of behavior immediately following tagging are not used to characterize normal occupation patterns. Based on the assumption that after six months, a tag's presence does not alter behavior, we examined the spatial and temporal aspects of adults tagged in 2013 and 2014 on their spawning runs in 2014 and 2015 to detect patterns (**Table 6**). Nine of the 13 male adults tagged in 2013 returned in 2014, but since one tag failed after several days, the true return rate was 75%. In 2015, 11 of the 12 adult males tagged in 2013 returned. Though two of the V13s implanted in 2013 had stopped working, we positively identified these fish on recapture due to PIT tags. Of the 34 adults tagged in 2014, 18 returned in 2015 (53%), including one female, so our total return rate for the 2013 and 2014 fish in 2015 was 29 out of 46 possible fish or 63%.

**Table 6. The immigration and emigration pathways and the months of detections (in parentheses following location abbreviation) are listed in the table below. 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. For geographical locations see**

| Transmitter Number | 2014 immigration | 2014 emigration | 2015 immigration | 2015 emigration |
|---|---|---|---|---|
| **Tagged 2013** | | | | |
| 27836 | TS(4) B(5) TS(6) | B(10) | B(7) | B(10) |
| 27837 | na | na | B(4) | unknown |
| 27838 | na | na | E,CBBT, TS 4) | unknown |
| 27839 | B(6) | unknown | TS(4) | unknown |
| 27840 | na | na | B(4) | unknown |
| 27842 | B(5) | B(11) | na | na |
| 27843 | B(4-5) | B(10) | TS(4) | B(11) |
| 27844 | B(4) | B(10) | B(4) | B(10) |
| 27846 | B(6-7) | B(11) | B(4-6) TS(6) | B(11) |
| 27847 | unknown | unknown | CBBT3(4) | E(10) |
| 13587 | unknown | unknown | dead tag | dead tag |
| 13589 | B(6) TS(6) B(7) | unknown | dead tag | dead tag |
| **Tagged in 2014** | | | | |
| 7698 | na | na | dead tag | dead tag |
| 27841 | na | na | E(4-5) B(6-7) | CBBT1(9) |
| 13588 (Female) | na | na | CBBT5(3) | unknown |
| 12732 | na | na | unknown | B(11) |
| 12737 | na | na | E (4) | E(10) |
| 12739 | na | na | TS(6) B(6) | unknown |
| 12740 | na | na | B(6) | unknown |
| 12741 | na | na | TS(4) B(5) E(5) | unknown |
| 12742 | na | na | E(5) | unknown |
| 12745 | na | na | CBBT1(5) | B(11) |
| 12746 | na | na | TS(4) B(6) B(8) | B(11) |
| 12747 | na | na | B(4) B(6) | E(10) |
| 12748 | na | na | CBBT3(4) B(6 and 7) | unknown |
| 12751 | na | na | E (5) B(6) | unknown |
| 12753 | na | na | E(4) B(6,7,8) | E(10) |
| 12754 | na | na | B(5 and 6) | unknown |
| 12756 | na | na | E (4) B(4) B(6-7) E(7) | B(10) |
| 12759 | na | na | B(6) B(7) B(8) | unknown |

Based upon the past two years of data, 24 out of 36 (67%) adults used the Baltimore Channel during their immigration run to the spawning grounds. Seven (19%) used the Baltimore and Thimble Shoals Channel, three (8%) used the Thimble Shoals Channel only, five (14%) were detected on the CBBT only, four (11%) were detected off the Eastern Shore, and two (6%) used unknown pathways. Fish were

present in the Chesapeake Bay from March until August, with fish arriving in the region from March until July. The majority of immigration occurs in April, the same month when some adults first arrive in the lower James River's mesohaline (>5-18 ppt) zone (Musick and Hager 2007) which is the Naval Station Norfolk Zone. Adults enter the York River's mouth or polyhaline (>18ppt) zone from late May through August. Despite our efforts to net adult sturgeon in the Pamunkey and upper York River in order to document a spring spawn, none have been collected or tracked.

Adult anadromous fish reside in saltwater for the majority of their lives and must metabolically adjust to fresh water environments when they make their spawning runs. In saltwater, fish must retain fresh water and expel salts to maintain metabolic function. In freshwater, they must retain salt and expel fresh water. Therefore, they must alter their osmotic regulation, a metabolic alteration that takes a varied amount of time depending upon the individual and the salinity attributes of the estuary. In a reduced number of cases, adult sturgeon move relatively rapidly into the lower oligohaline (>0.5-5 ppt) section of the Pamunkey arriving there as early as the end of May. Most however linger in the York River's upper mesohaline (>5-18 ppt) zone making repetitive upriver runs into the lower oligohaline (>0.5-5 ppt) zone prior to moving onto the purely fresh water spawning grounds. No adults have been detected on the freshwater spawning grounds before July where most males remain until mid to late September. Females appear to exit the spawning grounds after a series of upriver runs within suitable spawning habitats. Most often, these runs culminate with the farthest upriver run that the female will make followed by her rapid exit to higher salinity waters.

Males have been observed leaving the Pamunkey as early as the last week of September but the vast majority remain into October, with a very few fish residing in the river's lower oligohaline (>0.5-5 ppt) zone until early November. Males have been recorded leaving the farthest downriver receiver site at the Yorktown Bridge in the middle of the polyhaline (>18 ppt) as early as the end of September and as late as 3 December. Residence within the York River can be as short as a week or as long as two months. This period is often characterized by a series of up and down river movements and extended periods of time spent resting/staging in the lower mesohaline (>5-18 ppt) and upper polyhaline (>18 ppt) zones. Males begin to show up in the Bay as early as late September but the majority are first detected there in November. Emigration routes and characteristics are very different from those exemplified during immigration. Though the Baltimore Channel containing the York's submerged river bed is preferred, its use is greatly reduced (39%). Fish are not selecting the Thimble Shoals channel as an alternative; in fact, none have been recorded using this equally deep channel. Use of the Eastern Shore upon emigration appears equal to that during immigration. In stark contrast to immigration data is the large increase in the number of fish that are not detected leaving Bay. In the spring only 6% of returning fish used an undetected pathway. Upon emigration 44% were not detected, a percentage that is greater than that using the preferred immigration route through the Baltimore Channel.

In accordance with the findings of Smith (1986), many of the females tagged have been recorded leaving fresh water immediately after presumed spawning based on tracking data. The hypothesis that this is normal behavior is complicated by the fact that observations supporting it have occurred in the same year as tagging. So the question remains as to whether this behavior is normal or is an artifact due to capture and tagging. Female 13588's unique history offers for the first time a view into the undisturbed behavior of a female on the spawning run. She was tagged in 2014 late in the year (25 Sept.) several days after a very large down-river migration of fish was recorded leaving the middle of the Pamunkey River's spawning grounds. The fact that she was full of roe upon tagging and returned to the Bay in 2015 earlier than we had ever recorded any adult fish returning, lead us to believe she did not spawn in 2014. This hypothesis was supported when she was recaptured on the spawning grounds on 2 September

2015, still swollen with eggs. She was not expressing eggs at the time but temperatures at her capture site (**Figure 10**) were also not optimal at the time. The track of this female on her return year provided our least biased data for the identification of spawning grounds and female immigration and emigration. She immigrated into the Bay in March through the Little Creek zone earlier than we had ever recorded a male doing so and took up station at the mouth of the James within the Naval Base Norfolk zone. By contrast, this is not typical behavior for the numerous males we have observed. Despite this early lower Bay arrival, she arrived in the York a month after numerous males in the third week of June. Entering the Pamunkey in July, long after males had occupied the river, she entered onto the spawning grounds in early August (Maps for the spawning region found in **Appendix 4.4.1.**) where again the majority of males were already residing. She remained on these grounds until making what appeared to be a far upriver spawning run in mid-September. She exited the York River in mid-October skipping all Bay receivers until detected offshore during the third week of November.

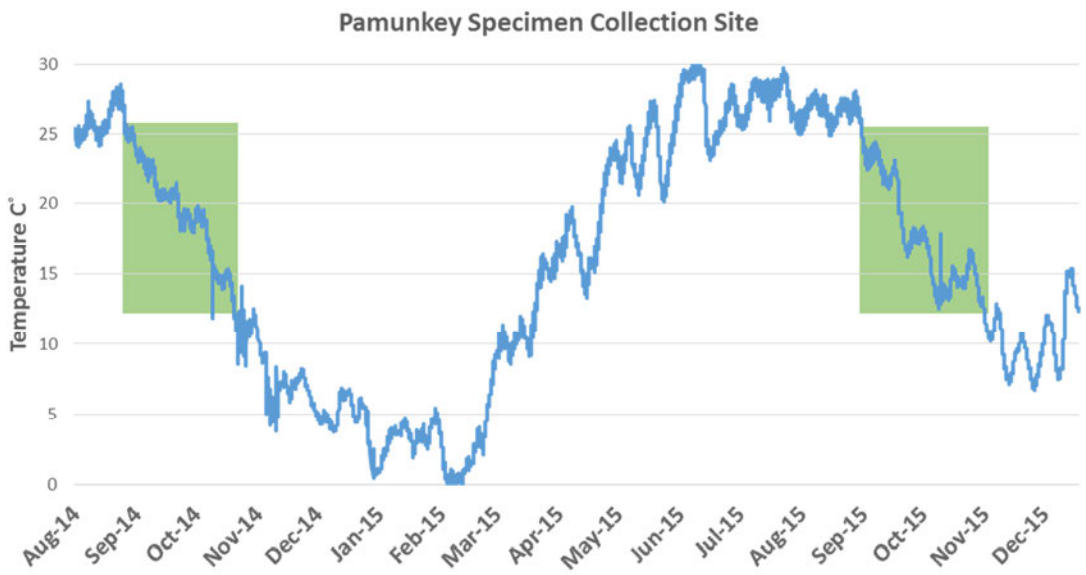


**Figure 10. Water temperatures observed at the Pamunkey River collection station located within the spawning region in 2014 and 2015 are presented above. The shaded areas denote suitable spawning temperatures.**

All returning tagged adults were present on the spawning grounds of the Pamunkey River by the third week of August and departed by the third week of October **(Figure 11)**. Males moved more often and with a larger range overlapping that of the females. In 2014, females were recorded making runs between hard-bottom habitats but primarily occupied the river section between river miles 43 and 48 (**Table 7**). In 2015, females chose to visit and occupy more upriver sites. Some the females (3/8=37.5%) remained in the lower portion of the spawning reaches preferred in 2014. Most made runs that ended between river miles 52 and 55. Two far exceeded previous upriver use (including female fish 13588) and entered river miles near 58 and 59. Residency was very short in both cases. One female was in the area the day the other arrived. Males (n=5) were already on the grounds when the first female arrived (14 Sept. 2015) and two tagged males remained when the second arrived (16 Sept. 2015). Following their two- to three-day occupation, both females dropped quickly into the oligohaline (>0.5-5 ppt) zone where they remained for several weeks prior to proceeding down into the York River. The rapid

ascensions followed by equally quick exits likely indicate that spawning occurred in this region (Smith 1986).

Upriver runs occurred in the Pamunkey when spawning ground temperatures were between 20 and 25 degrees Celsius (°C) in both years. As was found in the James River (Hager 2011), the availability of suitable spawning temperatures in the Pamunkey River can vary greatly between years (**Figure 10**), even when one considers the widest possible range from 13° to 26°C (Bain et al. 2000, Scott and Crossman 1973). Upon capture during spawning season, Atlantic sturgeon were found to produce low level frequency sounds accompanied by rhythmic body vibrations. This often occurred when males were being removed from the nets or immediately upon removal from the water. Such behavior in the aquatic environment would produce both near and far field (Kalmijn 1988, Rogers and Cox 1988) particle motion and thus be detectable in the ear as well as the lateral line. Benthic species that are territorial often produce sounds but this production may be elevated during periods of high aggression (Myrberg 1981) such as the breeding season.

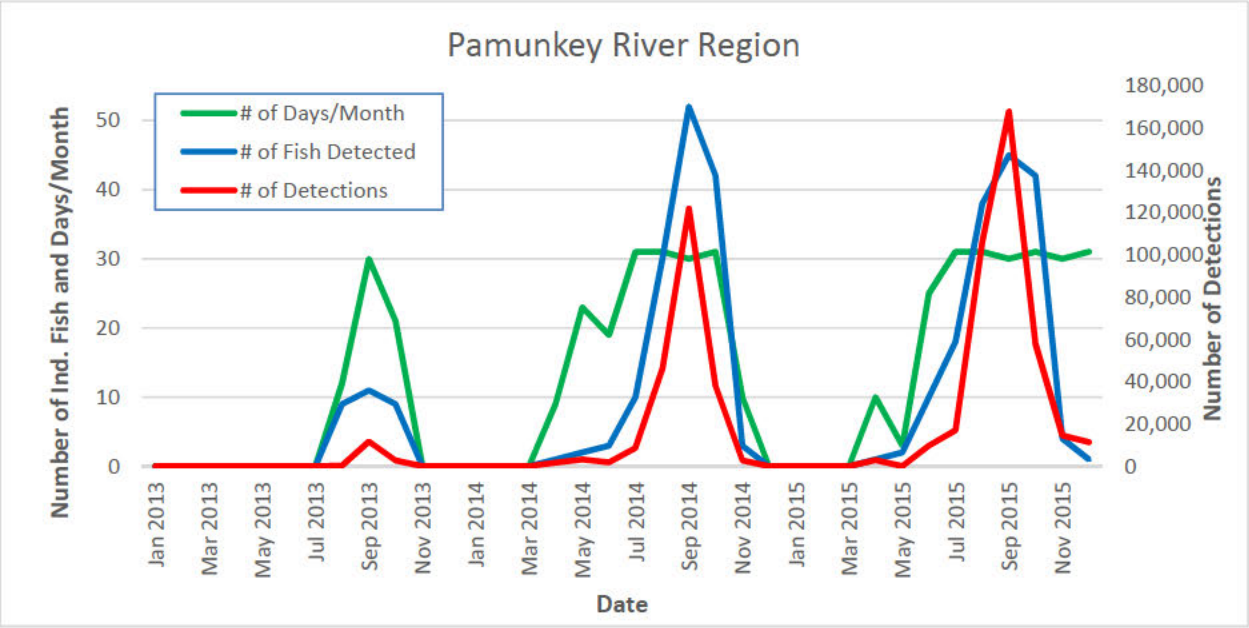


**Figure 11. Atlantic sturgeon occurrence based on receiver detections in the Pamunkey River region.**

1 **Table 7. Numbers of detections by month in the Pamunkey River region, December 2012–December 2015. Receiver sites are listed in descending river mile.**

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Dec. 2012 | Jan. 2013 | Feb. 2013 | Mar. 2013 | Apr. 2013 | May 2013 | June 2013 | July 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 | 1,878 | 59 | 0 | 0 | 1,937 |
| Pamunkey River | 49 | Pam. Upper (b) (6) | None | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 64 | 1,367 | 26 | 0 | 0 | 1,457 |
| Pamunkey River | 45 | Pam. (b) (6) | None | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 250 | 1,838 | 99 | 0 | 0 | 2,187 |
| Pamunkey River | 43 | Pam. Brick wall | None | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 800 | 195 | 0 | 0 | 995 |
| Pamunkey River | 30 | Pam. Res. | None | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 251 | 101 | 0 | 0 | 369 |
| Pamunkey River | 18 | Pam. (b) (6) | None | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 208 | 90 | 0 | 0 | 348 |
| Pamunkey River | 6 | Pam. (b) (6) | None | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3,568 | 1,781 | 0 | 0 | 5,349 |
| **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 | July 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 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,362 | 3,851 | 264 | 0 | 0 | 5,477 |
| Pamunkey River | 50 | Pam. top 1 | None | 0 | 0 | 0 | 0 | 0 | 0 | 40 | 0 | 3,074 | 1,354 | 0 | 0 | 4,468 |
| Pamunkey River | 50 | Pam. Rootball | None | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,719 | 5,747 | 928 | 0 | 0 | 8,394 |
| Pamunkey River | 50 | Pam. Hickory Tree | None | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 1,942 | 5,890 | 408 | 0 | 0 | 8,262 |
| Pamunkey River | 49 | Pam. H2O | None | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1,316 | 4,582 | 333 | 0 | 0 | 6,248 |
| Pamunkey River | 49 | Pam. Upper (b) (6) | None | 0 | 0 | 0 | 0 | 0 | 0 | 4,606 | 2,074 | 7,804 | 435 | 0 | 0 | 14,919 |
| Pamunkey River | 49 | Pam. L. Up (b) (6) | None | 0 | 0 | 0 | 0 | 0 | 0 | 94 | 2,983 | 8,308 | 521 | 0 | 0 | 11,906 |
| Pamunkey River | 45 | Pam. Fos. Cliff | None | 0 | 0 | 0 | 0 | 0 | 0 | 655 | 2,342 | 5,914 | 1,139 | 0 | 0 | 10,050 |
| Pamunkey River | 45 | Pam. (b) (6) | None | 0 | 0 | 0 | 0 | 0 | 0 | 485 | 4,295 | 7,417 | 1,537 | 0 | 0 | 13,734 |
| Pamunkey River | 47 | Pam. (b) (6) Lower | None | 0 | 0 | 0 | 0 | 0 | 0 | 1,634 | 5,285 | 10,758 | 2,643 | 0 | 0 | 20,320 |

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Jan. 2014 | Feb. 2014 | Mar. 2014 | Apr. 2014 | May 2014 | June 2014 | July 2014 | Aug. 2014 | Sep. 2014 | Oct. 2014 | Nov. 2014 | Dec. 2014 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pamunkey River | 46 | Pam. L. L. (b) (6) | None | 0 | 0 | 0 | 0 | 0 | 0 | not deployed | not deployed | 7,069 | 1,352 | 0 | 0 | 8,421 |
| Pamunkey River | 44 | Pam. poles | None | 0 | 0 | 0 | 0 | 0 | 0 | not deployed | not deployed | 16,398 | 4,883 | 0 | 0 | 21,281 |
| Pamunkey River | 43 | Pam. Brick wall | None | 0 | 0 | 0 | 0 | 0 | 0 | 35 | 7,047 | 12,384 | 1,703 | 0 | 0 | 21,169 |
| Pamunkey River | 30 | Pam. Res. | None | 0 | 0 | 0 | 0 | 0 | 763 | 201 | 3,537 | 5,377 | 1,149 | 0 | 0 | 11,027 |
| Pamunkey River | 18 | Pam. (b) (6) | None | 0 | 0 | 0 | 0 | 0 | 99 | 427 | 1,471 | 5,306 | 4,154 | 60 | 0 | 11,517 |
| Pamunkey River | 6 | Pam. (b) (6) | None | 0 | 0 | 0 | 1,677 | 3,168 | 950 | 430 | 7,846 | 2,886 | 9,844 | 2,656 | 0 | 29,457 |
| **Sum 2014** | | | | **0** | **0** | **0** | **1,677** | **3,168** | **1,812** | **8,646** | **45,598** | **115,485** | **32,718** | **2,716** | **0** | **211,820** |
| **Total 13-14** | | | | **0** | **0** | **0** | **1,677** | **3,168** | **1,812** | **8,646** | **45,979** | **125,395** | **35,069** | **2,716** | **0** | **224,462** |

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Jan. 2015 | Feb. 2015 | Mar. 2015 | Apr. 2015 | May 2015 | June 2015 | July 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 | 3,806 | 0 | 0 | 0 | 4,695 |
| Pamunkey River | 51 | Pam. Top $ | None | 0 | 0 | 0 | 0 | 0 | 0 | 71 | 726 | 2,819 | 375 | 0 | 0 | 3,991 |
| Pamunkey River | 50 | Pam. top 1 | None | 0 | 0 | 0 | 0 | 0 | 0 | 91 | 3,072 | 3,748 | 662 | 0 | 0 | 7,573 |
| Pamunkey River | 50 | Pam. Rootball | None | 0 | 0 | 0 | 0 | 0 | 0 | 86 | 2,249 | 3,410 | 683 | 0 | 0 | 6,428 |
| Pamunkey River | 50 | Pam. Hickory Tree | None | 0 | 0 | 0 | 0 | 0 | 0 | 499 | 3,038 | 4,526 | 784 | 0 | 0 | 8,847 |
| Pamunkey River | 49 | Pam. H2O | None | 0 | 0 | 0 | 0 | 0 | 0 | 413 | 2,599 | 3,352 | 670 | 0 | 0 | 7,034 |
| Pamunkey River | 49 | Pam. Upper (b) (6) | None | 0 | 0 | 0 | 0 | 0 | 76 | 4,173 | 14,648 | 4,294 | 728 | 0 | 0 | 23,919 |
| Pamunkey River | 49 | Pam. L. Up (b) (6) | None | 0 | 0 | 0 | 0 | 0 | 1,300 | 1,521 | 4,289 | 5,200 | 1,008 | 0 | 0 | 13,318 |
| Pamunkey River | 45 | Pam. Fos. Cliff | None | 0 | 0 | 0 | 0 | 0 | 472 | 214 | 1,787 | 5,086 | 886 | 0 | 0 | 8,445 |

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Jan. 2015 | Feb. 2015 | Mar. 2015 | Apr. 2015 | May 2015 | June 2015 | July 2015 | Aug. 2015 | Sep. 2015 | Oct. 2015 | Nov. 2015 | Dec. 2015 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pamunkey River | 45 | Pam. (b) (6) | None | 0 | 0 | 0 | 0 | 0 | 1,168 | 387 | 2,370 | 7,333 | 968 | 0 | 0 | 12,226 |
| Pamunkey River | 47 | Pam. (b) (6) Lower | None | 0 | 0 | 0 | 0 | 0 | 316 | 84 | 3,319 | 7,362 | 1,331 | 0 | 0 | 12,412 |
| Pamunkey River | 46 | Pam. (b) (6) (b) (6) | None | 0 | 0 | 0 | 0 | 0 | 34 | 43 | 3,089 | 6,417 | 574 | 0 | 0 | 10,157 |
| Pamunkey River | 44 | Pam 4.5 | None | 0 | 0 | 0 | 0 | 0 | 16 | 165 | 21,070 | 25,295 | 3,781 | 0 | 0 | 50,327 |
| Pamunkey River | 44 | Pam. poles | None | 0 | 0 | 0 | 0 | 0 | 16 | 25 | 23,820 | 27,773 | 3,455 | 0 | 0 | 55,089 |
| Pamunkey River | 43 | Pam. Brick wall | None | 0 | 0 | 0 | 0 | 0 | 44 | 14 | 3,922 | 15,984 | 2,009 | 0 | 0 | 21,973 |
| Pamunkey River | 41 | Pam. BBW | None | 0 | 0 | 0 | 0 | 0 | 42 | 38 | 2,638 | 19,400 | 1,398 | 0 | 0 | 23,516 |
| Pamunkey River | 30 | Pam. Res. | None | 0 | 0 | 0 | 0 | 0 | 612 | 786 | 8,152 | 8,268 | 2,418 | 0 | 0 | 20,236 |
| Pamunkey River | 18 | Pam. (b) (6) | None | 0 | 0 | 0 | 0 | 25 | 213 | 1,294 | 1,520 | 3,177 | 4,810 | 60 | 0 | 11,099 |
| Pamunkey River | 6 | Pam. (b) (6) | None | 0 | 0 | 0 | 2,866 | 36 | 5,442 | 7,032 | 3,116 | 5,668 | 14,953 | 29 | 0 | 39,142 |
| **Sum 2015** | | | | **0** | **0** | **0** | **2,866** | **61** | **9,751** | **16,947** | **106,302** | **162,918** | **41,493** | **89** | **0** | **340,427** |
| **Total 13-15** | | | | **0** | **0** | **0** | **4,543** | **3,229** | **11,563** | **25,593** | **152,281** | **288,313** | **76,562** | **2,805** | **0** | **564,889** |

### 4.4.2 York River Region (Naval Weapons Station Yorktown/Cheatham Annex zone)

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. A single fish tagged by a researcher in the Northeast was detected in the river's military zone in February. Consequently, very little is known about sub-adults in the York River and almost nothing is known about YOY. Since reproduction is occurring in the Pamunkey, a tributary of the York, native YOY are present year-round within fresh and brackish water nursery areas for several years following hatching (Scott and Crossman 1973, Secor et al. 2000). Three very small (525-575 mm) natal sub-adults (Tim King, USGS) were tagged as a part of this study, two in December of 2012 and one in February 2015. The first two left the York River in the same month as tagged and the third's tag failed to function. VIMS researchers have tagged 12 sub-adults. Two in the spring of 2014 in the middle river and 10 in 2015. The two tagged in 2014 entered the Pamunkey for the summer and emigrated (migrated out of the system) in mid-fall. One has yet to return and the other spent most of 2014 and 2015 in the James River's watershed. In late summer of 2015, we helped VIMS implant 10 more tags in sub-adults collected from the Pamunkey and Mattaponi rivers. Subsequent tracking of these fish suggests that sub-adults spend most of their time in the Pamunkey's oligohaline (>0.5-5 ppt) zone far upriver of the Naval Weapons Station Yorktown/Cheatham Annex zone. Most were recorded migrating through the zone from mid-April through May and again in mid-October until early December. These data are based upon a limited number of sub-adults and this life stage is known to be highly mobile and transient which makes predicting their location more difficult. In addition, the genetic origin of the sub-adults tagged by VIMS has not established. Consequently, these behaviors may not represent the behavior of natal fish. The only data we positively have on native sub-adults (age 2-3), suggest that once they reach approximately 500 mm in fork length, they emigrate to coastal environments passing through the military zone in winter and do not return until maturity.

All but one of the adult fish tagged in the Pamunkey River were detected on their migrations through the York River as they passed through the channel adjacent to the Naval Weapons Station Yorktown/Cheatham Annex. The one exception appears to have had a faulty tag that was not detected again after the day of surgery. In 2014, the detection of nine returning adults from 2013 suggested that zone residence began in June and ended in mid-August. Since then our number of returning adults has grown from 9 to 29 and our understanding of the zone's use has expanded congruently. Adults are now known to occupy the zone upon immigration from late May until early September but occupation by individuals is relatively short, usually only several days. The vast majority of adults are in the zone from the third week in May until the end of June **(Figure 12)**. In 2014, the emigration (river departure) of native adults was believed to start in October and be complete by November**.** Our expanded data show adults leaving the farthest downriver receiver site at the Yorktown Bridge in the middle of the polyhaline zone (>18 ppt) as early as the end of September and as late as 3 December (males). The majority of adults move through the zone in October **(Table 8)**. Maps of monthly detections are found in **Appendix 4.4.2**.

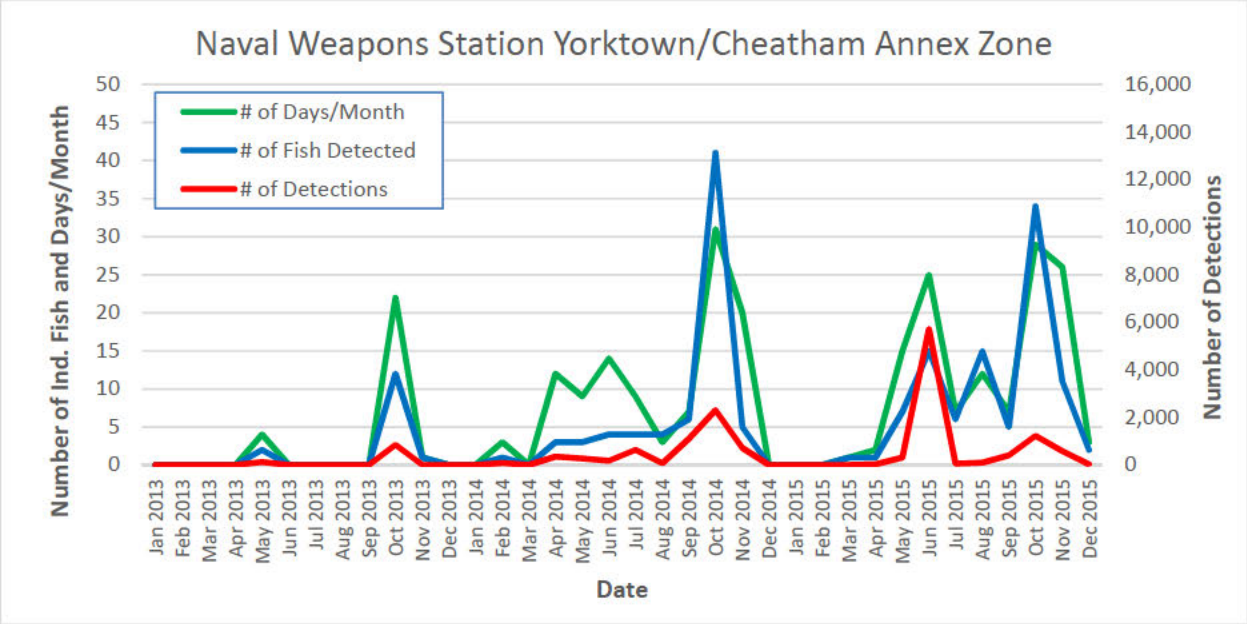


**Figure 12. Atlantic sturgeon occurrence based on receiver detections in the Naval Weapons Station Yorktown/Cheatham Annex zone.**

**Table 8. Numbers of detections by month in the York River region, December 2012–December 2015. Receiver sites are listed in descending river mile. Note that the Pages Rock Light was removed in 2015 and this station was replaced with York 6.**

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Dec. 2012 | Jan. 2013 | Feb. 2013 | Mar. 2013 | Apr. 2013 | May 2013 | June 2013 | July 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 | 20 | 244 | 0 | 0 | 264 |
| York River | 29 | Y BELL NOAA | None | 48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 52 | 148 | 0 | 0 | 248 |
| York River | 25 | Y20 NOAA | None | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 127 | 0 | 0 | 148 |
| York River | 23 | Y18 NOAA | None | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 432 | 0 | 0 | 464 |
| York River | 17 | Y12 | None | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 531 | 0 | 0 | 544 |
| York River | 14 | Y PAGE | NW/Ch. | 7 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 160 | 0 | 0 | 176 |
| York River | 13 | Y8 | NW/Ch. | 17 | 0 | 0 | 0 | 0 | 85 | 0 | 0 | 0 | 0 | 272 | 0 | 0 | 374 |
| York River | 9 | Y2 | NW/Ch. | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 37 | 0 | 0 | 38 |
| York River | 7 | Y WAT | NW/Ch. | 0 | 0 | 0 | 0 | 0 | 32 | 0 | 0 | 0 | 0 | 119 | 0 | 0 | 151 |
| **Sum** | | | | **92** | **0** | **0** | **0** | **0** | **140** | **0** | **0** | **0** | **105** | **2,070** | **0** | **0** | **2,407** |

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Jan. 2014 | Feb. 2014 | Mar. 2014 | Apr. 2014 | May 2014 | June 2014 | July 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 | 1,611 | 39 | 0 | 3,468 |
| York River | 29 | Y BELL NOAA | None | 0 | 48 | 0 | 281 | 62 | 17 | 68 | 6 | 559 | 2,423 | 80 | 0 | 3,544 |
| York River | 25 | Y20 NOAA | None | 0 | 159 | 0 | 125 | 48 | 32 | 108 | 3 | 388 | 1,756 | 33 | 0 | 2,652 |
| York River | 23 | Y18 NOAA | None | 0 | 72 | 0 | 81 | 38 | 29 | 44 | 8 | 388 | 1,524 | 55 | 0 | 2,239 |
| York River | 17 | Y12 | None | 0 | 26 | 0 | 30 | 117 | 66 | 15 | 2 | 990 | 5,003 | 83 | 0 | 6,332 |
| York River | 14 | Y PAGE | NW/Ch. | 0 | 6 | 0 | 46 | 29 | 5 | 3 | 0 | 10 | 272 | 75 | 0 | 446 |
| York River | 13 | Y8 | NW/Ch. | 0 | 21 | 0 | 144 | 224 | 104 | 215 | 37 | 906 | 1,044 | 386 | 0 | 3,081 |
| York River | 9 | Y2 | NW/Ch. | 0 | 8 | 0 | 110 | 10 | 21 | 4 | 0 | 22 | 132 | 206 | 0 | 513 |
| York River | 7 | Y WAT | NW/Ch. | 0 | 56 | 0 | 51 | 11 | 49 | 418 | 37 | 172 | 715 | 53 | 0 | 1,562 |
| **Sum 2014** | | | | **0** | **483** | **0** | **1,161** | **661** | **436** | **966** | **106** | **4,534** | **14,480** | **1,010** | **0** | **23,837** |
| **Total 13-14** | | | | **0** | **483** | **0** | **1,161** | **801** | **436** | **966** | **106** | **4,639** | **16,550** | **1,010** | **0** | **26,154** |

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Jan. 2015 | Feb. 2015 | Mar. 2015 | Apr. 2015 | May 2015 | June 2015 | July 2015 | Aug. 2015 | Sep. 2015 | Oct. 2015 | Nov. 2015 | Dec. 2015 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| York River | | Y 35 | None | 0 | 0 | 0 | 140 | 147 | 299 | 489 | 793 | 85 | 873 | 41 | 0 | 2,867 |
| York River | 31 | Y29 NOAA | None | 0 | 0 | 0 | 211 | 150 | 521 | 537 | 1,105 | 129 | 1,004 | 33 | 0 | 3,690 |
| York River | 29 | Y BELL NOAA | None | 0 | 0 | 8 | 88 | 43 | 141 | 270 | 1,359 | 172 | 1,331 | 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 | 161 | 103 | 1,570 | 189 | 0 | 3,635 |
| York River | | Y 16 | None | 0 | 0 | 14 | 15 | 46 | 375 | 41 | 107 | 143 | 3,799 | 1,362 | 4 | 5,906 |
| York River | 17 | Y 12 | None | 0 | 0 | 27 | 30 | 85 | 401 | 351 | 105 | 107 | 1,394 | 1,377 | 33 | 3,910 |
| York River | 14 | Y PAGE/Y 6 | NW/Ch. | 0 | 0 | 6 | 15 | 58 | 316 | 422 | 23 | 28 | 433 | 134 | 8 | 1,443 |
| York River | 13 | Y 8 | NW/Ch. | 0 | 0 | 0 | 6 | 148 | 169 | 23 | 17 | 9 | 336 | 356 | 15 | 1,079 |
| York River | 9 | Y 2 | NW/Ch. | 0 | 0 | 0 | 4 | 28 | 59 | 3 | 17 | 10 | 185 | 68 | 2 | 376 |
| York River | 7 | Y WAT | NW/Ch. | 0 | 0 | 3 | 2 | 81 | 5,179 | 21 | 72 | 396 | 709 | 162 | 15 | 6,640 |
| **Sum 2015** | | | | **0** | **0** | **128** | **695** | **1,349** | **8,452** | **3,320** | **4,230** | **1,281** | **12,747** | **3,929** | **77** | **36,208** |
| **Total 13-15** | | | | **0** | **483** | **128** | **1,856** | **2,150** | **8,888** | **4,286** | **4,336** | **5,920** | **29,297** | **4,939** | **77** | **62,362** |

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

### 4.4.3 Chickahominy River Region

The Chickahominy River is a tributary of the James. It was originally monitored for a separate U.S. Navy blueback herring (*Alosa aestivalis*) study (N62470-09-D-2003 conducted for the CNRMA). Sturgeon were present in the Chickahominy from May to October in 2013, April to December in 2014, and April to November in 2015. The peak availability period in 2013, 2014, and 2015 was August–October with 13, 21, and 17 sturgeon present in the peak month of September in 2013, 2014, and 2015, respectively (**Figure 13**). Further examination of 2014 data indicated that most detections were due to four sedentary sub-adults tagged in the lower James during the VIMS spring tagging effort. This pattern repeated in 2015 and, although the total number of fish detected in the Chickahominy in 2015 was reduced, the number of days with detections was enlarged due to the extended residence of these sub-adults (n=7) (**Table 9**). Most were tagged in 2015 in the same location as 2014 in the lower James River in Burwell's Bay. Between 2013 and 2014, the vast majority of sturgeon occupying this region were adults tagged in the James River, about a fifth were adults tagged in northern systems, and one fish tagged in North Carolina was detected each year. In 2015, of the 30 individuals detected, only two were tagged in systems other than the James. These were both adults tagged in Delaware. More sub-adults than adults occupied the region in 2015, including the same sub-adult tagged in the York in 2013 that spent the previous summer in this location. Adults began to show in the river in August 2015 and availability peaks in September when confirmed adults outnumbered sub-adults (10 to 7). Adults remained in the region into early October but most emigrated in September. Sub-adults occupied the region from April until November.

Sturgeon of varied ages have been previously recorded occupying the Chickahominy River (Hager 2011) and it is not unusual for fishermen to encounter Atlantic sturgeon of varied sizes at the river's mouth. Ten adults of the 18 sturgeon detected in the Chickahominy in 2013 were tagged in the upper James River near Hopewell in September 2012. They did not return to the James River in 2013 and spent the fall spawning period in the lower Chickahominy River where no spawning habitat exists (Bushnoe et al. 2005). Four of these adults returned to the Chickahominy again in 2014. They were joined by ten other locally tagged adults and four sub-adults tagged by VIMS in spring 2014, whose sedentary behavior and residence in the fall increased detections significantly. Fish of northern tagging origin were present in 2013 (n=3), 2014 (n=5), and 2015 (n=3) but those tagged in the James outnumbered these fish each year. In 2015, sub-adults and adults again mixed in the region with September consistently having the largest numbers of both fish and adults across years. Sub-adults tagged in 2015 in the lower James were again prevalent with characteristically expanded periods of detection (August–September). In September, adults outnumbered sub-adults in every year.

The increased numbers of adult detections recorded in the Chickahominy in late summer, accompanied by reduced movement, typifies the behavior of adults observed in the upper James River from 2007 to 2011 during the same warm-water season prior to the occurrence of appropriate spawning temperatures. This observation supports the assertion that fish are seeking physiological refuge (Hager 2011). This "lazy" behavior was followed by a marked increase in mobility accompanying cooling water temperatures during October, which was quickly followed by emigration. Future years of tracking will help determine if increased use within this region is due to altered behavior being exhibited by recently tagged fish, or if the region is normally inhabited as adult presence suggests. Maps are found in **Appendix 4.4.3**.

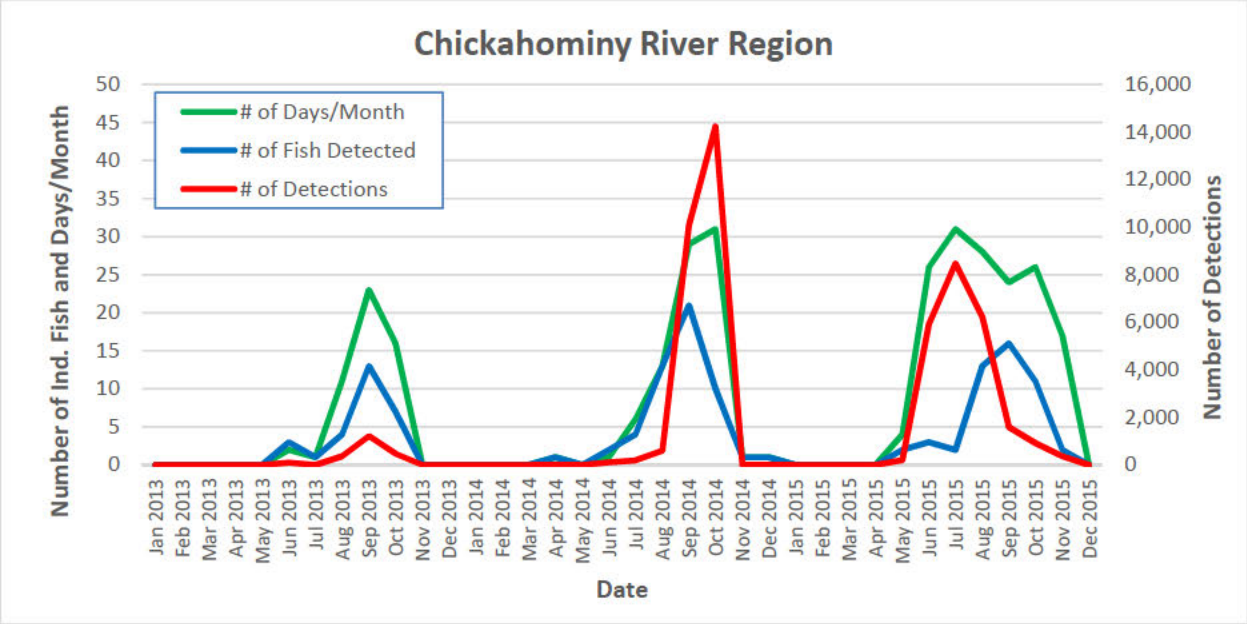


**Figure 13. Atlantic sturgeon occurrence based on receiver detections at the mouth of the Chickahominy River.**

**Table 9. Numbers of detections by month in the Chickahominy River region, December 2012–December 2015. Receiver sites are listed in descending river mile.**

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Dec. 2012 | Jan. 2013 | Feb. 2013 | Mar. 2013 | Apr. 2013 | May 2013 | June 2013 | July 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. (b) (6) | None | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 93 | 446 | 217 | 0 | 0 | 756 |
| Chickahominy River | 3 | Chick. Bridge | None | 0 | 0 | 0 | 0 | 0 | 34 | 73 | 2 | 369 | 660 | 161 | 0 | 0 | 1,299 |
| **Sum** | | | | **0** | **0** | **0** | **0** | **0** | **34** | **73** | **2** | **462** | **1,106** | **378** | **0** | **0** | **2,055** |

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Jan. 2014 | Feb. 2014 | Mar. 2014 | Apr. 2014 | May 2014 | June 2014 | July 2014 | Aug. 2014 | Sep. 2014 | Oct. 2014 | Nov. 2014 | Dec. 2014 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chickahominy River | 3 | Chick. Bridge | None | 0 | 0 | 0 | 13 | 0 | 108 | 191 | 850 | 9,823 | 14,131 | 14 | 11 | 25,141 |
| Chickahominy River | 3 | Chick. W. bank bridge | None | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 13 | 387 | 110 | 4 | 2 | 519 |
| **Sum** | | | | **0** | **0** | **0** | **13** | **0** | **109** | **193** | **863** | **10,210** | **14,241** | **18** | **13** | **25,660** |
| **Total 13-14** | | | | **0** | **0** | **0** | **13** | **34** | **182** | **195** | **1,325** | **11,316** | **14,619** | **18** | **13** | **27,715** |

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Jan. 2015 | Feb. 2015 | Mar. 2015 | Apr. 2015 | May 2015 | June 2015 | July 2015 | Aug. 2015 | Sep. 2015 | Oct. 2015 | Nov. 2015 | Dec. 2015 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chickahominy River | 3 | Chick. Bridge | None | 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 13-15** | | | | **0** | **0** | **0** | **224** | **235** | **6,110** | **8,671** | **7,544** | **12,903** | **15,532** | **384** | **13** | **51,616** |

Note: Sites are listed in a descending down river order.

### 4.4.4 James River Region (Naval Station Norfolk and the Elizabeth River Zones)

The number of sturgeon detected within the Naval Station Norfolk zone has recorded steady annual increases from 157 (2013) to 206 (2014) and 256 (2015). An unusual year-round presence and consistently high number of days with detections highlights the zone's importance as sturgeon habitat. Sizable tagging efforts have been ongoing during the past two years in the James River and this has augmented both fish number and detection volume in the region but not necessarily within the zone. Size-range data for fish detected in the Naval Station Norfolk zone indicate that the zone provides natal and transient sub-adults with feeding habitats (Matt Fisher, Delaware Department of Natural Resources, personal communication), while also being occupied by numerous adults. In contrast to the extended occupancy exhibited by younger fish, adults generally pass through the zone but do not appear to linger. Detection volume indicates that the zone is heavily occupied by sturgeon, with 29,006, 60,548, and 72,232 detections in 2013, 2014, and 2015, respectively (**Table 10**).

Sturgeon occupied the zone year-round in all years. The months with the greatest numbers of detections were January (5,822) and February (5,288) of 2013, with the majority of detections attributed to five very sedentary sub-adults. This mid-winter apex in detections has not been repeated. In fact, these two months have since recorded the lowest values for all three parameters examined during the past two years. Similar patterns of increasing fish numbers in April and May in each year are indicative of spring immigration into the river by adults and increased activity levels of sub-adults. Emigration patterns are evidenced in October, with consistently large numbers of fish passing through the zone. Adults tagged in the James and other regions both north and south of the Bay were present in all years, with reception periods of generally less than a week, which indicates migration and staging rather than residence. In the past two years, this month has also recorded the largest annual number of detections (**Figure 14)** due in most part to extended residence times by a sub-set of fish (6/111 in 2014 and 8/133 in 2015). In 2014, these fish were from varied tagging locations (3 from Virginia, 2 from North Carolina, 1 from South Carolina) and of different age classes (2 adults, 2 sub-adults, 1 unknown). Though in 2014 VIMS tagged fish from the James River were detected, they did not significantly contribute to reception volume until November (4,817 detections). 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. As this is the month when most James River sub-adults and adults emigrate, (Hager 2011) these patterns are supported by known life history.

In 2013, five sturgeon were recorded occupying the Elizabeth River zone (354 detections): three tagged in northern systems, one in North Carolina, and one in the James. The zone was occupied from late May through July. The month with the greatest number of detections was June **(Table 10)** and these were from a single fish tagged in North Carolina. In 2014, 22 sturgeon were recorded (1,842 detections). Half were from the James, with only two sub-adults tagged by VIMS detected. Both had short residence periods. Ten fish were tagged in northern systems and one was again from North Carolina. Fish were within the zone from March to June and from August through October in 2014. The largest number of detections occurred in August and were attributed to 10 fish: 6 tagged in the James River and 4 from northern waters. In 2015, 29 sturgeon were detected (2,271 detections). Twenty-one fish were tagged in the James, 7 of which were sub-adults. Six more were of northern origin and unknown age, but the researchers primarily tag adults, two fish were from North Carolina and also of unknown age. Peak period of availability across years was June and August-September. These periods correspond to the immigration of adults to spawn into the James River's freshwater reaches. We are not suggesting that these adults in the Elizabeth are there to spawn but that they are following the freshwater source to determine if it is the correct path to the spawning grounds. Adults have been documented

**Table 10. Numbers of detections by month in the Naval Station Norfolk and Elizabeth River zones, December 2012–December 2015. Receiver sites are listed in descending river mile. It should be noted that one of the sites (N14) which is within the Naval Station Norfolk zone, actually occurs within the mouth of the Elizabeth River and is thus listed at the bottom of the table since sites are listed in descending river order. The na that occurred at NN Danger was due to a computer failure.**

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Dec. 2012 | Jan. 2013 | Feb. 2013 | Mar. 2013 | Apr. 2013 | May 2013 | June 2013 | July 2013 | Aug. 2013 | Sep. 2013 | Oct. 2013 | Nov. 2013 | Dec. 2013 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| James River | 5 | NN8 | Naval Station Norfolk | 134 | 13 | 3 | 217 | 18 | 46 | 68 | 60 | 165 | 26 | 276 | 75 | 15 | 1,116 |
| James River | 5 | NH10 | Naval Station Norfolk | 17 | 9 | 52 | 57 | 14 | 19 | 69 | 93 | 49 | 17 | 52 | 55 | 0 | 503 |
| James River | 5 | NH12 | Naval Station Norfolk | 0 | 0 | 149 | 0 | 0 | 26 | 22 | 96 | 21 | 9 | 38 | 14 | 0 | 375 |
| James River | 5 | NH14 | Naval Station Norfolk | 0 | 0 | 170 | 0 | 0 | 23 | 24 | 54 | 14 | 6 | 9 | 0 | 40 | 340 |
| James River | 4 | NH8 | Naval Station Norfolk | 603 | 732 | 140 | 750 | 163 | 87 | 115 | 161 | 128 | 83 | 82 | 125 | 10 | 3,179 |
| James River | 4 | NN5 | Naval Station Norfolk | 2,140 | 1,585 | 277 | 1,330 | 768 | 35 | 53 | 66 | 69 | 4 | 270 | 19 | 26 | 6,642 |
| 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 | 127 | 36 | 52 | 60 | 61 | 28 | 167 | 77 | 36 | 9,174 |
| James River | 2 | NN 3ER NOAA SP | Naval Station Norfolk | 0 | 0 | 0 | 0 | 25 | 136 | 166 | 93 | 240 | 101 | 67 | 43 | 61 | 932 |
| James River | 1 | NN 1ER FWS | Naval Station Norfolk | 0 | 0 | 0 | 0 | 36 | 197 | 185 | 250 | 250 | 123 | 128 | 76 | 47 | 1,292 |
| James River | 1 | NN DANGER FWS | Naval Station Norfolk | 0 | 0 | 0 | 0 | 42 | 103 | 192 | 201 | 241 | 58 | 96 | 35 | 60 | 1,028 |

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Dec. 2012 | Jan. 2013 | Feb. 2013 | Mar. 2013 | Apr. 2013 | May 2013 | June 2013 | July 2013 | Aug. 2013 | Sep. 2013 | Oct. 2013 | Nov. 2013 | Dec. 2013 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| James River | 1 | NN R22 NOAA SP | Naval Station Norfolk | 0 | 0 | 0 | 0 | 63 | 161 | 265 | 286 | 1,145 | 62 | 370 | 85 | 978 | 3,415 |
| 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 | 0 | 0 | 0 | 162 |
| Elizabeth River | 5 | NH29 | Elizabeth River | 0 | 0 | 0 | 0 | 0 | 6 | 3 | 11 | 0 | 0 | 0 | 0 | 0 | 20 |
| Elizabeth River | 4 | APMI | Elizabeth River | 0 | 0 | 0 | 0 | 0 | 5 | 15 | 17 | 14 | 0 | 0 | 0 | 0 | 51 |
| **Sum** | | | | **3,271** | **6,098** | **5,596** | **2,704** | **1,269** | **1,020** | **1,489** | **1,512** | **2,397** | **517** | **1,555** | **604** | **1,273** | **29,305** |

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Jan. 2014 | Feb. 2014 | Mar. 2014 | Apr. 2014 | May 2014 | June 2014 | July 2014 | Aug. 2014 | Sep. 2014 | Oct. 2014 | Nov. 2014 | Dec. 2014 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| James River | 5 | NN8 | Naval Station Norfolk | 30 | 0 | 238 | 128 | 354 | 556 | 69 | 140 | 67 | 756 | 270 | 44 | 2,652 |
| 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 | 202 | 454 | 170 | 310 | 149 | 454 | 369 | 782 | 696 | 1,747 | 5,333 |
| James River | 4 | NN5 | Naval Station Norfolk | 105 | 0 | 497 | 324 | 456 | 776 | 99 | 140 | 110 | 9,079 | 3,968 | 3,681 | 19,235 |
| James River | 3 | NH5 | Naval Station Norfolk | na | na | na | na | na | na | na | na | Na | Na | na | na | na |
| James River | 3 | NN2 | Naval Station Norfolk | 7 | 19 | 397 | 524 | 114 | 620 | 113 | 555 | 297 | 561 | 810 | 1,595 | 5,612 |
| James River | 2 | NN 3ER NOAA SP | Naval Station Norfolk | 6 | 0 | 423 | 812 | 222 | 523 | 174 | 646 | 275 | 229 | 194 | 36 | 3,540 |
| James River | 1 | NN 1ER FWS | Naval Station Norfolk | 6 | 22 | 499 | 220 | 321 | 534 | 232 | 724 | 744 | 574 | 201 | 89 | 4,166 |
| James River | 1 | NN DANGER FWS | Naval Station Norfolk | 16 | 9 | 465 | 561 | 480 | 868 | 336 | 1,252 | 2,286 | 1,254 | 78 | 72 | 7,677 |
| James River | 1 | NN R22 NOAA SP | Naval Station Norfolk | 105 | 25 | 307 | 435 | 413 | 893 | 1,406 | 2,324 | 656 | 832 | 203 | 154 | 7,753 |
| 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 | 0 | 202 | 146 | 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** | **3,922** | **4,552** | **3,075** | **6,218** | **2,765** | **7,465** | **5,422** | **14,402** | **6,583** | **7,636** | **62,390** |
| **Total 13-14** | | | | **6,373** | **5,671** | **6,626** | **5,821** | **4,095** | **7,707** | **4,277** | **9,862** | **5,939** | **15,957** | **7,187** | **8,909** | **91,695** |

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Jan. 2015 | Feb. 2015 | Mar. 2015 | Apr. 2015 | May 2015 | June 2015 | July 2015 | Aug. 2015 | Sep. 2015 | Oct. 2015 | Nov. 2015 | Dec. 2015 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| James River | 5 | NN8 | Naval Station Norfolk | 229 | 127 | 143 | 377 | 539 | 511 | 74 | 180 | 800 | 2,987 | 1,548 | 82 | 7,597 |
| James River | 5 | NH10 | Naval Station Norfolk | 49 | 96 | 33 | 229 | 163 | 306 | 89 | 199 | 76 | 53 | 656 | 600 | 2,549 |
| 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 | 168 | 76 | 136 | 874 | 376 | 489 | 107 | 241 | 199 | 74 | 701 | 513 | 3,954 |
| James River | 4 | NN5 | Naval Station Norfolk | 2,049 | 14 | 1,050 | 2,628 | 647 | 420 | 60 | 358 | 2,648 | 8,045 | 3,046 | 1,497 | 22,462 |
| James River | 3 | NN2 | Naval Station Norfolk | 306 | 596 | 396 | 455 | 381 | 635 | 1,147 | 370 | 931 | 3,321 | 1,493 | 591 | 10,622 |
| James River | 2 | NN 3ER NOAA SP | Naval Station Norfolk | 60 | 32 | 115 | 202 | 478 | 395 | 334 | 862 | 770 | 227 | 289 | 293 | 4,057 |
| James River | 1 | NN 1ER FWS | Naval Station Norfolk | 63 | 51 | 80 | 313 | 520 | 549 | 457 | 823 | 262 | 319 | 264 | 155 | 3,856 |
| James River | 1 | NN DANGER FWS | Naval Station Norfolk | 48 | 17 | 45 | 745 | 770 | 390 | 460 | 93 | Na | 365 | 286 | 76 | 3,295 |
| James River | 1 | NN R22 NOAA SP | Naval Station Norfolk | 147 | 61 | 70 | 765 | 919 | 495 | 1,917 | 1,265 | 284 | 557 | 367 | 116 | 6,963 |
| 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 | 0 | 0 | 325 | 26 | 112 | 155 | 0 | 175 | 14 | 31 | 0 | 0 | 838 |
| **Sum 2015** | | | | **3,178** | **1,070** | **2,648** | **7,007** | **5,832** | **5,495** | **4,997** | **5,064** | **6,529** | **16,194** | **10,101** | **6,383** | **74,498** |
| **Total 13-15** | | | | **9,551** | **6,741** | **9,274** | **12,828** | **9,927** | **13,202** | **9,274** | **14,926** | **12,468** | **32,151** | **17,288** | **15,292** | **166,193** |

Key: na = not available.

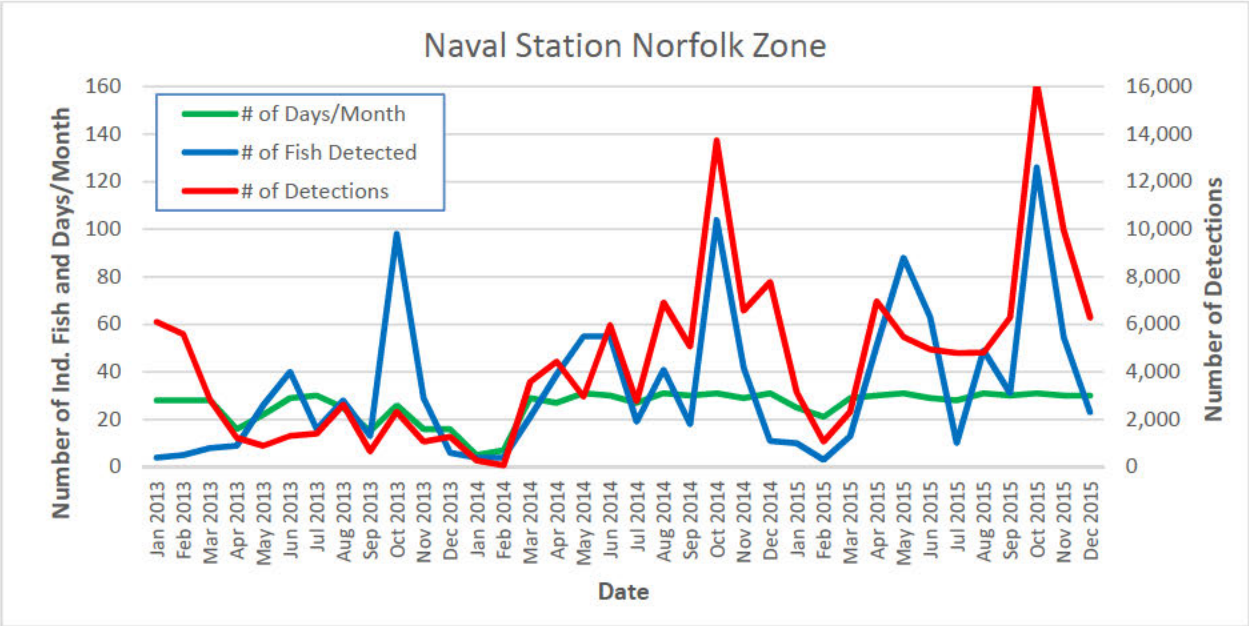


**Figure 14. Atlantic sturgeon occurrence based on receiver detections in the Naval Station Norfolk zone.**

investigating freshwater tributaries prior to correctly selecting their natal spawning locations in the York River system. This habit may explain the large numbers of adults present during these immigration periods, the odd scarcity in July, and the fact that none of these adult fish is recorded in the region during emigration.

In all years, detection peaks in spring and fall coincide with immigration and emigration. The graph of the number of detections and days reflects the characteristically short duration of adult residence during these periods **(Figure 15)**. No fish went 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 Norfolk Naval Base and Elizabeth River zones in **Appendix 4.4.4.**

### 4.4.5 Lower Chesapeake Region (Little Creek and Fort Story Zones)

The Chesapeake region contained 26 receivers that formed an irregular gate across the mouth of the Chesapeake Bay, extending up both the Baltimore and Thimble Shoals Channels **(Appendix 4.2 B)**. Annual reception totals grew from 7,534 in 2013 to 32,149 in 2014. This increase was not due to the sub-adults tagged during the VIMS spring tagging effort, nor any other fish tagged in the Chesapeake region. Instead it appears to have been in large part due to an influx of fish tagged in southern locations. Reception numbers in the lower Chesapeake region (**Figure 16**) were largest in June in 2013 (1,693) and in July in 2014 (9,635), with most detections occurring at the Bay's mouth within the deep water sections of the Baltimore Channel from B9 to B15 (**Table 11**). This apparent thermal refuge site is not within any zone of military interest. However, a closer examination of similar data in the Little Creek zone suggests that similar patterns of habitat occupation also occur there. General increases in detections throughout the lower Chesapeake region in the spring and fall record fish migrating through the mouth of the Bay and clearly mark the region's importance as a migration corridor **(Table 11)**.

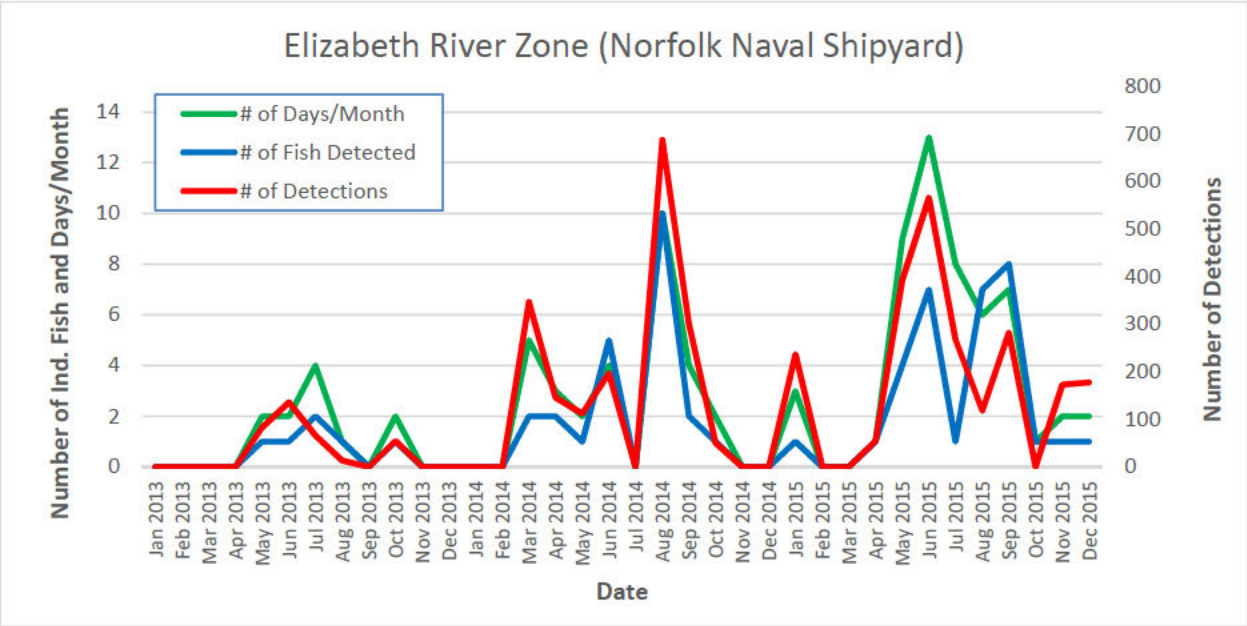


**Figure 15. Atlantic sturgeon occurrence based on receiver detections in the Elizabeth River zone.**

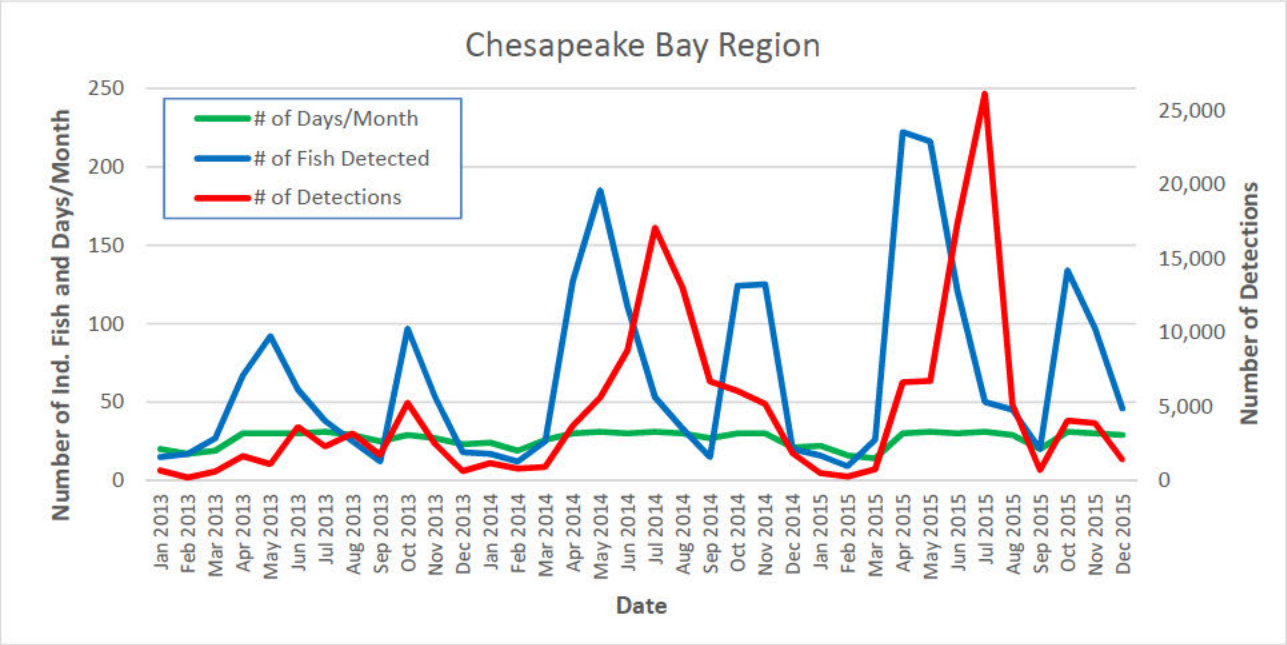


**Figure 16. Atlantic sturgeon occurrence based on receiver detections occurring at the mouth of the Chesapeake Bay from 2013 through 2015.**

**Table 11. Numbers 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 2015. Receiver sites are listed in descending river mile.**

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Dec. 2012 | Jan. 2013 | Feb. 2013 | Mar. 2013 | Apr. 2013 | May 2013 | June 2013 | July 2013 | Aug. 2013 | Sep. 2013 | Oct. 2013 | Nov. 2013 | Dec. 2013 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chesapeake Bay | 10 | B15 | None | 5 | 38 | 5 | 1 | 26 | 69 | 688 | 193 | 117 | 514 | 267 | 610 | 0 | 2,533 |
| Chesapeake Bay | 8 | B13 | None | 204 | 12 | 0 | 40 | 54 | 50 | 47 | 16 | 93 | 177 | 68 | 17 | 17 | 795 |
| 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 | 15 | 0 | 62 | 68 | 47 | 5 | 2 | 0 | 0 | 30 | 10 | 9 | 248 |
| Chesapeake Bay | 8 | CBBT7 | None | 0 | 0 | 0 | 8 | 48 | 57 | 13 | 0 | 0 | 0 | 14 | 8 | 18 | 166 |
| Chesapeake Bay | 8 | LS | None | 4 | 6 | 4 | 22 | 47 | 28 | 2 | 0 | 0 | 0 | 18 | 1 | 0 | 132 |
| Chesapeake Bay | 7 | CBBT3 | None | 0 | 79 | 7 | 27 | 39 | 0 | 0 | 8 | 35 | 9 | 44 | 37 | 4 | 289 |
| Chesapeake Bay | 7 | 11 CAPE CHARLES | None | 0 | 19 | 13 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 41 |
| Chesapeake Bay | 6 | 10N | None | 17 | 37 | 0 | 36 | 37 | 115 | 29 | 9 | 4 | 0 | 44 | 4 | 21 | 353 |
| Chesapeake Bay | 5 | B11 | None | 20 | 0 | 4 | 0 | 53 | 32 | 681 | 212 | 72 | 39 | 112 | 129 | 6 | 1,360 |
| Chesapeake Bay | 4 | B9 | None | 5 | 0 | 18 | 29 | 28 | 33 | 44 | 24 | 20 | 7 | 75 | 107 | 1 | 391 |
| Chesapeake Bay | 4 | TS5 | None | 35 | 33 | 13 | 48 | 121 | 107 | 102 | 43 | 42 | 29 | 0 | 0 | 21 | 594 |
| Chesapeake Bay | 3 | B7 | None | 12 | 0 | 0 | 0 | 27 | 20 | 64 | 45 | 17 | 11 | 58 | 56 | 10 | 320 |
| Chesapeake Bay | 2 | B5 | None | 2 | 4 | 0 | 33 | 45 | 33 | 18 | 14 | 16 | 15 | 82 | 51 | 3 | 316 |
| **Sum** | | | | **304** | **206** | **78** | **315** | **600** | **603** | **1,693** | **566** | **416** | **801** | **812** | **1,030** | **110** | **7,534** |

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Jan. 2014 | Feb. 2014 | Mar. 2014 | Apr. 2014 | May 2014 | June 2014 | July 2014 | Aug. 2014 | Sep. 2014 | Oct. 2014 | Nov. 2014 | Dec. 2014 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chesapeake Bay | 10 | B15 | None | 23 | 0 | 6 | 78 | 762 | 2,463 | 1,986 | 2,096 | 4 | 157 | 240 | 0 | 7,815 |
| Chesapeake Bay | 8 | B13 | None | 126 | 13 | 1 | 82 | 127 | 140 | 0 | 23 | 24 | 101 | 153 | 133 | 923 |
| Chesapeake Bay | 8 | CBBT1 | None | 16 | 0 | 4 | 86 | 218 | 2 | 0 | 0 | 5 | 4 | 14 | 0 | 349 |
| Chesapeake Bay | 8 | CBBT2 | None | 0 | 0 | 9 | 319 | 870 | 61 | 12 | 11 | 2 | 261 | 122 | 0 | 1,667 |
| Chesapeake Bay | 8 | CBBT7 | None | 3 | 11 | 0 | 201 | 597 | 33 | 0 | 4 | 1 | 111 | 75 | 1 | 1,037 |
| Chesapeake Bay | 8 | LS | None | 0 | 0 | 0 | 119 | 212 | 68 | 3 | 3 | 3 | 68 | 20 | 8 | 504 |
| Chesapeake Bay | 7 | CBBT3 | None | 3 | 0 | 67 | 233 | 250 | 100 | 78 | 26 | 0 | 258 | 373 | 53 | 1,441 |
| Chesapeake Bay | 7 | 11 CAPE CHARLES | None | na | na | na | na | na | na | na | na | na | na | na | na | na |
| Chesapeake Bay | 6 | 10N | None | 14 | 11 | 25 | 389 | 420 | 63 | 0 | 0 | 1 | 82 | 39 | 7 | 1,051 |
| Chesapeake Bay | 5 | B11 | None | 27 | 5 | 46 | 68 | 103 | 236 | 464 | 149 | 146 | 196 | 233 | 25 | 1,698 |
| Chesapeake Bay | 4 | B9 | None | 66 | 11 | 26 | 143 | 140 | 1,435 | 4,608 | 292 | 615 | 446 | 1,082 | 210 | 9,074 |
| Chesapeake Bay | 4 | TS5 | None | 41 | 88 | 53 | 108 | 142 | 543 | 2,391 | 615 | 322 | 560 | 144 | 22 | 5,029 |
| Chesapeake Bay | 3 | B7 | None | 26 | 8 | 0 | 89 | 63 | 96 | 93 | 4 | 166 | 172 | 173 | 17 | 907 |

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Jan. 2014 | Feb. 2014 | Mar. 2014 | Apr. 2014 | May 2014 | June 2014 | July 2014 | Aug. 2014 | Sep. 2014 | Oct. 2014 | Nov. 2014 | Dec. 2014 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chesapeake Bay | 2 | B5 | None | 17 | 11 | 49 | 81 | 89 | 63 | 0 | 0 | 5 | 200 | 116 | 23 | 654 |
| **Sum 2014** | | | | **362** | **158** | **286** | **1,996** | **3,993** | **5,303** | **9,635** | **3,223** | **1,294** | **2,616** | **2,784** | **499** | **32,149** |
| **Total 13-14** | | | | **568** | **236** | **601** | **2,596** | **4,596** | **6,996** | **10,201** | **3,639** | **2,095** | **3,428** | **3,814** | **609** | **39,683** |

Key: na = not available.

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Jan. 2015 | Feb. 2015 | Mar. 2015 | Apr. 2015 | May 2015 | June 2015 | July 2015 | Aug. 2015 | Sep. 2015 | Oct. 2015 | Nov. 2015 | Dec. 2015 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chesapeake Bay | 10 | B15 | None | 3 | 31 | 17 | 75 | 561 | 990 | 302 | 213 | 27 | 231 | 274 | 58 | 2,782 |
| Chesapeake Bay | 8 | B13 | None | 75 | 0 | 12 | 75 | 606 | 357 | 55 | 13 | 2 | 90 | 89 | 29 | 1,403 |
| Chesapeake Bay | 8 | CBBT1 | None | 2 | 0 | 1 | 54 | 29 | 1 | 0 | 0 | 4 | 11 | 0 | 9 | 111 |
| Chesapeake Bay | 8 | CBBT2 | None | 46 | 4 | 2 | 414 | 281 | 55 | 0 | 0 | 11 | 28 | 0 | 31 | 872 |
| Chesapeake Bay | 8 | CBBT7 | None | 1 | 25 | 68 | 349 | 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 | 71 | 3,266 |
| Chesapeake Bay | 6 | 10N | None | 14 | 0 | 17 | 982 | 285 | 35 | 0 | 0 | 13 | 161 | 18 | 20 | 1,545 |
| Chesapeake Bay | 5 | B11 | None | 12 | 1 | 37 | 105 | 190 | 766 | 281 | 70 | 42 | 411 | 260 | 90 | 2,265 |
| Chesapeake Bay | 4 | B9 | None | 17 | 7 | 21 | 335 | 178 | 6,504 | 20,913 | 2,722 | 5 | 600 | 687 | 78 | 32,067 |
| Chesapeake Bay | 4 | TS5 | None | 30 | 1 | 17 | 115 | 38 | 722 | 447 | 126 | 48 | 245 | 330 | 23 | 2,142 |
| Chesapeake Bay | 3 | B7 | None | 6 | 5 | 0 | 177 | 61 | 413 | 70 | 207 | 4 | 85 | 113 | 47 | 1,188 |
| Chesapeake Bay | 2 | B5 | None | 12 | 7 | 21 | 57 | 58 | 231 | 46 | 12 | 38 | 116 | 111 | 29 | 738 |
| **Sum 2015** | | | | **230** | **104** | **400** | **3,936** | **3,815** | **10,510** | **22,141** | **3,368** | **202** | **2,377** | **2,066** | **516** | **49,665** |
| **Total 13-15** | | | | **798** | **340** | **1,001** | **6,532** | **8,411** | **17,506** | **32,342** | **7,007** | **2,297** | **5,805** | **5,880** | **1,125** | **89,348** |

Both the Little Creek and the Fort Story zones occur within the lower bay region along the southern side of the Chesapeake Bay **(Figure 2)**. Little Creek is monitored by seven receivers that cover 23 percent of its area (**Table 3**). Due to the zone's location directly southeast of the mouth of the James River, it receives a large volume of fresh water which turns right as it exits the James River due to the Coriolis affect. The benthos of this zone is characterized by extensive sandy shallows with the Thimble Shoals Channel to the north.

In 2013, 2014 and 2015 there were 159, 204, and 256 sturgeon recorded in the Little Creek zone respectively. Although much smaller in area and receiver number, the total number of detections recorded in the Little Creek zone (**Table 12**) in 2013 and 2014 (39,153) was nearly equal to the number of detections recorded in the lower Chesapeake (39,683) **(Table 11)**. In 2015, the number of detections in the lower Chesapeake region increased (32,149 to 49,665) but those in the Little Creek recorded a marked reduction (32,542 to 13,973).

Peak occupancy within the zone occurred in June in 2013 and 2014 and two months earlier in April of 2015. Again, a large tagging effort was ongoing in the James River in the spring of both 2014 and 2015. Since many fish descend downriver after tagging, this large influx in fish number may be due not only to immigrating fish but those exiting the James River following tag implantation. Fall occupancy peaked in October in all three years (**Figure 17**). Though clear immigration and emigration patterns are evidenced in spring and fall by seasonal increases in fish number, other detection variables suggest that behavior during the summer months varied greatly inter-annually. Such dramatic inter-annual alterations in seasonal behavioral patterns have yet to be recorded in other zones and speak to the need for continued monitoring to potentially understand the factors contributing to this zone's highly varied occupation patterns.

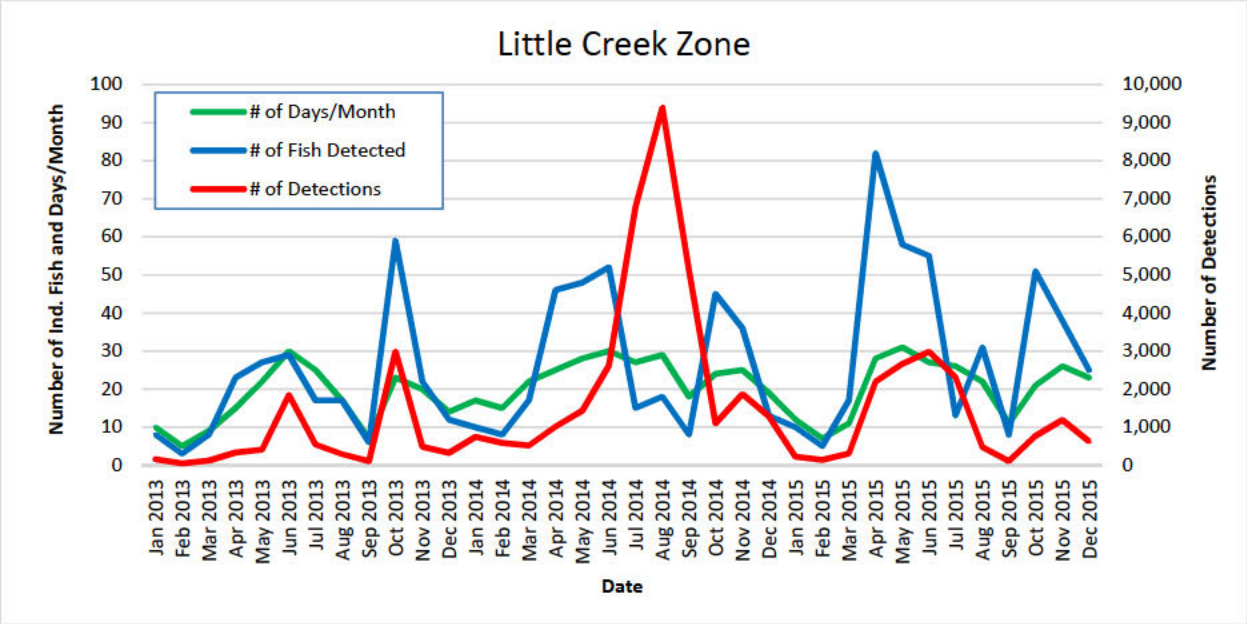


**Figure 17. Atlantic sturgeon occurrence based on receiver detections in the Little Creek zone.**

1 **Table 12. Numbers of detections by month in the Little Creek military zone, December 2012–December 2015. Receiver sites are listed in descending river mile.**

| Geographic Region | Channel mile | Receiver Site Name | Military Interest Zone | Dec. 2012 | Jan. 2013 | Feb. 2013 | Mar. 2013 | Apr. 2013 | May 2013 | June 2013 | July 2013 | Aug. 2013 | Sep. 2013 | Oct. 2013 | Nov. 2013 | Dec. 2013 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chesapeake Bay | 7 | LC1 | Little Creek | 18 | 4 | 5 | 5 | 54 | 2 | 7 | 0 | 0 | 6 | 5 | 4 | 33 | 143 |
| Chesapeake Bay | 7 | TS11 | Little Creek | 2 | 10 | 2 | 14 | 73 | 40 | 118 | 74 | 119 | 5 | 1,419 | 98 | 51 | 2,025 |
| Chesapeake Bay | 6 | LC2 | Little Creek | 0 | 50 | 8 | 0 | 25 | 42 | 31 | 19 | 38 | 12 | 0 | 17 | 47 | 289 |
| Chesapeake Bay | 6 | TS9 | Little Creek | 36 | 3 | 0 | 3 | 60 | 34 | 105 | 29 | 46 | 6 | 528 | 182 | 111 | 1,143 |
| Chesapeake Bay | 5 | TS7 | Little Creek | 8 | 57 | 4 | 81 | 68 | 43 | 123 | 116 | 49 | 44 | 157 | 21 | 24 | 795 |
| Chesapeake Bay | 4 | CBBT4 | Little Creek | 0 | 9 | 16 | 4 | 12 | 4 | 39 | 66 | 14 | 2 | 2 | 15 | 0 | 183 |
| Chesapeake Bay | 3 | CBBT5 | Little Creek | 0 | 0 | 9 | 7 | 46 | 229 | 1,436 | 228 | 53 | 13 | 0 | 2 | 10 | 2,033 |
| **Sum** | | | | **64** | **133** | **44** | **114** | **338** | **394** | **1,859** | **532** | **319** | **88** | **2,111** | **339** | **276** | **6,611** |

| Geographic Region | Channel mile | Receiver Site Name | Military Interest Zone | Jan. 2014 | Feb. 2014 | Mar. 2014 | Apr. 2014 | May 2014 | June 2014 | July 2014 | Aug. 2014 | Sep. 2014 | Oct. 2014 | Nov. 2014 | Dec. 2014 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chesapeake Bay | 7 | LC1 | Little Creek | 4 | 5 | 58 | 61 | 62 | 18 | 1 | 4 | 19 | 213 | 23 | 5 | 473 |
| Chesapeake Bay | 7 | TS11 | Little Creek | 536 | 306 | 270 | 101 | 563 | 436 | 163 | 114 | 162 | 279 | 834 | 802 | 4,566 |
| 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 | 77 | 176 | 527 | 6,371 | 9,211 | 4,819 | 314 | 639 | 343 | 22,660 |
| Chesapeake Bay | 5 | TS7 | Little Creek | 6 | 83 | 69 | 172 | 176 | 284 | 166 | 98 | 43 | 193 | 146 | 50 | 1,486 |
| Chesapeake Bay | 4 | CBBT4 | Little Creek | 4 | 144 | 5 | 178 | 91 | 52 | 24 | 5 | 2 | 27 | 79 | 43 | 654 |
| Chesapeake Bay | 3 | CBBT5 | Little Creek | 16 | 1 | 33 | 358 | 345 | 1,240 | 39 | 42 | 53 | 23 | 39 | 41 | 2,230 |
| **Sum 2014** | | | | **652** | **580** | **519** | **1,026** | **1,459** | **2,622** | **6,780** | **9,498** | **5,123** | **1,130** | **1,869** | **1,284** | **32,542** |
| **Total 13-14** | | | | **785** | **624** | **633** | **1,364** | **1,853** | **4,481** | **7,312** | **9,817** | **5,211** | **3,241** | **2,208** | **1,560** | **39,153** |

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Jan. 2015 | Feb. 2015 | Mar. 2015 | Apr. 2015 | May 2015 | June 2015 | July 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 | 79 | 951 |
| Chesapeake Bay | 7 | TS11 | Little Creek | 27 | 8 | 18 | 150 | 208 | 333 | 512 | 83 | 33 | 385 | 249 | 146 | 2,152 |
| 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 | 26 | 5 | 36 | 135 | 688 | 536 | 1,654 | 146 | 19 | 136 | 537 | 56 | 3,974 |
| Chesapeake Bay | 5 | TS7 | Little Creek | 48 | 28 | 58 | 227 | 192 | 258 | 88 | 89 | 11 | 223 | 265 | 75 | 1,562 |
| Chesapeake Bay | 4 | CBBT4 | Little Creek | 37 | 6 | 78 | 435 | 257 | 154 | 25 | 21 | 9 | 3 | 13 | 53 | 1,091 |
| Chesapeake Bay | 3 | CBBT5 | Little Creek | 18 | 13 | 48 | 562 | 796 | 1,044 | 21 | 61 | 6 | 1 | 37 | 142 | 2,749 |
| **Sum 2015** | | | | **218** | **134** | **306** | **2,191** | **2,664** | **2,979** | **2,311** | **474** | **106** | **771** | **1,191** | **628** | **13,973** |
| **Total 13-15** | | | | **1,003** | **758** | **939** | **3,555** | **4,517** | **7,460** | **9,623** | **10,291** | **5,317** | **4,012** | **3,399** | **2,188** | **53,126** |

In 2013, as water temperatures increased in summer, fewer fish were detected and a corresponding reduction in the number of detections and days with detections congruently occurred, suggesting fish left the zone. The few that remained moved into deeper channel habitats. Sturgeon again showed a marked reduction in number and mobility in 2014 and moved into deeper channel environments during this period. Trends in fish number were similar in 2013 and 2014 with marked reductions occurring from June to July and reduced fish presence in July–September. Interestingly, the tagging origins of these fish suggest that both aggregations contained transient fish from other systems of varied origins; northern in 2013 and southern in 2014. In 2013 and 2014, fish congregated within the Thimble Shoals Channel (TS11, 14 m deep; TS9, 14 m) and this habitat selection pattern mimicked that observed just north, in a similar region of the Baltimore Channel, between buoys B9 and B15. The numbers of detections within Thimble Shoals Channel sites in the Little Creek zone during the summer months of 2015 were drastically reduced in comparison to those recorded in 2014 (17,370 vs. 3,699) despite a slight increase in fish number during August. Similar reductions were not recorded in the corresponding section of the Baltimore Channel. In fact, the number of fish within the channel sites remained relatively consistent between 2014 (n=15) and 2015 (n=10) and the residence period grew substantially with detection number increasing from 4,608 to 20,913. Interestingly, though much smaller in numeric value, June detections at the CBBT5 site, located under the Chesapeake Bay Bridge-Tunnel in a relatively deep hole (9 m) surrounded by shallow (2–3 m) sandy flats, remained unusually high but relatively constant across all years (1,000–1,500).

The Fort Story military zone was monitored by five receivers that cover 23 percent of its area (**Table 3**). One ocean receiver (2C off Cape Henry, defined as such because it is east of the COLREGS line) is contained within the Fort Story military zone. This zone is characterized by extreme currents and a deep nearshore channel located just north of Cape Henry **(Figure 2).**

Totals of 174, 211, and 276 fish with 8,647, 9,091, and 11,401 detections were recorded in 2013, 2014, and 2015, respectively, within the Fort Story zone (**Figure 18**). Although the number of fish in the Little Creek and Fort Story zones zone was similar in 2014 (204 vs. 214), the number of detections within Little Creek (32,542) dwarfed that recorded within the Fort Story zone (9,053). This was not the case in 2015 when the numbers of detections for the year were very similar (13,973 vs. 11,401).

By far the largest numbers of detections occurred in July and August in 2013. Peaks in 2014 were in June, July and October **(Figure 18, Table 13)** and by far the largest number of fish thus far recorded occurred in April of 2015**.** Many of these fish were subsequently detected within the Little Creek zone later in the same month. The largest numbers of fish occurred in spring and fall, concurrent with seasonal coastal migrations and immigration and emigration into the Chesapeake Bay (Hager 2011). The relatively high numbers of individuals detected combined with the reduced numbers of detections during these periods is indicative of highly mobile behavior, in this case migration **(Figure 18)**.

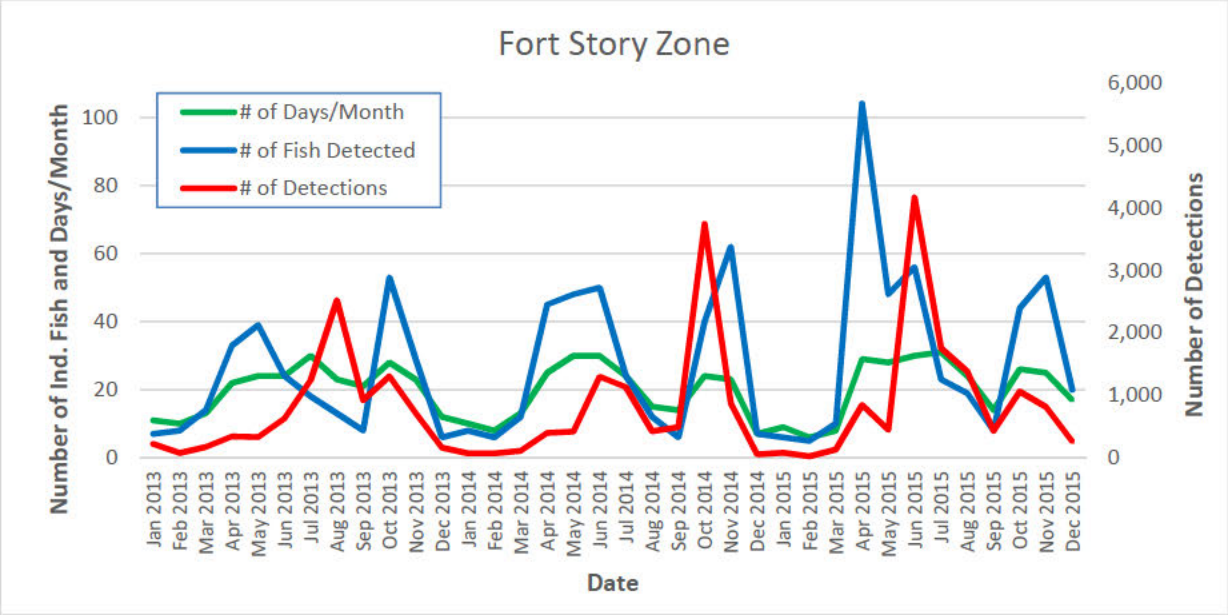


**Figure 18. Atlantic sturgeon occurrence based on receiver detections in the Fort Story zone.**

**Table 13. Numbers of detections by month in the Fort Story military zone, December 2012–December 2015. Receiver sites are listed in descending river mile.**

| 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 | 28 | 52 | 106 | 50 | 68 | 52 | 92 | 23 | 231 | 308 | 15 | 1,169 |
| Chesapeake Bay | 1 | 2CH CAPE HENRY | Fort Story | 0 | 10 | 13 | 60 | 63 | 60 | 72 | 49 | 43 | 71 | 136 | 81 | 53 | 711 |
| Chesapeake Bay | 1 | TS1 | Fort Story | 8 | 55 | 10 | 40 | 95 | 93 | 442 | 1,125 | 2,358 | 702 | 430 | 138 | 73 | 5,569 |
| Chesapeake Bay | 1 | B3 | Fort Story | 27 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 52 |
| Atlantic Ocean | 2 | 2C CAPE HENRY | Fort Story | 17 | 7 | 0 | 8 | 88 | 134 | 64 | 0 | 19 | 74 | 0 | 0 | 0 | 411 |
| **Sum** | | | | **93** | **200** | **51** | **160** | **352** | **337** | **646** | **1,226** | **2,512** | **870** | **797** | **527** | **141** | **7,912** |

| 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 | 137 | 124 | 370 | 650 | 213 | 6 | 379 | 215 | 47 | 2,209 |
| Chesapeake Bay | 1 | 2CH CAPE HENRY | Fort Story | 9 | 15 | 26 | 61 | 117 | 309 | 82 | 165 | 125 | 371 | 210 | 1 | 1,491 |
| Chesapeake Bay | 1 | TS1 | Fort Story | 48 | 40 | 35 | 89 | 110 | 416 | 343 | 43 | 82 | 1,336 | 260 | 7 | 2,809 |
| 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 | 116 | 57 | 207 | 59 | 1 | 277 | 1,599 | 215 | 0 | 2,544 |
| **Sum 2014** | | | | **70** | **70** | **114** | **403** | **408** | **1,302** | **1,134** | **422** | **490** | **3,685** | **900** | **55** | **9,053** |
| **Total 13-14** | | | | **270** | **121** | **274** | **755** | **745** | **1,948** | **2,360** | **2,934** | **1,360** | **4,482** | **1,427** | **196** | **16,965** |

| Geographic Region | River mile | Receiver Site Name | Military Interest Zone | Jan. 2015 | Feb. 2015 | Mar. 2015 | Apr. 2015 | May 2015 | June 2015 | July 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 | 207 | 301 | 20 | 529 | 209 | 114 | 3,841 |
| Chesapeake Bay | 1 | 2CH CAPE HENRY | Fort Story | 13 | 8 | 34 | 195 | 98 | 769 | 897 | 662 | 196 | 171 | 147 | 51 | 3,241 |
| Chesapeake Bay | 1 | TS1 | Fort Story | 4 | 4 | 26 | 366 | 123 | 1,037 | 593 | 341 | 163 | 204 | 263 | 79 | 3,203 |
| Atlantic Ocean | 2 | 2C CAPE HENRY | Fort Story | 22 | 7 | 39 | 152 | 94 | 246 | 61 | 79 | 49 | 156 | 194 | 17 | 1,116 |
| **Sum 2015** | | | | **83** | **22** | **131** | **846** | **446** | **4,170** | **1,758** | **1,383** | **428** | **1,060** | **813** | **261** | **11,401** |
| **Total 13-15** | | | | **353** | **143** | **405** | **1,601** | **1,191** | **6,118** | **4,118** | **4,317** | **1,788** | **5,542** | **2,240** | **457** | **28,366** |

Key: na = not available.

### 4.4.6 Atlantic Region (Dam Neck Naval Firing Range Surrogate Zone)

Twenty receivers were distributed in the nearshore Atlantic region, 19 of which occurred within the Dam Neck Firing Range Surrogate zone. The array within this zone detected 284 individual sturgeon in 2013, 352 in 2014, and 455 in 2015, with 4,206, 6,829, and 5,585 detections occurring per year. These are the largest numbers of tagged fish recorded in any zone of military interest, and makes biological sense in that this array records coastal-migrating sturgeon that do not subsequently enter the Chesapeake Bay. Though sturgeon were not detected in every month of every year (no fish were detected in August 2013, with only one in September 2013), trends in the numbers of detections were consistent between years. Each year was marked by a dearth of fish in this zone during the heat of late summer–early fall (**Table 14**). Congruently, the few fish remaining in the lower Bay shift into channel habitats and become sedentary. Others assume a similar behavior in freshwater tributaries or are found on the spawning grounds (Hager et al. 2014, Kahn et al. 2014). Coastal migrations in this nearshore region and Surrogate zone were extremely well defined, generally extending from March through May and October through January, with consistent peaks in April and November, respectively **(Figure 19)**. These peaks are approximately a month behind those recorded in other zones at the mouths of the rivers. The fact that peak of migration shifts slightly inter-annually supports the assertion that such migrations are affected by coastal water temperature (Smith 1985). Maps are presented in **Appendix 4.4.6**.

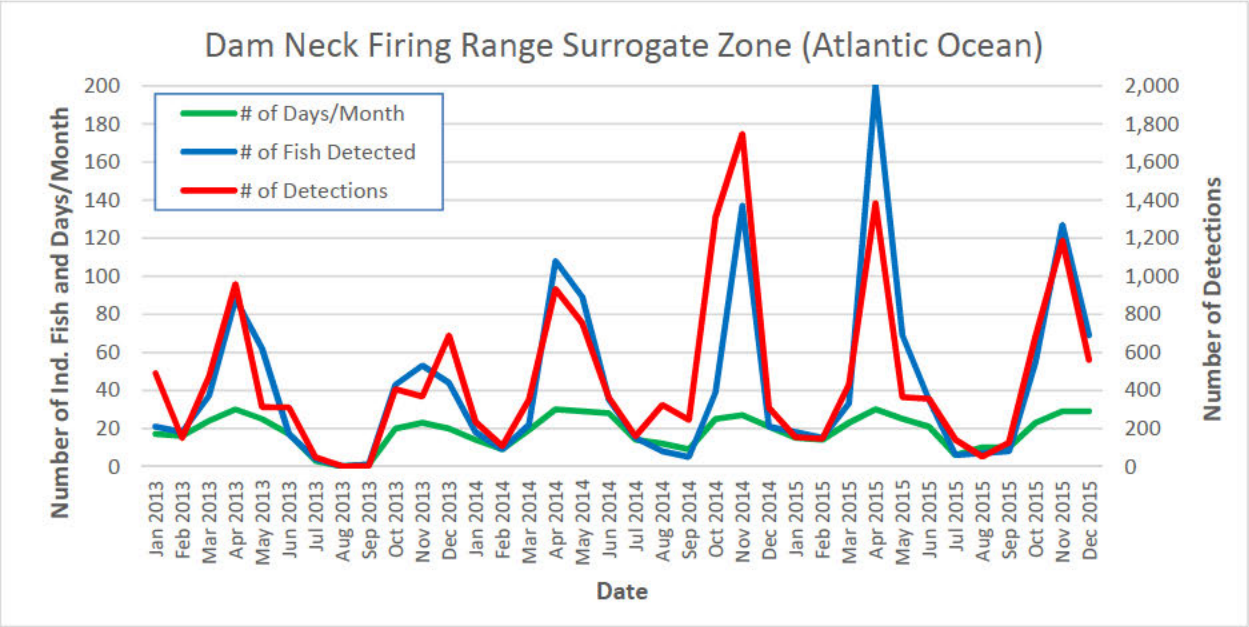


**Figure 19. Atlantic sturgeon occurrence based on receiver detections in the Dam Neck Naval Firing Range Surrogate zone.**

**Table 14. Numbers of detections by month in the Atlantic region, December 2012–December 2014. Receiver sites are listed in descending river mile.**

| Geographic Region | Miles from COLREGS | Receiver Site Name | Military Interest Zone | Dec. 2012 | Jan. 2013 | Feb. 2013 | Mar. 2013 | Apr. 2013 | May 2013 | June 2013 | July 2013 | Aug. 2013 | Sep. 2013 | Oct. 2013 | Nov. 2013 | Dec. 2013 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic | 11 | NCA | None | 0 | 1 | 0 | 0 | 74 | 31 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 107 |
| Atlantic | 14 | CB | Range Sur. | 26 | 78 | 12 | 43 | 95 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 57 | 313 |
| Atlantic | 13 | CB1 | Range Sur. | 0 | 52 | 13 | 11 | 28 | 3 | 0 | 0 | 0 | 0 | 19 | 39 | 95 | 260 |
| Atlantic | 11 | CB3 | Range Sur. | 8 | 22 | 9 | 47 | 11 | 9 | 1 | 0 | 0 | 0 | 0 | 28 | 98 | 233 |
| Atlantic | 10 | CB5 | Range Sur. | 0 | 12 | 0 | 26 | 44 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| Atlantic | 10 | NCB | Range Sur. | 0 | 0 | 1 | 0 | 46 | 3 | 4 | 0 | 0 | 2 | 0 | 0 | 0 | 56 |
| Atlantic | 9 | CB7 | Range Sur. | 10 | 0 | 0 | 0 | 22 | 21 | 0 | 15 | 0 | 0 | 31 | 33 | 9 | 141 |
| Atlantic | 9 | RA OUT | Range Sur. | 1 | 25 | 10 | 22 | 27 | 1 | 3 | 0 | 0 | 0 | 29 | 17 | 0 | 135 |
| Atlantic | 8 | CB9 | Range Sur. | 13 | 0 | 1 | 16 | 19 | 8 | 10 | 5 | 0 | 0 | 0 | 0 | 52 | 124 |
| Atlantic | 8 | NCC | Range Sur. | 15 | 5 | 9 | 7 | 31 | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 116 |
| Atlantic | 7 | CB11 | Range Sur. | 0 | 0 | 42 | 23 | 52 | 35 | 5 | 0 | 0 | 0 | 102 | 64 | 79 | 402 |
| Atlantic | 7 | RA | Range Sur. | 17 | 1 | 10 | 45 | 35 | 16 | 2 | 0 | 0 | 0 | 1 | 5 | 34 | 166 |
| Atlantic | 6 | CB13 | Range Sur. | 0 | 0 | 0 | 19 | 29 | 42 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 102 |
| Atlantic | 6 | NCD | Range Sur. | 5 | 1 | 12 | 12 | 32 | 22 | 6 | 0 | 0 | 0 | 44 | 33 | 25 | 192 |
| Atlantic | 5 | NCE | Range Sur. | 16 | 13 | 0 | 10 | 21 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 66 |
| Atlantic | 5 | CB15 | Range Sur. | 2 | 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 62 |
| Atlantic | 3 | CH | Range Sur. | 5 | 13 | 5 | 42 | 60 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 130 |
| Atlantic | 3 | RI2 | Range Sur. | 16 | 60 | 11 | 59 | 214 | 17 | 8 | 4 | 0 | 0 | 0 | 0 | 23 | 412 |
| Atlantic | 3 | RI1 | Range Sur. | 13 | 0 | 0 | 28 | 56 | 7 | 1 | 0 | 0 | 0 | 5 | 14 | 8 | 132 |
| Atlantic | 2 | CH1 | Range Sur. | 9 | 14 | 10 | 35 | 50 | 22 | 9 | 9 | 0 | 0 | 27 | 13 | 56 | 254 |
| **Sum** | | | | **156** | **357** | **145** | **445** | **946** | **303** | **62** | **33** | **0** | **2** | **258** | **246** | **550** | **3,503** |

| Geographic Region | Miles from COLREGS | Receiver Site Name | Military Interest Zone | Jan. 2014 | Feb. 2014 | Mar. 2014 | Apr. 2014 | May 2014 | June 2014 | July 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 | 112 | 31 | 258 |
| 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 | 0 | 0 | 0 | 0 | 5 | 90 | 15 | 127 |
| Atlantic | 10 | NCB | Range Sur. | 0 | 0 | 11 | 35 | 9 | 0 | 0 | 0 | 0 | 2 | 45 | 9 | 111 |
| Atlantic | 9 | CB7 | Range Sur. | 0 | 10 | 0 | 49 | 18 | 0 | 1 | 0 | 0 | 18 | 40 | 2 | 138 |
| Atlantic | 9 | RA OUT | Range Sur. | 0 | 1 | 27 | 26 | 13 | 0 | 0 | 0 | 0 | 22 | 183 | 57 | 329 |
| 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 | 22 | 90 | 16 | 238 |
| 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 |

| Geographic Region | Miles from COLREGS | Receiver Site Name | Military Interest Zone | Jan. 2014 | Feb. 2014 | Mar. 2014 | Apr. 2014 | May 2014 | June 2014 | July 2014 | Aug. 2014 | Sep. 2014 | Oct. 2014 | Nov. 2014 | Dec. 2014 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic | 6 | CB13 | Range Sur. | 36 | 3 | 65 | 28 | 48 | 18 | 0 | 2 | 7 | 95 | 248 | 17 | 567 |
| Atlantic | 6 | NCD | Range Sur. | 0 | 0 | 0 | 80 | 23 | 18 | 0 | 0 | 0 | 16 | 44 | 120 | 301 |
| 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 | 95 | 127 | 172 | 136 | 287 | 232 | 535 | 191 | 10 | 1,823 |
| Atlantic | 3 | RI2 | Range Sur. | 3 | 8 | 71 | 86 | 40 | 6 | 0 | 5 | 0 | 4 | 40 | 2 | 265 |
| 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** | | | | **231** | **107** | **349** | **915** | **744** | **360** | **158** | **324** | **244** | **1,307** | **1,719** | **449** | **6,907** |
| **Total 13-14** | | | | **588** | **252** | **794** | **1,861** | **1,047** | **422** | **191** | **324** | **246** | **1,565** | **1,965** | **999** | **10,410** |

| Geographic Region | Miles from COLREGS | Receiver Site Name | Military Interest Zone | Jan. 2015 | Feb. 2015 | Mar. 2015 | Apr. 2015 | May 2015 | June 2015 | July 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 | 0 | 14 | 0 | 18 | 29 | 0 | 0 | 0 | 17 | 45 | 13 | 145 |
| Atlantic | 10 | NCB | Range Sur. | 4 | 3 | 7 | 12 | 16 | 2 | 0 | 0 | 0 | 39 | 54 | 17 | 154 |
| Atlantic | 9 | CB7 | Range Sur. | 5 | 27 | 32 | 23 | 16 | 0 | 0 | 0 | 5 | 24 | 100 | 26 | 258 |
| Atlantic | 9 | RA OUT | Range Sur. | 16 | 10 | 21 | 51 | 32 | 0 | 0 | 0 | 0 | 6 | 50 | 79 | 265 |
| 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 | 14 | 46 | 17 | 171 |
| Atlantic | 5 | NCE | Range Sur. | 0 | 0 | 29 | 97 | 29 | 29 | 0 | 0 | 3 | 12 | 53 | 16 | 268 |
| Atlantic | 3 | CH | Range Sur. | 7 | 24 | 23 | 133 | 21 | 113 | 17 | 24 | 29 | 136 | 114 | 5 | 646 |
| Atlantic | 3 | RI2 | Range Sur. | 36 | 3 | 32 | 79 | 16 | 8 | 0 | 1 | 0 | 0 | 12 | 35 | 222 |
| 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** | **131** | **446** | **1,365** | **353** | **385** | **140** | **51** | **126** | **684** | **1,189** | **561** | **5,585** |
| **Total 13-15** | | | | **742** | **383** | **1,240** | **3,226** | **1,400** | **807** | **331** | **375** | **372** | **2,249** | **3,154** | **1,560** | **15,995** |

Key: na = not available.

# 5. DISCUSSION

The best data available on operational 69-kilohertz VEMCO® tags along the U.S. Atlantic coast are found in the Atlantic Coastal Telemetry (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 and 2015. These estimates calculate annual increases in the number of species carrying tags and specifically Atlantic sturgeon. As of December 2012, there were 1,243 sturgeon carrying tags and by the end of 2013, there were 1,392. We detected 400 of those from December 2012 through January 2014, thus approximately 29 percent in 2013. The total number of active sturgeon tags was projected to drop to 967 in 2014, due to estimated tag expiration. In order to ensure ample numbers of 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 sturgeon tags. We recorded 511 sturgeon in 2014 or approximately 33 percent of these tagged Atlantic sturgeon. In 2015, 637 sturgeon were detected which represented approximately 37 percent of the operational transmitters (637/1,745). 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. Our habitat use and detection rates are even more impressive when one considers the fact that many of the tags reported in the ACT network are being placed in juvenile fish that have not yet matured enough to undertake ocean migrations and are thus not available for detection in our array.

Aside from our large amount of telemetry data, several attributes of the sturgeon detected emphasize the region's importance to the species' sustainability. First, the majority of sturgeon recorded were not from native Chesapeake Bay stocks based on the locality of transmitter implantation (**Table 5**) and a previous genetic examination of a subset of fish randomly collected from the throughout the Bay (Bartron et al. 2007). Second, the fish detected were of highly varied age structure. Third, there were numerous examples of extended occupation by individual sub-adult and adult sturgeon within the Chesapeake Bay and its tributaries. Therefore, not only do the Bay and its tributaries support multiple reproducing populations of native sturgeon through the provision of spawning and nursery grounds but the 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 DPS are listed as "endangered" under the ESA. The one exception was a fish tagged in Maine. Only 36 of the 886 sturgeon detected within the array were tagged south of Virginia. Since so few sturgeon from south of Virginia were recorded using Virginia's waters, the actual percentage of sturgeon detected originating within NOAA's Northeast Region may be larger than the predicted range between 29 and 37 percent. But since many of the fish being tagged in the Northeast are being collected in the ocean where sturgeon from varied origin are known to congregate only genetic analysis that has not yet been completed will allow us to determine which inshore habitats are critical to which DPS.

Prior to our research very little was known about sturgeon in the York River system. Previous tracking based behavior research had targeted the much larger population residing in the James River. Subsequent tracking of these and other sturgeon tagged along the coast suggested that the York River was rarely occupied by transient or local sturgeon (Hager 2011). This lack of data on the York River system was turned into an opportunity through our York River system specific tagging efforts and it is now becoming evident that our previous perception of lack of use by the species was due to our lack of data on fish of York River origin. While our original assertion that very few transient fish from other systems use the York River is still holding true, it is increasingly obvious that the York River system contains a unique stock of highly active fish that use the York and other Virginia waters in distinct ways.

In 2013, Navy-funded research provided data proving that a naturally 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 it has enabled subsequent years of sampling, tagging and tracking that are now providing data critical to understanding and protecting this native York River stock.

Preliminary genetic results (Tim King, U.S. Geological Survey, personal communication) conclude that the Pamunkey population is genetically unique and not closely related to the James River's stock as once hypothesized. The total adult population for the Pamunkey River at 289 fish is the smallest documented reproducing population in existence, which could have enormous consequences for how the stock and its critical habitats are managed. There are only two other published population estimates both from much larger river systems. The Hudson River estimate ((Kahnle et al. 2007) suggests at least 870 adults based on fisheries data from the 1980-90s. Spawning abundances of 143-667 in 2004 and 216-787 in 2005 were estimated for the Altamaha River (Peterson et al. 2008). Both of these estimates are from much larger river systems and both much less statistically confident in their estimates than ours for the Pamunkey River.

Based upon both mark-recapture techniques and supported by genetic analysis, the number of adults tagged in the Pamunkey River now represents approximately 20 percent of the adult spawning population (Kahn et al. 2014). Since a sizable portion of the Pamunkey's adult population has been tagged, we can confidently describe numerous behavior inherent to the stock, even though the duration of this research effort is relatively short.

We have determined that no spring spawning is currently occurring in the York River system. Balazik and Musick's (2015) suggestion that a dual annual spawning migration is common throughout the entire range of Atlantic sturgeon is not supported by our York River data nor by regional historic records. The past two years of sampling and tracking in the Pamunkey and upper York River have provided no evidence of spring spawning. A complete lack of adult bycatch observed and/or reported by fishers through the Fisheries Resource Grant Program's 2005–2010 sturgeon bycatch and reward program lends further credence to there being no spring spawning in the Pamunkey and likely the York River watershed. In addition, no historic record of a spring fishery exists, though mid-summer fisheries and even techniques are citable. Captain John Smith's observations in 1607–1609 report that large fish were not available in the James River until summer (Barbour 1986). During the peak of the sturgeon fishery (1890–1900), sturgeon were being taken during July and August by men of the Pamunkey and Mattaponi tribes using bush nets, a type of blocking gear (Speck 1928). One large sturgeon was taken as bycatch in the Mattaponi in the 1970s when a very large American shad gillnet fishery was annually conducted, but this rare event was so unusual it made the local newspaper (personal communication with Mattaponi Chief Custalow and article found at the Mattaponi Indian museum).

We have found that males are much more mobile on the spawning grounds and thus much more susceptible to our gill net collection gear. In agreement with the findings of others, we have also documented that adult males arrive on the spawning grounds at lower water temperatures than females (Fox et al. 2000) and remain on the spawning grounds throughout the spawning season (Smith 1986, Hager 2011). We have discovered that a large percentage of adult males of Pamunkey origin return every year to spawn. This is in contrast with the findings of some researchers who have suggested that adult Atlantic sturgeon do not spawn every year (Van Eenennaam et al. 1996, Caron et al. 2002) but in agreement with others. Smith (1985) indicated that males spawn every 1–5 years, and several researchers have documented repetitive spawning by males in southern rivers (Fox et al. 2000, Collins et al. 2000a). Numerous researchers have reported that Atlantic sturgeon growth rate is

negatively correlated with latitude and that and maximum size is positively correlated with latitude (Smith 1985, Collins et al. 1996, Stevenson and Secor 1999). Others recognize that Atlantic sturgeon mature at different rates along the coast with southern populations maturing more rapidly (Vladdykov and Greenley 1963). The pattern of anadromy (returning to fresh water to spawn) varies with latitude for shortnosed sturgeon, and this pattern likely reflects bioenergetic adaptations to latitudinal differences in thermal and foraging habitat suitability (Kynard 1997). Our findings support the hypothesis that sturgeon development varies with latitude, and this impacts behavior and life history. For example, in concert with the findings of Scott and Crossman (1973) who suggested that some females spawn every year, we also recorded females returning in consecutive years. Consequently, though our findings are not in the majority, especially with regard to northern stocks, they likely exemplify the species' natural flexibility tied intrinsically to latitudinal differences in growth and development due to temperature and consumption. In some cases fish follow instinctive patterns, as is the case with migration patterns/homing for spawning purposes and there is increasing evidence that this programming is genetic (Gerlach et al. 2006). Differences in behavior, documented to correlate with natal latitude, are likely the product of natural selection. This natural selection is influenced by habitat variation along with the rate of genetic alteration and is dependent upon physiological/bioenergetics and genetic flexibility. Resulting genetic variations presumably impart inherent advantages to a given population and uniquely suit it for the characteristics of its native habitat. Species that rapidly evolve in response to variations in geological conditions (natural selection) are more likely to survive over time. The Atlantic sturgeon DPSs are genetically unique, at least in part due to selection pressures that have resulted in adaptations specific to their regions of origin (Damon-Randall et al. 2010). Regionally specific adaptations would explain why the bioenergetic thresholds defined by Niklitschek (2001) based on sub-adults of northern origin, do not correlate to the observed behavior of southern sub-adults. His research failed to include fish of southern genetic composition and thus did not define regionally specific thresholds.

The high annual rate of adults returning to spawn each fall in the Pamunkey over the past three years has begun to provide enough data to delineate the temporal and spatial characteristics of the spawning run. These data are especially applicable to Navy goals because they provide a means of differentiating naval activities in order to provide for the protection of the smallest documented population of reproducing Atlantic sturgeon, in particular while the adult sturgeon are on their spawning run and the stock's reproductive success is most vulnerable to negative impacts. Substantial differences in the number and location of detections during immigration and emigration have also begun to suggest that characteristics of these migrations vary significantly. The fact that so few fish are being detected at such a reduced number of sites upon emigration stands in stark contrast to the robust detection data during immigration. This detection variation likely indicates behavioral and/or detectability differences between immigration and emigration and/or the environment when these migrations occur. Musick and Hager (2007) recorded different patterns in depth distribution and use in the James River seasonally based upon pressure sensor data. Variations in detection volume may suggest that emigration is quicker, with less time spent congregating and traversing between locations within the Bay's mouth. Many anadromous fish must stage their movements between varied salinities in order to allow time to allow for osmotic adjustment (Brown 1957). Based on tracking data from sturgeon running up the Pamunkey for spawning, staging may occur in greater part within the Bay upon immigration and mostly within the York River upon emigration. Adults may be using different potentially shallower pathways that are not well monitored. This assertion may be supported by there being a nearly equal number of fish using shallow-water Eastern Shore sites in both spring and fall migrations. Alterations in sturgeon behavior upon emigration were noticed very early on in the fishery. Differences in catch rates upon immigration versus emigration in anchored gillnets in the Delaware 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." An alternative explanation for such reduced detections upon emigration is that environmental conditions exist in the fall that make detection more difficult, though this hypothesis does not seem supported by similar detection variability in the detection volume of other fishes.

Interesting inter-annual alterations in the duration of suitable fall spawning temperatures were noted in the Pamunkey River in 2014 and 2015 as they were in the James River 2007-2011 (Hager 2011). Such alterations expand or contract the duration of the spawning season. Similar inter- and intra-annual alterations in spawning habitat selection have been documented in other systems (Smith 1986) including the nearby James River (Hager 2011). Interestingly, Mohler (2003) witnessed fish spawning in aquaculture facilities between 20 and 21°C, correlating to similar upper James River temperatures of 19–22°C each spring (2008-2011), a time when peak activity/movements believed to be associated with spawning runs occurred (Hager 2011). This temperature range also correlates with increased adult activity in the Pamunkey River, as indicated by large gillnet catches of sturgeon and tracking females, which have only been attained in mid-spawn in 22–25°C. Further information on the spawning of adults in the upper river can be found in Kahn et al. (2014).

Research on the Pamunkey River's spawning population has also provided very interesting evidence that suggests that sound may be important to Atlantic sturgeon. Some fish have produced audible sounds as well as rapid muscle movements similar to those that male alligators generate during mating season upon capture. Sound production by sturgeon has been recorded by others and it is more common for fish to produce sounds during the breeding season (Myrberg 1981). Johnstone and Phillips (2003) recorded that both species of *Scapirhynchus* (pallid and shovelnosed) sturgeon produce four different types of sounds with energy in the signals varying by sound and species. In addition, they cite work by several unpublished Russian researchers claiming that *Acipenser* also produce sounds. Using physiological methods Meyers' and Popper's (unpublished) research suggests that the *Acipenser* species can detect sounds below 100hz to close to 100hz or a little more. While this research did not determine true thresholds, it does suggest that sturgeon should be able to localize sound and thus avoid or direct movement towards it (Popper 2005). While these data are preliminary, fish generally produce sounds within frequencies that can be heard by the species and thus offer some sort of evolutionary survival advantage.

Post-surgical holding experiments designed to test the effectiveness of surgical procedures and assure that such procedures were not negatively affecting sturgeon or altering behavior conducted in 2007 suggested that sturgeon once released remained near their release site for a significant amount of time, with this resting period positively correlated with holding time (Hager 2011). Annual tagging and subsequent tracking in the Pamunkey River has provided greater insight into the response of pre-spawning adult fish to surgical implantations. Adults collected in the fresh water spawning grounds and released immediately following surgery often drop down river, even reentering the oligohaline zone after internal implantation. They reside down river for a short period prior (up to a week maximum) before returning upriver where they resume normal behavior. This behavior is not observed consistently, however and may be sexually divergent. Females were less likely to exhibit this response and spawning stage may explain this apparent discrepancy. A female once in the spawning mode may be more motivated to remain in suitable spawning habitat. If the female is tagged at the end of her spawning run she may already be emigrating and thus not return upriver at all. Males often make alternating upriver and downriver runs apparently searching for partners. Surgery appears to exaggerate the extent of this behavior but only in the downriver direction. Continued research focusing on the

aspect of behavior is necessary to determine if this behavior is truly a response to surgery and if so if it has any significant effect. We do know that all fish have returned upriver with the exception of one spawned out (no eggs left) female. It should also be noted that when a down river site surgical recovery site is within an array's receptive area, this behavior might artificially enlarge the number of detections that would naturally occur at a given site without the surgical tagging effect. Because our fish were not tagged in a location anywhere near York River zones of military interest, occupancy patterns within the Naval Weapons Station Yorktown and Cheatham Annex zone are not due to the effects of implantation. However, VIMS and VCU were tagging fish in the Burwell Bay area of the James River (mesohaline zone) in 2014 and 2015. If the fish they tagged also dropped down river into the next salinity zone (polyhaline zone) this behavior could have artificially inflated the number of detections that would have occurred in the Naval Station Norfolk zone without the surgical activities occurring in a relatively near upriver site. Most of the fish implanted in Burwell's Bay were sub-adults and it is unclear if this life stage exhibits the same post-surgical response as adults on the spawning run.

The Chickahominy is the largest freshwater tributary entering the lower James River. In fact, its input is so large that in combination with fresh water flowing down the James, it creates the James River's oligohaline (>0.5-5 ppt) zone and where it enters the James it creates the fresh water delineation line. During the late summer when sub-adult and adult fish gather in the mouth of the Chickahominy, it is the same temperature as the surrounding James River but it is higher in dissolved oxygen and fresher in comparison (VECOS 2016). The Chickahominy does not contain any known spawning habitat, unlike the upper James River where adult fish congregate at this time. Therefore, it was thus not included in Bushnoe et al.'s (2005) spawning ground assessment of Virginia waters. The fact that adults and sub-adults of varied DPS origin (based on location of transmitter implantation) returned to and intermix in this location during the heat of summer supports the assertion that adult and sub-adult fish seek out such locations at least in part for physiological benefit (Collins et al. 2000b, Hager 2011). Tracking data from the Chickahominy River suggest that sturgeon of varied ages seek out habitats with physical attributes that resemble those required for spawning such as lower temperatures, reduced salinity, increased flow, and higher dissolved oxygen for more reasons than reproduction. It also seems to suggest that the assertion that the only reason adult sturgeon are found in fresh water is to spawn (Balazik et al. 2012) is false. It is possible that some sturgeon are spawning somewhere in the lower Chickahominy River or that fish are blocked at some point from further upriver migration due to some not yet determined physiochemical blockage (e.g., relatively warm water and/or lower dissolved oxygen). It is also worth noting that some of the sub-adults tagged by VIMS and VCU in Burwell's Bay subsequently went upriver, not down, and entered and were sedentary in the mouth of the Chickahominy River following surgery. This may suggest life stages differentiate in their behavior response to surgical stress.

Detection data suggest that the geographically diverse military zones of interest within Virginia waters vary substantially in their Atlantic sturgeon occupation and use patterns. For all zones but the York River, the number of individual sturgeon detected within each military zone was inversely correlated with its distance from the ocean. In other words, more fish were detected in the ocean than any other zone and as one approached the James River passing through Fort Story zone, Little Creek zone and then into Naval Station Norfolk zone, the number of fish detected gradually reduced (**Figure 9**). The Fort Story zone, Little Creek zone and Naval Station Norfolk zones all receive James River water and are very closely linked in the number and even individual identity of sturgeon detected. In fact, the Little Creek zone is so closely associated with the Naval Station Norfolk zone that annual values of the number of sturgeon detected overlap when plotted. The Naval Station Norfolk zone extends into the Elizabeth

River and become the Elizabeth River zone. Fish that enter this are a much smaller subset of fish that wander up river from Norfolk. Fish become progressively more sedentary as they enter lower salinities and thus more detections are recorded in the Naval Station Norfolk zone than either Fort story or Little Creek zones (**Figure 8**). A trend of increasing sturgeon numbers within more saline environments reflects the species anadromous life history in which more age classes of sturgeon are located in coastal waters but it also is the result of the fact that most fish carrying transmitters have been tagged in locations other than Virginia waters. Therefore, it is a natural consequence of tagging efforts that fish from other systems would be recorded unequally occupying monitored zones. Transients from other systems and adults that are not making spawning runs would be most likely detected in coastal zones during migration, followed by occasional transient trips into lower salinity estuarine waters, followed by much rarer runs farther up fresher tributaries. Reduced mobility within fresher waters upon immigration is likely a consequence of the species need to adjust to its osmotic regulation but may also be due to other factors such as sub-adults feeding or even recovery from recent interactions including tagging.

A closer examination of the York River's detections evidences that the migration corridors and habitat use patterns of this natal population are different from those shown by fish occupying the southern Chesapeake Bay military zones. This biological flexibility is due to the very different environmental and biological attributes inherent to the York River system. The York River is physically very different from the James River. Located much farther north than the James River, the York River's watershed is much smaller. Consequently, its waters are saltier and its fresh water signal greatly reduced. In contrast, the James River has a massive fresh water input into the lower bay. Its polyhaline zone (>18 ppt), the Naval Station Norfolk zone, is greatly reduced and it outflow dominates the physical characteristics along the bay's entire southern shore including the Little Creek and Fort Story zones. In addition, the York River's channel is geologically separate from the James River's joining the Baltimore Channel in the middle of the Bay. These physical properties appear to largely separate the York River system and its spawning migrations from the more southern military zones which are directly linked to each other through their common James River water source. Instead of immigrating along the Chesapeake Bay's southern shore around Cape Henry and through numerous military zones, the York River's adult population predominantly enters along the eastern shore and through the Baltimore Channel and are not detected until they enter the Naval Weapons Station Yorktown and Cheatham Annex zone. The geographical separation and the increased salinity /different physical characteristics of the waters that exit the York River are likely the reason that so few transient fish are attracted to the York River. A fact that stands in stark contrast to the highly varied tagging origin of fish detected farther south and entering the James River.

The Naval Weapons Station Yorktown and Cheatham Annex zone has recorded a steadily increasing number of sturgeon and average number of detections because we have been tagging fish every year in the Pamunkey River, a tributary of the York River, since 2013 when our research discovered a previously unknown reproducing population of native Atlantic sturgeon there (Hager et al. 2014). Equally influential, however, is the fact that most fish tagged were adult males that subsequently exhibited a very high rate of annual return (approximately 75 percent). Tracking efforts of sub-adults tagged through a collaboration with the Virginia Institute of Marine Science (VIMS) also augmented detections slightly. Sub-adults were primarily located in the York River's oligohaline (>0.5-5 ppt) region which extends into the Pamunkey River and evidenced minimal occupation of the naval zone downriver. A steady augmentation of detection parameters of native fish and a dearth of transient fish detections supports our original hypothesis: that a lack of York River detections prior to our Pamunkey River tagging efforts (2007-2011) did not reflect reduced occupancy or habitat importance but a lack of transient fish occupation.

Consistently larger number of detections recorded within the Naval Station Norfolk zone are due to several factors inherent to the zone including receiver coverage, upriver tagging efforts and its geological characteristics. In small part, the zone's expanded receiver coverage bolsters its reception capabilities. This zone has slightly better reception coverage than other zones (**Table 3**). Though it has less coverage than the Elizabeth River, its coverage is 6 percent greater than that which occurs in Fort Story zone and is 8 percent higher than the Little Creek zone. Though its coverage is slightly greater it in no way explains why its total detection number (161,786) was approximately 37 times that recorded in the Elizabeth River zone, 6 times that recorded in the Fort Story zone, and over 3 times the number documented within the Little Creek zone (39,153). **Figure 8,** which conveys the average number of detections per receiver within each zone, illustrates the importance of the Naval Station Norfolk zone to sturgeon very evident. Enlarged average detection numbers do reflect tagging efforts undertaken in the James River upriver of the Naval Station Norfolk zone and the Elizabeth River zone. However, despite the fact that tagging efforts by other investigators in the James River have far exceeded those in the York River system there appears to be less dramatic deviation in the average number of detections and numbers of days with detections within James River zones than one would expect. This data likely reflects the much larger abundance of fish tagged in other regions and the greater age diversity of tagged fish occupying the Naval Station Norfolk zone.

The increased detection rate recorded within the Naval Station Norfolk zone of temporary resident and transient sturgeon makes perfect sense from a geological and biological perspective. Naval Station Norfolk's location at the mouth of the James River compels every fish migrating or transiting through the James River to pass through its zone. The James River historically contained a very 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 sturgeon in the Chesapeake Bay. The mouth of the James River historically referred to as the Hampton Roads, where the Naval Station Norfolk is located, contains a naturally deep, low-salinity harbor with easy access to deep water channels. The same physical traits that make this river's estuary/mouth exceptionally suitable as a port result in its selection and active use by sturgeon. In addition, these physical characteristics result in diverse benthic infauna indicated by its marked availability of bivalves (Mann et al. 2005). This prolific benthic community and its associated food sources likely attract sub-adult Atlantic sturgeon due to an increased availability of food resources.

Initial assessment of occupation patterns within the Naval Station Norfolk zone suggests that sturgeon of different life stages vary in the way they occupy the zone. The majority of fish detected occupy the zone for short duration often during migration periods; some occupy it for extended time remaining within receiver detection for over a month. Interestingly, the final destination of those migrating through is highly varied. Fish do not simply stage here prior to migrations into or out of the James River though this is most common. Adults that ultimately will end up in much more northern bay tributaries to spawn or even return to the sea and continue up the coast to spawn in other DPS regions can be found to temporarily occupy the zone during spring and early summer. Patterns of more sedentary fish that may congregate within the zone are varied and less easily interpreted. Better data on the genetic origin and age structure of these more resident fish would help explain why these patterns of occupation are so different. Several very young sub-adults from Delaware were recorded occupying the zone for an extended period of time, which suggests that the zone is being used as a sub-adult feeding ground. Recent sub-adult detections originating from fish tagged in the middle James River in 2015 may support this assertion. They also congregated within the zone for an extended period. However, since these fish also recently underwent surgery this occupation may not illustrate normal behavior and instead may be

due to their recovering from tagging. 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 (**Figure 8**) and number of fish recorded (**Figure 9**) in the Elizabeth River reflect its reduced use as habitat. This hypothesis is supported by the fact that so many fish are detected within the Naval Station Norfolk zone and so few enter the Elizabeth River. In fact, since a large number of the fish that enter the Elizabeth River are adults previously tagged far upriver in the James River recorded entering the Elizabeth River prior to the following spawning season, these fish may simply be exploring this down river fresh water source by mistake.

Intra-annual variations in number of detections within the Little Creek zone suggest inconsistent seasonal behaviors. 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 being used as a staging area where fish would reside sometimes for extended periods prior to entering the James River. This assumption seemed logical due to the zone's geographic position just south of the James River's mouth. However, fish availability peaked much earlier in April 2015 and patterns of augmentation across the three detection parameters did not persist in early summer. Instead, detection parameters indicated that fish were not holding in the area, as they had in 2013 and 2014, but were instead passing through it to stage elsewhere, potentially in the Naval Base Norfolk zone. Fish detections in late summer were also incongruent across years. In 2014, a reduced number of fish occupied the Thimble Shoals Channel sites (TS 9 and 11) on the zone's northern border during the heat of summer. These fish demonstrated sedentary behavior and vastly increased the number of detections in channel sites within the zone. Sturgeon did not take up residence in channel sites within the Little Creek zone in 2013 or 2015, but demonstrated more transient behavior. In contrast, preferential residence within the Baltimore Channel was consistent during the same period over the last two years, with the preferred location shifting downstream from B15 towards B9 in 2015.

Sturgeon are known to prefer deeper habitats (Moser and Ross 1995, Savoy and Pacileo 2003) but it is unclear why channel sites at the mouth of the Bay are preferentially selected by transient sturgeon of such varied origin or why these fish exhibited such sedentary behavior. Similar site selection and behavior by sub-adults and adults have been recorded in tributaries during warm-water periods and researchers have suggested it is associated with increasing water temperature (Moser and Ross, 1995). This behavior was documented in the James River by sub-adults but not adults (Hager, 2011), when surface water temperatures neared or even slightly exceeded the 27°C physiological temperature threshold proposed by NItlischek and Secor (2005). Deep channels at the mouth of estuaries are recognized by the Atlantic States Marine Fisheries Commission (2009) as a habitat of particular concern due to their critical provision of migration corridors and their high level of anthropogenic alteration. Inter-estuarine migrations have been extensively documented (Welsh et al. 2002; Savoy and Pacileo 2003), as have the value of such non-natal habitats for growth (Dovel and Berggren 1983, Stevenson 1997), provision of important nursery areas, and thermal and salinity refuges (Moser and Ross, 1995). Sub-adults and adults within the Bay's tributaries are recorded at varied times preferentially occupying waters that are fresher, higher in dissolved oxygen, and/or containing preferred temperature (Hager 2011).

Other previously overlooked factors may also motivate differences in inter-annual habitat selection. Are fish being displaced from the Little Creek zone and alternatively using the Baltimore Channel or are these simply normal patterns of variation due to fish origin, age composition, or other biological or physical factors not yet considered? Little Creek and Naval Base Norfolk zones are inherently tied due to

their geographic positions. Little Creek is located just south of the mouth of the James River thus the physical characteristics of Little Creek's marine environment are directly dependent upon the James River. In the York River, adult sturgeon immigration patterns provide a means of gradually decreasing salinity and thus allowing osmotic adjustment. If the Little Creek zone is being used as a staging ground for the James River its suitability likely linked to its salinity intrinsically tied to the river's seasonally varied flow. In dry years, sturgeon might need to move further up river into Naval Station Norfolk to find the preferred lower salinity. In addition, the Little Creek zone is much shallower and harder due to its sandy bottom and thus detections may be occurring at greater distances than within deeper zones with softer benthos. For whatever reasons, detection data suggest that sturgeon within the Little Creek zone demonstrate less consistent patterns of behavior than those in other zones. A great deal more data and analysis will be necessary to determine if seasonal variations in detections between years are due to normal behavior or if anthropogenic activities are resulting in temporal alterations.

Migration through a zone or region is indicated by higher numbers of individual fish per receiver per month with a congruently lower number of total detections per fish. The number of detection days may be reduced if the migration is of short duration or, if well-dispersed, the migration may occur over many days and thus the total number of detection days will not be drastically reduced. Similarities between detection patterns within the Fort Story and Dam Neck Naval Firing Range Surrogate zone suggest increased use by transient fish at both sites. The detection pattern of sturgeon within the Dam Neck Surrogate Firing Range zone typifies that of dispersed migration. Commonality in patterns of use of these zones is likely due to their geographic locations. Fort Story is located along a primary channel leading to the largest estuary in North America and the James River, the largest Virginia River known to contain the Bay's largest historical population. The Dam Neck Firing Range Surrogate zone is located just north of overwintering habitat for numerous Atlantic sturgeon stocks (Hager 2011; Wilson Laney, USFWS, personal communication). The fact that so many of the tagged fish detected migrating up the coast (Dam Neck Naval Firing Range Surrogate zone) subsequently entered the Chesapeake Bay specifically the Fort Story, Little Creek and Norfolk Naval Base zones supports the assertion that Virginia's estuaries provide the species with important habitats that may be crucial to the species.

It has long been recognized that tracking can identify patterns of behavior. Migration can be delineated and characteristics defined through repetitive observations. Upon immigration, offshore sites first record increases in fish number, followed progressively by further inshore stations, lower river sites, and finally spawning reaches. Sequential detections of fish within zones thus illustrate the power of the array to describe the temporal and spatial attributes of migrations. However, over time these repeated measurements also provide an opportunity to use the array's historic data as a means to predict future parameters of interest, such as the number of fish that will be within a given zone and when they will most likely be there. The array currently supplies the Maryland Division of Natural Resources with striped bass tracking data so that they can tailor their harvest dates and quotas to achieve improved management. Even with only three years of data, correlations between detection parameters within sequential zones are beginning to suggest that detection parameters can supply the data necessary to calculate the relative probability of how many fish will be present in a given zone based upon another zone's recent detections. It appears that such patterns may eventually even provide a means of predicting the actual fish number within a zone temporally. A total coastal population must first be calculated to do this and numerous scientists are working on providing such an estimate. Given our current data, we already have the ability to calculate such data for the Naval Weapons Station Yorktown and Cheatham Annex zone based upon our Pamunkey River adult population estimates.

The array is very young and its current dataset far too limited to predict all of its future applications. The array must first be deployed for long enough to accurately document the behavior of this highly migratory, long-lived species with an increasingly complex life history—a life history that this very research is helping to define. Once the stocks' life histories are properly described and populations are estimated, we will be able to estimate zone-specific populations over time. It will take many more years of similar efforts to design effective tools for the efficient protection of the species within the Chesapeake Bay.

# 6. DEPLOYMENT CHALLENGES

Our first-generation offshore receiver deployment method was an improvement 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 Chesapeake Bay Bridge-Tunnel. 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. Though no receivers were ever lost using this approach, receivers failed due to suspected vibration and buoy impact.

Since 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 very 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, 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 been working well. However, no matter how we deploy these units, some breakage and loss will occur, especially in offshore environments.

# 7. ACKNOWLEDGEMENTS

We would like to thank U.S. Fleet Forces Command and the Commander, Navy Region Mid-Atlantic for funding the work. 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, NOAA, USFWS, and Jason Kahn for the use of their equipment, as well as the private citizens who donated their private docks and time to assist: (b) (6)(b) (6)(b) (6); (b) (6) (b) (6) (b) (6) (b) (6) and (b) (6) (b) (6) We also want to thank Carter Watterson (United States Navy), Jason Kahn (West Virginia University and NOAA) as well as Jay Russo, Craig Marcuson, Tracy Massey and Kirk Moore of our crew for the work and specimen33 collection. They make this research possible. All sturgeon research was conducted under a federal collection permit managed thanks to Albert Spells (USFWS, NOAA permit 16547-01), as well as Virginia Department of Game and Inland Fish and Virginia Marine Resource permits.

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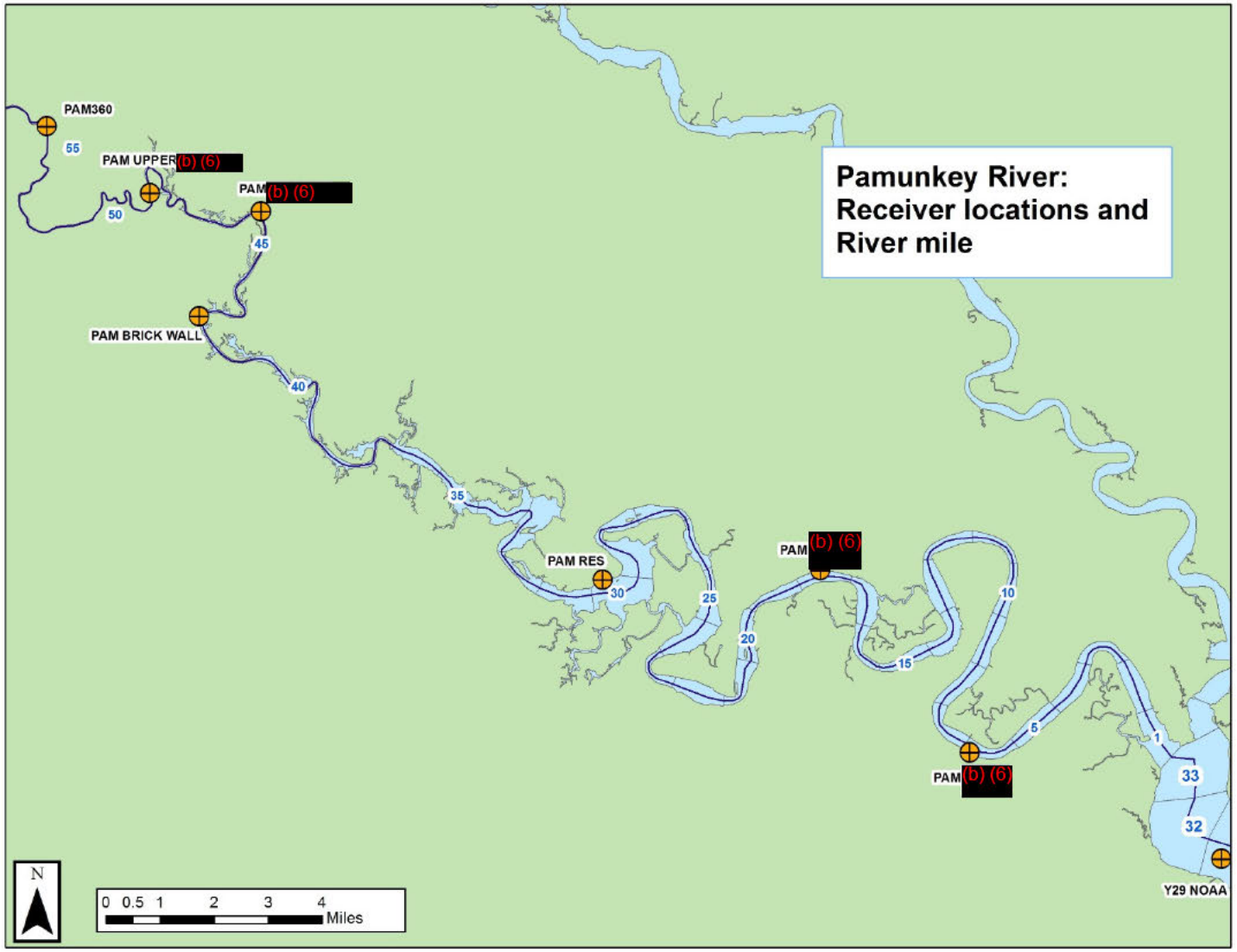
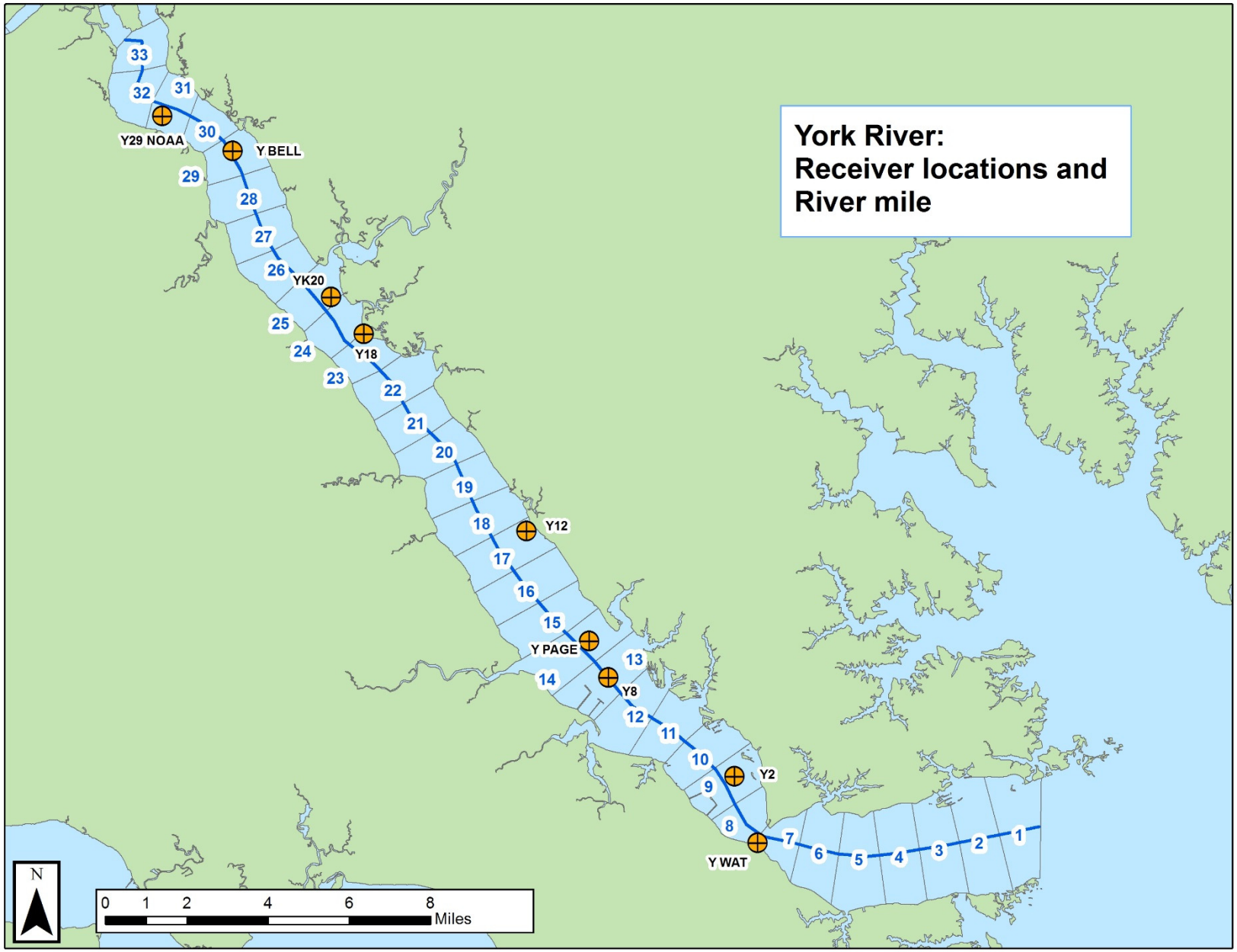
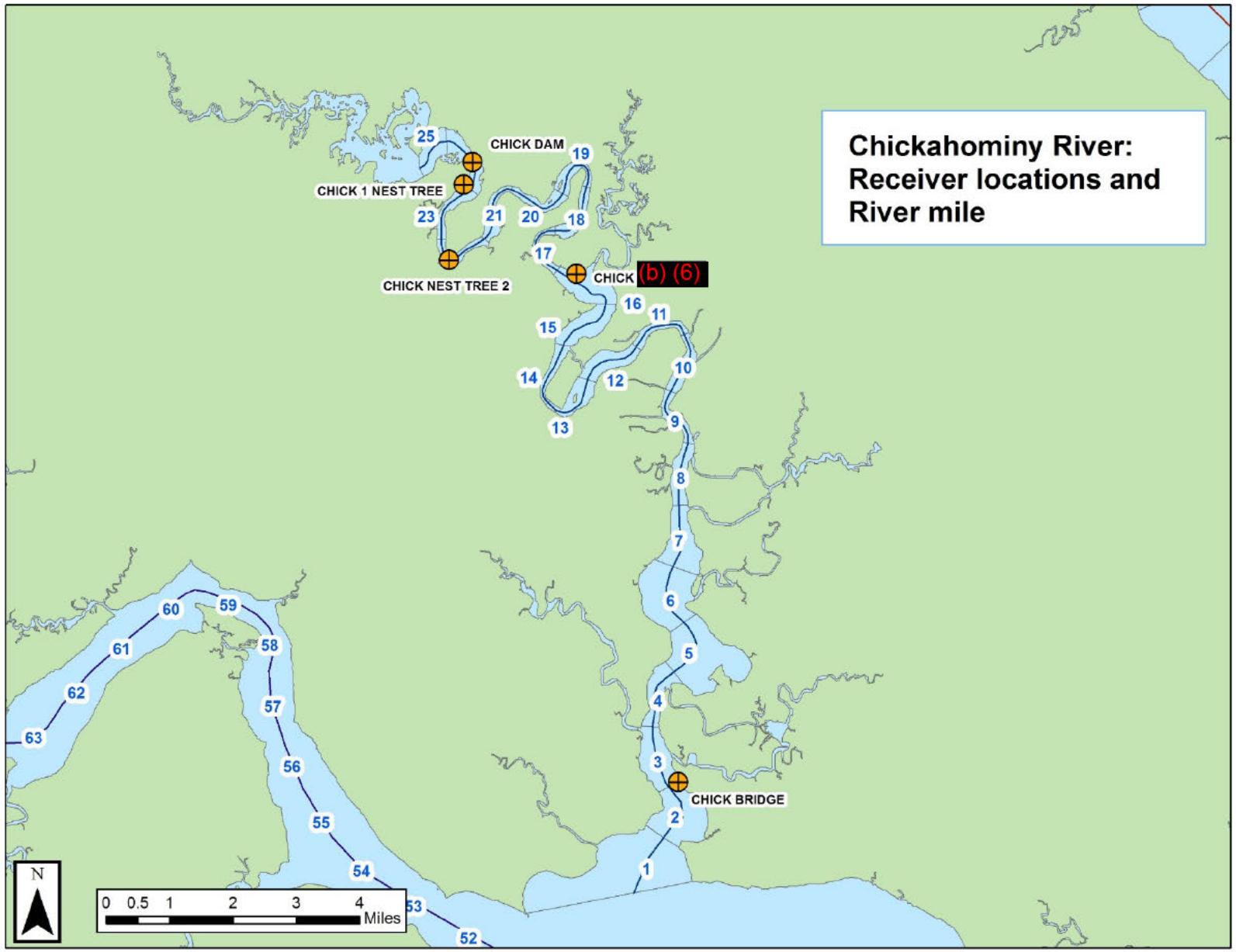
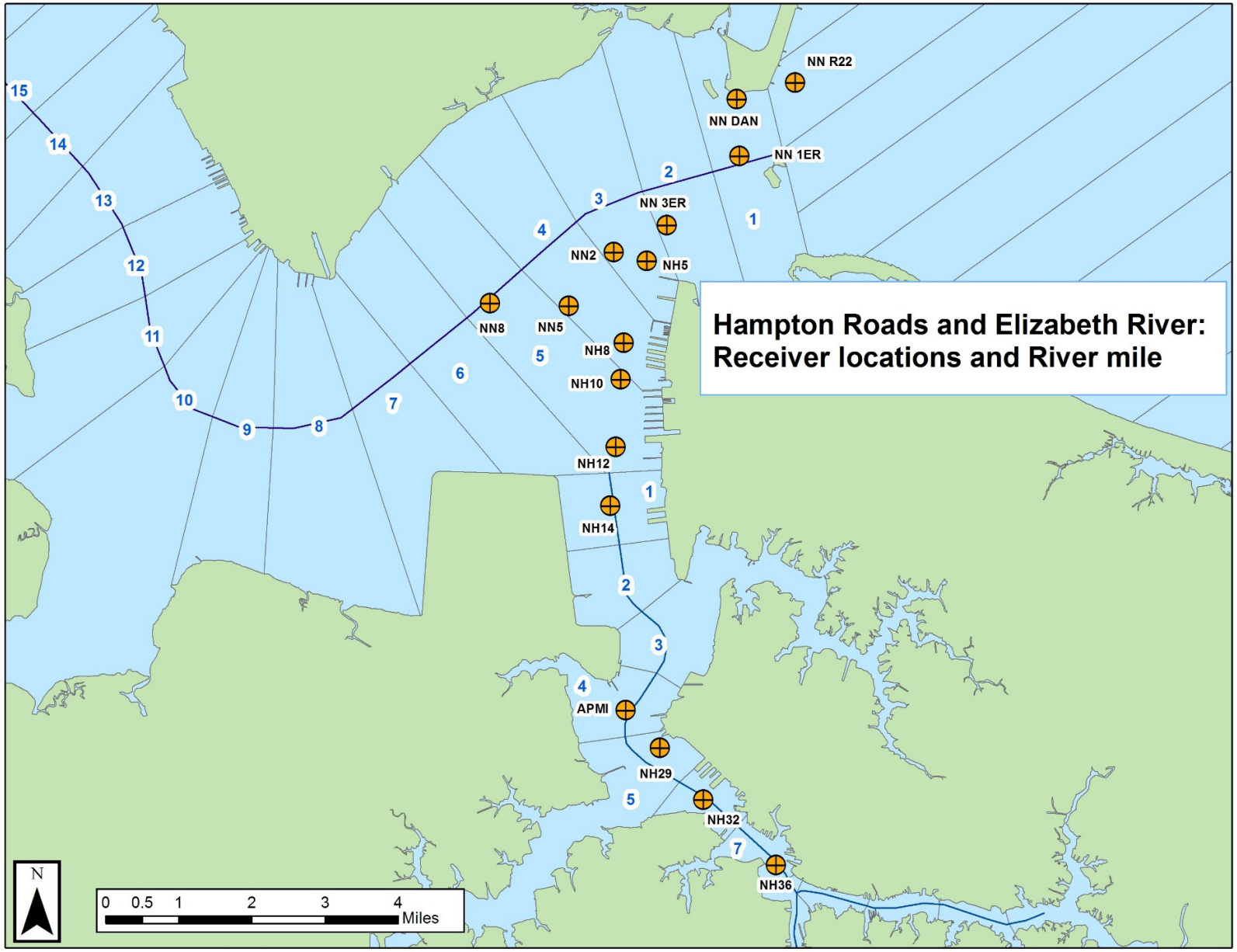
# 9. MAP APPENDICES

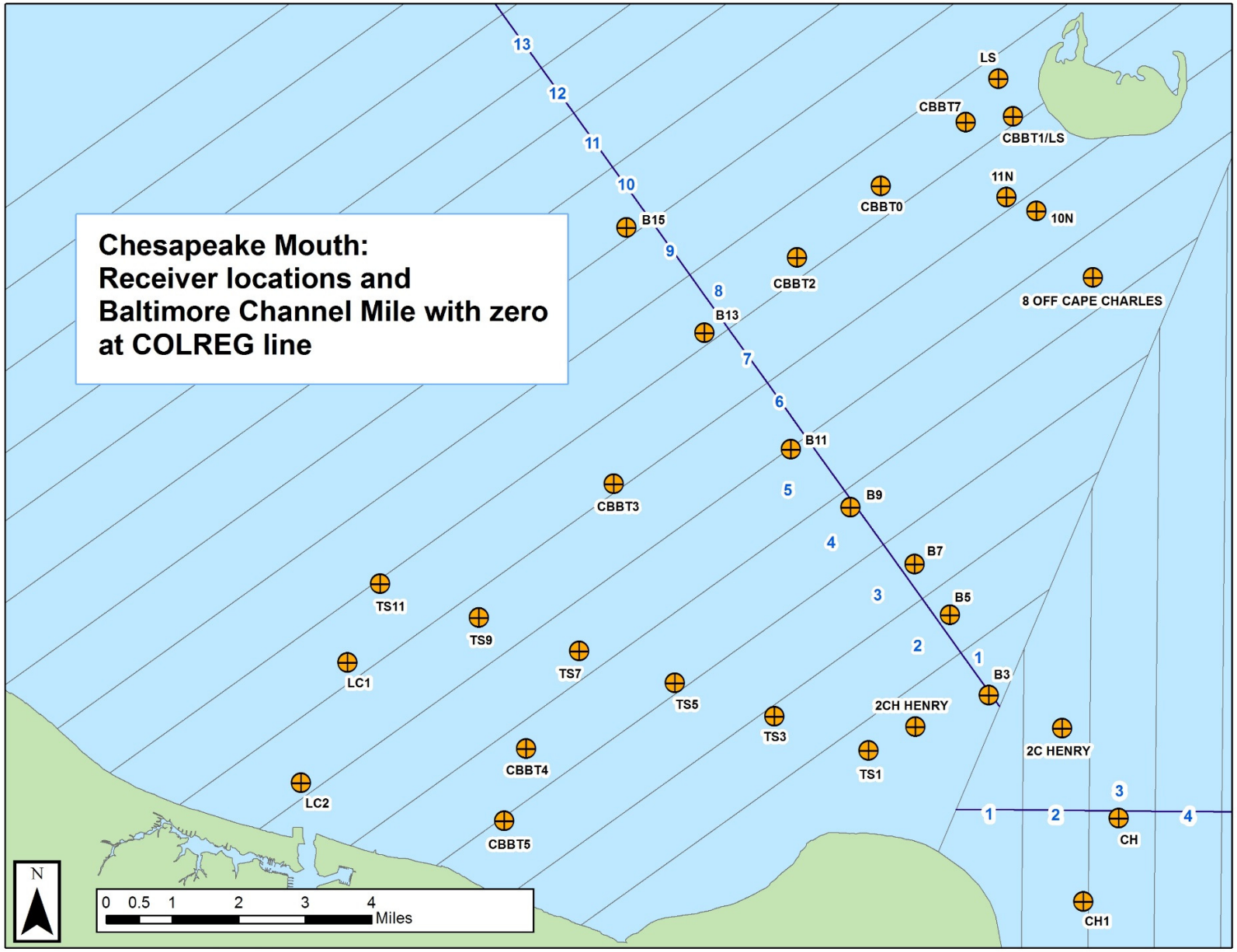
## 9.1 APPENDIX 4.2 A: RECEIVER LOCATIONS AND MILE DESIGNATIONS FOR EACH STUDY REGION

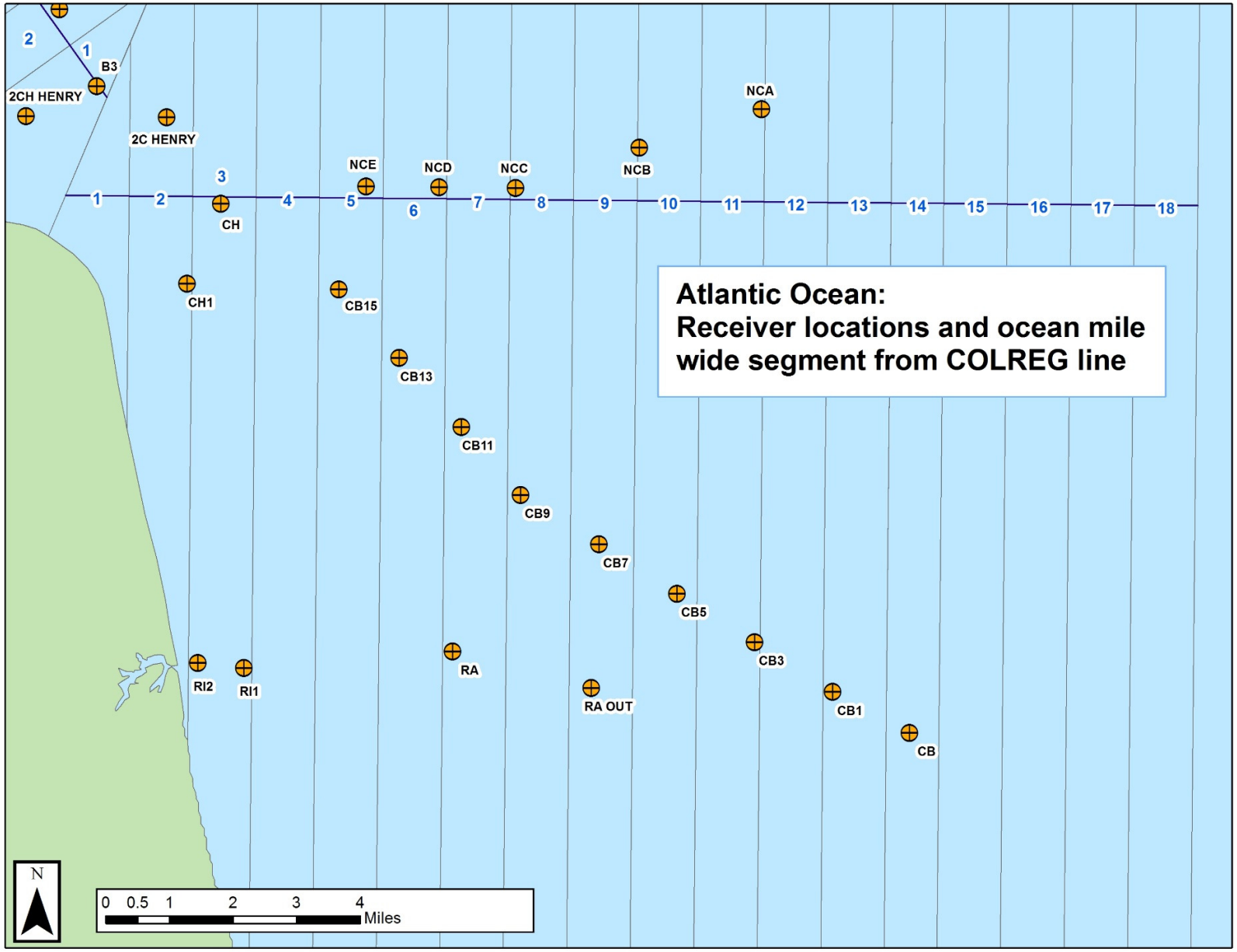



York River:
Receiver locations and
River mile
Y29 NOAA
Y BELL
YK20
Y18
Y12
Y PAGE
Y8
Y2
Y WAT
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
N
0 1 2 4 6 8
Miles

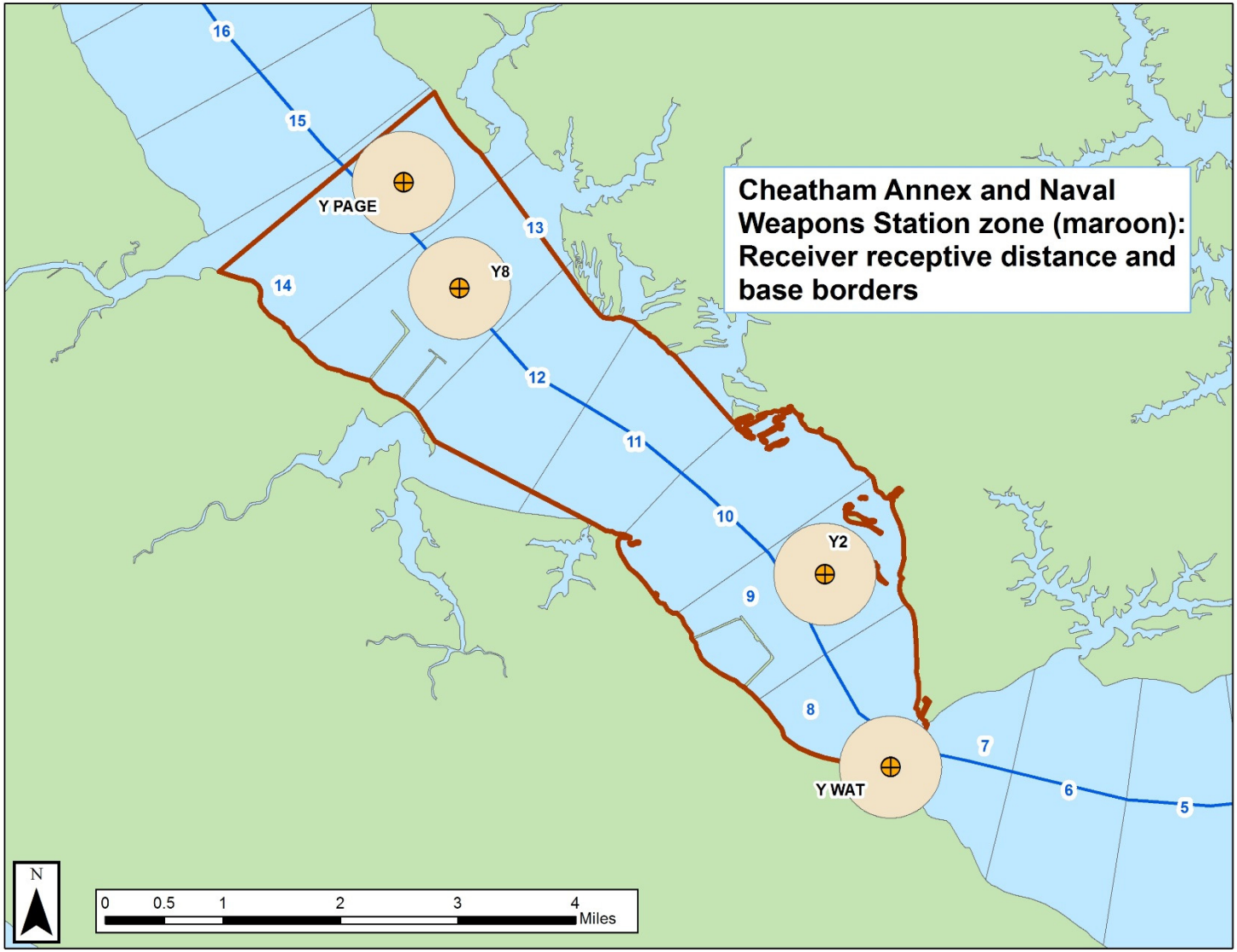

Chickahominy River:
Receiver locations and
River mile
CHICK DAM
CHICK 1 NEST TREE
CHICK NEST TREE 2
CHICK (b) (6)
CHICK BRIDGE
25
19
23
21
20
18
17
16
11
15
10
14
12
13
9
8
7
6
5
4
3
2
1
60
59
61
58
62
57
63
56
55
54
53
52
N
0 0.5 1 2 3 4
Miles

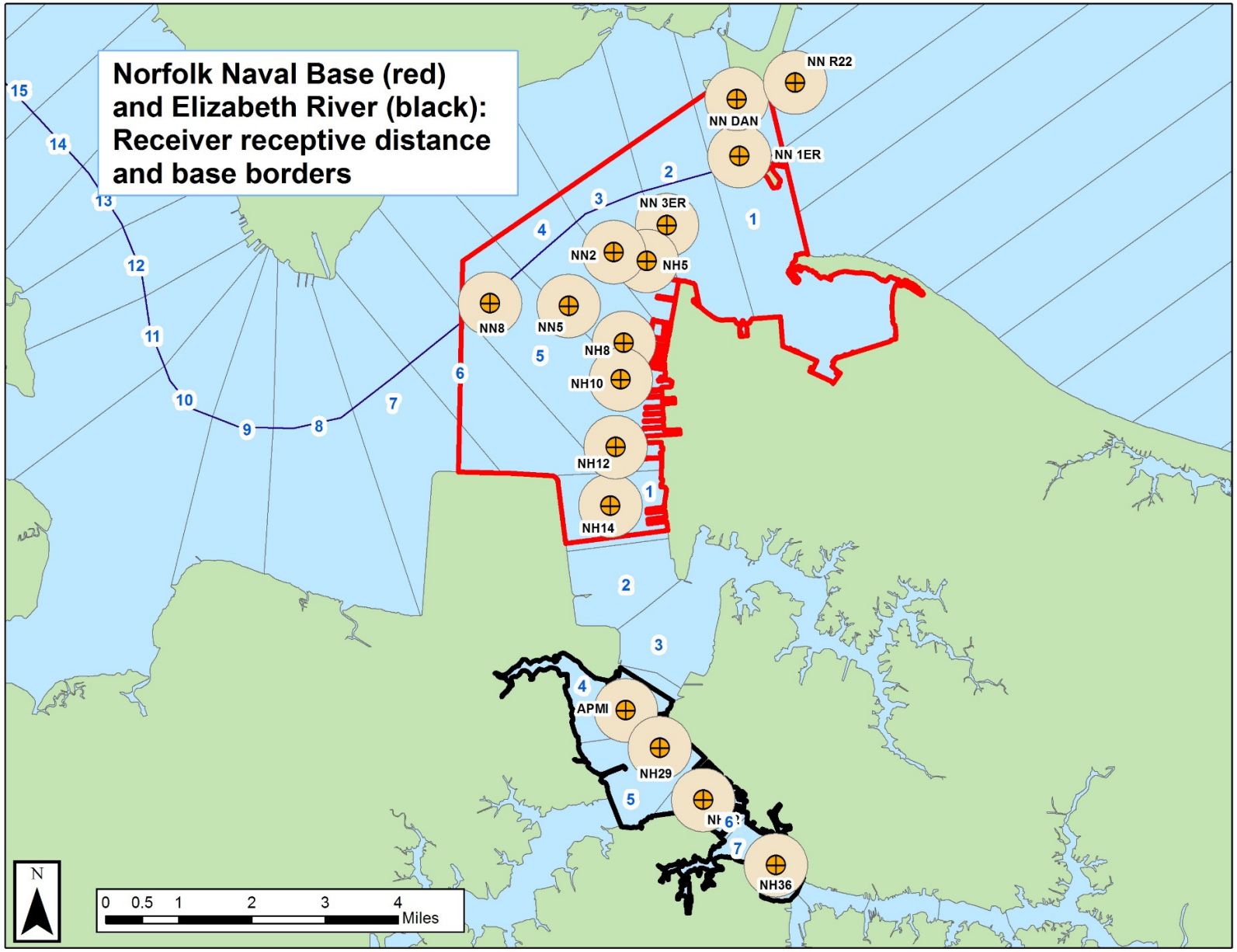

Hampton Roads and Elizabeth River:
Receiver locations and River mile
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
N
0 0.5 1 2 3 4
Miles

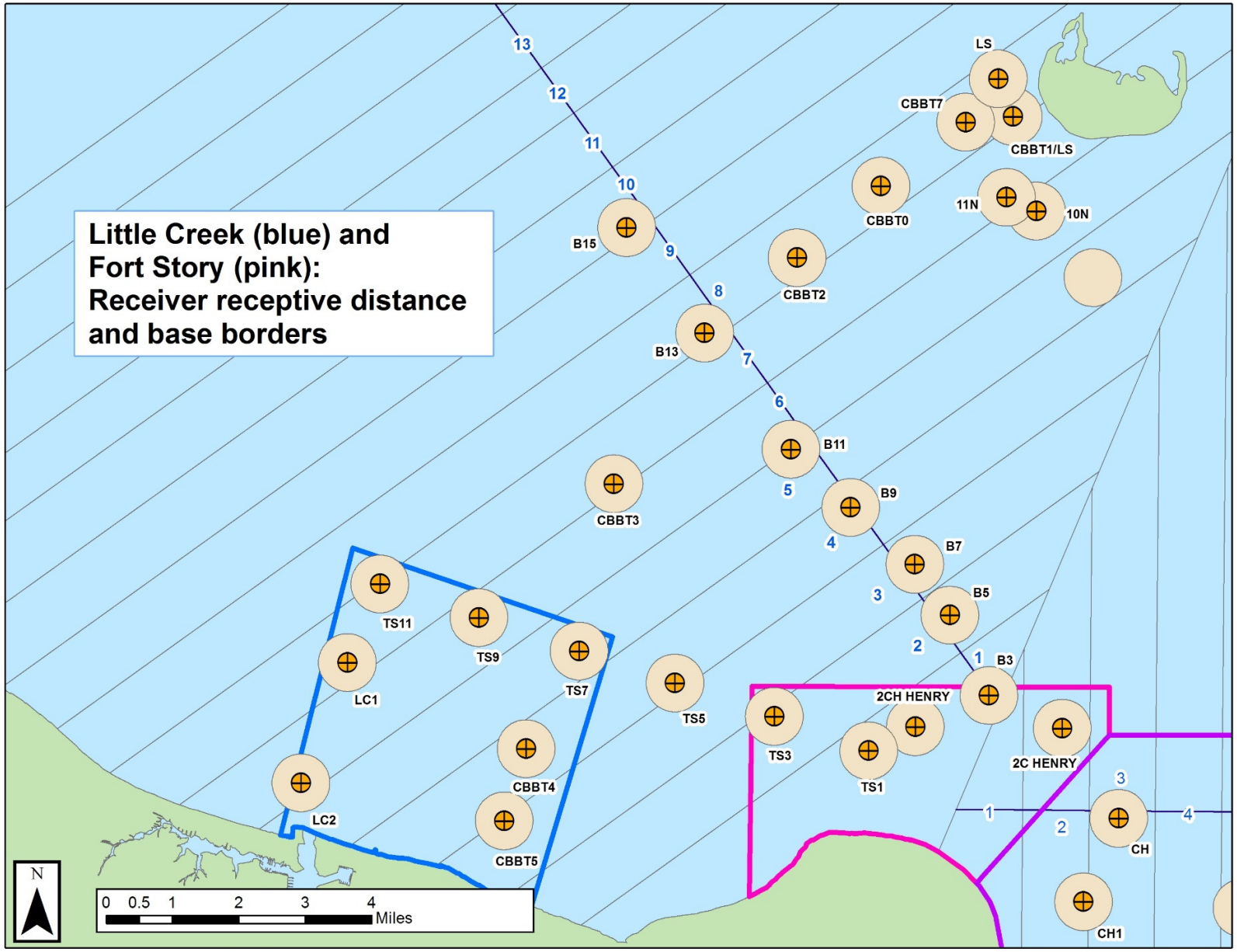

Chesapeake Mouth:
Receiver locations and
Baltimore Channel Mile with zero
at COLREG line
13
12
11
10
9
8
7
6
5
4
3
2
1
LS
CBBT7
CBBT1/LS
11N
10N
CBBT0
B15
CBBT2
8 OFF CAPE CHARLES
B13
B11
CBBT3
B9
B7
B5
B3
TS11
TS9
TS7
TS5
TS3
TS1
LC1
LC2
CBBT4
CBBT5
2CH HENRY
2C HENRY
CH
CH1
N
0 0.5 1 2 3 4
Miles

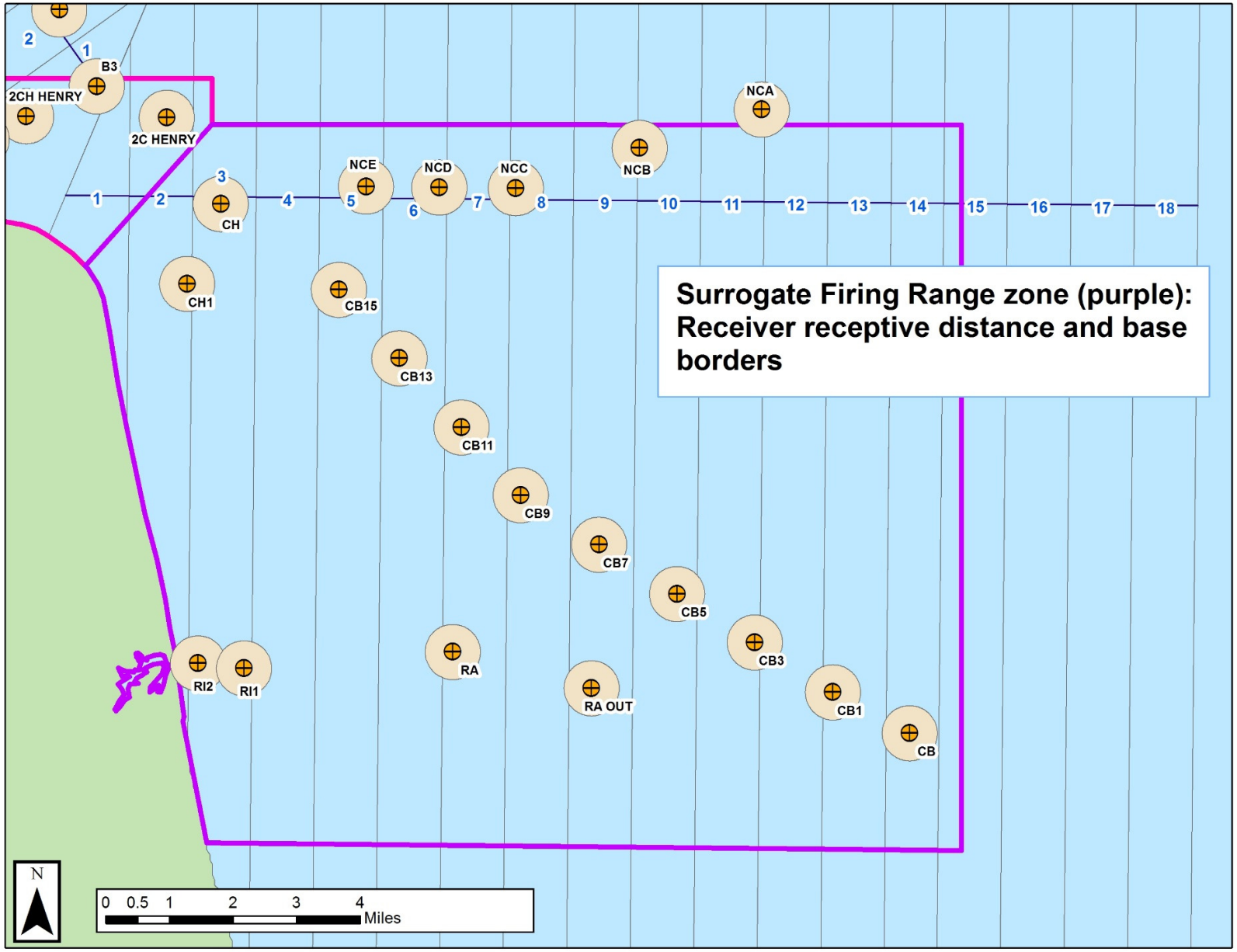

Atlantic Ocean:
Receiver locations and ocean mile wide segment from COLREG line
2
1
B3
2CH HENRY
2C HENRY
3
CH
NCE
NCD
NCC
NCB
NCA
1
2
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
N
0 0.5 1 2 3 4
Miles

## 9.2 APPENDIX 4.2 B: RECEIVER LOCATIONS AND RECEPTIVE DISTANCES WITHIN ZONES

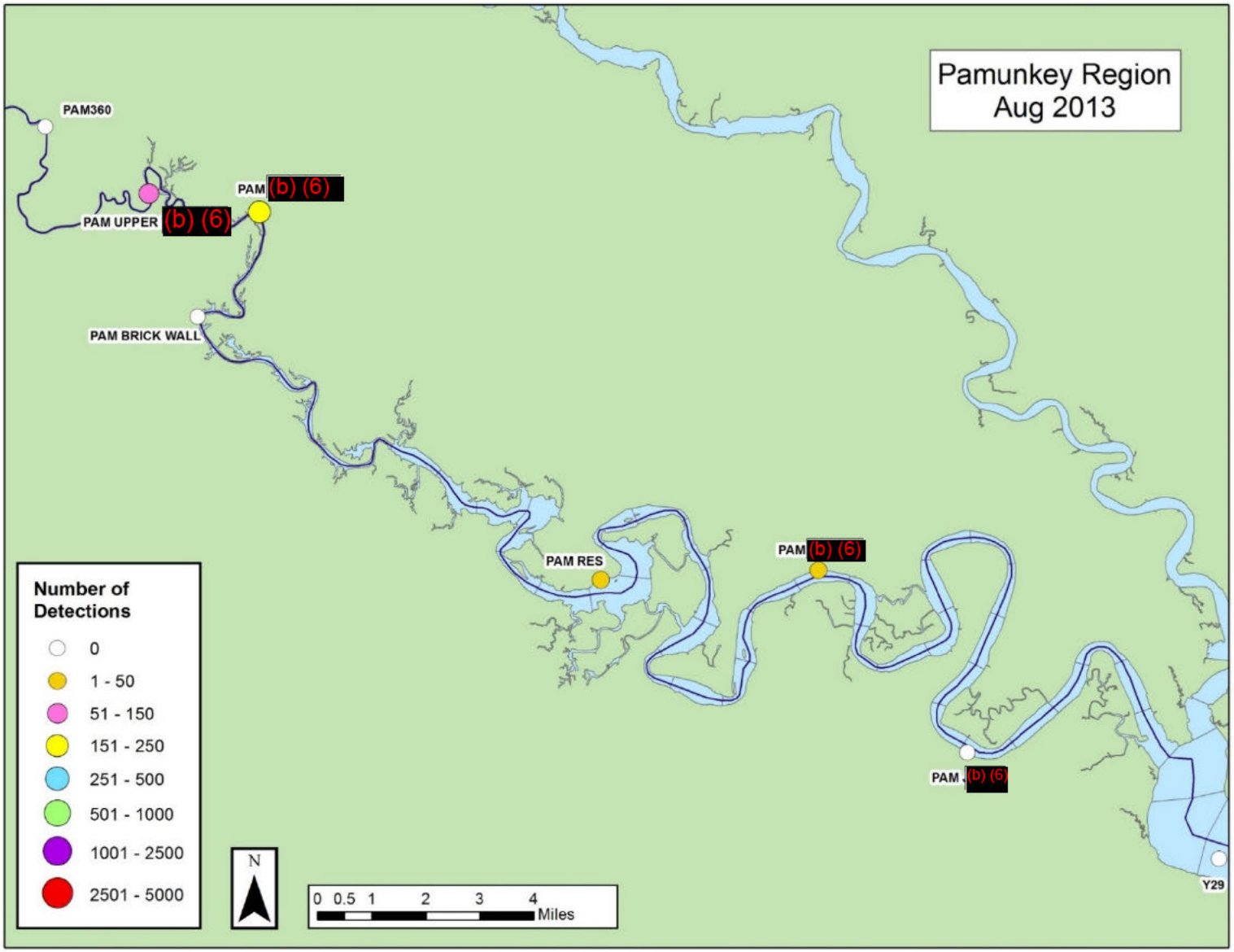


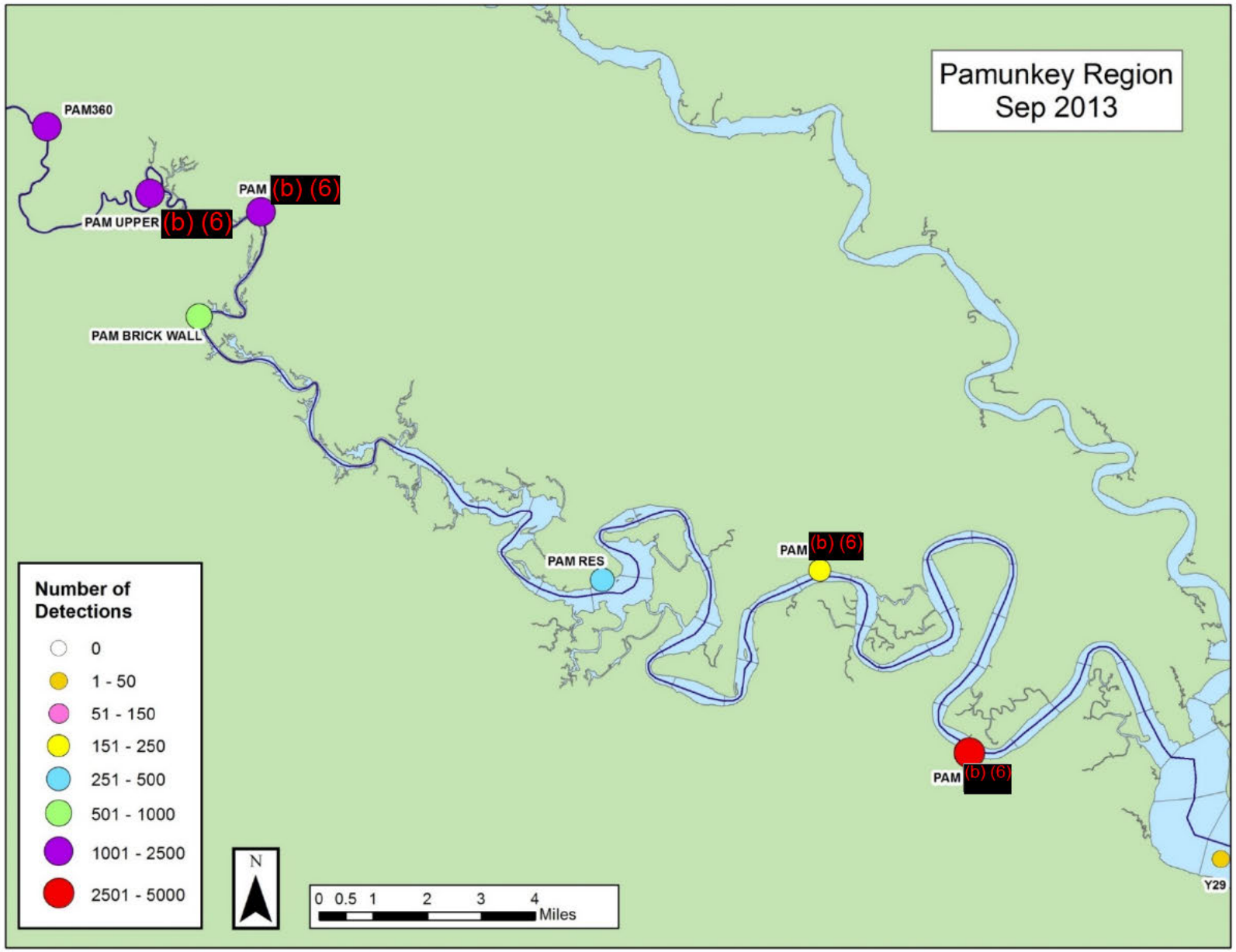

Norfolk Naval Base (red) and Elizabeth River (black): Receiver receptive distance and base borders
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH36
N
0 0.5 1 2 3 4
Miles

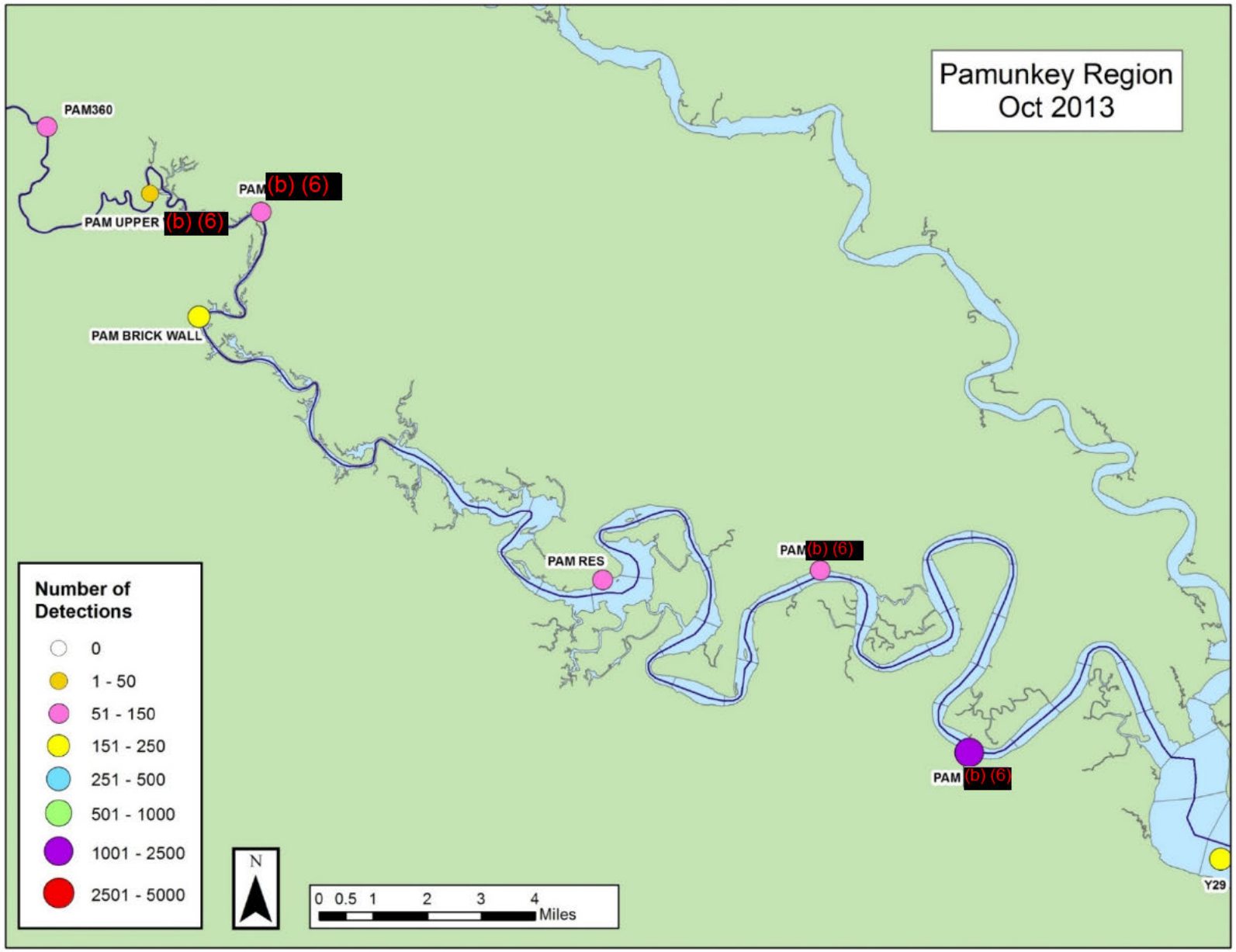

Little Creek (blue) and
Fort Story (pink):
Receiver receptive distance
and base borders
13
12
11
10
9
8
7
6
5
4
3
2
1
LS
CBBT7
CBBT1/LS
CBBT0
11N
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
B3
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
LC2
CBBT4
CBBT5
CH
CH1
N
0 0.5 1 2 3 4
Miles

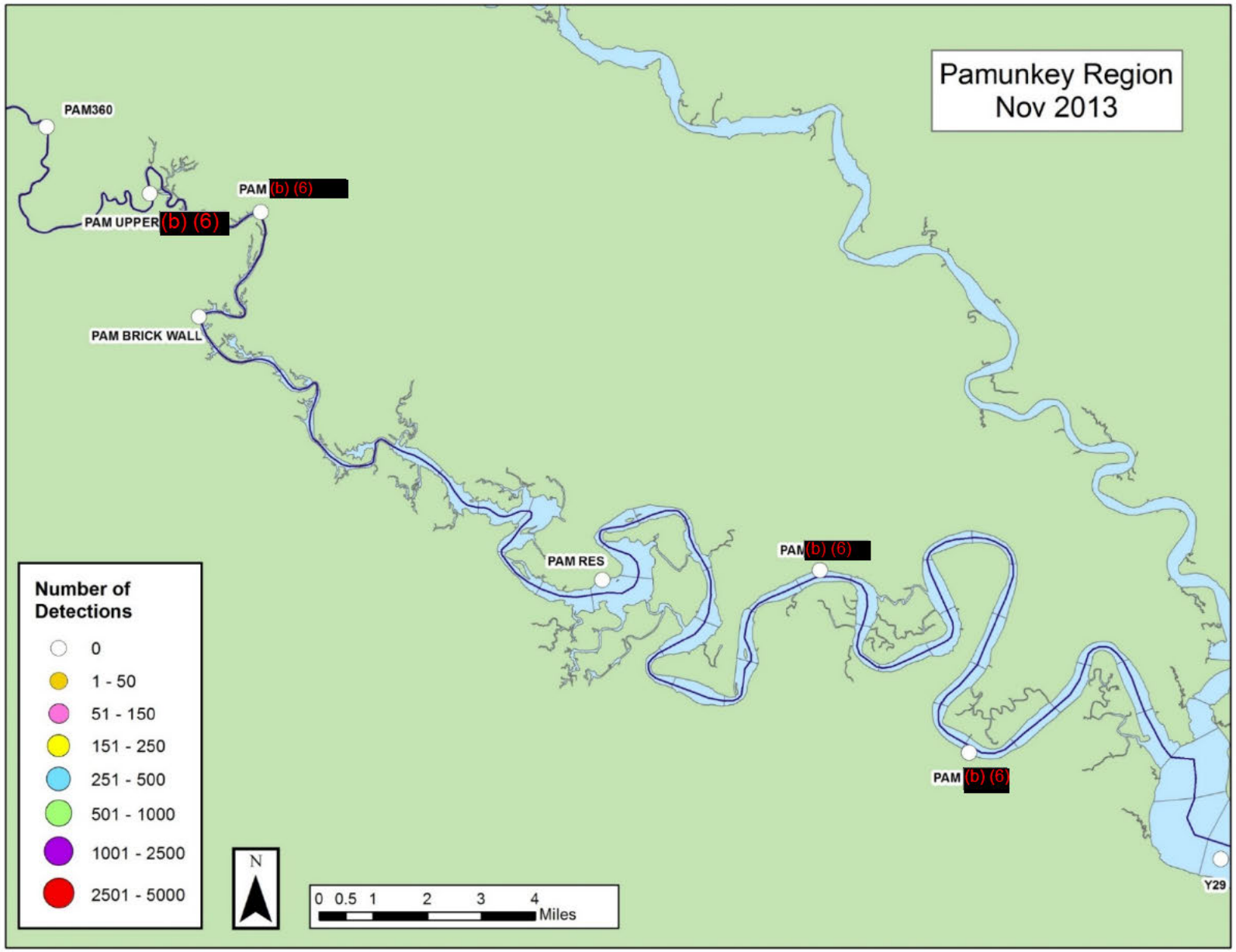

Surrogate Firing Range zone (purple): Receiver receptive distance and base borders
2CH HENRY
B3
2C HENRY
CH
CH1
NCE
NCD
NCC
NCB
NCA
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
N
0 0.5 1 2 3 4
Miles

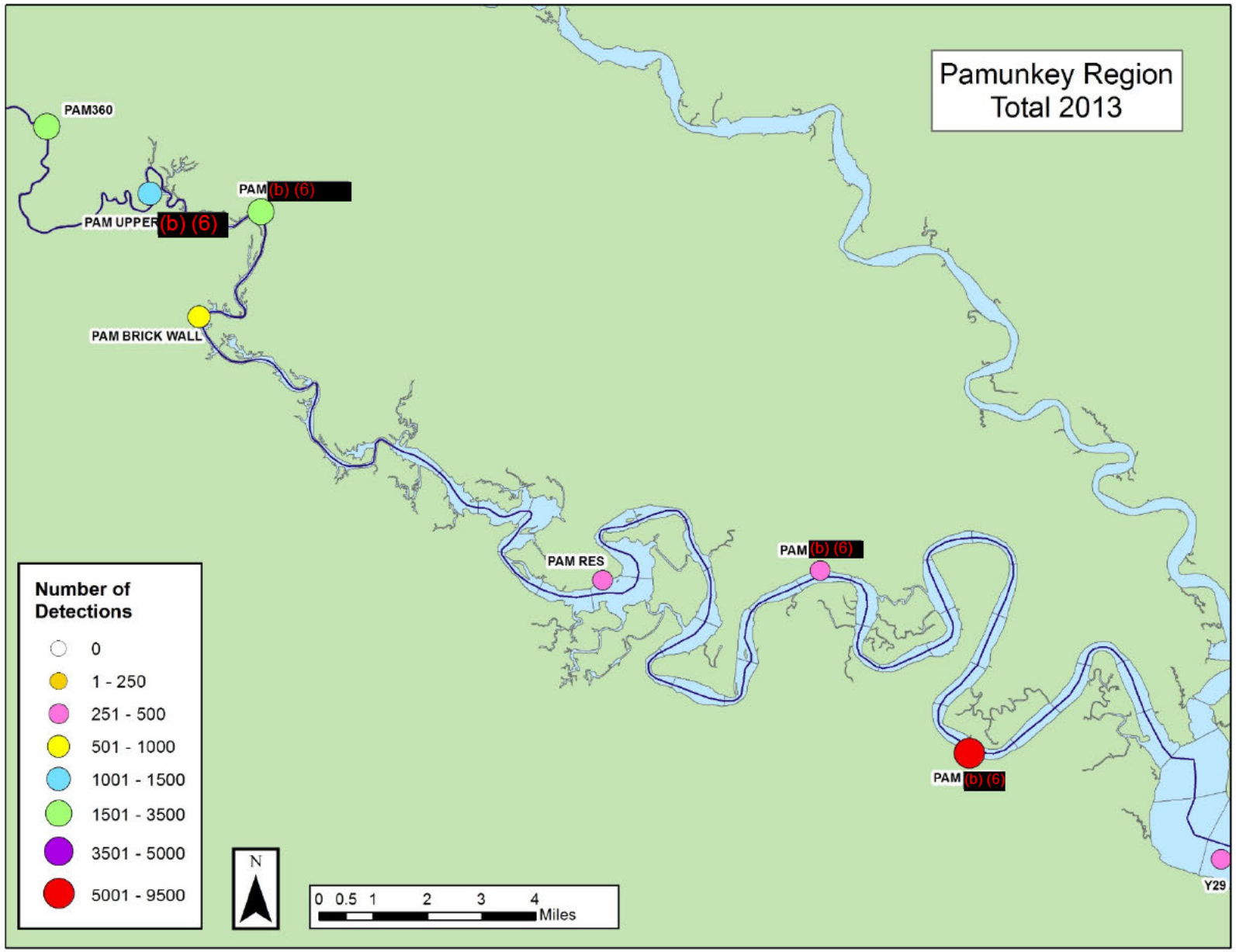
## 9.3 Appendix 4.4.1: Detections of sonic-tagged Atlantic sturgeon in the Pamunkey River Region, by month, year, and overall

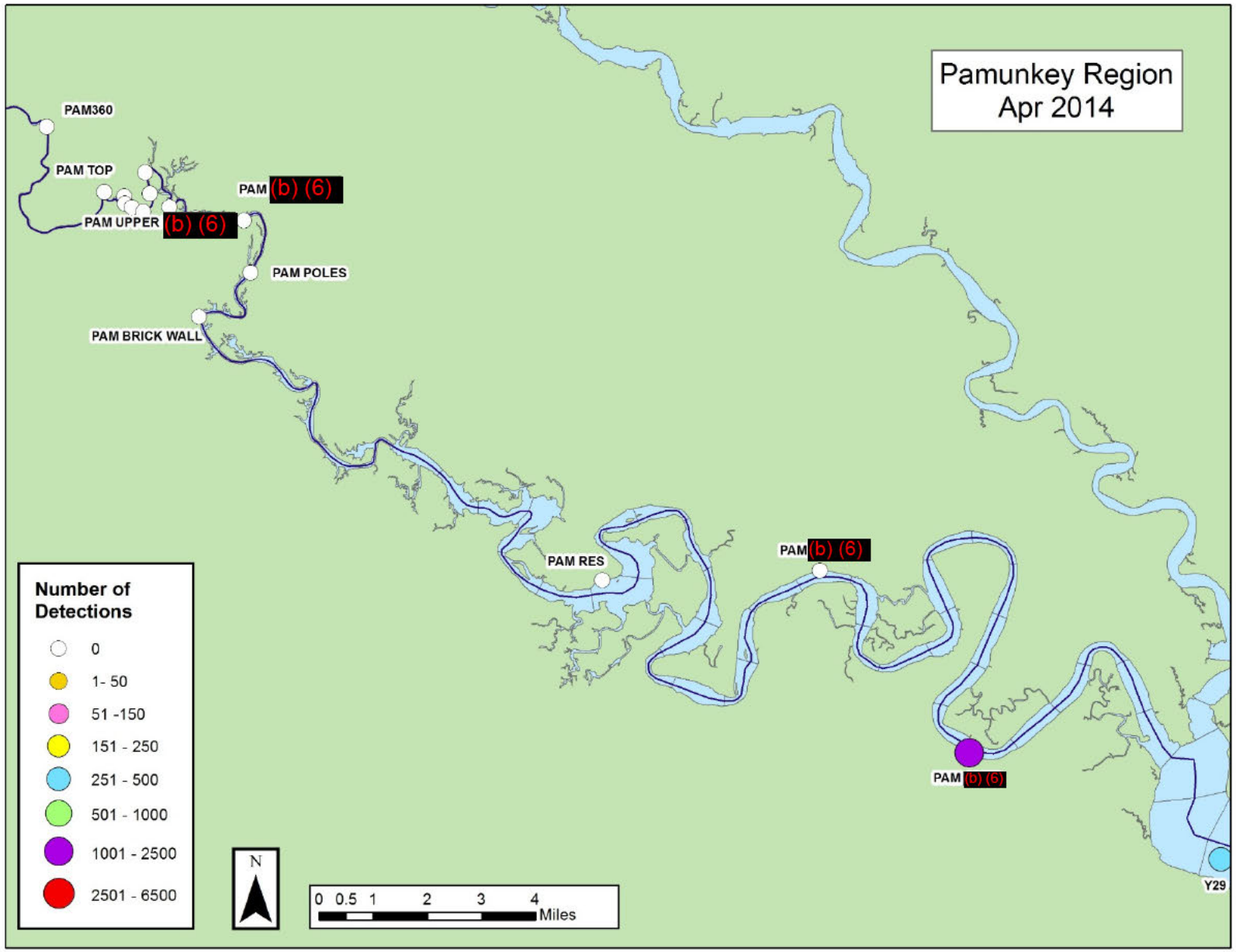


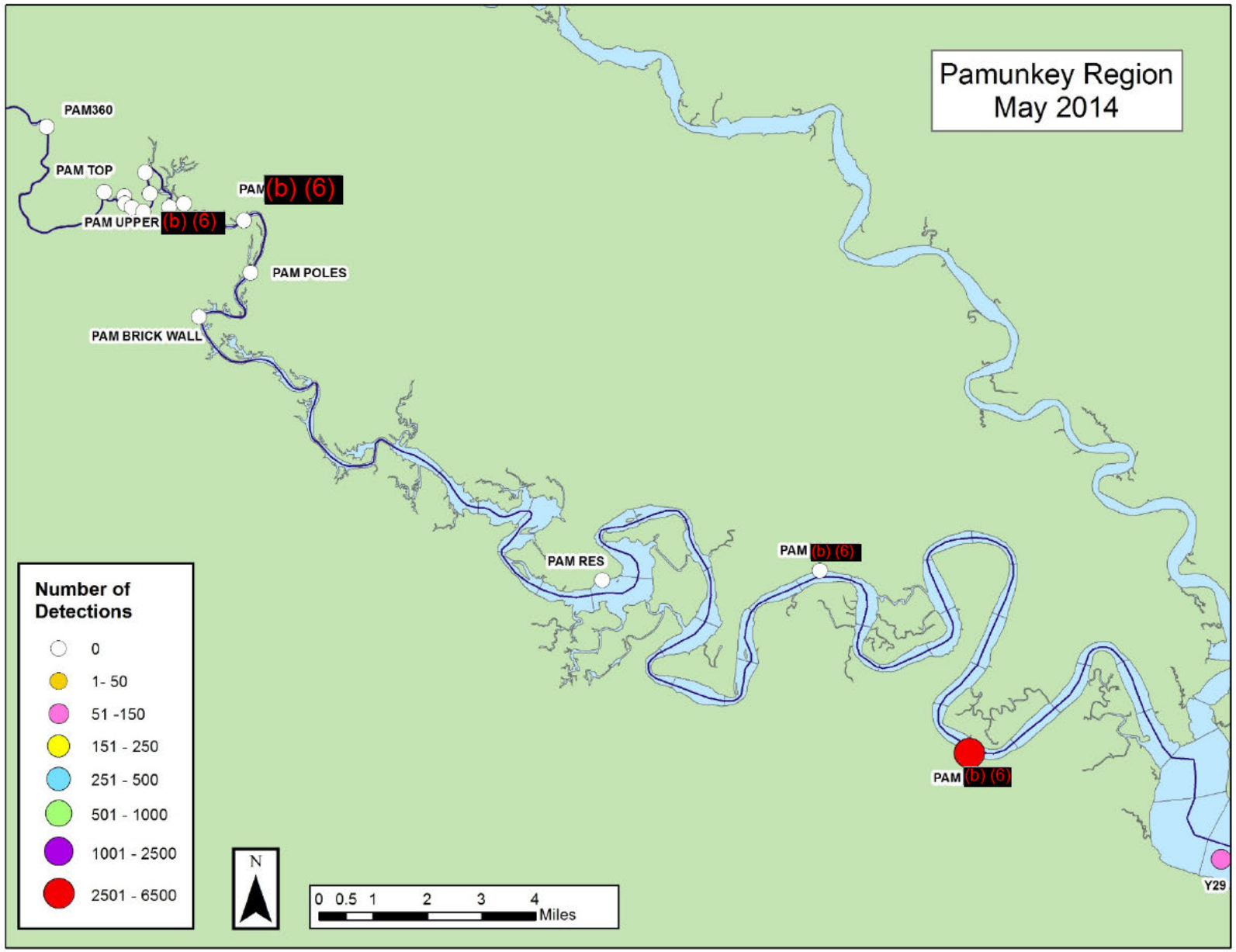

Pamunkey Region
Sep 2013
PAM360
PAM (b) (6)
PAM UPPER (b) (6)
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y29
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

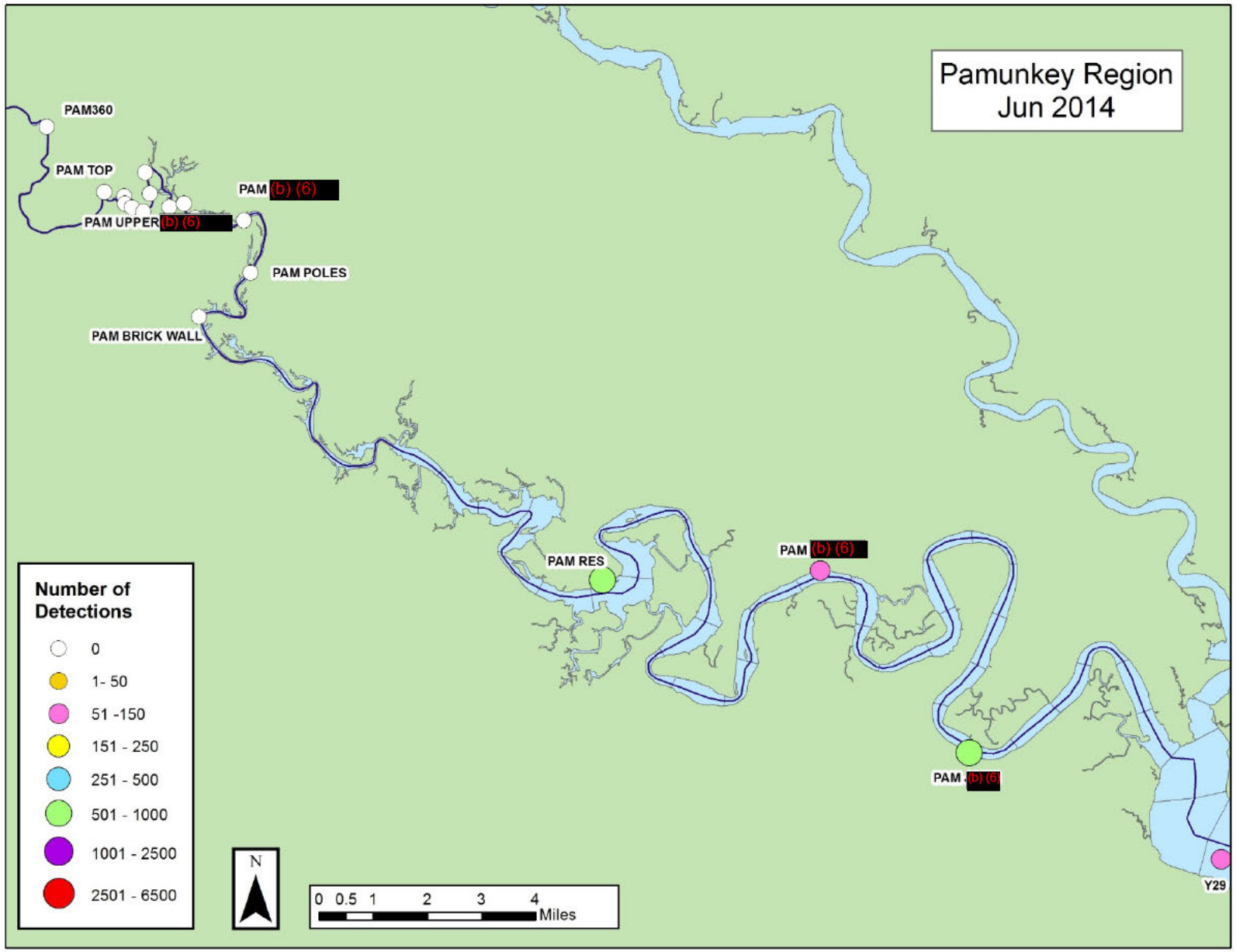

Pamunkey Region
Oct 2013
PAM360
PAM (b) (6)
PAM UPPER (b) (6)
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y29
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

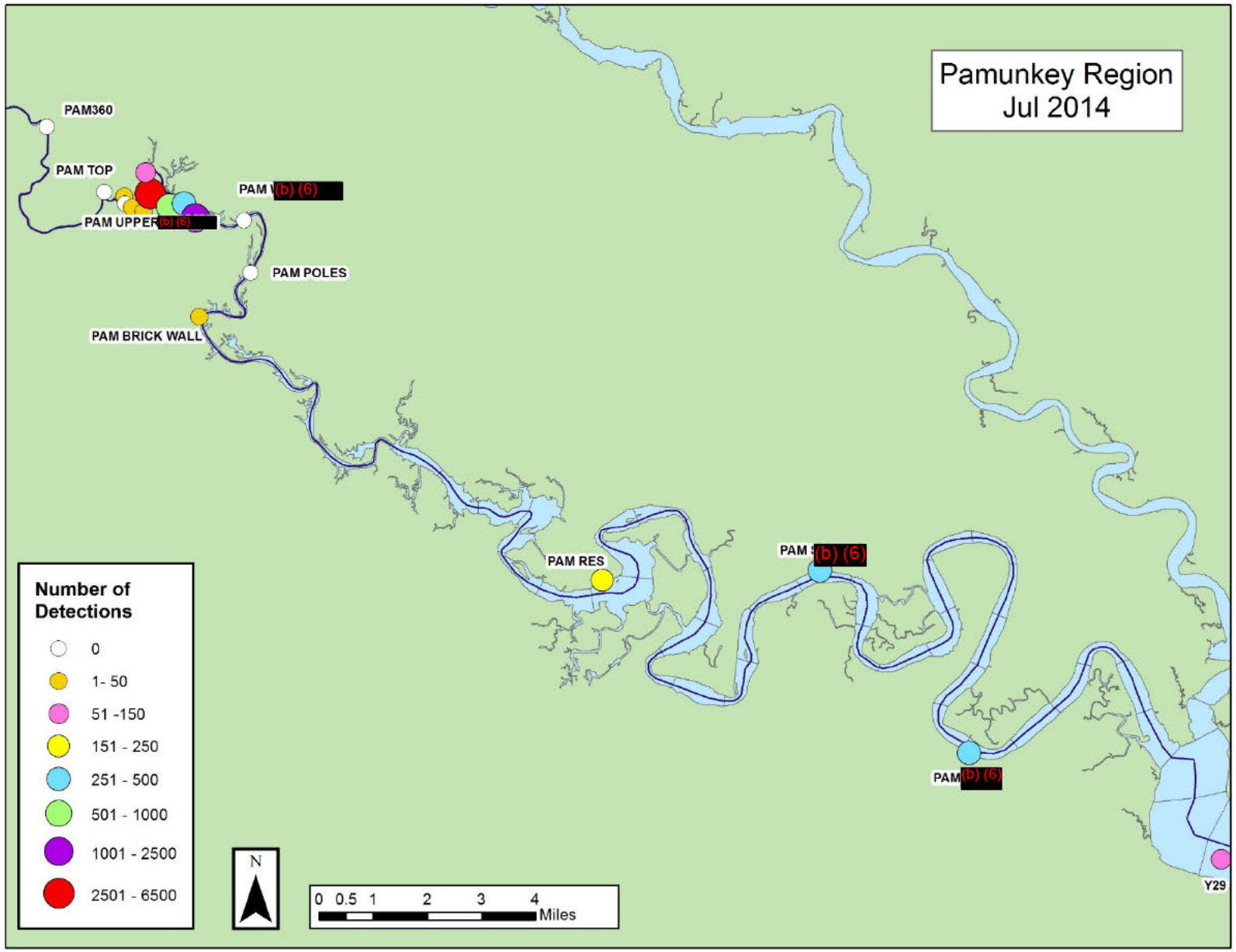

Pamunkey Region
Nov 2013
PAM360
PAM (b) (6)
PAM UPPER (b) (6)
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y29
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

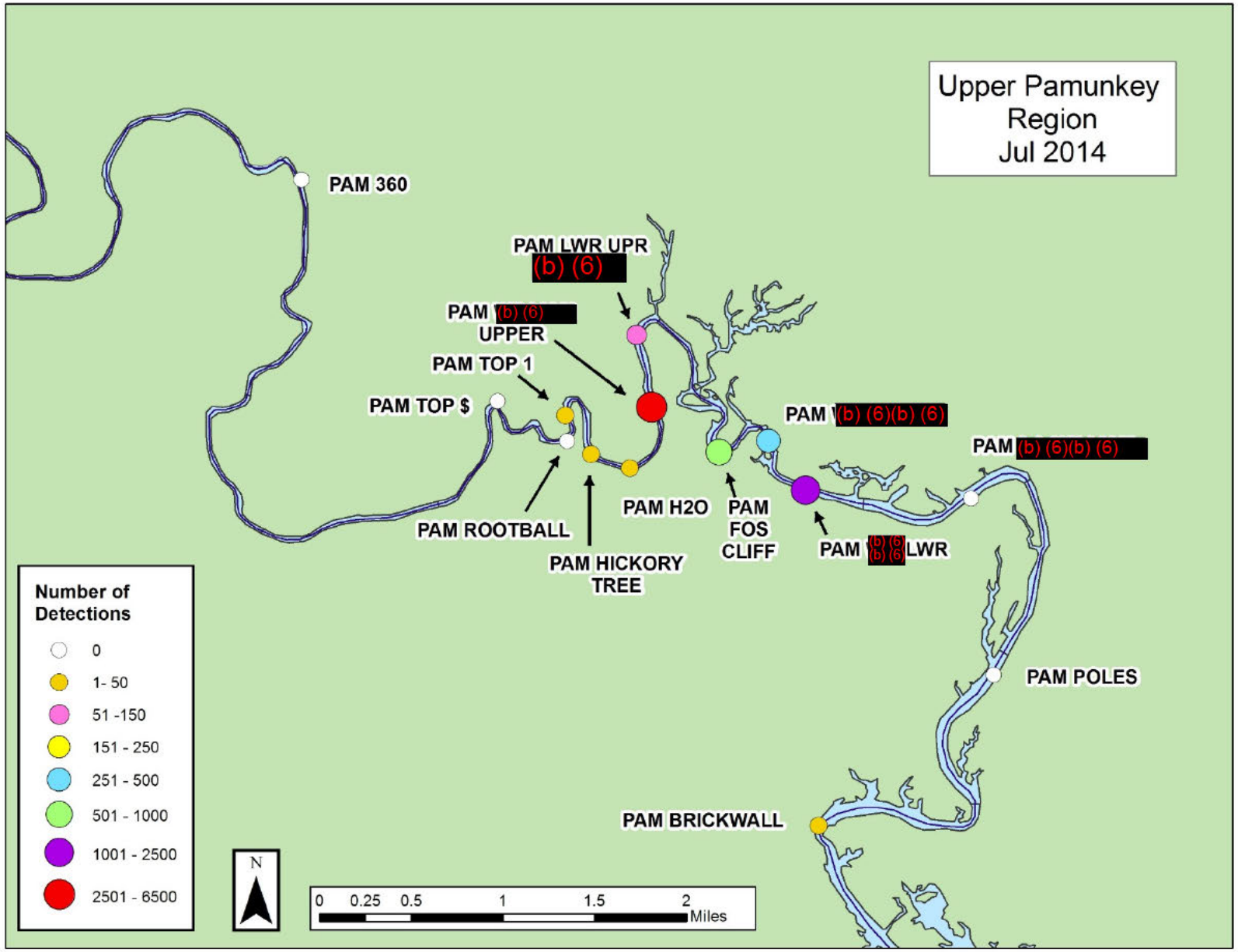

Pamunkey Region
Total 2013
PAM360
PAM (b) (6)
PAM UPPER (b) (6)
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y29
Number of Detections
0
1 - 250
251 - 500
501 - 1000
1001 - 1500
1501 - 3500
3501 - 5000
5001 - 9500
N
0 0.5 1 2 3 4
Miles

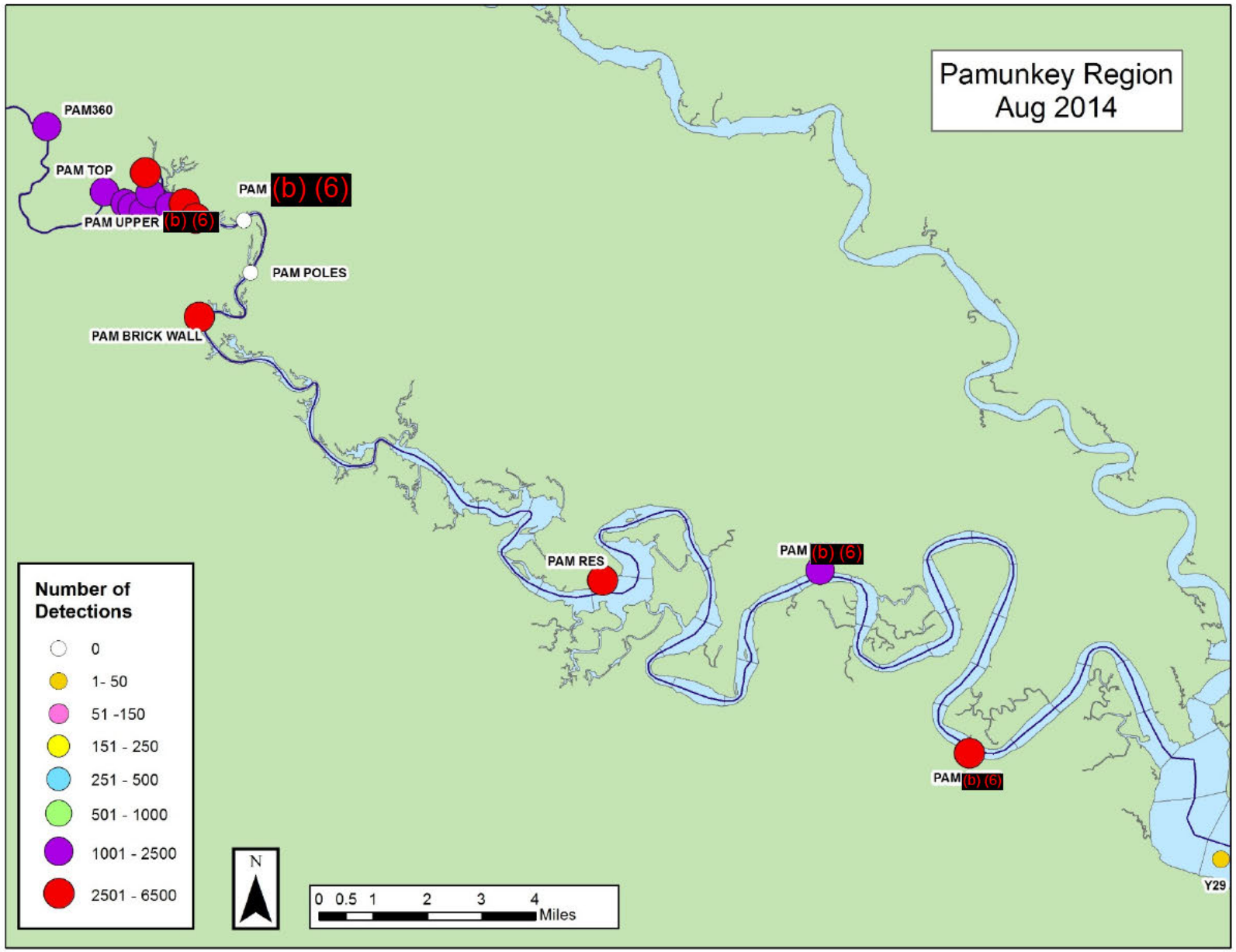

Pamunkey Region
Apr 2014
PAM360
PAM TOP
PAM (b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y29
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

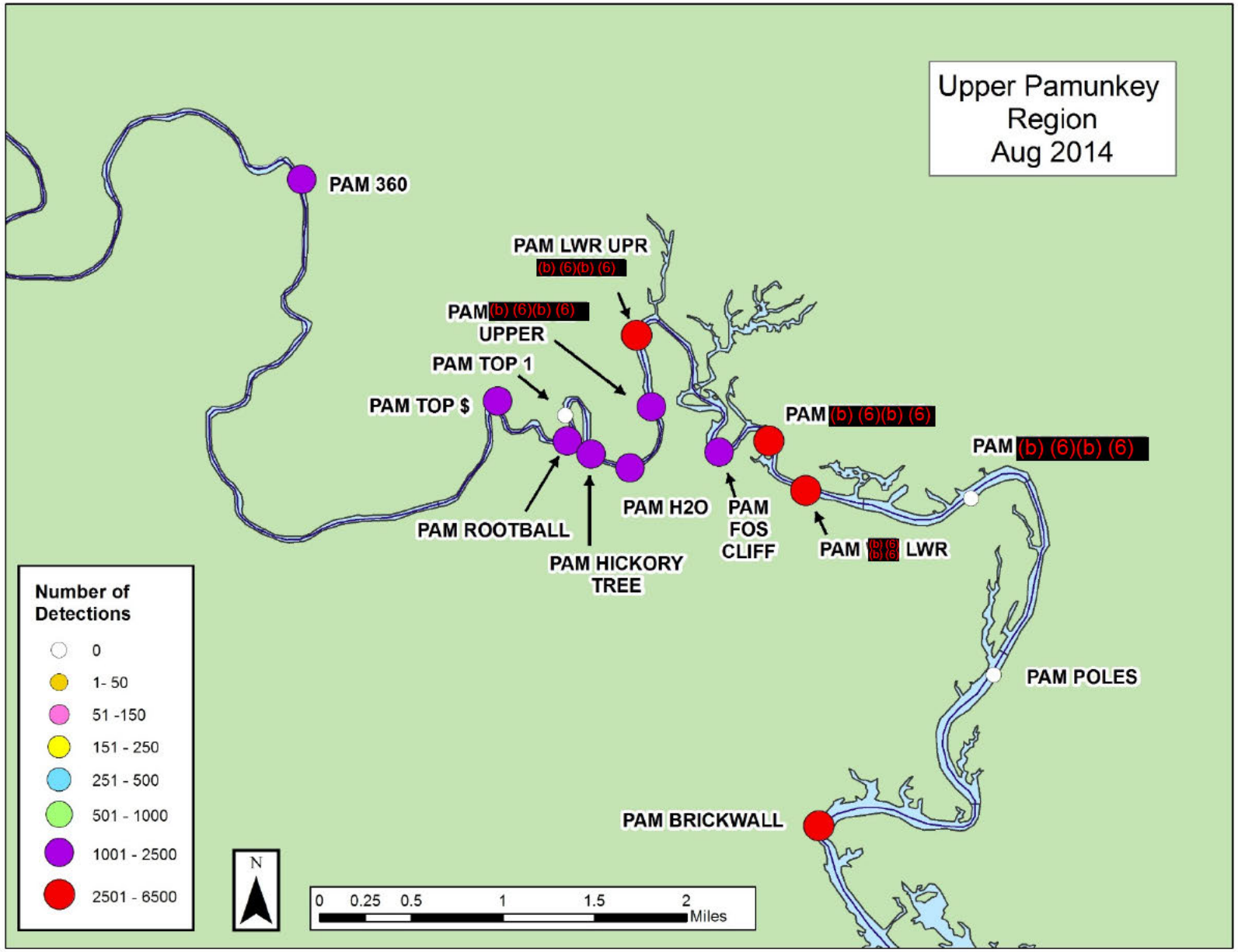

Pamunkey Region
May 2014
PAM360
PAM TOP
PAM (b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y29
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

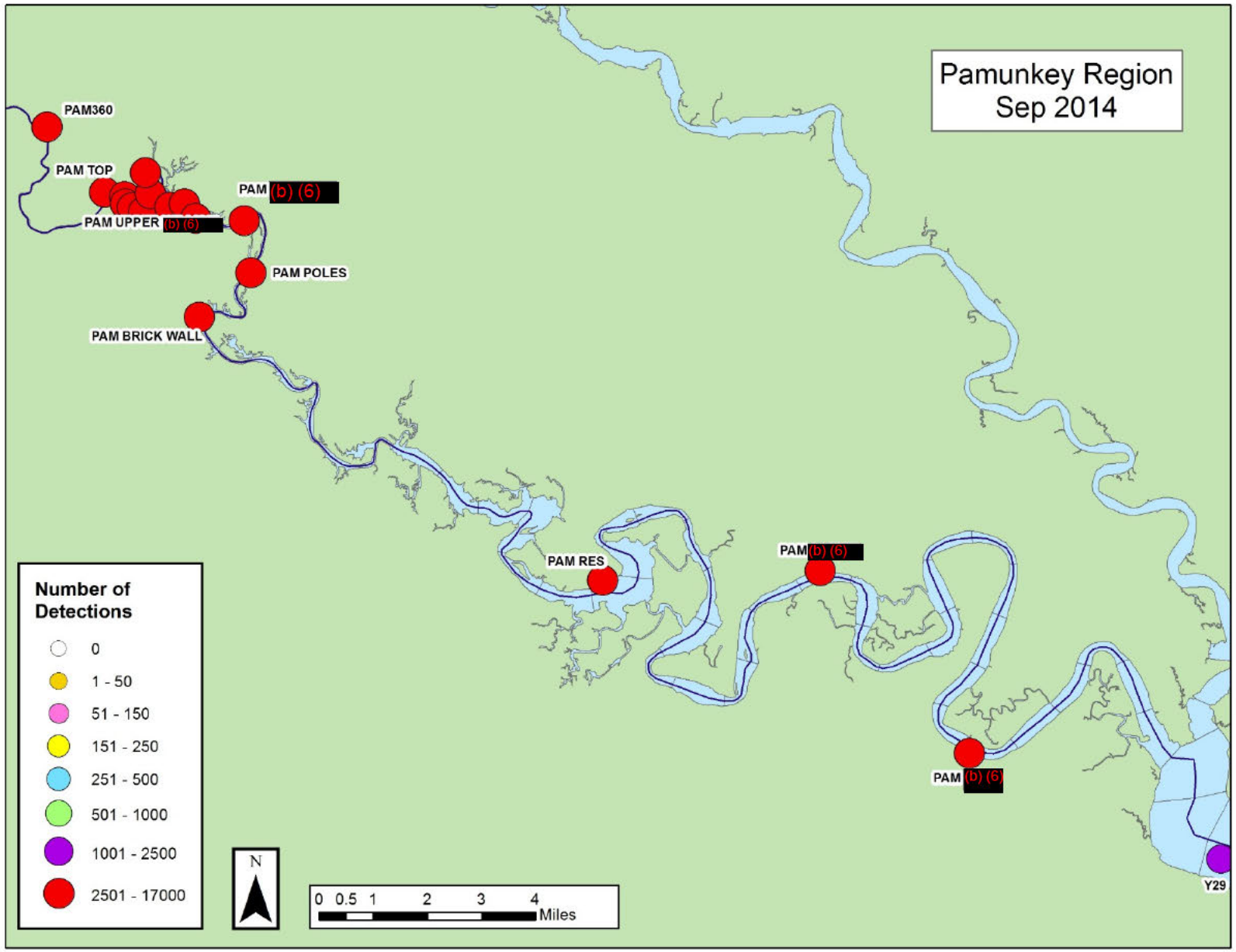

Pamunkey Region
Jun 2014
PAM360
PAM TOP
PAM (b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y29
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

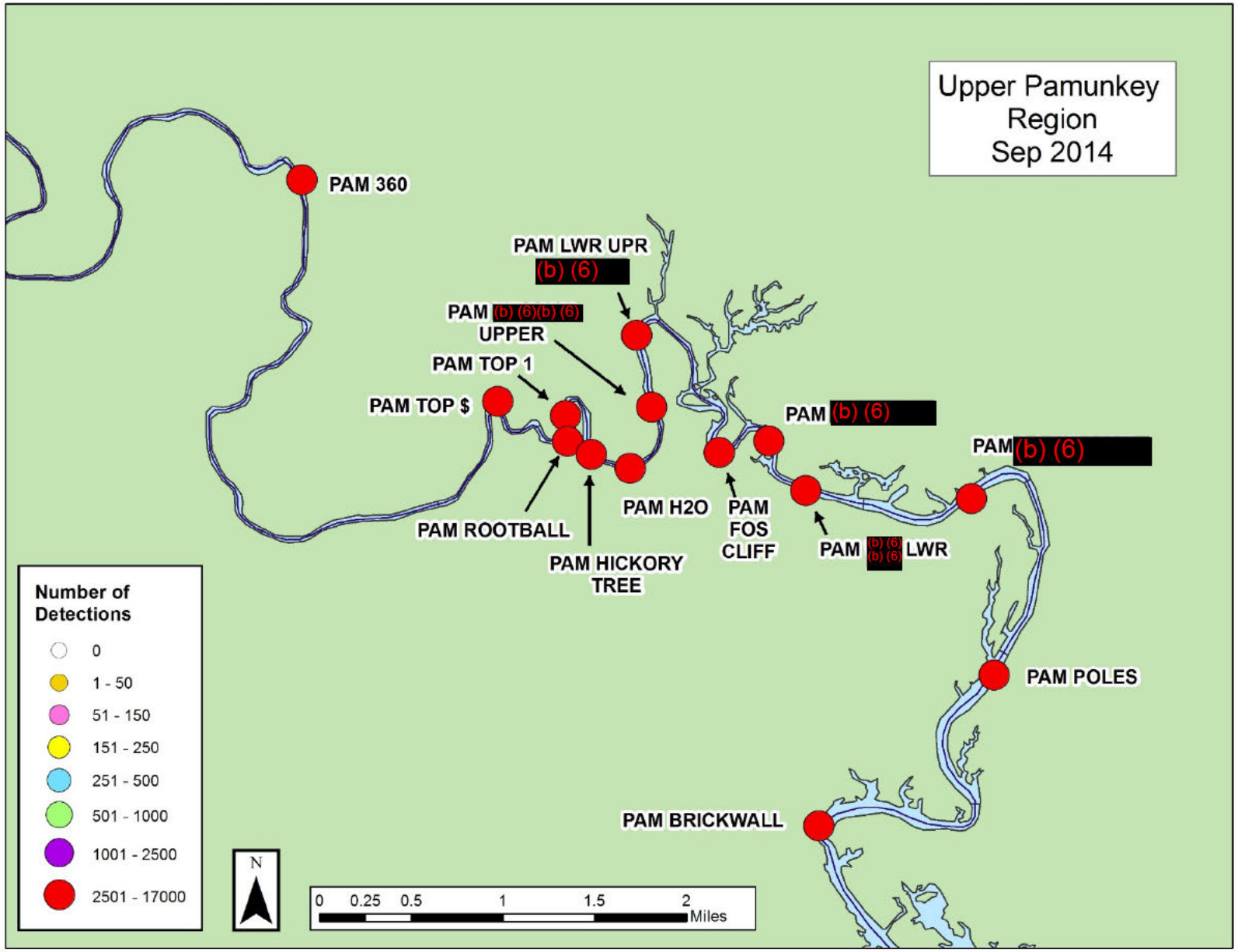

Pamunkey Region
Jul 2014
PAM360
PAM TOP
PAM (b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y29
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

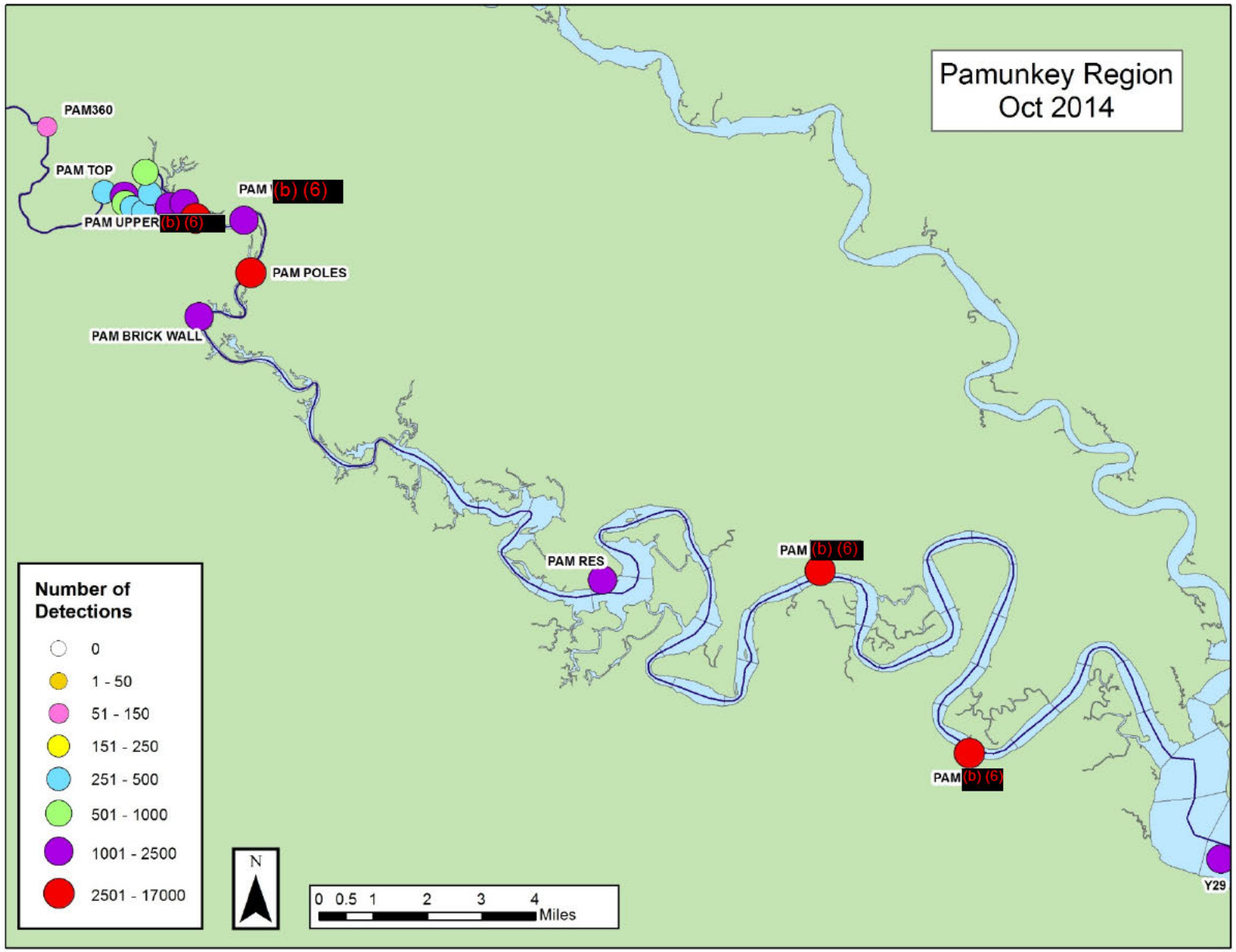

Upper Pamunkey Region
Jul 2014
PAM 360
PAM LWR UPR
(b) (6)
PAM (b) (6)
UPPER
PAM TOP 1
PAM TOP $
PAM (b) (6)(b) (6)
PAM (b) (6)(b) (6)
PAM H2O
PAM FOS CLIFF
PAM ROOTBALL
PAM HICKORY TREE
PAM (b) (6) (b) (6) LWR
PAM POLES
PAM BRICKWALL
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.25 0.5 1 1.5 2
Miles

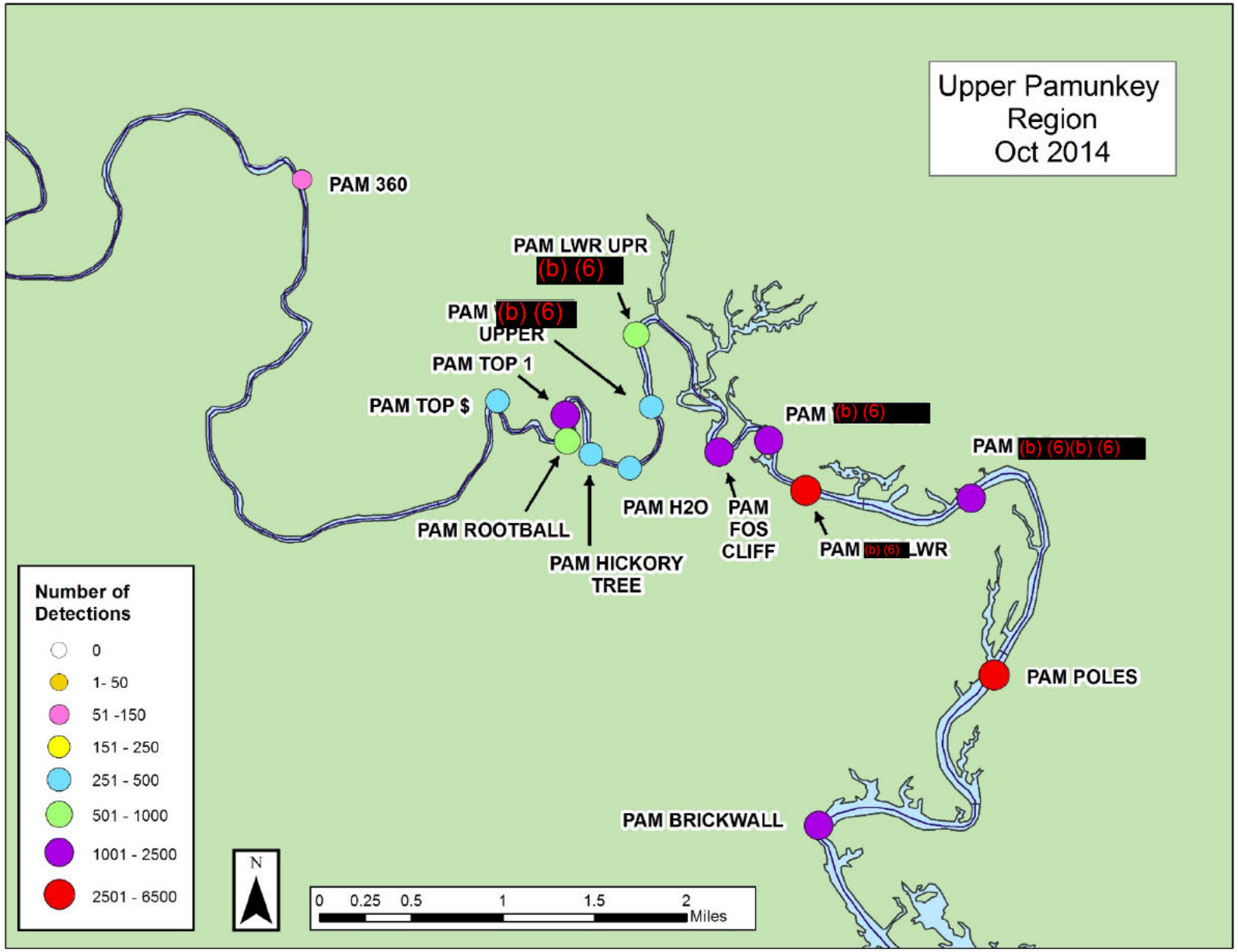

Pamunkey Region
Aug 2014
PAM360
PAM TOP
PAM (b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y29
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

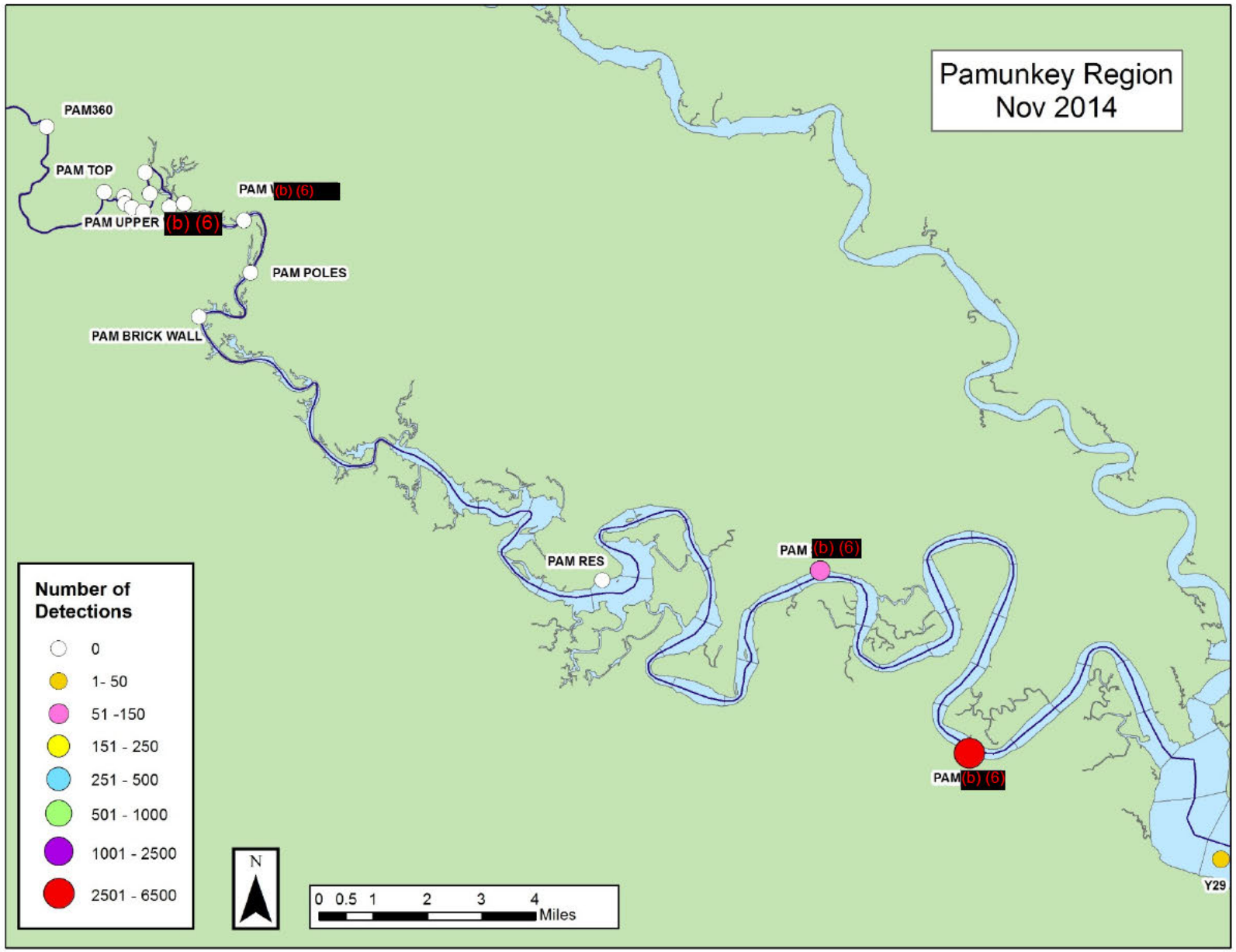

Upper Pamunkey Region Aug 2014
PAM 360
PAM LWR UPR
(b) (6)(b) (6)
PAM (b) (6)(b) (6)
UPPER
PAM TOP 1
PAM TOP $
PAM (b) (6)(b) (6)
PAM (b) (6)(b) (6)
PAM H2O
PAM FOS CLIFF
PAM ROOTBALL
PAM HICKORY TREE
PAM (b) (6) (b) (6) LWR
PAM POLES
PAM BRICKWALL
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.25 0.5 1 1.5 2
Miles

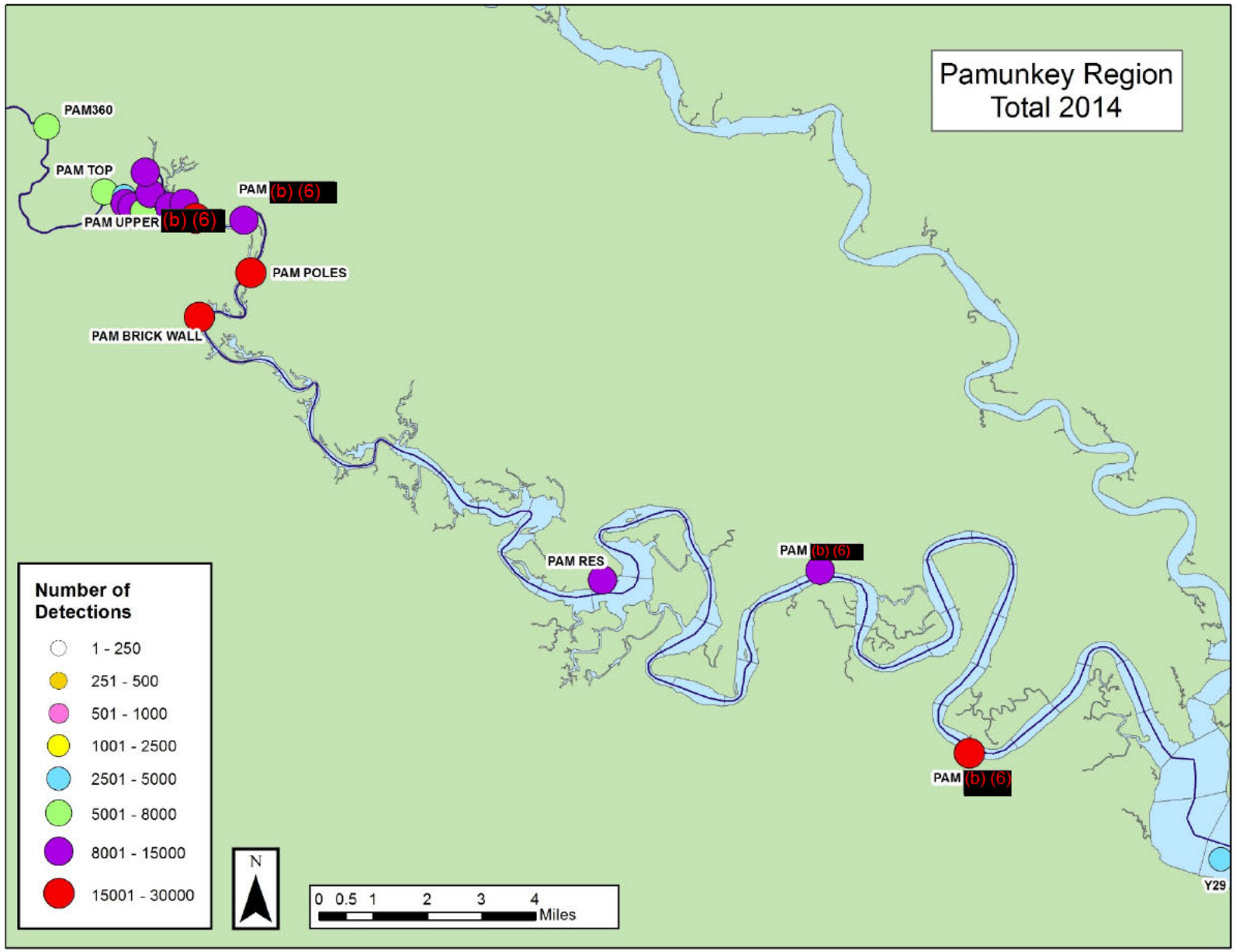

Pamunkey Region
Sep 2014
PAM360
PAM TOP
PAM (b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y29
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 17000
N
0 0.5 1 2 3 4
Miles

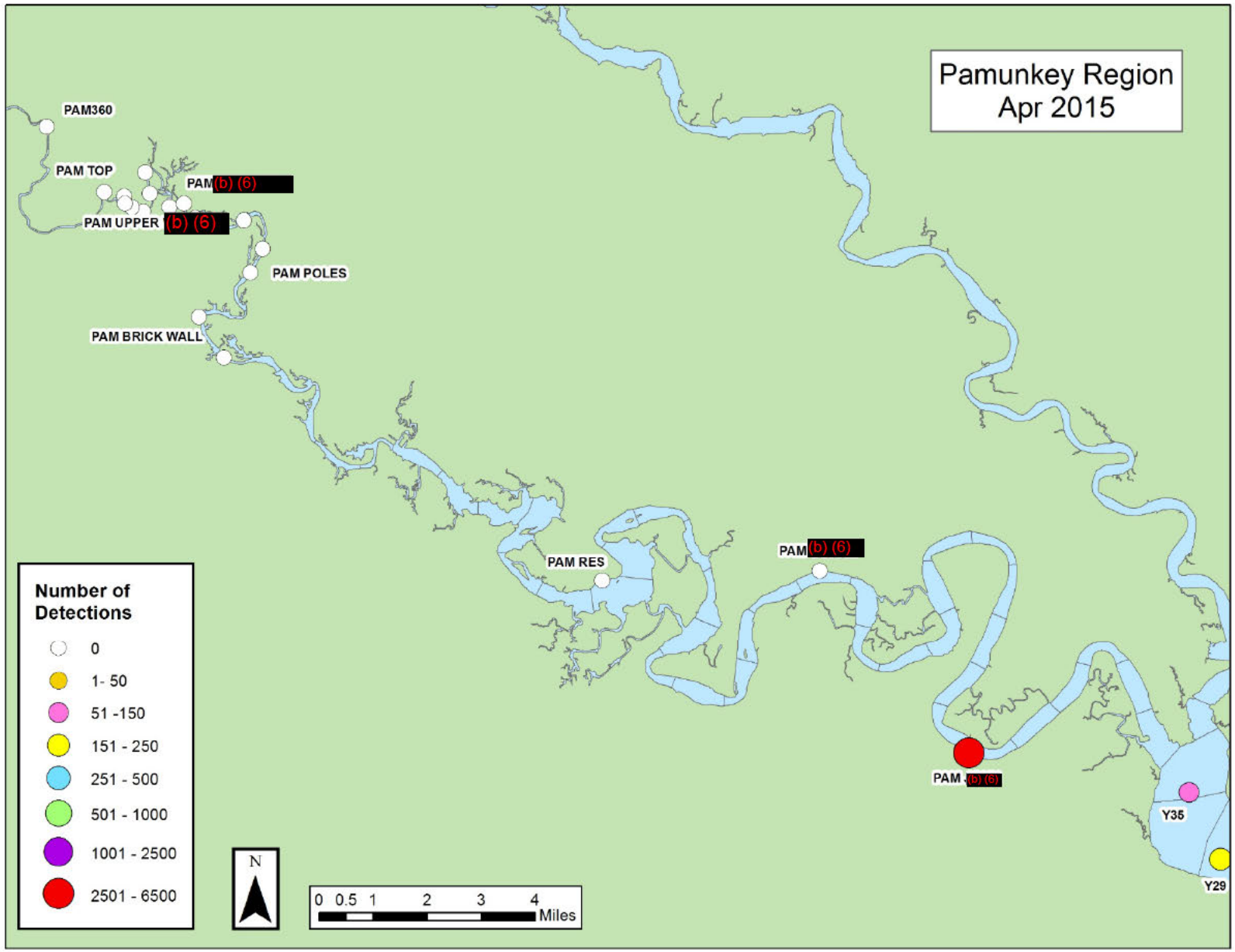

Upper Pamunkey Region Sep 2014
PAM 360
PAM LWR UPR
(b) (6)
PAM (b) (6)(b) (6)
UPPER
PAM TOP 1
PAM TOP $
PAM (b) (6)
PAM (b) (6)
PAM H2O
PAM FOS CLIFF
PAM ROOTBALL
PAM HICKORY TREE
PAM (b) (6) (b) (6) LWR
PAM POLES
PAM BRICKWALL
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 17000
N
0 0.25 0.5 1 1.5 2
Miles

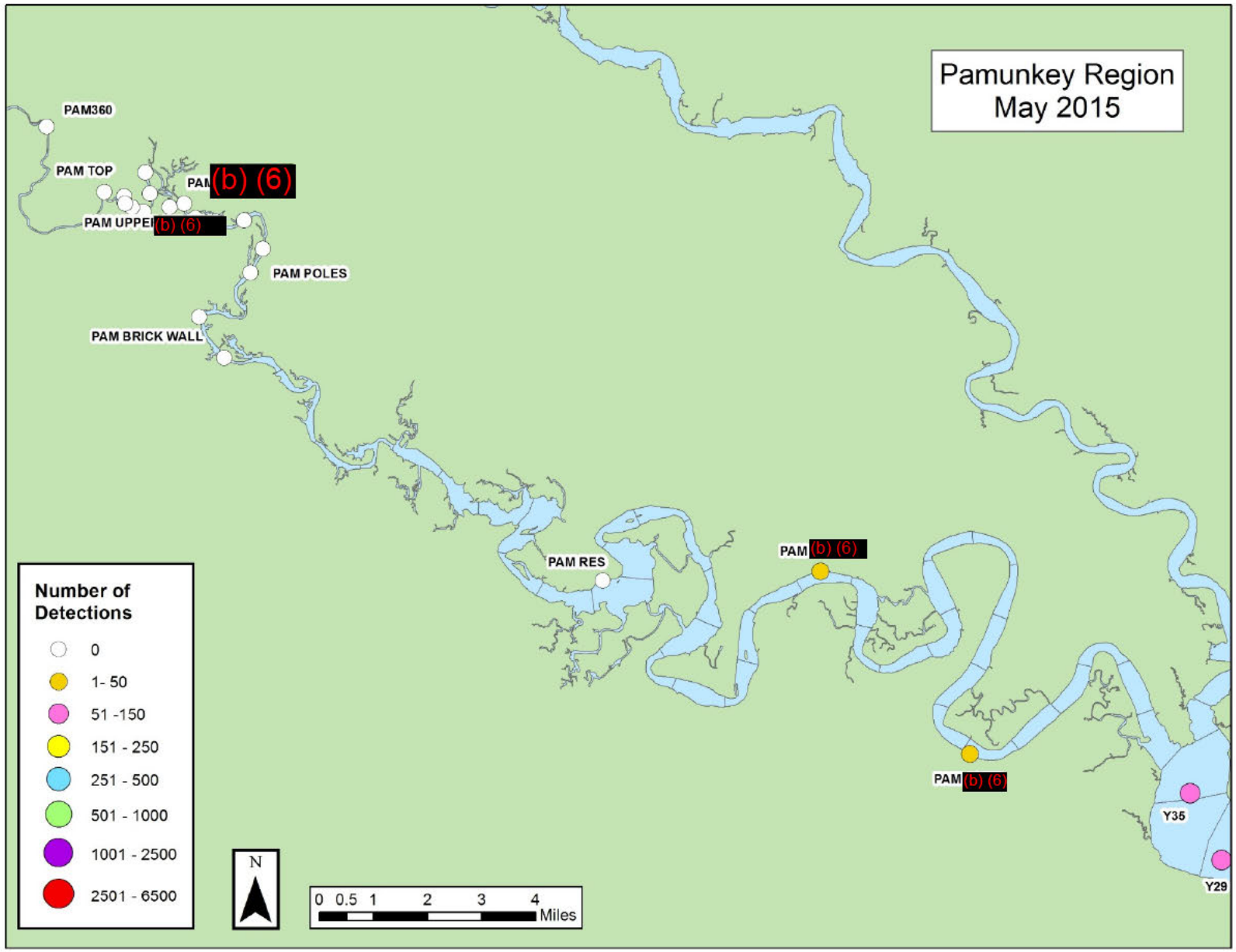

Pamunkey Region
Oct 2014
PAM360
PAM TOP
PAM (b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y29
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 17000
N
0 0.5 1 2 3 4
Miles

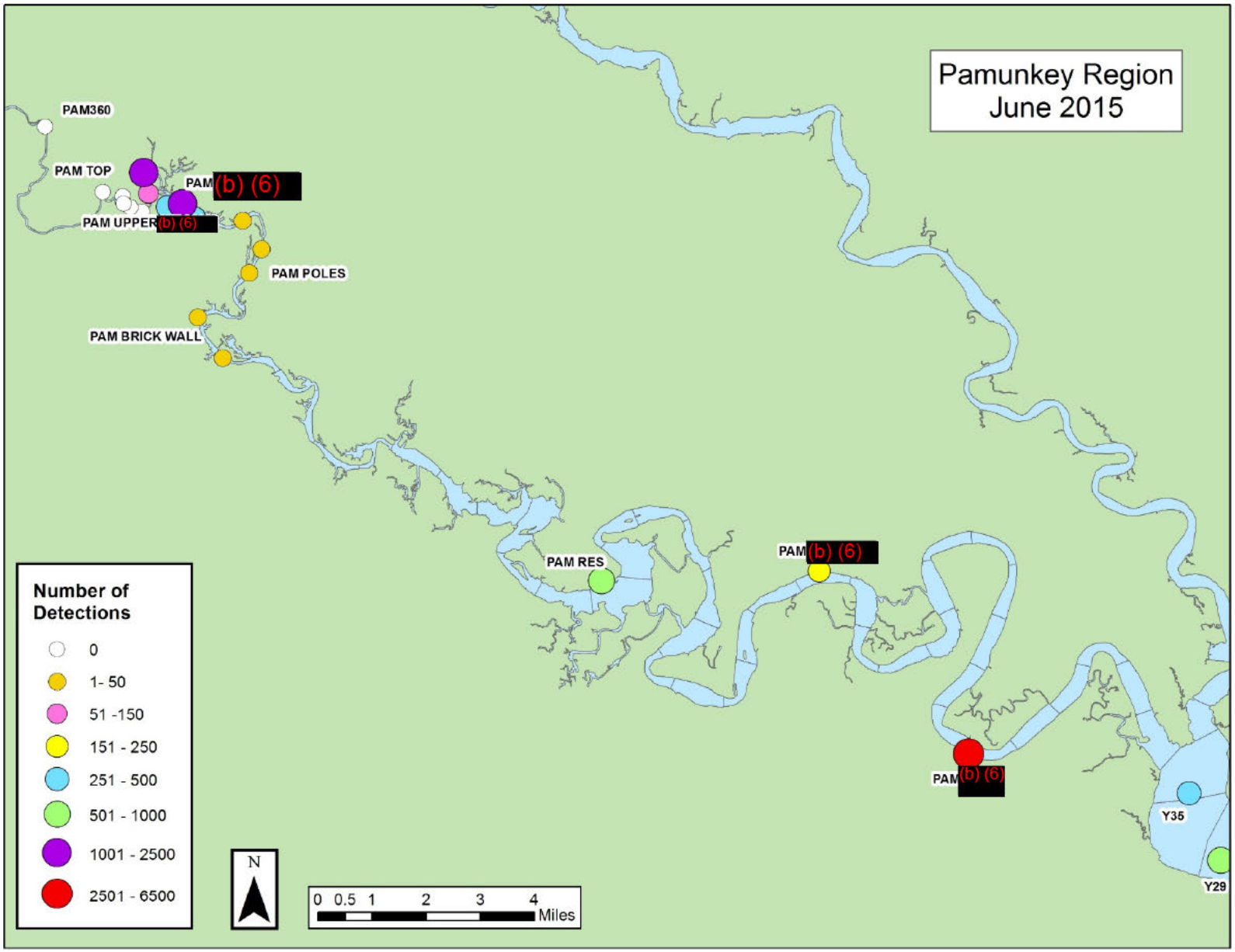

Upper Pamunkey Region Oct 2014
PAM 360
PAM LWR UPR
(b) (6)
PAM (b) (6) UPPER
PAM TOP 1
PAM TOP $
PAM ROOTBALL
PAM HICKORY TREE
PAM H2O
PAM FOS CLIFF
PAM (b) (6)
PAM (b) (6)(b) (6)
PAM (b) (6) LWR
PAM POLES
PAM BRICKWALL
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.25 0.5 1 1.5 2
Miles

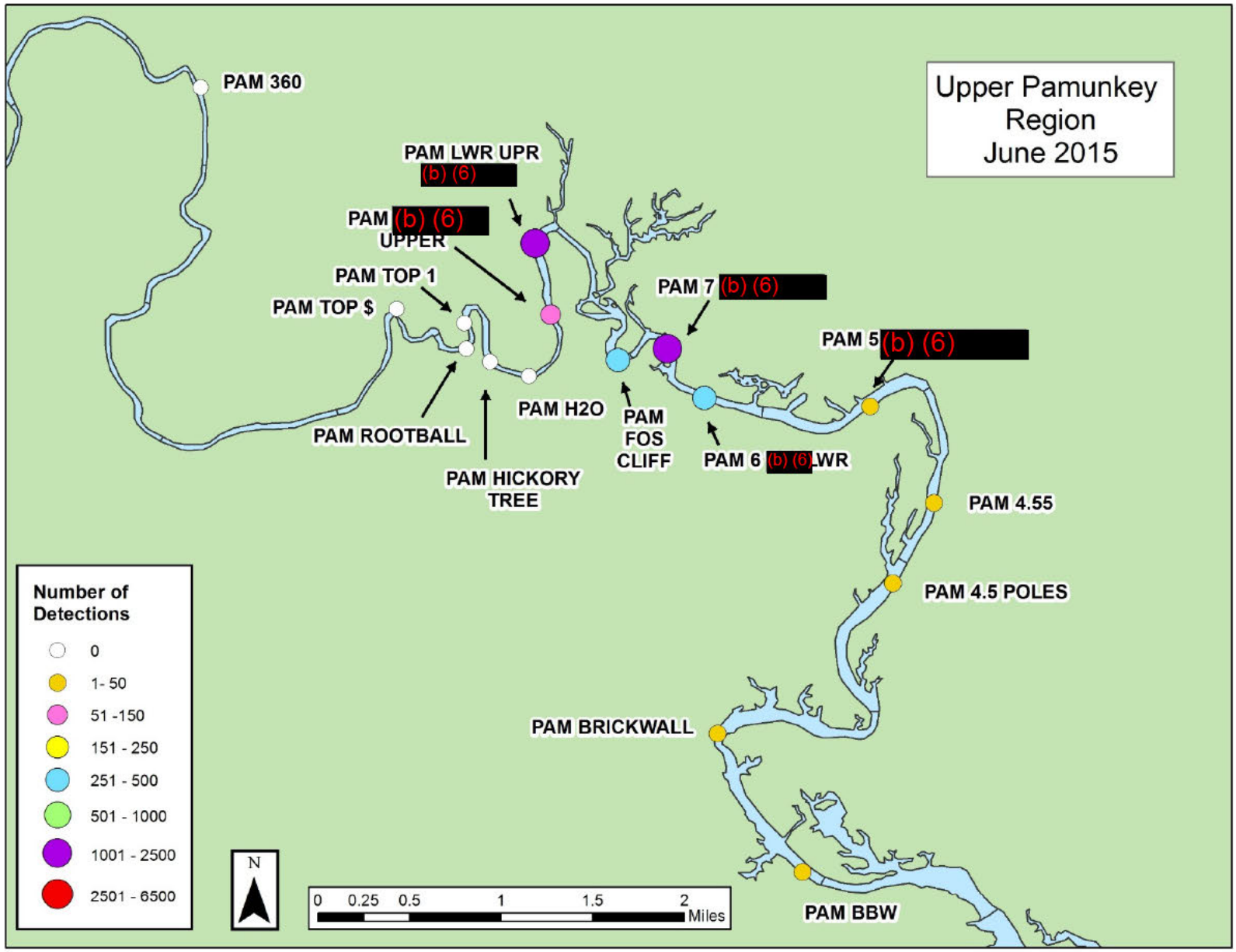

Pamunkey Region
Nov 2014
PAM360
PAM TOP
PAM (b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y29
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

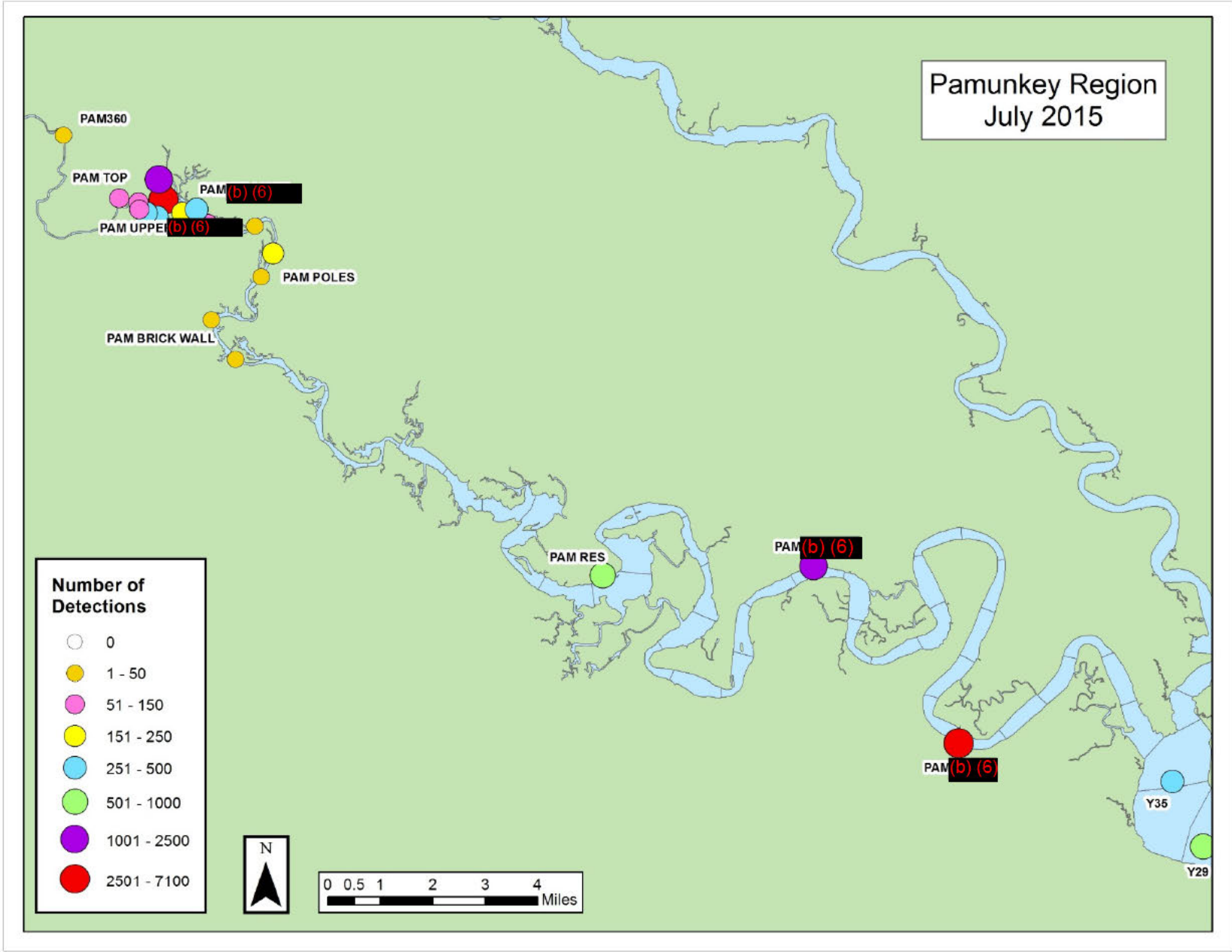

Pamunkey Region
Total 2014
PAM360
PAM TOP
PAM (b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y29
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
N
0 0.5 1 2 3 4
Miles

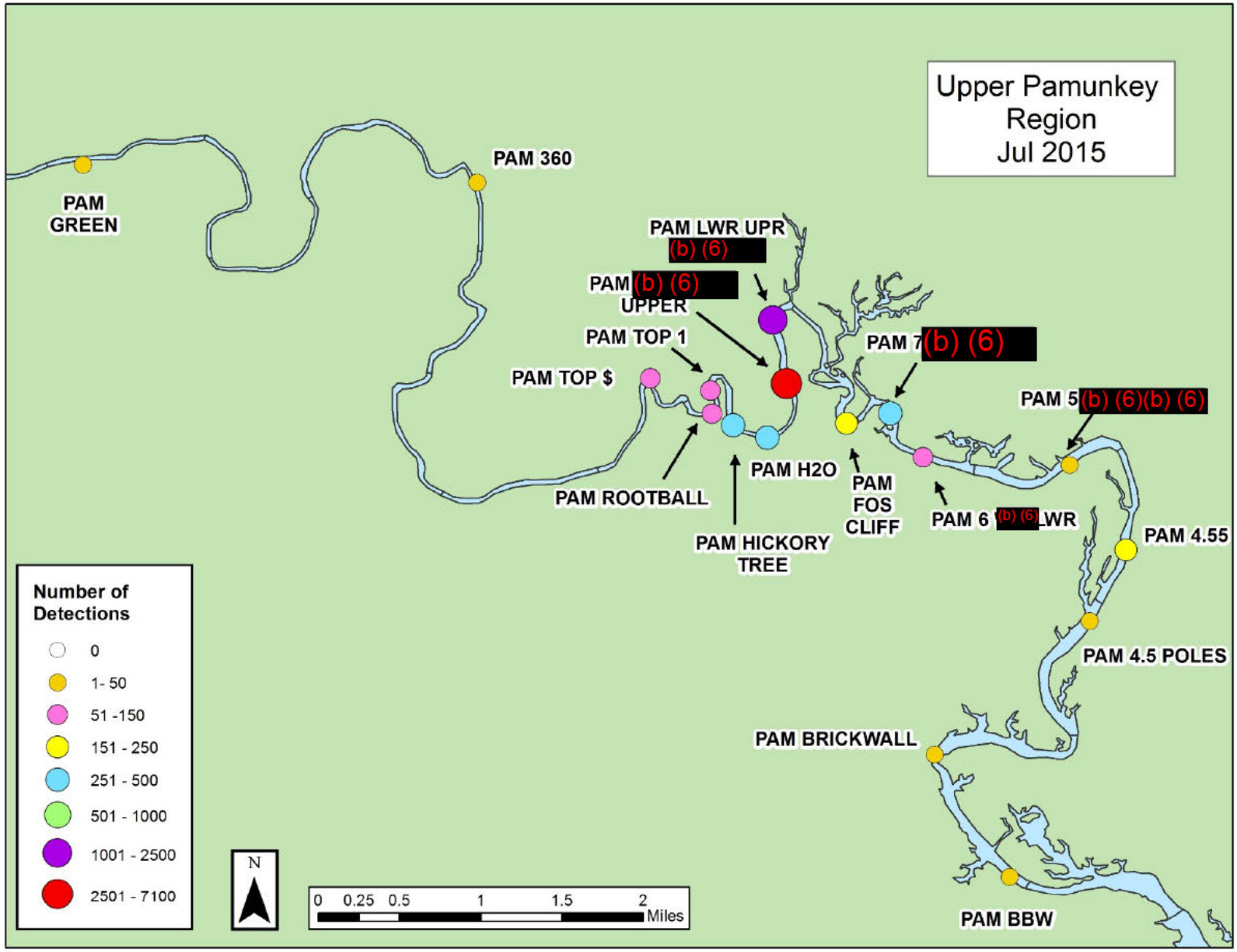

Pamunkey Region
Apr 2015
PAM360
PAM TOP
PAM (b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y35
Y29
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

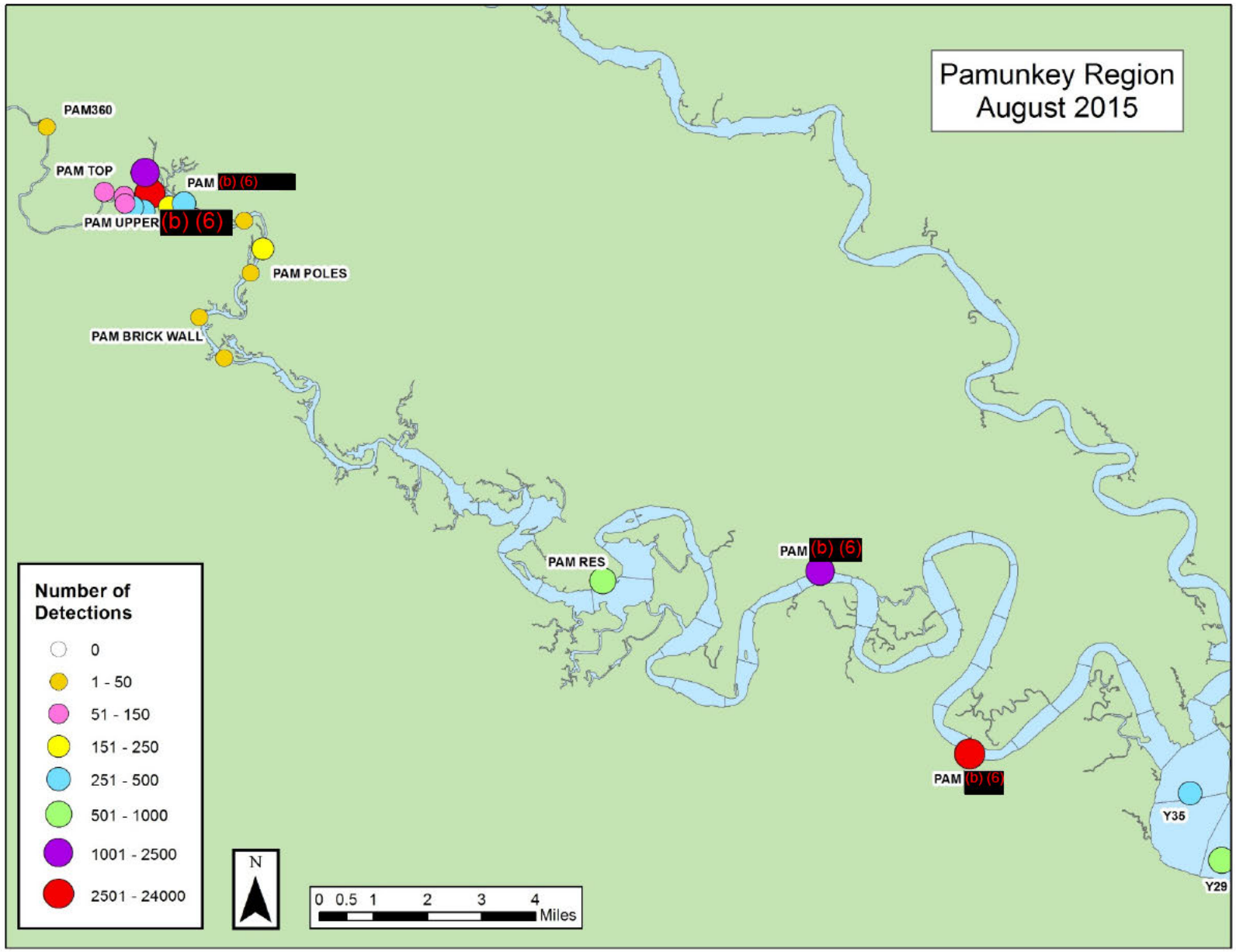

Pamunkey Region
May 2015
PAM360
PAM TOP
PAM (b) (6)
PAM UPPE (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y35
Y29
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

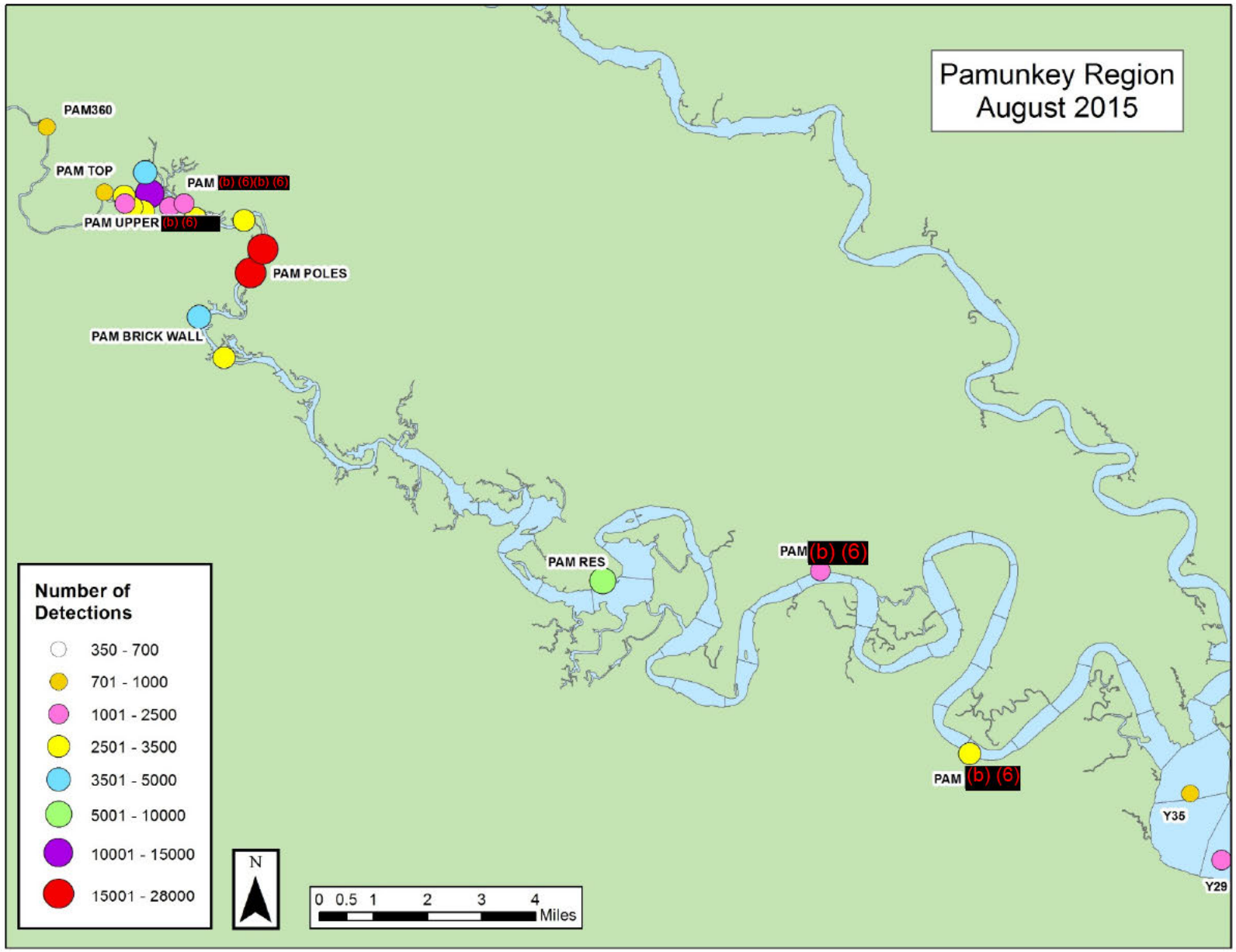

Pamunkey Region
June 2015
PAM360
PAM TOP
PAM (b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y35
Y29
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

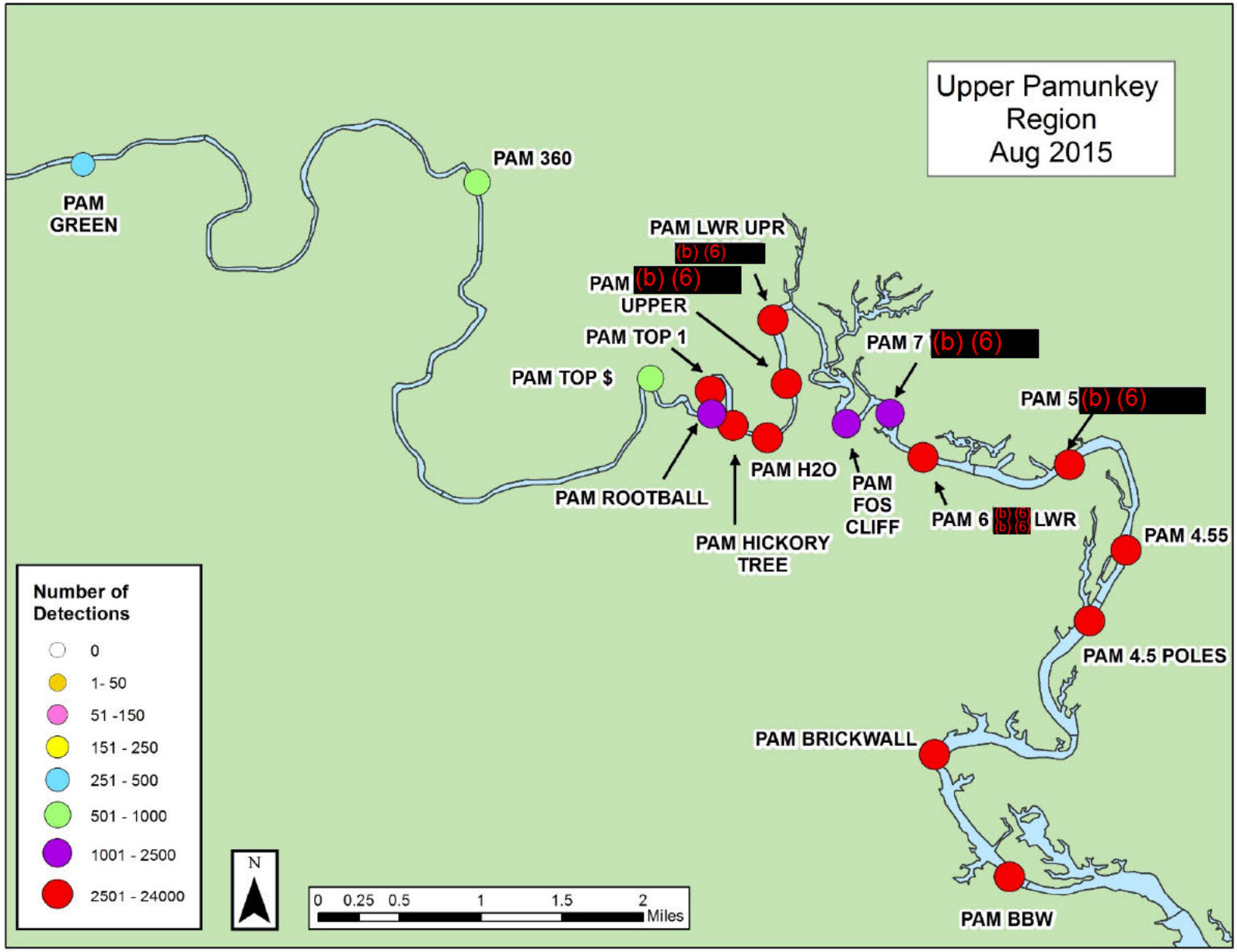

Upper Pamunkey Region June 2015
PAM 360
PAM LWR UPR (b) (6)
PAM (b) (6) UPPER
PAM TOP 1
PAM TOP $
PAM 7 (b) (6)
PAM 5 (b) (6)
PAM H2O
PAM FOS CLIFF
PAM 6 (b) (6) LWR
PAM ROOTBALL
PAM HICKORY TREE
PAM 4.55
PAM 4.5 POLES
PAM BRICKWALL
PAM BBW
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.25 0.5 1 1.5 2 Miles

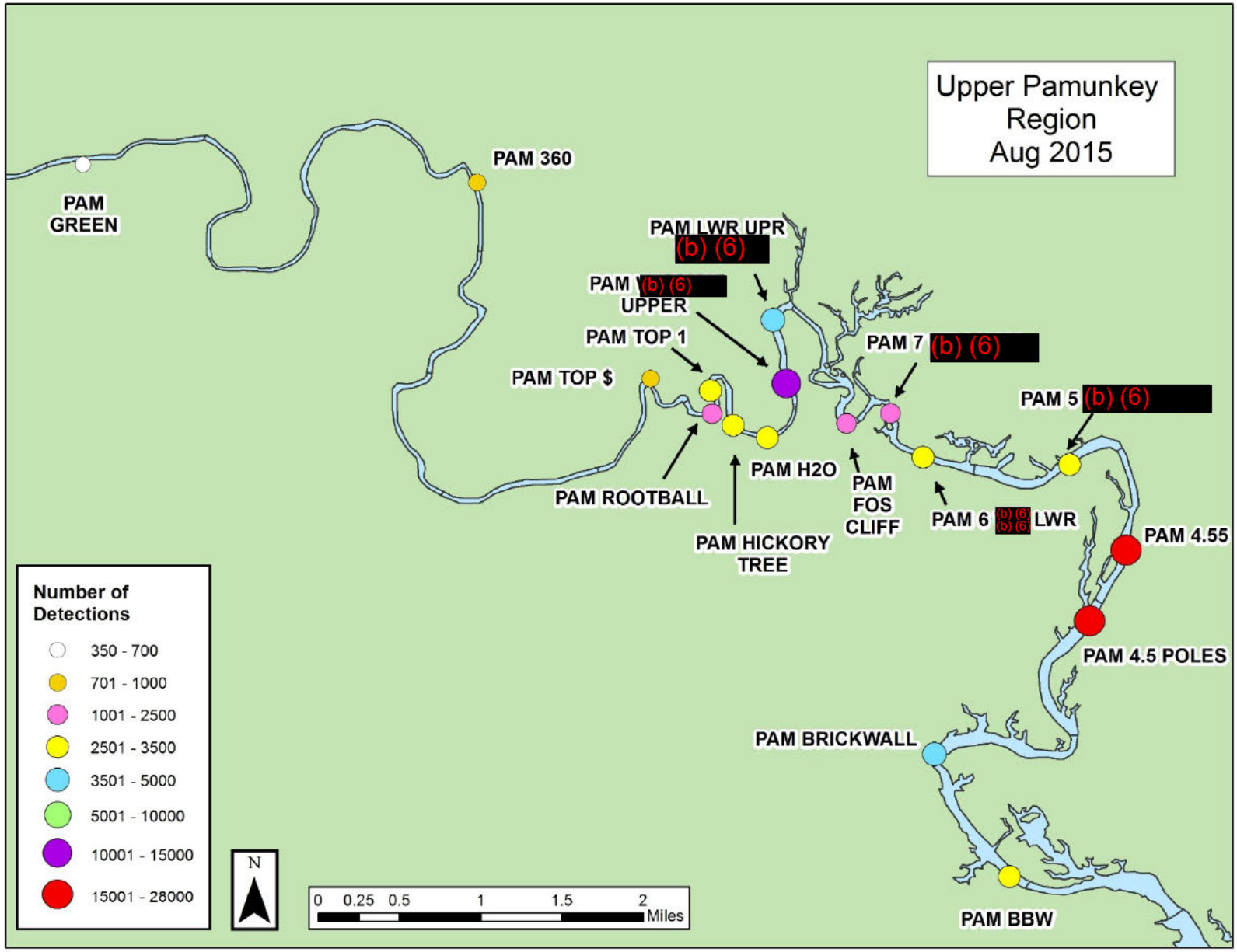

Pamunkey Region
July 2015
PAM360
PAM TOP
PAM (b) (6)
PAM UPPE (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y35
Y29
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 7100
N
0 0.5 1 2 3 4
Miles

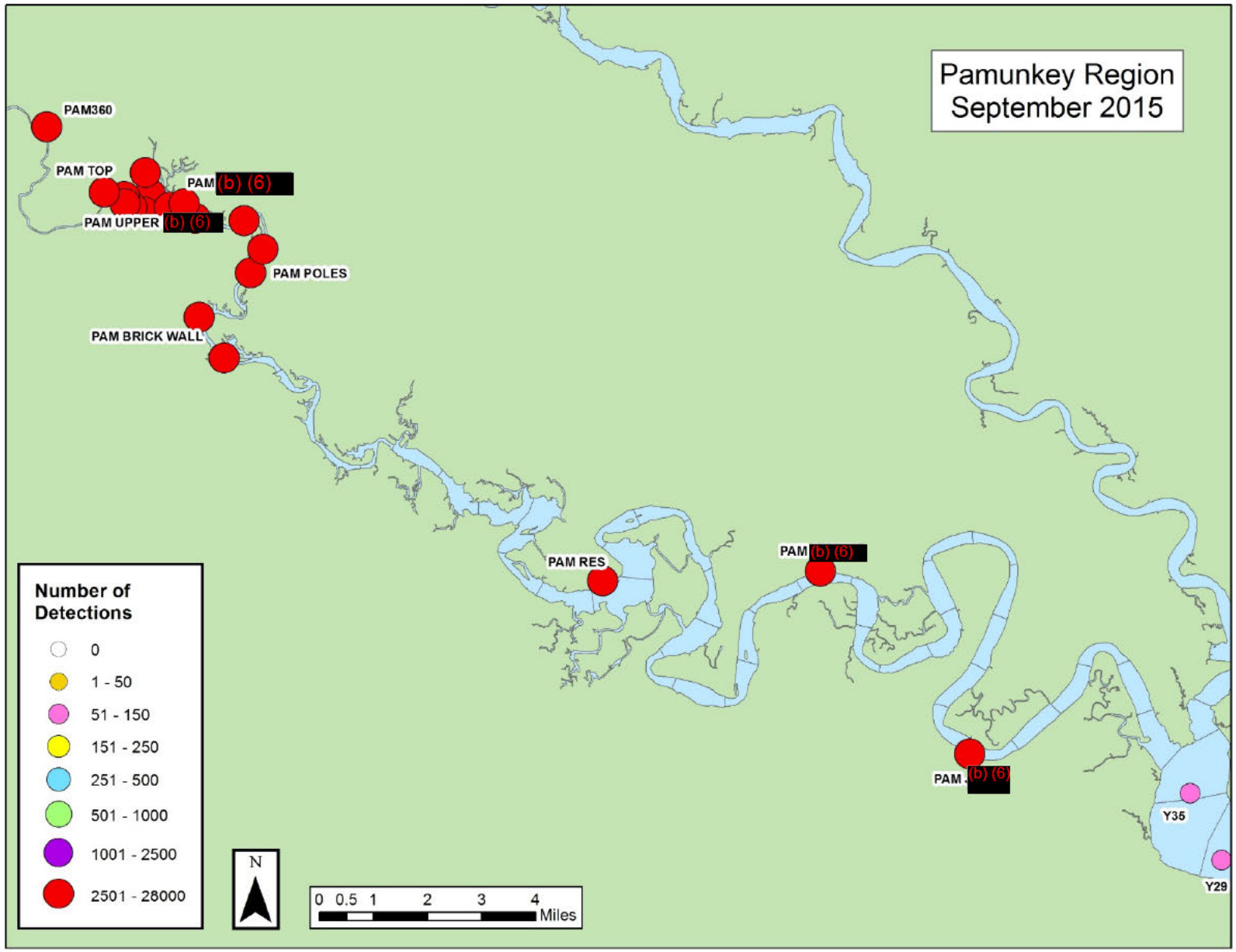

Upper Pamunkey Region
Jul 2015
PAM GREEN
PAM 360
PAM LWR UPR
(b) (6)
PAM (b) (6)
UPPER
PAM TOP 1
PAM TOP $
PAM 7 (b) (6)
PAM 5 (b) (6)(b) (6)
PAM H2O
PAM ROOTBALL
PAM FOS CLIFF
PAM 6 (b) (6) LWR
PAM HICKORY TREE
PAM 4.55
PAM 4.5 POLES
PAM BRICKWALL
PAM BBW
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 7100
N
0 0.25 0.5 1 1.5 2 Miles

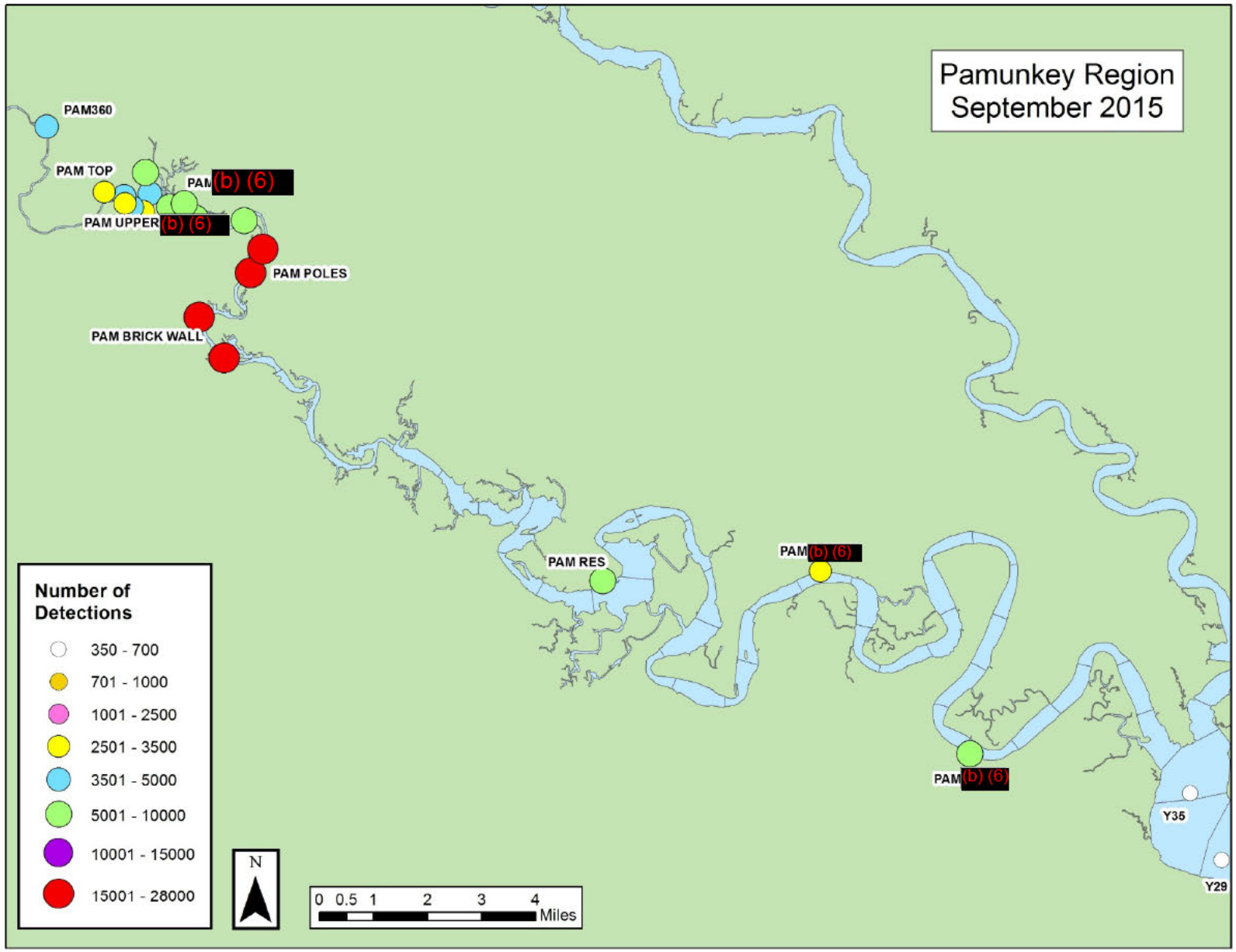

Pamunkey Region
August 2015
PAM360
PAM TOP
PAM (b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y35
Y29
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 24000
N
0 0.5 1 2 3 4
Miles

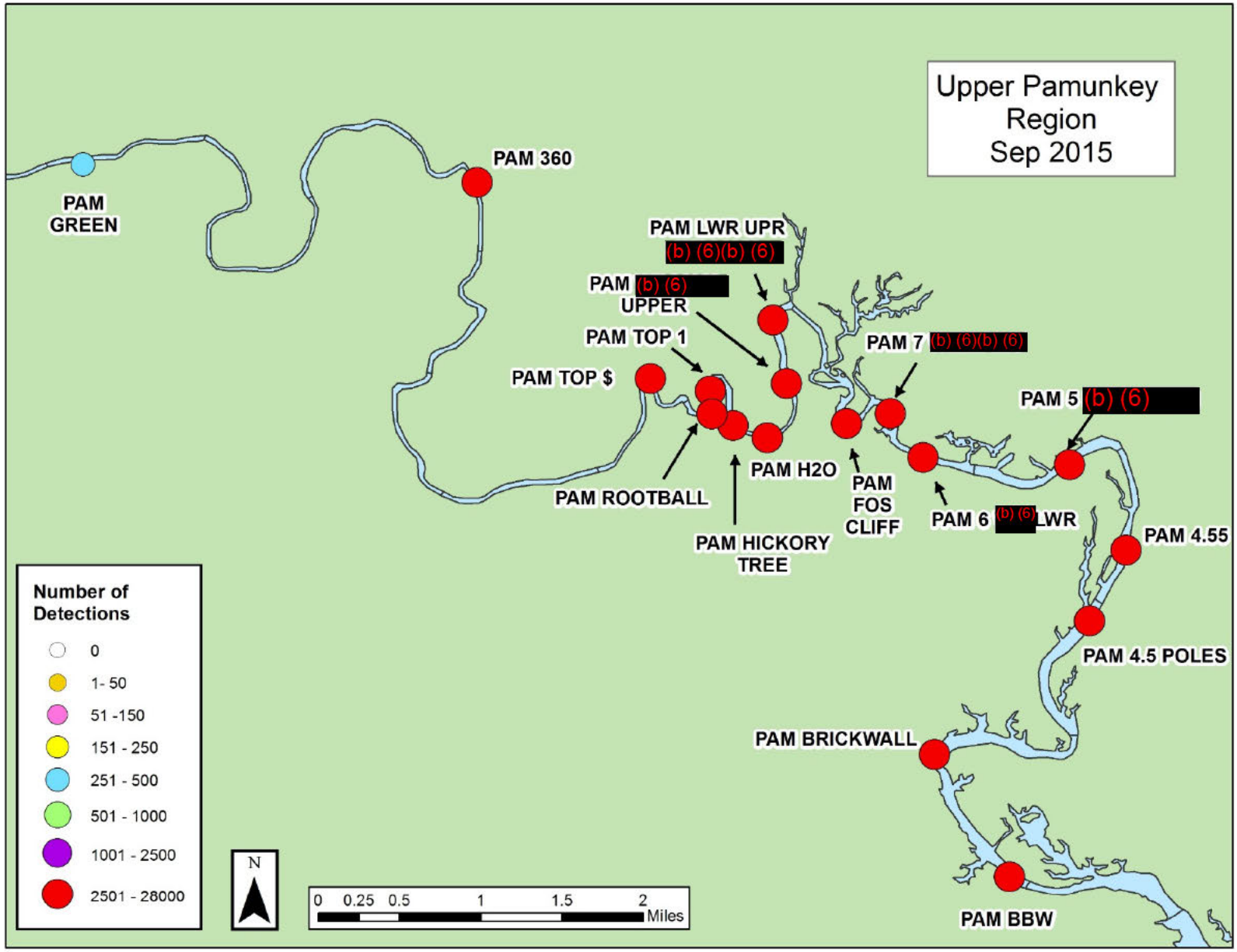

Pamunkey Region
August 2015
PAM360
PAM TOP
PAM (b) (6)(b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y35
Y29
Number of Detections
350 - 700
701 - 1000
1001 - 2500
2501 - 3500
3501 - 5000
5001 - 10000
10001 - 15000
15001 - 28000
N
0 0.5 1 2 3 4
Miles

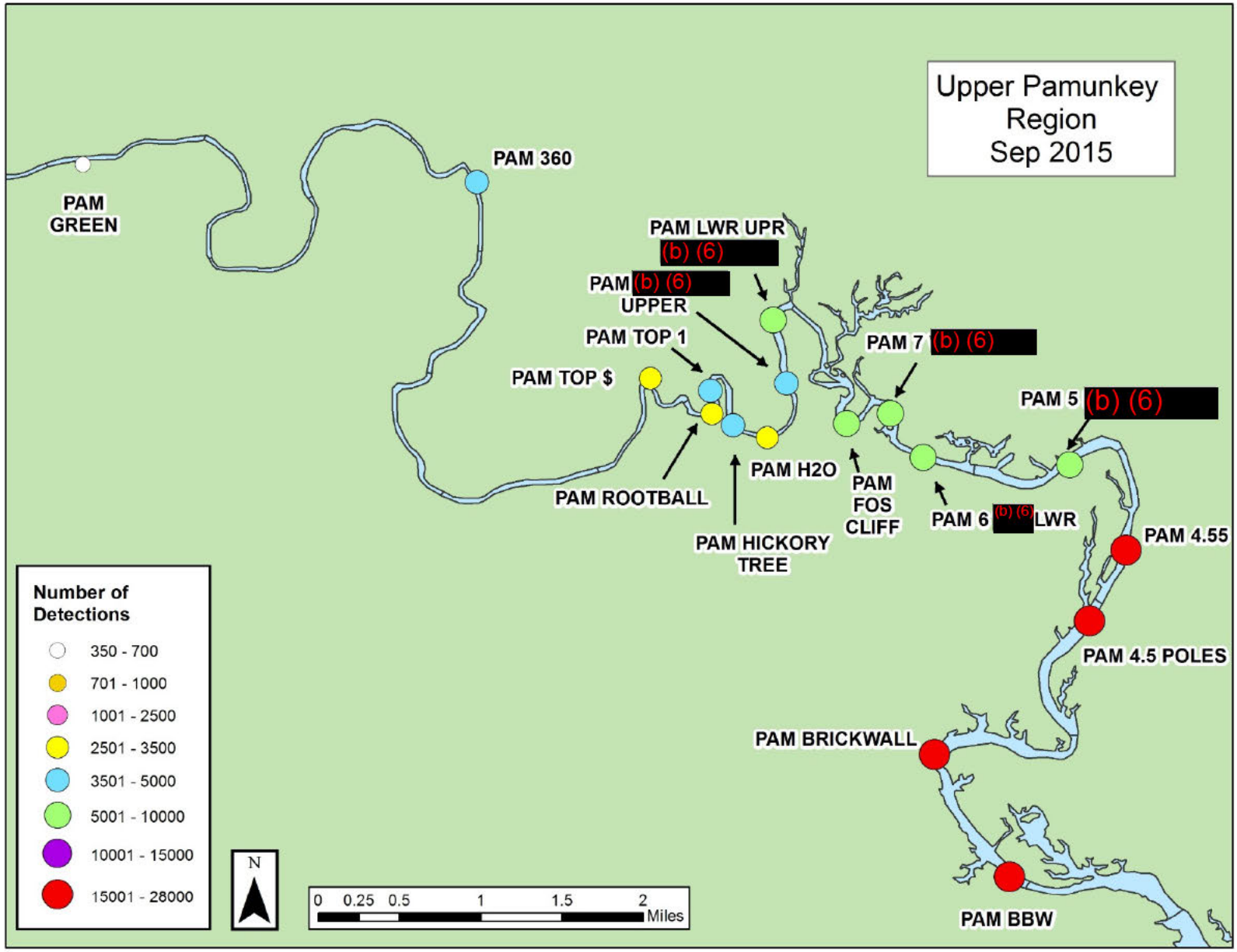

Upper Pamunkey Region Aug 2015
PAM GREEN
PAM 360
PAM LWR UPR
(b) (6)
PAM (b) (6)
UPPER
PAM TOP 1
PAM TOP $
PAM 7 (b) (6)
PAM 5 (b) (6)
PAM H2O
PAM ROOTBALL
PAM FOS CLIFF
PAM 6 (b) (6) (b) (6) LWR
PAM HICKORY TREE
PAM 4.55
PAM 4.5 POLES
PAM BRICKWALL
PAM BBW
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 24000
N
0 0.25 0.5 1 1.5 2 Miles

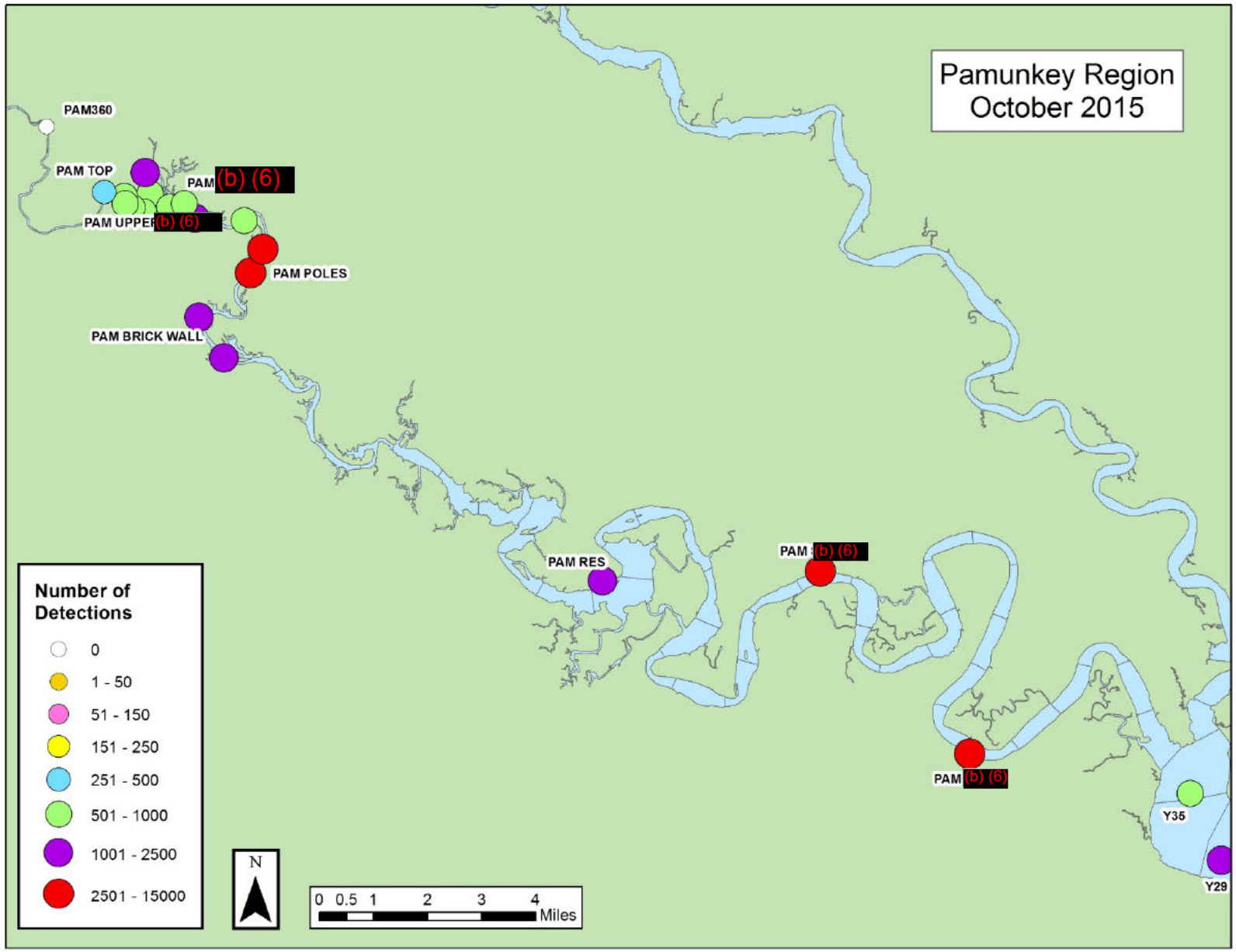

Upper Pamunkey Region Aug 2015
PAM 360
PAM GREEN
PAM LWR UPR (b) (6)
PAM (b) (6) UPPER
PAM TOP 1
PAM TOP $
PAM 7 (b) (6)
PAM 5 (b) (6)
PAM H2O
PAM ROOTBALL
PAM FOS CLIFF
PAM 6 (b) (6) (b) (6) LWR
PAM HICKORY TREE
PAM 4.55
PAM 4.5 POLES
PAM BRICKWALL
PAM BBW
Number of Detections
350 - 700
701 - 1000
1001 - 2500
2501 - 3500
3501 - 5000
5001 - 10000
10001 - 15000
15001 - 28000
N
0 0.25 0.5 1 1.5 2 Miles

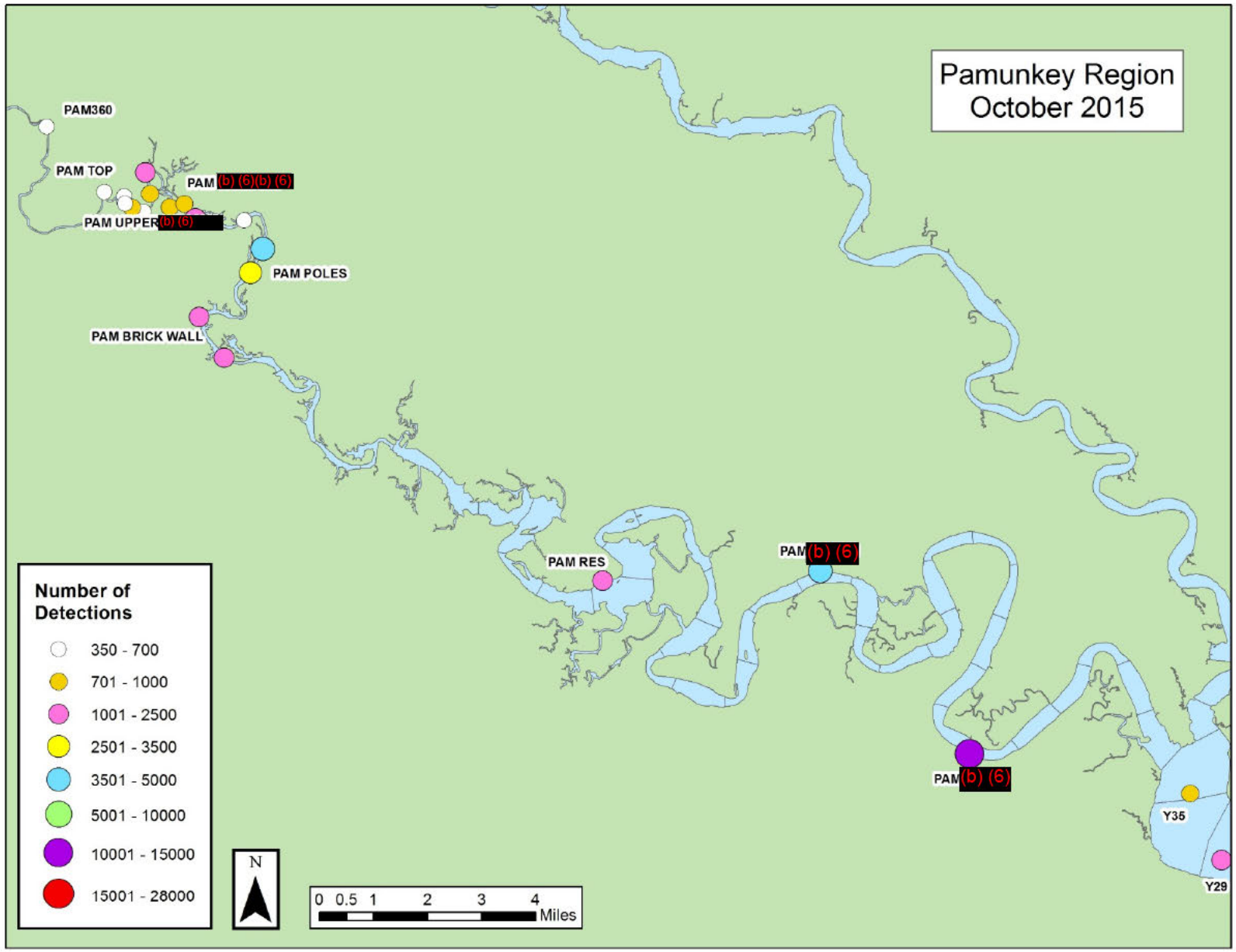

Pamunkey Region
September 2015
PAM360
PAM TOP
PAM (b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y35
Y29
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 28000
N
0 0.5 1 2 3 4
Miles

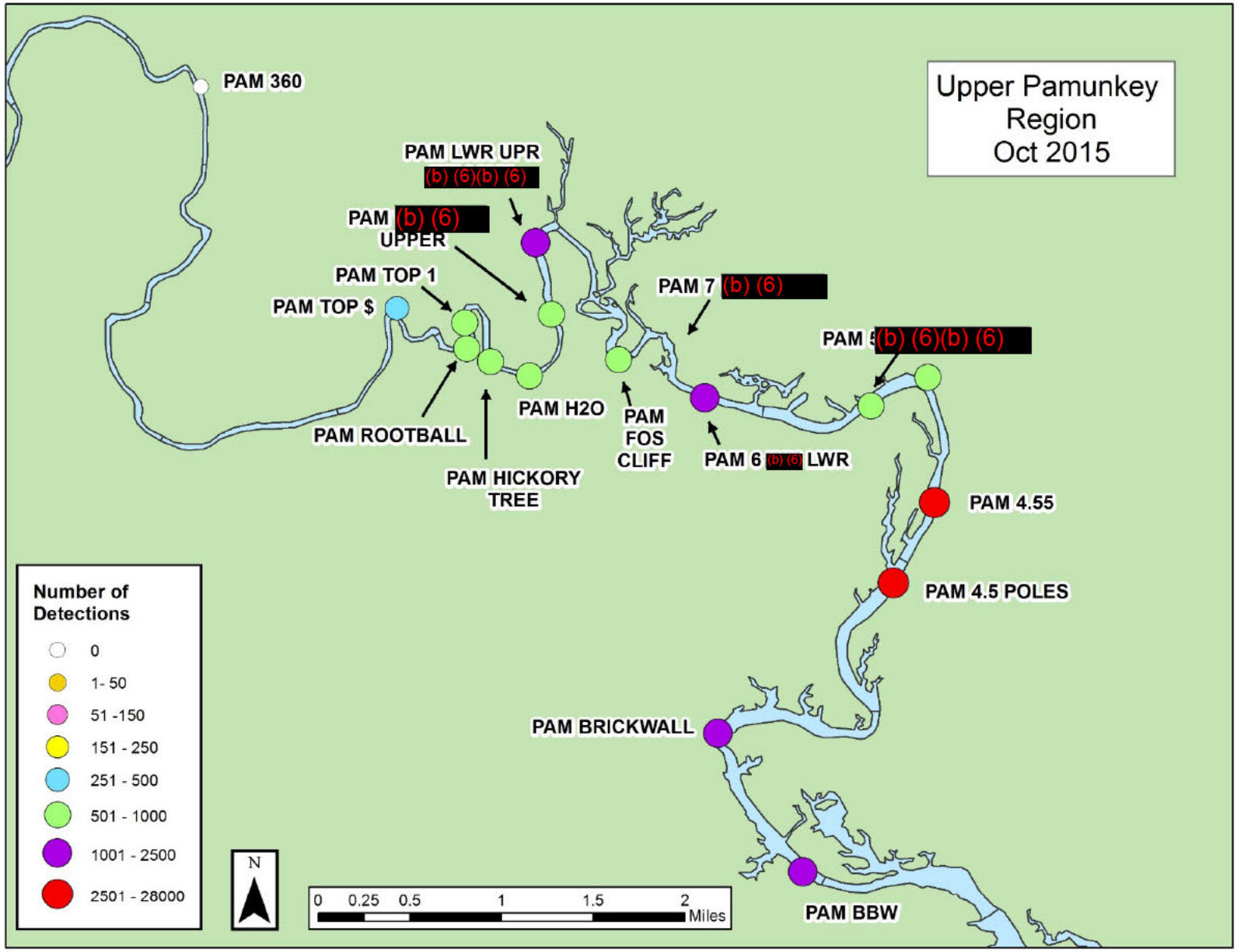

Pamunkey Region
September 2015
PAM360
PAM TOP
PAM (b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y35
Y29
Number of Detections
350 - 700
701 - 1000
1001 - 2500
2501 - 3500
3501 - 5000
5001 - 10000
10001 - 15000
15001 - 28000
N
0 0.5 1 2 3 4
Miles

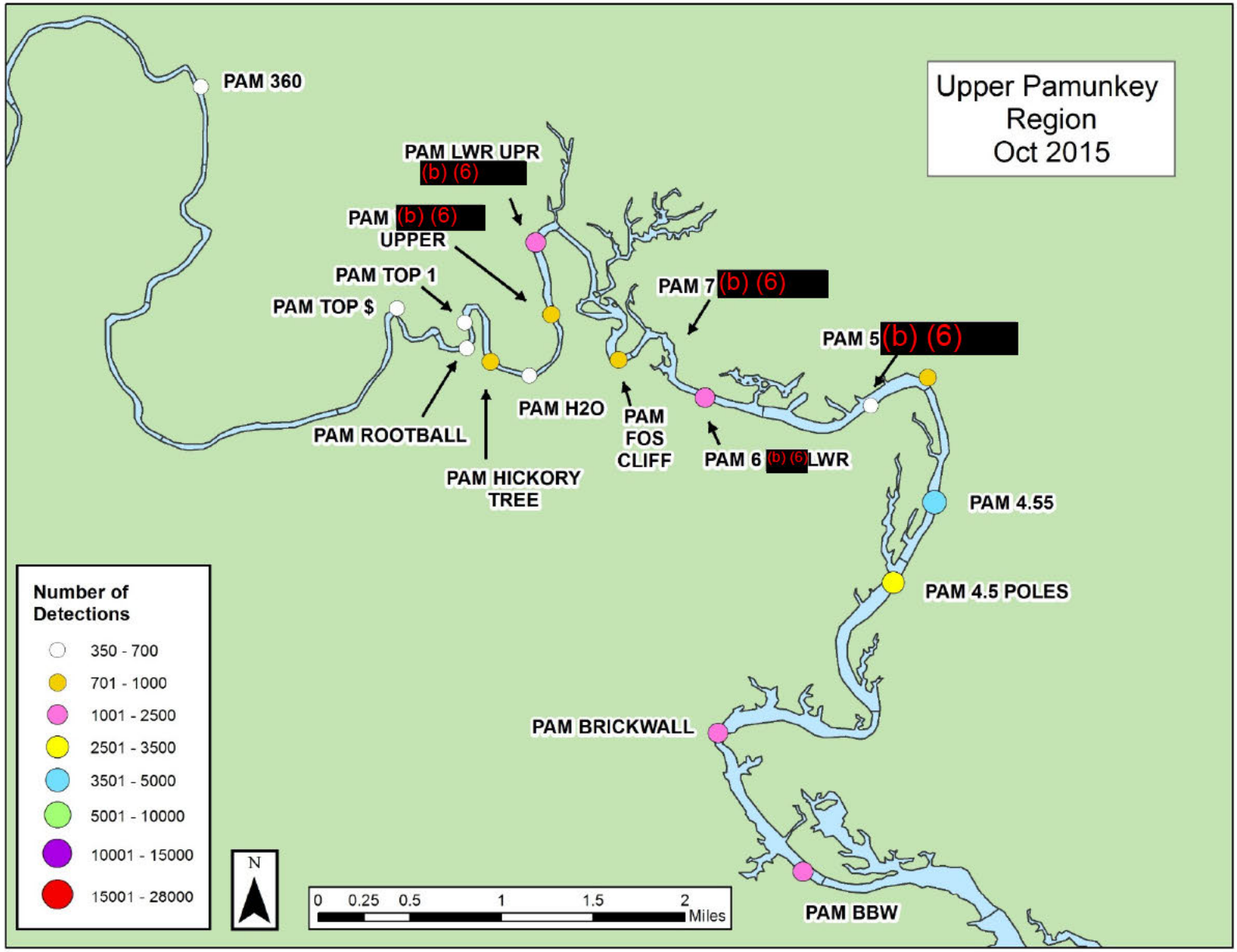

Upper Pamunkey Region Sep 2015
PAM GREEN
PAM 360
PAM LWR UPR
(b) (6)(b) (6)
PAM (b) (6) UPPER
PAM TOP 1
PAM TOP $
PAM 7 (b) (6)(b) (6)
PAM 5 (b) (6)
PAM H2O
PAM ROOTBALL
PAM FOS CLIFF
PAM 6 (b) (6) LWR
PAM HICKORY TREE
PAM 4.55
PAM 4.5 POLES
PAM BRICKWALL
PAM BBW
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 28000
N
0 0.25 0.5 1 1.5 2 Miles

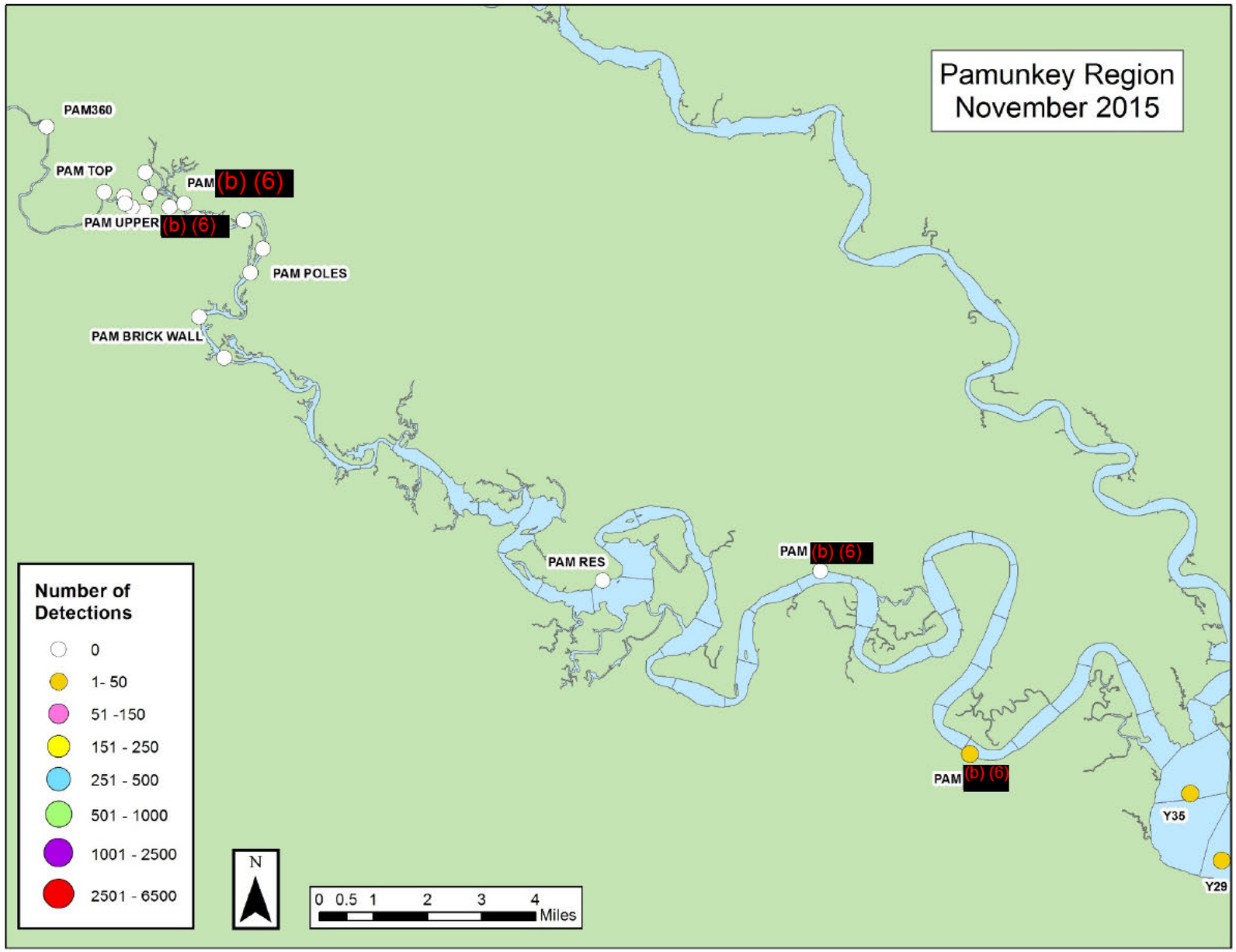

Upper Pamunkey Region Sep 2015
PAM 360
PAM GREEN
PAM LWR UPR (b) (6)
PAM (b) (6) UPPER
PAM TOP 1
PAM TOP $
PAM 7 (b) (6)
PAM 5 (b) (6)
PAM H2O
PAM ROOTBALL
PAM FOS CLIFF
PAM 6 (b) (6) LWR
PAM HICKORY TREE
PAM 4.55
PAM 4.5 POLES
PAM BRICKWALL
PAM BBW
Number of Detections
350 - 700
701 - 1000
1001 - 2500
2501 - 3500
3501 - 5000
5001 - 10000
10001 - 15000
15001 - 28000
N
0 0.25 0.5 1 1.5 2 Miles

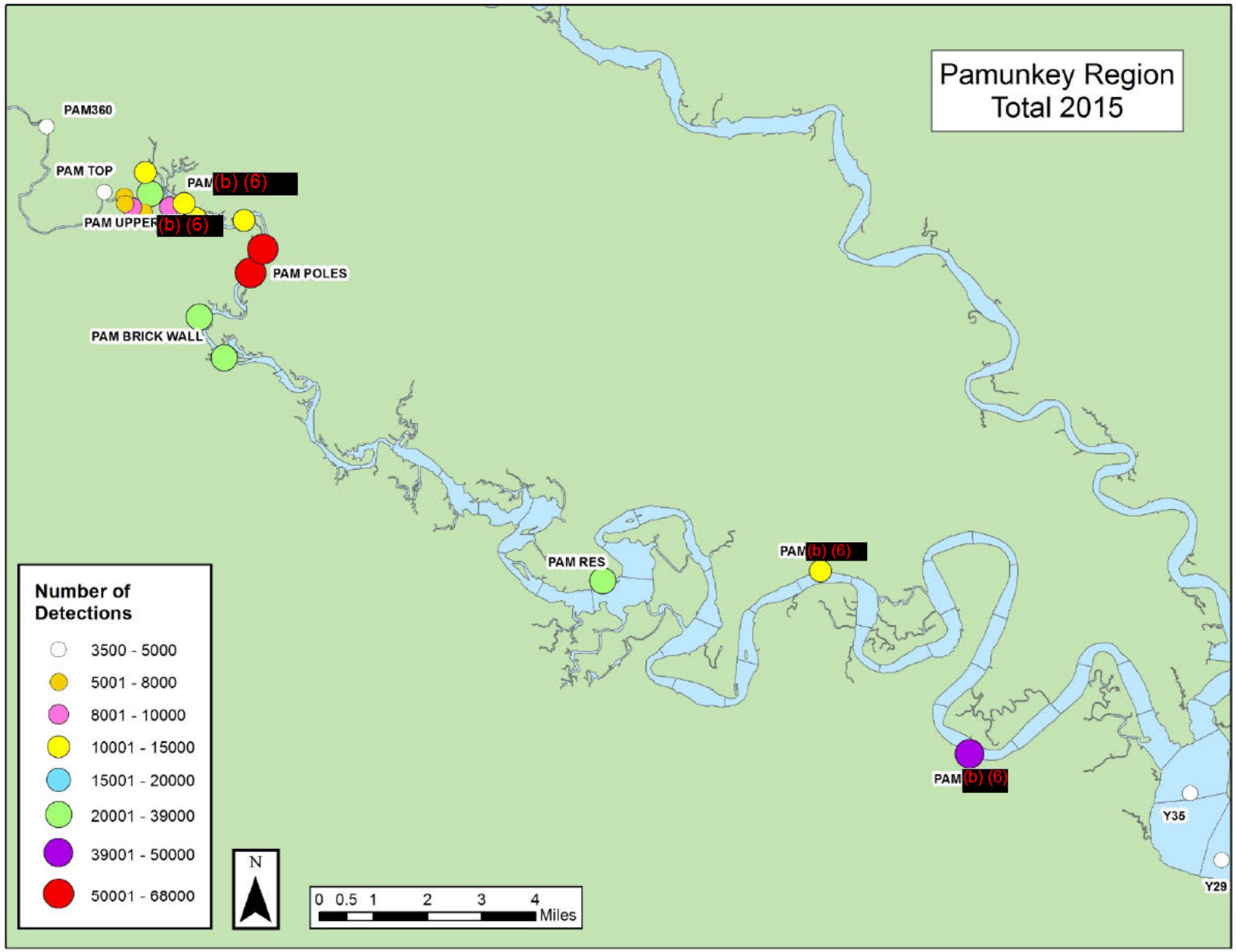

Pamunkey Region
October 2015
PAM360
PAM TOP
PAM (b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y35
Y29
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 15000
N
0 0.5 1 2 3 4
Miles

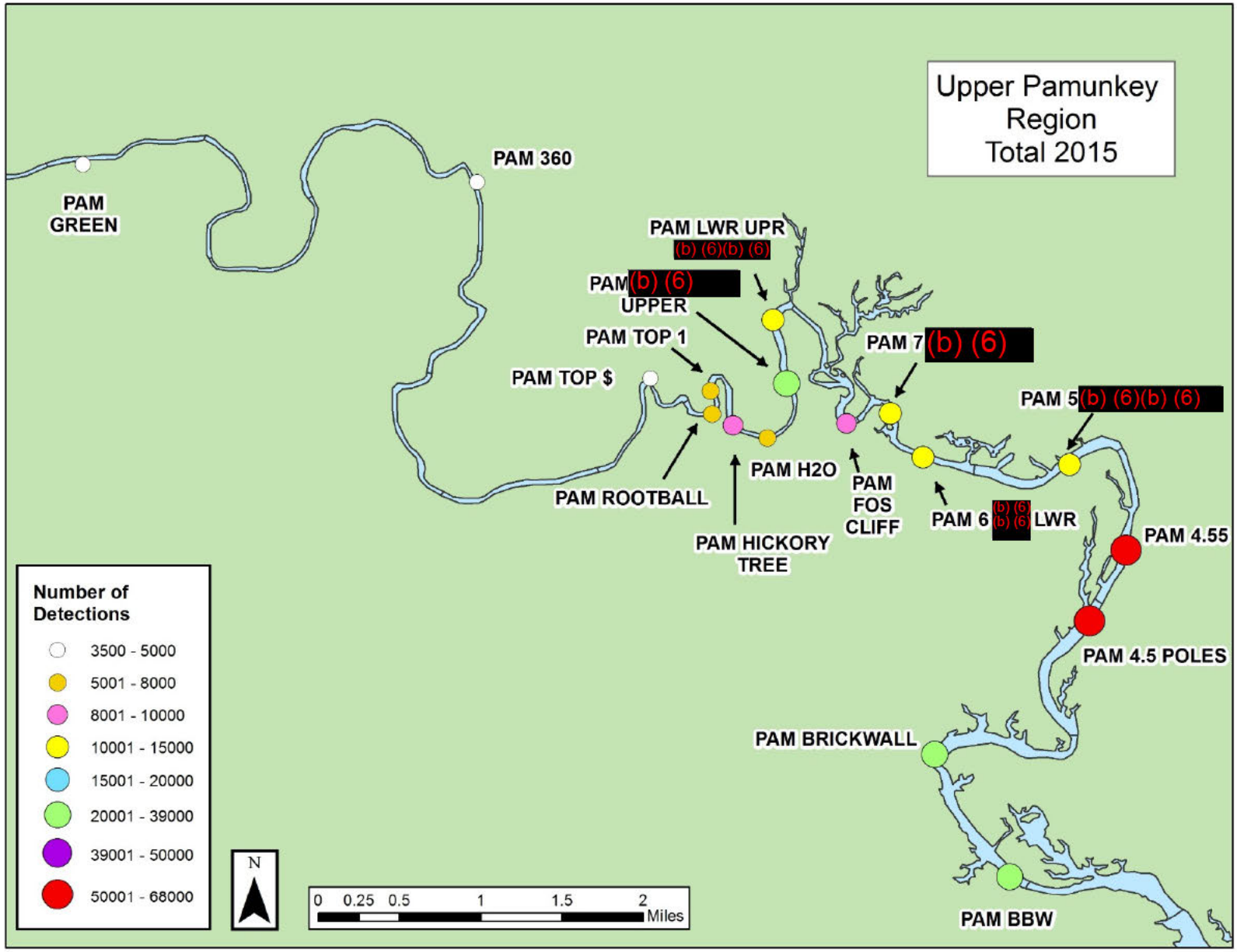

Pamunkey Region
October 2015
PAM360
PAM TOP
PAM (b) (6)(b) (6)
PAM UPPER(b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM(b) (6)
PAM(b) (6)
Y35
Y29
Number of Detections
350 - 700
701 - 1000
1001 - 2500
2501 - 3500
3501 - 5000
5001 - 10000
10001 - 15000
15001 - 28000
N
0 0.5 1 2 3 4
Miles

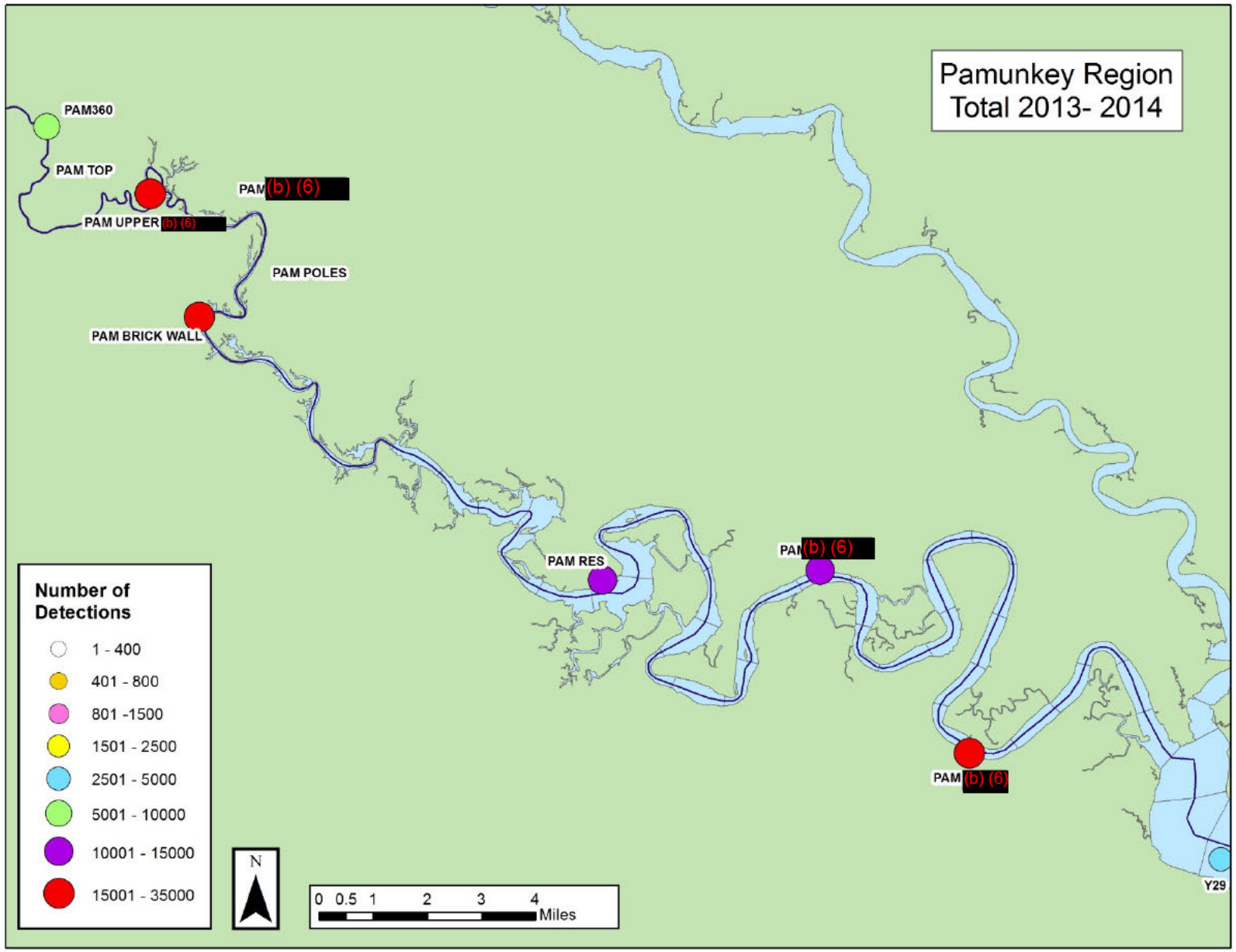

Upper Pamunkey Region Oct 2015
PAM 360
PAM LWR UPR
(b) (6)(b) (6)
PAM (b) (6)
UPPER
PAM TOP 1
PAM TOP $
PAM 7 (b) (6)
PAM 5(b) (6)(b) (6)
PAM H2O
PAM ROOTBALL
PAM HICKORY TREE
PAM FOS CLIFF
PAM 6 (b) (6) LWR
PAM 4.55
PAM 4.5 POLES
PAM BRICKWALL
PAM BBW
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 28000
N
0 0.25 0.5 1 1.5 2 Miles

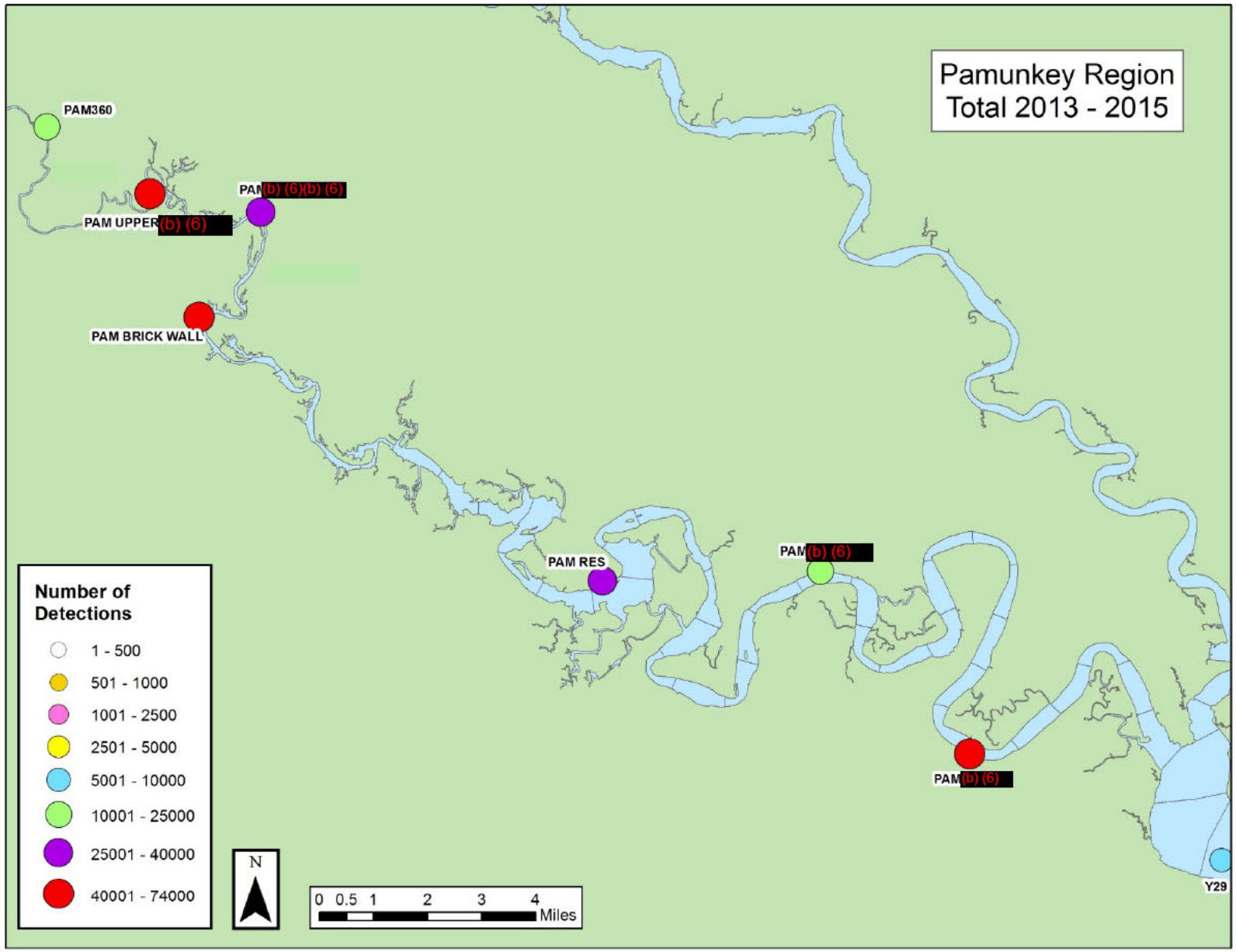

Upper Pamunkey Region Oct 2015
PAM 360
PAM LWR UPR (b) (6)
PAM (b) (6) UPPER
PAM TOP 1
PAM TOP $
PAM 7 (b) (6)
PAM 5 (b) (6)
PAM H2O
PAM ROOTBALL
PAM HICKORY TREE
PAM FOS CLIFF
PAM 6 (b) (6) LWR
PAM 4.55
PAM 4.5 POLES
PAM BRICKWALL
PAM BBW
Number of Detections
350 - 700
701 - 1000
1001 - 2500
2501 - 3500
3501 - 5000
5001 - 10000
10001 - 15000
15001 - 28000
N
0 0.25 0.5 1 1.5 2 Miles


Pamunkey Region
November 2015
PAM360
PAM TOP
PAM (b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y35
Y29
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

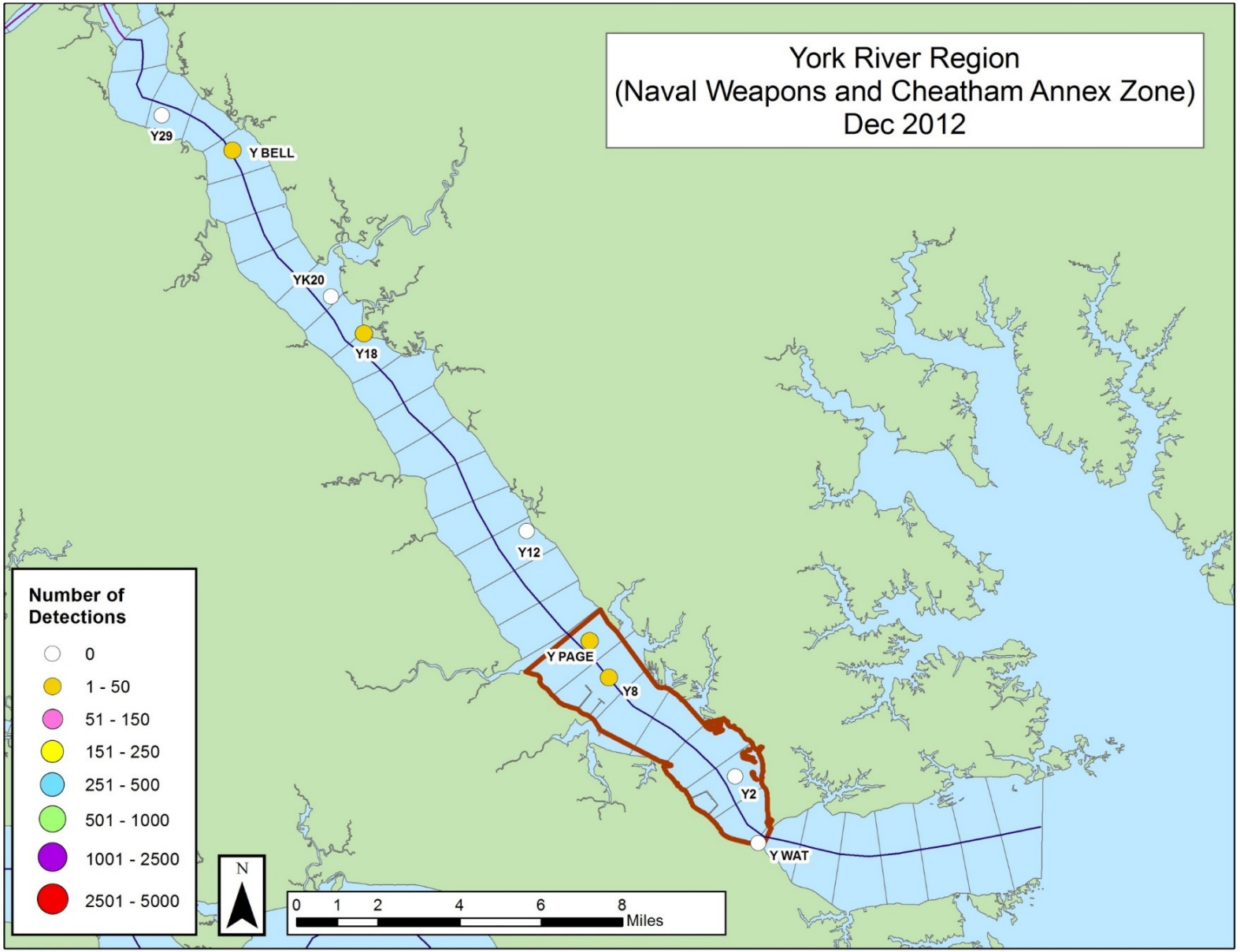

Pamunkey Region
Total 2015
PAM360
PAM TOP
PAM (b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAM (b) (6)
PAM (b) (6)
Y35
Y29
Number of Detections
3500 - 5000
5001 - 8000
8001 - 10000
10001 - 15000
15001 - 20000
20001 - 39000
39001 - 50000
50001 - 68000
N
0 0.5 1 2 3 4
Miles

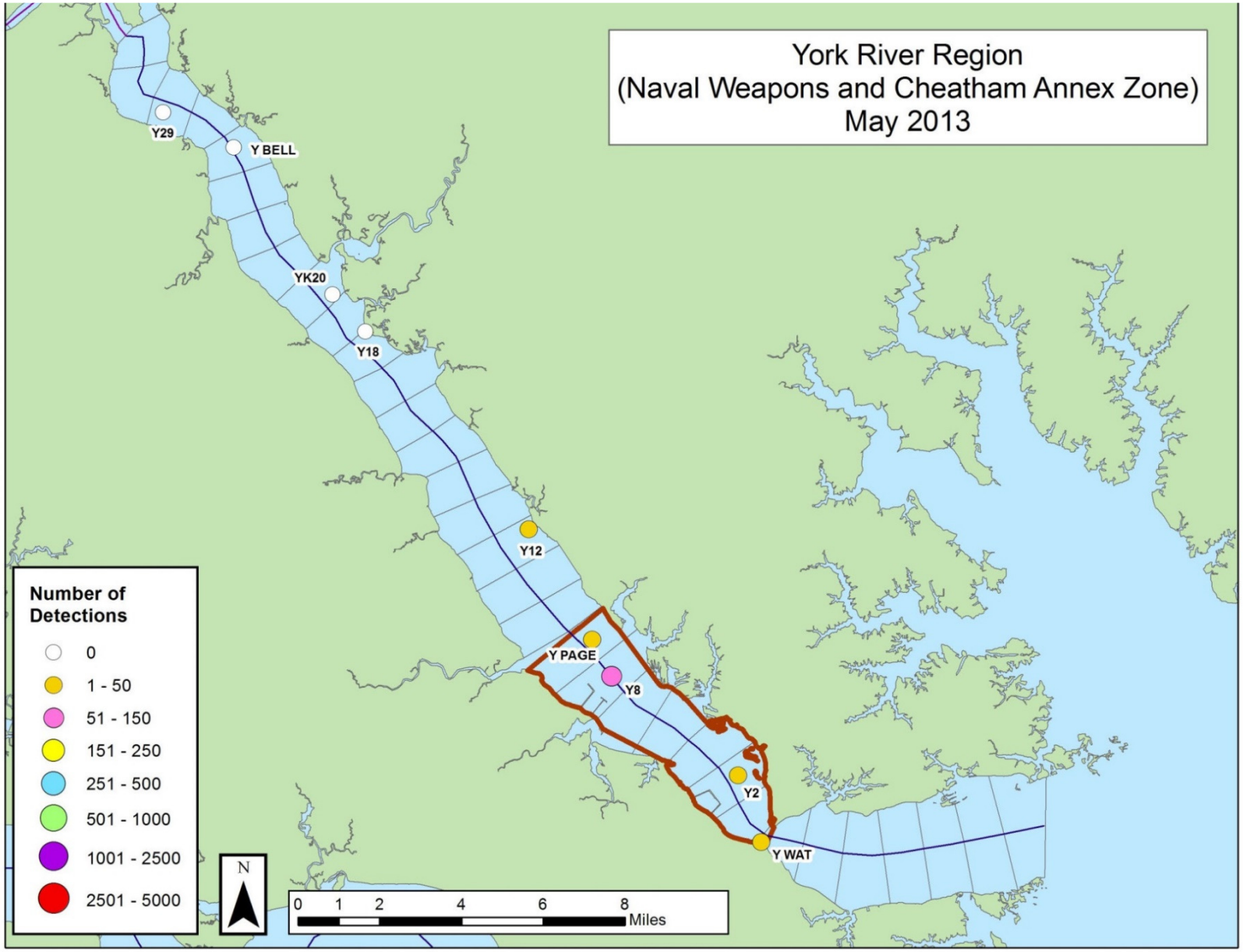

Upper Pamunkey Region Total 2015
PAM 360
PAM GREEN
PAM LWR UPR
(b) (6)(b) (6)
PAM (b) (6)
UPPER
PAM TOP 1
PAM TOP $
PAM 7 (b) (6)
PAM 5 (b) (6)(b) (6)
PAM H2O
PAM ROOTBALL
PAM FOS CLIFF
PAM 6 (b) (6) (b) (6) LWR
PAM HICKORY TREE
PAM 4.55
PAM 4.5 POLES
PAM BRICKWALL
PAM BBW
Number of Detections
3500 - 5000
5001 - 8000
8001 - 10000
10001 - 15000
15001 - 20000
20001 - 39000
39001 - 50000
50001 - 68000
N
0 0.25 0.5 1 1.5 2 Miles

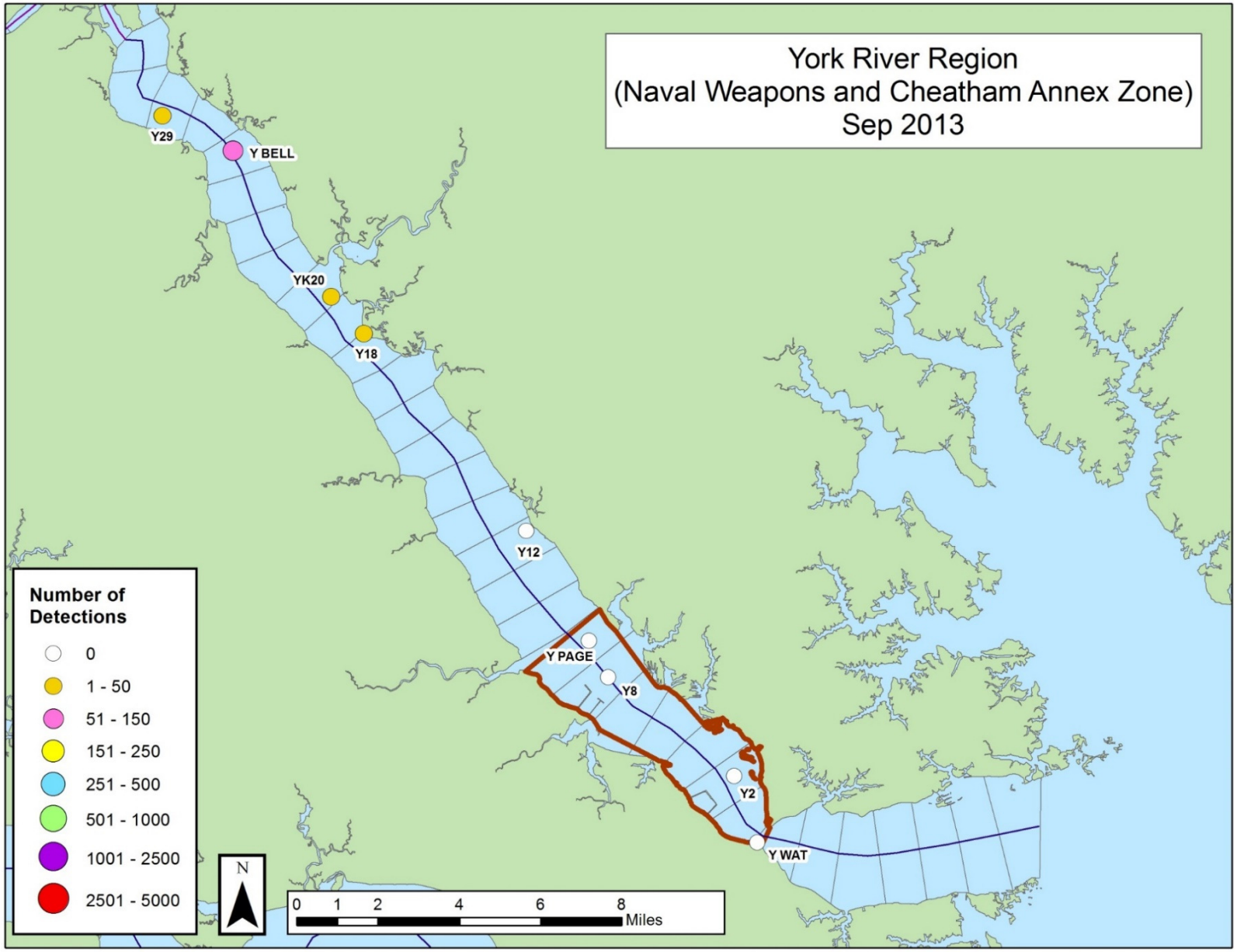

Pamunkey Region
Total 2013- 2014
PAM360
PAM TOP
PAM (b) (6)
PAM UPPER (b) (6)
PAM POLES
PAM BRICK WALL
PAM RES
PAI (b) (6)
PAM (b) (6)
Y29
Number of Detections
1 - 400
401 - 800
801 -1500
1501 - 2500
2501 - 5000
5001 - 10000
10001 - 15000
15001 - 35000
N
0 0.5 1 2 3 4
Miles

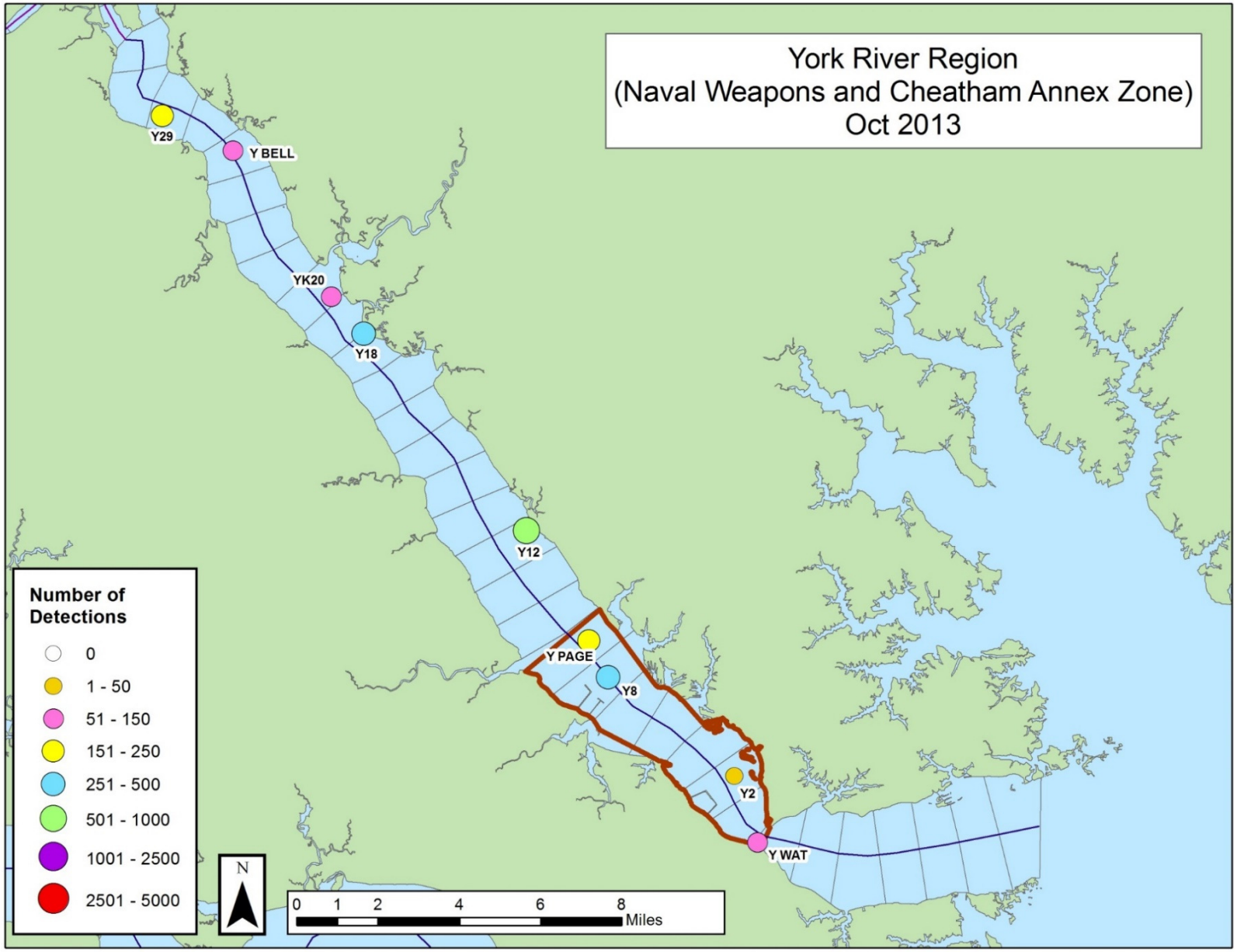

Pamunkey Region
Total 2013 - 2015
PAM360
PAM UPPER
PAM BRICK WALL
PAM RES
Y29
Number of Detections
1 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 10000
10001 - 25000
25001 - 40000
40001 - 74000
N
0 0.5 1 2 3 4
Miles

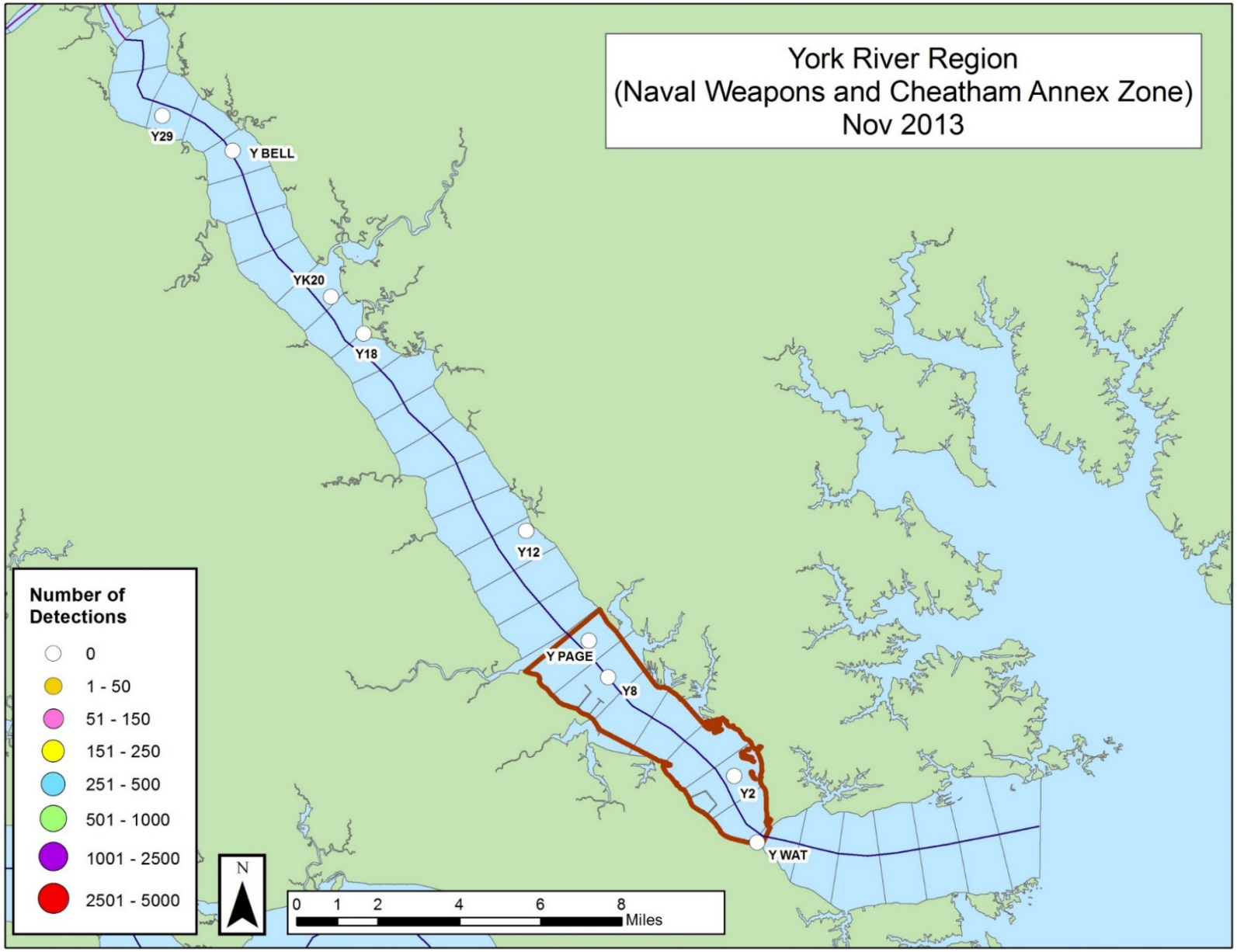
## 9.4 APPENDIX 4.4.2: YORK RIVER REGION (NAVAL WEAPONS STATION YORKTOWN AND CHEATHAM ANNEX ZONE)

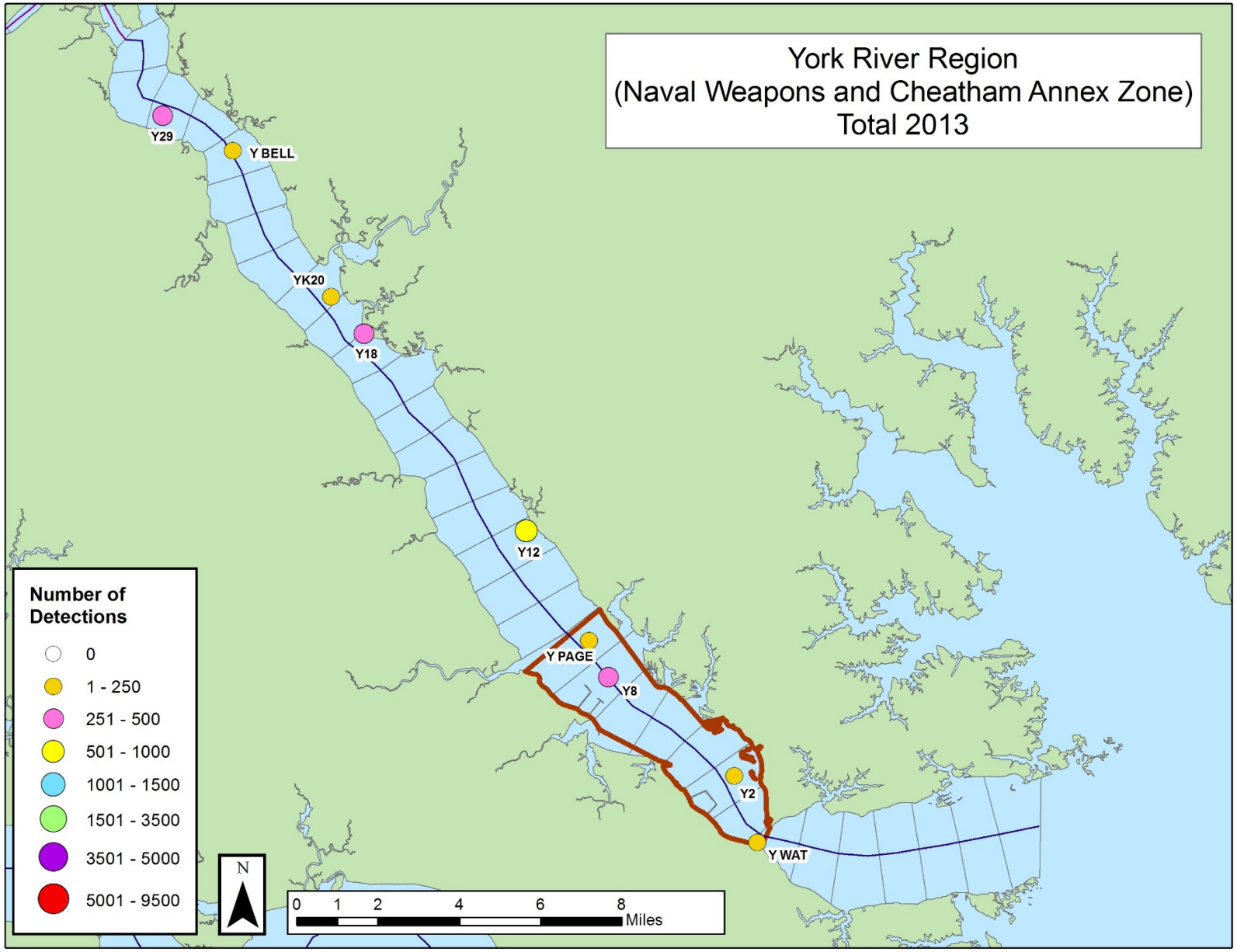


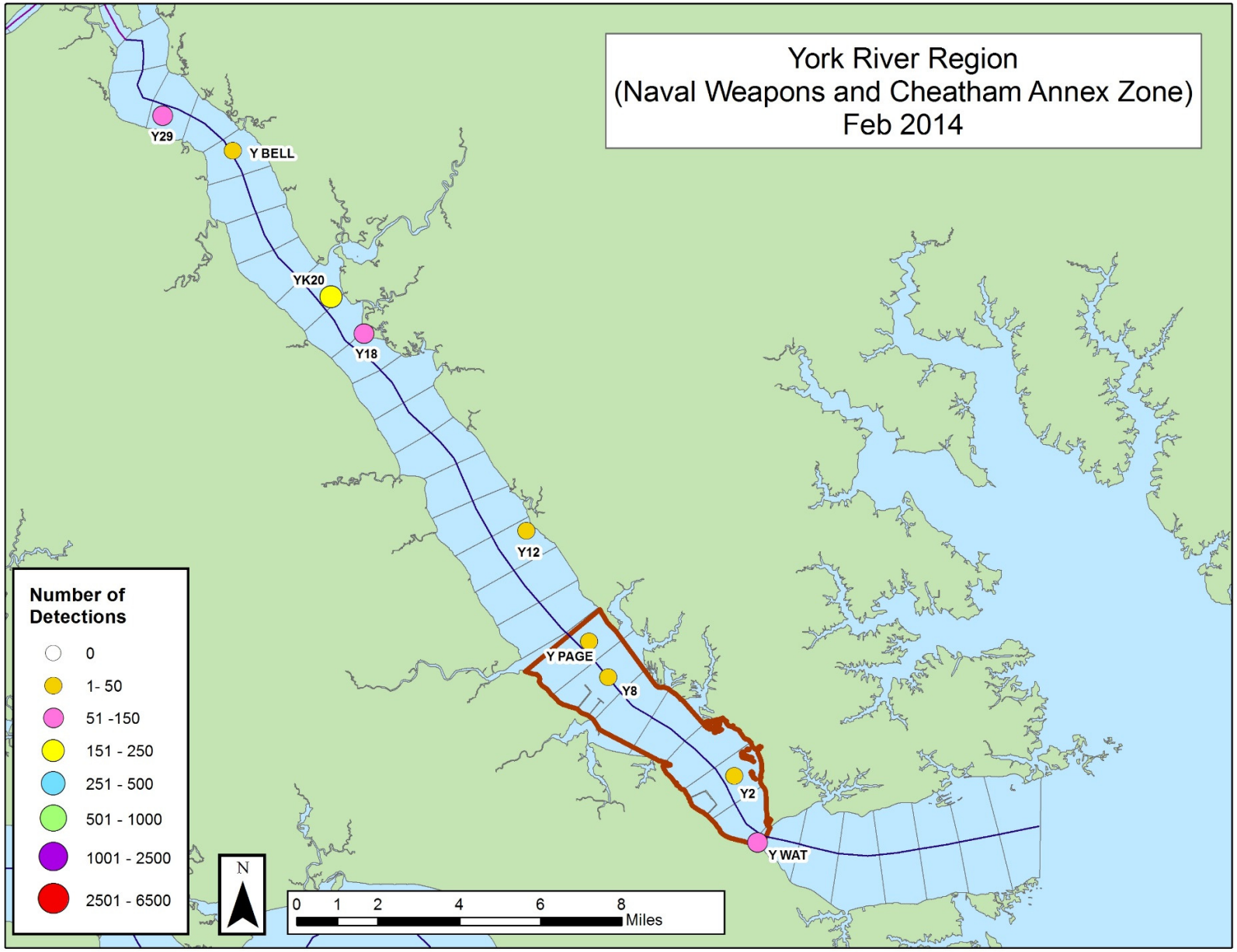

York River Region
(Naval Weapons and Cheatham Annex Zone)
May 2013
Y29
Y BELL
YK20
Y18
Y12
Y PAGE
Y8
Y2
Y WAT
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 1 2 4 6 8
Miles

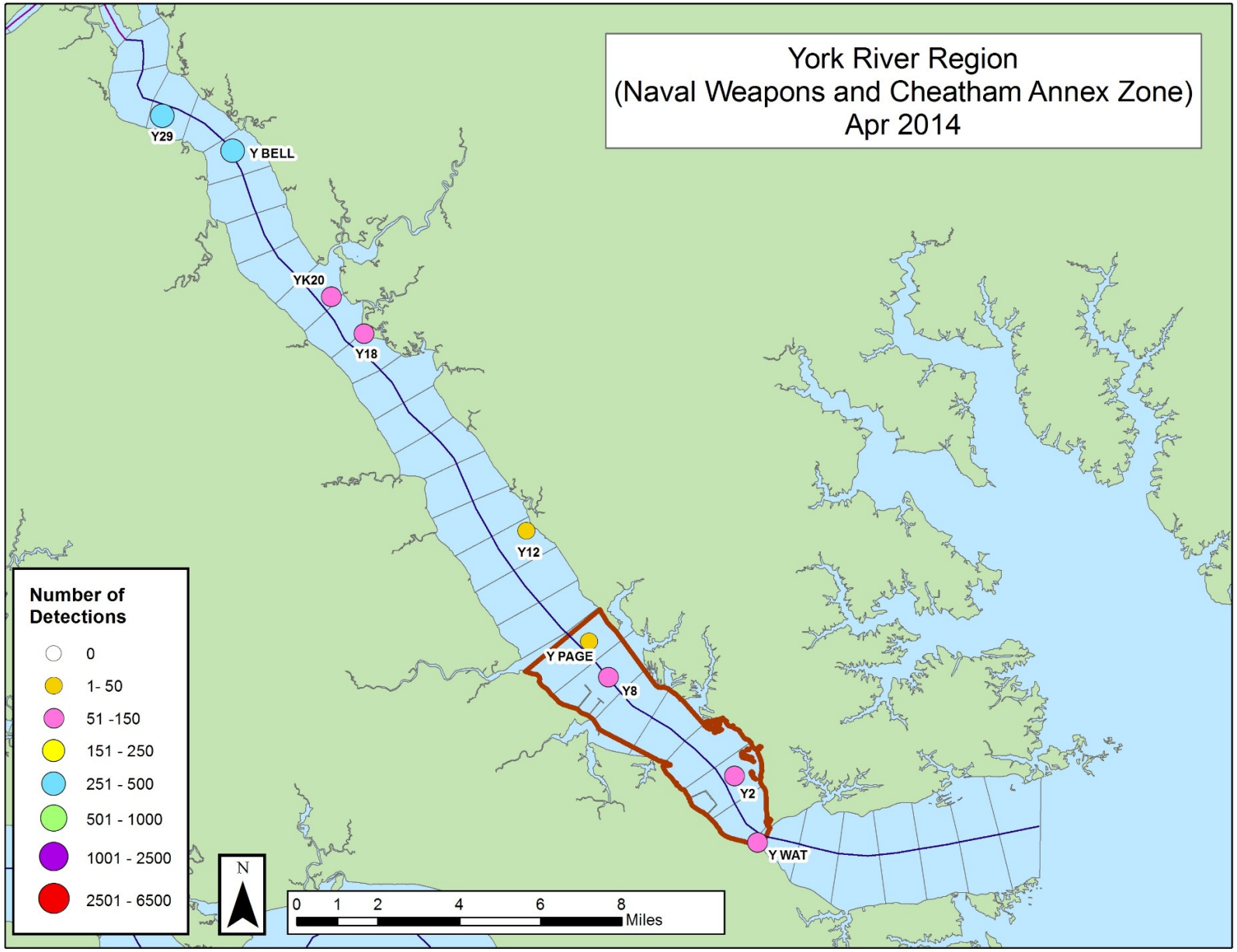

York River Region
(Naval Weapons and Cheatham Annex Zone)
Sep 2013
Y29
Y BELL
YK20
Y18
Y12
Y PAGE
Y8
Y2
Y WAT
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 1 2 4 6 8
Miles

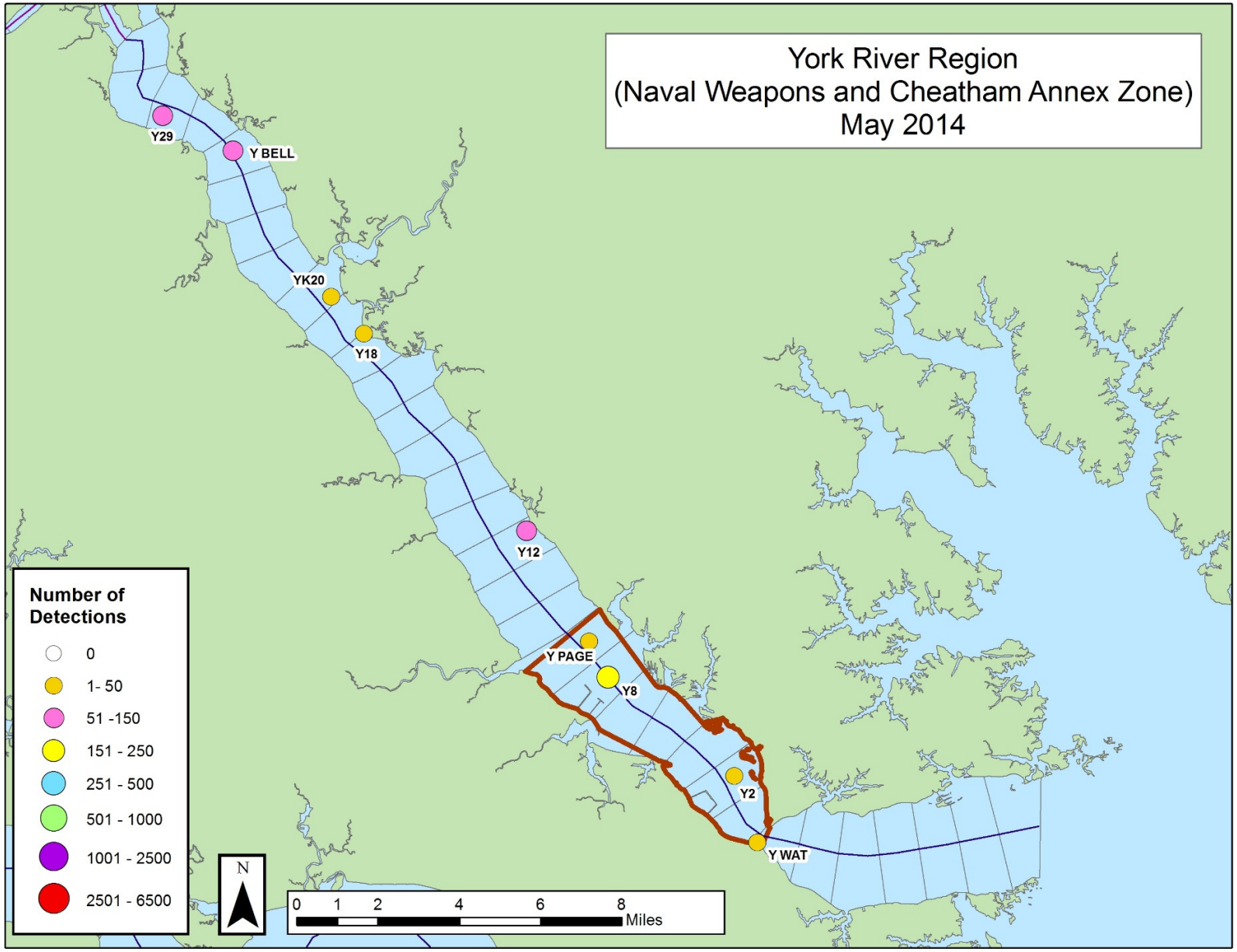

York River Region
(Naval Weapons and Cheatham Annex Zone)
Oct 2013
Y29
Y BELL
YK20
Y18
Y12
Y PAGE
Y8
Y2
Y WAT
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 1 2 4 6 8
Miles

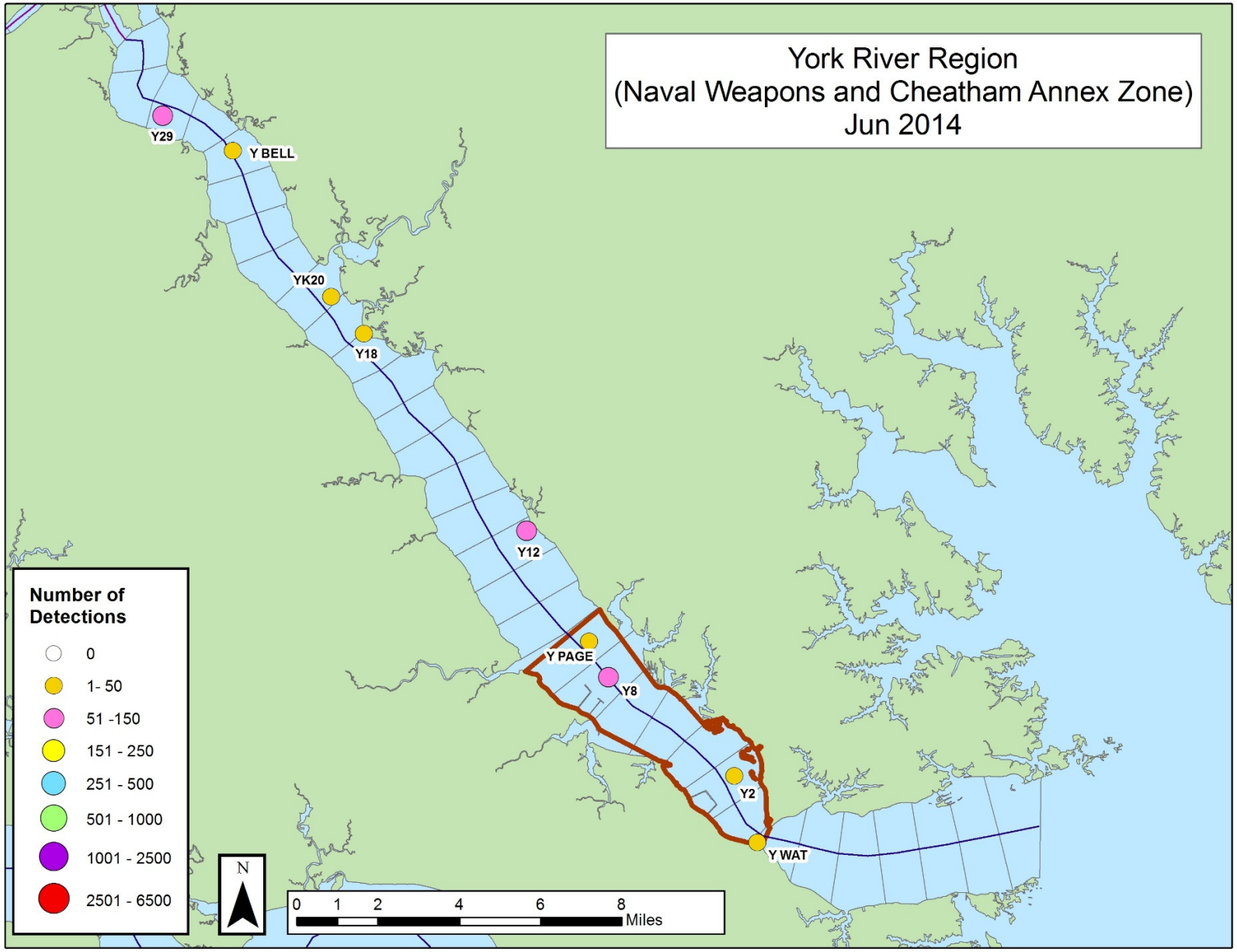

York River Region
(Naval Weapons and Cheatham Annex Zone)
Nov 2013
Y29
Y BELL
YK20
Y18
Y12
Y PAGE
Y8
Y2
Y WAT
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 1 2 4 6 8
Miles

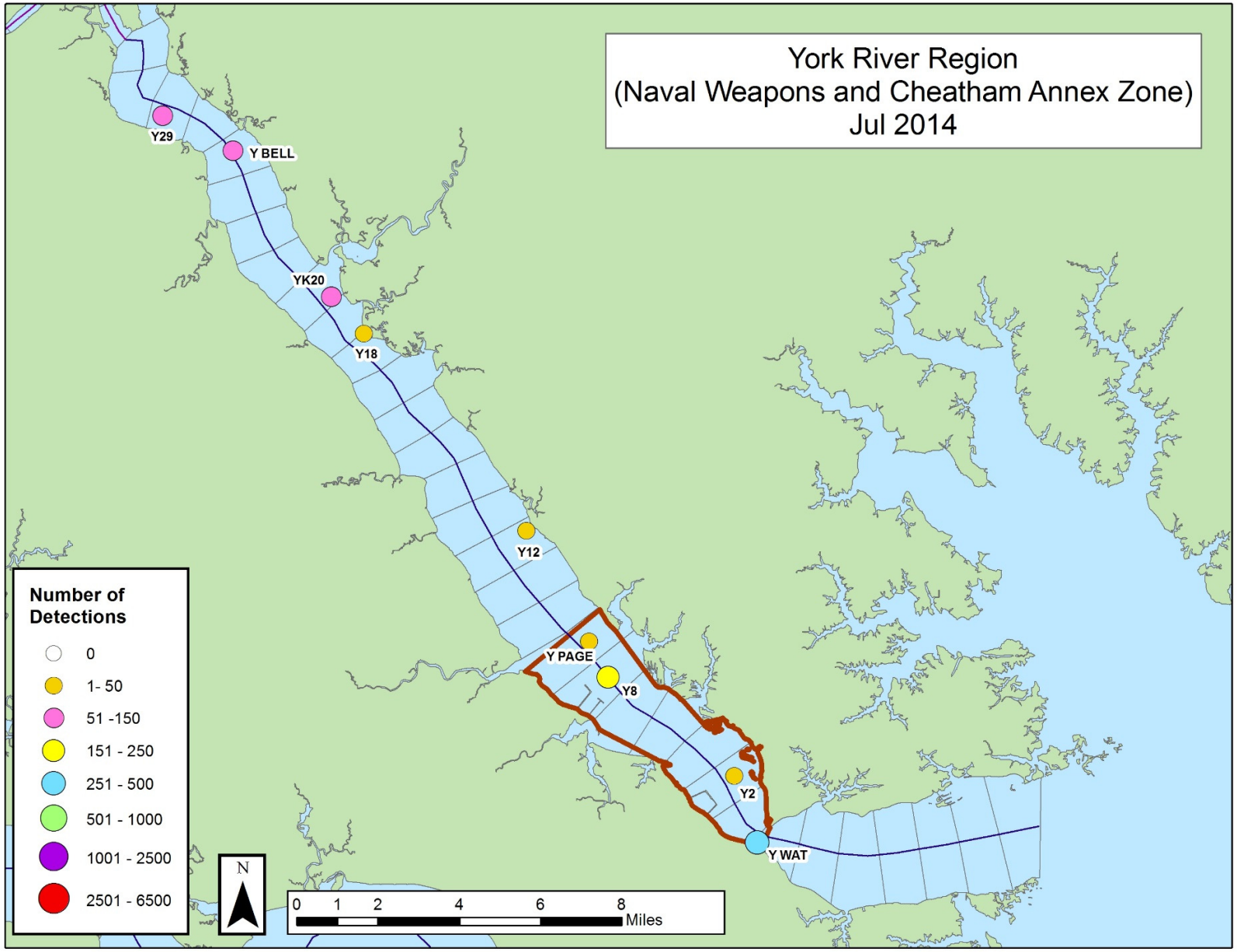

York River Region
(Naval Weapons and Cheatham Annex Zone)
Total 2013
Y29
Y BELL
YK20
Y18
Y12
Y PAGE
Y8
Y2
Y WAT
Number of Detections
0
1 - 250
251 - 500
501 - 1000
1001 - 1500
1501 - 3500
3501 - 5000
5001 - 9500
N
0 1 2 4 6 8
Miles

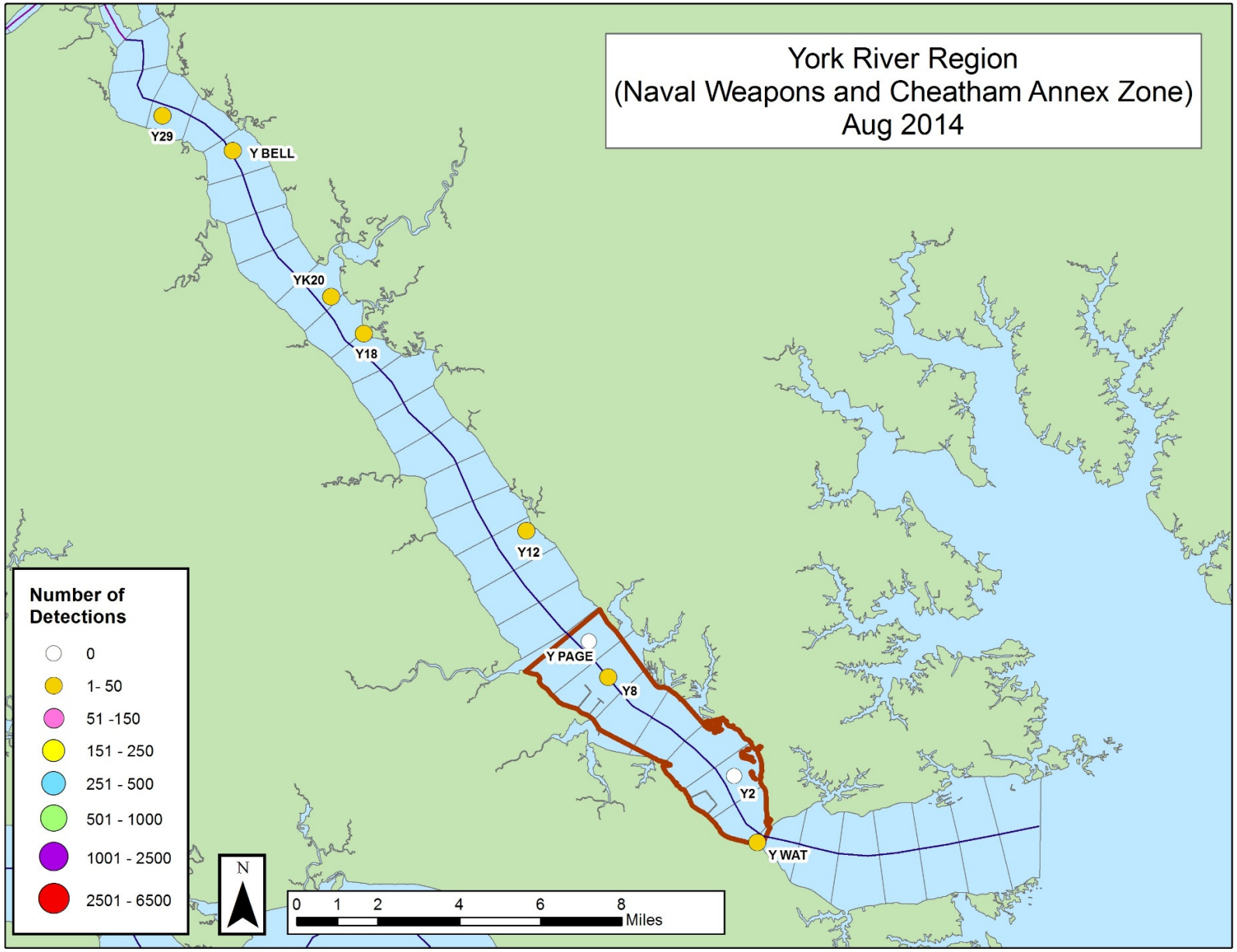

York River Region
(Naval Weapons and Cheatham Annex Zone)
Feb 2014
Y29
Y BELL
YK20
Y18
Y12
Y PAGE
Y8
Y2
Y WAT
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles

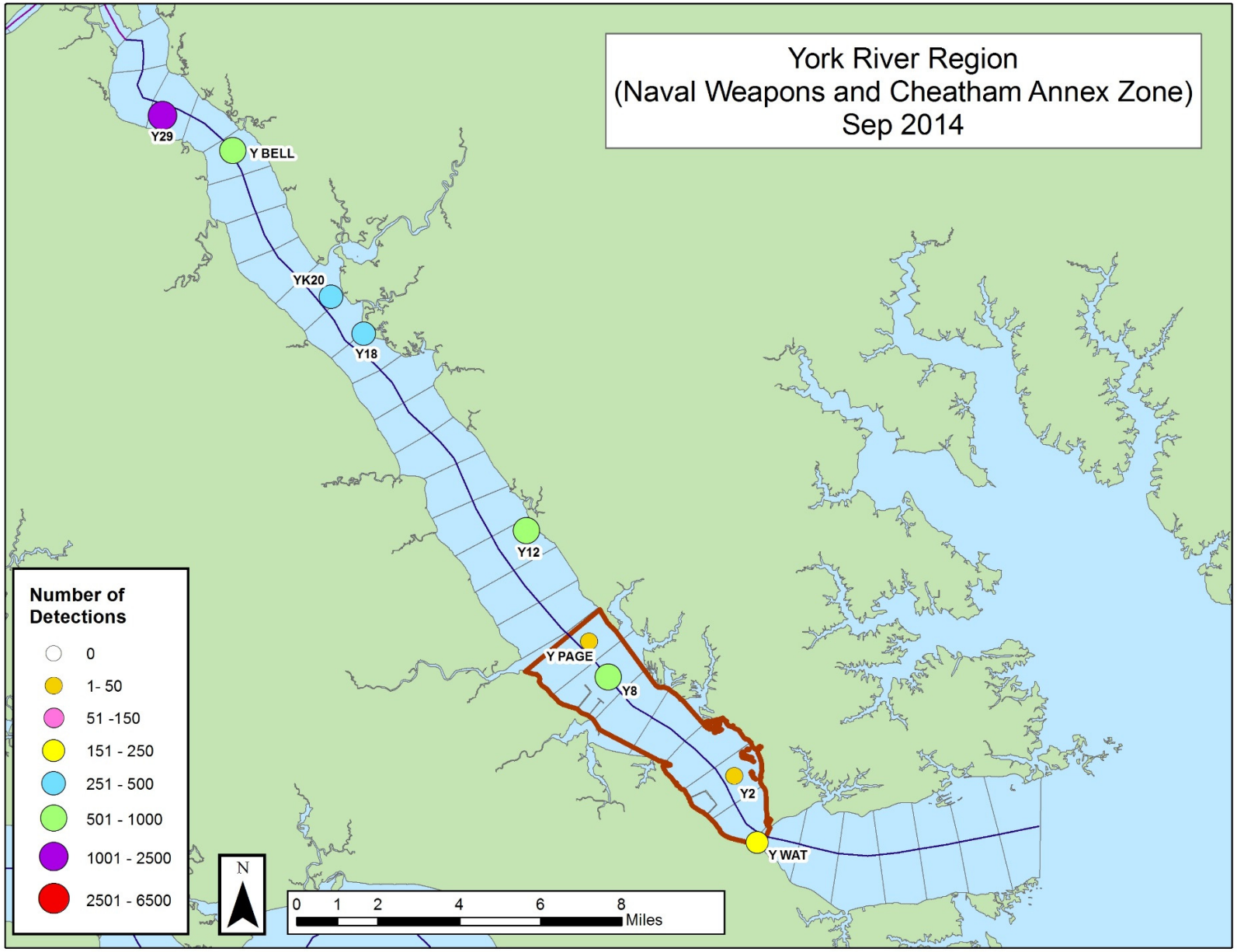

York River Region
(Naval Weapons and Cheatham Annex Zone)
Apr 2014
Y29
Y BELL
YK20
Y18
Y12
Y PAGE
Y8
Y2
Y WAT
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles

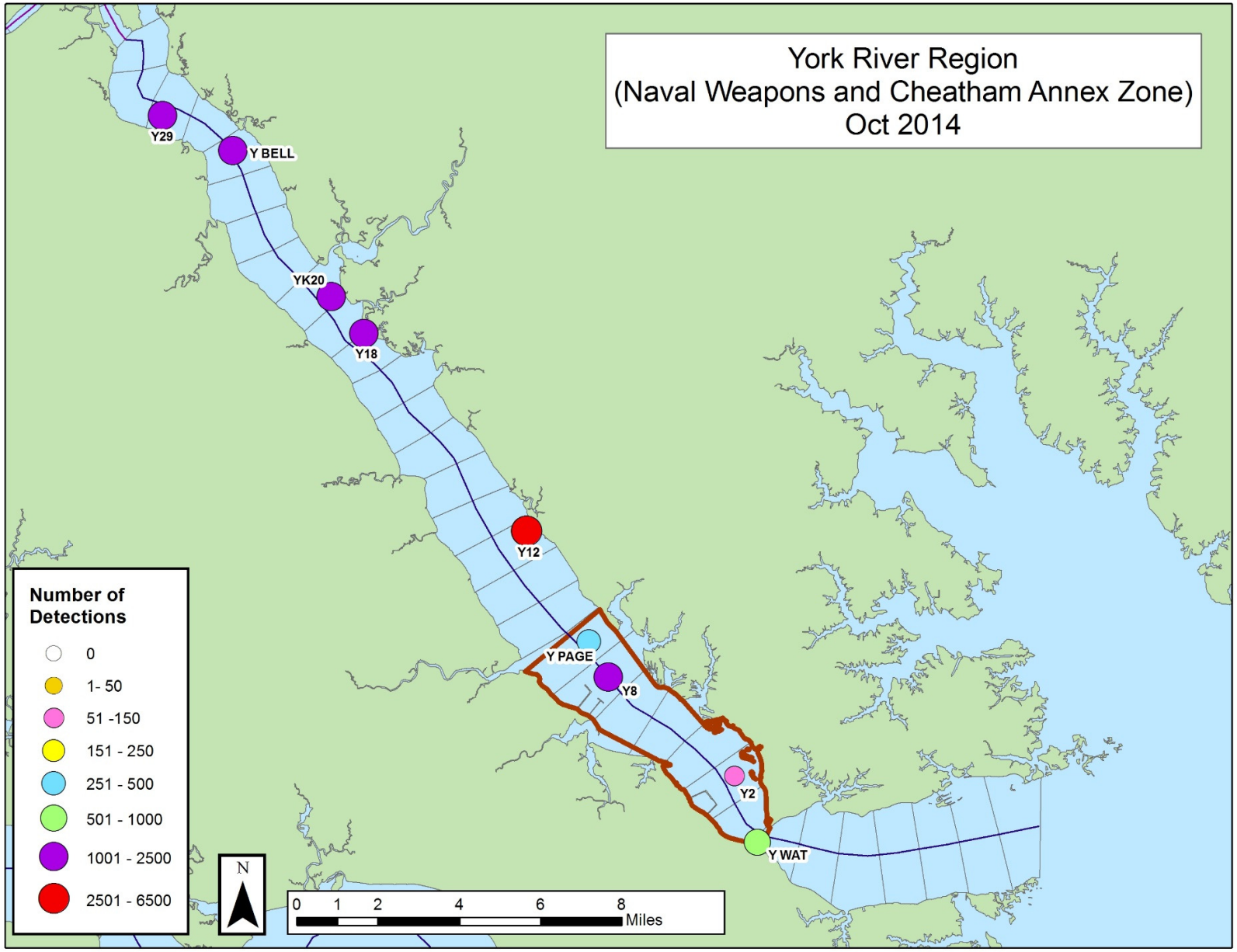

York River Region
(Naval Weapons and Cheatham Annex Zone)
May 2014
Y29
Y BELL
YK20
Y18
Y12
Y PAGE
Y8
Y2
Y WAT
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles

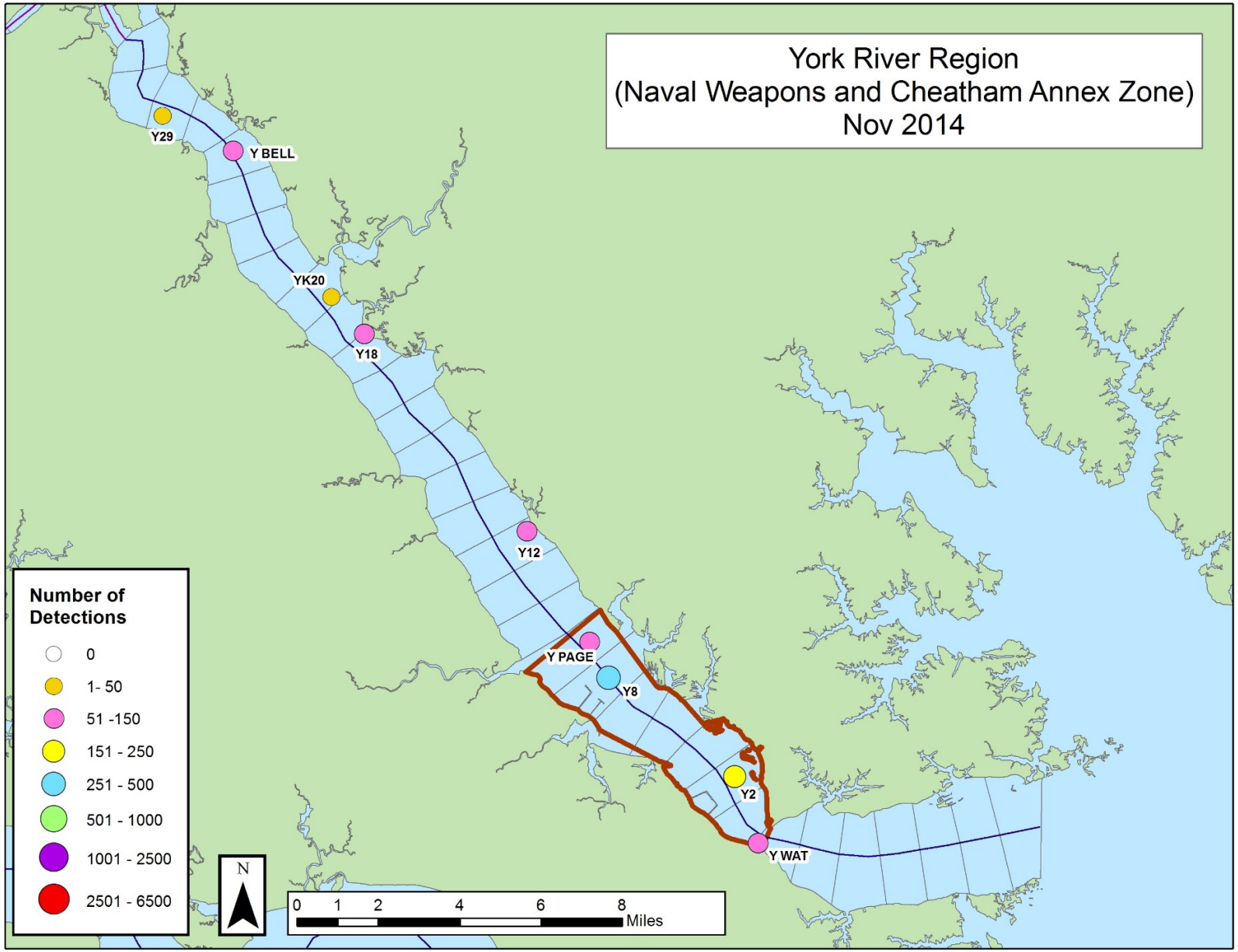

York River Region
(Naval Weapons and Cheatham Annex Zone)
Jun 2014
Y29
Y BELL
YK20
Y18
Y12
Y PAGE
Y8
Y2
Y WAT
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles

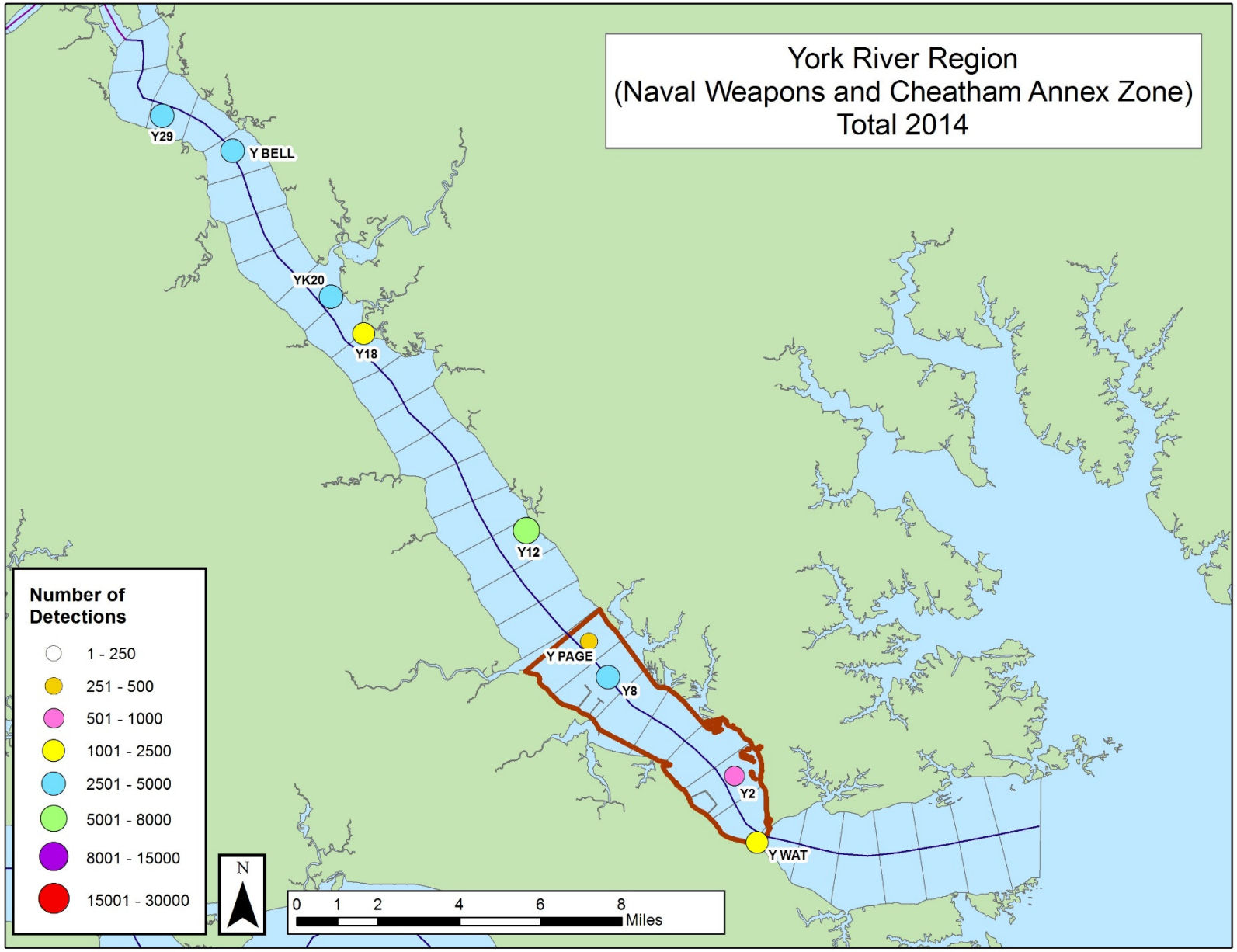

York River Region
(Naval Weapons and Cheatham Annex Zone)
Jul 2014
Y29
Y BELL
YK20
Y18
Y12
Y PAGE
Y8
Y2
Y WAT
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles

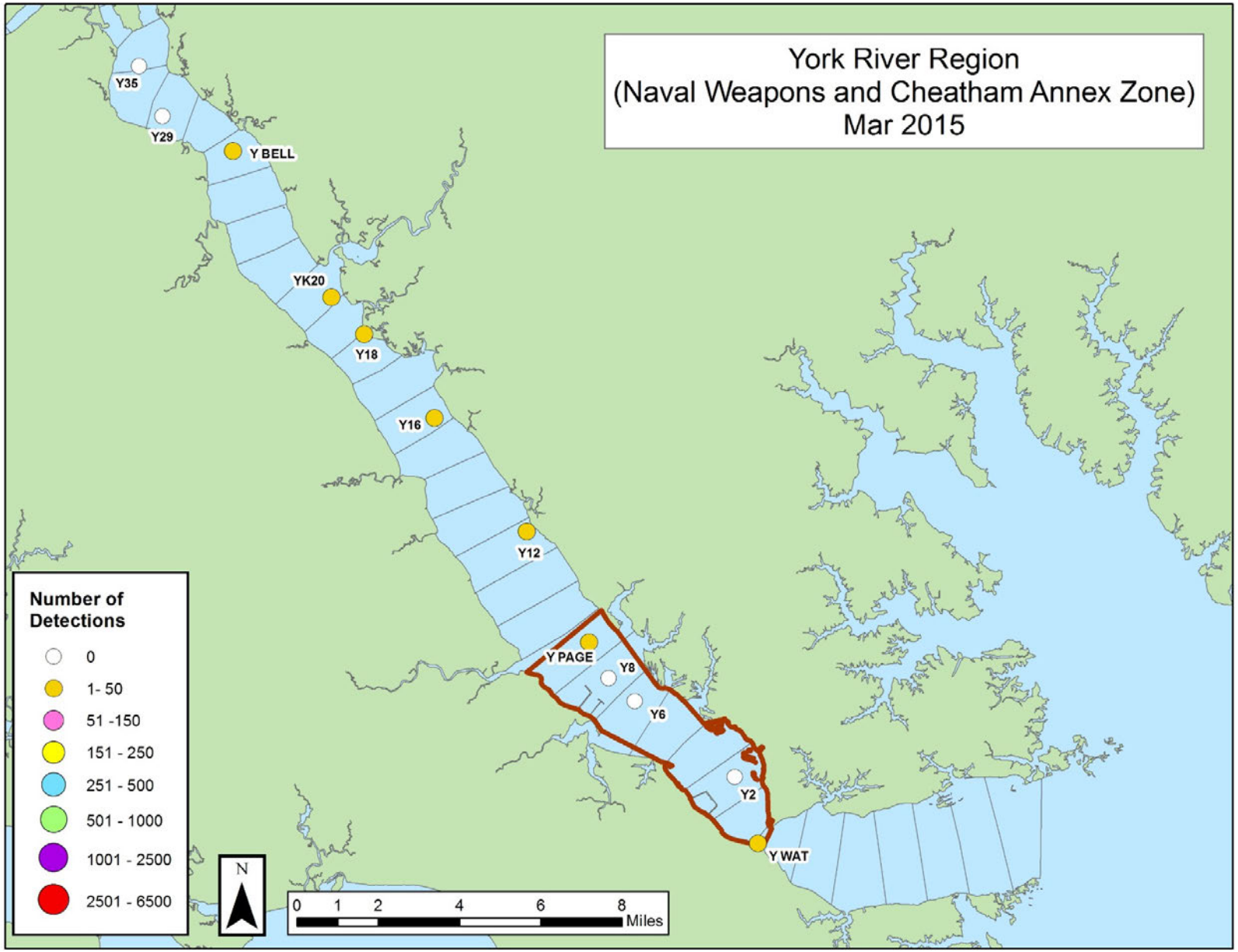

York River Region
(Naval Weapons and Cheatham Annex Zone)
Aug 2014
Y29
Y BELL
YK20
Y18
Y12
Y PAGE
Y8
Y2
Y WAT
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles


York River Region
(Naval Weapons and Cheatham Annex Zone)
Sep 2014
Y29
Y BELL
YK20
Y18
Y12
Y PAGE
Y8
Y2
Y WAT
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles


York River Region
(Naval Weapons and Cheatham Annex Zone)
Oct 2014
Y29
Y BELL
YK20
Y18
Y12
Y PAGE
Y8
Y2
Y WAT
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles


York River Region
(Naval Weapons and Cheatham Annex Zone)
Nov 2014
Y29
Y BELL
YK20
Y18
Y12
Y PAGE
Y8
Y2
Y WAT
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles


York River Region
(Naval Weapons and Cheatham Annex Zone)
Total 2014
Y29
Y BELL
YK20
Y18
Y12
Y PAGE
Y8
Y2
Y WAT
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
N
0 1 2 4 6 8
Miles


York River Region
(Naval Weapons and Cheatham Annex Zone)
Mar 2015
Y35
Y29
Y BELL
YK20
Y18
Y16
Y12
Y PAGE
Y8
Y6
Y2
Y WAT
Number of Detections
0
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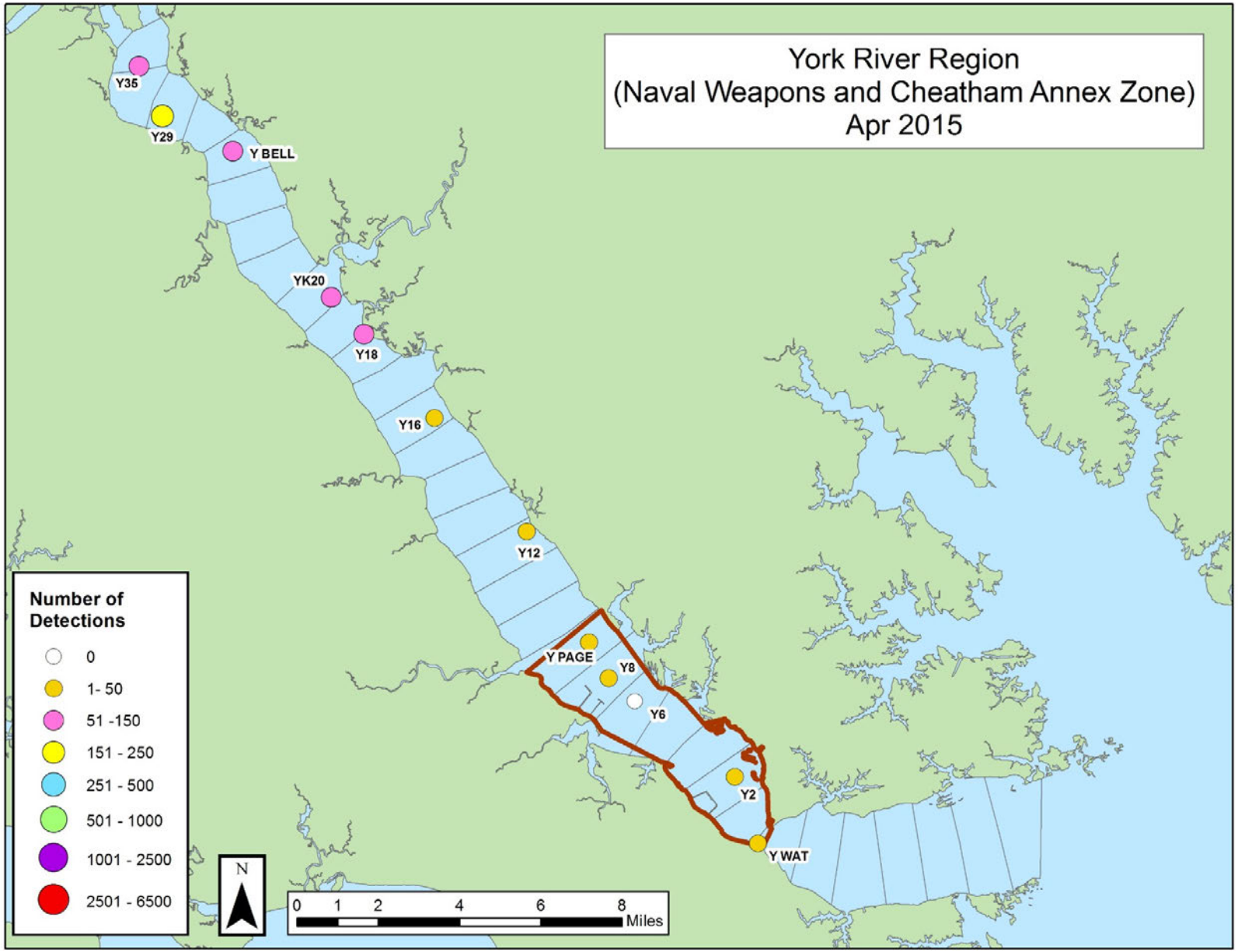
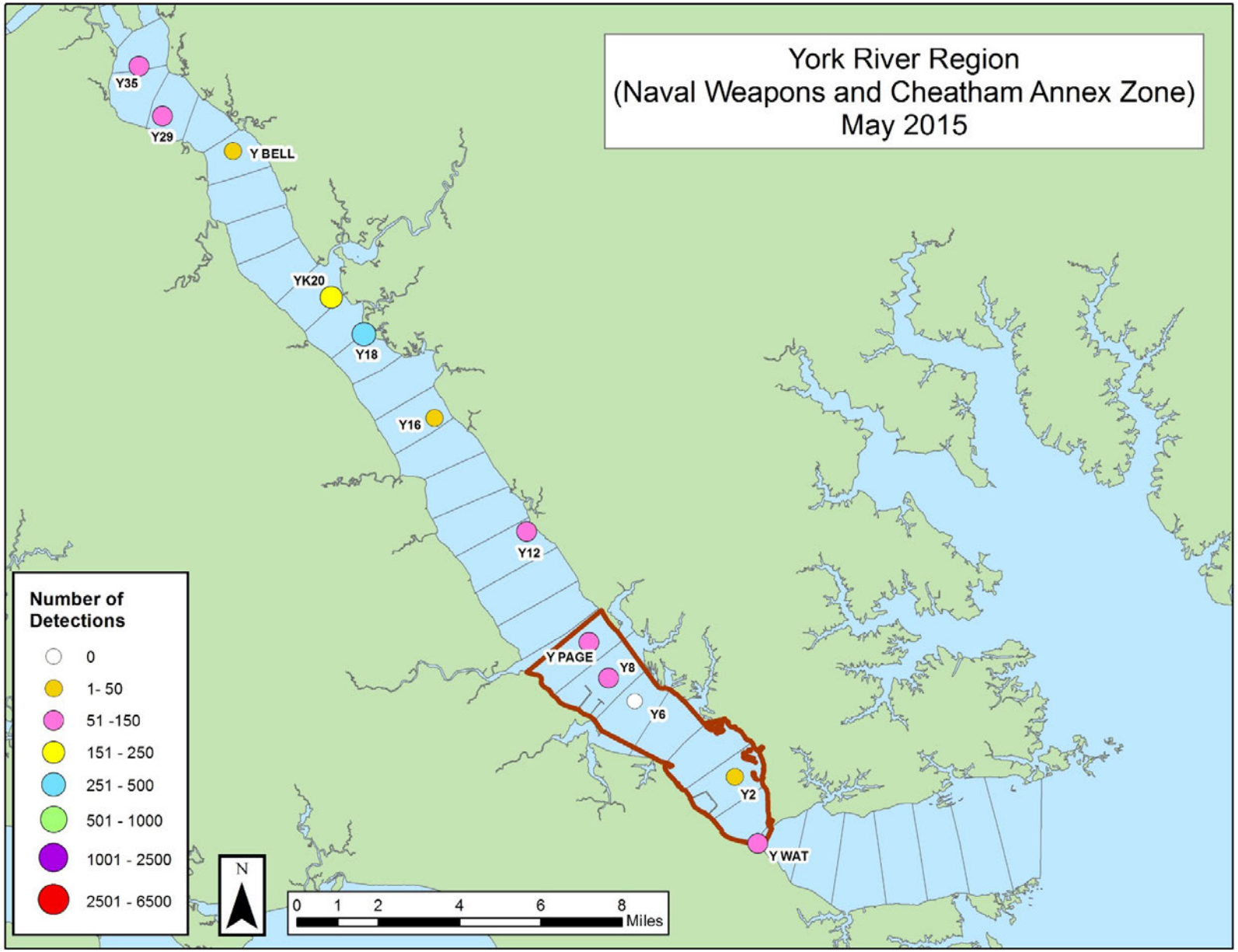
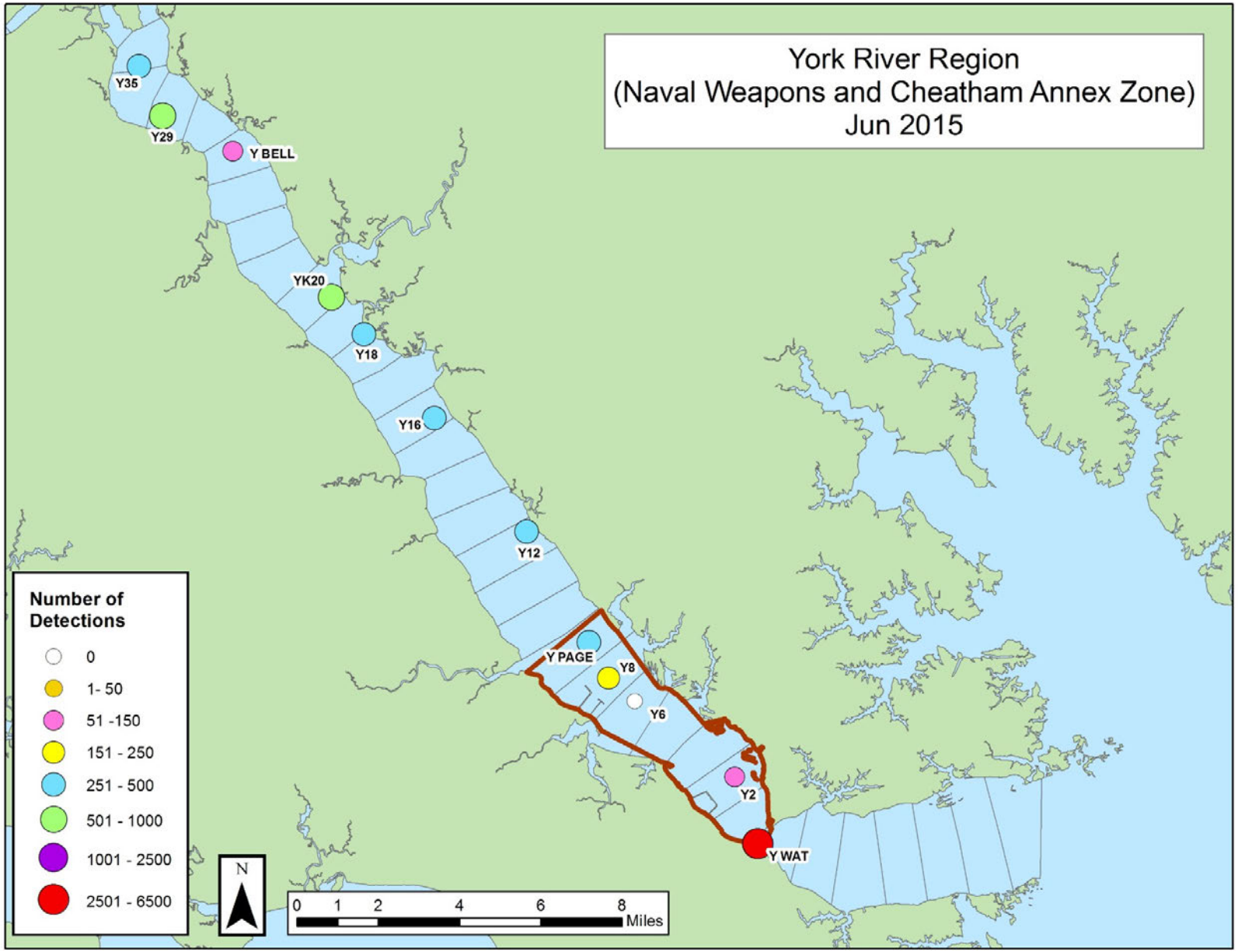
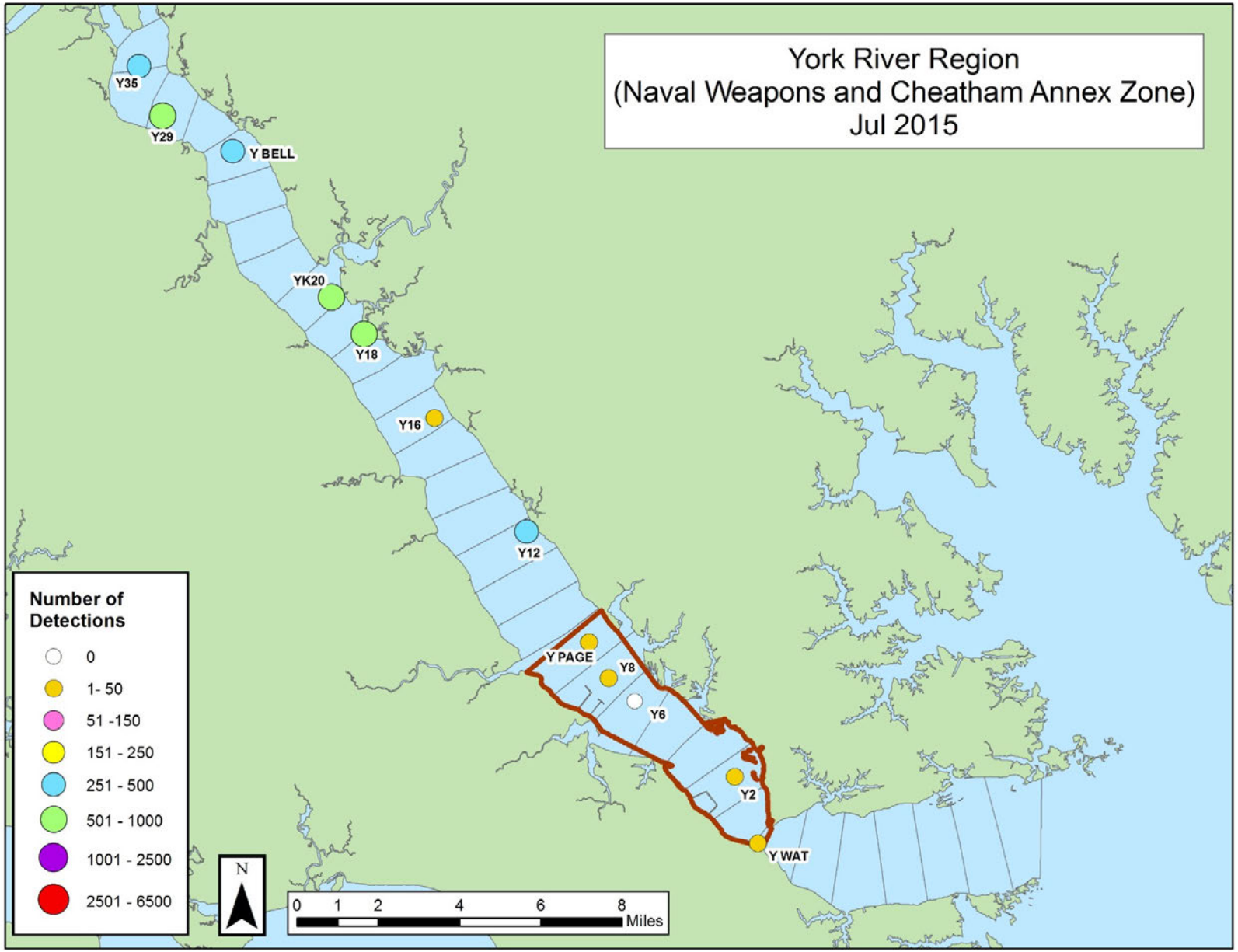
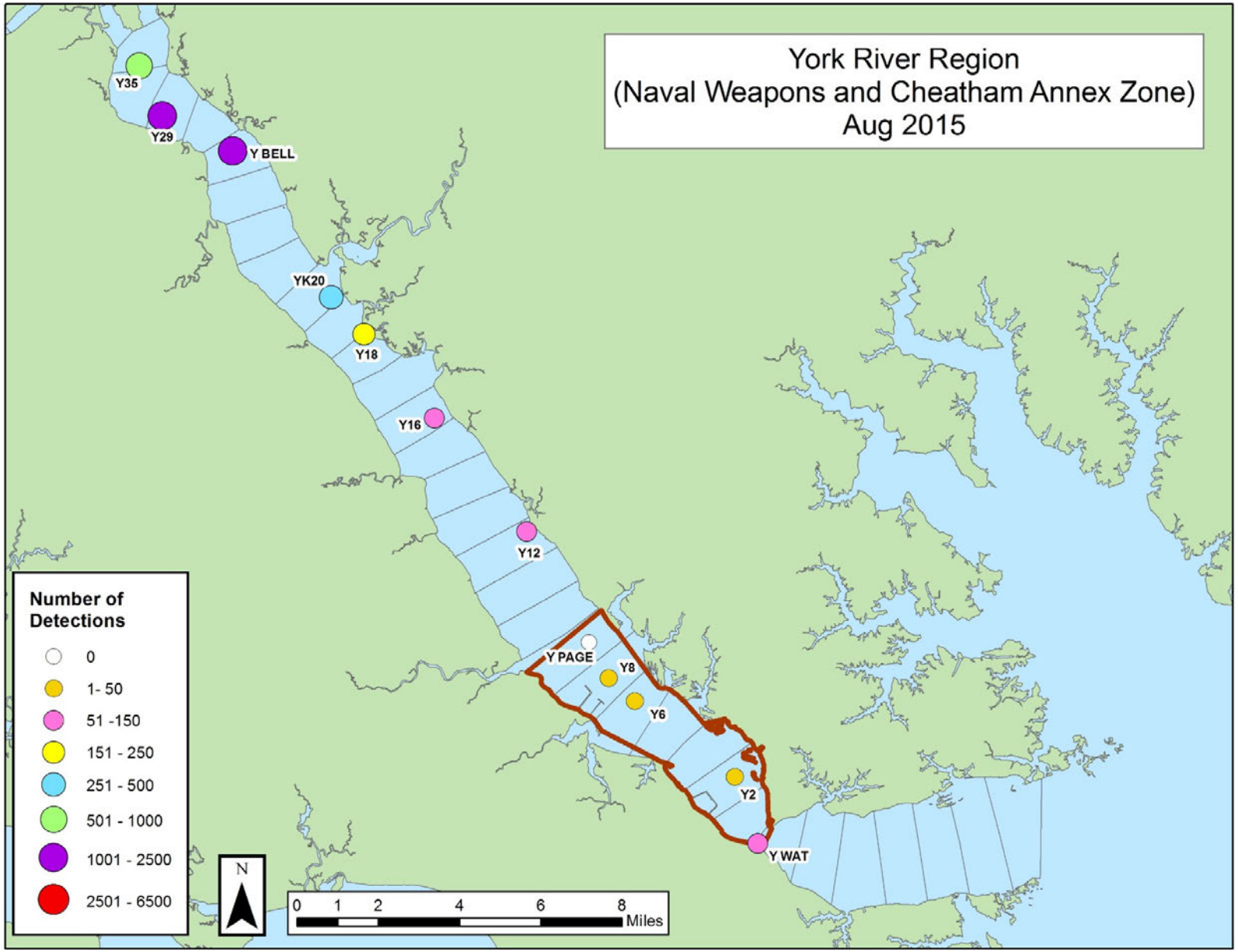
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles

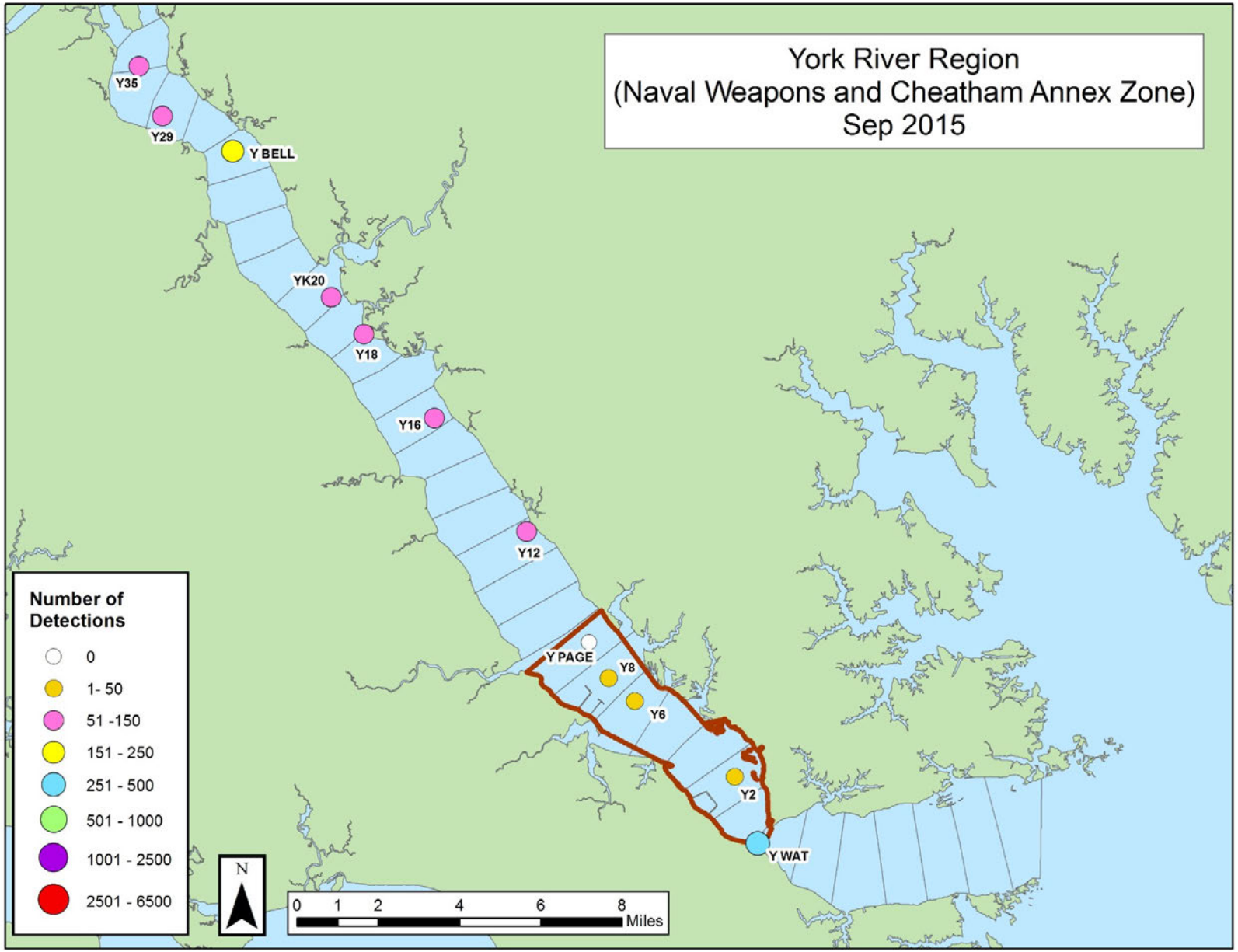

York River Region
(Naval Weapons and Cheatham Annex Zone)
Apr 2015
Y35
Y29
Y BELL
YK20
Y18
Y16
Y12
Y PAGE
Y8
Y6
Y2
Y WAT
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles

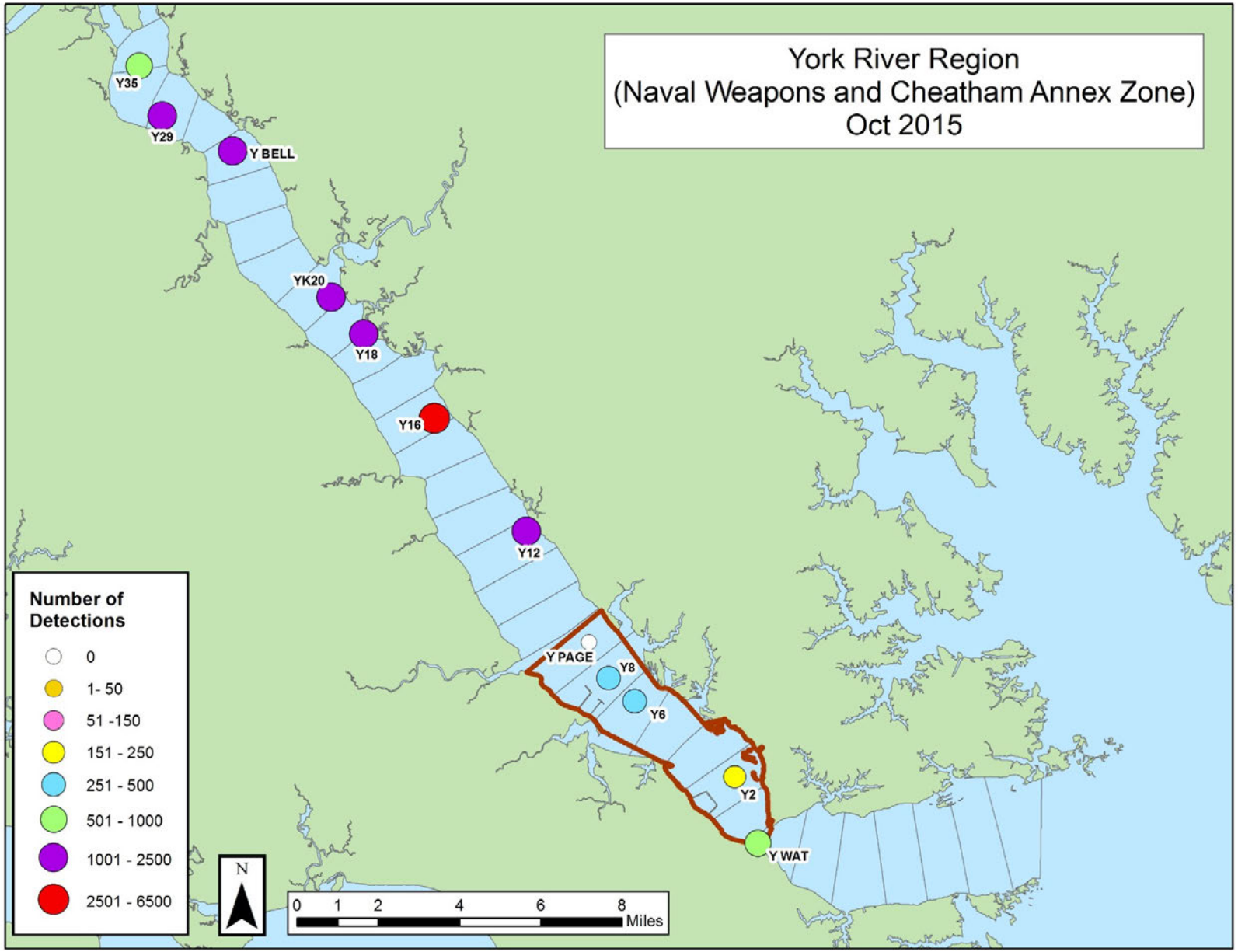

York River Region
(Naval Weapons and Cheatham Annex Zone)
May 2015
Y35
Y29
Y BELL
YK20
Y18
Y16
Y12
Y PAGE
Y8
Y6
Y2
Y WAT
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles

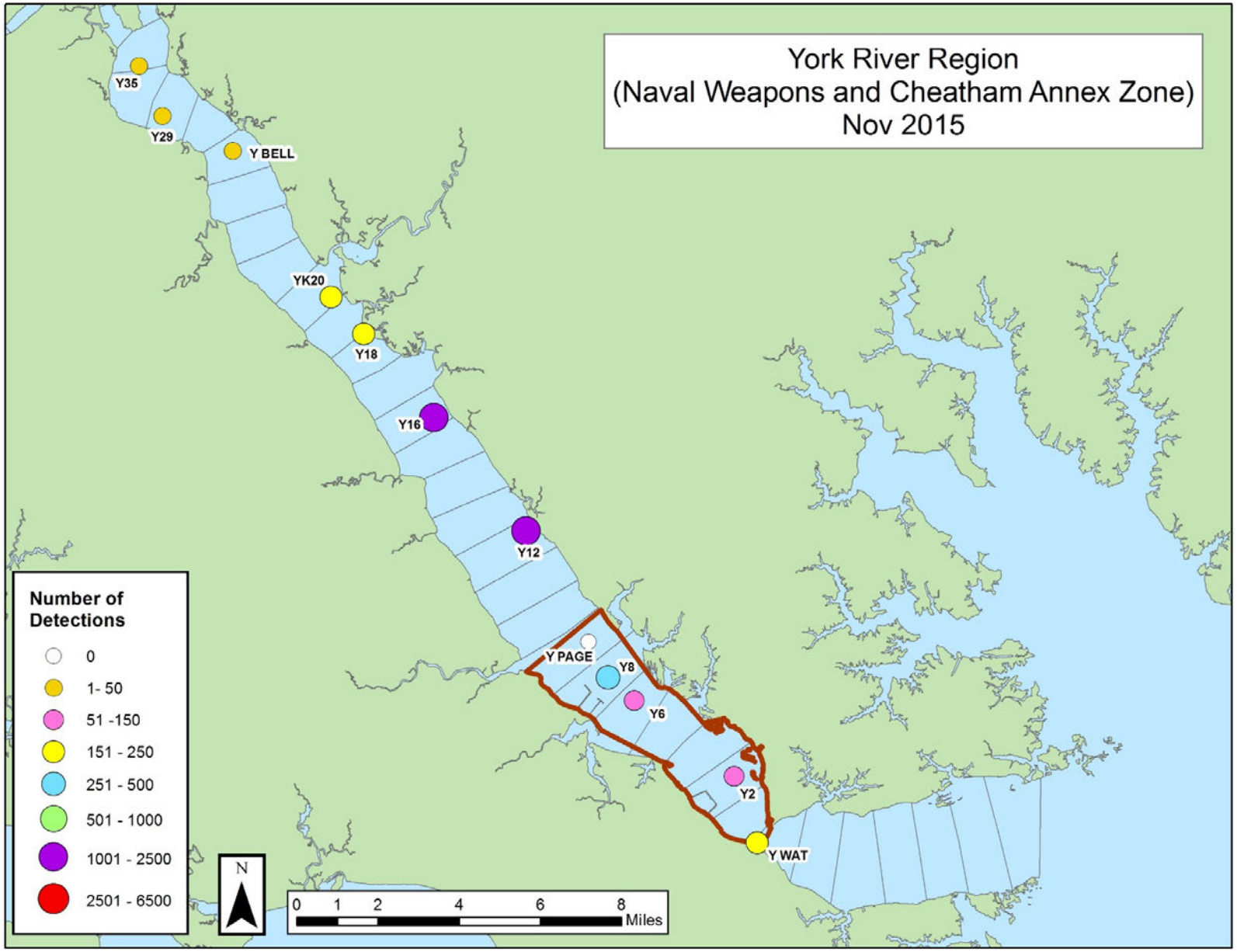

York River Region
(Naval Weapons and Cheatham Annex Zone)
Jun 2015
Y35
Y29
Y BELL
YK20
Y18
Y16
Y12
Y PAGE
Y8
Y6
Y2
Y WAT
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles

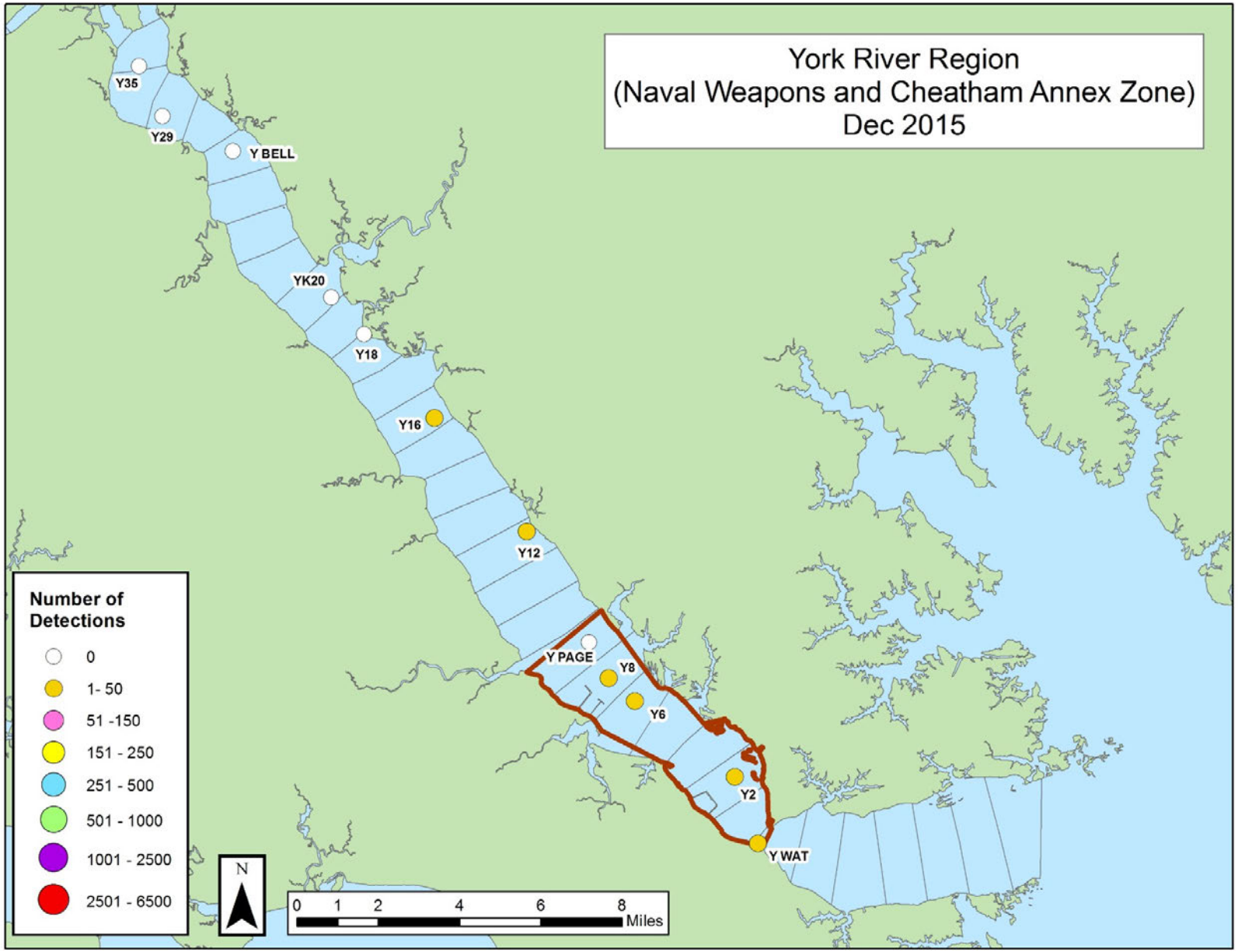

York River Region
(Naval Weapons and Cheatham Annex Zone)
Jul 2015
Y35
Y29
Y BELL
YK20
Y18
Y16
Y12
Y PAGE
Y8
Y6
Y2
Y WAT
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles

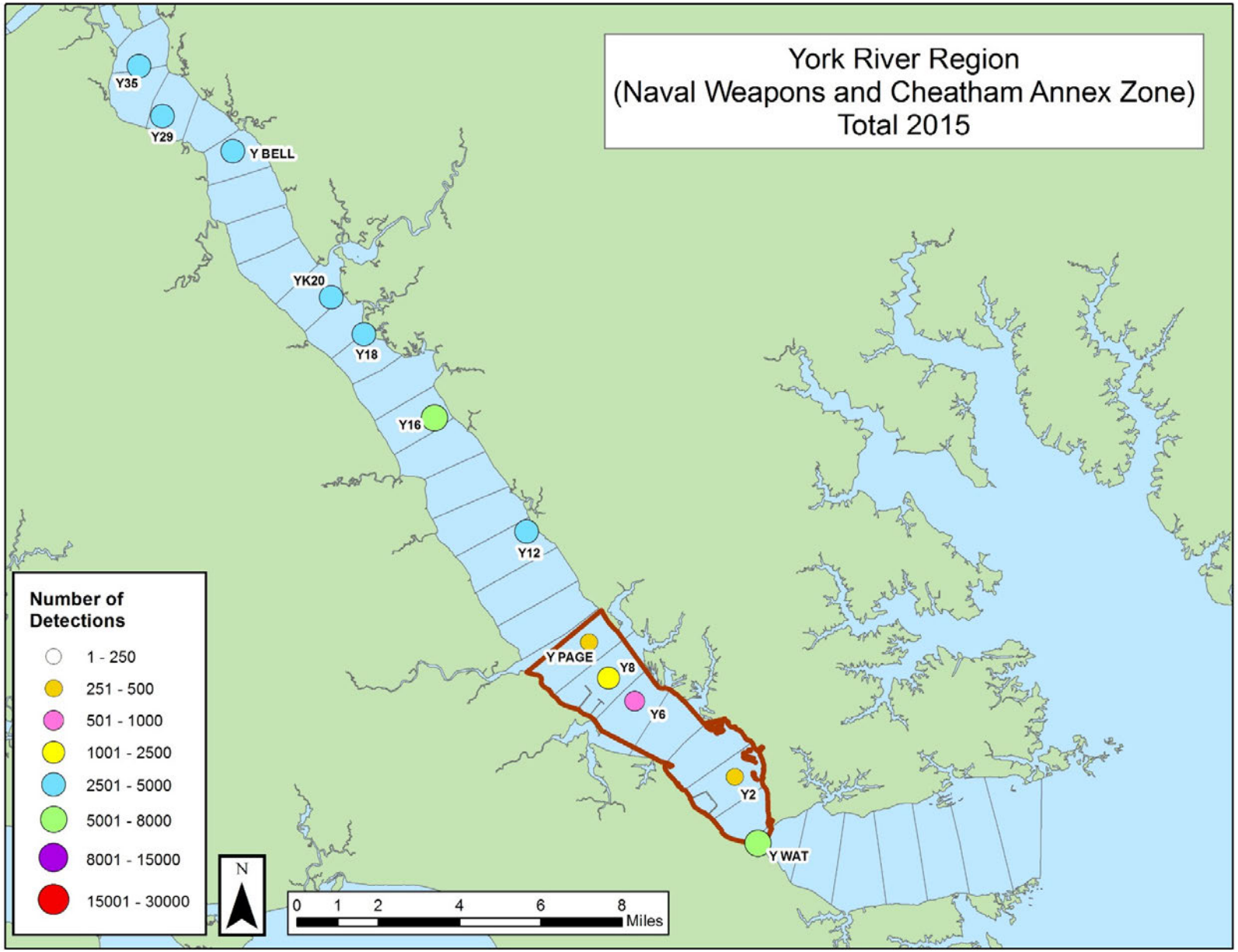

York River Region
(Naval Weapons and Cheatham Annex Zone)
Aug 2015
Y35
Y29
Y BELL
YK20
Y18
Y16
Y12
Y PAGE
Y8
Y6
Y2
Y WAT
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles

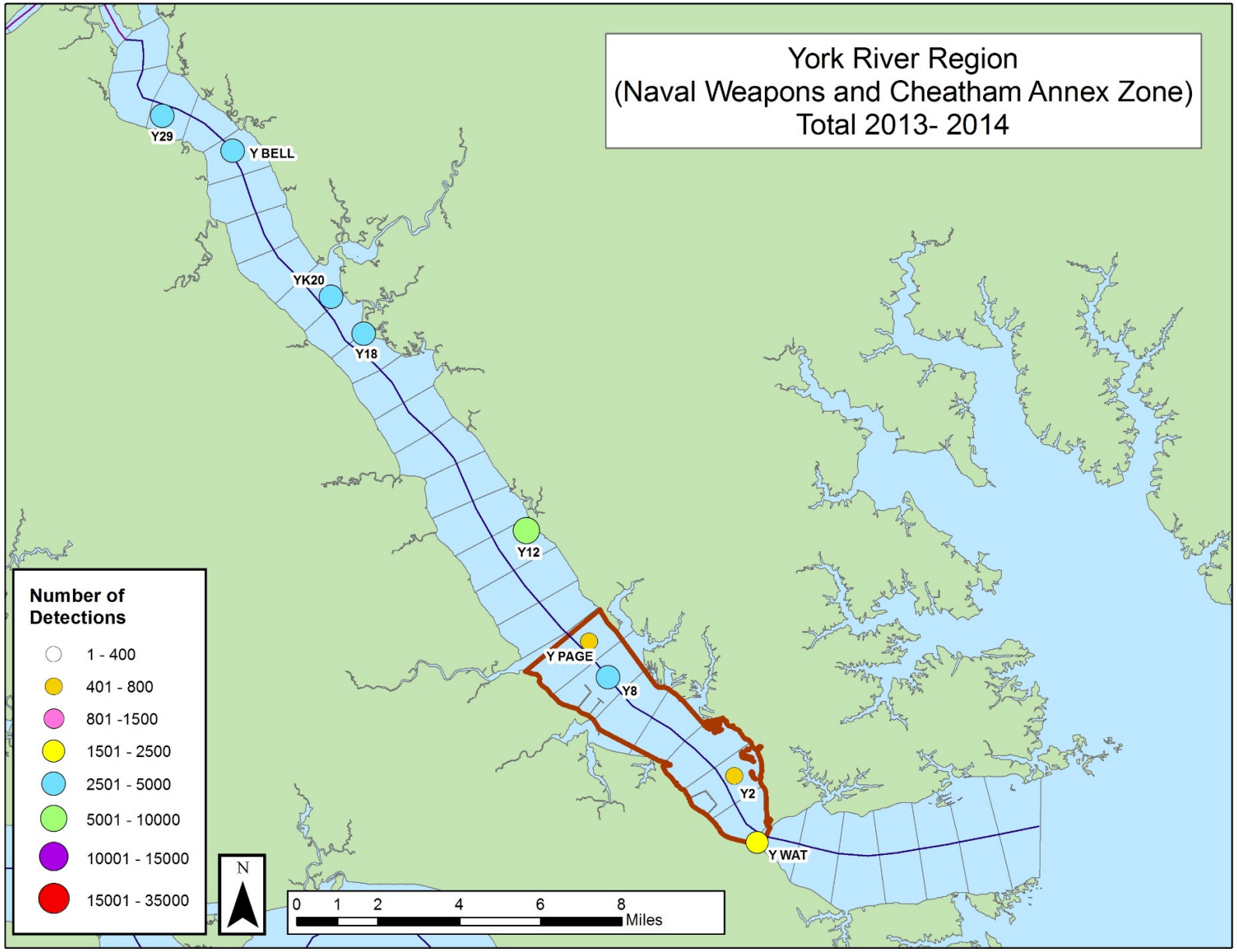

York River Region
(Naval Weapons and Cheatham Annex Zone)
Sep 2015
Y35
Y29
Y BELL
YK20
Y18
Y16
Y12
Y PAGE
Y8
Y6
Y2
Y WAT
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles

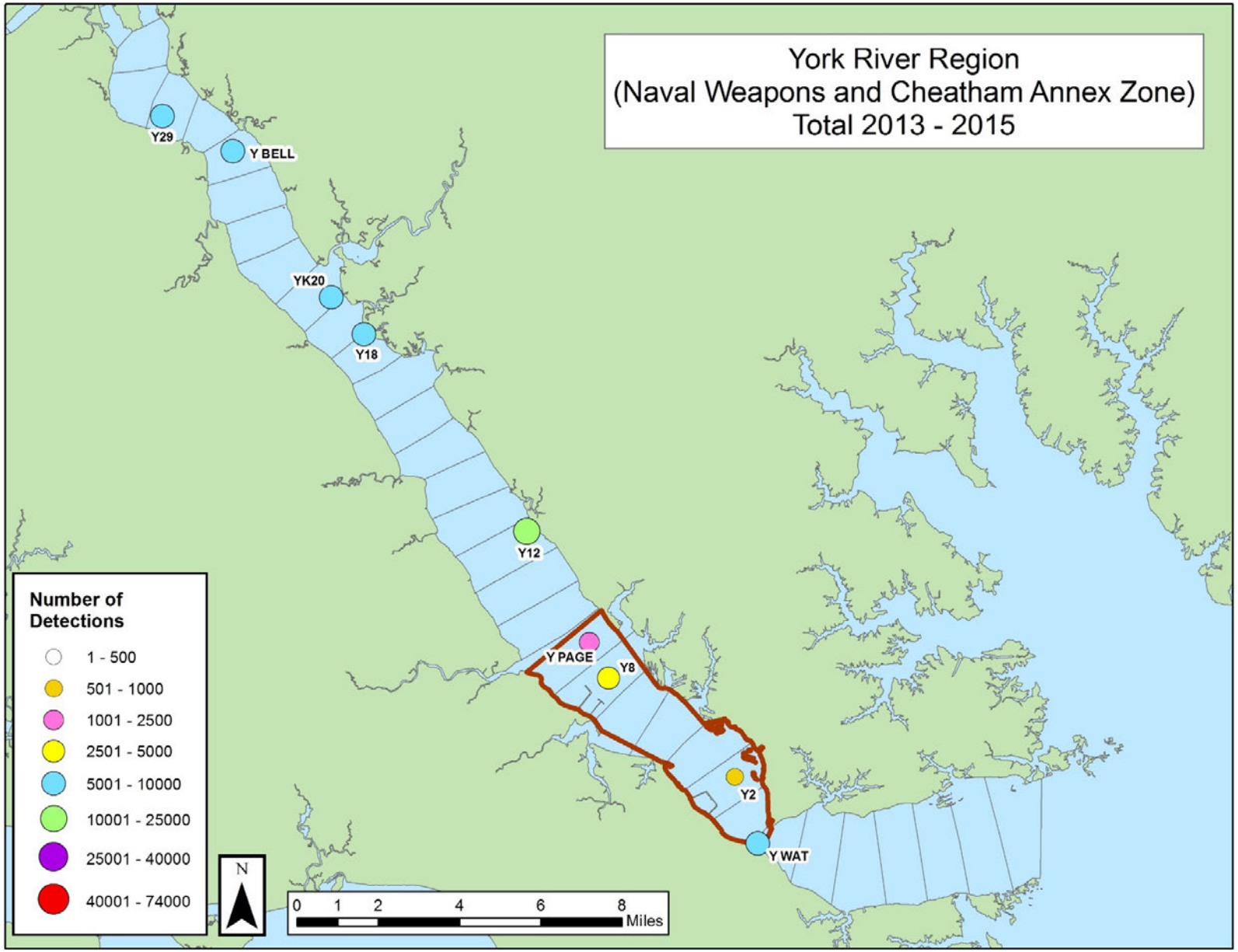

York River Region
(Naval Weapons and Cheatham Annex Zone)
Oct 2015
Y35
Y29
Y BELL
YK20
Y18
Y16
Y12
Y PAGE
Y8
Y6
Y2
Y WAT
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles


York River Region
(Naval Weapons and Cheatham Annex Zone)
Nov 2015
Y35
Y29
Y BELL
YK20
Y18
Y16
Y12
Y PAGE
Y8
Y6
Y2
Y WAT
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles

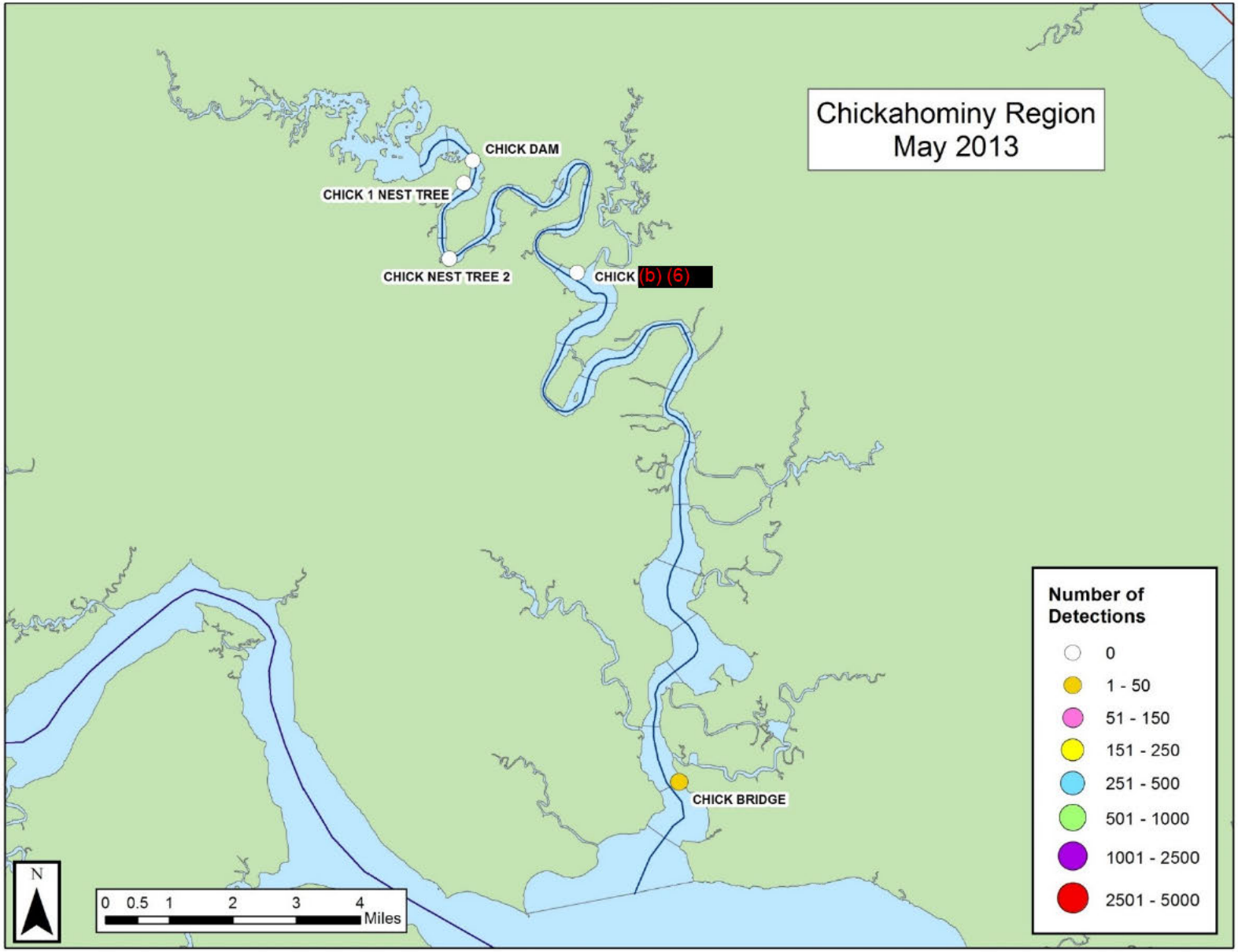

York River Region
(Naval Weapons and Cheatham Annex Zone)
Dec 2015
Y35
Y29
Y BELL
YK20
Y18
Y16
Y12
Y PAGE
Y8
Y6
Y2
Y WAT
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 1 2 4 6 8
Miles

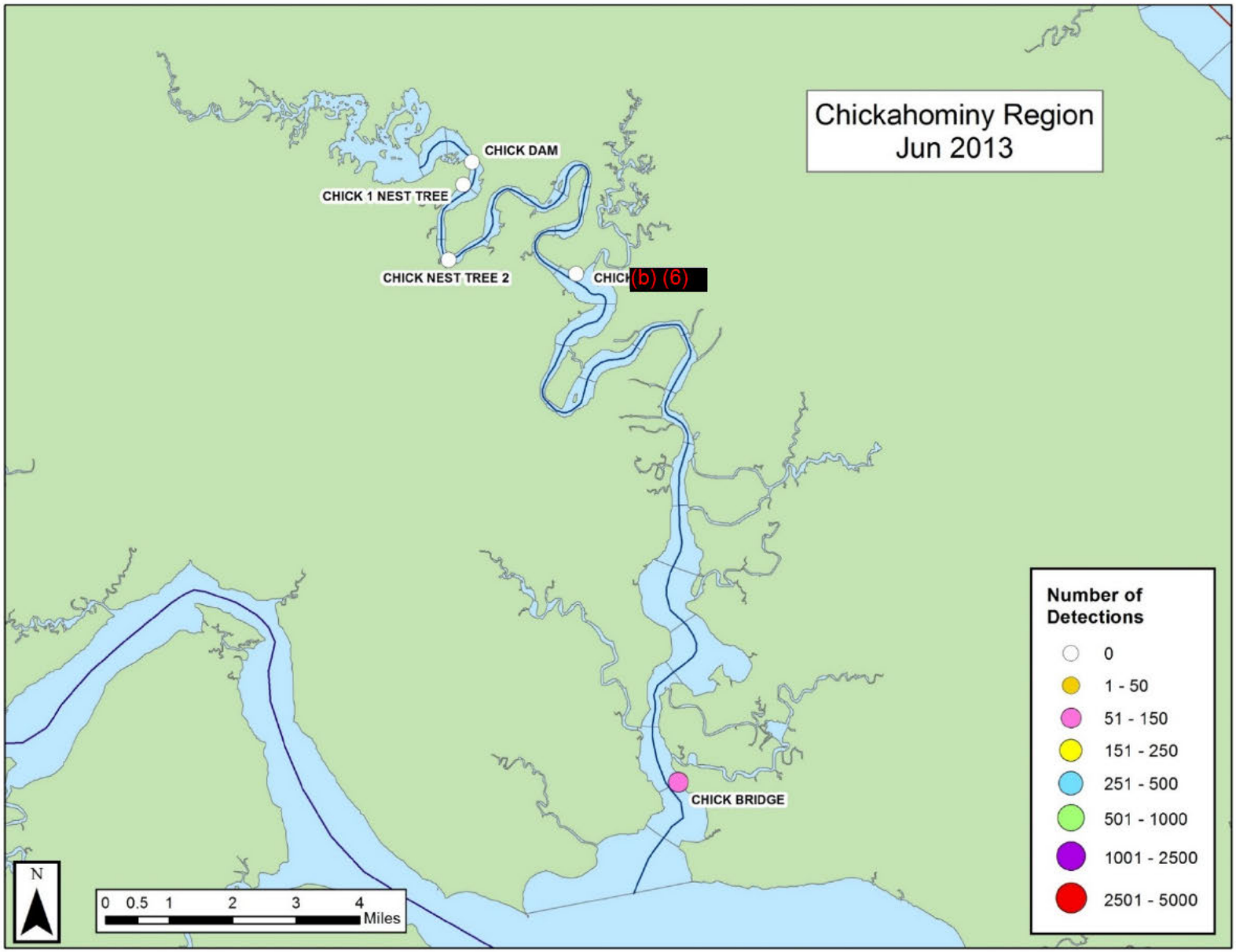

York River Region
(Naval Weapons and Cheatham Annex Zone)
Total 2015
Y35
Y29
Y BELL
YK20
Y18
Y16
Y12
Y PAGE
Y8
Y6
Y2
Y WAT
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
N
0 1 2 4 6 8
Miles

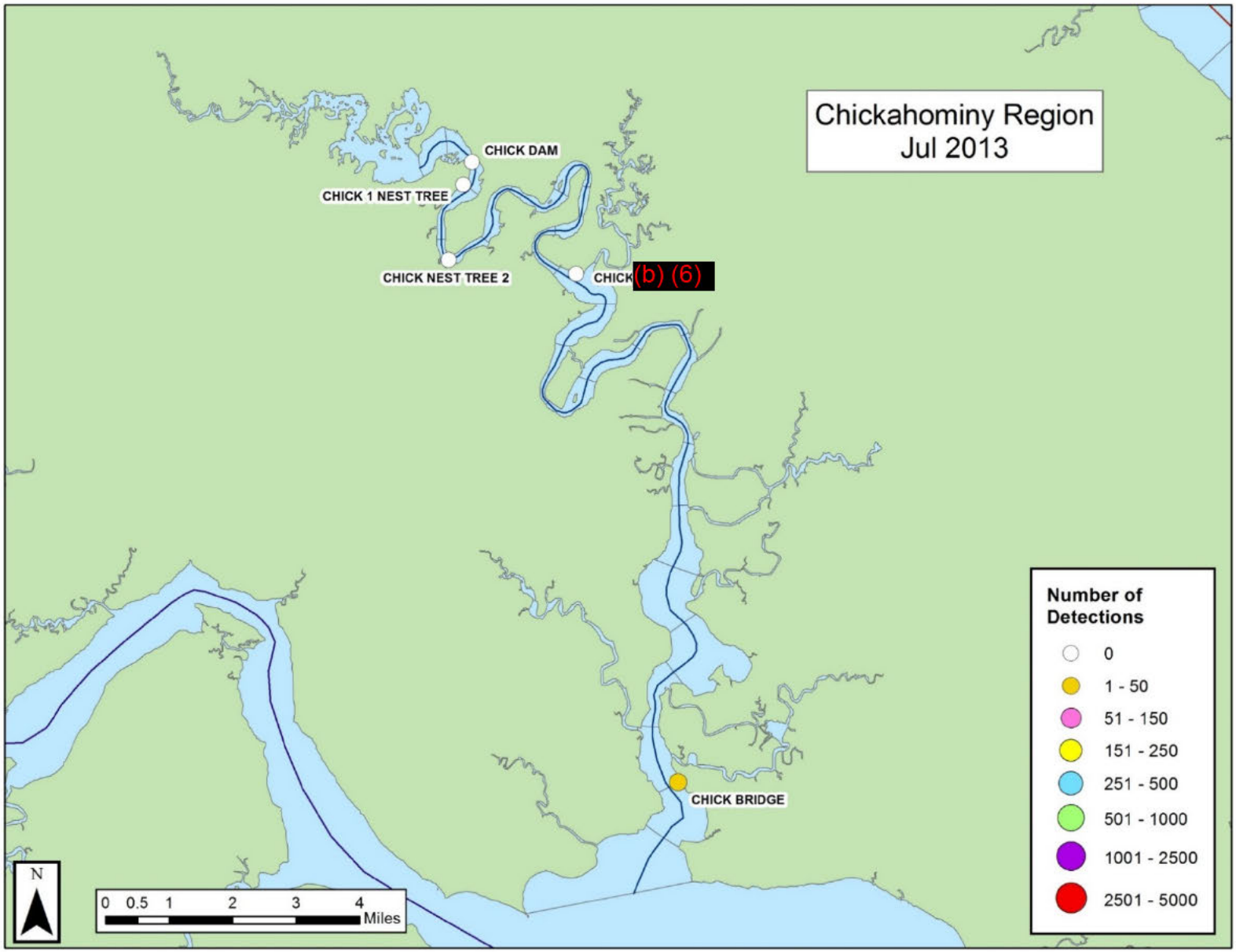

York River Region
(Naval Weapons and Cheatham Annex Zone)
Total 2013- 2014
Y29
Y BELL
YK20
Y18
Y12
Y PAGE
Y8
Y2
Y WAT
Number of Detections
1 - 400
401 - 800
801 -1500
1501 - 2500
2501 - 5000
5001 - 10000
10001 - 15000
15001 - 35000
N
0 1 2 4 6 8
Miles

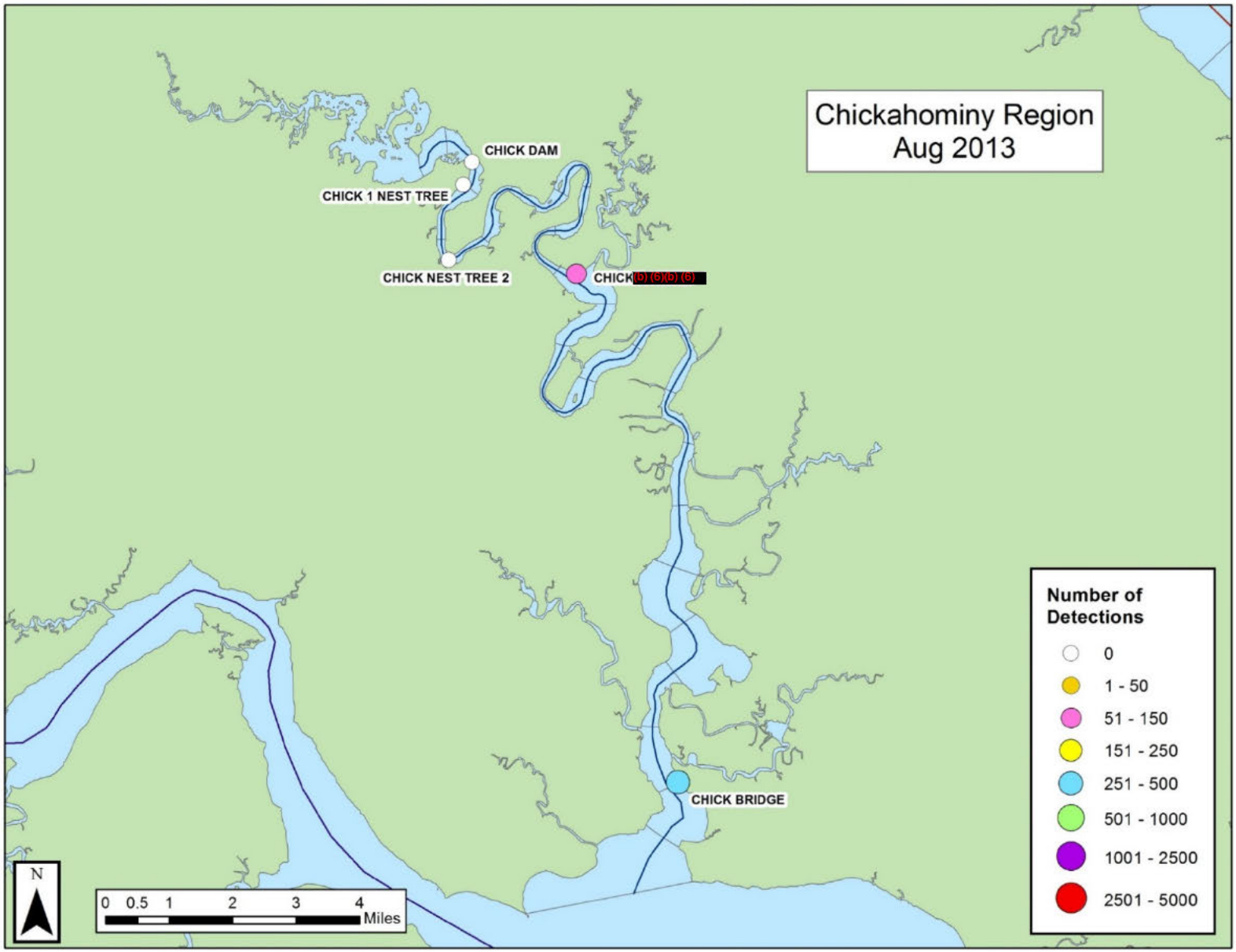

York River Region
(Naval Weapons and Cheatham Annex Zone)
Total 2013 - 2015
Y29
Y BELL
YK20
Y18
Y12
Y PAGE
Y8
Y2
Y WAT
Number of Detections
1 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 10000
10001 - 25000
25001 - 40000
40001 - 74000
N
0 1 2 4 6 8
Miles

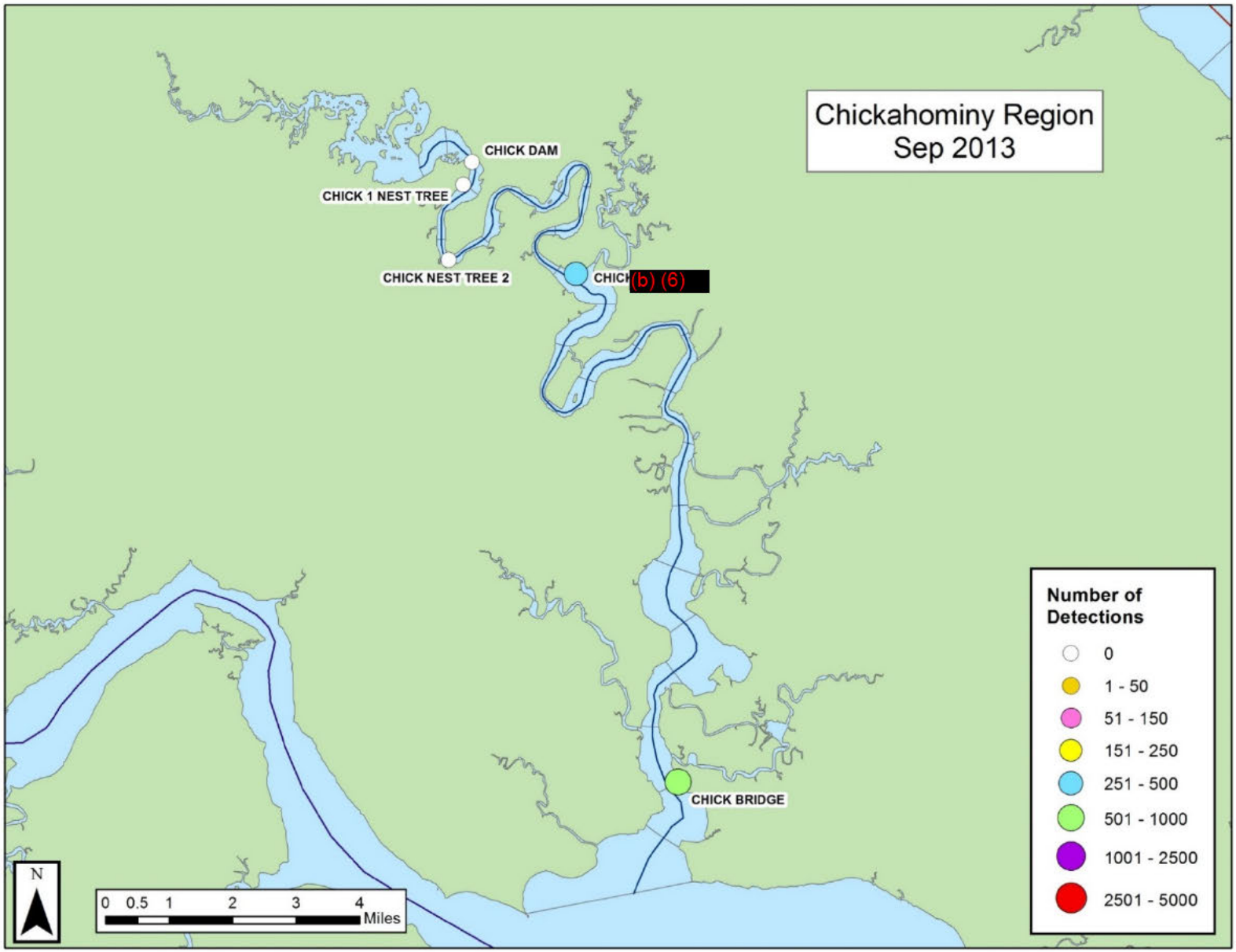
## 9.5 APPENDIX 4.4.3: CHICKAHOMINY REGION

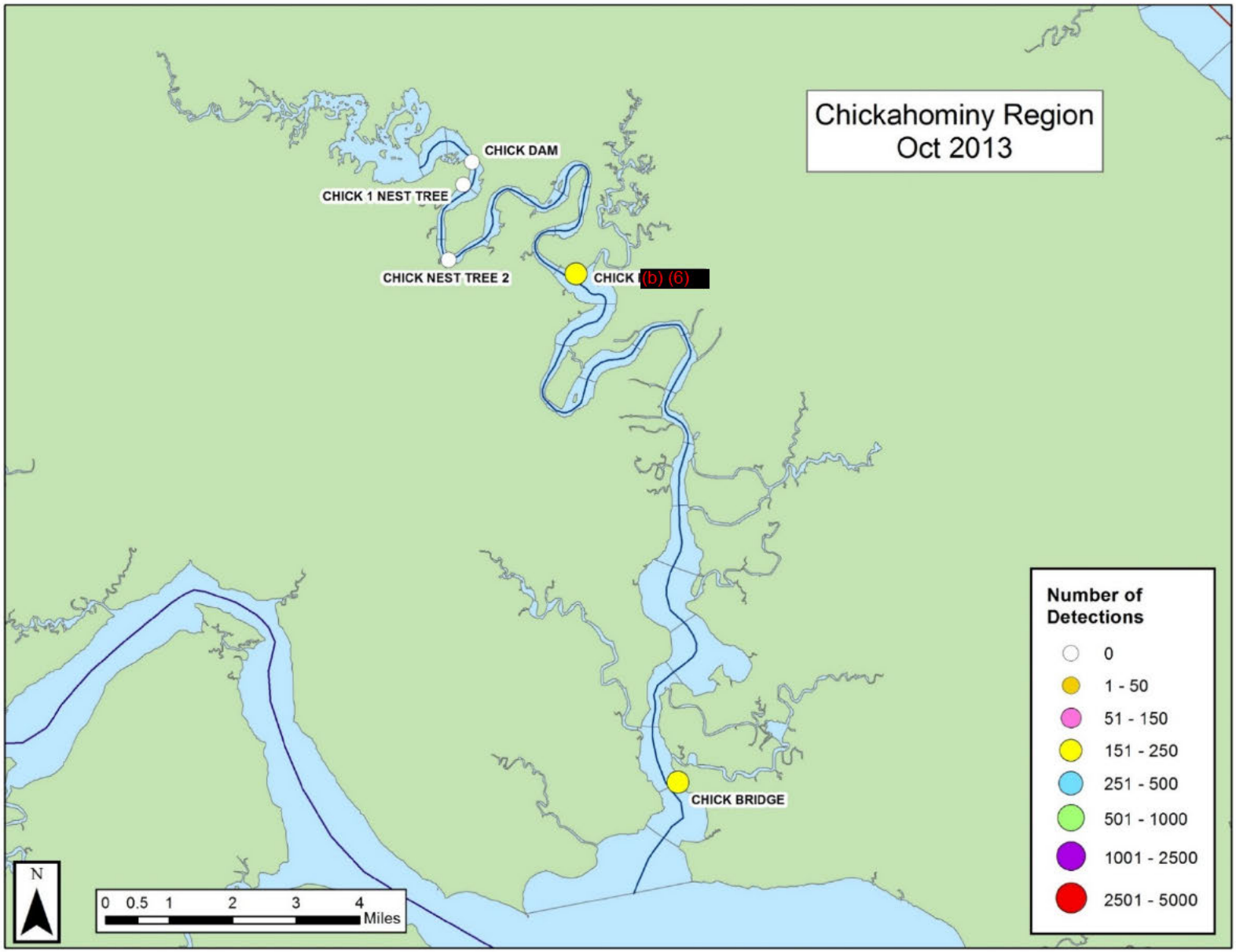


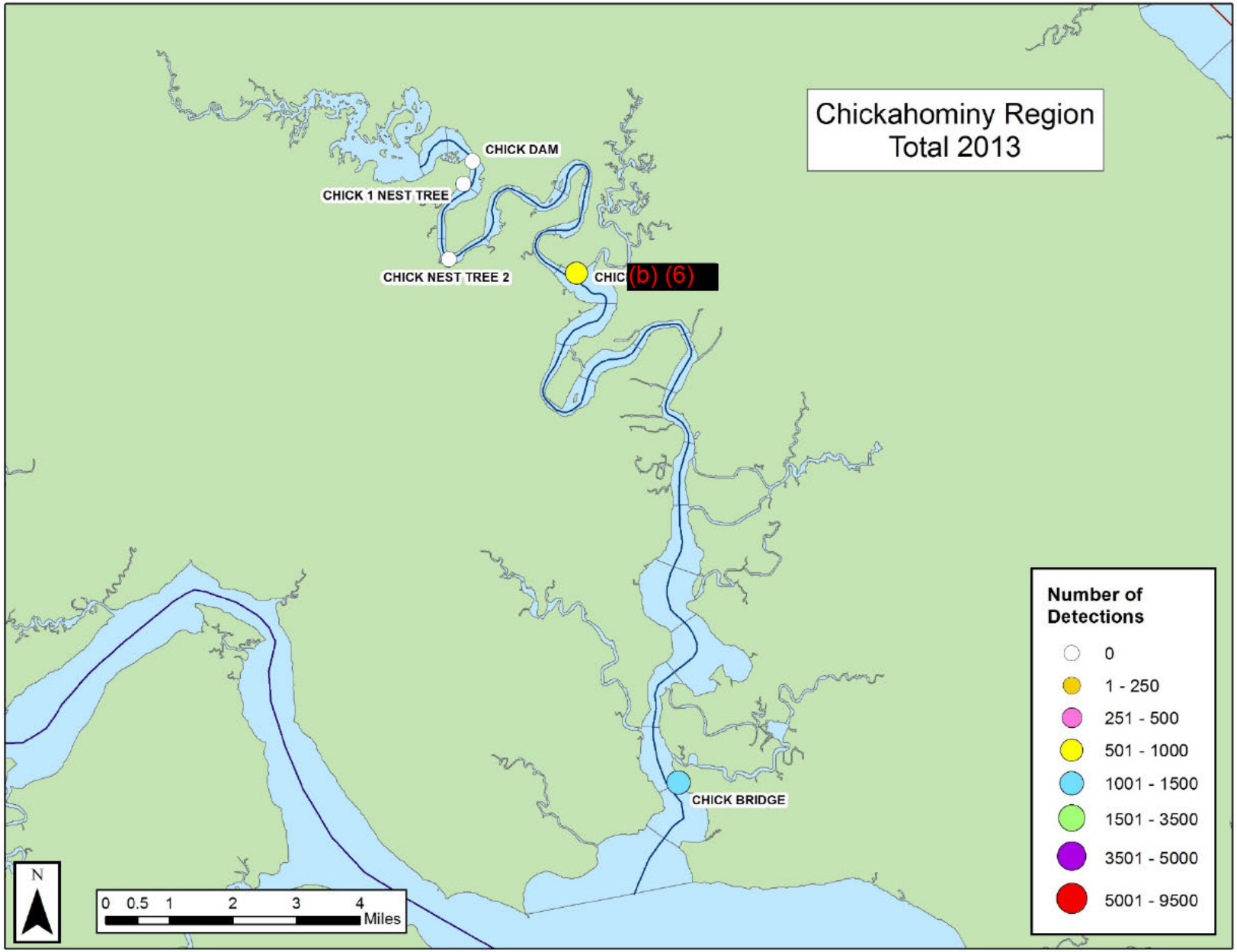

Chickahominy Region
Jun 2013
CHICK DAM
CHICK 1 NEST TREE
CHICK NEST TREE 2
CHICK
(b) (6)
CHICK BRIDGE
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

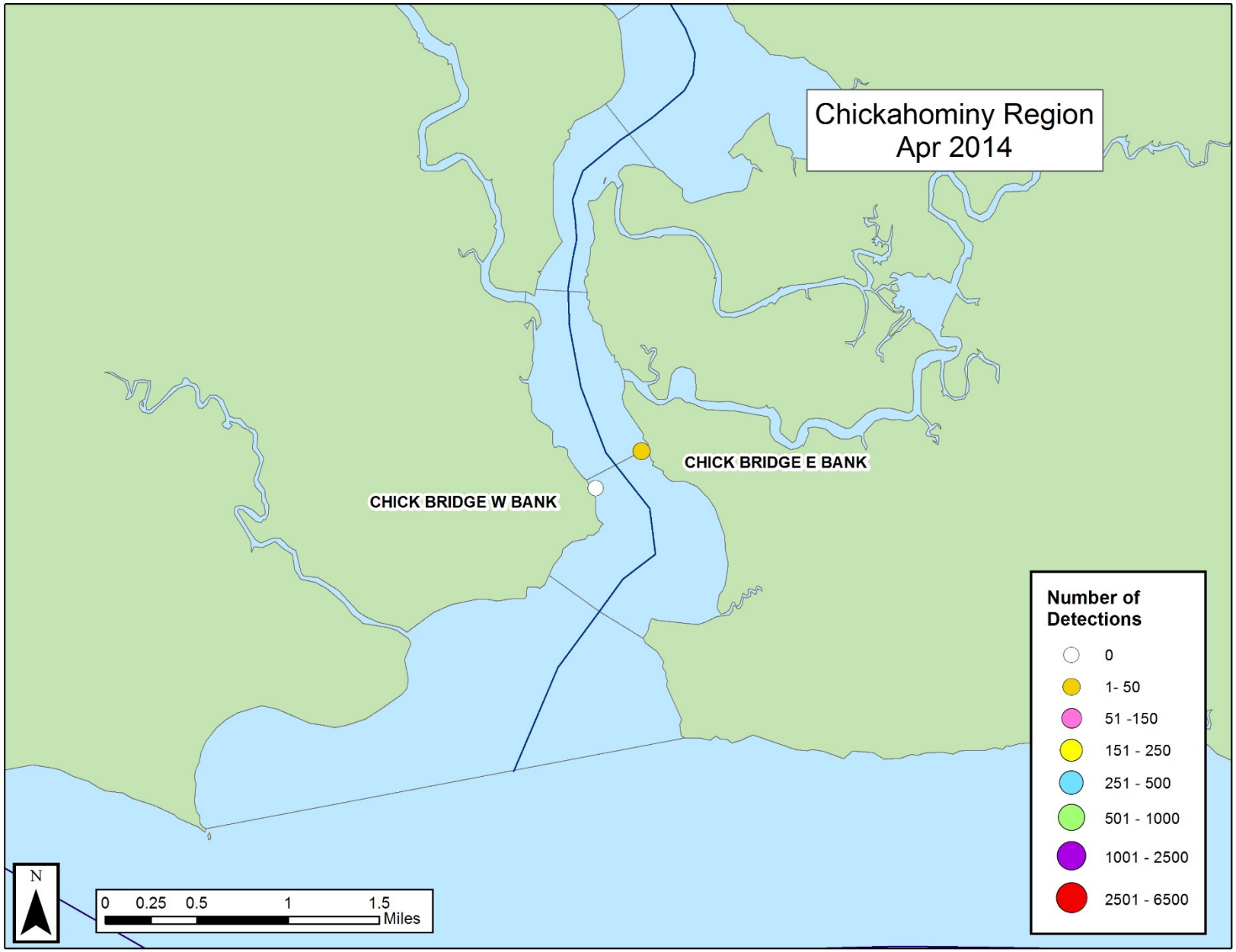

Chickahominy Region
Jul 2013
CHICK DAM
CHICK 1 NEST TREE
CHICK NEST TREE 2
CHICK
(b) (6)
CHICK BRIDGE
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

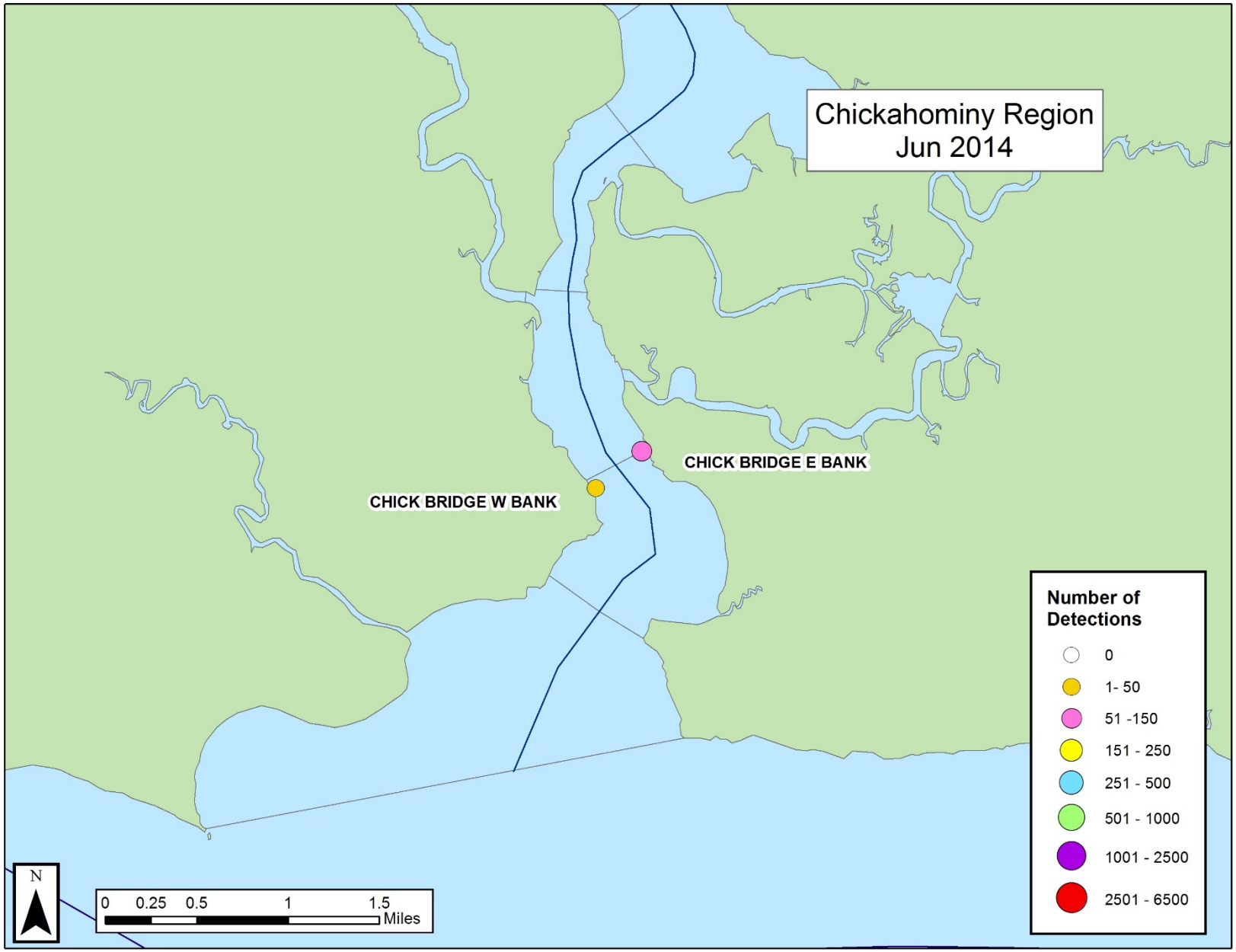

Chickahominy Region
Aug 2013
CHICK DAM
CHICK 1 NEST TREE
CHICK NEST TREE 2
CHICK (b)(6)(b)(6)
CHICK BRIDGE
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

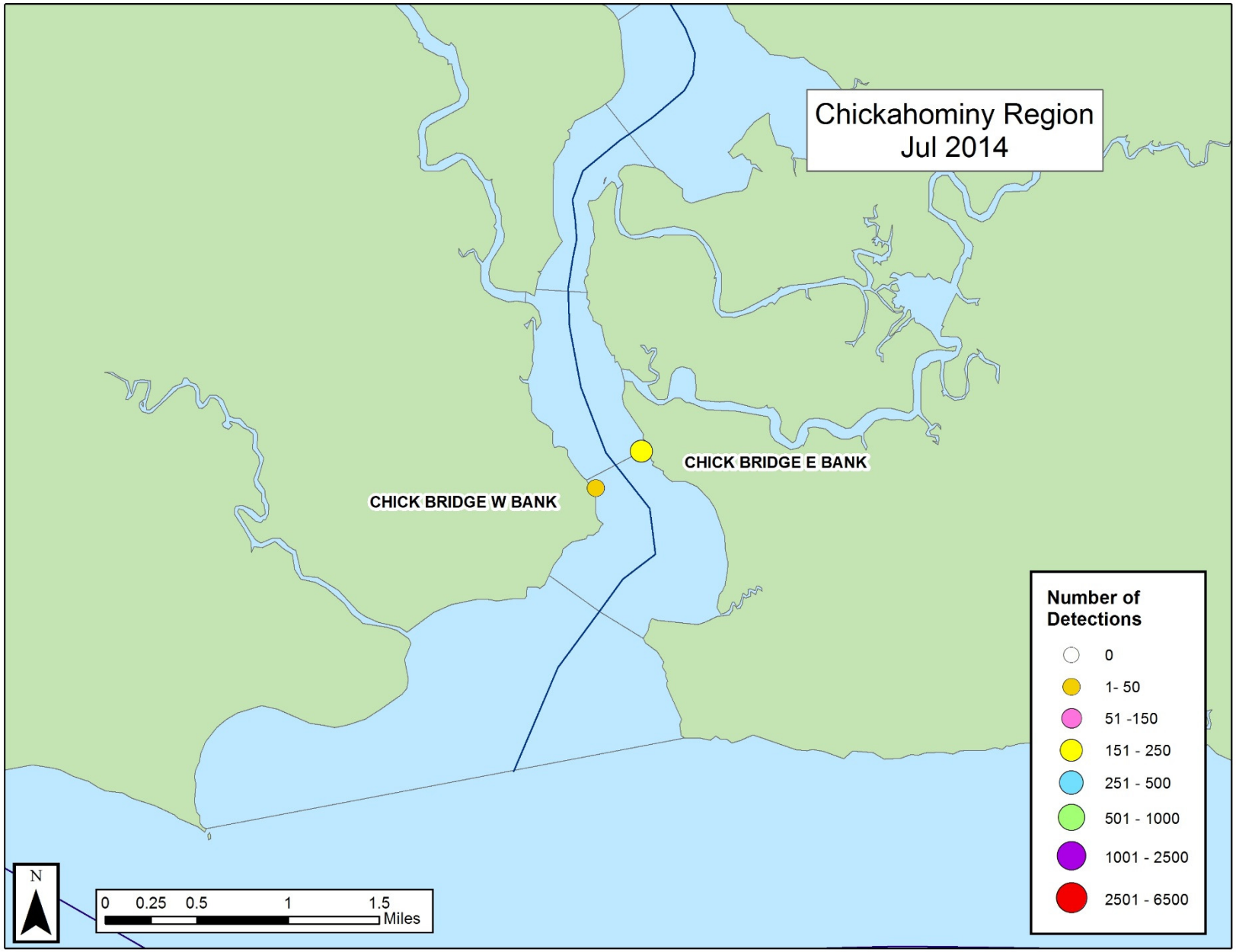

Chickahominy Region
Sep 2013
CHICK DAM
CHICK 1 NEST TREE
CHICK NEST TREE 2
CHICK
(b) (6)
CHICK BRIDGE
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

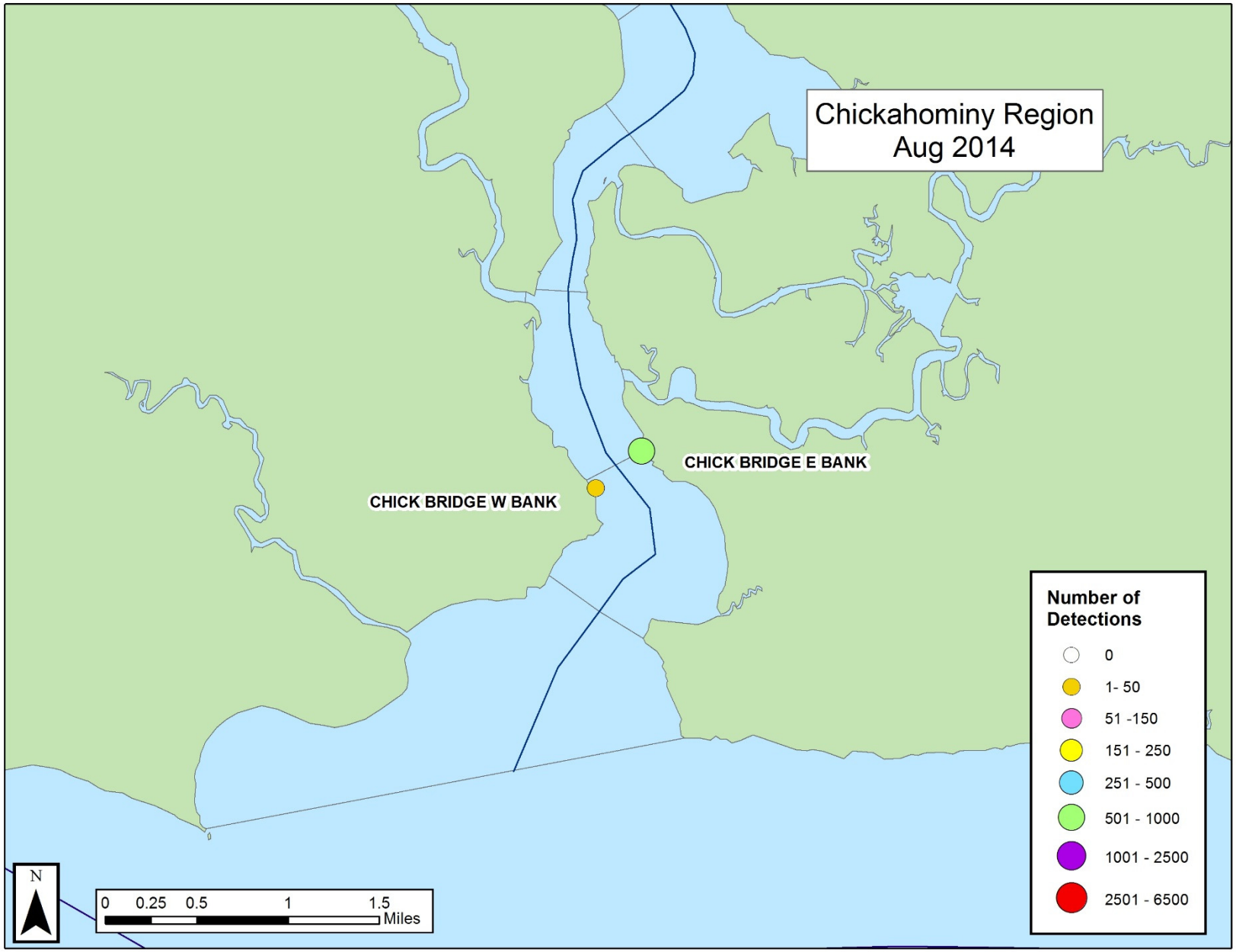

Chickahominy Region
Oct 2013
CHICK DAM
CHICK 1 NEST TREE
CHICK NEST TREE 2
CHICK
(b) (6)
CHICK BRIDGE
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

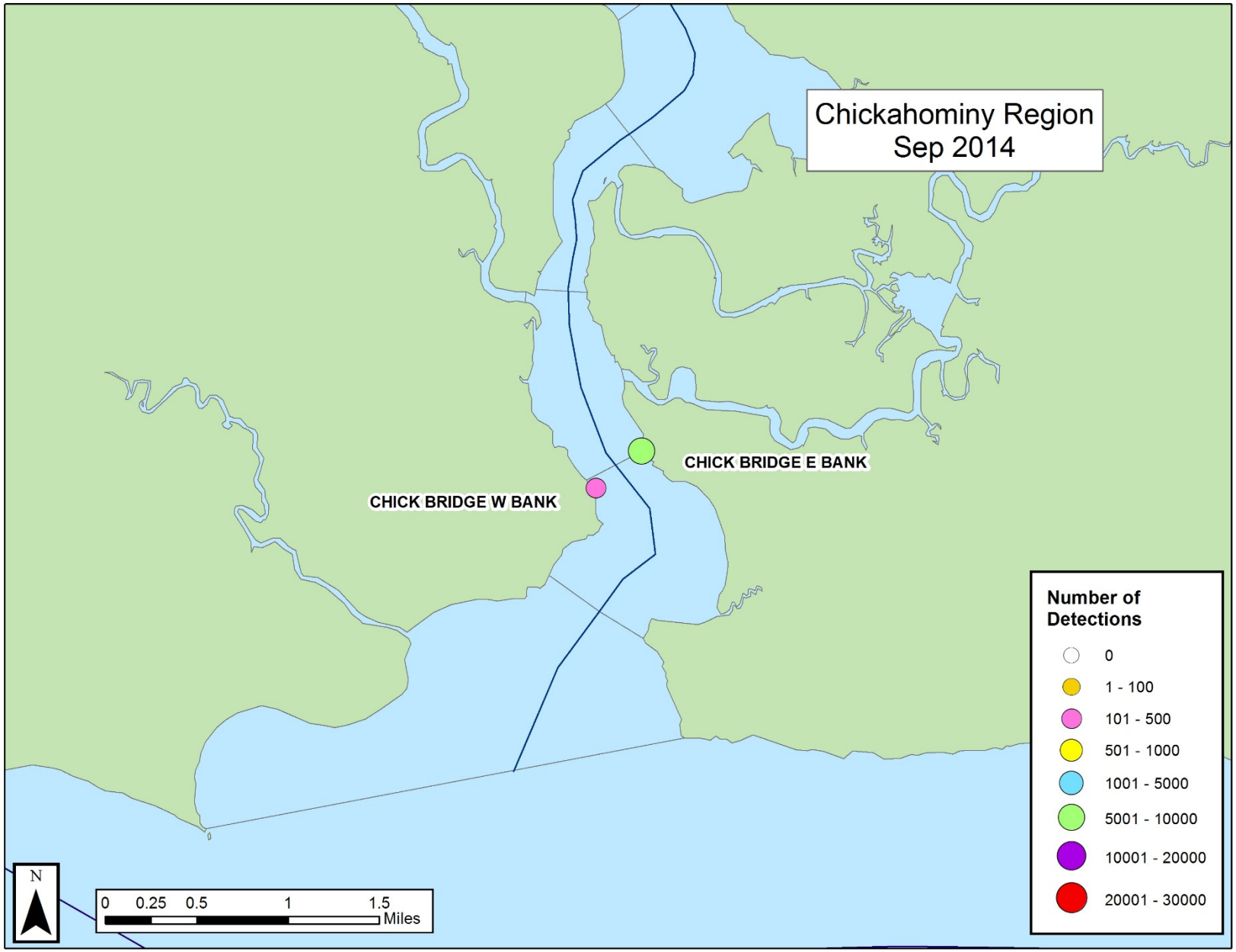

Chickahominy Region
Total 2013
CHICK DAM
CHICK 1 NEST TREE
CHICK NEST TREE 2
CHIC
(b) (6)
CHICK BRIDGE
Number of Detections
0
1 - 250
251 - 500
501 - 1000
1001 - 1500
1501 - 3500
3501 - 5000
5001 - 9500
N
0 0.5 1 2 3 4
Miles

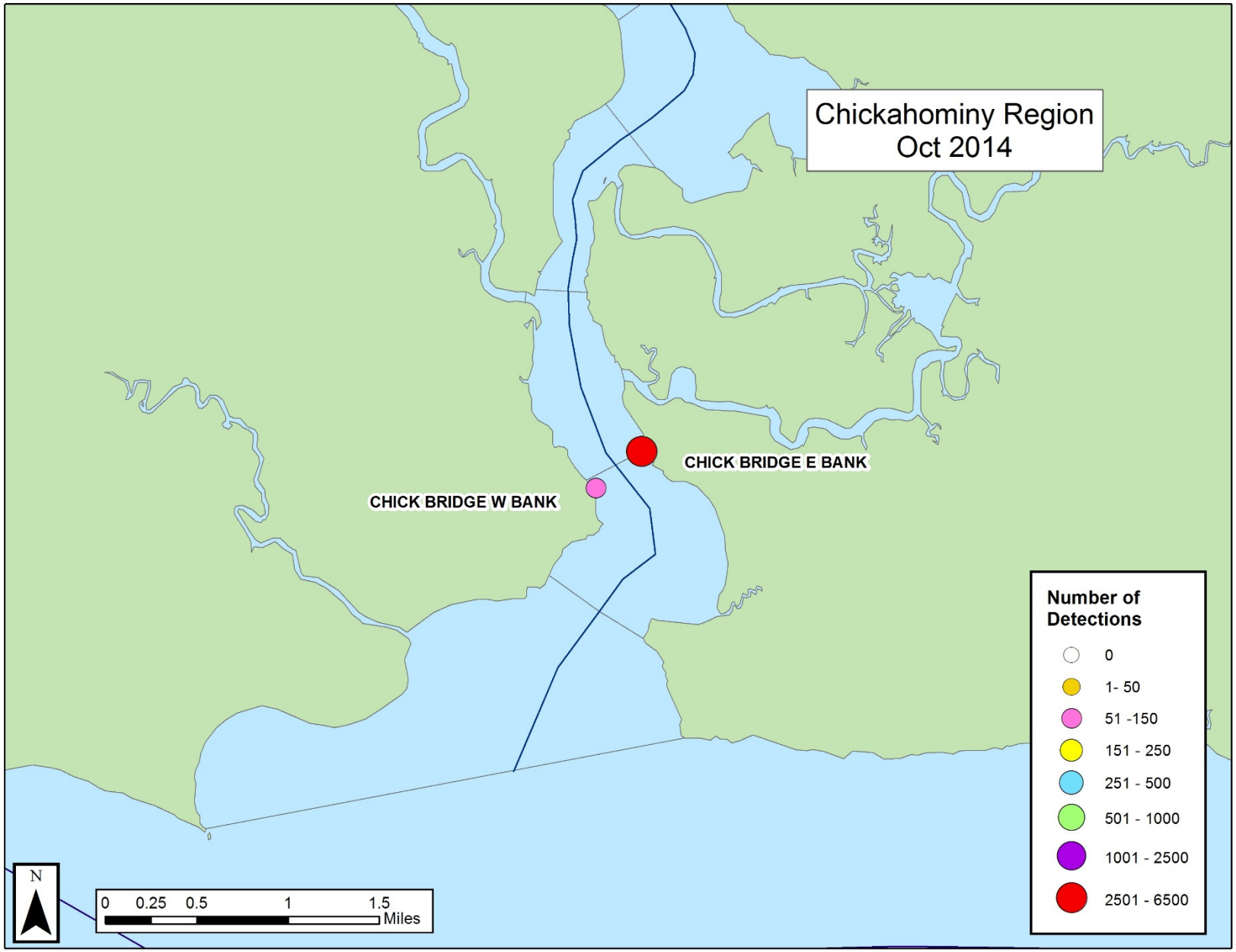

Chickahominy Region
Apr 2014
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.25 0.5 1 1.5
Miles

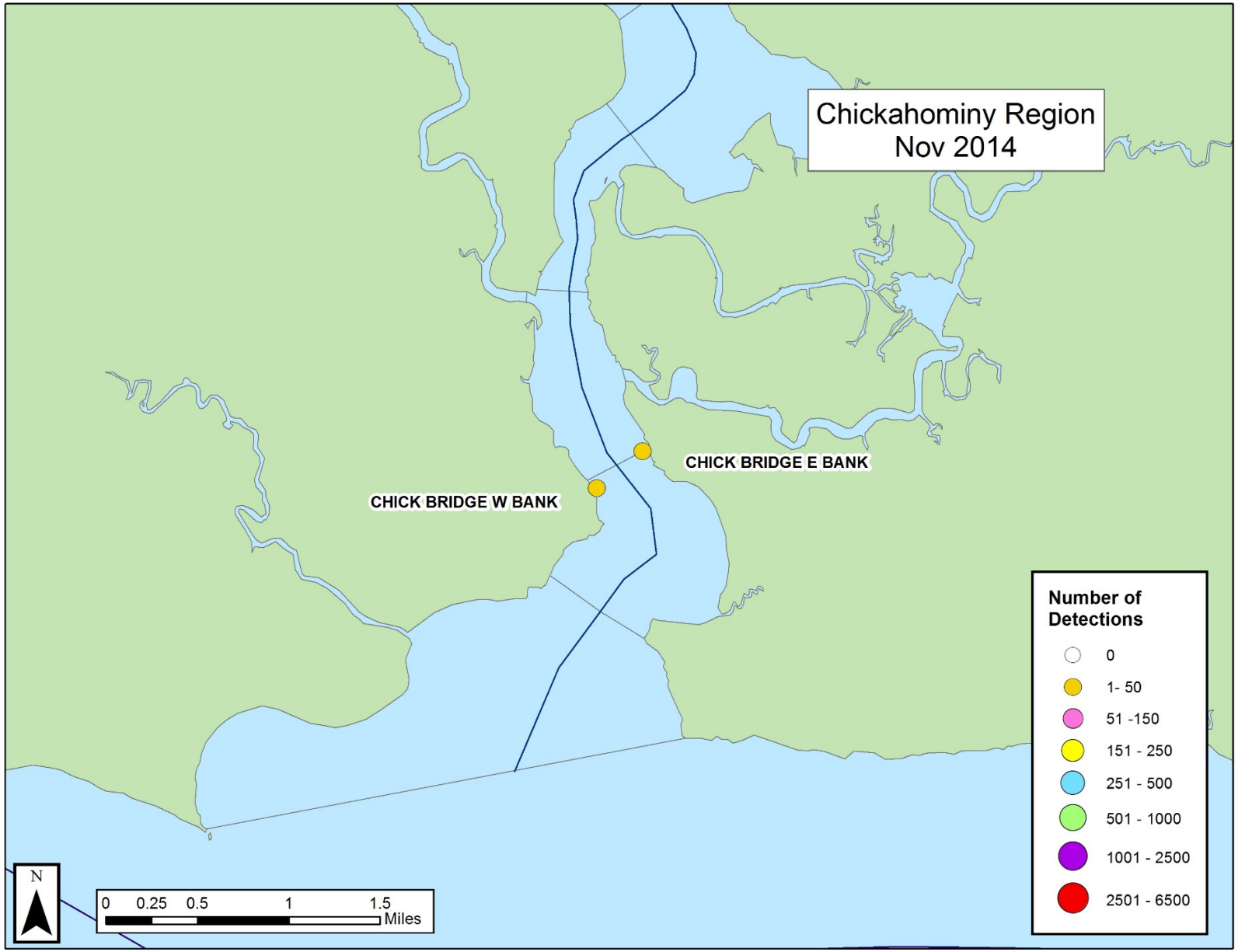

Chickahominy Region
Jun 2014
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.25 0.5 1 1.5
Miles

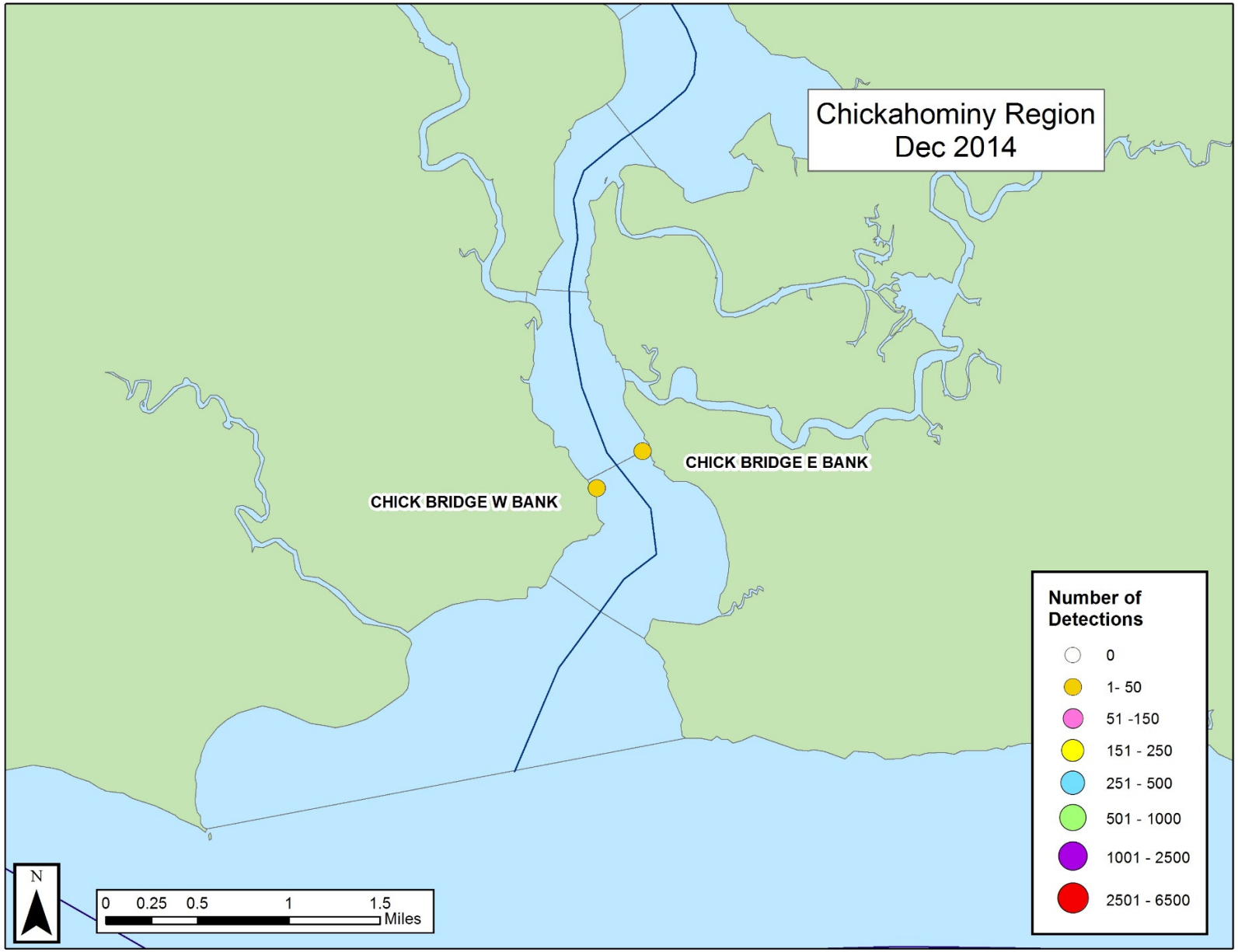

Chickahominy Region
Jul 2014
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.25 0.5 1 1.5
Miles

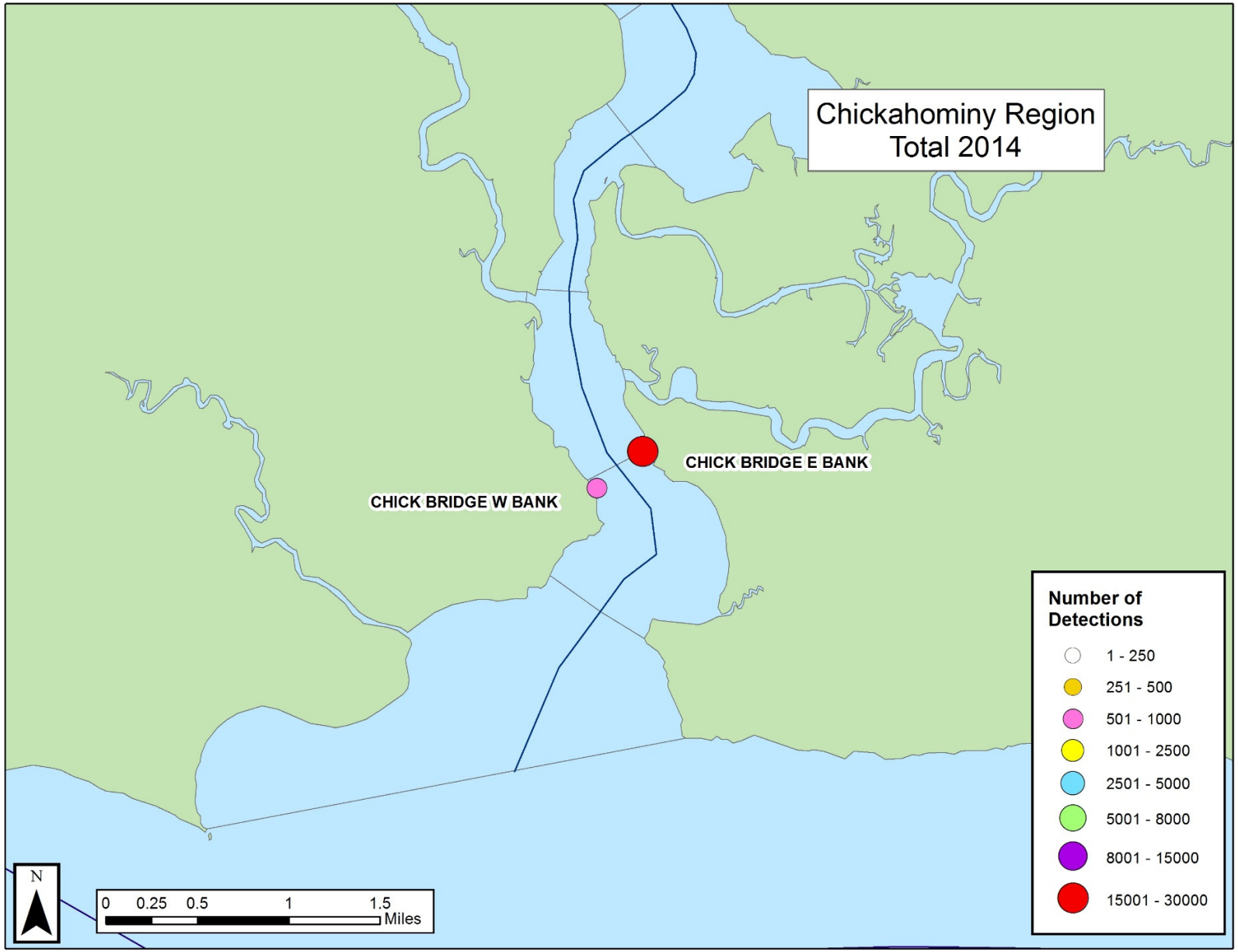

Chickahominy Region
Aug 2014
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.25 0.5 1 1.5
Miles

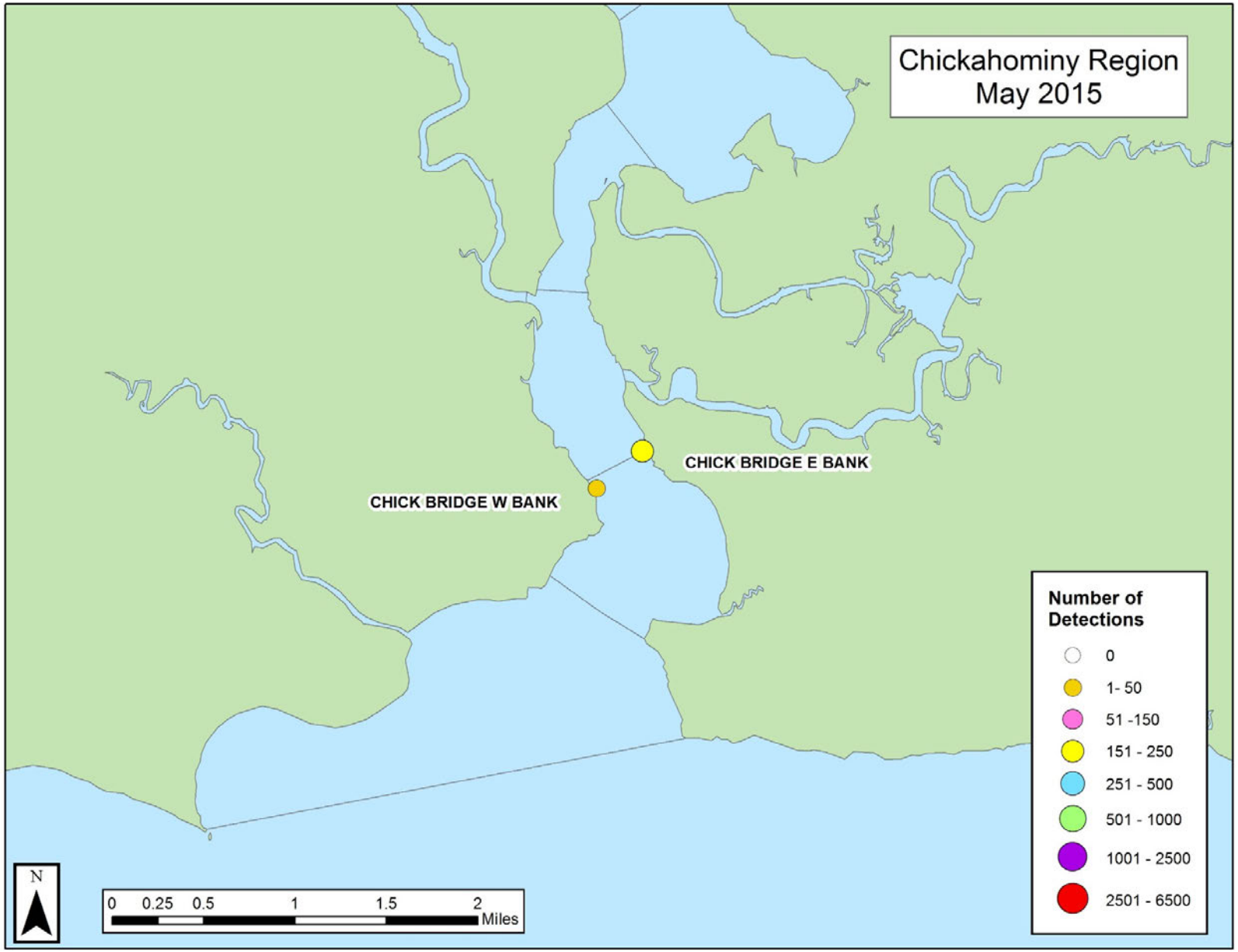

Chickahominy Region
Sep 2014
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
0
1 - 100
101 - 500
501 - 1000
1001 - 5000
5001 - 10000
10001 - 20000
20001 - 30000
N
0 0.25 0.5 1 1.5
Miles

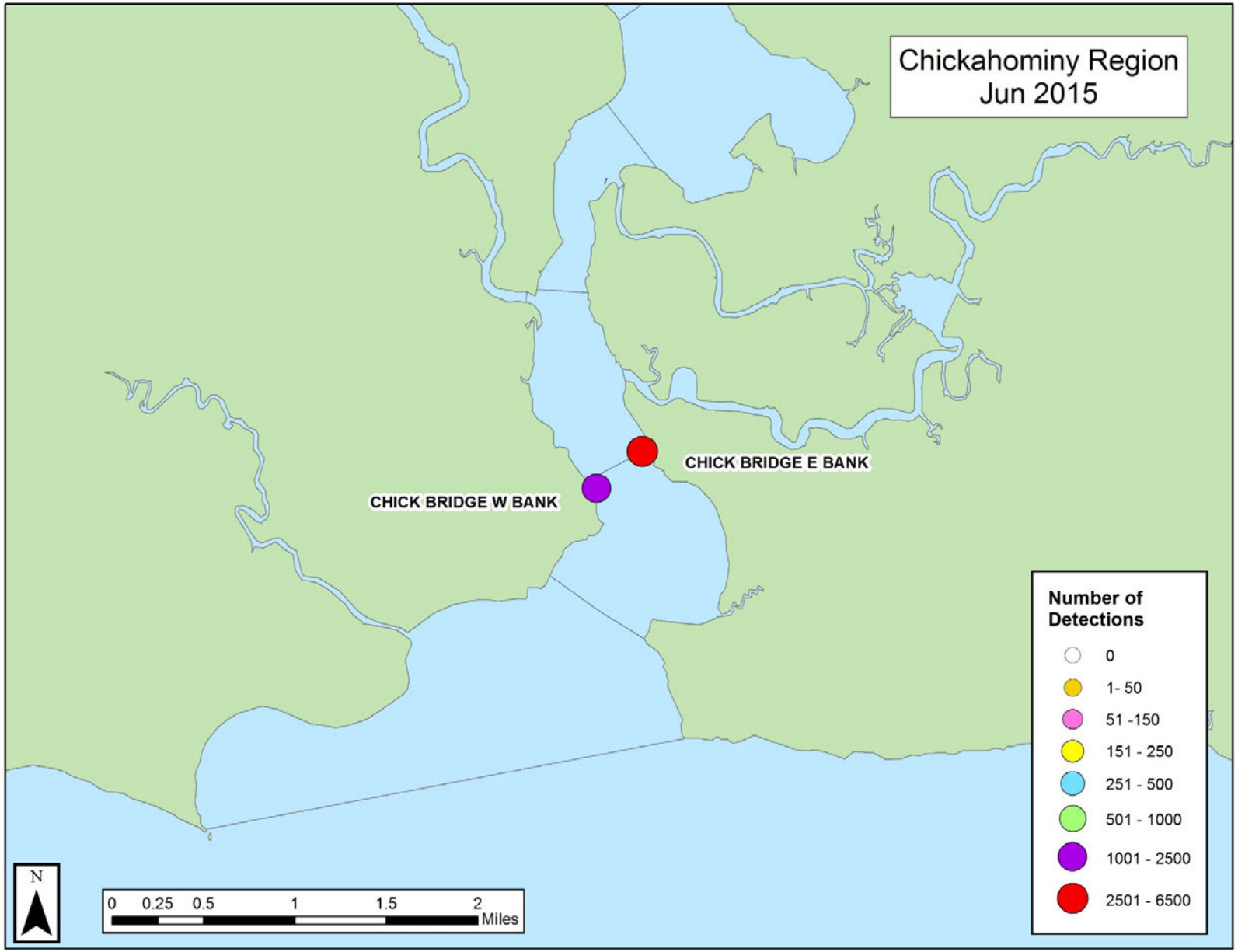

Chickahominy Region
Oct 2014
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.25 0.5 1 1.5
Miles

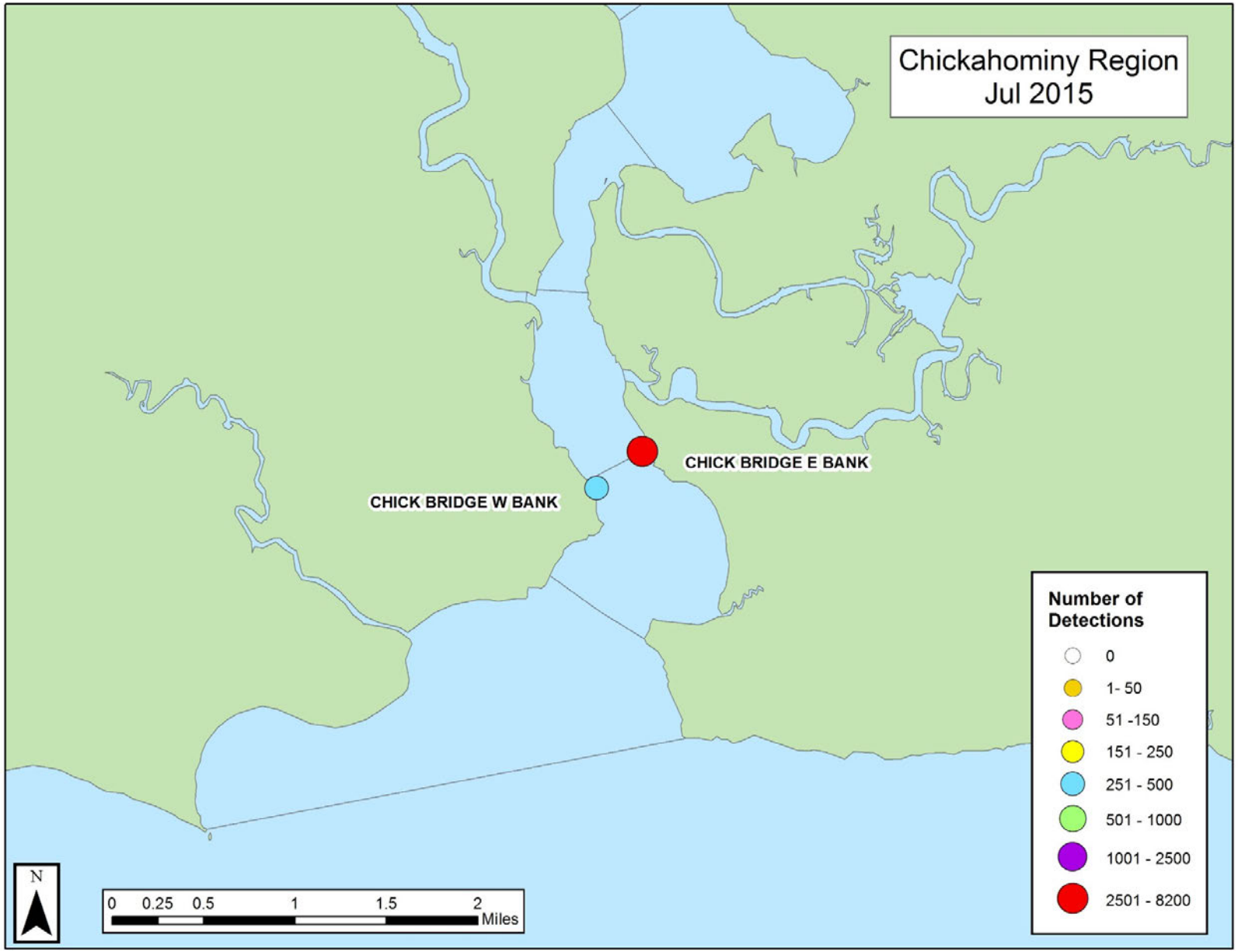

Chickahominy Region
Nov 2014
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.25 0.5 1 1.5
Miles

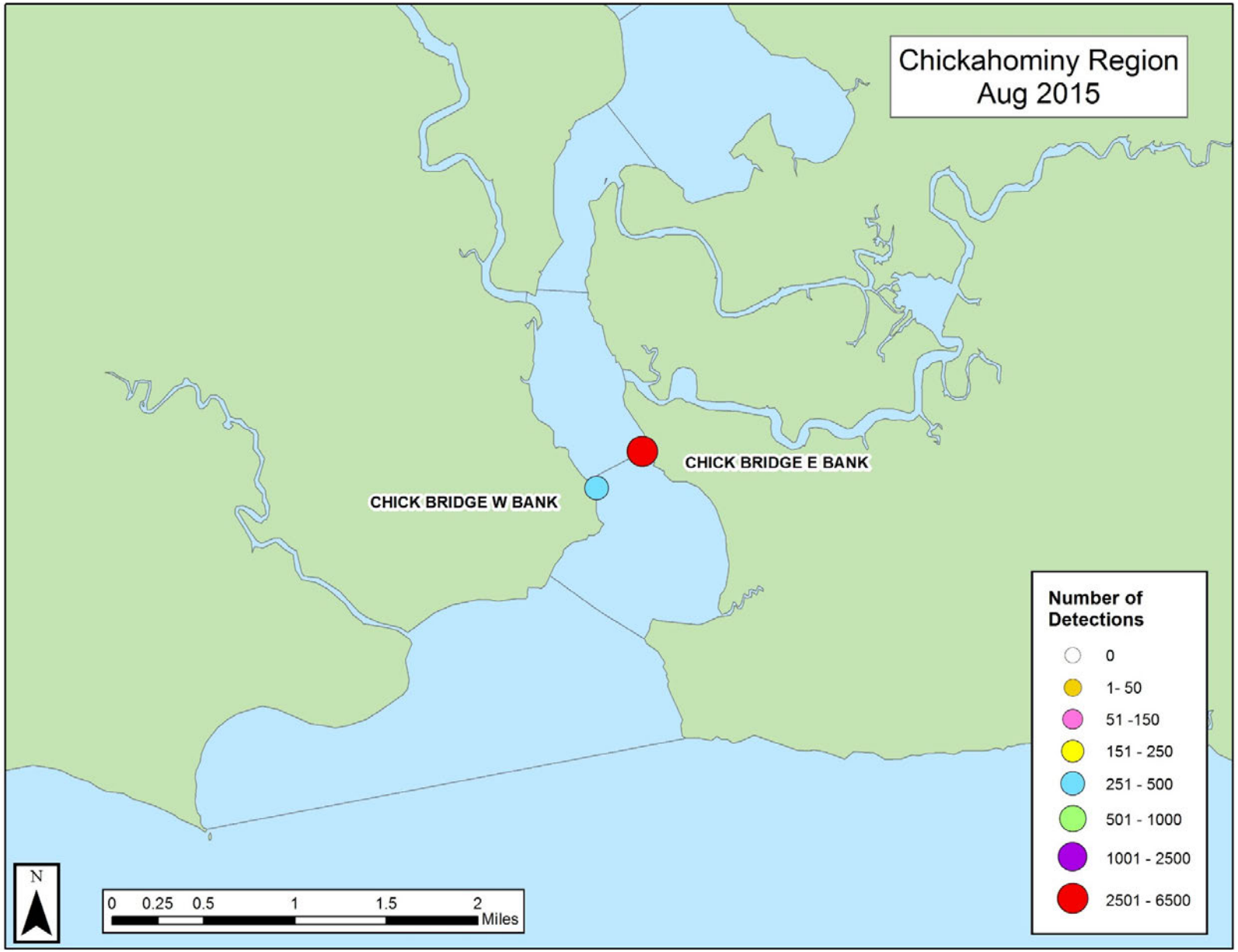

Chickahominy Region
Dec 2014
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.25 0.5 1 1.5
Miles

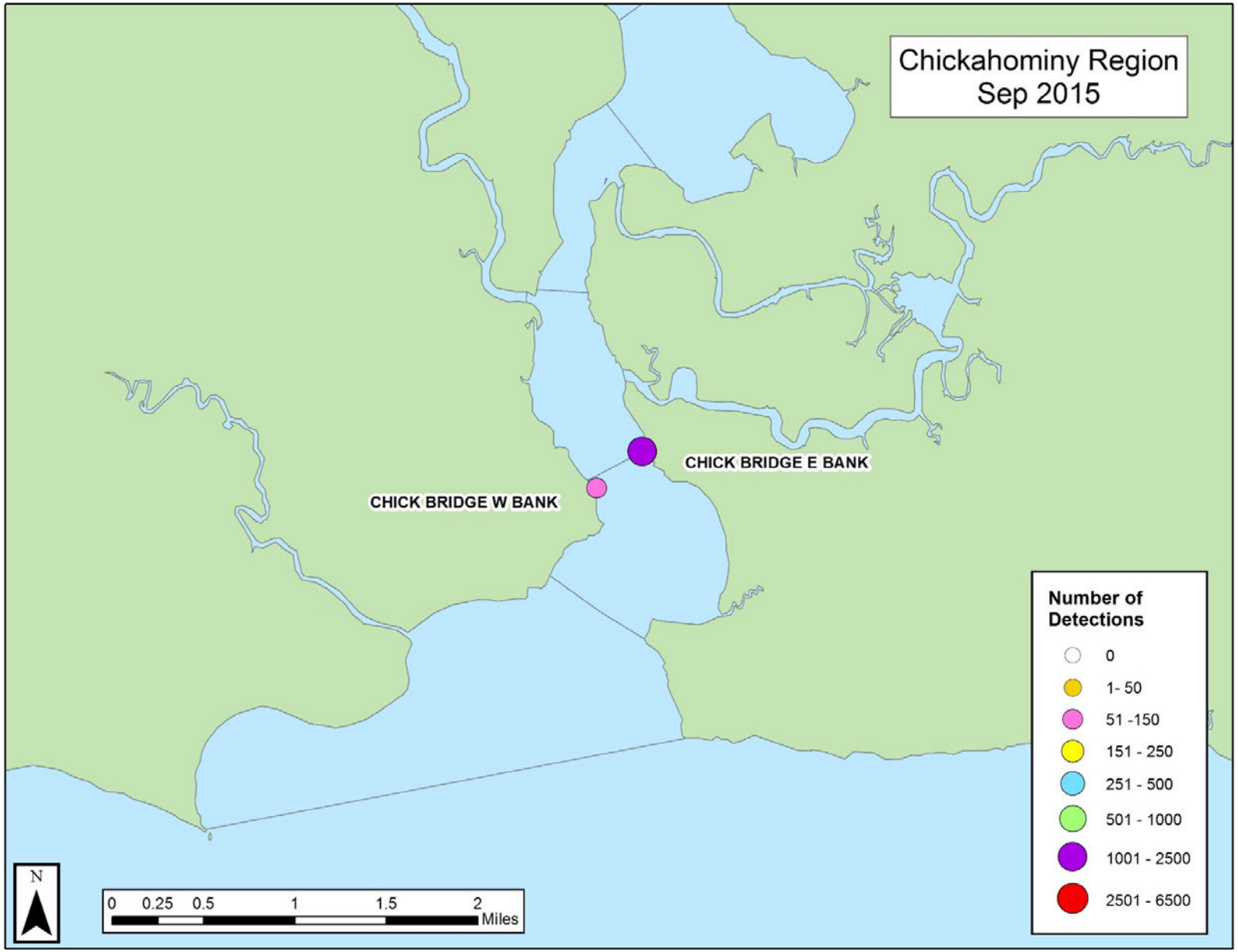

Chickahominy Region
Total 2014
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
N
0 0.25 0.5 1 1.5
Miles

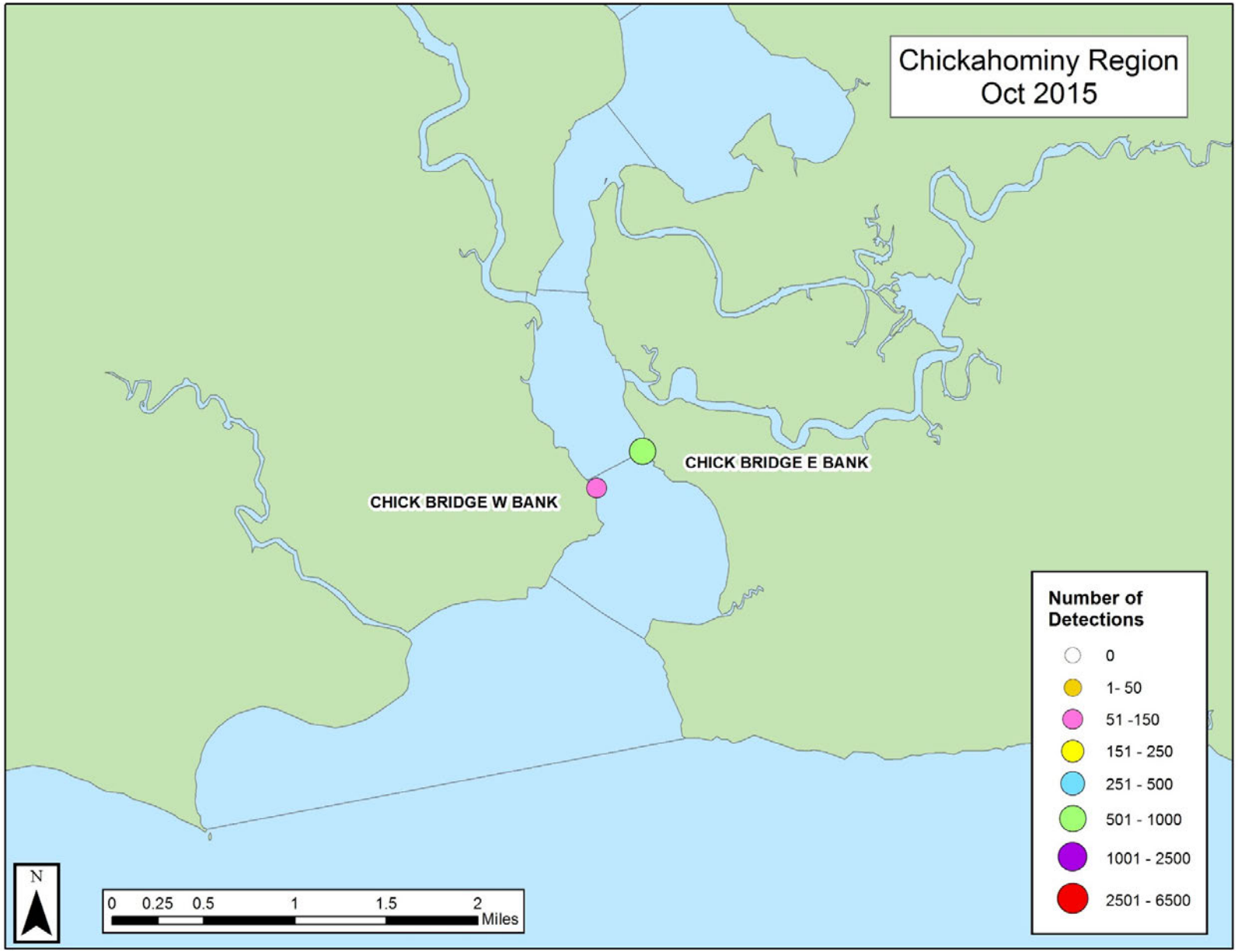

Chickahominy Region
May 2015
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.25 0.5 1 1.5 2
Miles

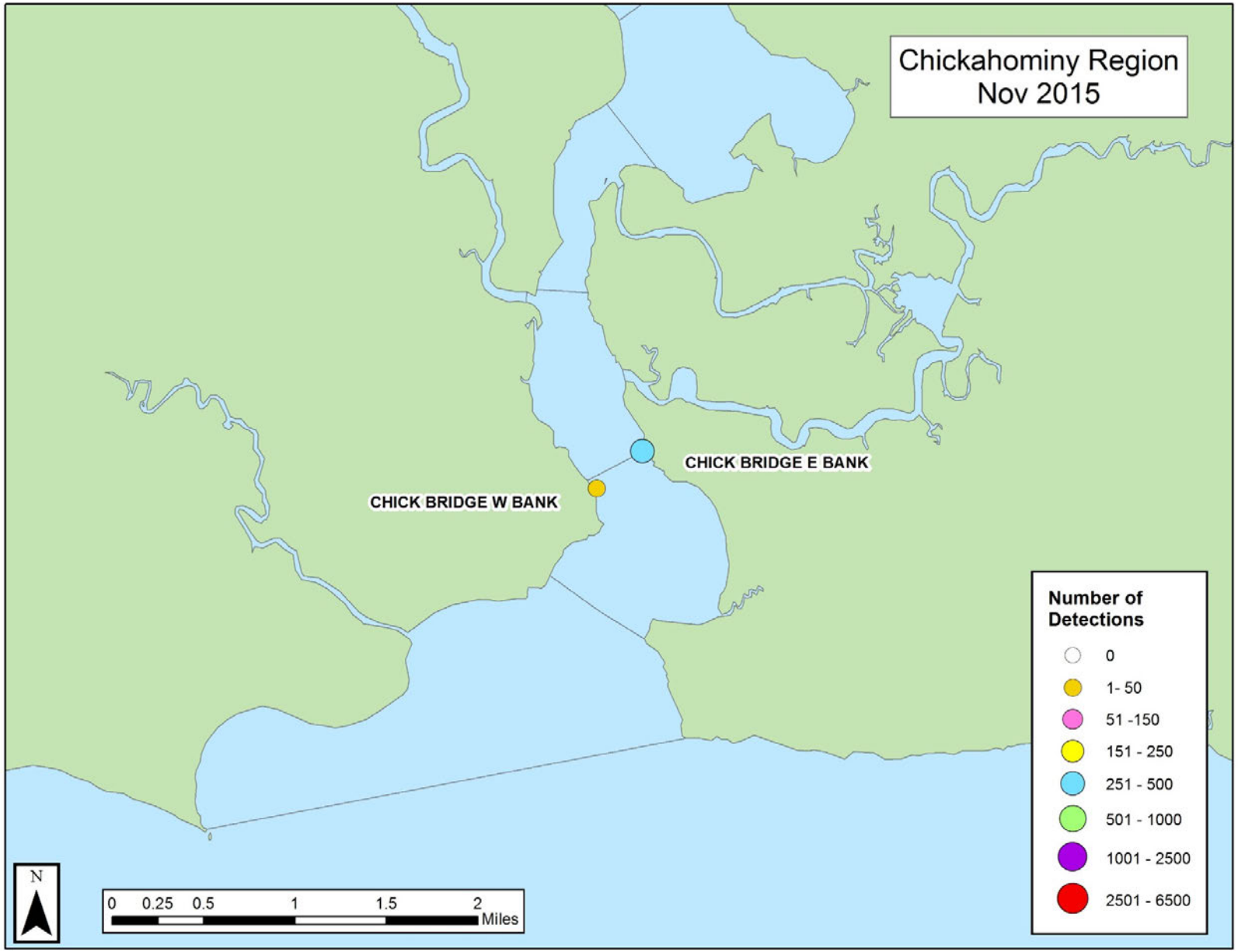

Chickahominy Region
Jun 2015
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.25 0.5 1 1.5 2
Miles

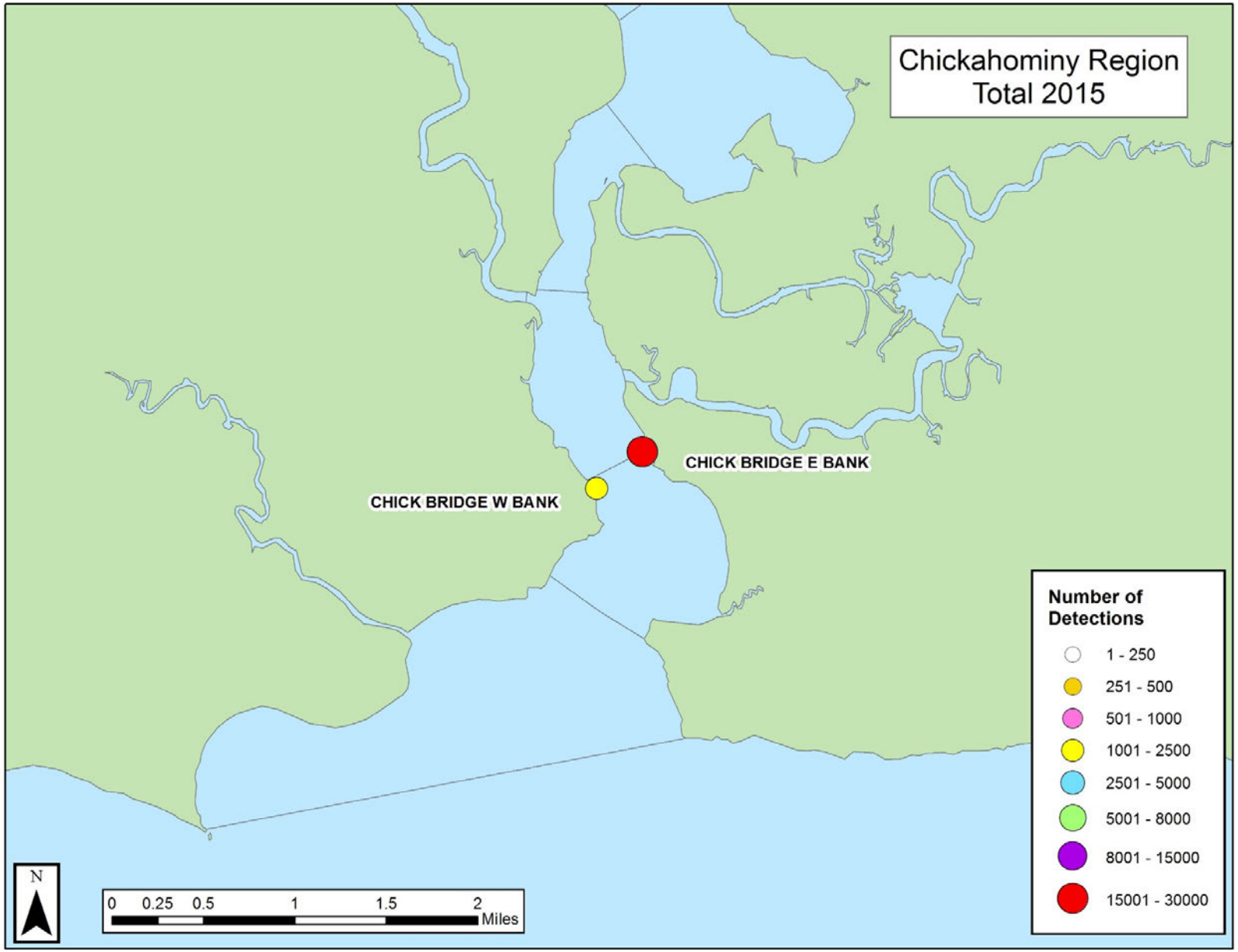

Chickahominy Region
Jul 2015
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 8200
N
0 0.25 0.5 1 1.5 2
Miles

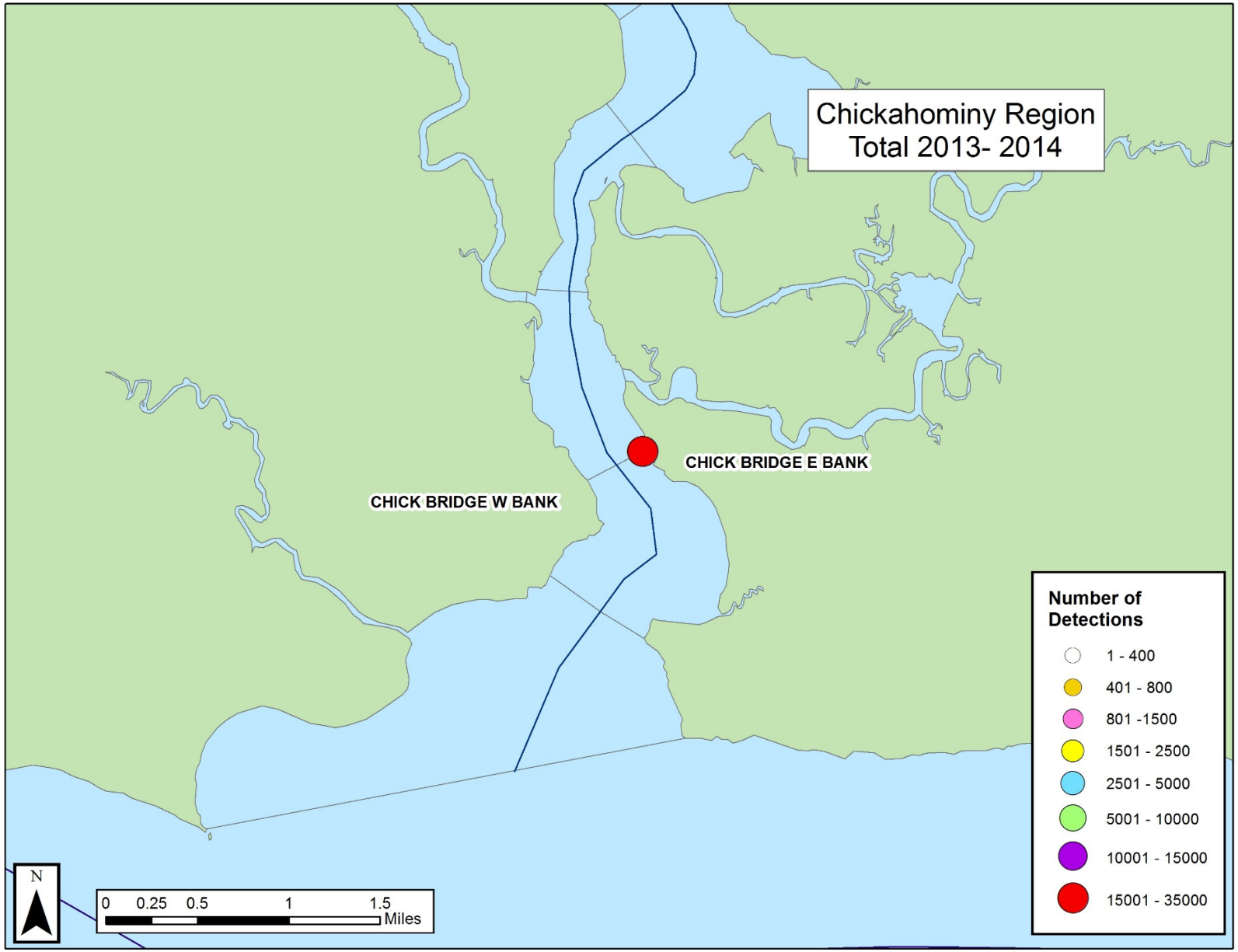

Chickahominy Region
Aug 2015
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.25 0.5 1 1.5 2
Miles

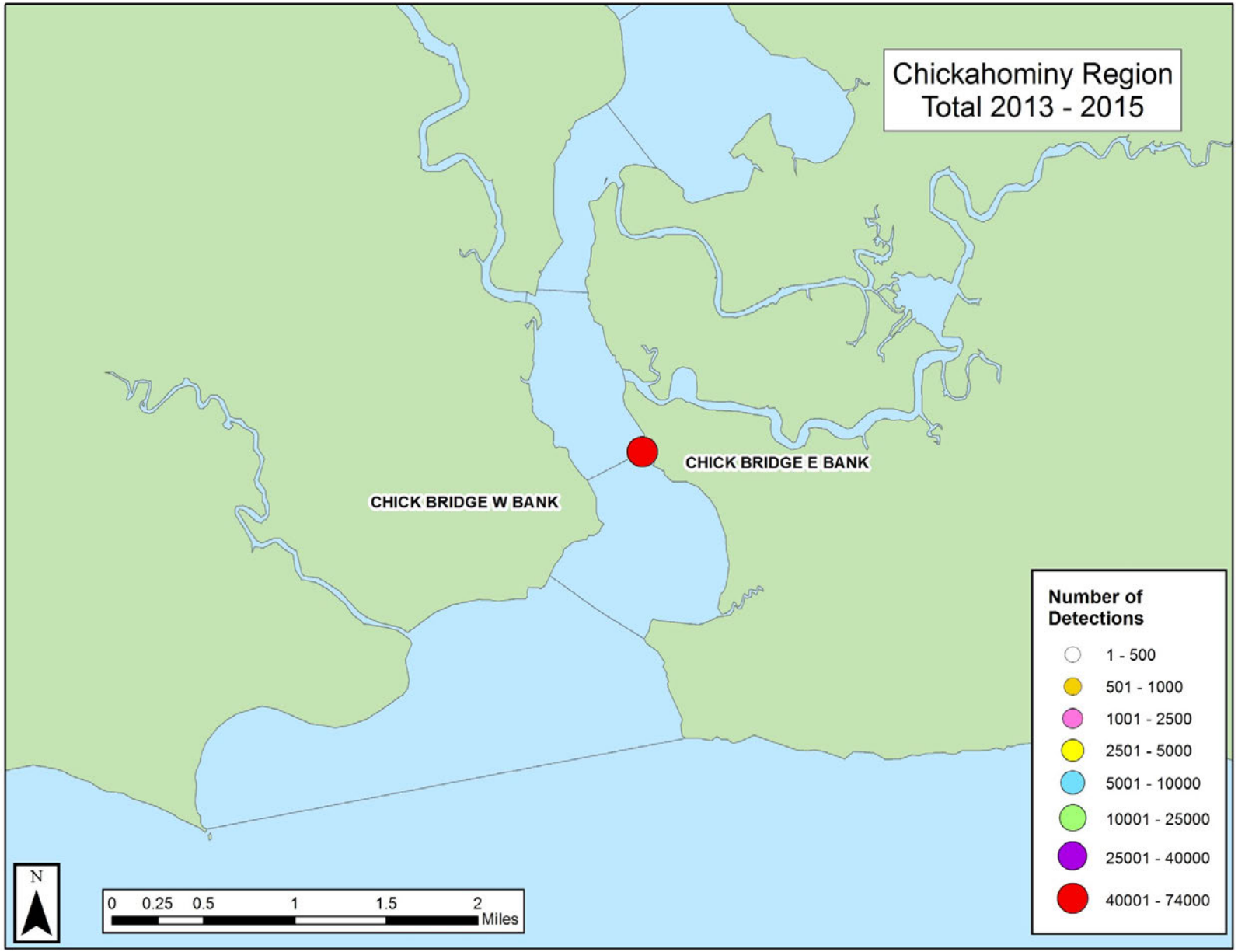

Chickahominy Region
Sep 2015
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.25 0.5 1 1.5 2
Miles


Chickahominy Region
Oct 2015
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.25 0.5 1 1.5 2
Miles

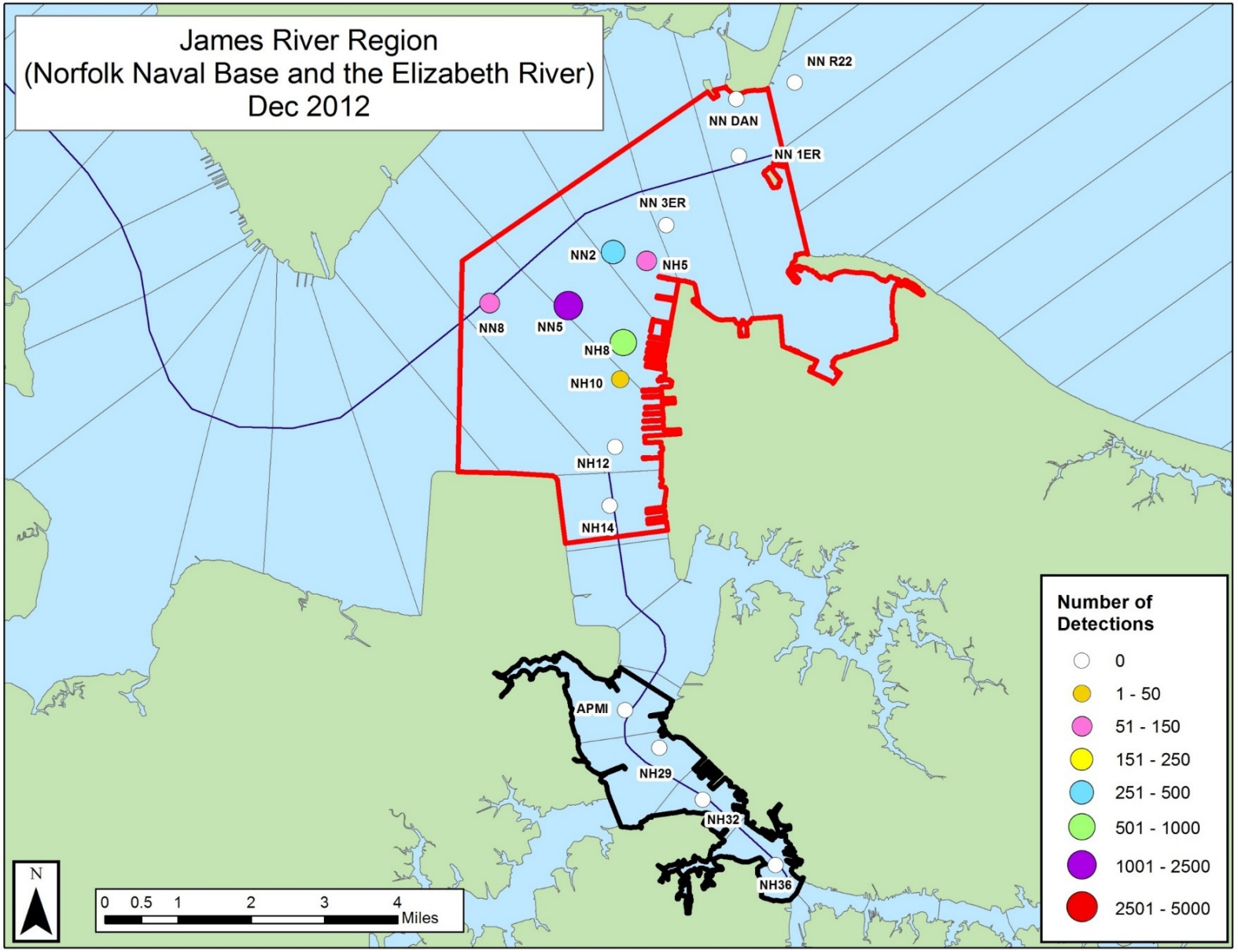

Chickahominy Region
Nov 2015
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.25 0.5 1 1.5 2
Miles

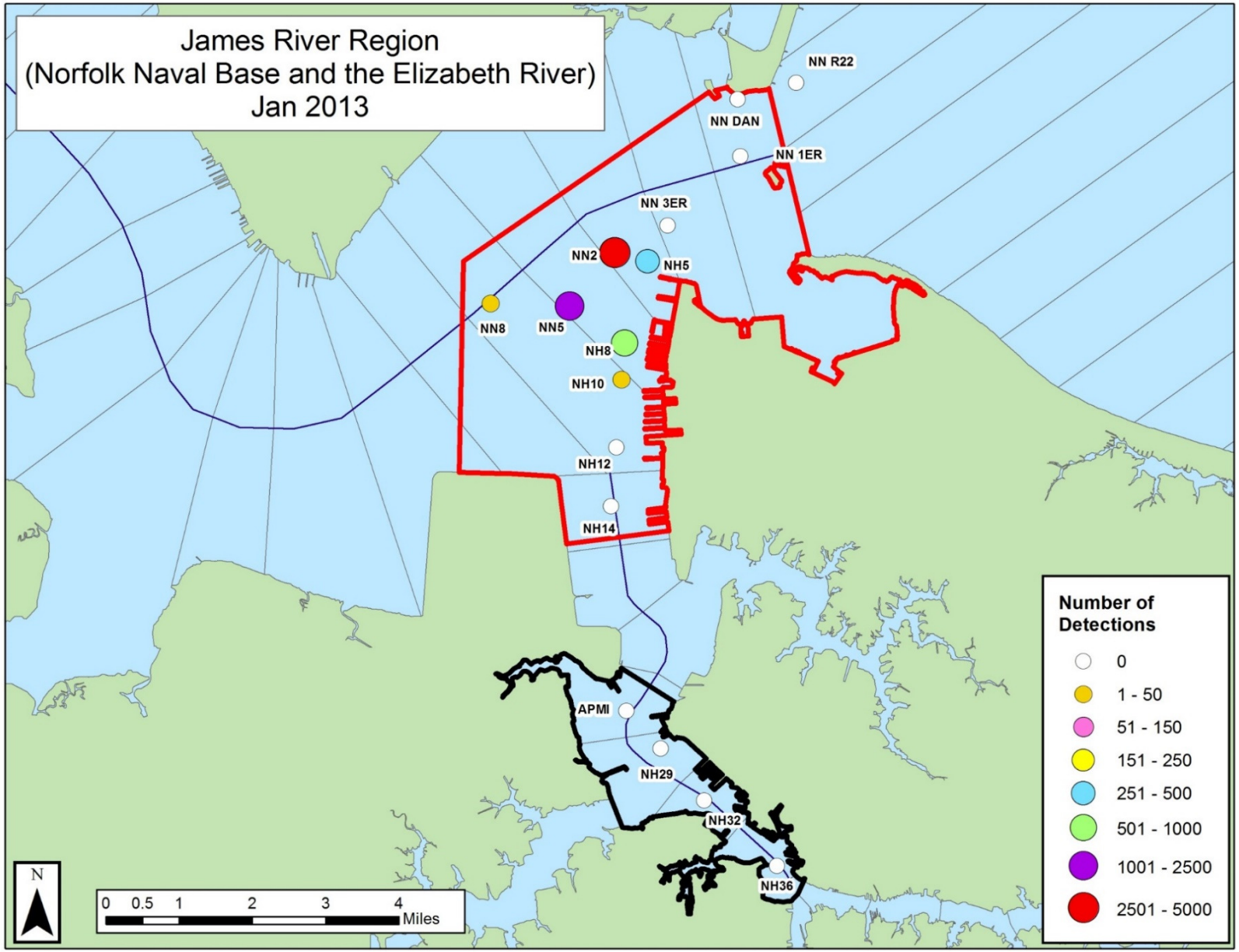

Chickahominy Region
Total 2015
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
N
0 0.25 0.5 1 1.5 2
Miles

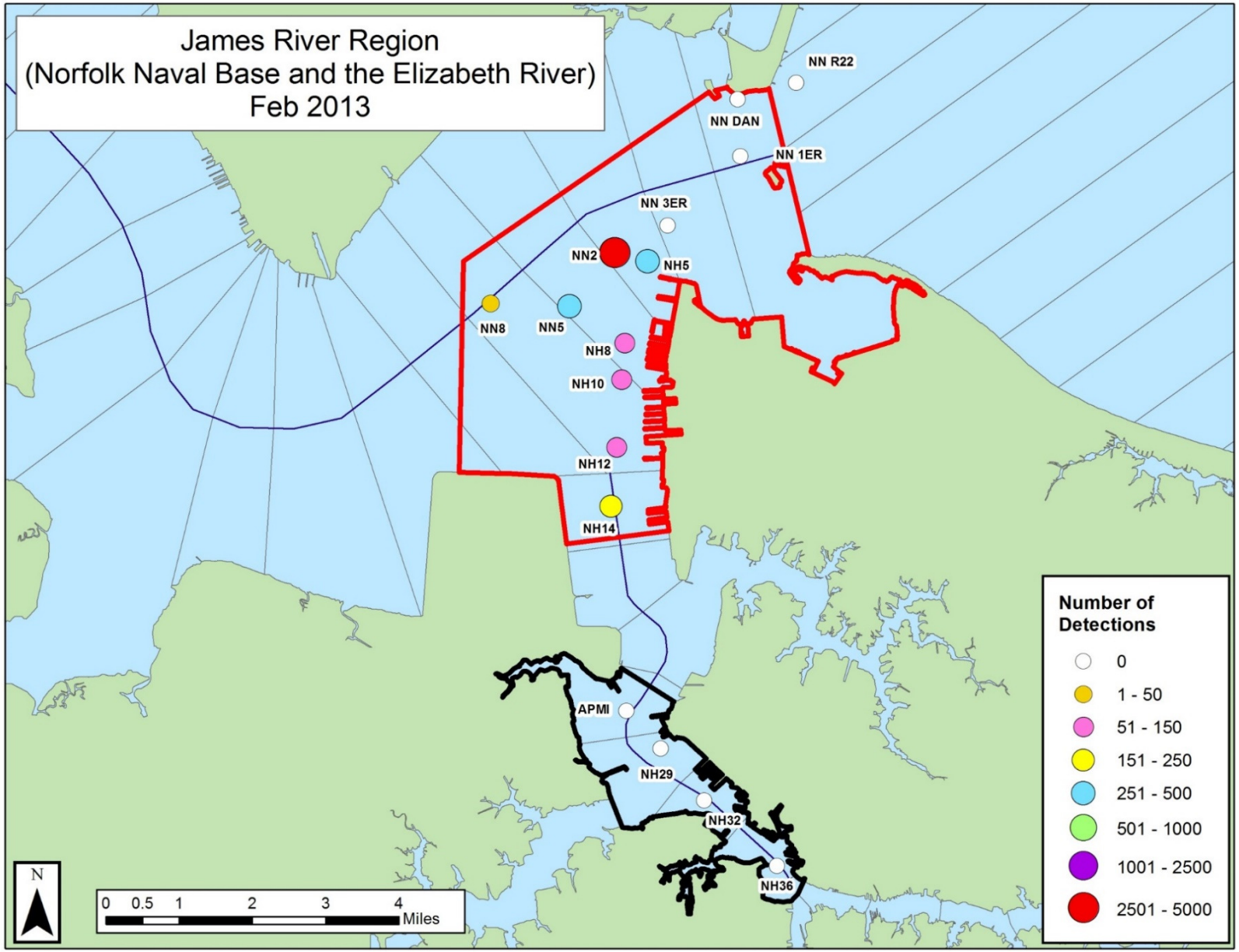

Chickahominy Region
Total 2013- 2014
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
1 - 400
401 - 800
801 -1500
1501 - 2500
2501 - 5000
5001 - 10000
10001 - 15000
15001 - 35000
N
0 0.25 0.5 1 1.5
Miles

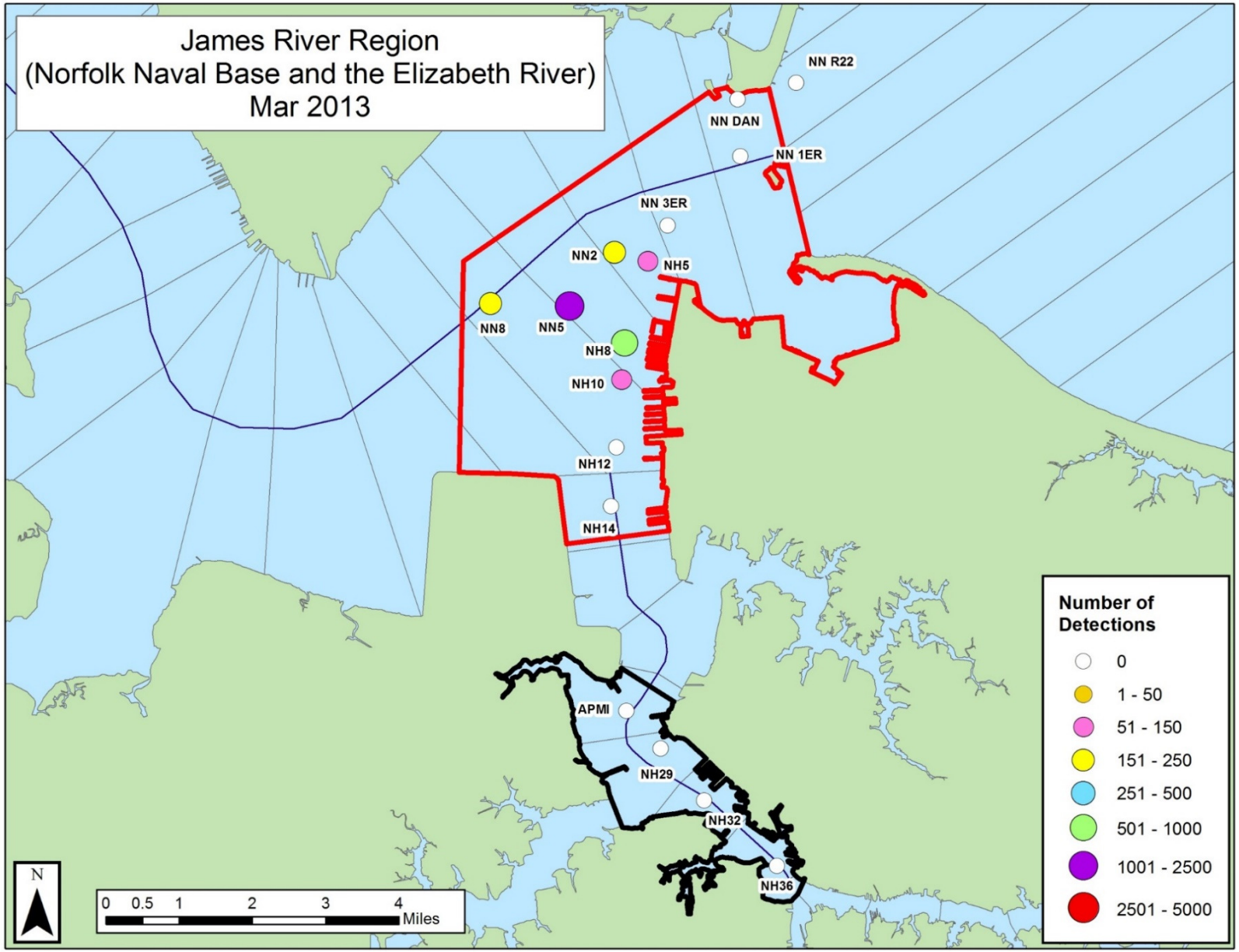

Chickahominy Region
Total 2013 - 2015
CHICK BRIDGE E BANK
CHICK BRIDGE W BANK
Number of Detections
1 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 10000
10001 - 25000
25001 - 40000
40001 - 74000
N
0 0.25 0.5 1 1.5 2
Miles

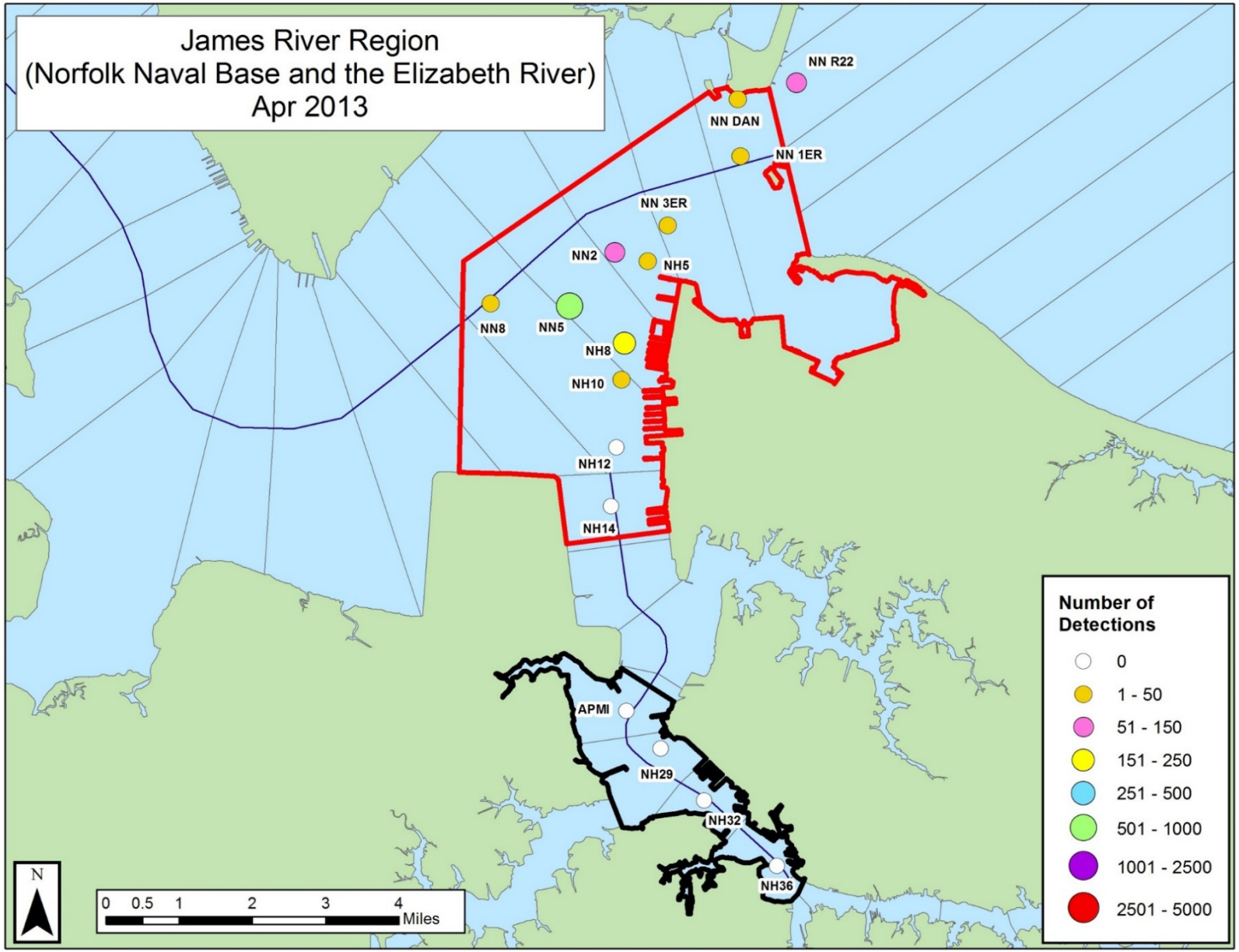
## 9.6 APPENDIX 4.4.4: JAMES RIVER REGION (NORFOLK NAVAL BASE AND ELIZABETH RIVER)

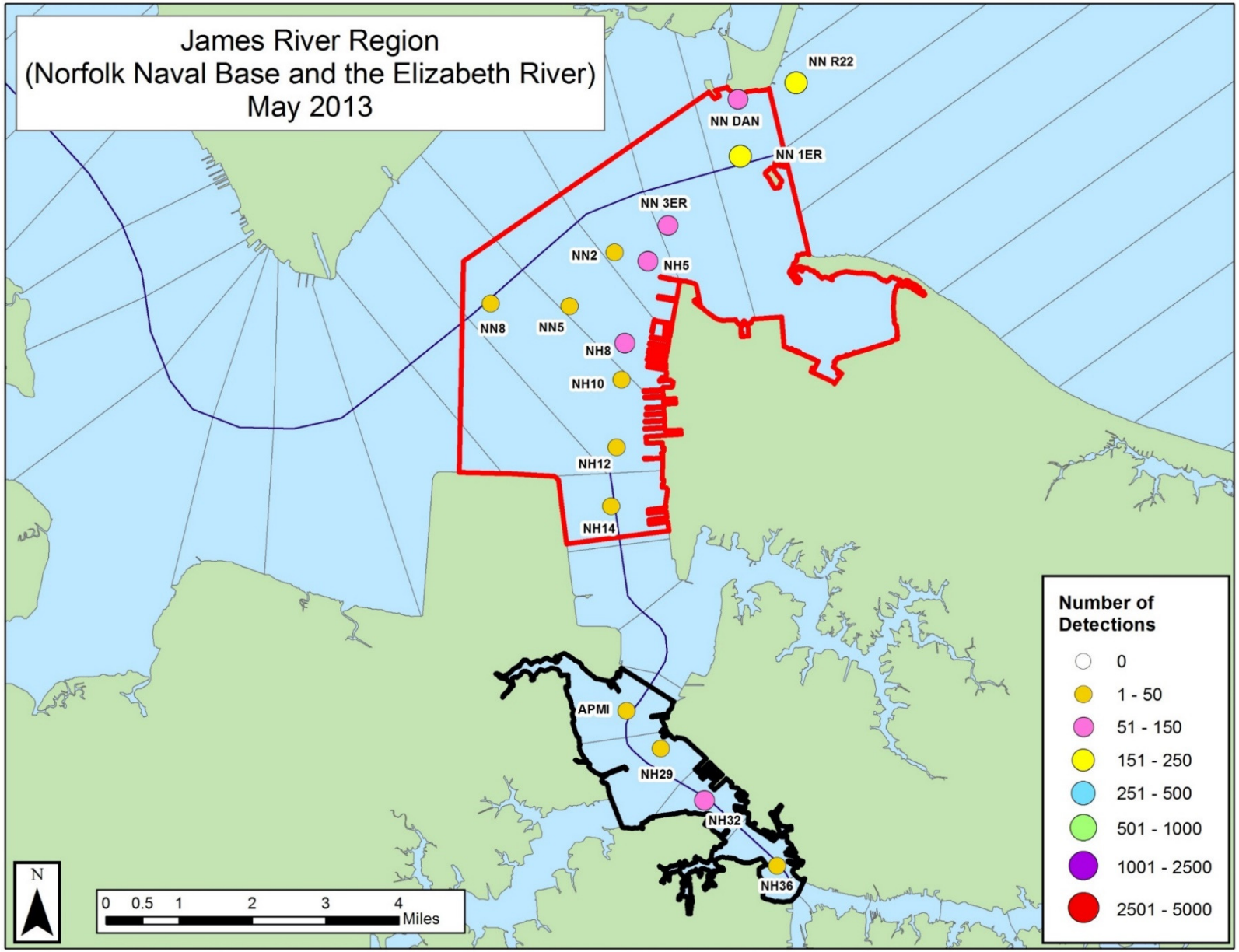


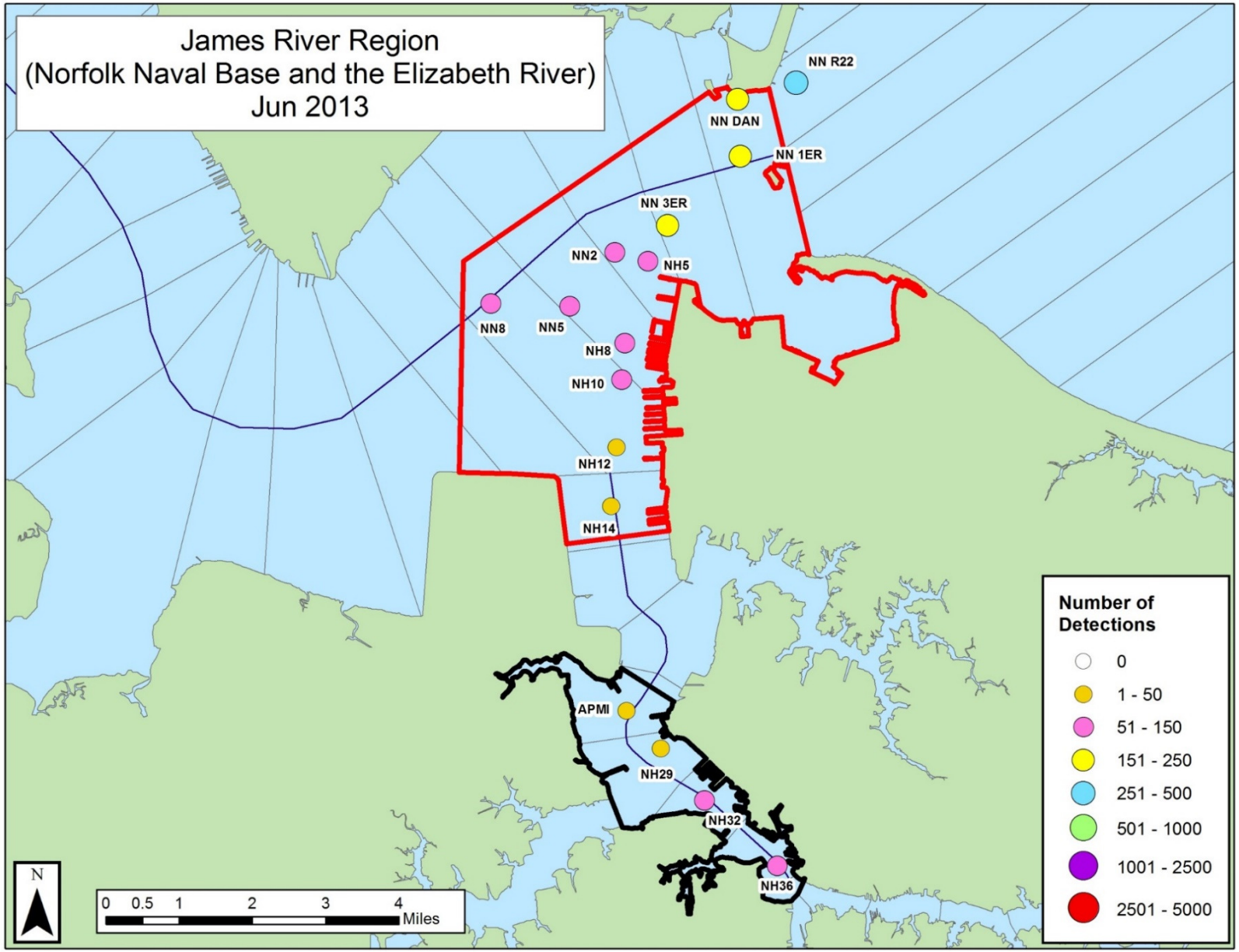

James River Region
(Norfolk Naval Base and the Elizabeth River)
Jan 2013
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

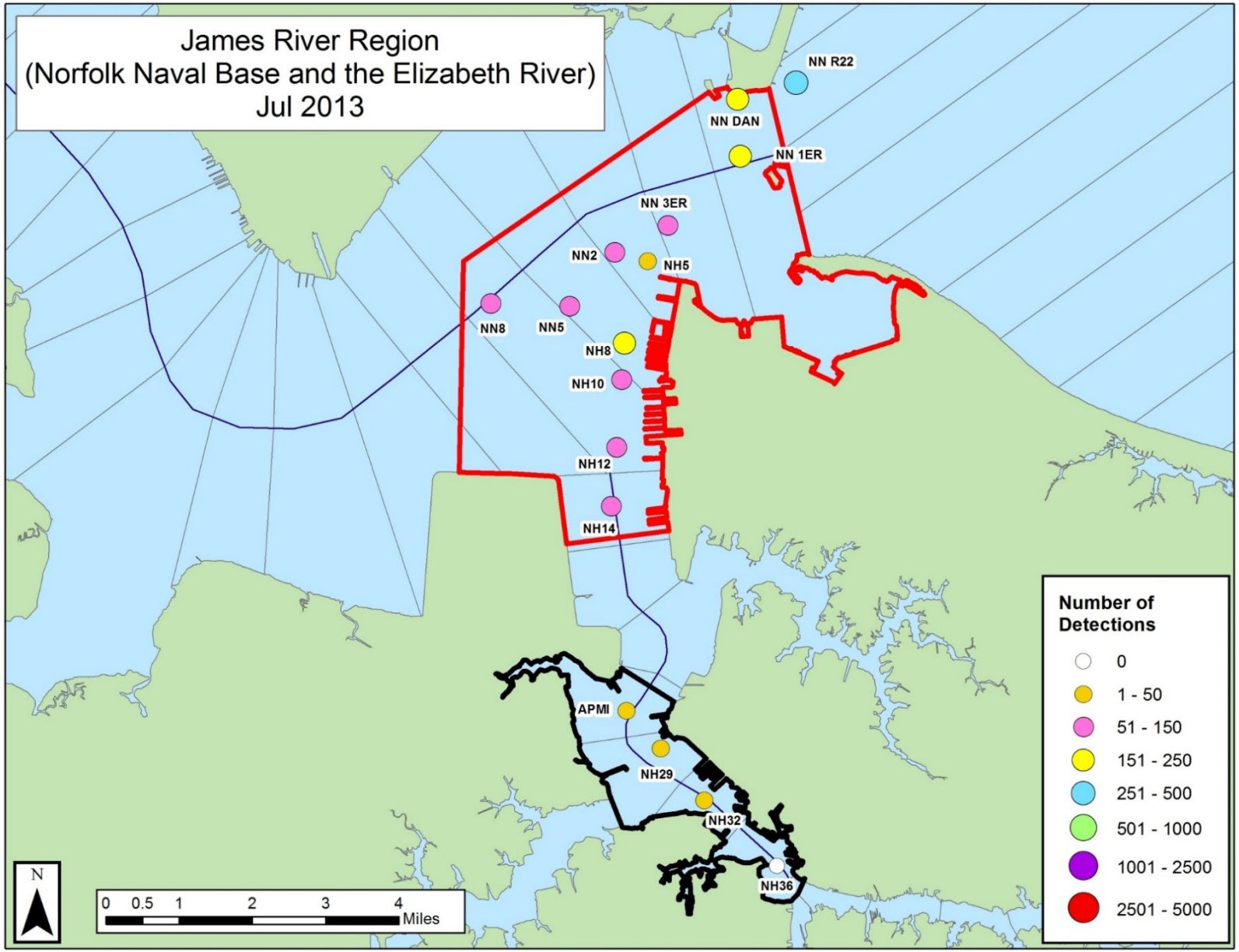

James River Region
(Norfolk Naval Base and the Elizabeth River)
Feb 2013
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

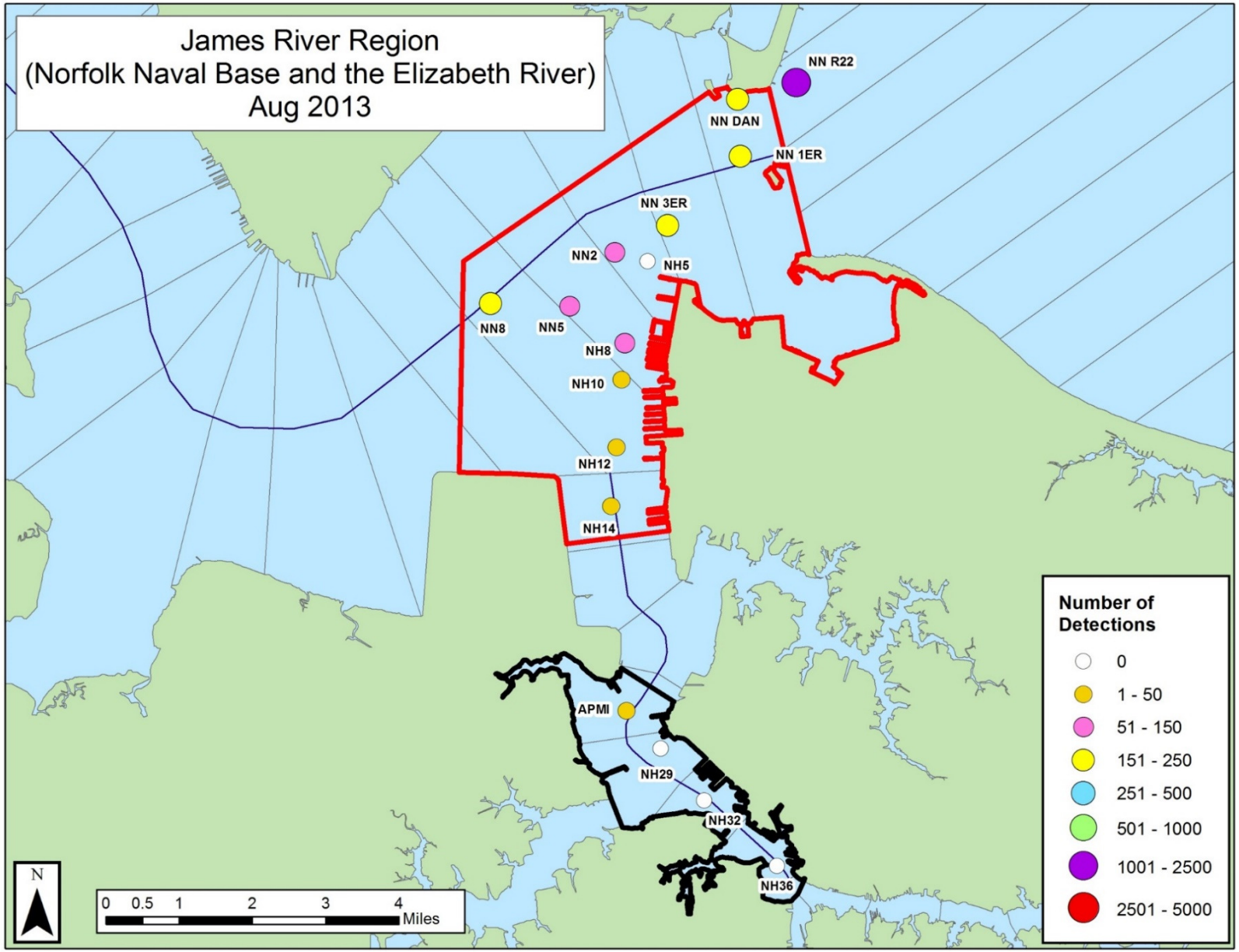

James River Region
(Norfolk Naval Base and the Elizabeth River)
Mar 2013
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

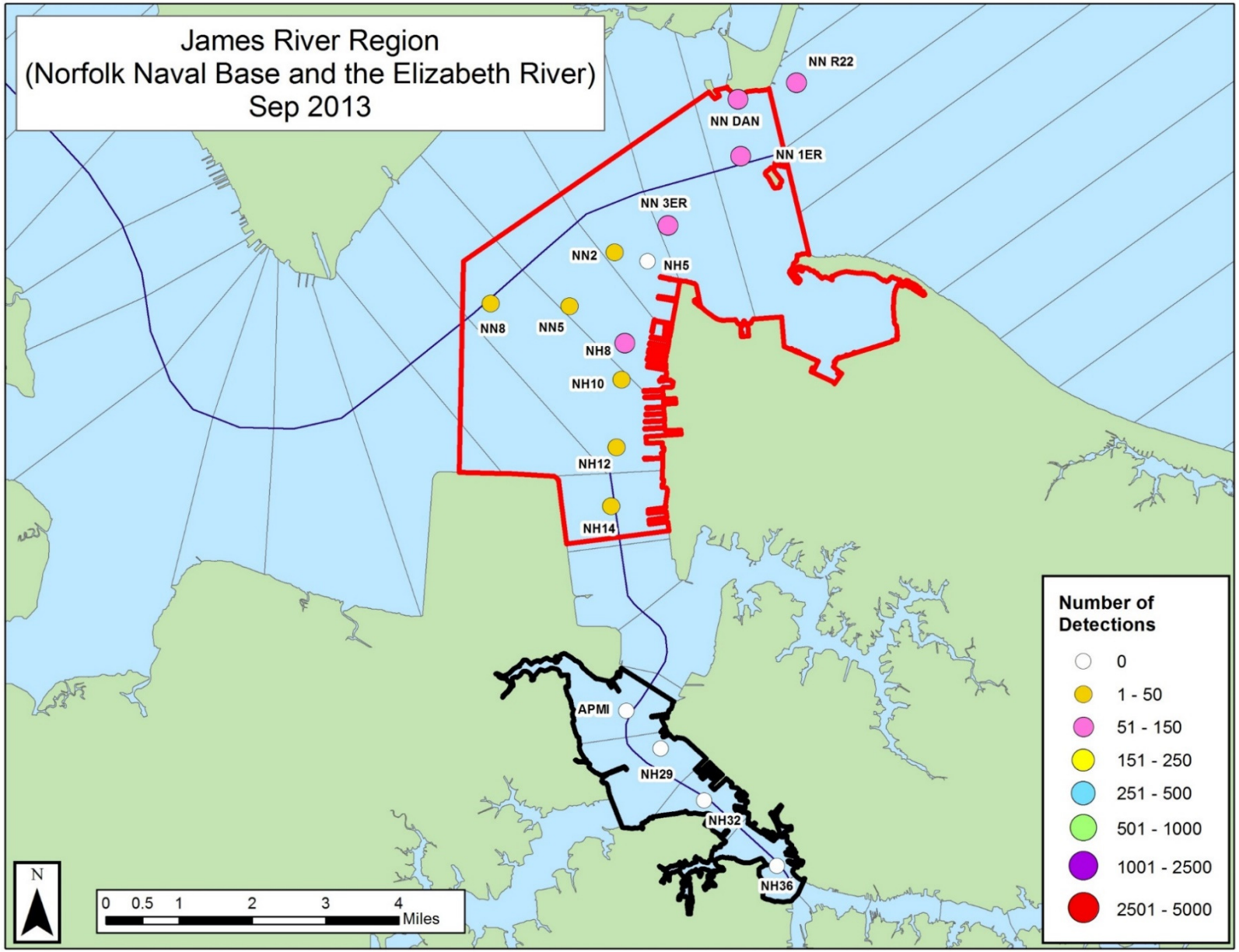

James River Region
(Norfolk Naval Base and the Elizabeth River)
Apr 2013
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

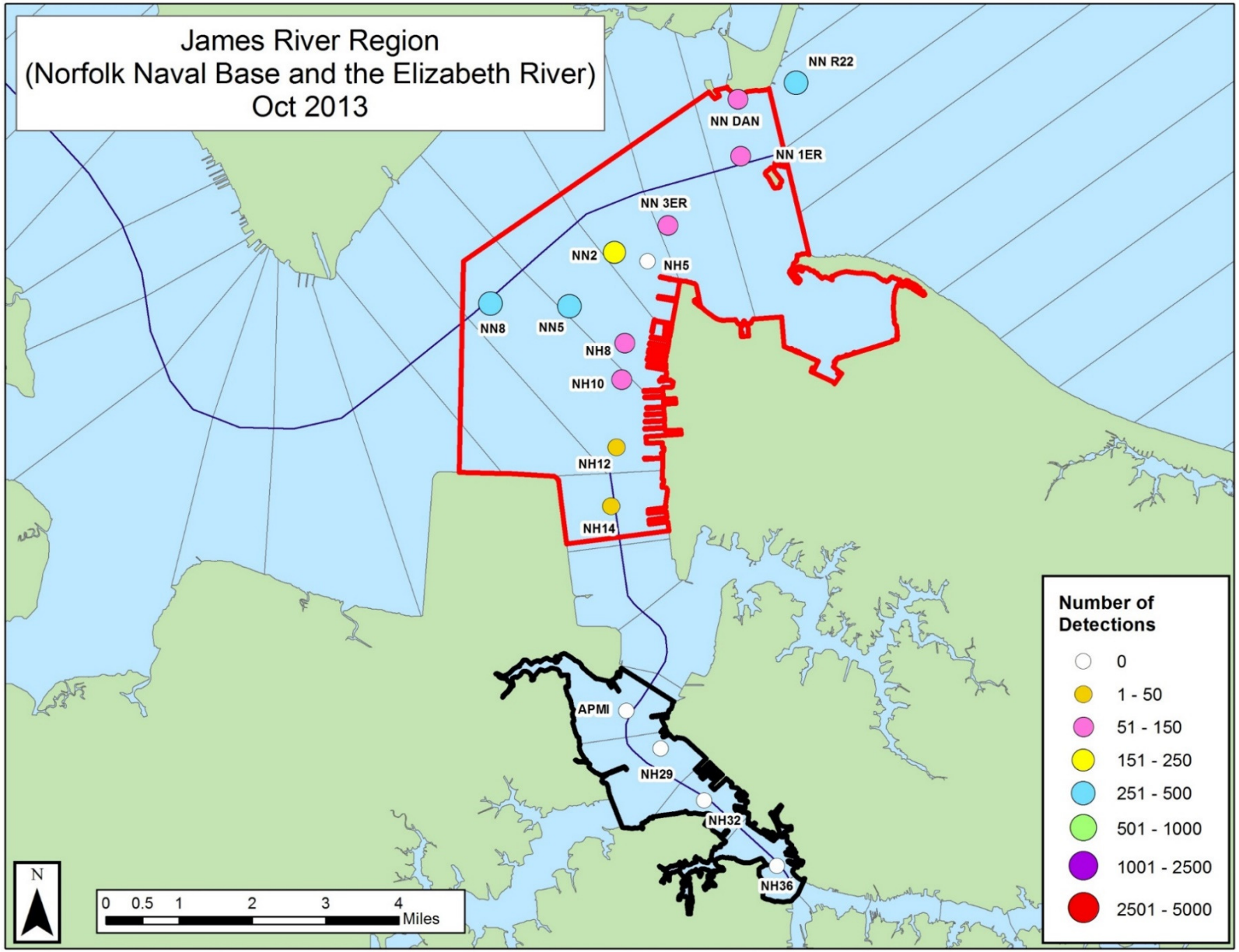

James River Region
(Norfolk Naval Base and the Elizabeth River)
May 2013
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

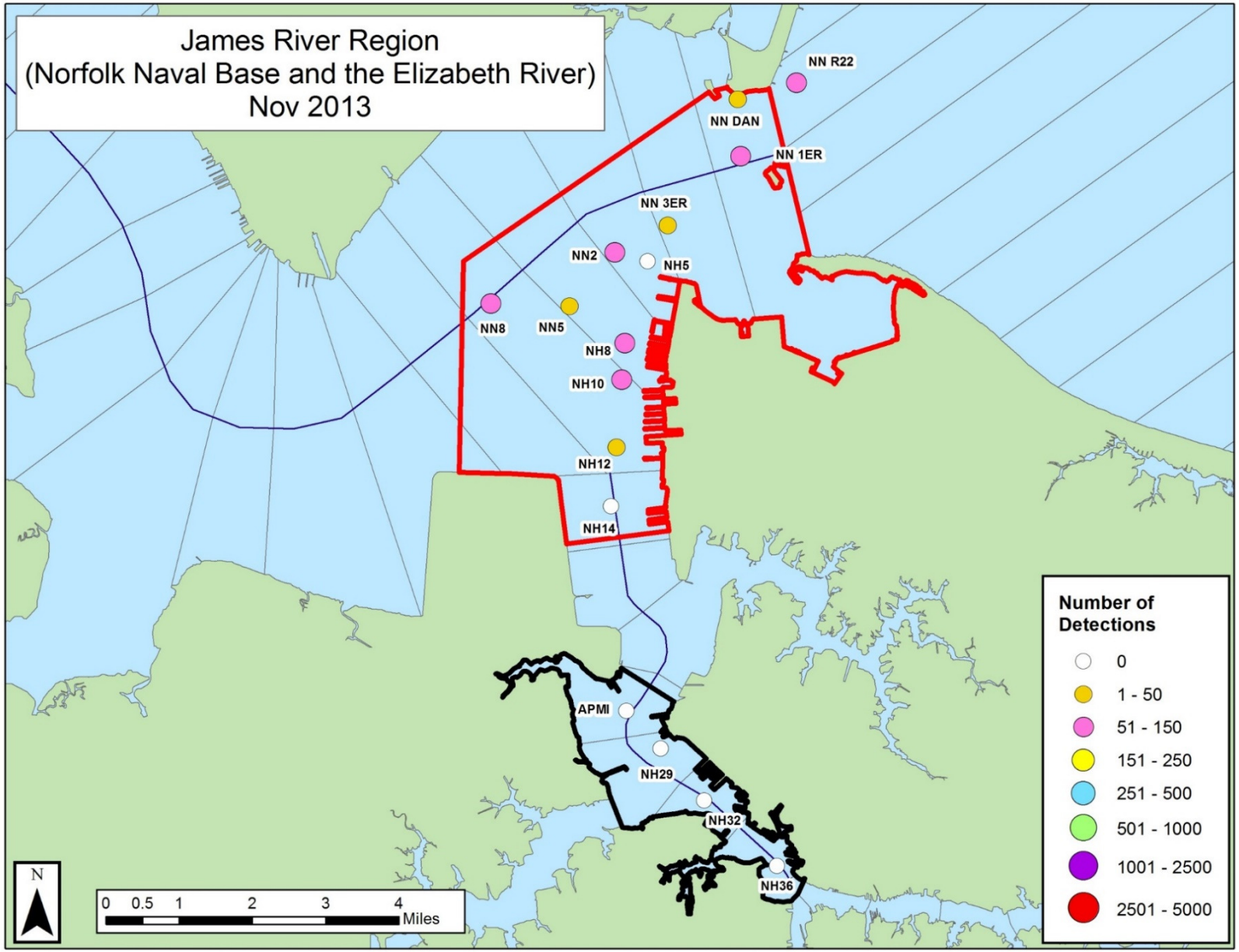

James River Region
(Norfolk Naval Base and the Elizabeth River)
Jun 2013
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

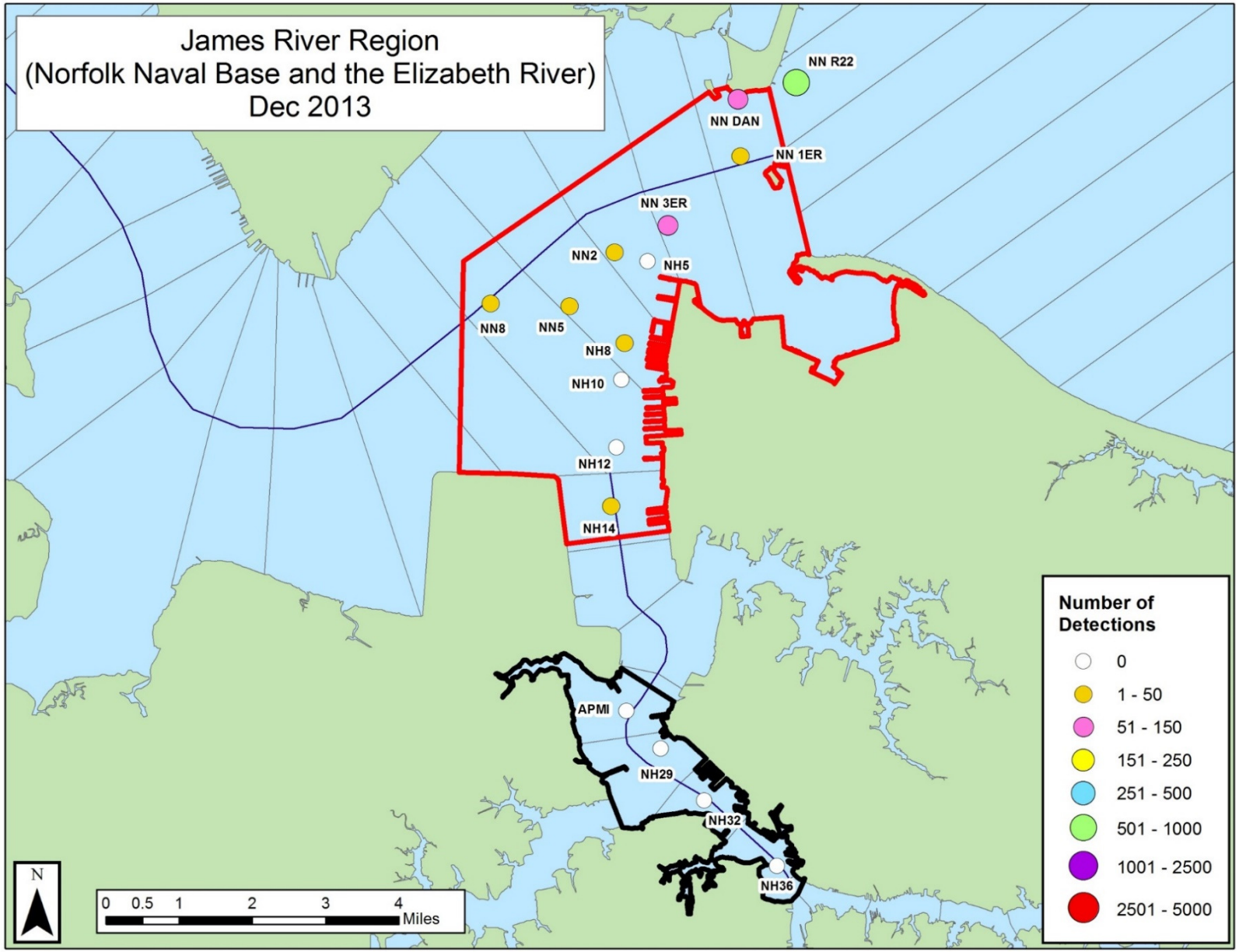

James River Region
(Norfolk Naval Base and the Elizabeth River)
Jul 2013
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

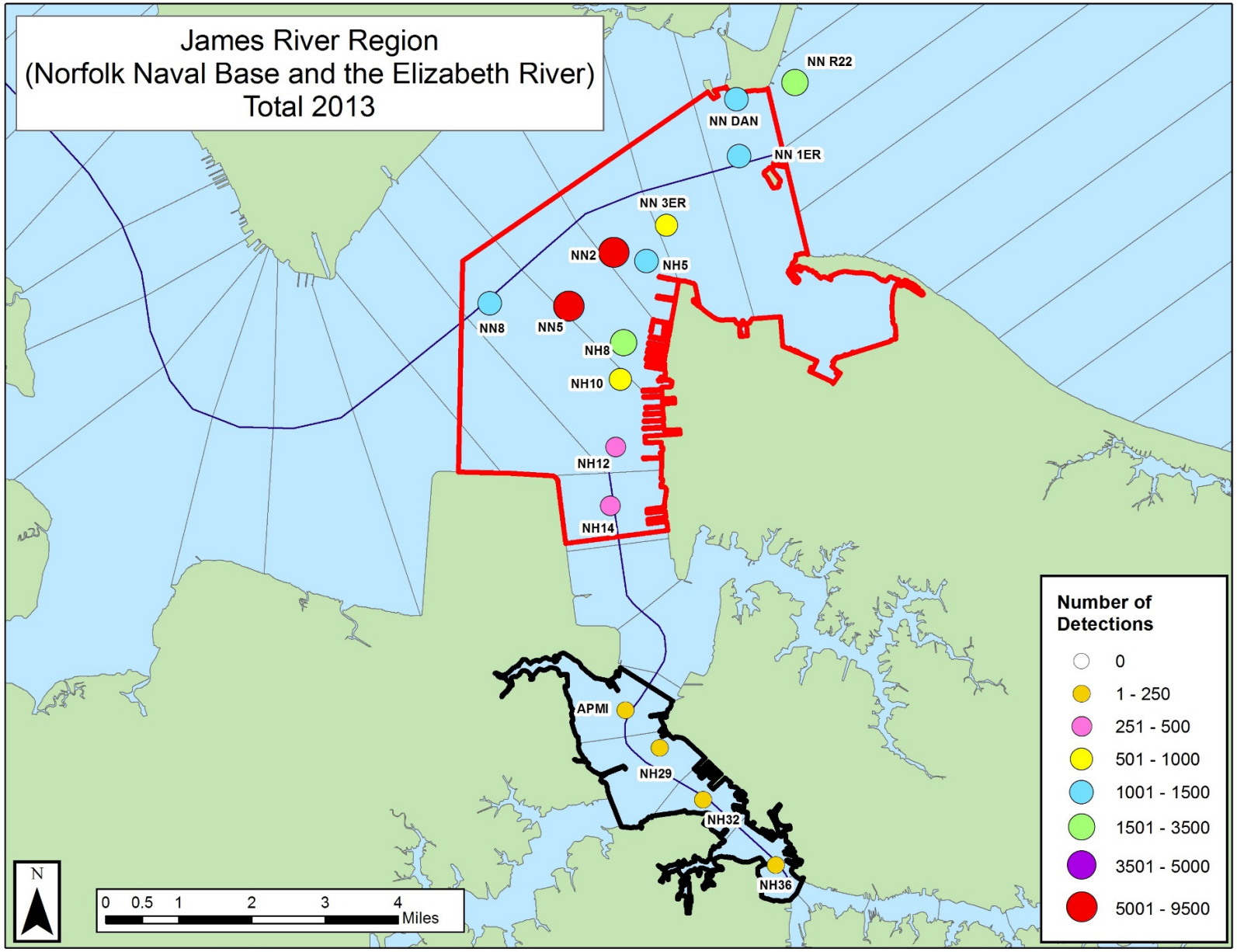

James River Region
(Norfolk Naval Base and the Elizabeth River)
Aug 2013
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

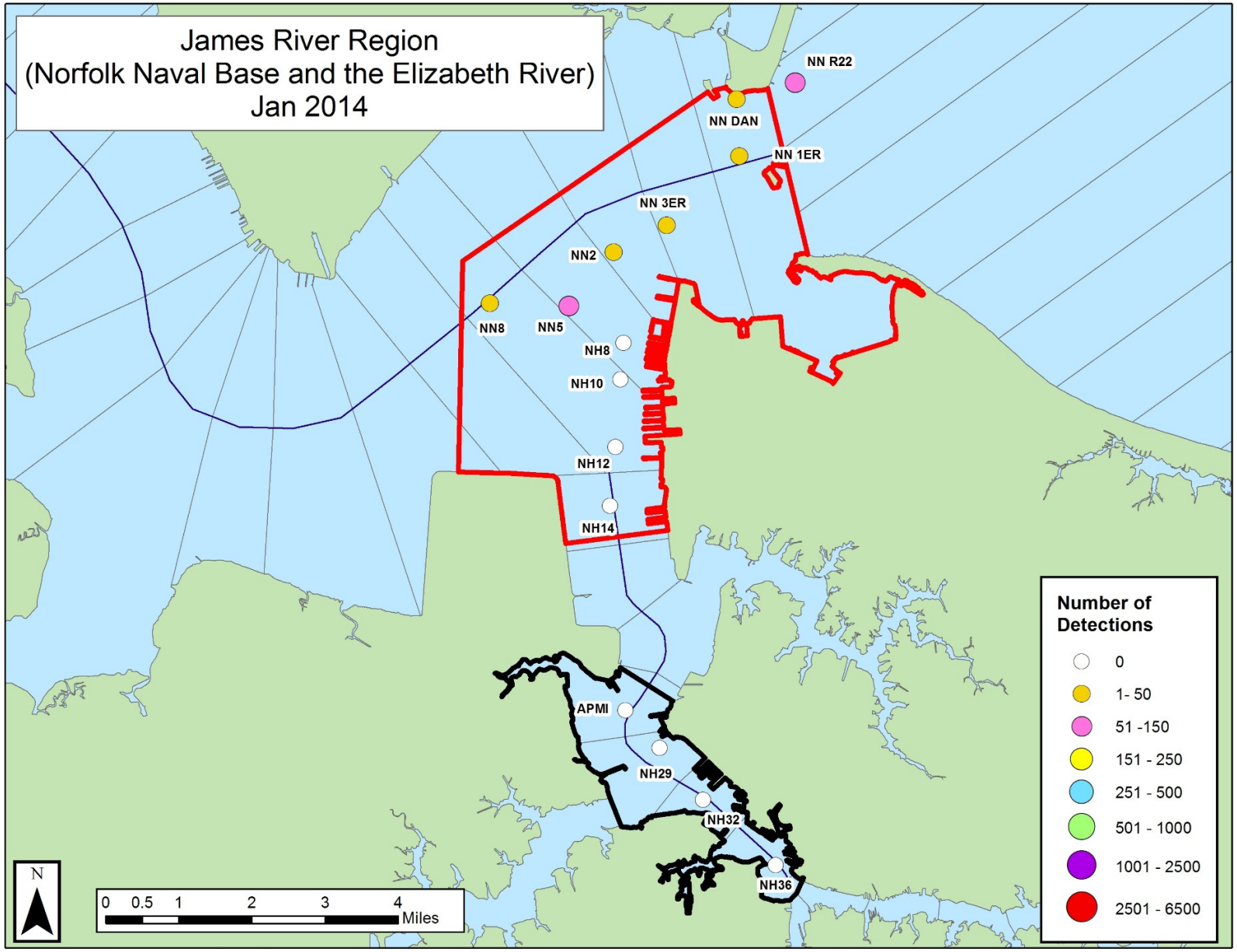

James River Region
(Norfolk Naval Base and the Elizabeth River)
Sep 2013
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

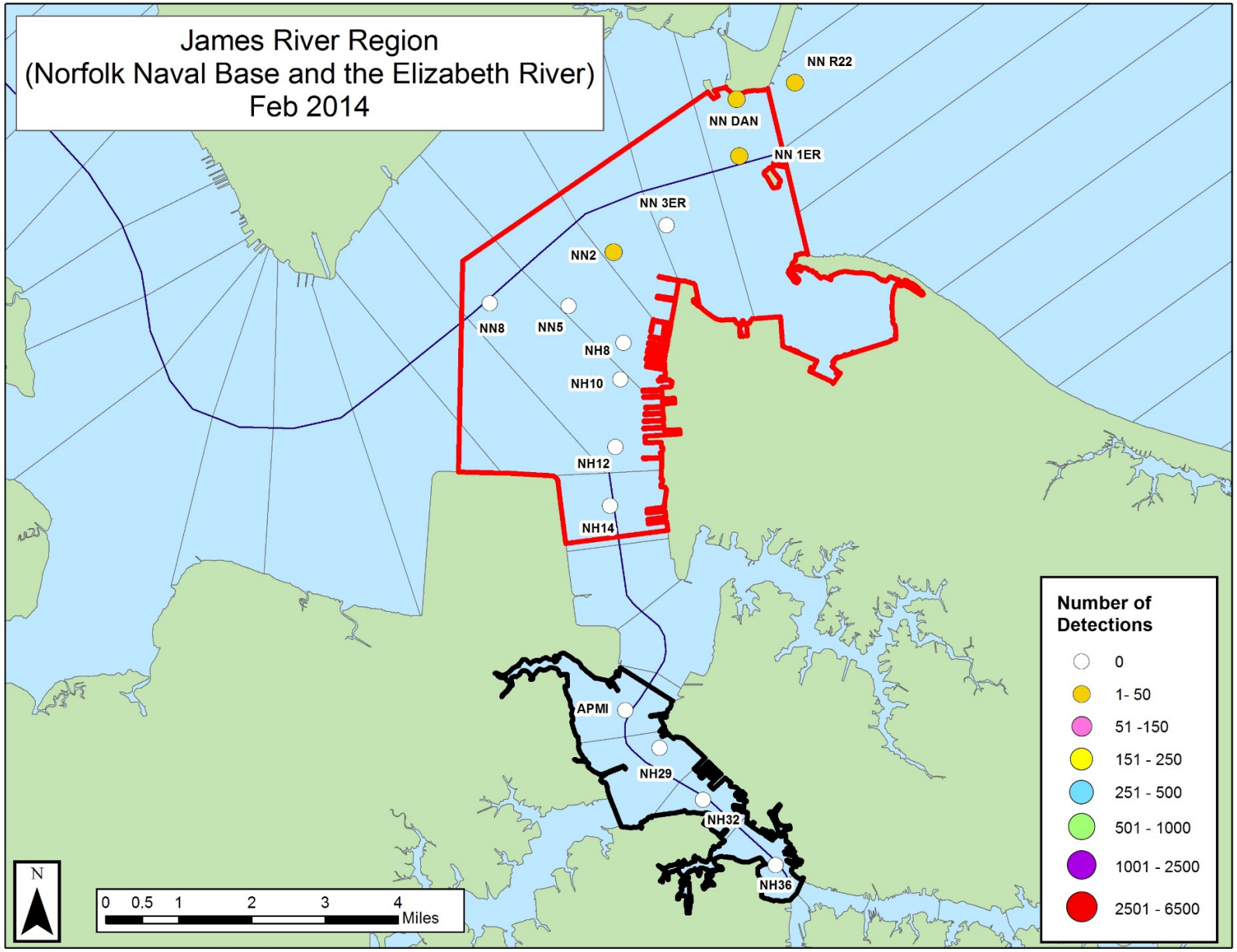

James River Region
(Norfolk Naval Base and the Elizabeth River)
Oct 2013
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

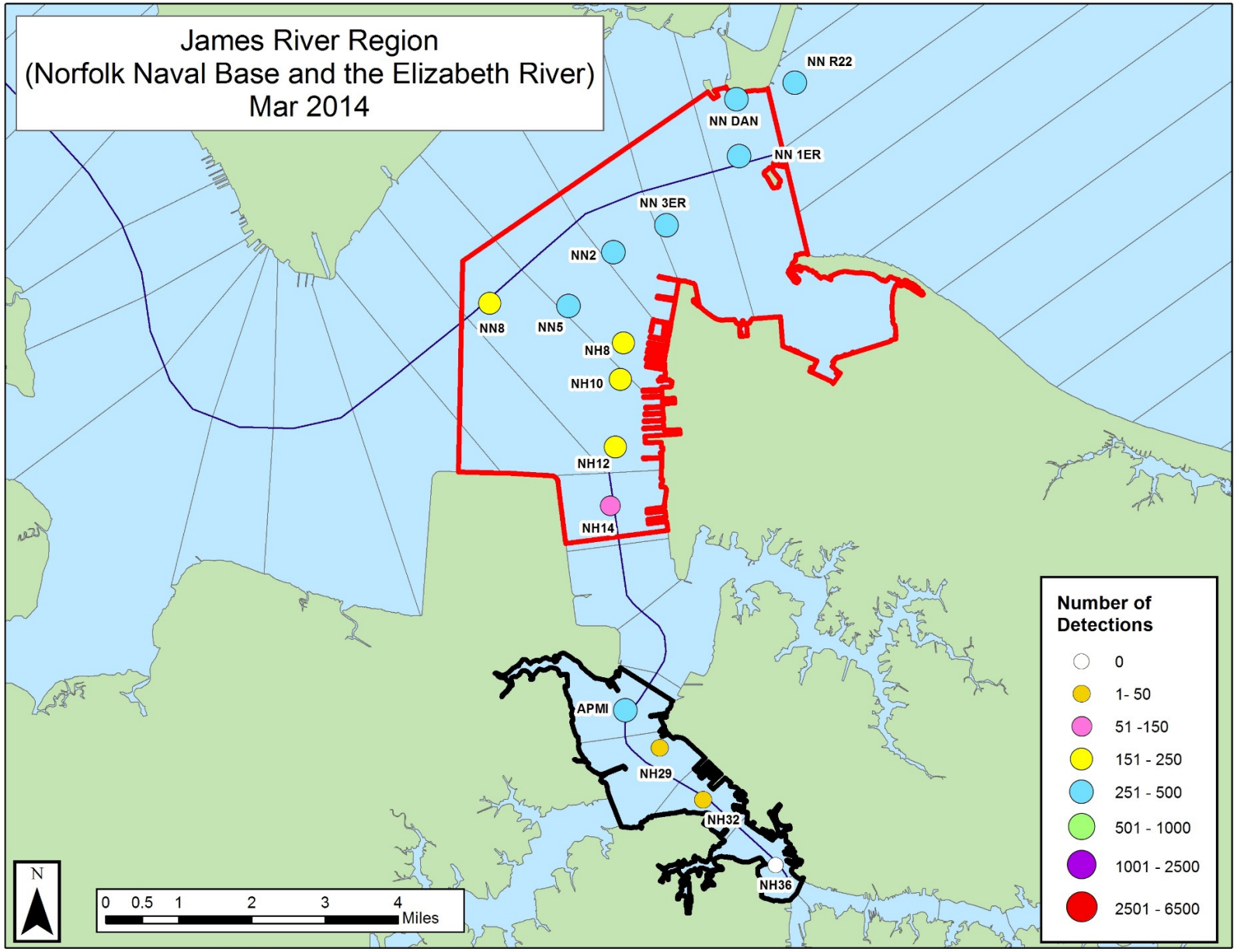

James River Region
(Norfolk Naval Base and the Elizabeth River)
Nov 2013
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

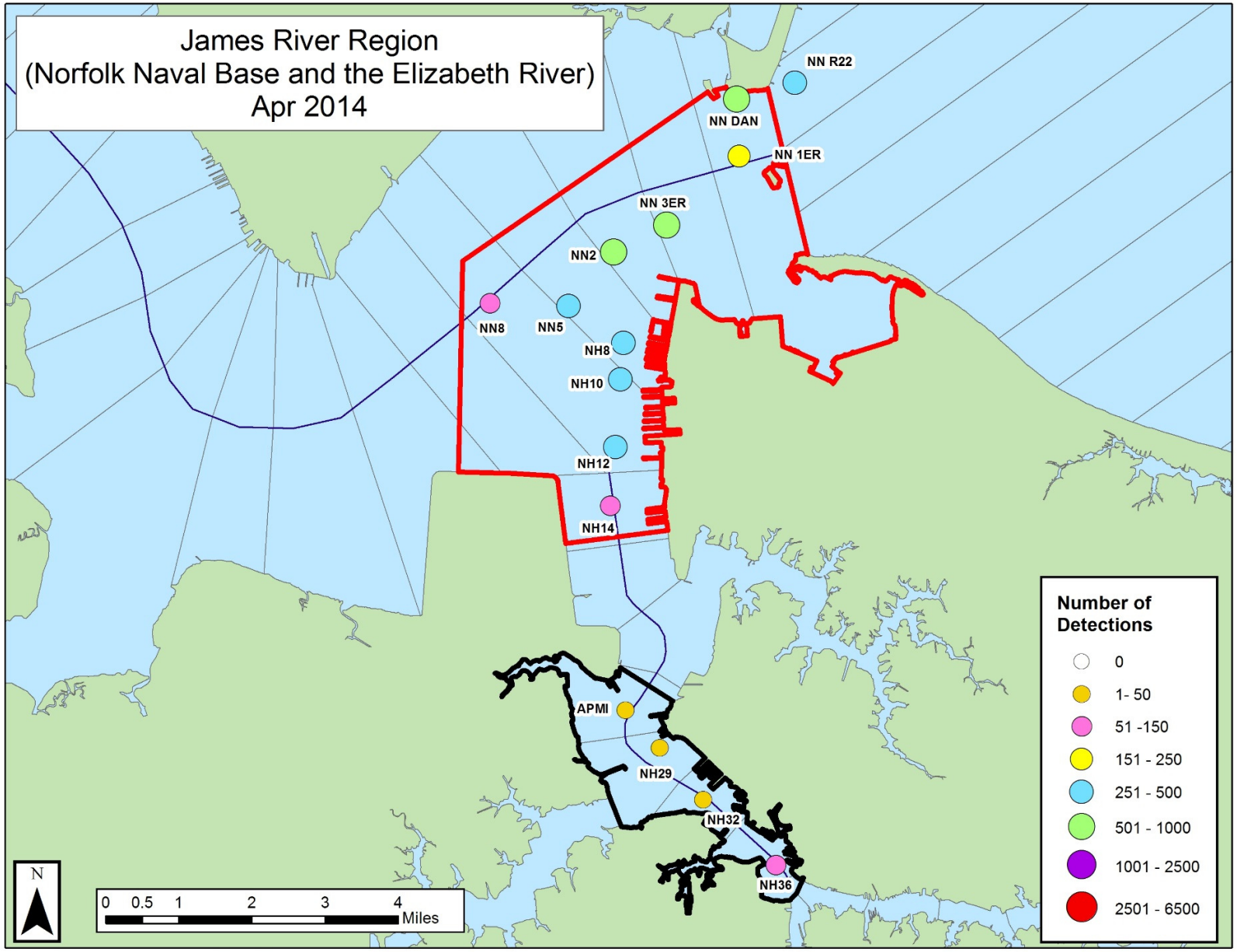

James River Region
(Norfolk Naval Base and the Elizabeth River)
Dec 2013
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

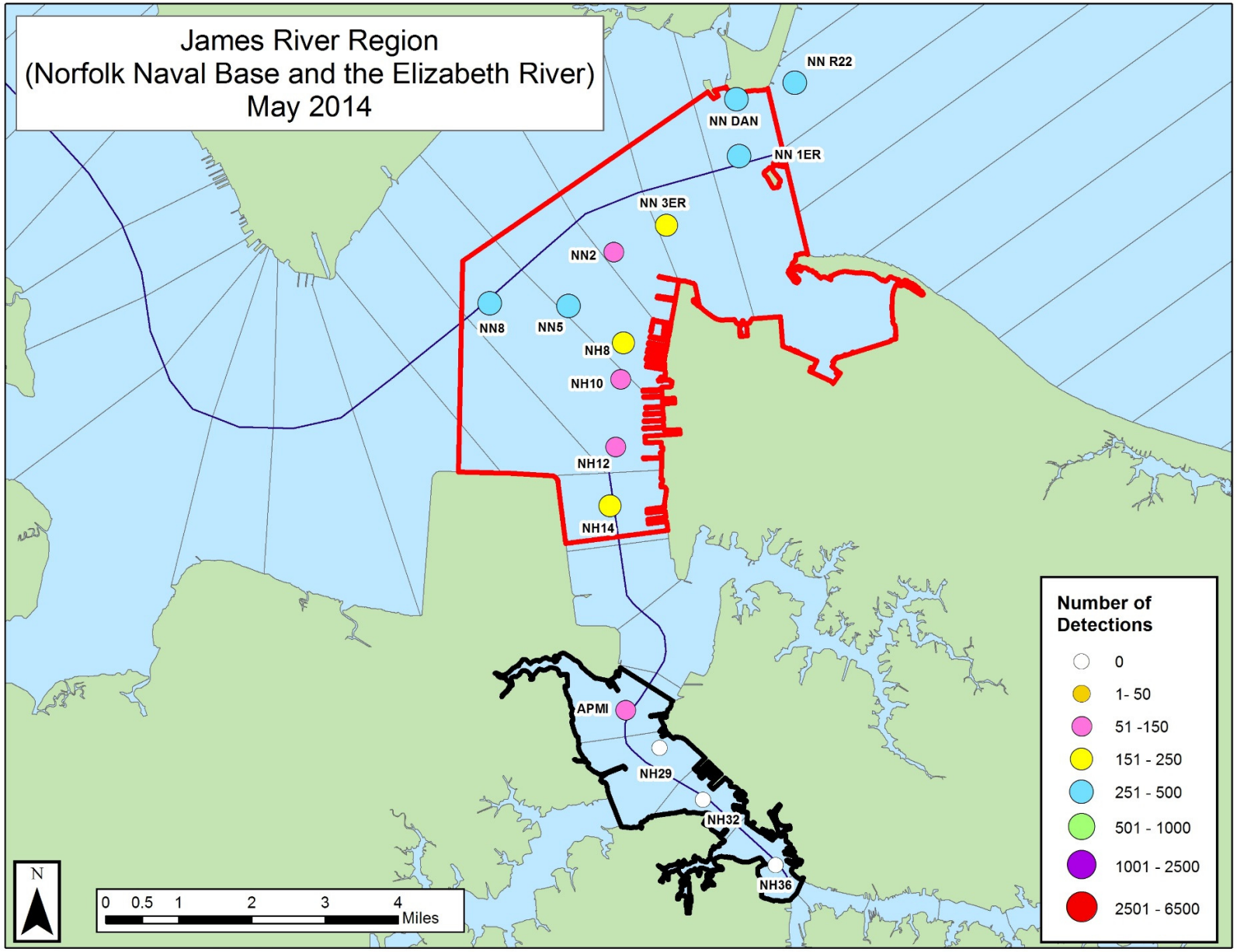

James River Region
(Norfolk Naval Base and the Elizabeth River)
Total 2013
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NH5
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1 - 250
251 - 500
501 - 1000
1001 - 1500
1501 - 3500
3501 - 5000
5001 - 9500
N
0 0.5 1 2 3 4
Miles

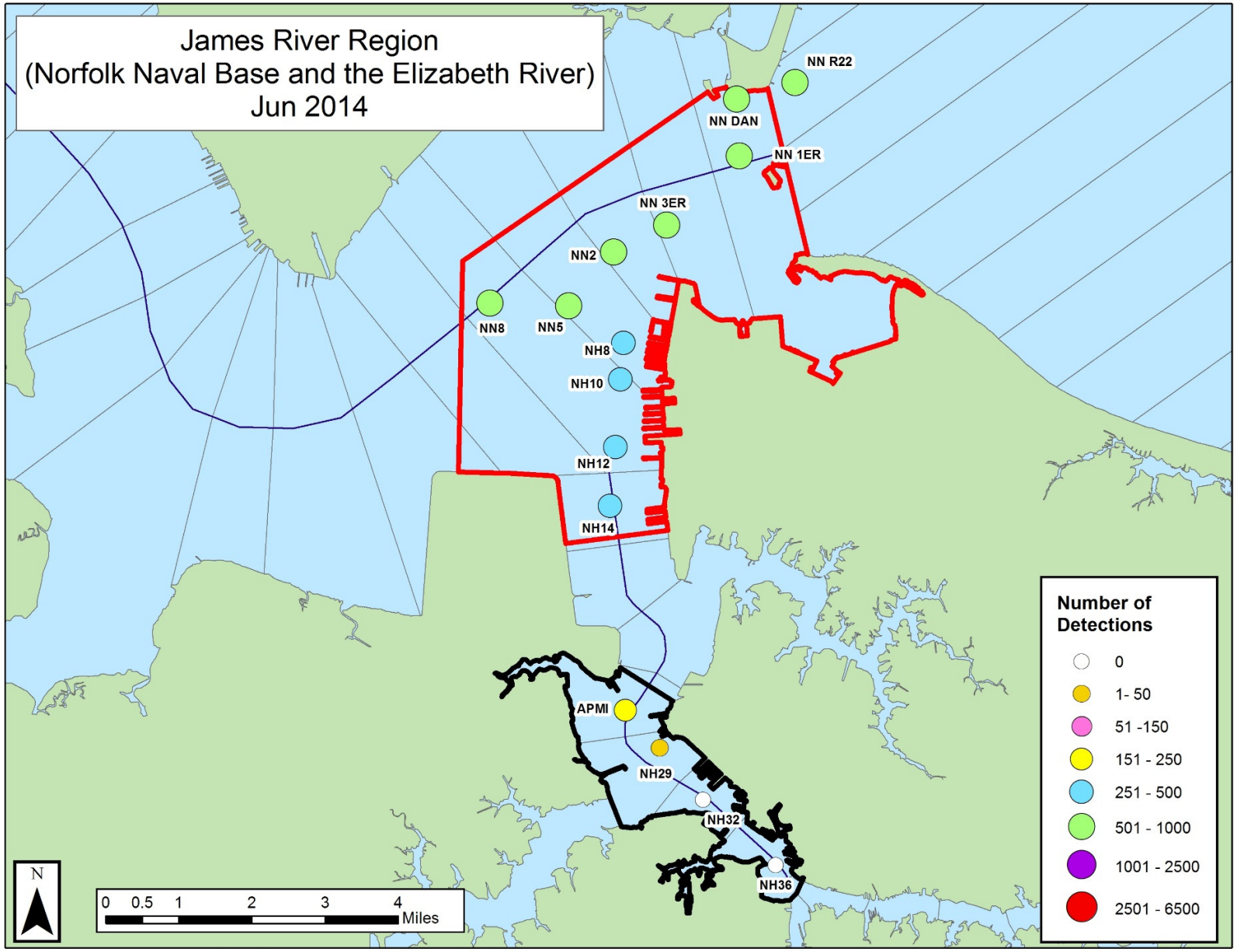

James River Region
(Norfolk Naval Base and the Elizabeth River)
Jan 2014
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

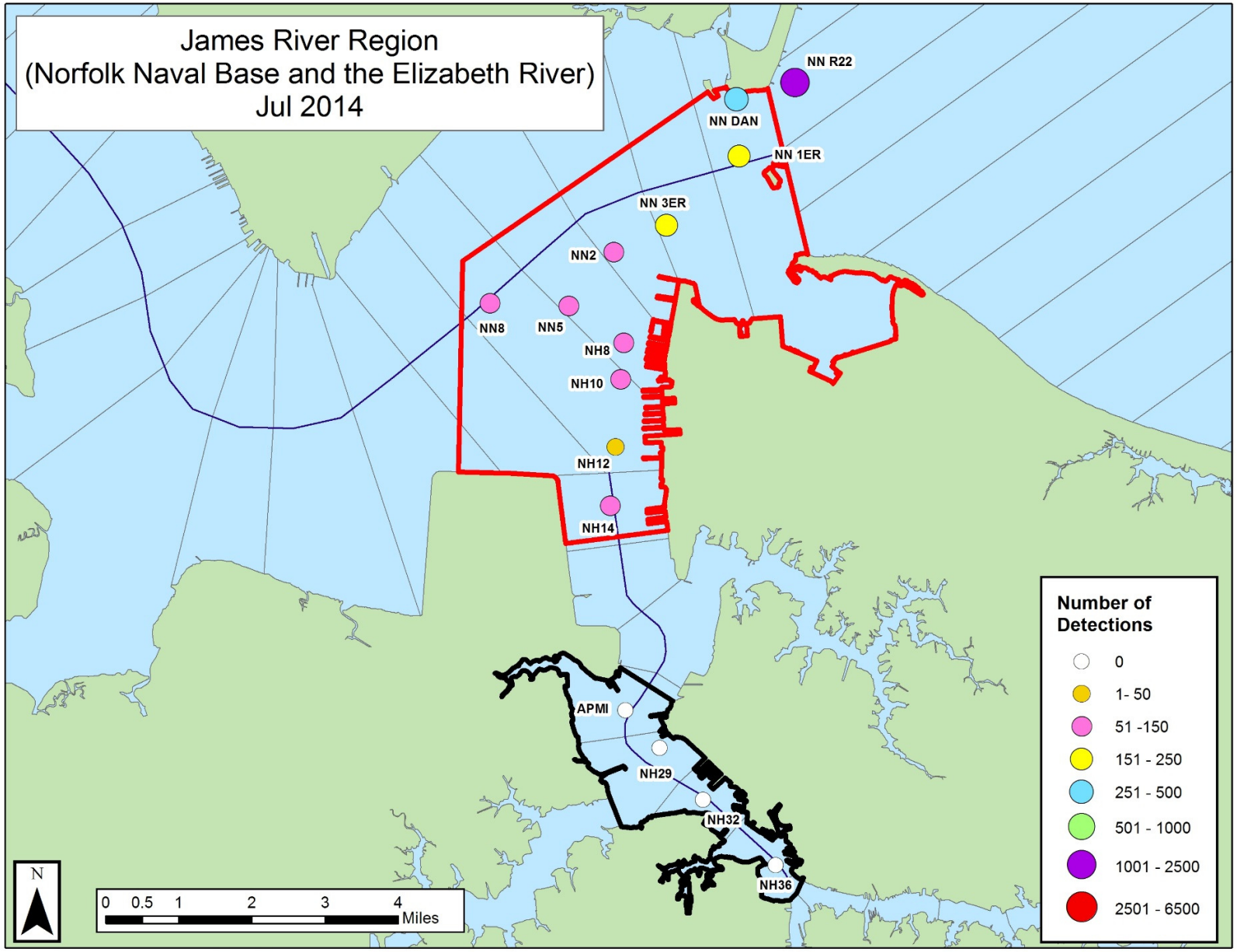

James River Region
(Norfolk Naval Base and the Elizabeth River)
Feb 2014
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

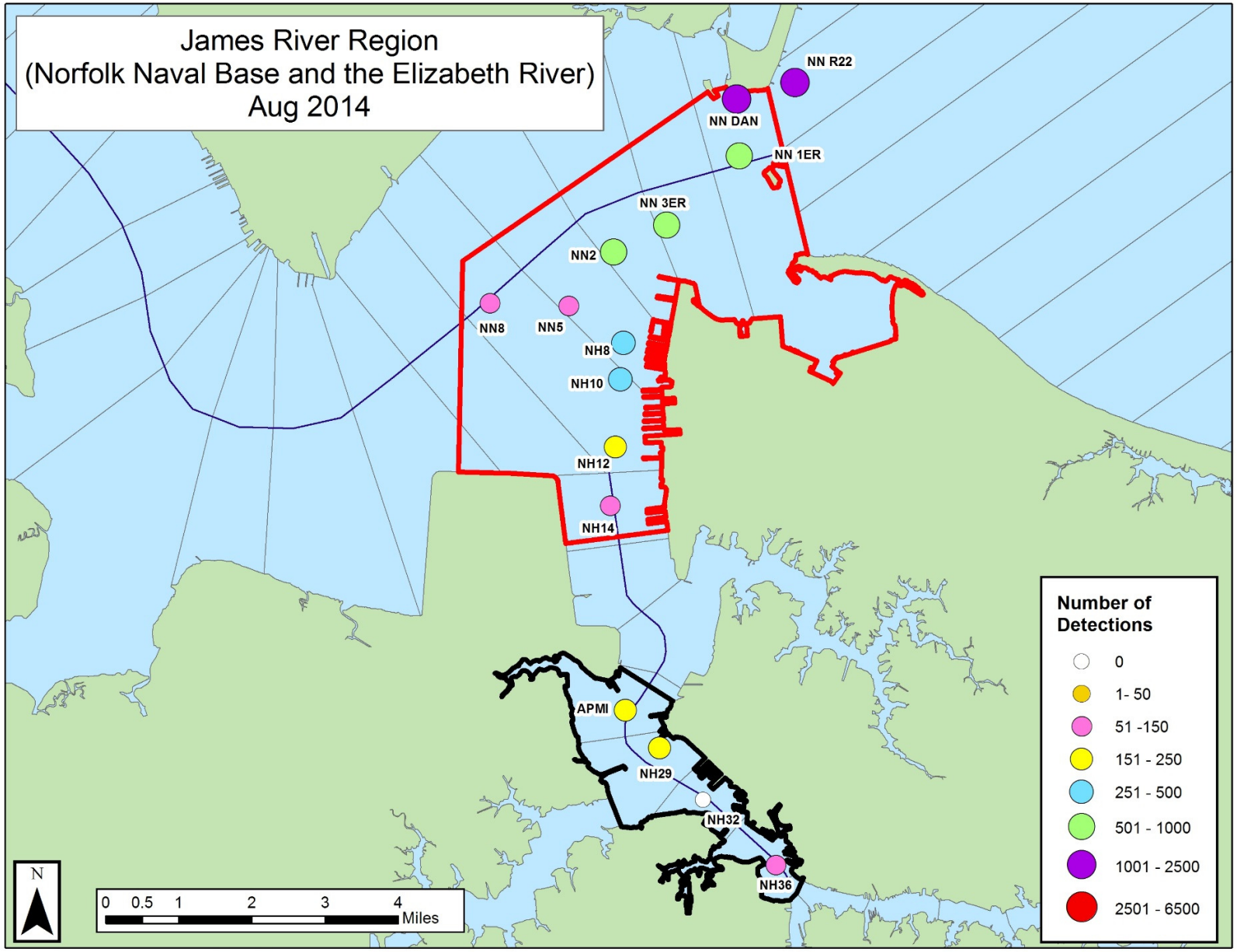

James River Region
(Norfolk Naval Base and the Elizabeth River)
Mar 2014
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

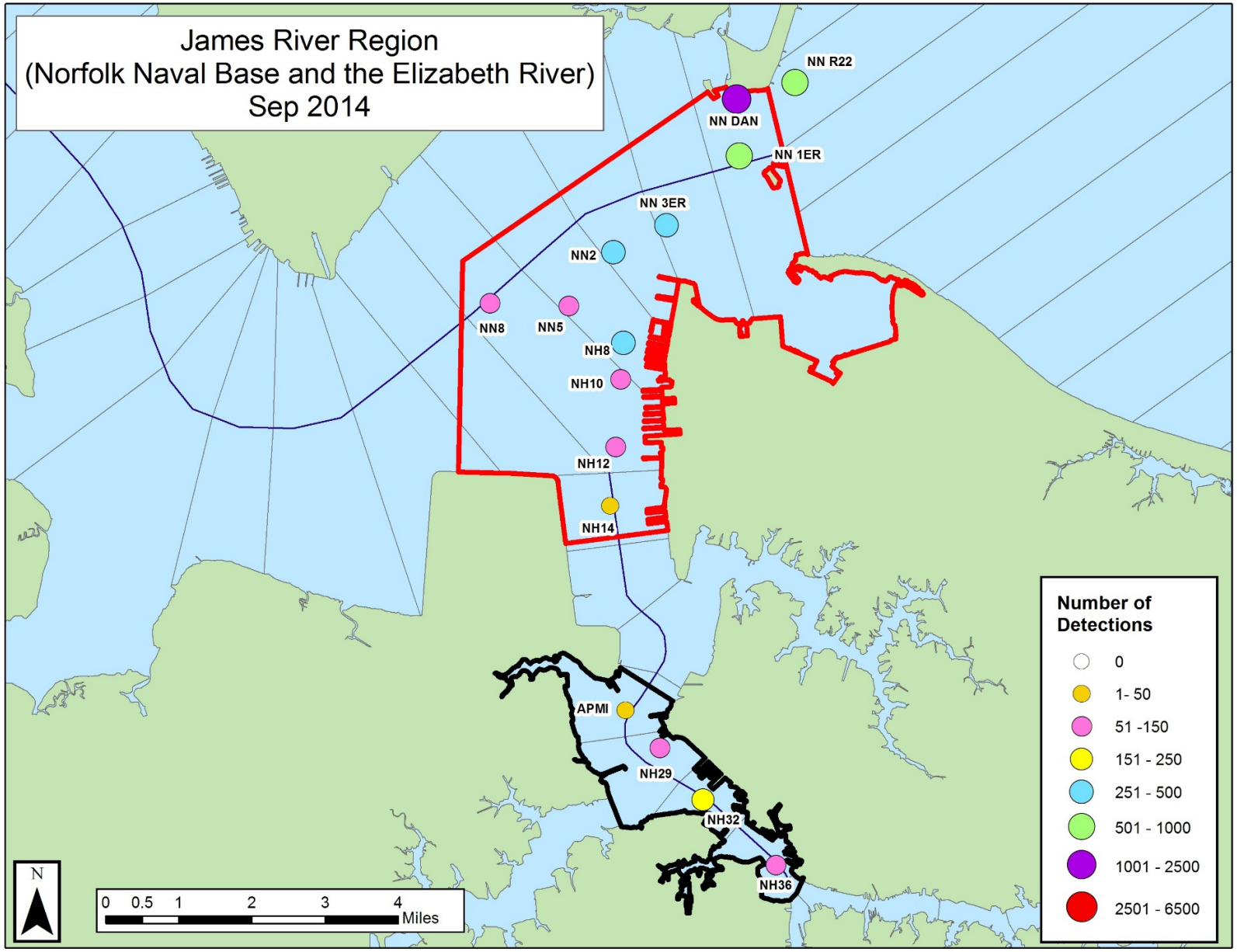

James River Region
(Norfolk Naval Base and the Elizabeth River)
Apr 2014
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

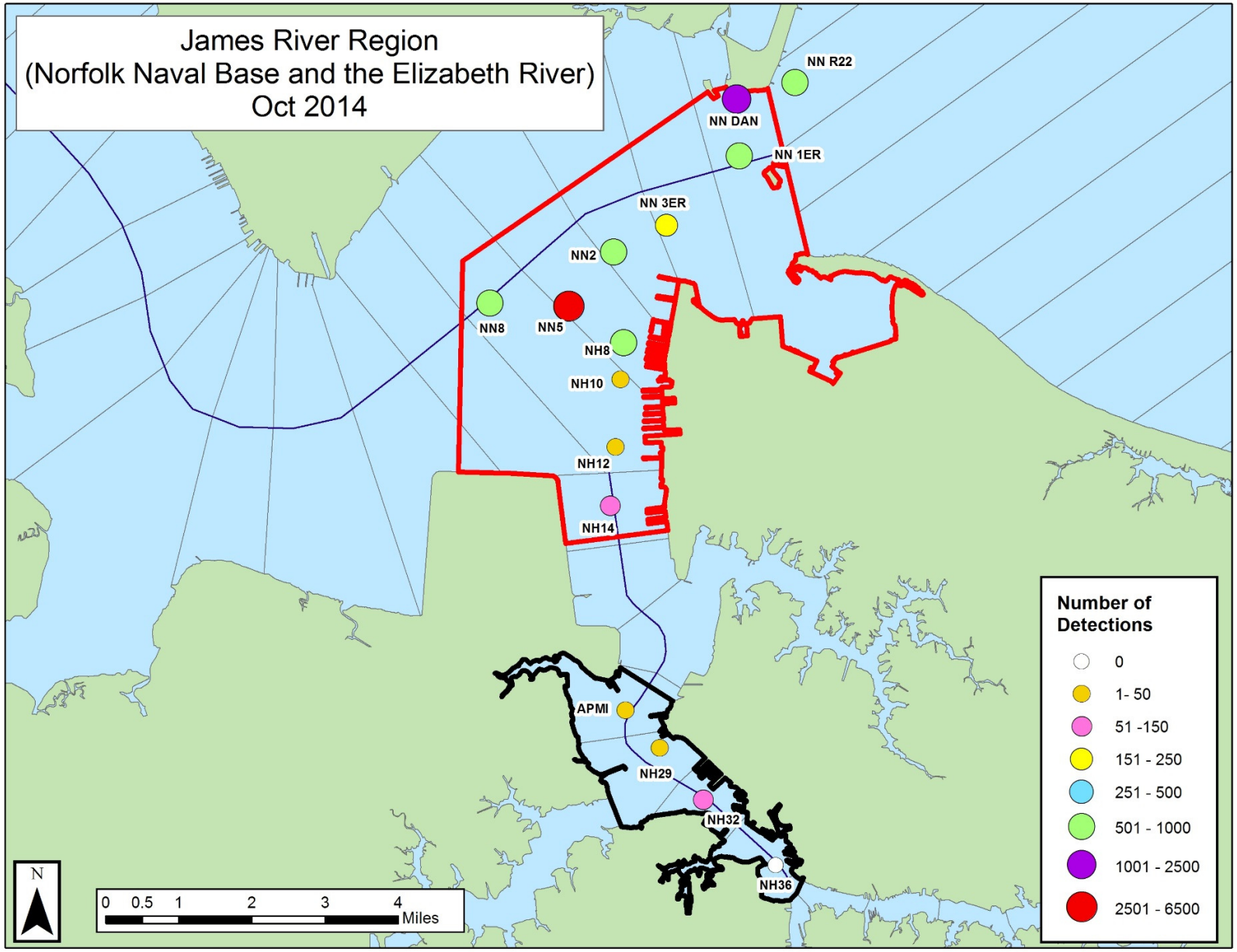

James River Region
(Norfolk Naval Base and the Elizabeth River)
May 2014
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

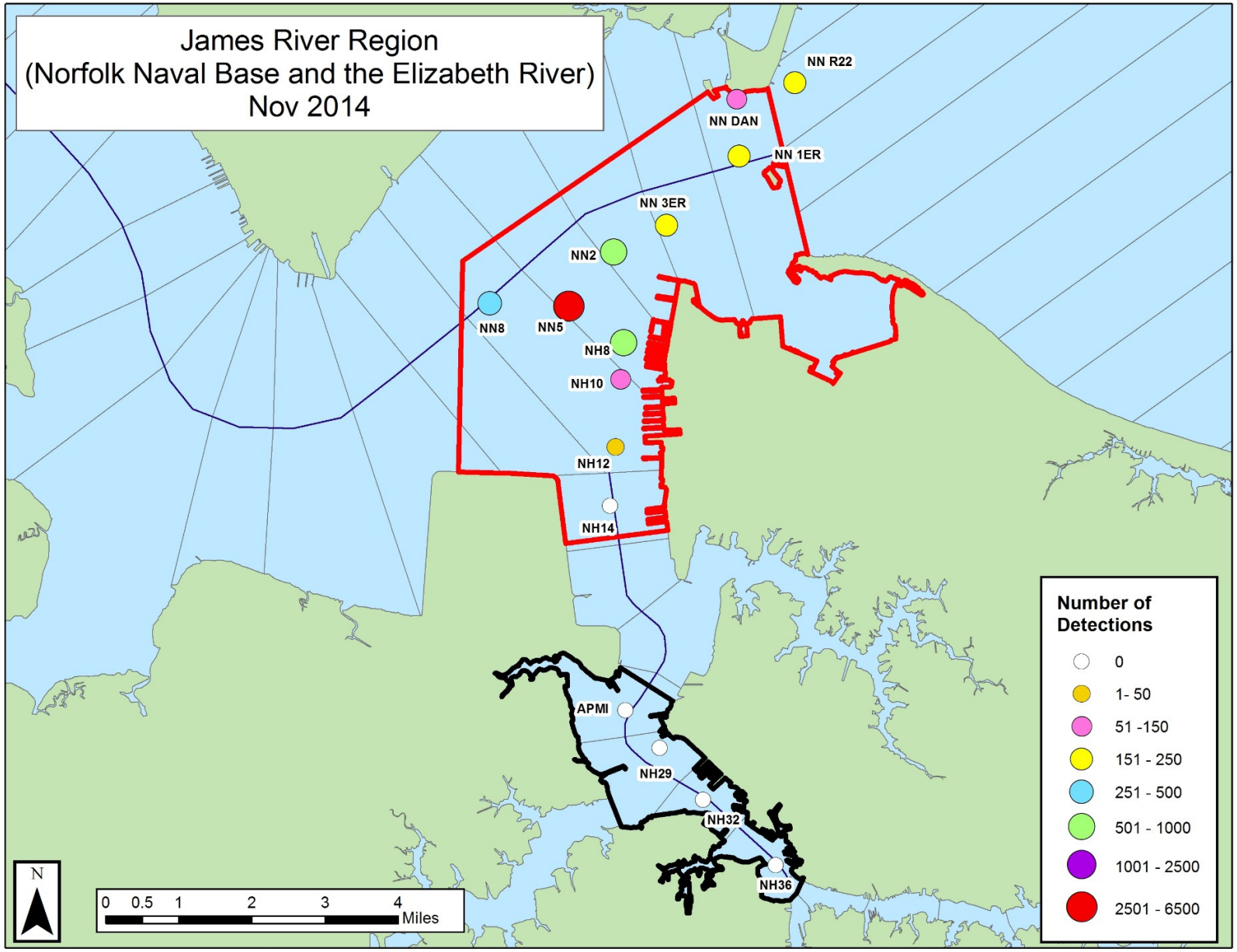

James River Region
(Norfolk Naval Base and the Elizabeth River)
Jun 2014
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

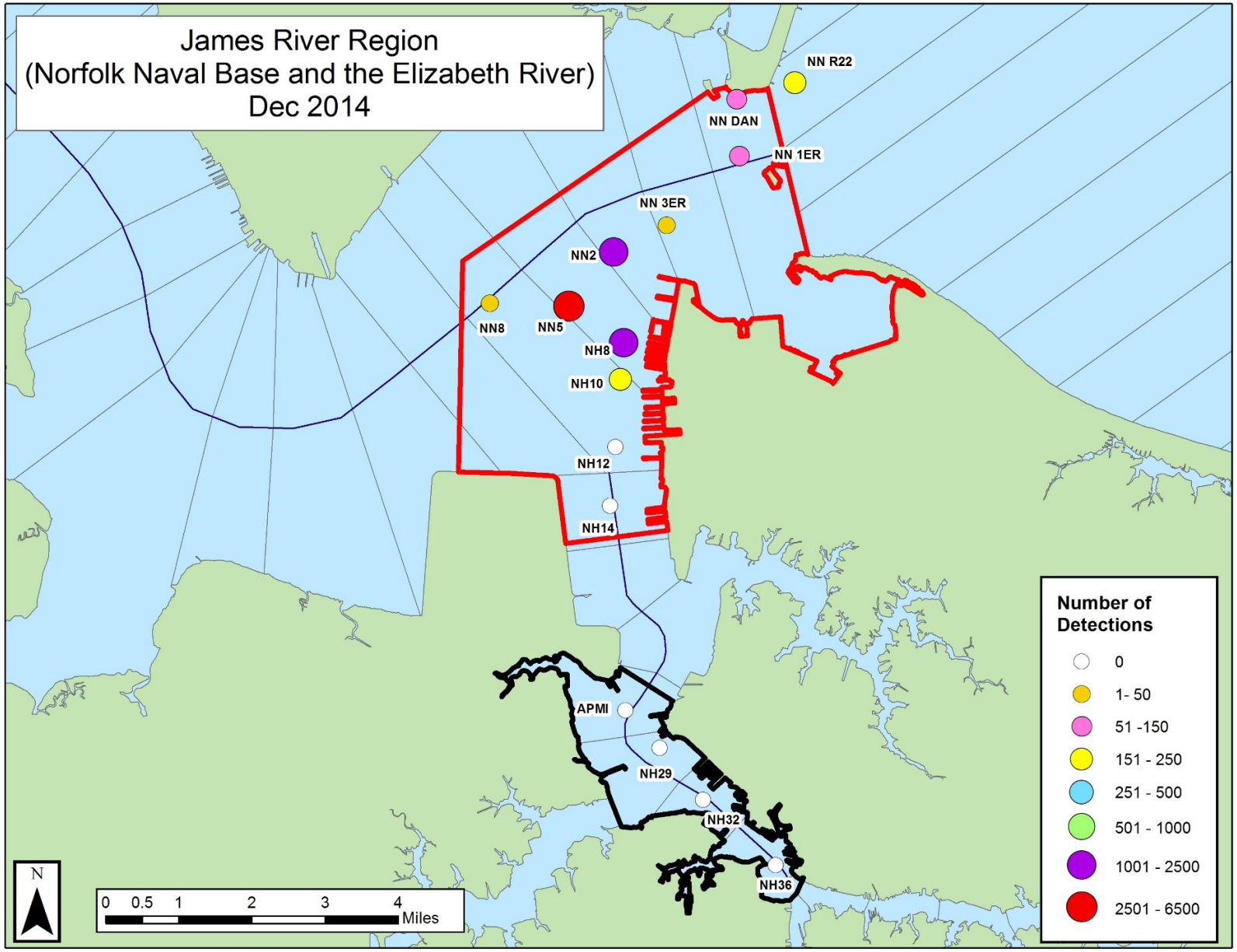

James River Region
(Norfolk Naval Base and the Elizabeth River)
Jul 2014
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

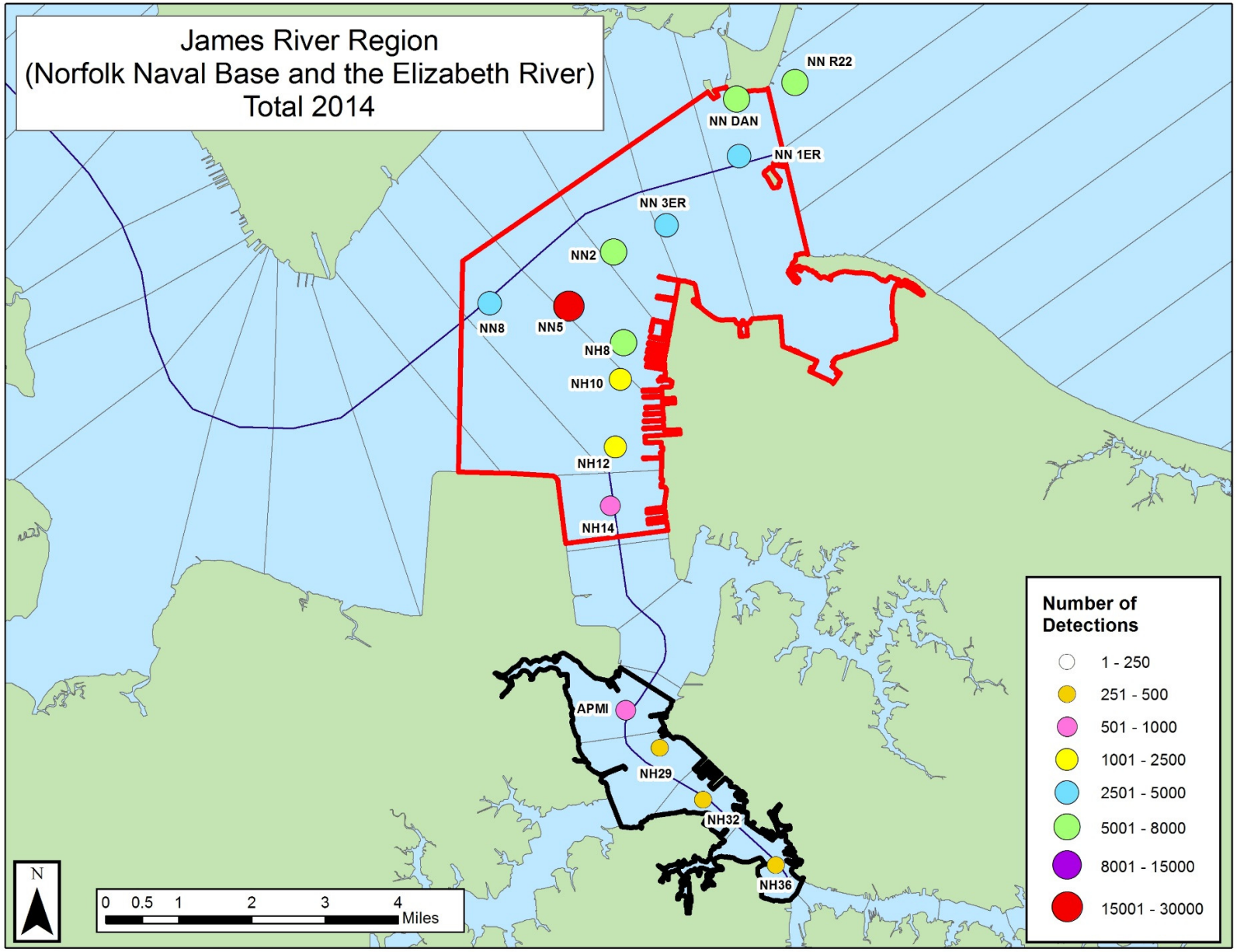

James River Region
(Norfolk Naval Base and the Elizabeth River)
Aug 2014
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

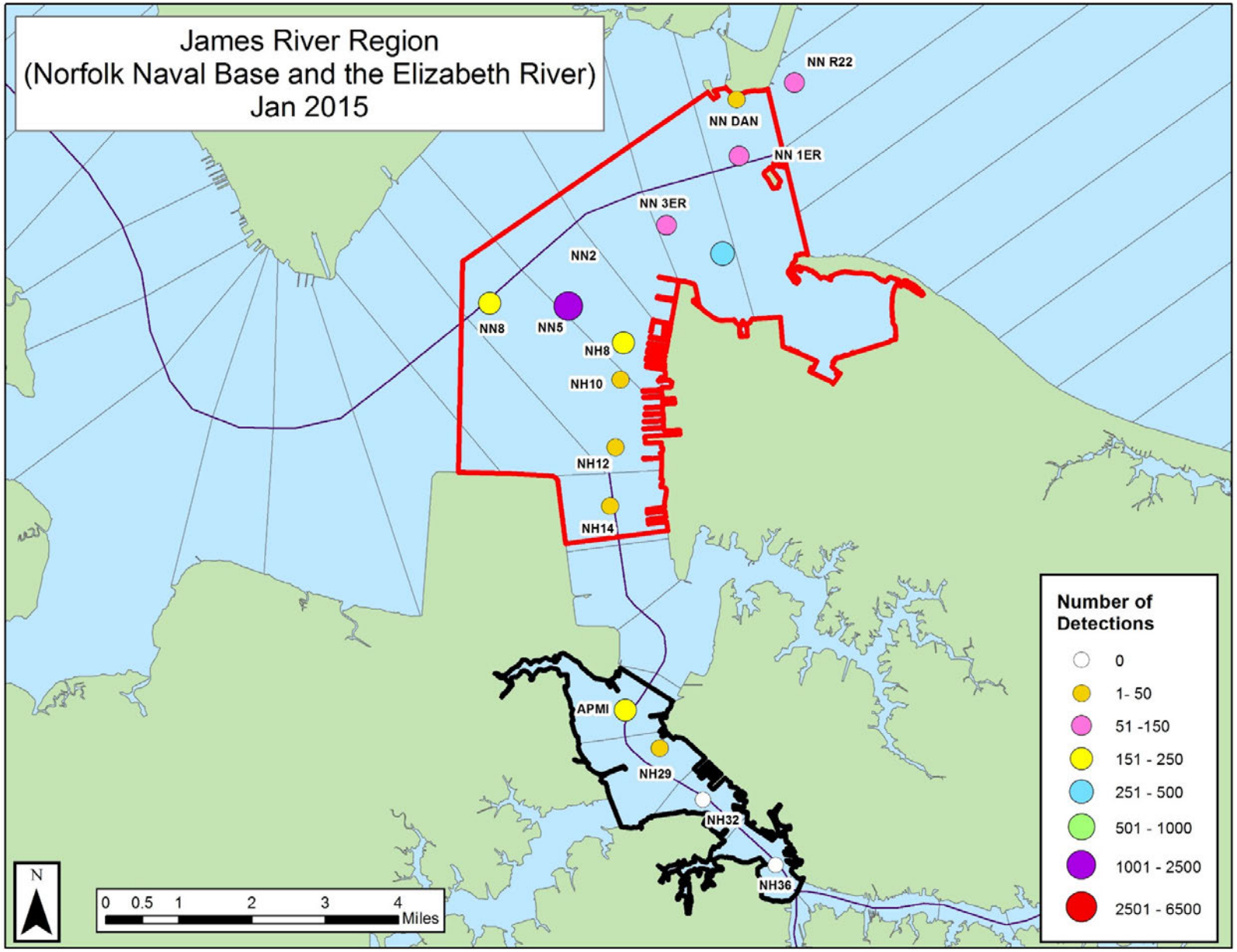

James River Region
(Norfolk Naval Base and the Elizabeth River)
Sep 2014
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

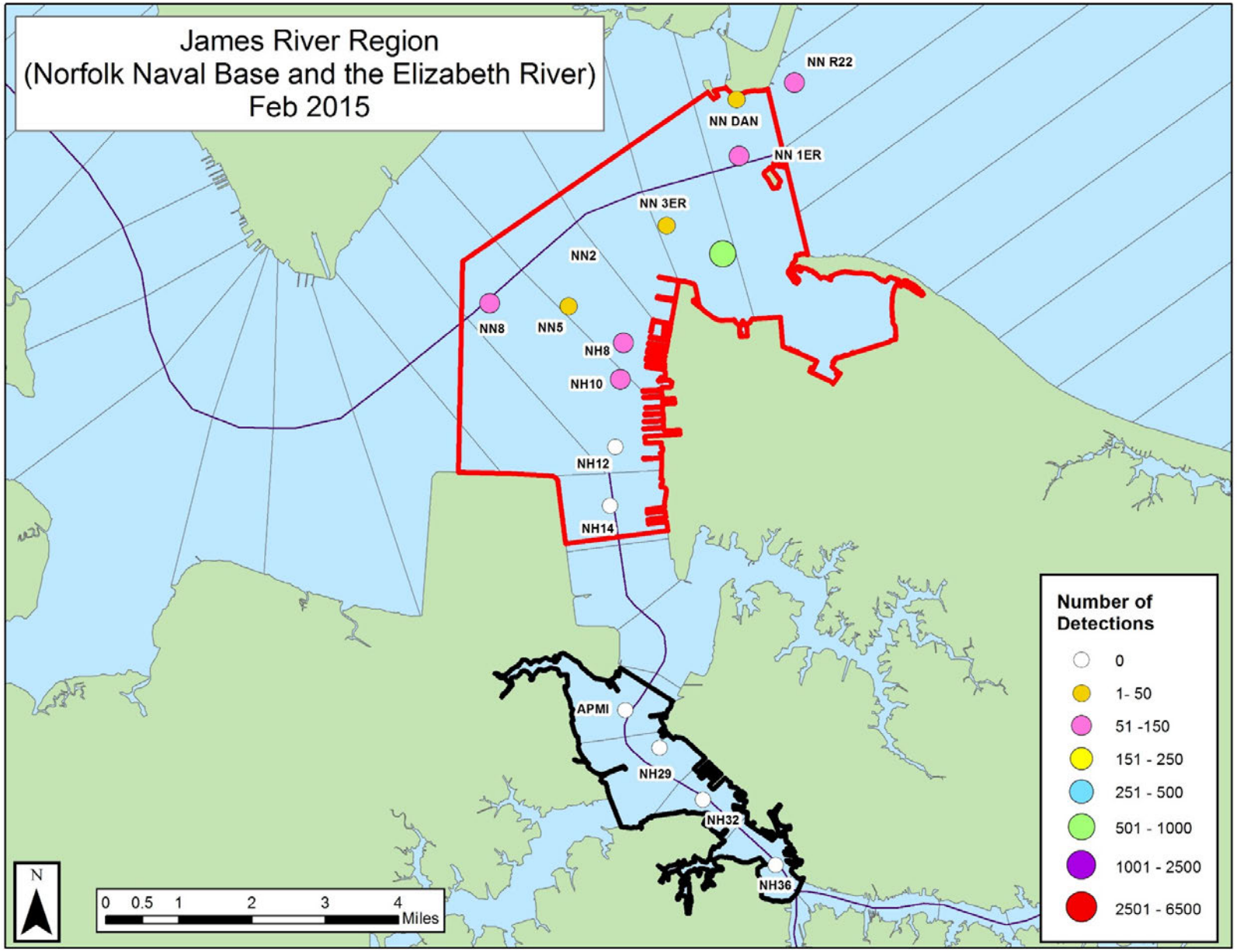

James River Region
(Norfolk Naval Base and the Elizabeth River)
Oct 2014
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

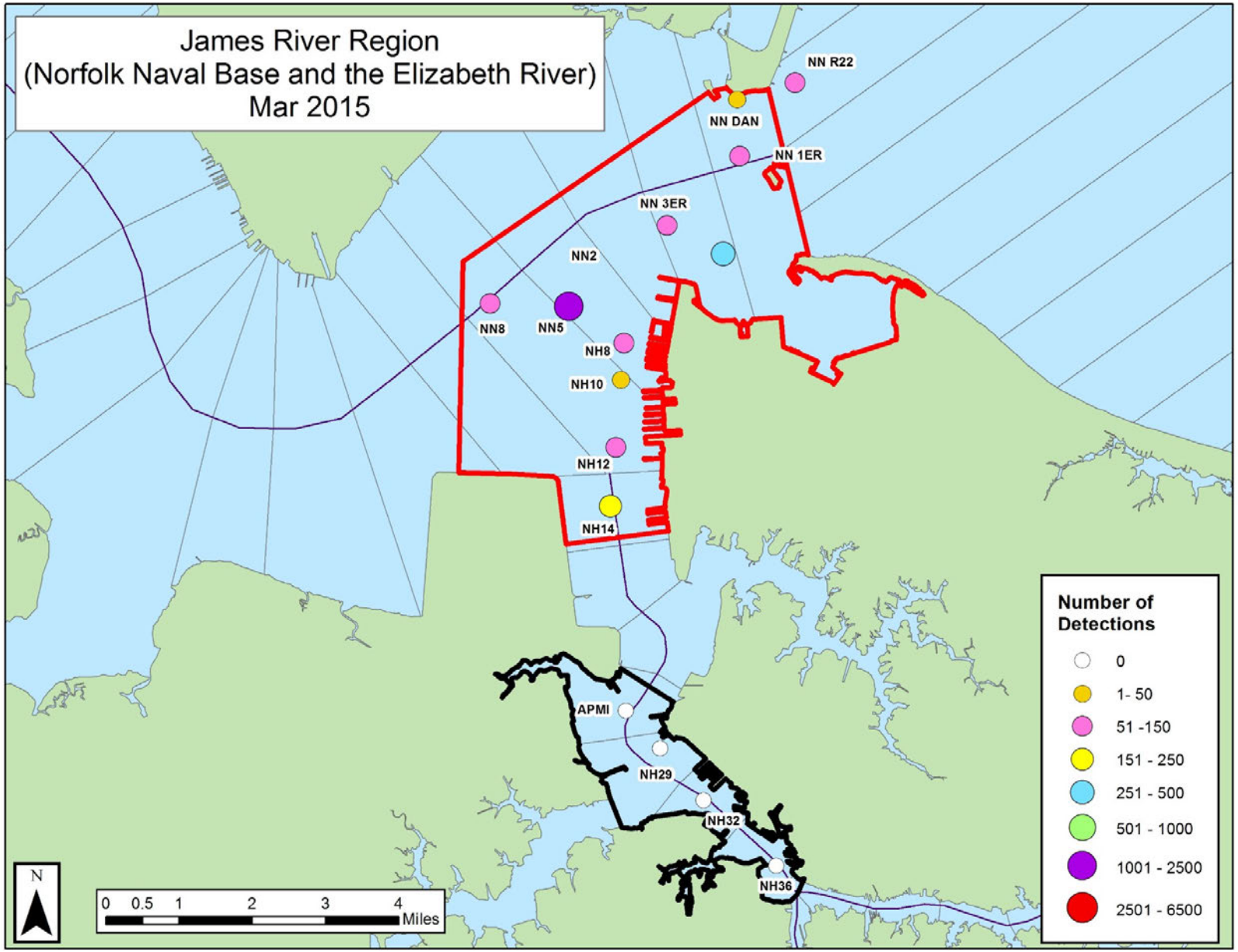

James River Region
(Norfolk Naval Base and the Elizabeth River)
Nov 2014
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

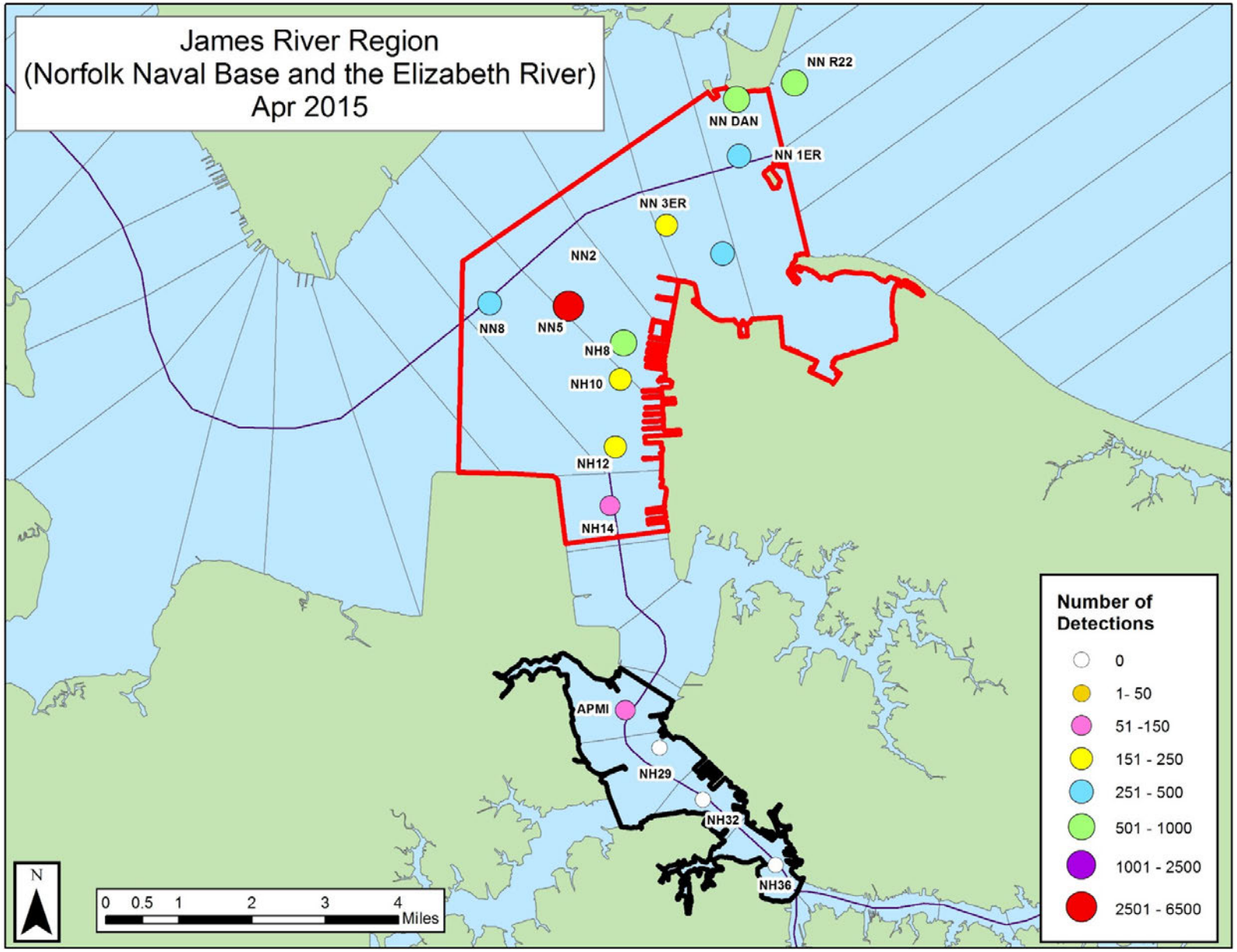

James River Region
(Norfolk Naval Base and the Elizabeth River)
Dec 2014
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

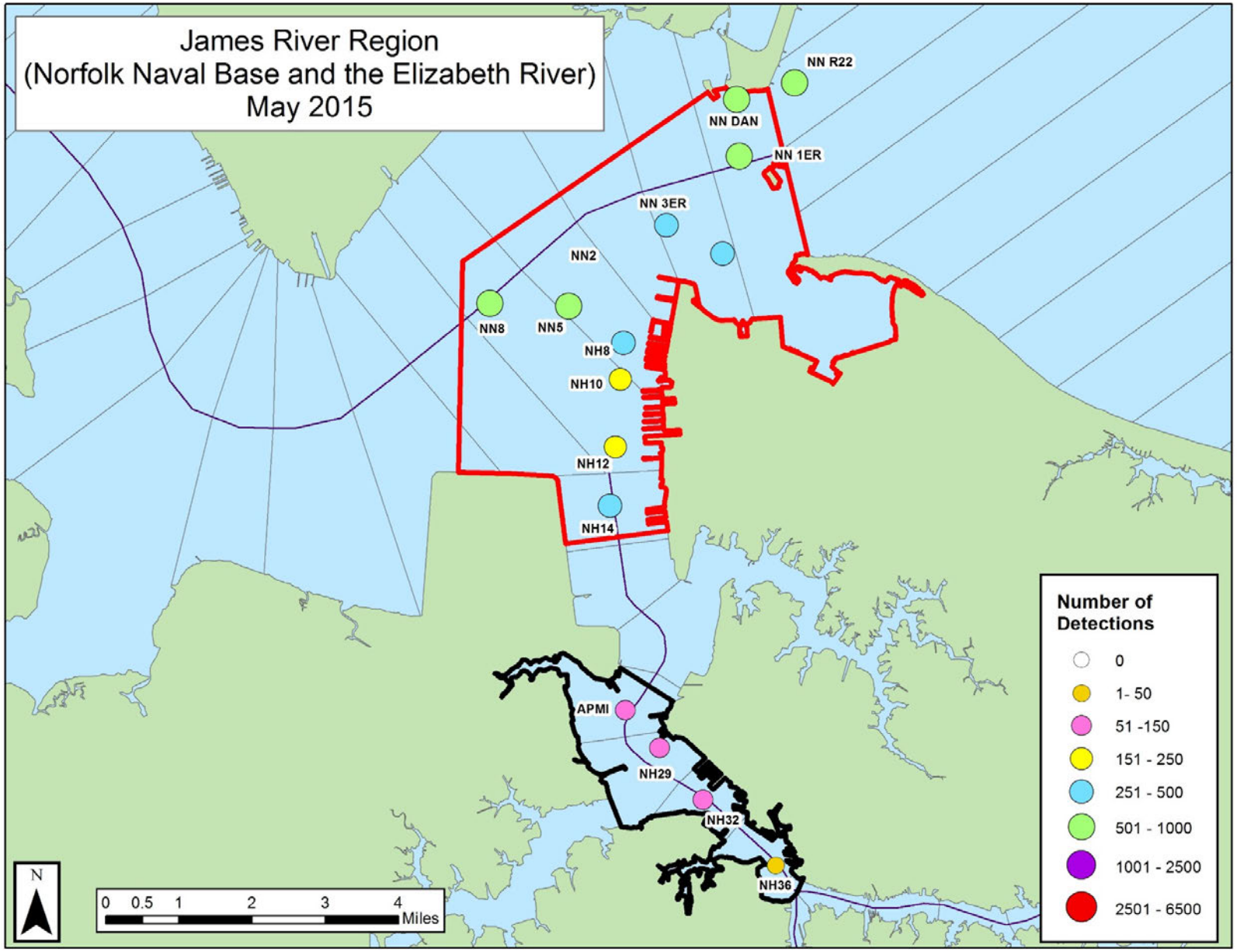

James River Region
(Norfolk Naval Base and the Elizabeth River)
Total 2014
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
N
0 0.5 1 2 3 4
Miles

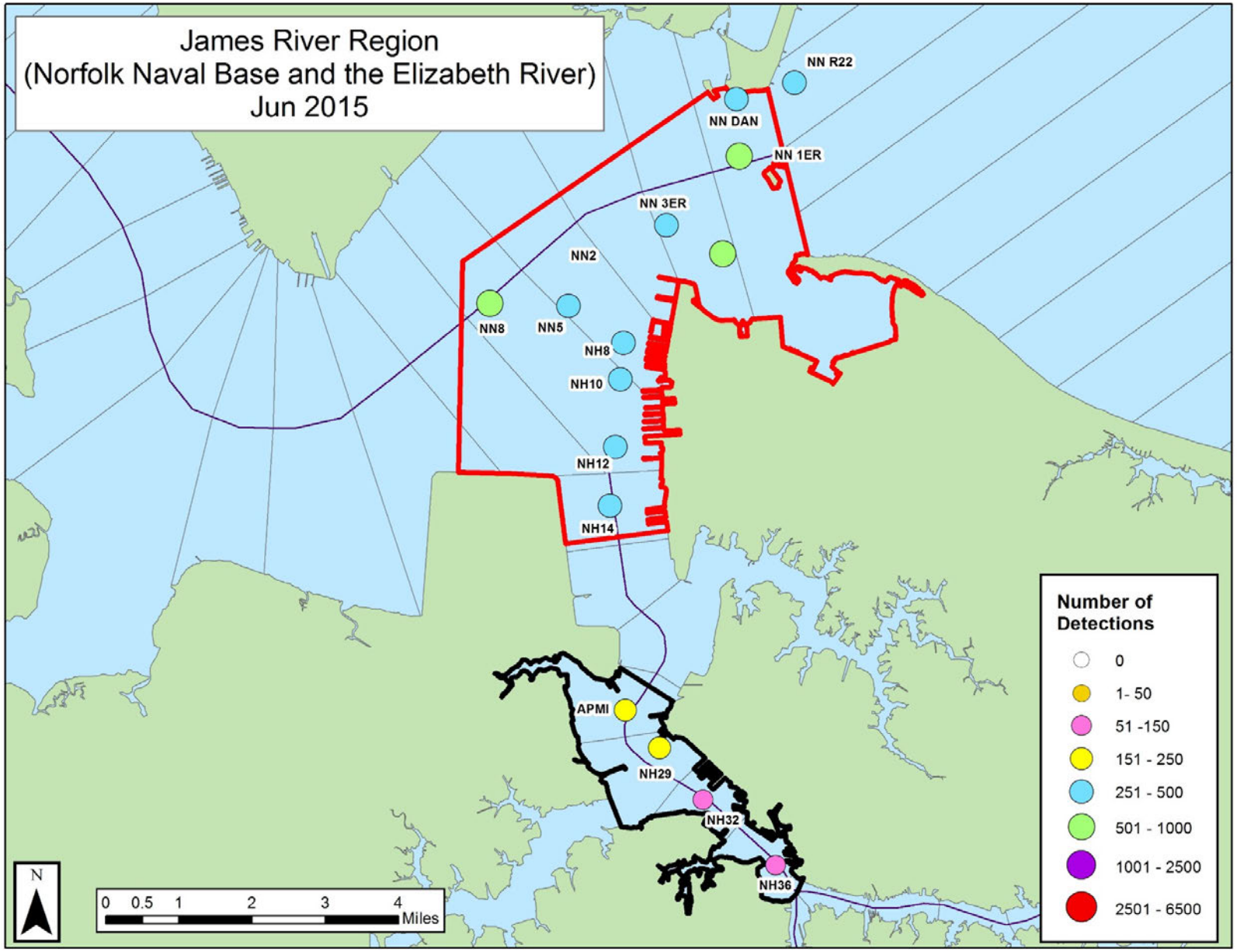

James River Region
(Norfolk Naval Base and the Elizabeth River)
Jan 2015
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

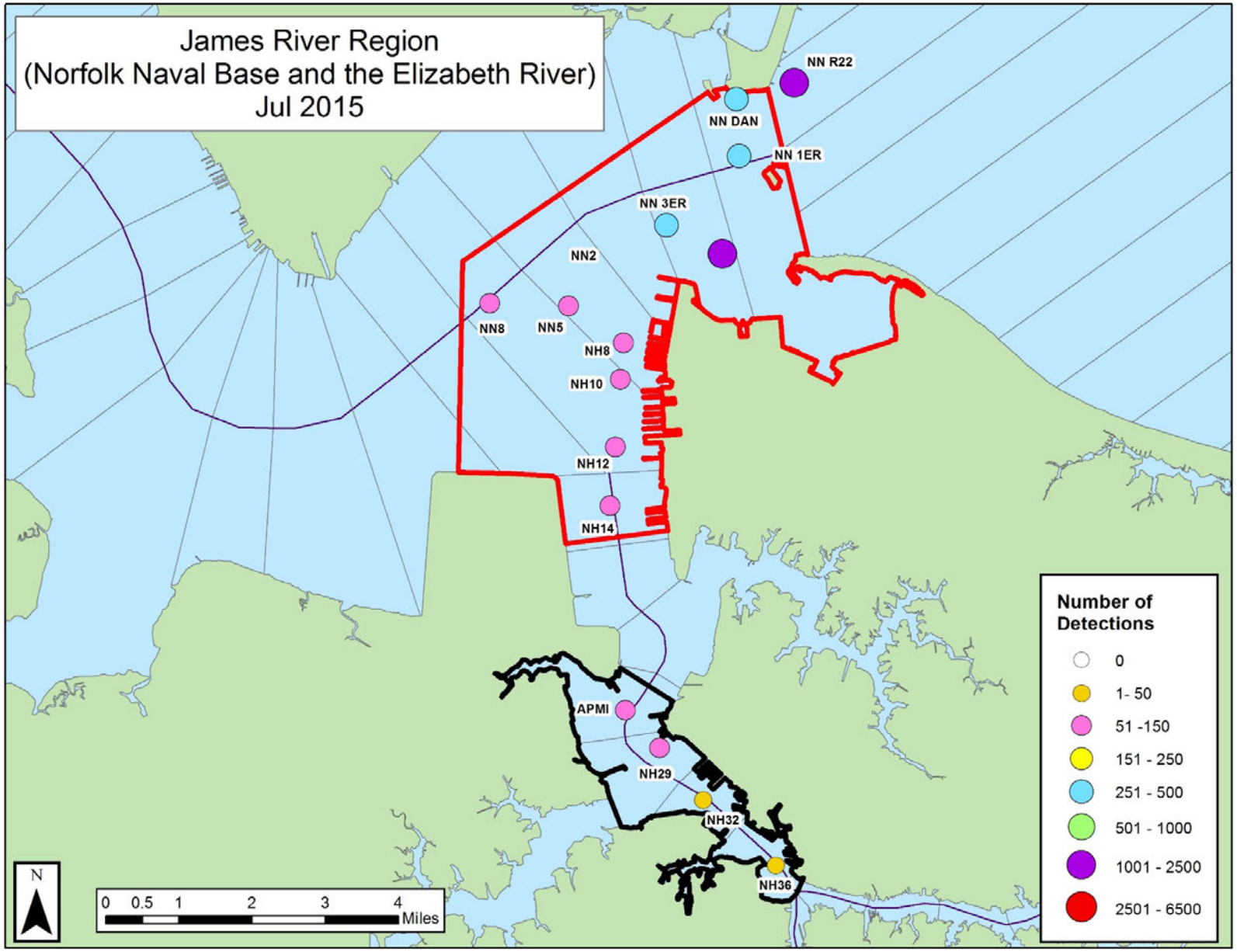

James River Region
(Norfolk Naval Base and the Elizabeth River)
Feb 2015
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

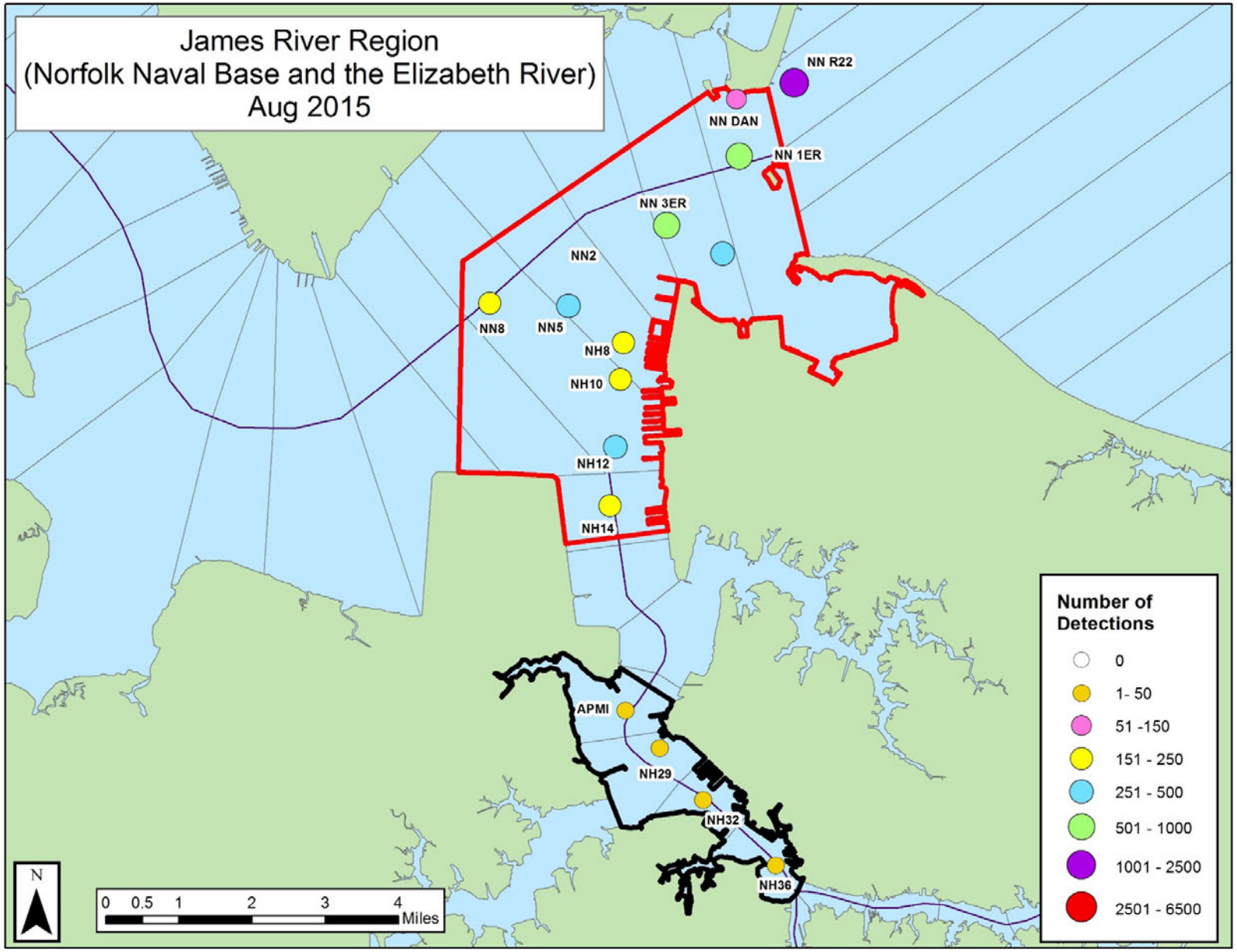

James River Region
(Norfolk Naval Base and the Elizabeth River)
Mar 2015
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

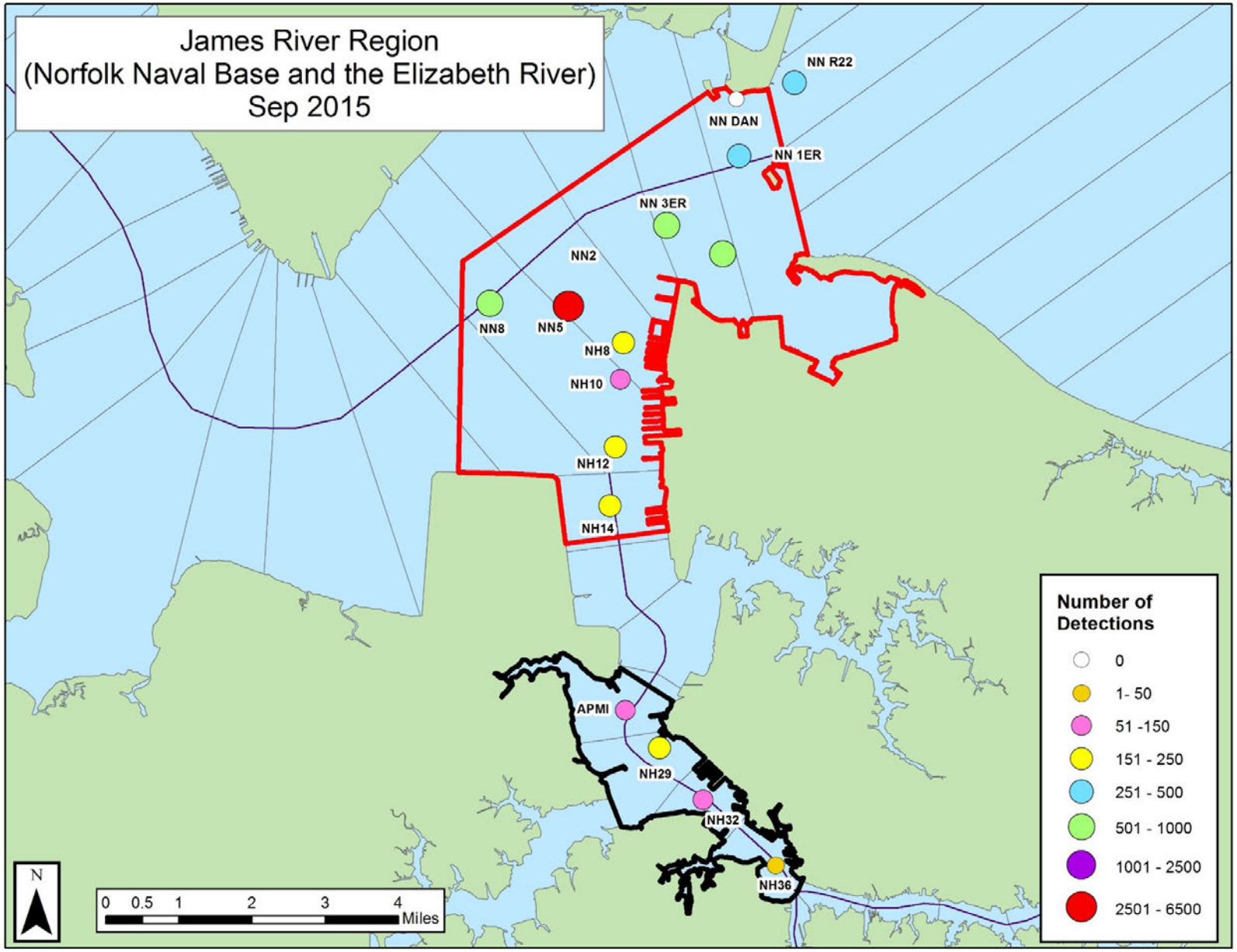

James River Region
(Norfolk Naval Base and the Elizabeth River)
Apr 2015
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

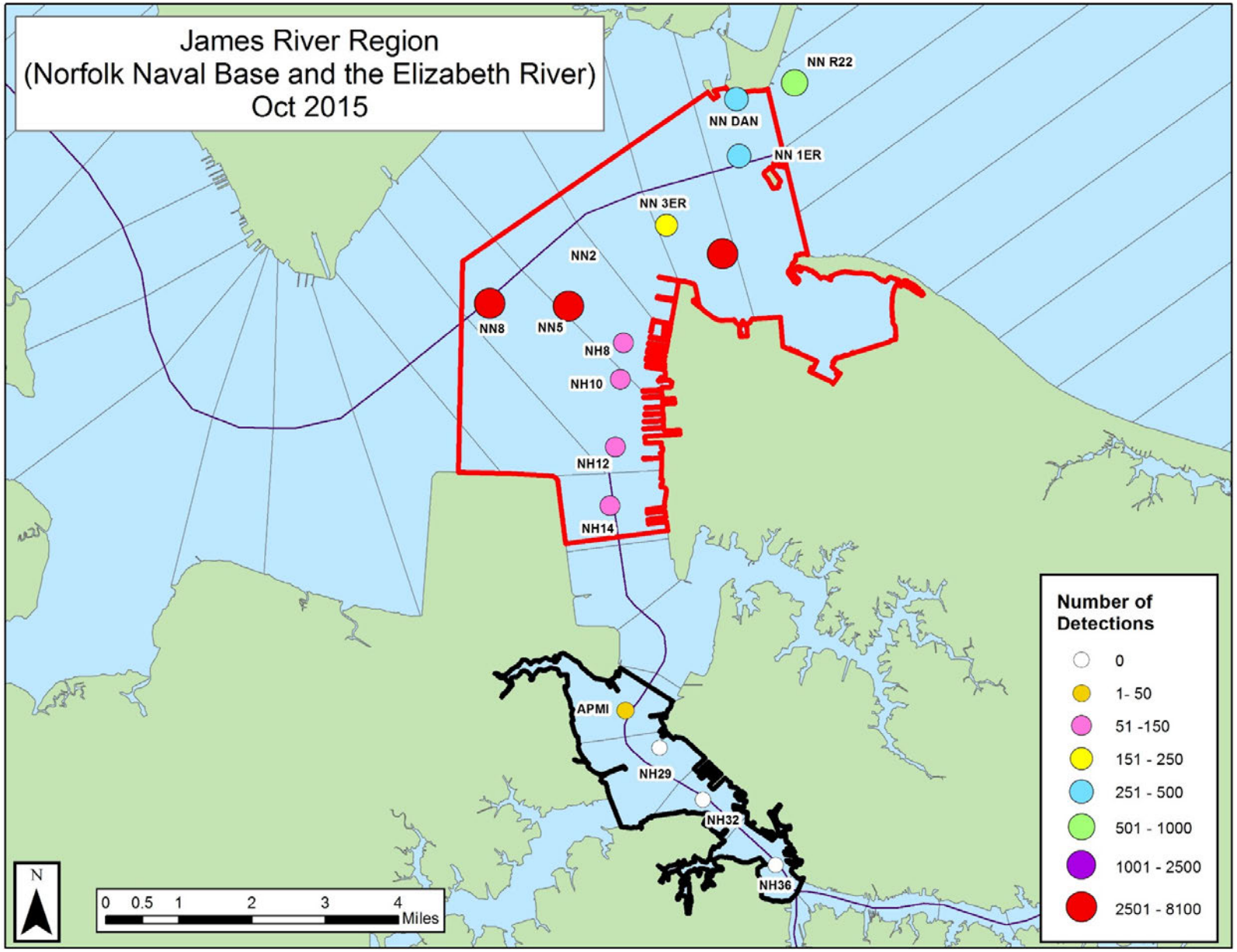

James River Region
(Norfolk Naval Base and the Elizabeth River)
May 2015
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

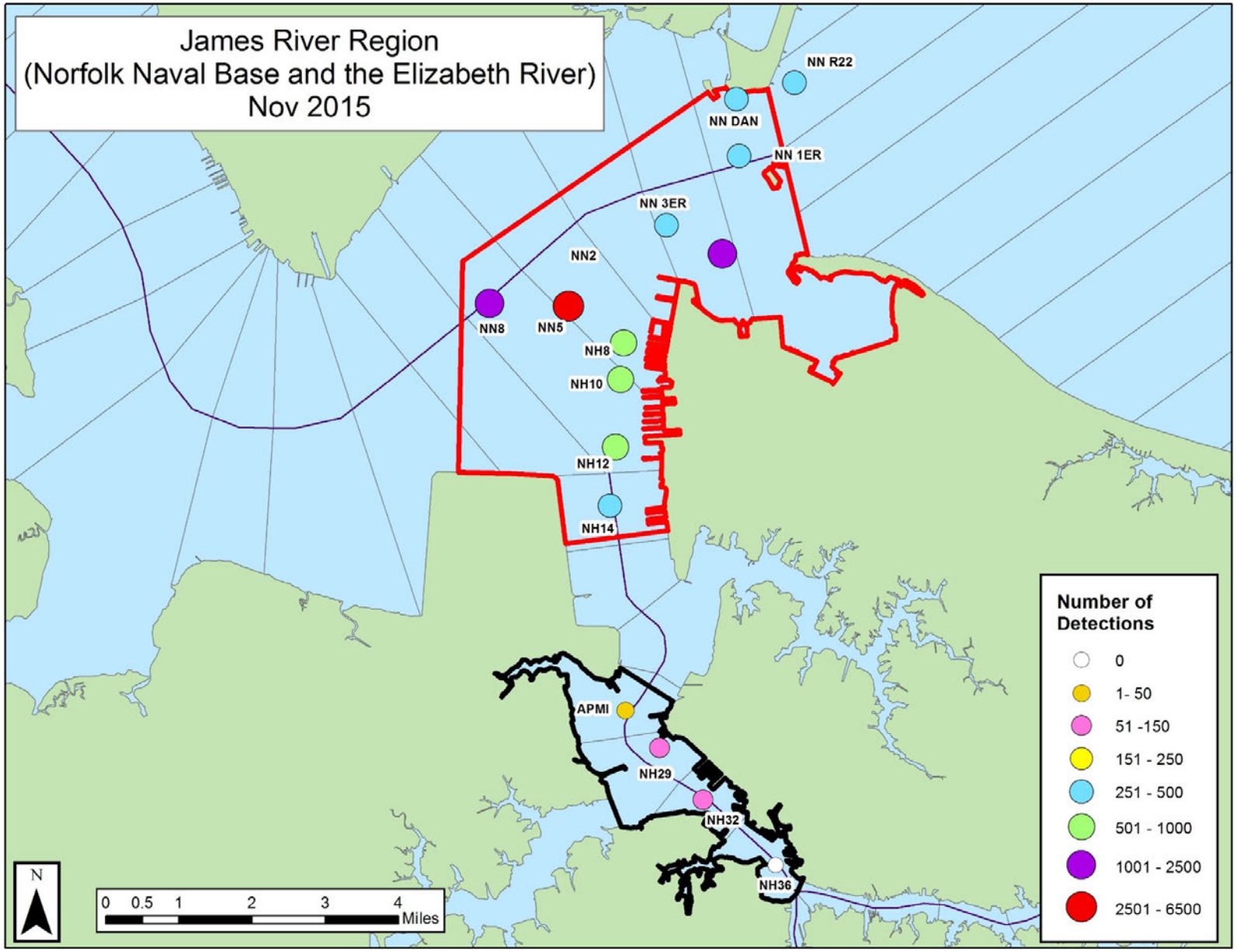

James River Region
(Norfolk Naval Base and the Elizabeth River)
Jun 2015
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

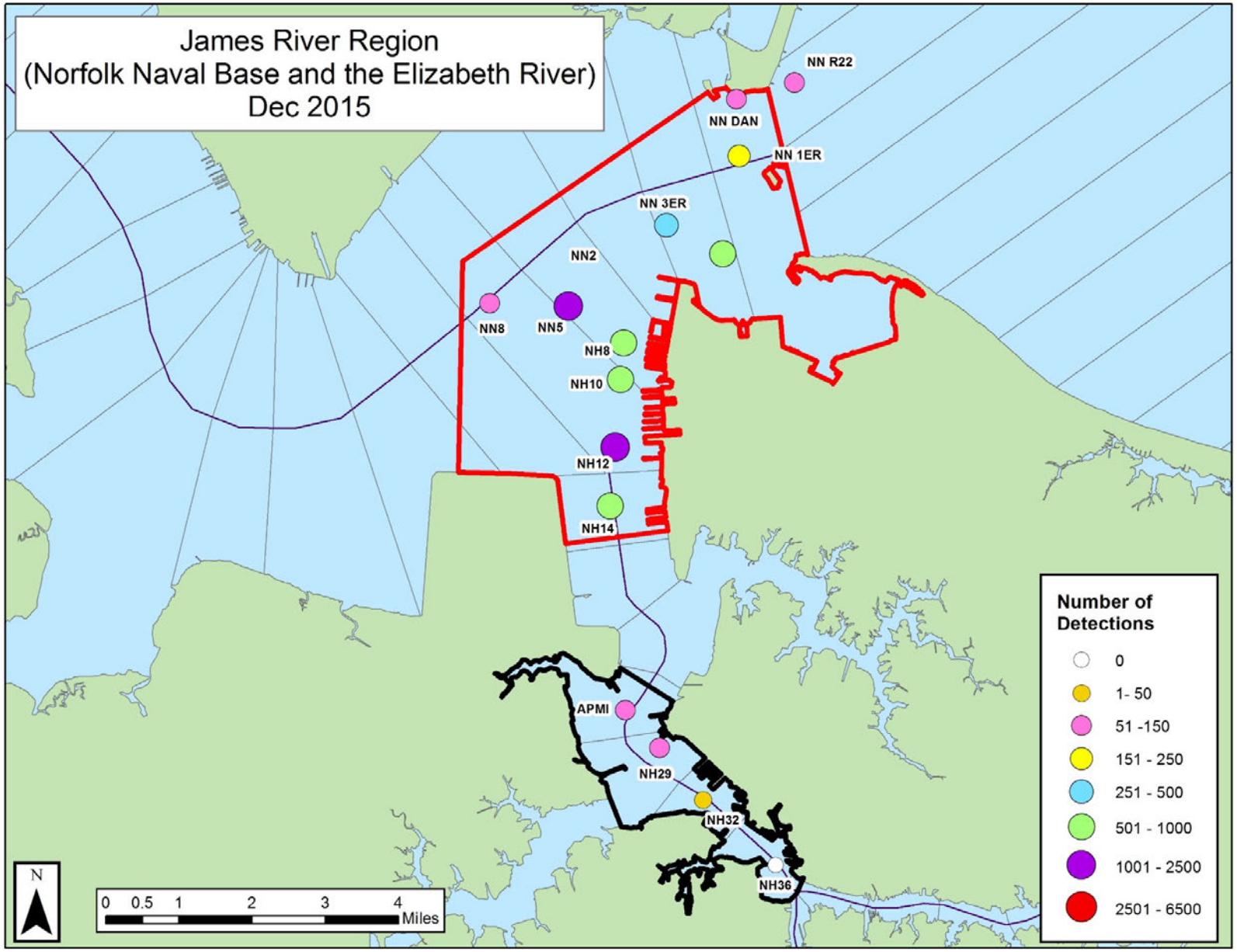

James River Region
(Norfolk Naval Base and the Elizabeth River)
Jul 2015
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

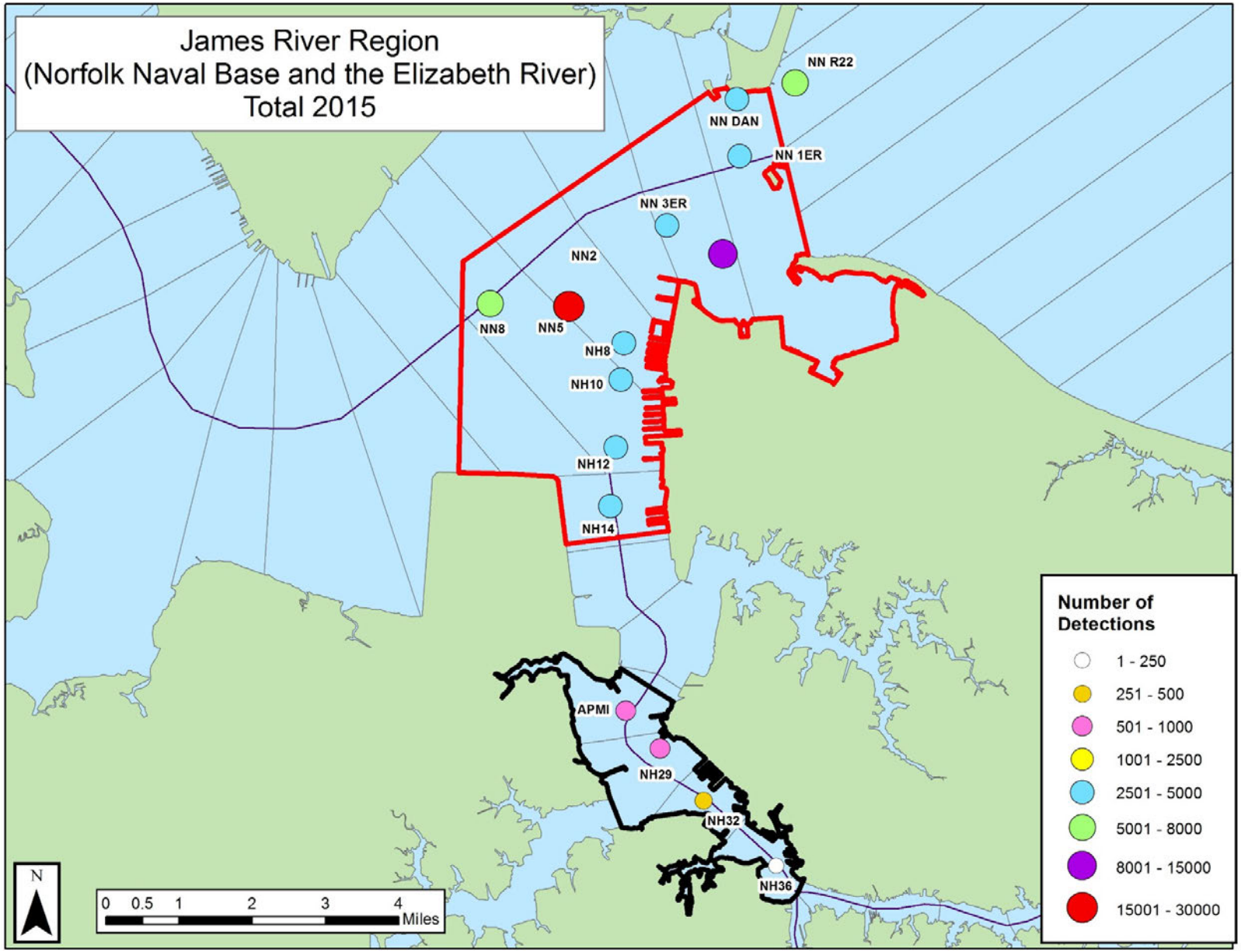

James River Region
(Norfolk Naval Base and the Elizabeth River)
Aug 2015
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

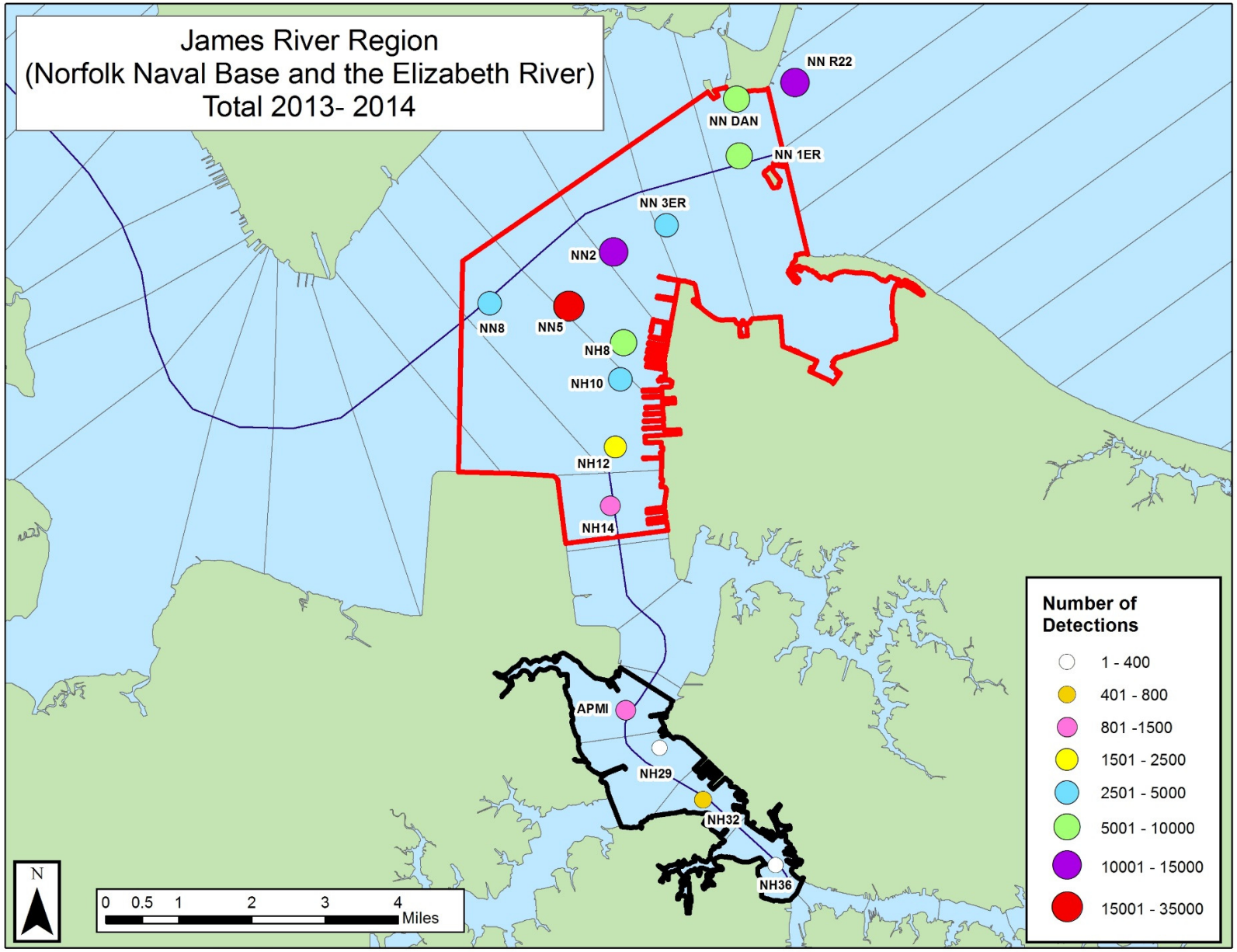

James River Region
(Norfolk Naval Base and the Elizabeth River)
Sep 2015
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

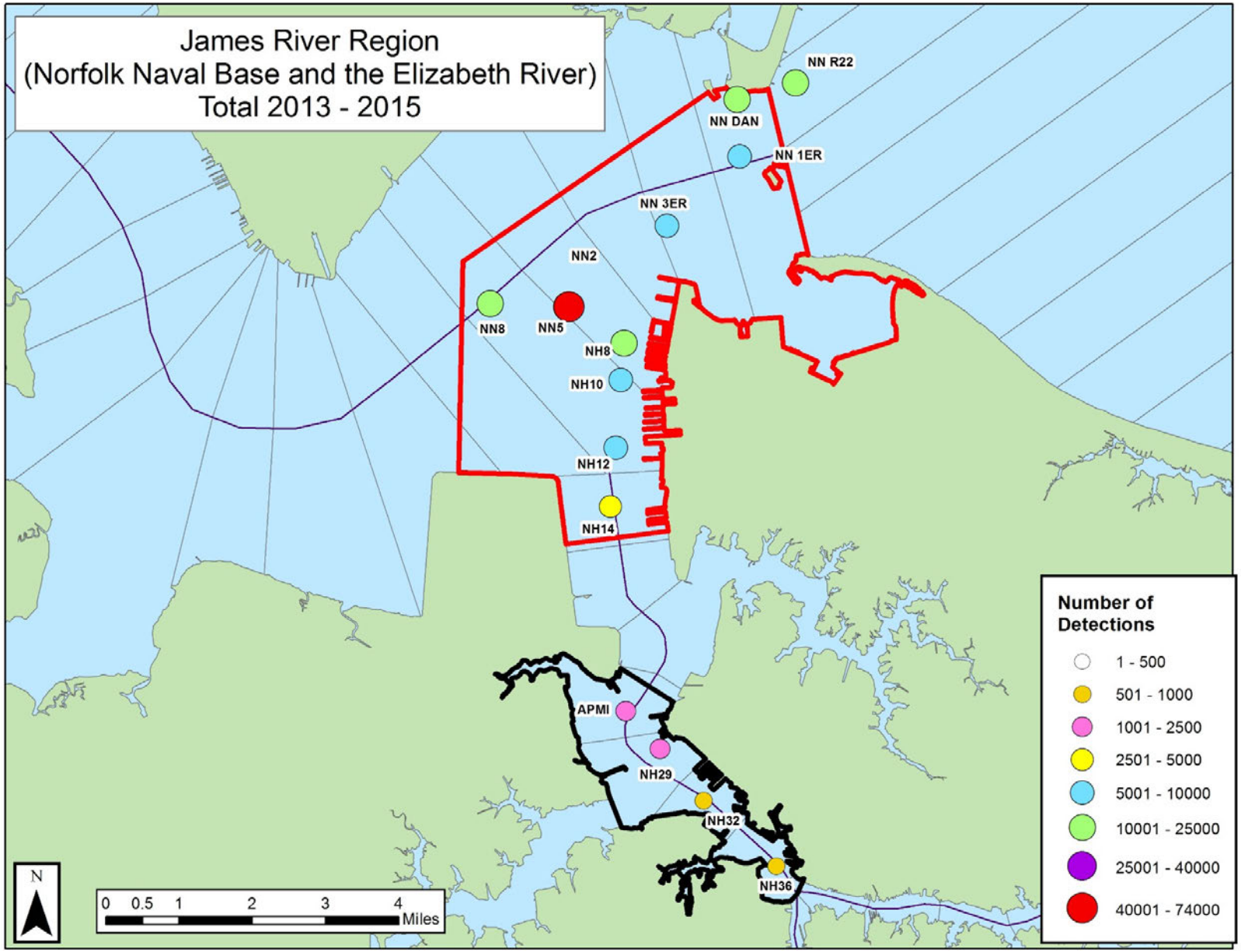

James River Region
(Norfolk Naval Base and the Elizabeth River)
Oct 2015
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 8100
N
0 0.5 1 2 3 4
Miles


James River Region
(Norfolk Naval Base and the Elizabeth River)
Nov 2015
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

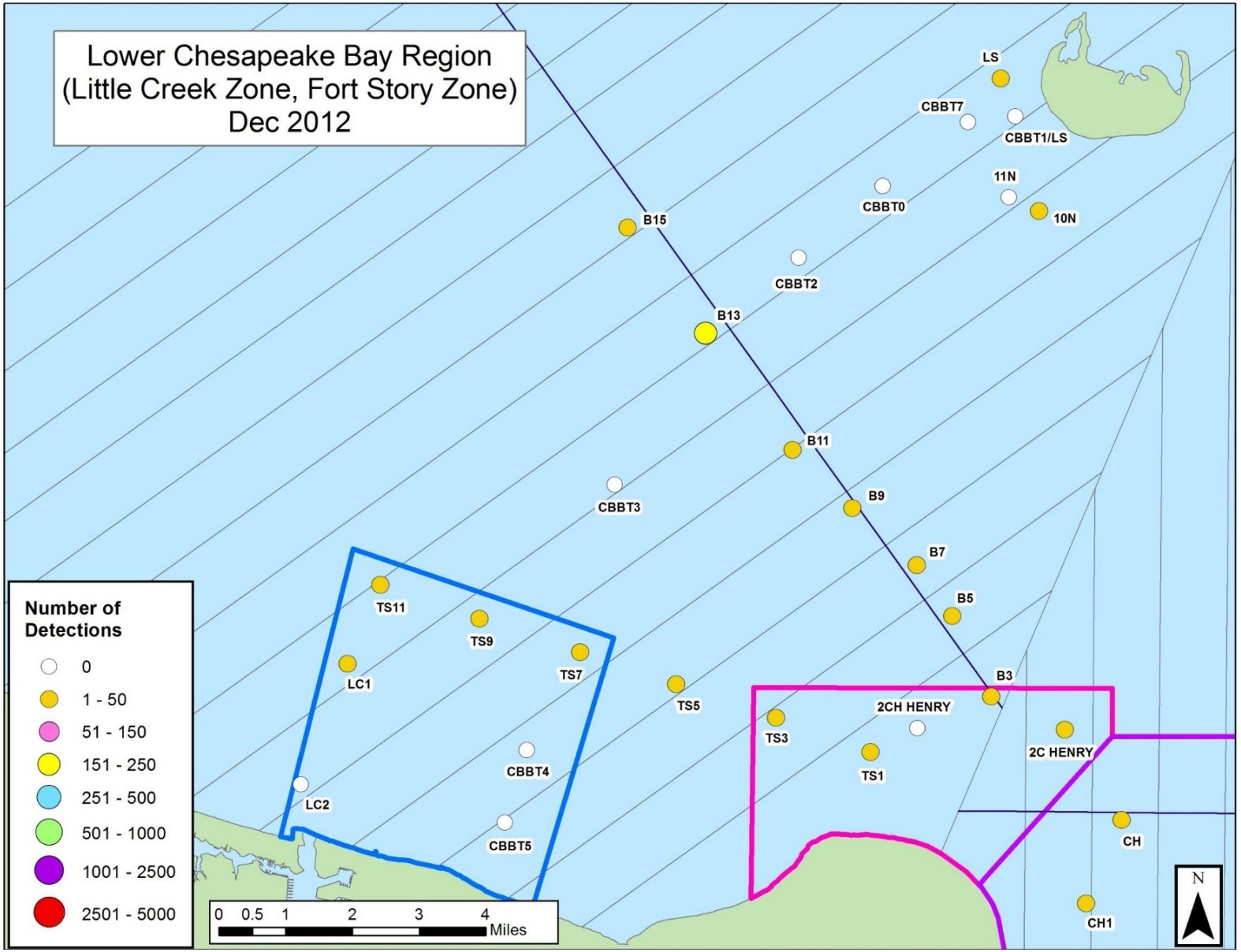

James River Region
(Norfolk Naval Base and the Elizabeth River)
Dec 2015
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
N
0 0.5 1 2 3 4
Miles

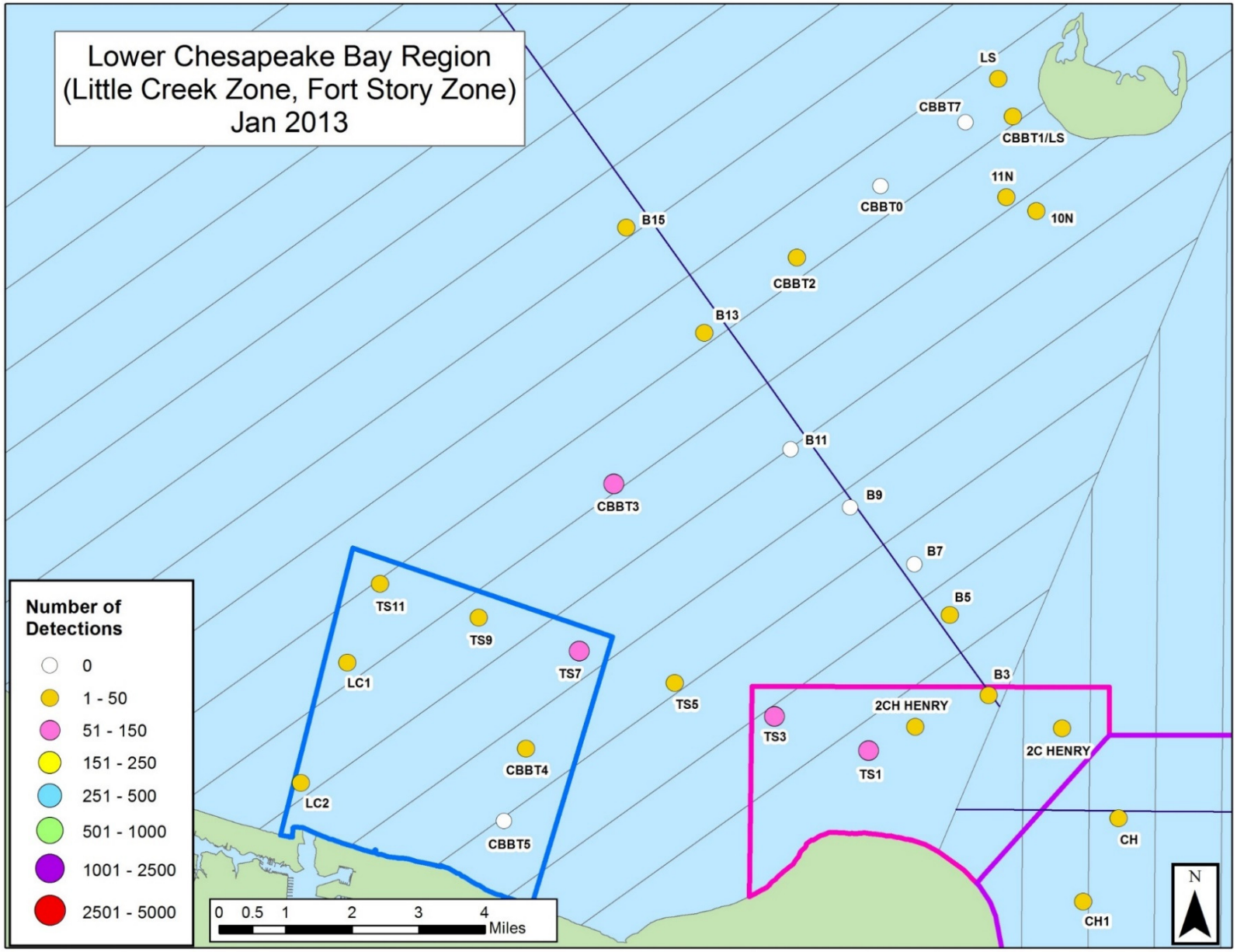

James River Region
(Norfolk Naval Base and the Elizabeth River)
Total 2015
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
N
0 0.5 1 2 3 4
Miles

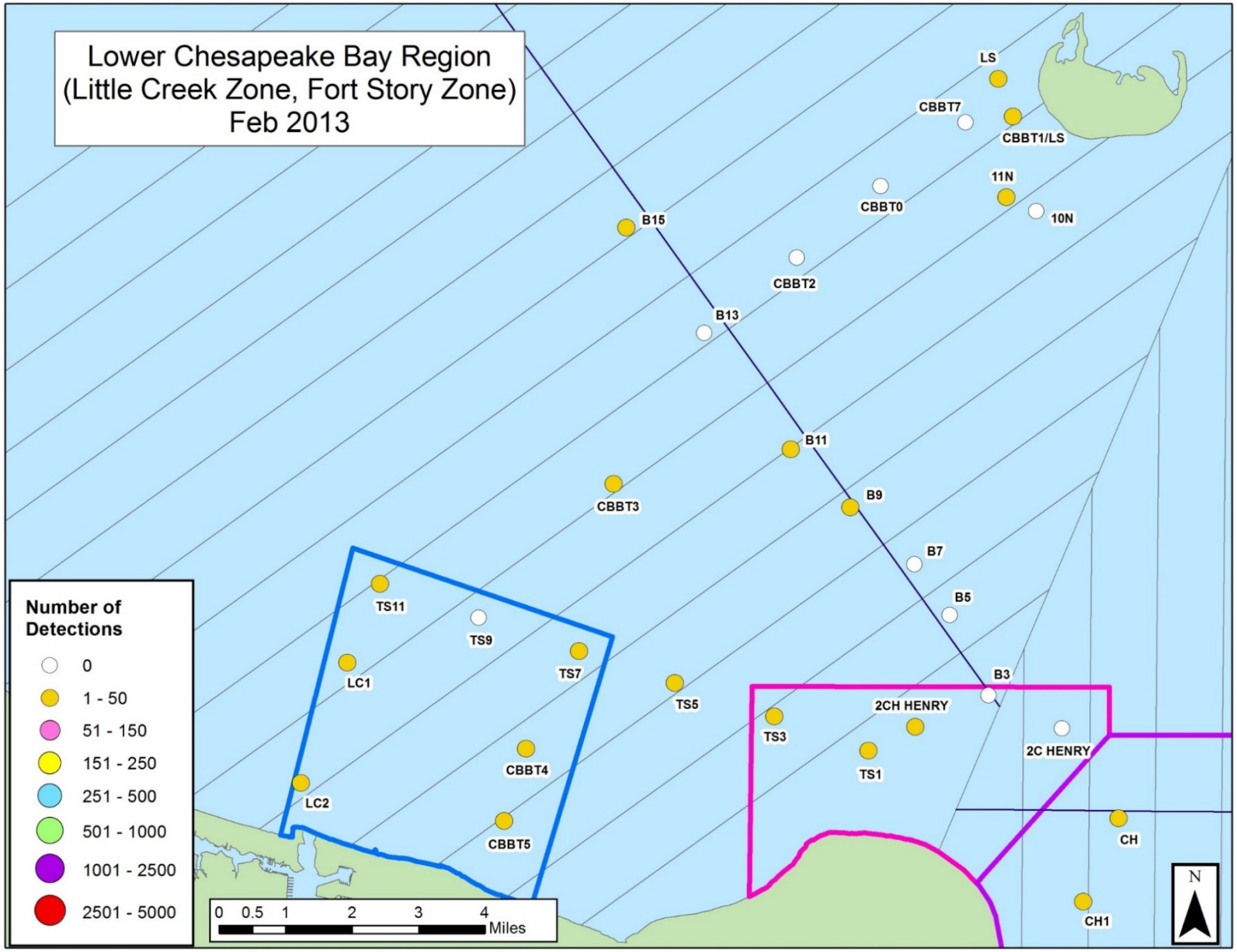

James River Region
(Norfolk Naval Base and the Elizabeth River)
Total 2013- 2014
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
1 - 400
401 - 800
801 -1500
1501 - 2500
2501 - 5000
5001 - 10000
10001 - 15000
15001 - 35000
N
0 0.5 1 2 3 4
Miles

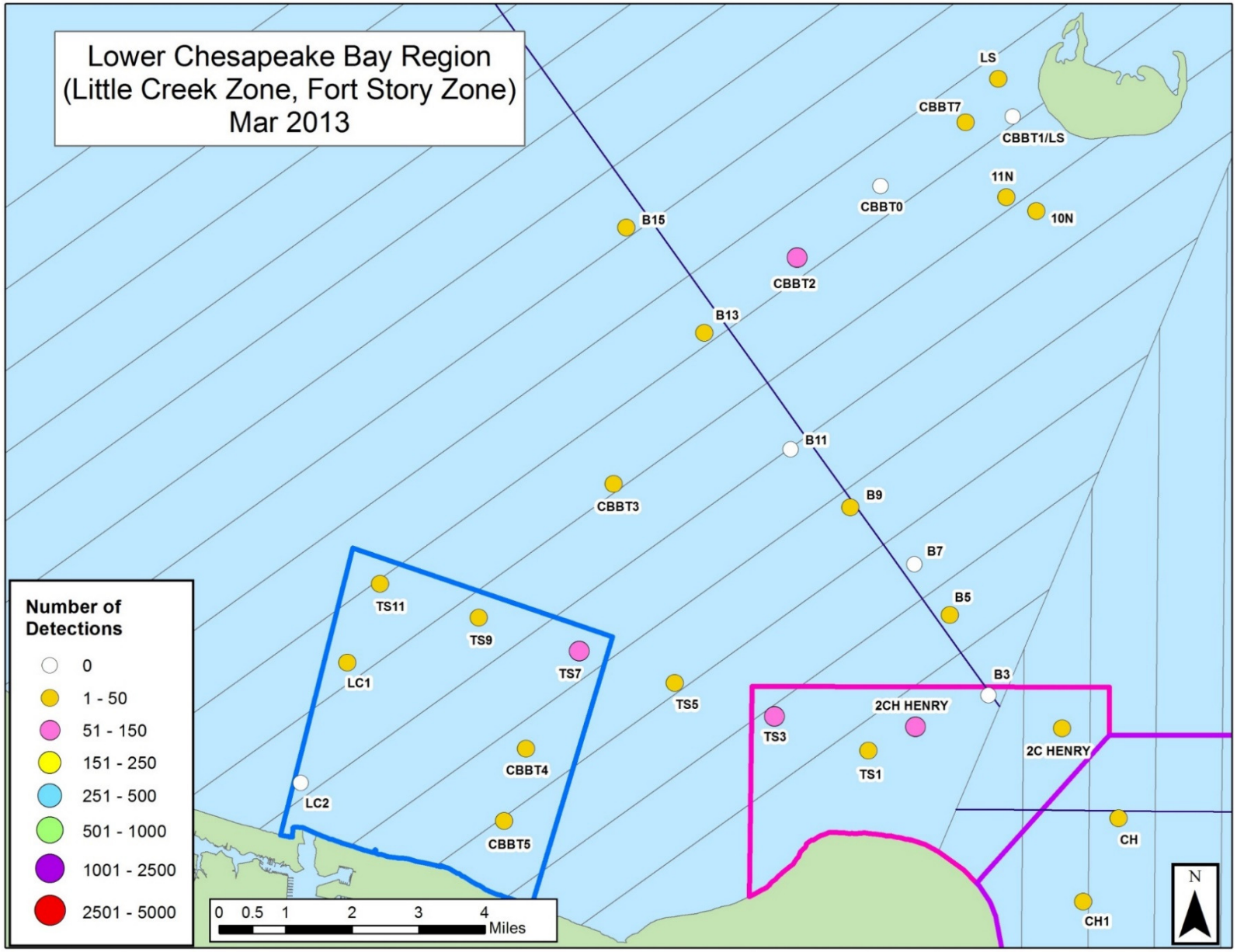

James River Region
(Norfolk Naval Base and the Elizabeth River)
Total 2013 - 2015
NN R22
NN DAN
NN 1ER
NN 3ER
NN2
NN8
NN5
NH8
NH10
NH12
NH14
APMI
NH29
NH32
NH36
Number of Detections
1 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 10000
10001 - 25000
25001 - 40000
40001 - 74000
N
0 0.5 1 2 3 4
Miles

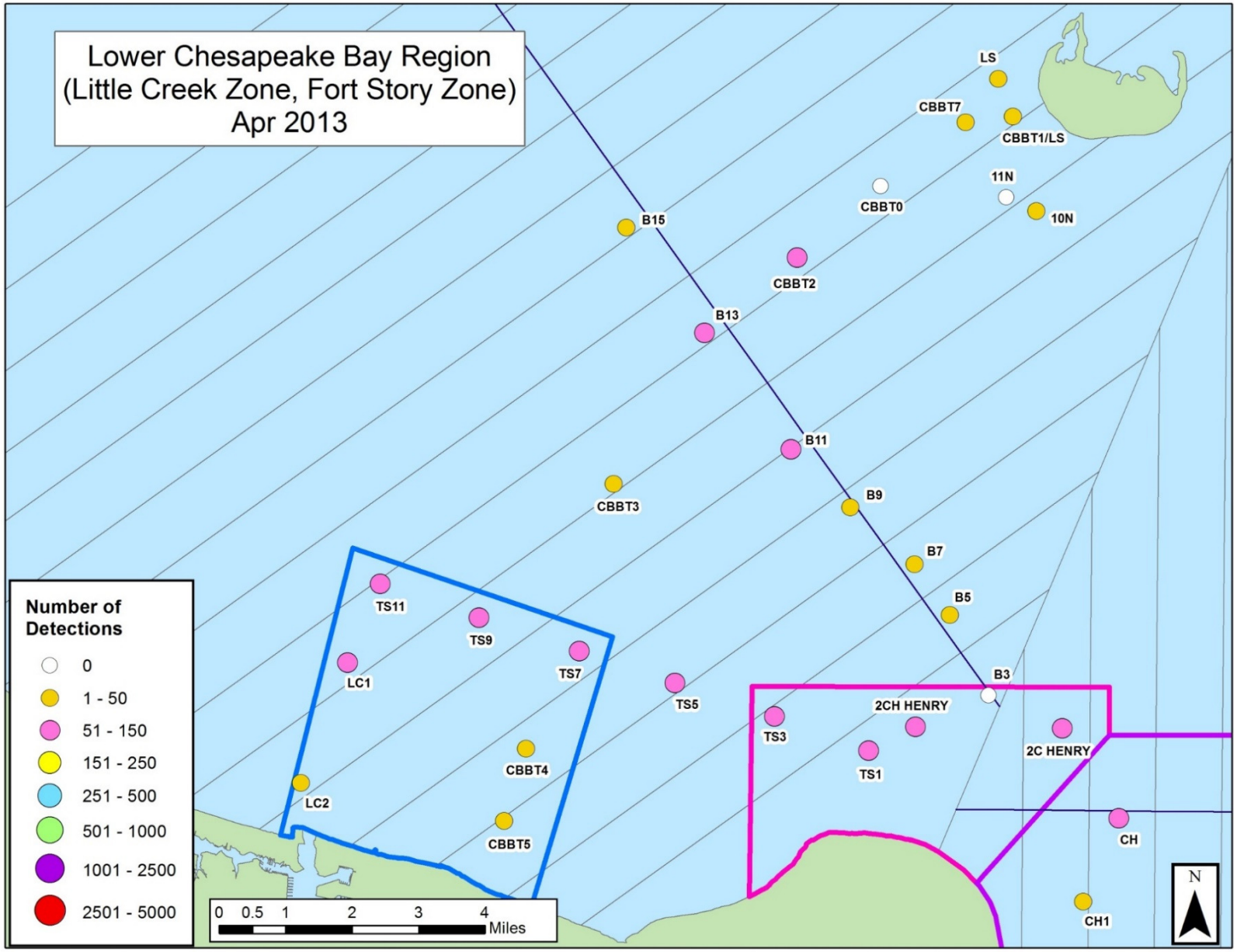
## 9.7 APPENDIX 4.4.5: LOWER CHESAPEAKE BAY REGION (LITTLE CREEK ZONE, FORT STORY ZONE)

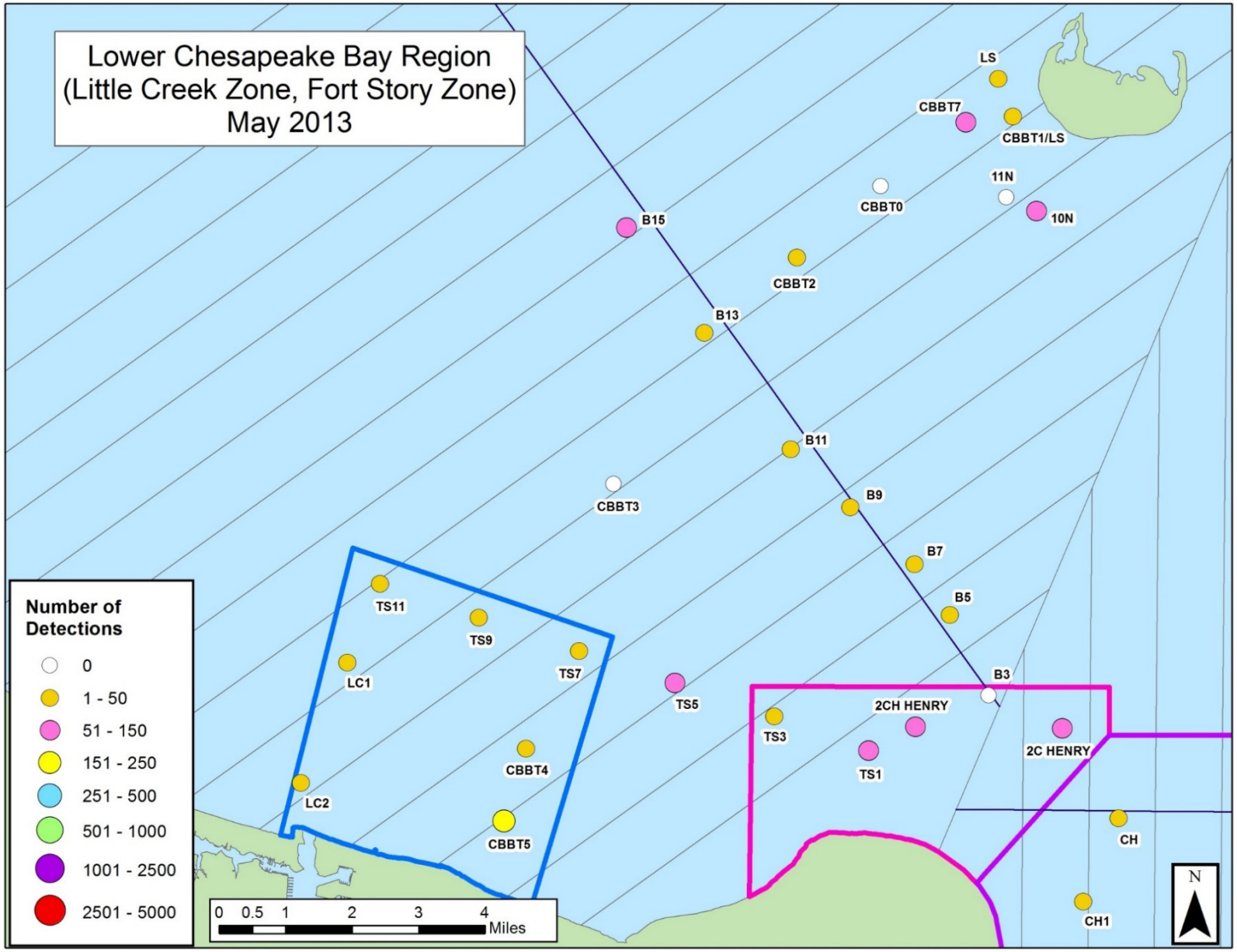


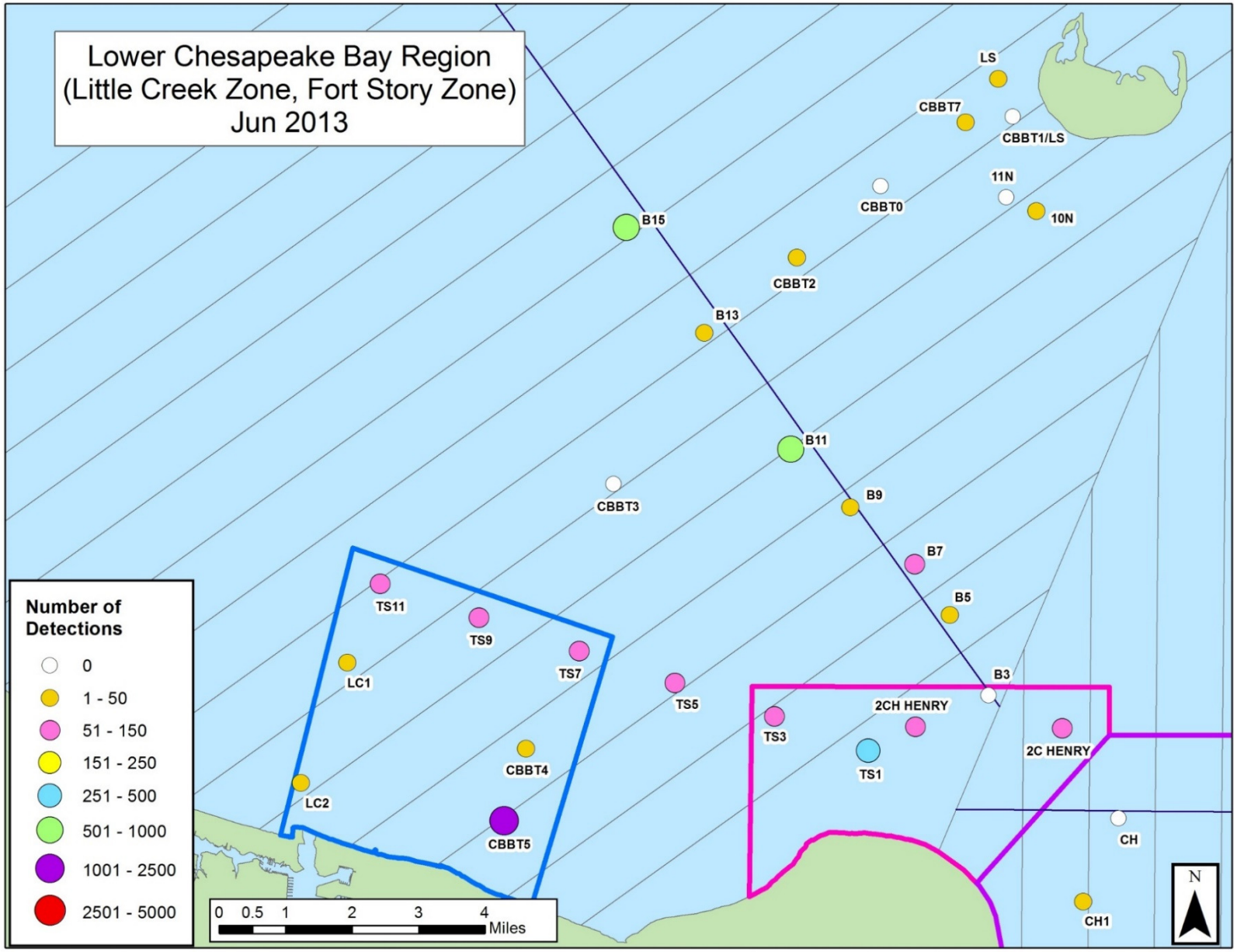

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Jan 2013
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
11N
10N
CBBT0
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
B3
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

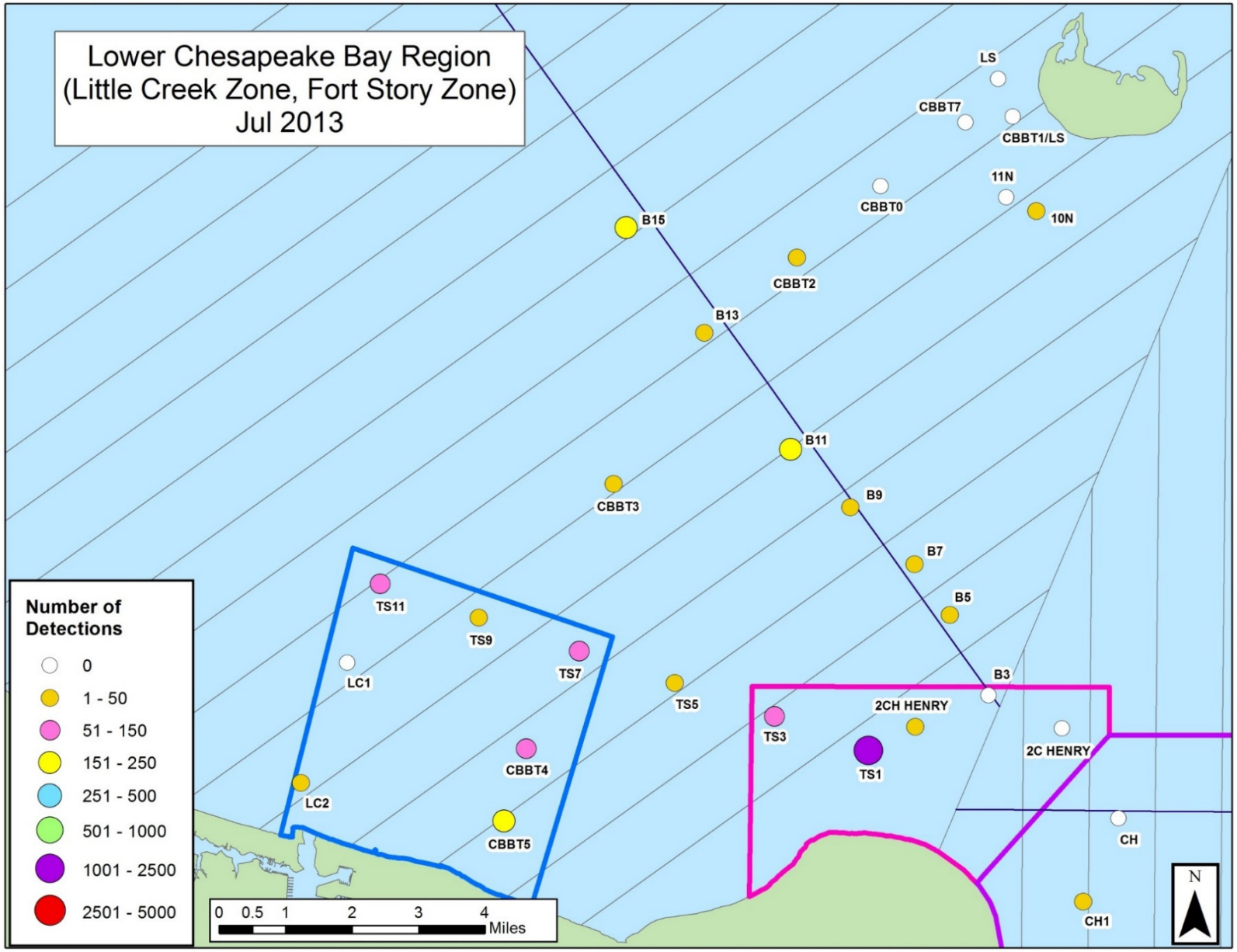

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Feb 2013
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
11N
10N
CBBT0
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
B3
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

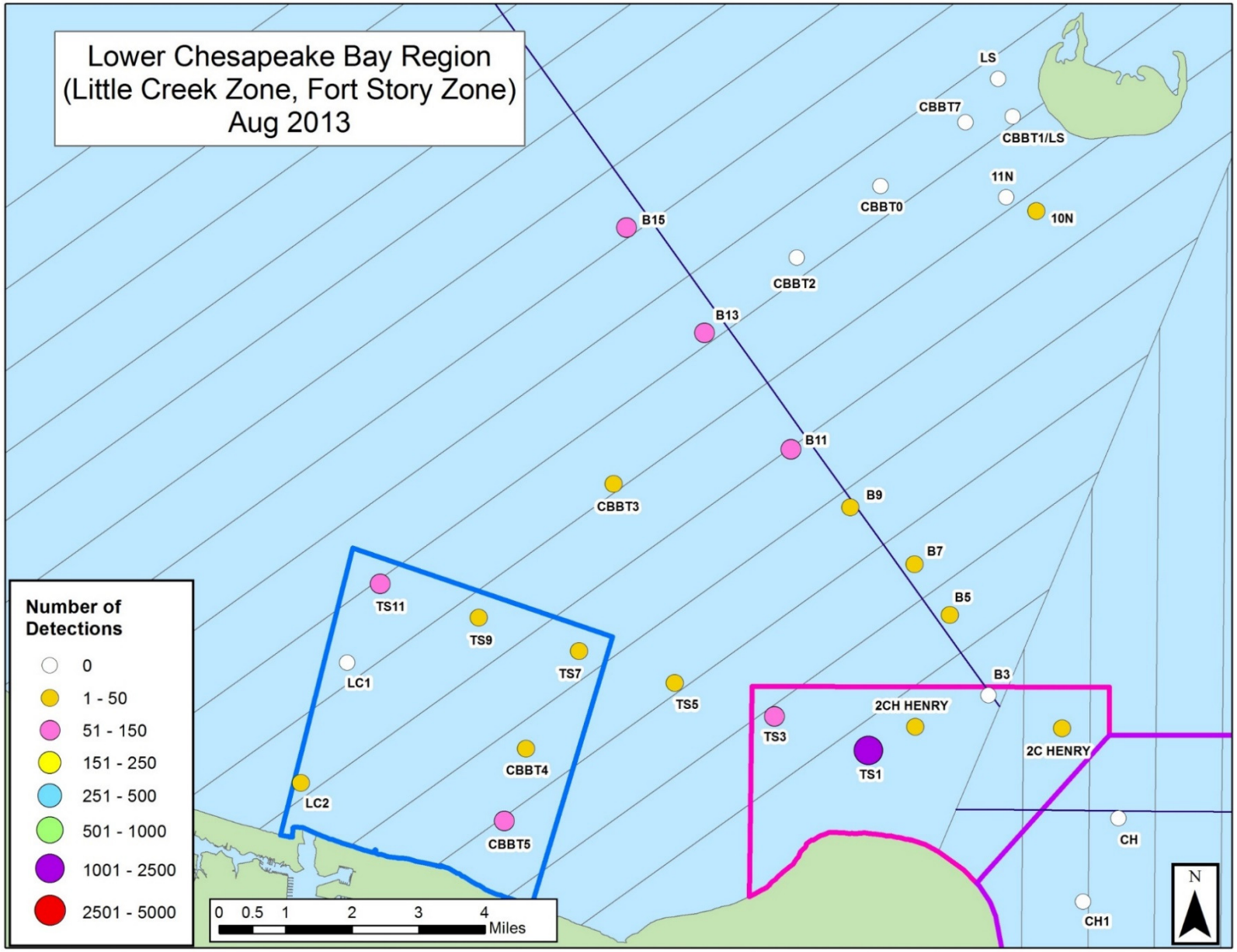

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Mar 2013
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
11N
10N
CBBT0
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
B3
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

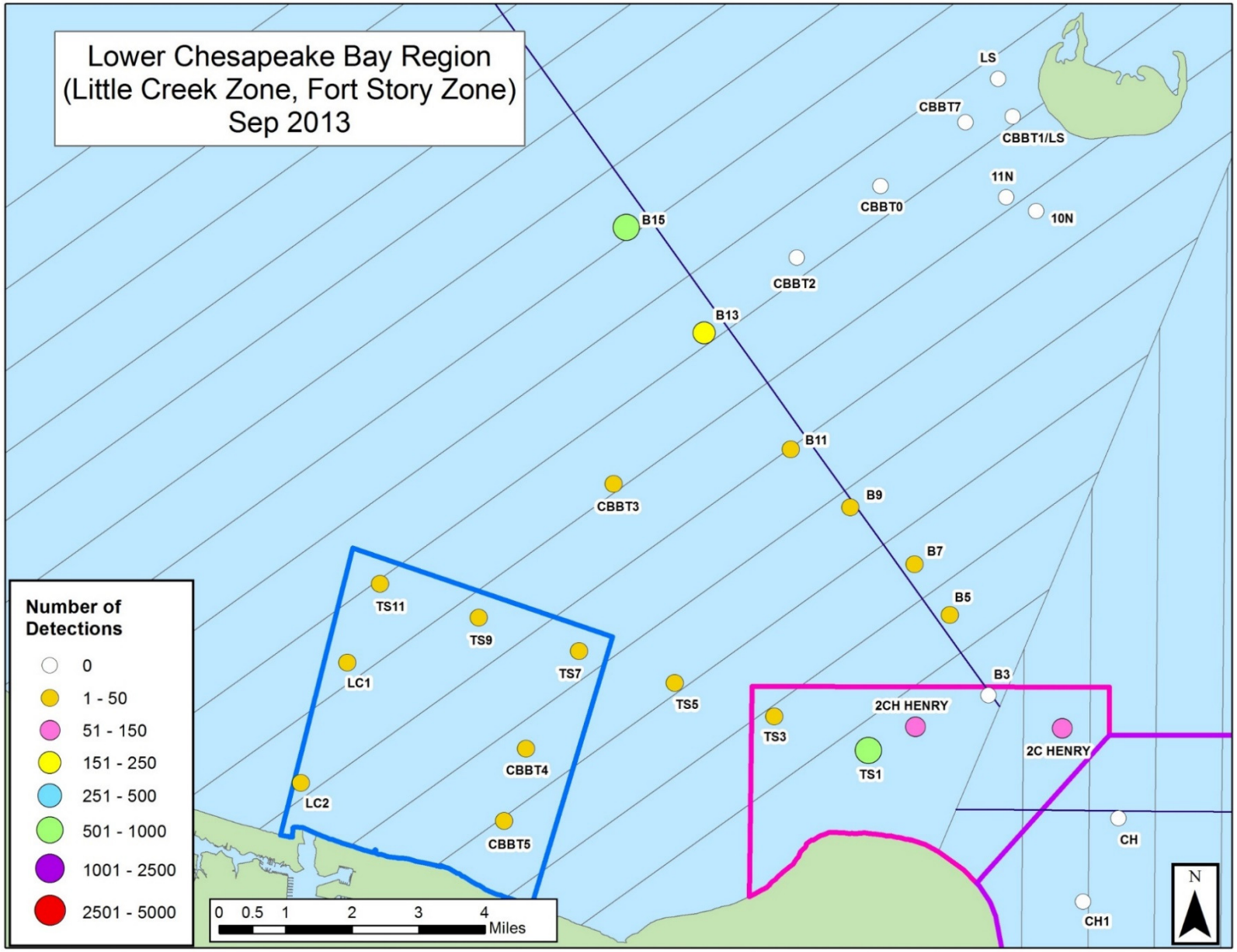

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Apr 2013
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
11N
10N
CBBT0
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
B3
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

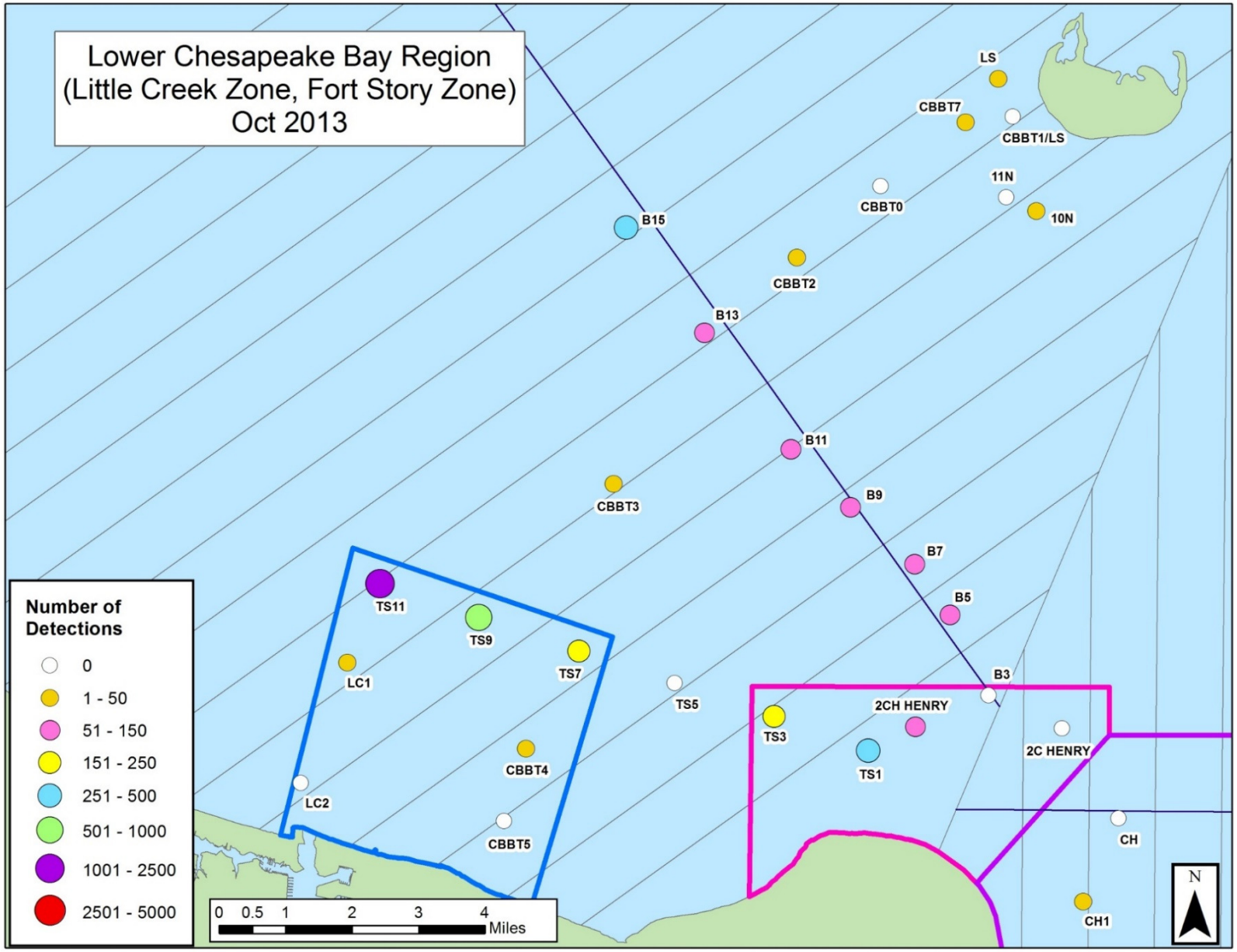

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
May 2013
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
11N
10N
CBBT0
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
B3
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

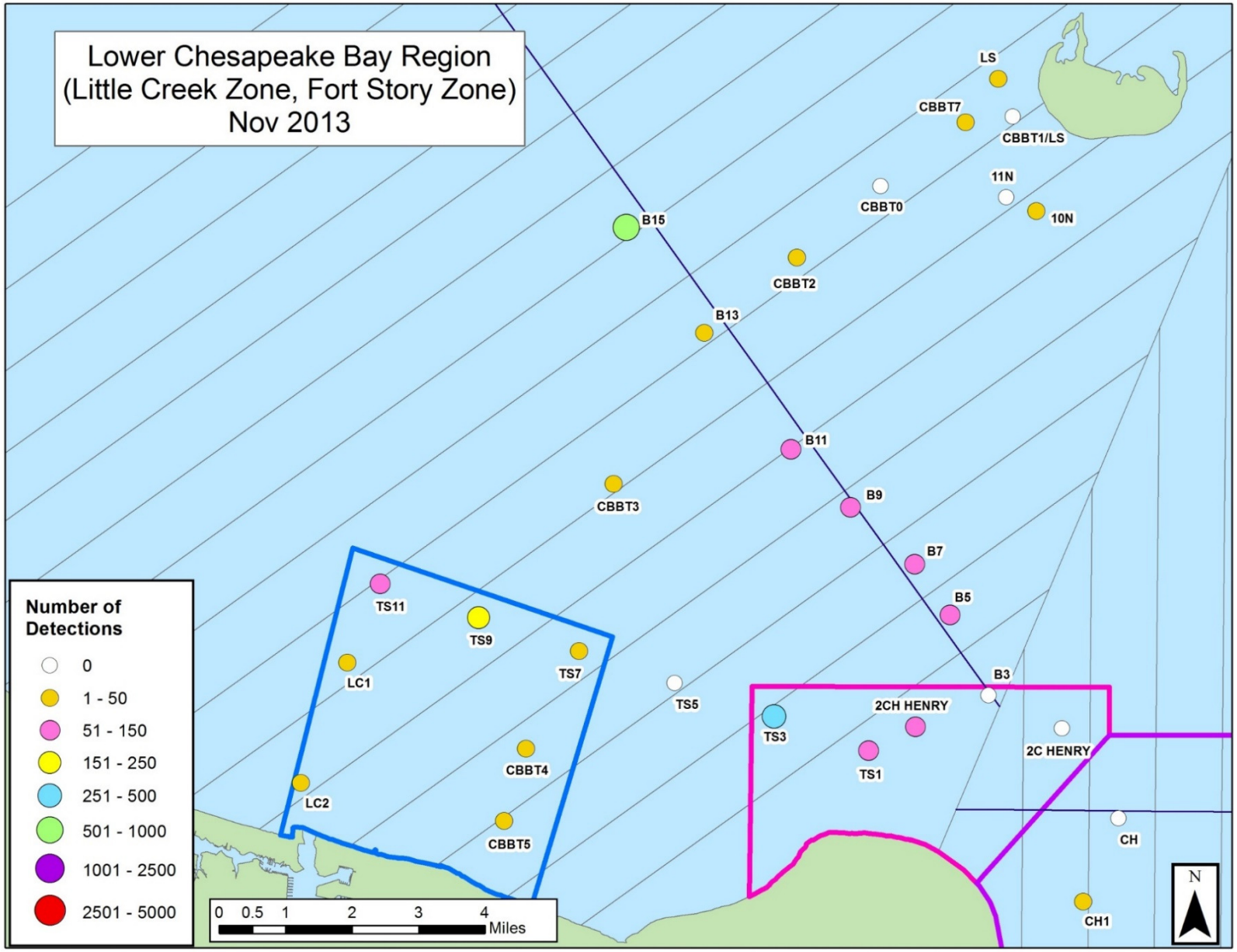

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Jun 2013
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
11N
10N
CBBT0
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
B3
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

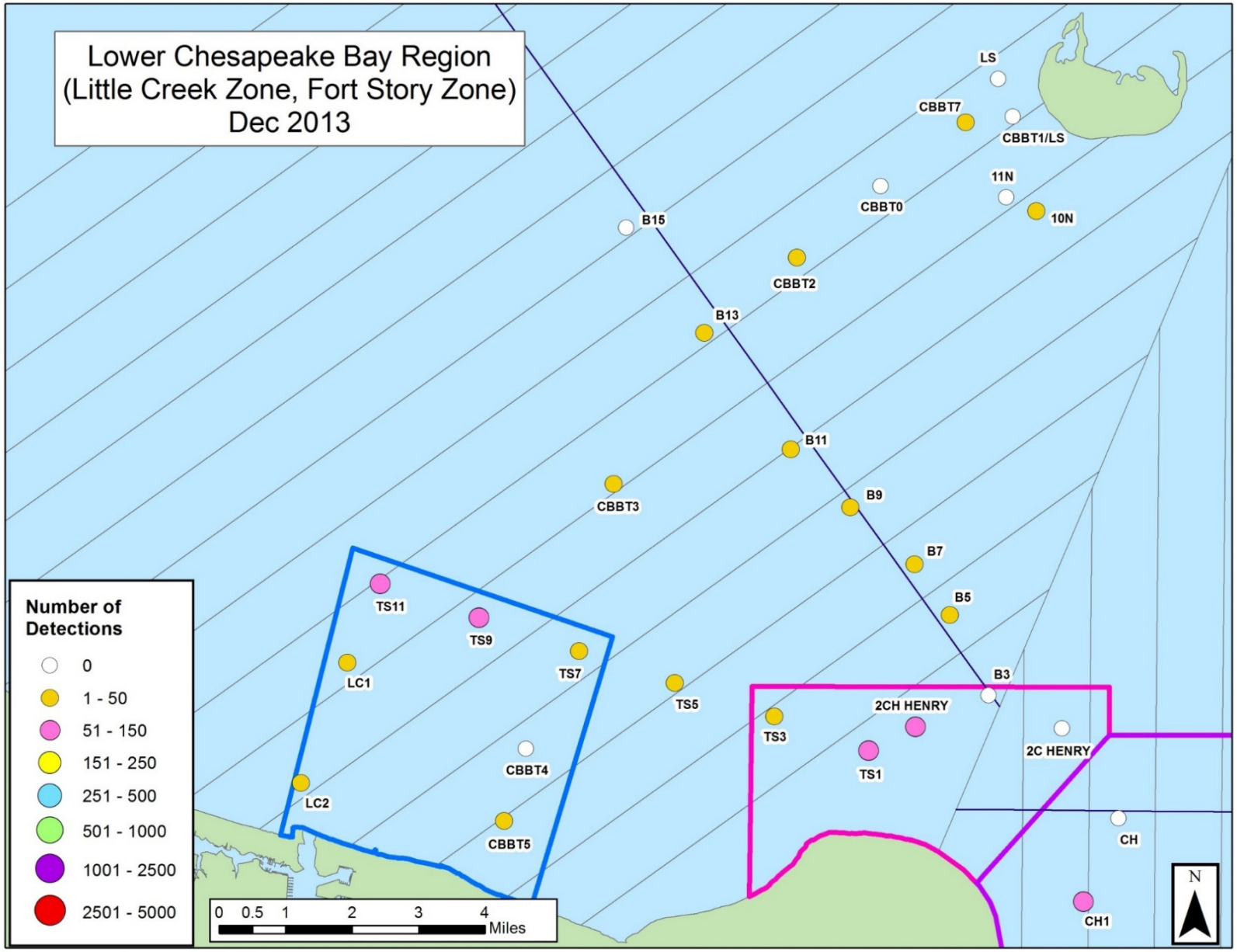

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Jul 2013
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
11N
10N
CBBT0
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
B3
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

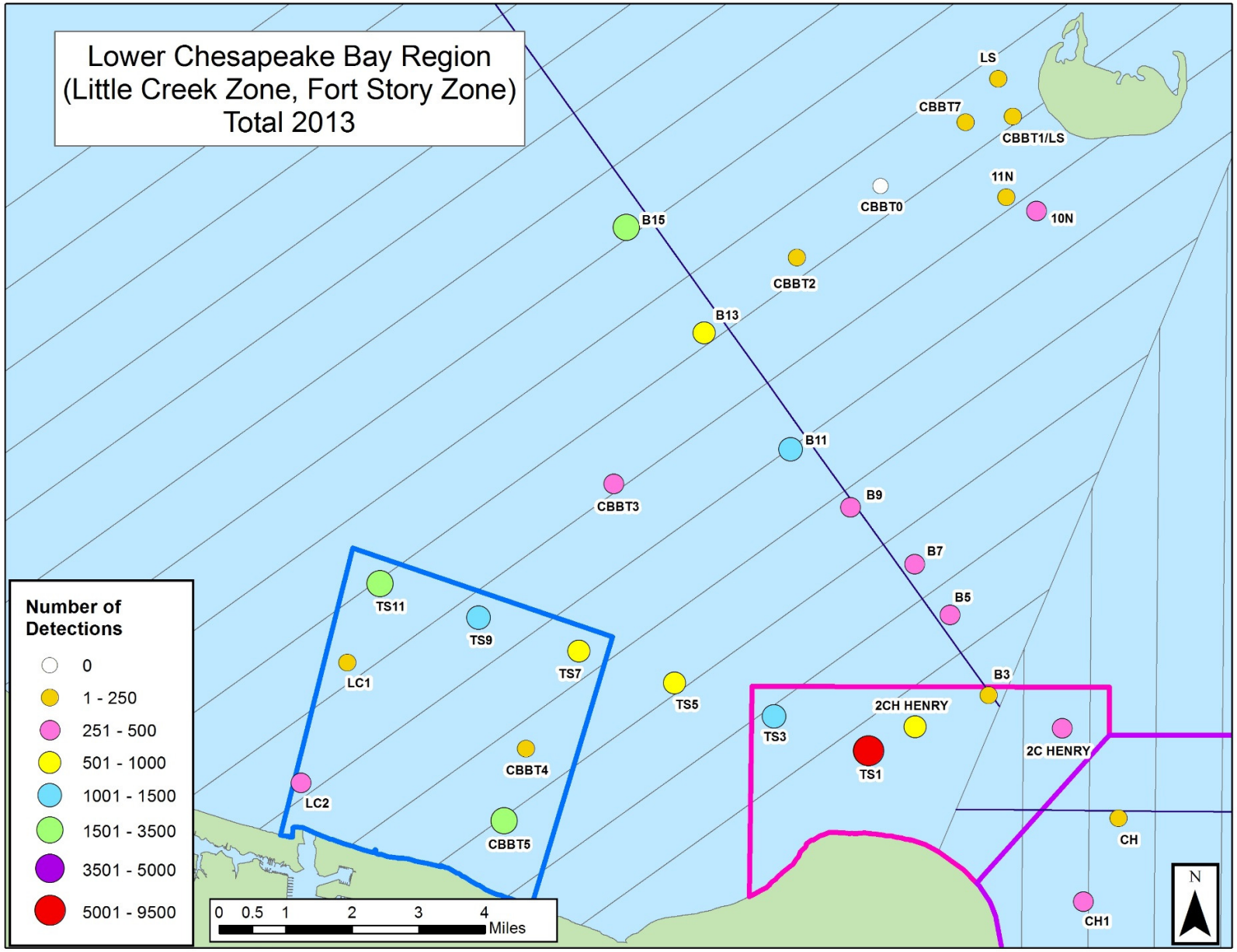

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Aug 2013
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
11N
10N
CBBT0
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
B3
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

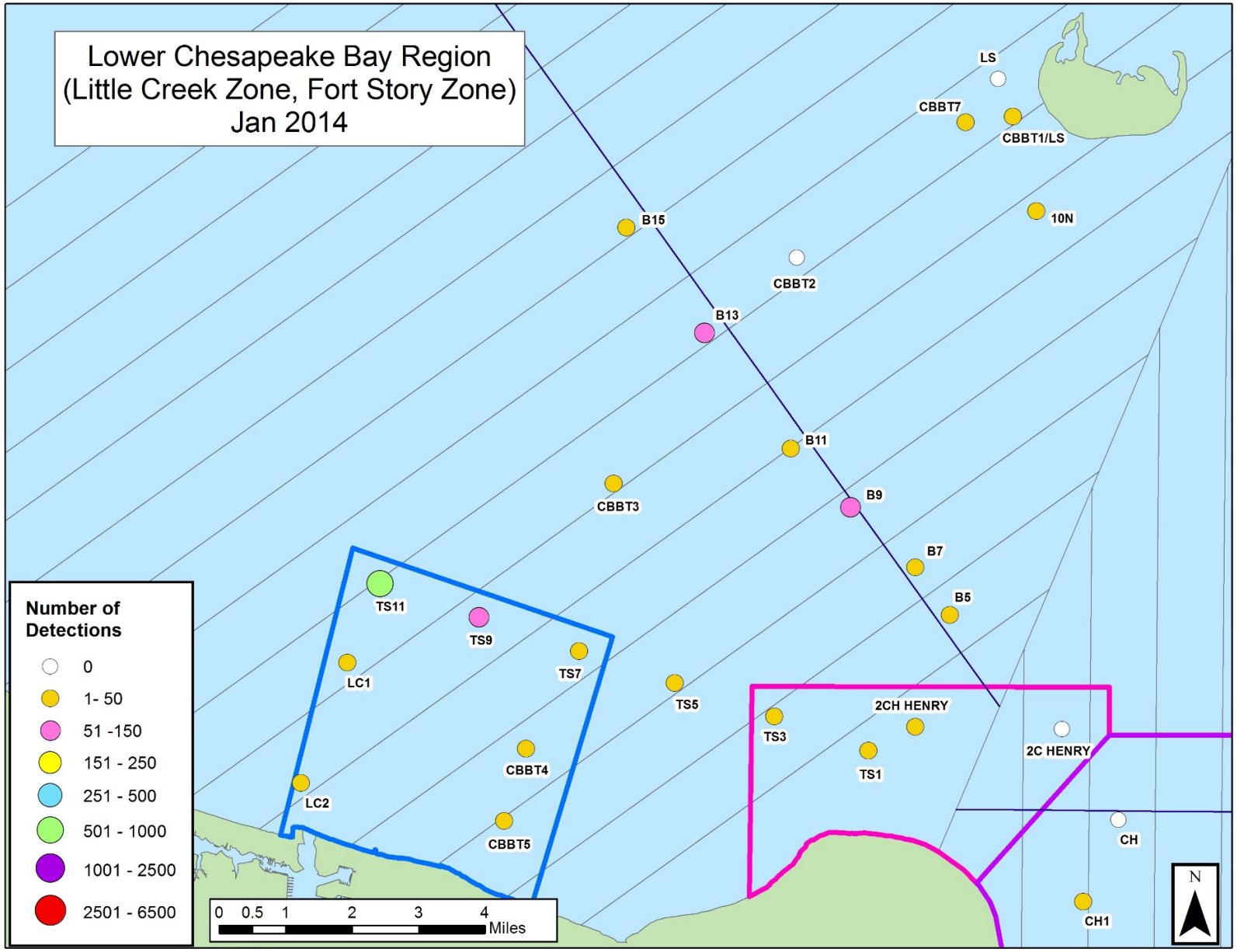

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Sep 2013
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
11N
10N
CBBT0
B15
CBBT2
B13
B11
B9
CBBT3
B7
B5
B3
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

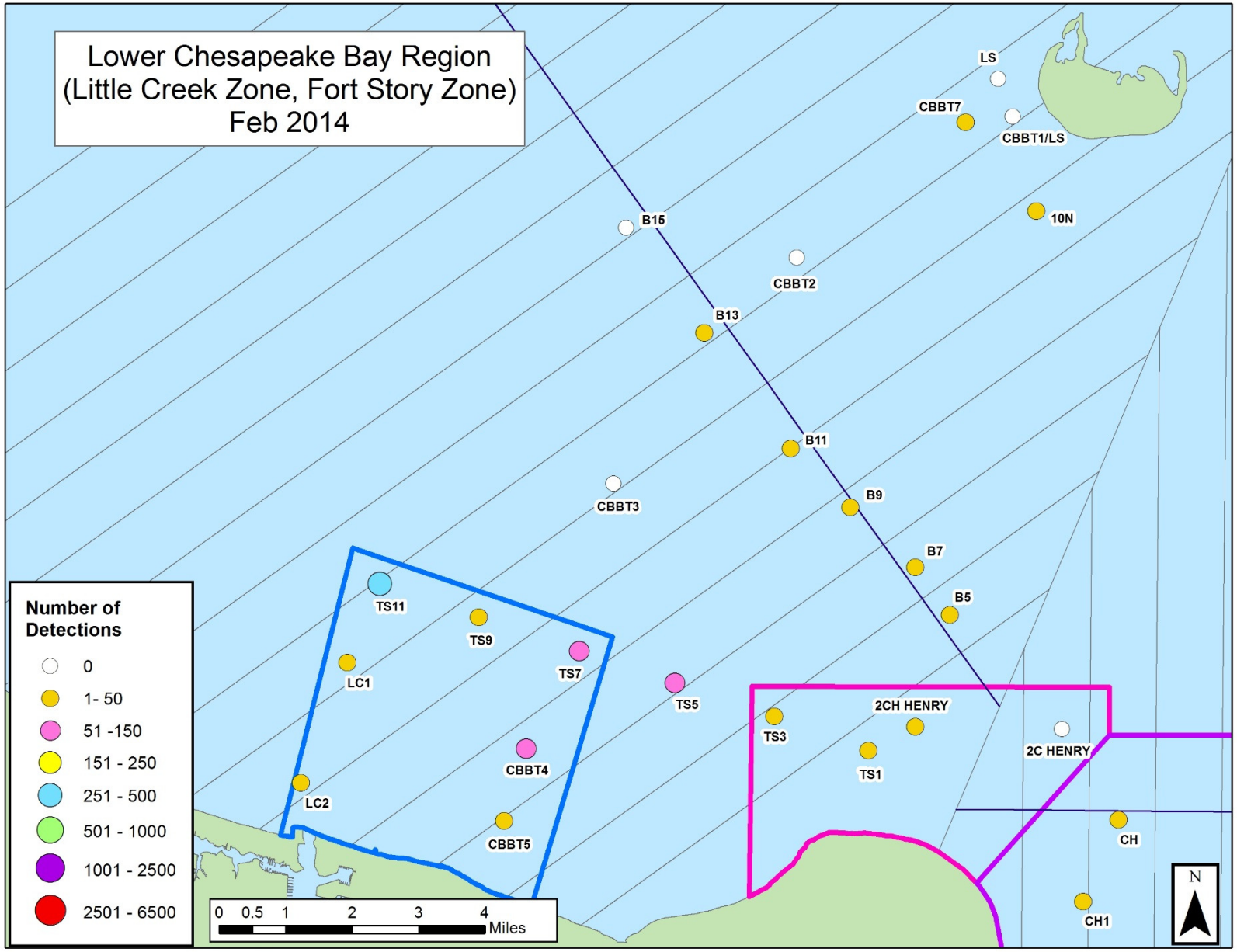

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Oct 2013
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
11N
10N
CBBT0
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
B3
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

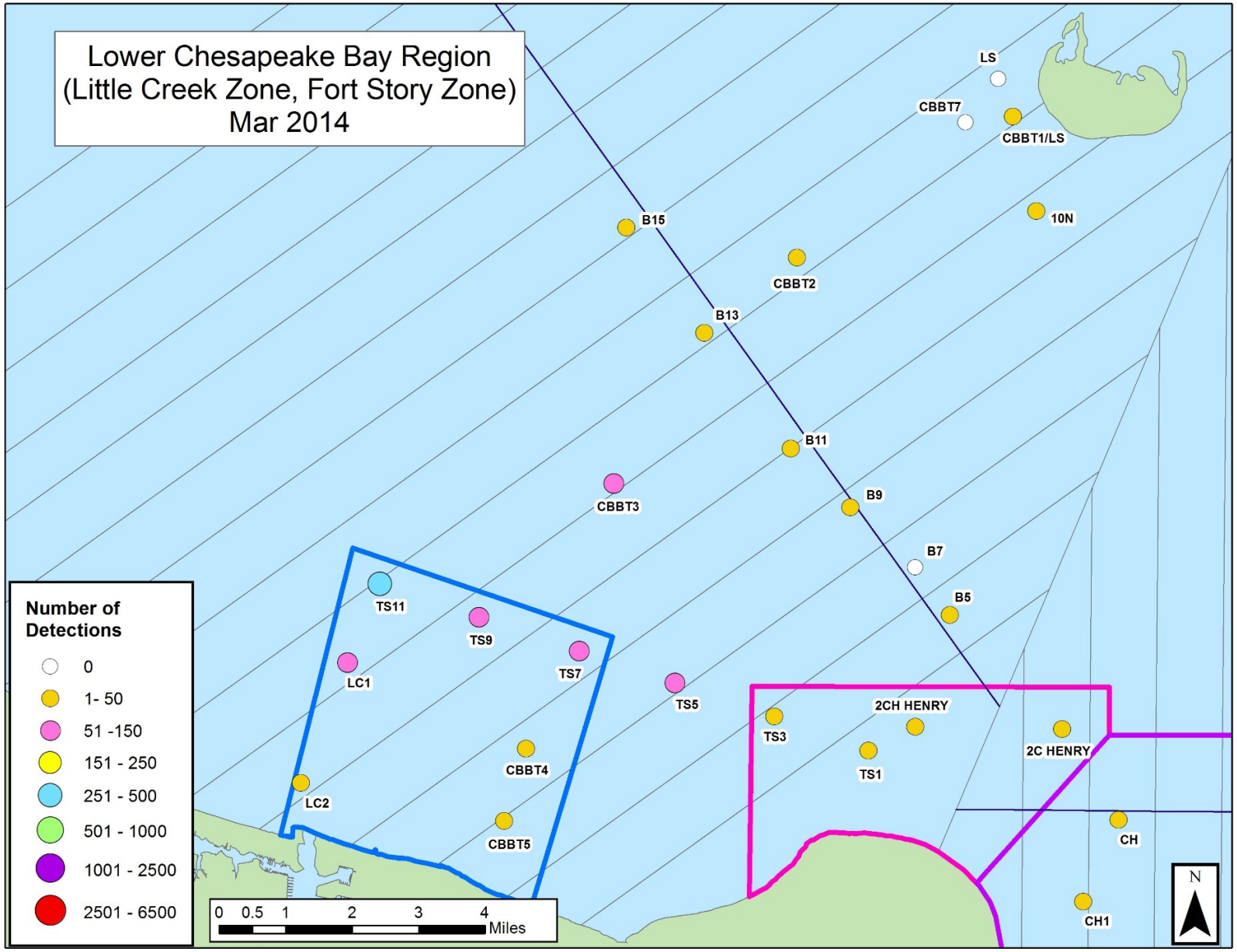

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Nov 2013
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
11N
10N
CBBT0
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
B3
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

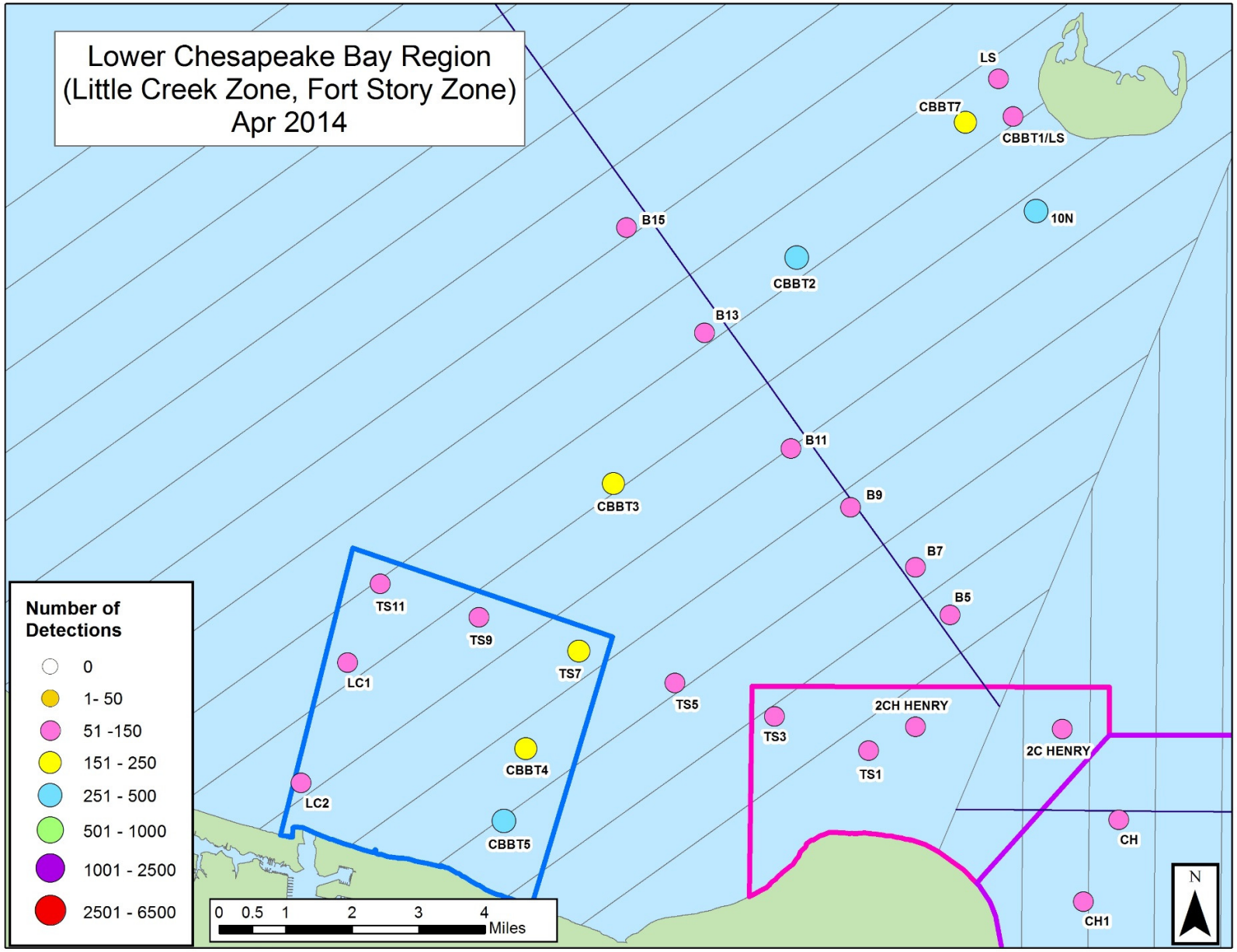

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Dec 2013
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
11N
10N
CBBT0
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
B3
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

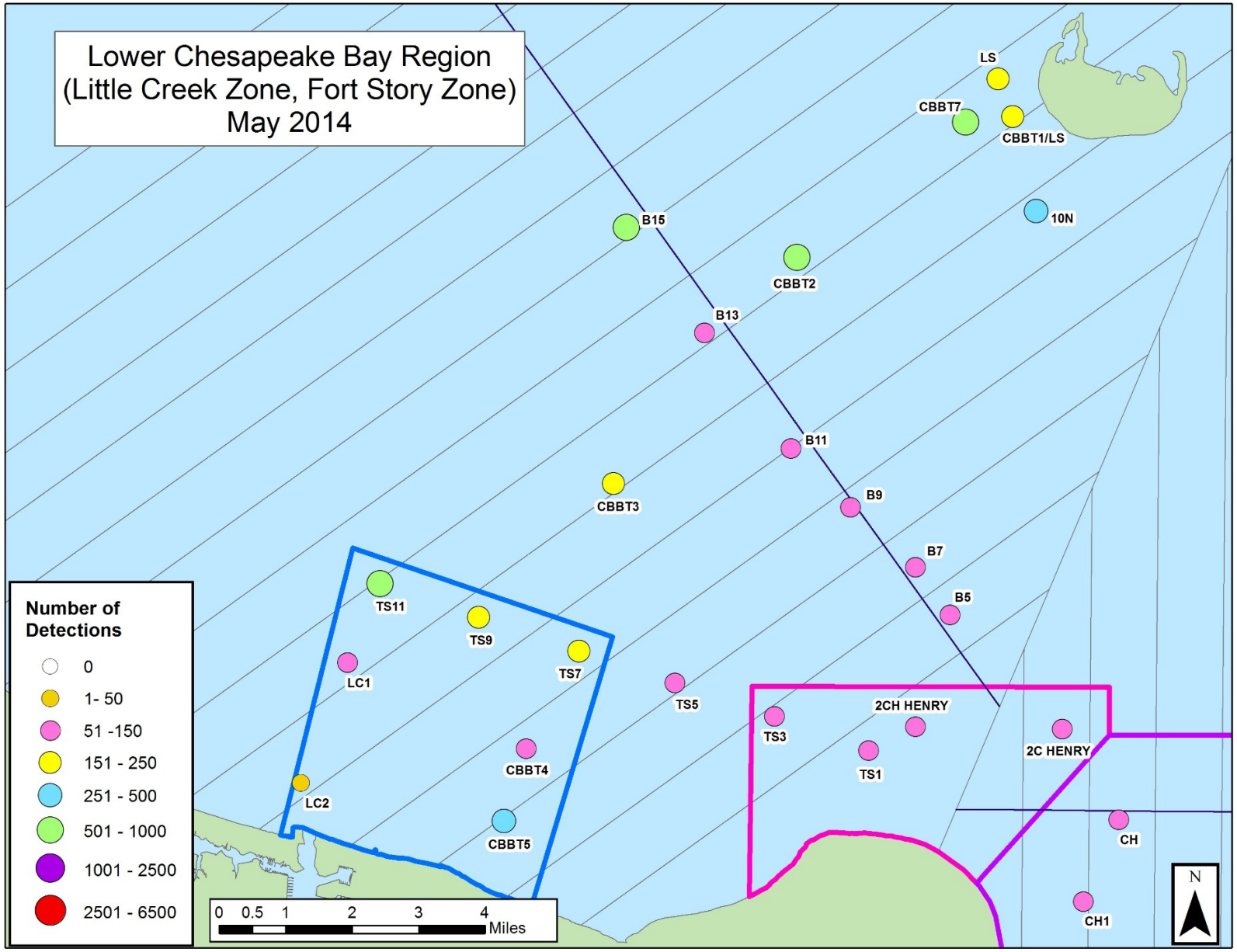

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Total 2013
Number of Detections
0
1 - 250
251 - 500
501 - 1000
1001 - 1500
1501 - 3500
3501 - 5000
5001 - 9500
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
11N
10N
CBBT0
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
B3
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

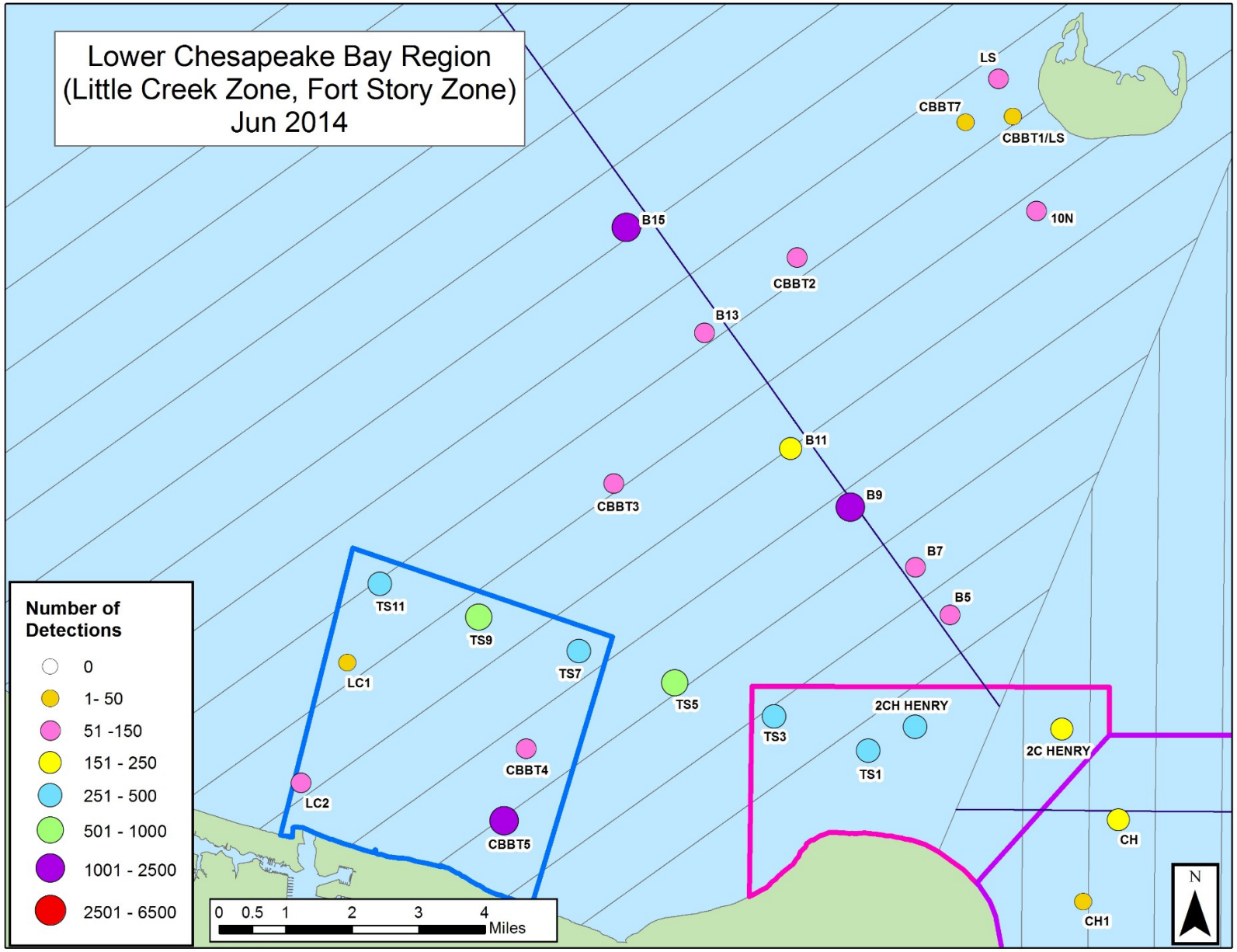

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Jan 2014
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
B9
CBBT3
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N

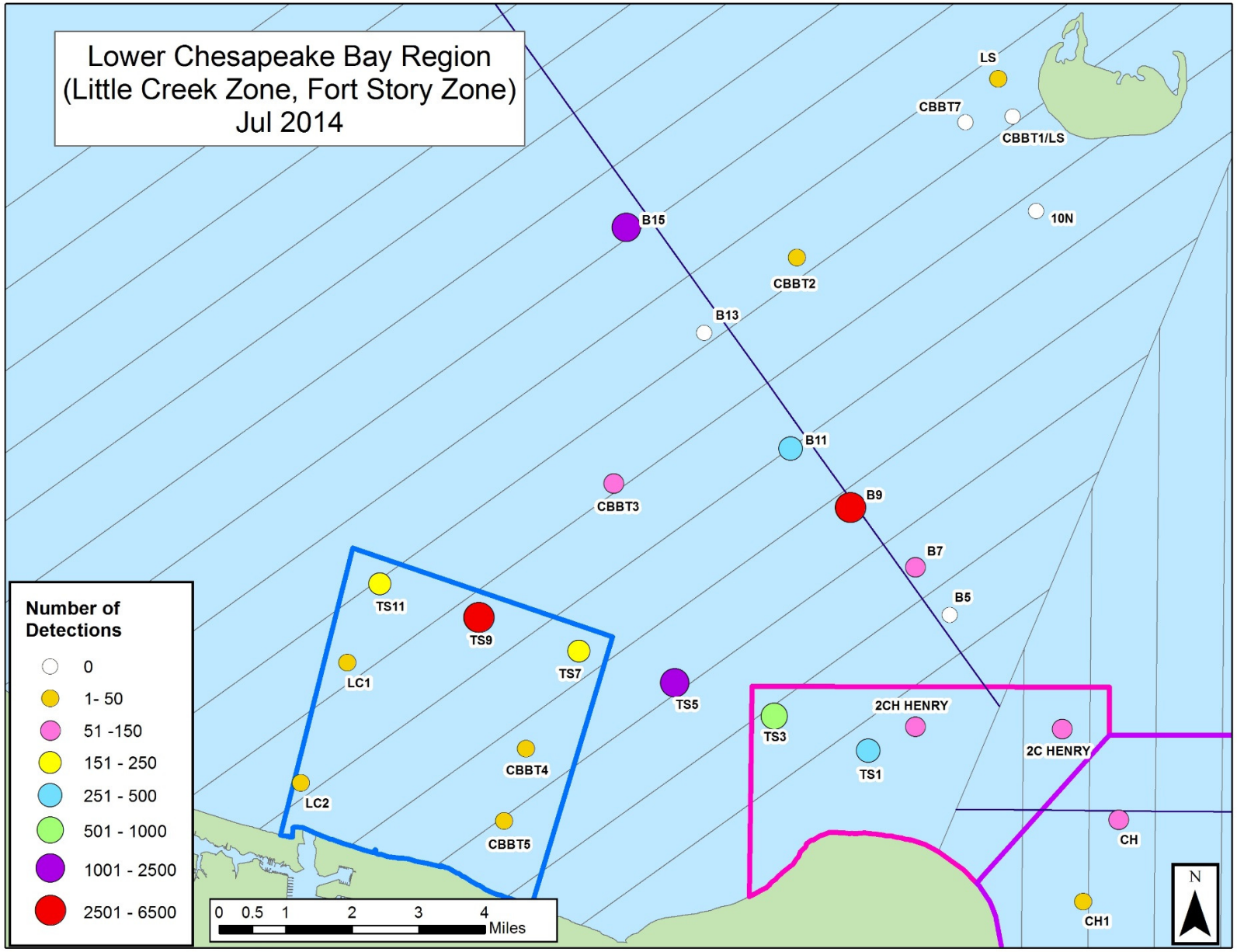

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Feb 2014
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N

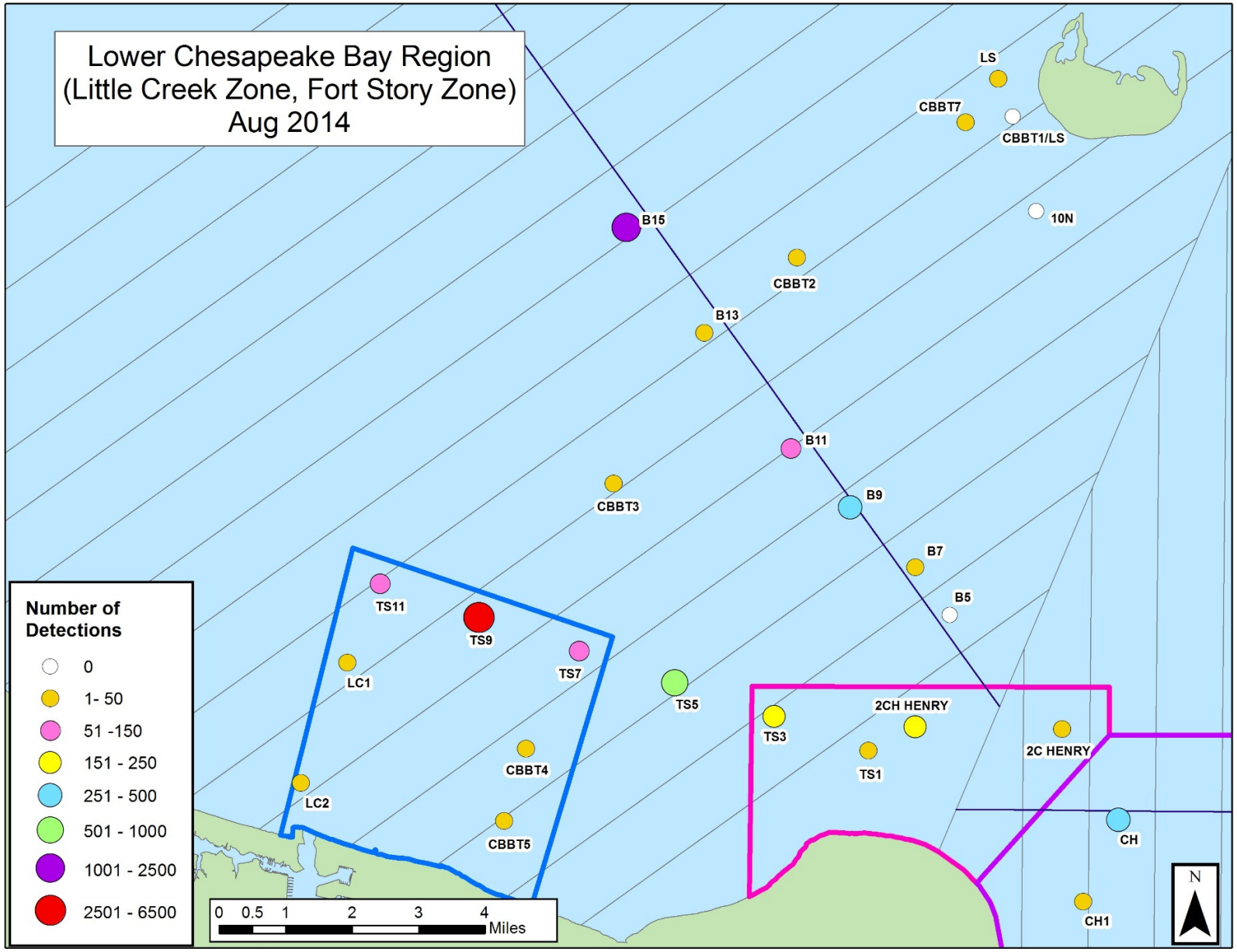

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Mar 2014
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N

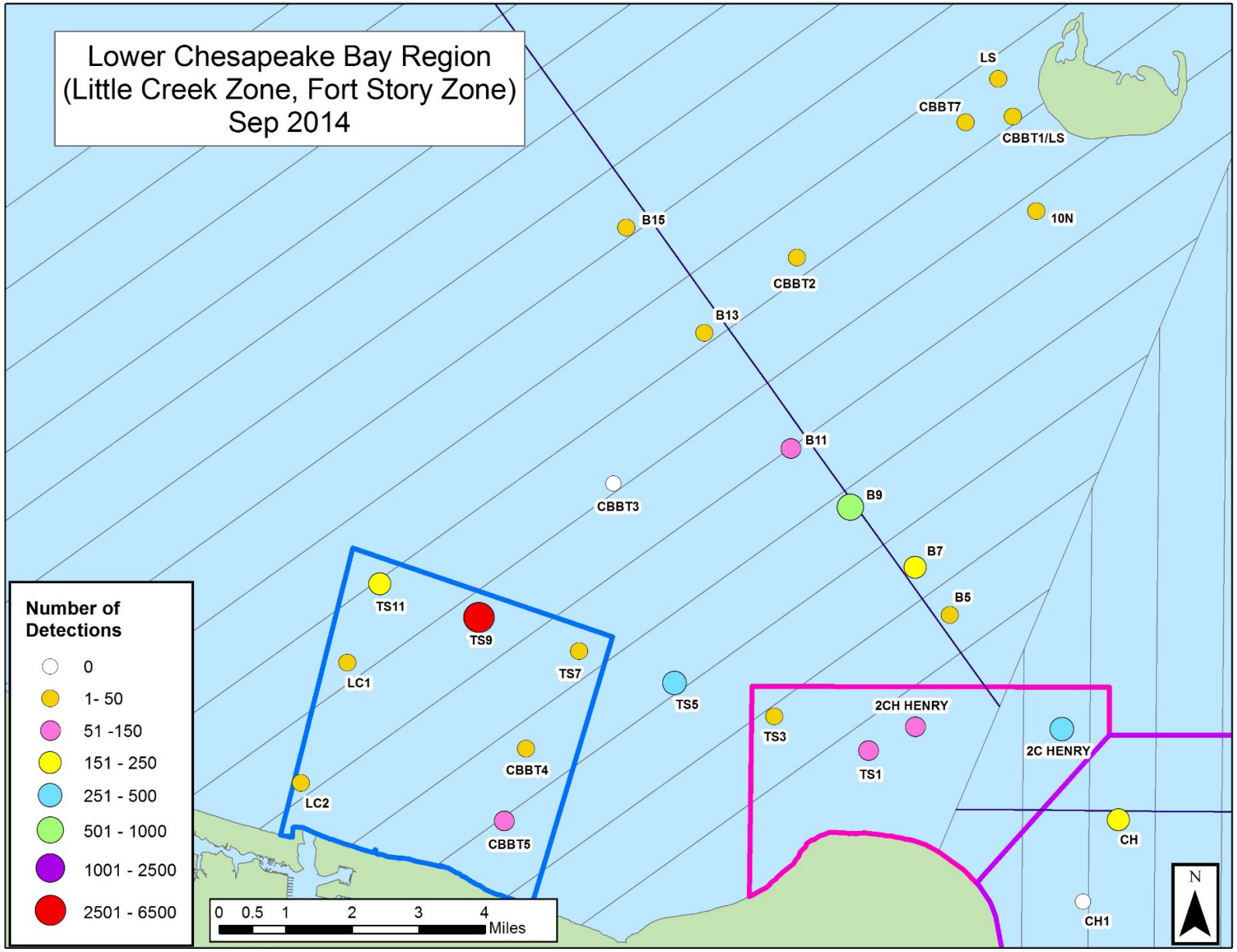

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Apr 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

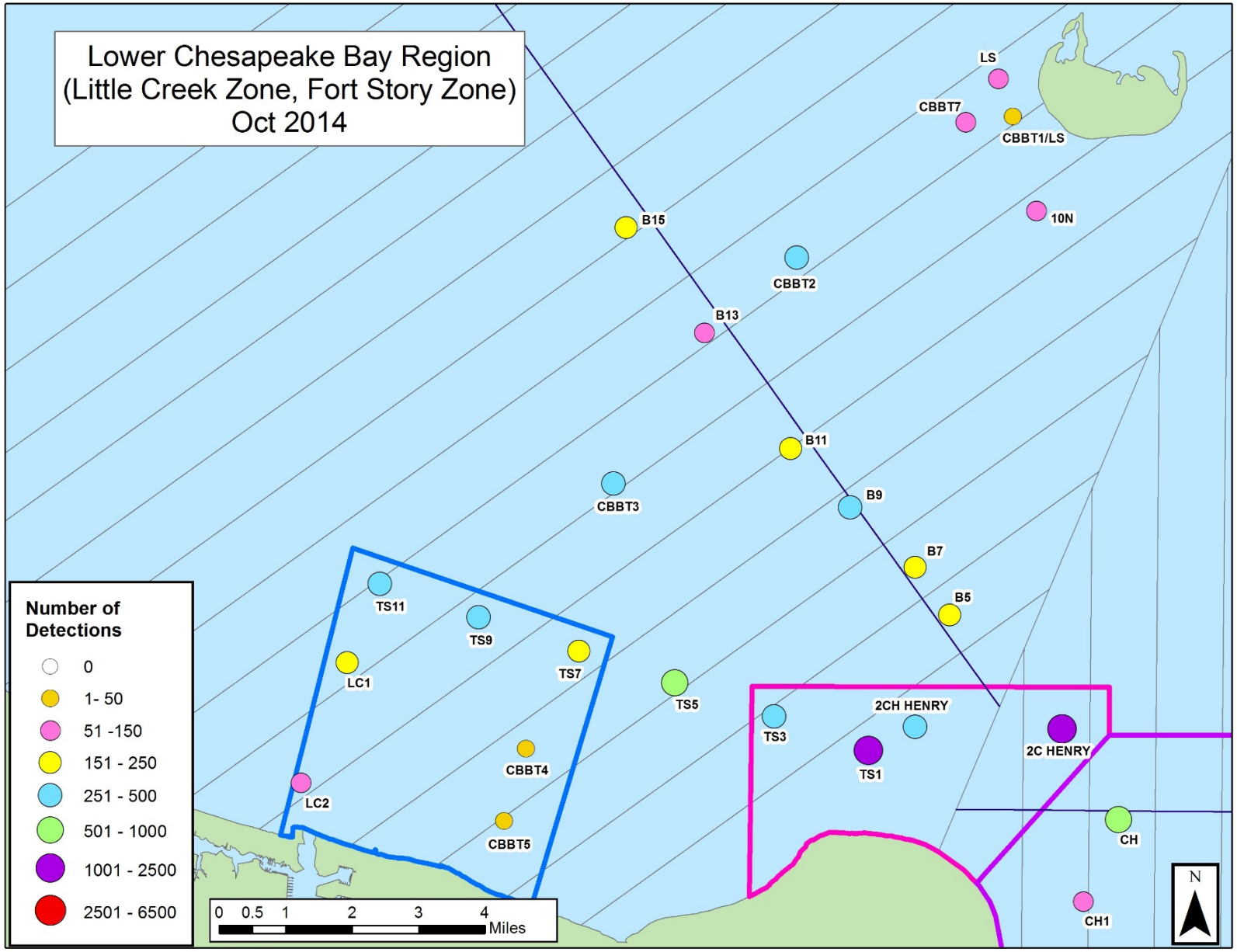

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
May 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
B9
CBBT3
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

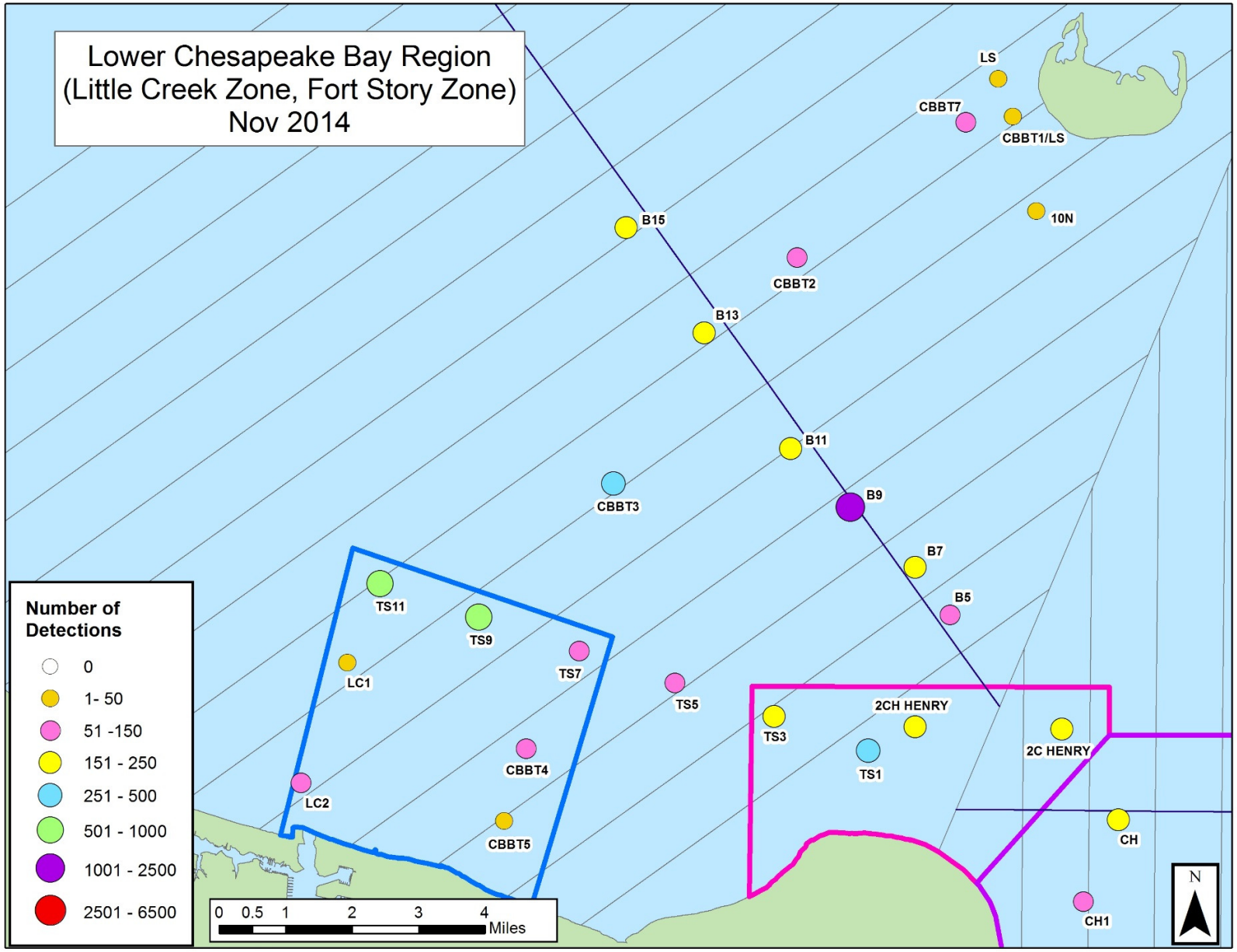

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Jun 2014
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N

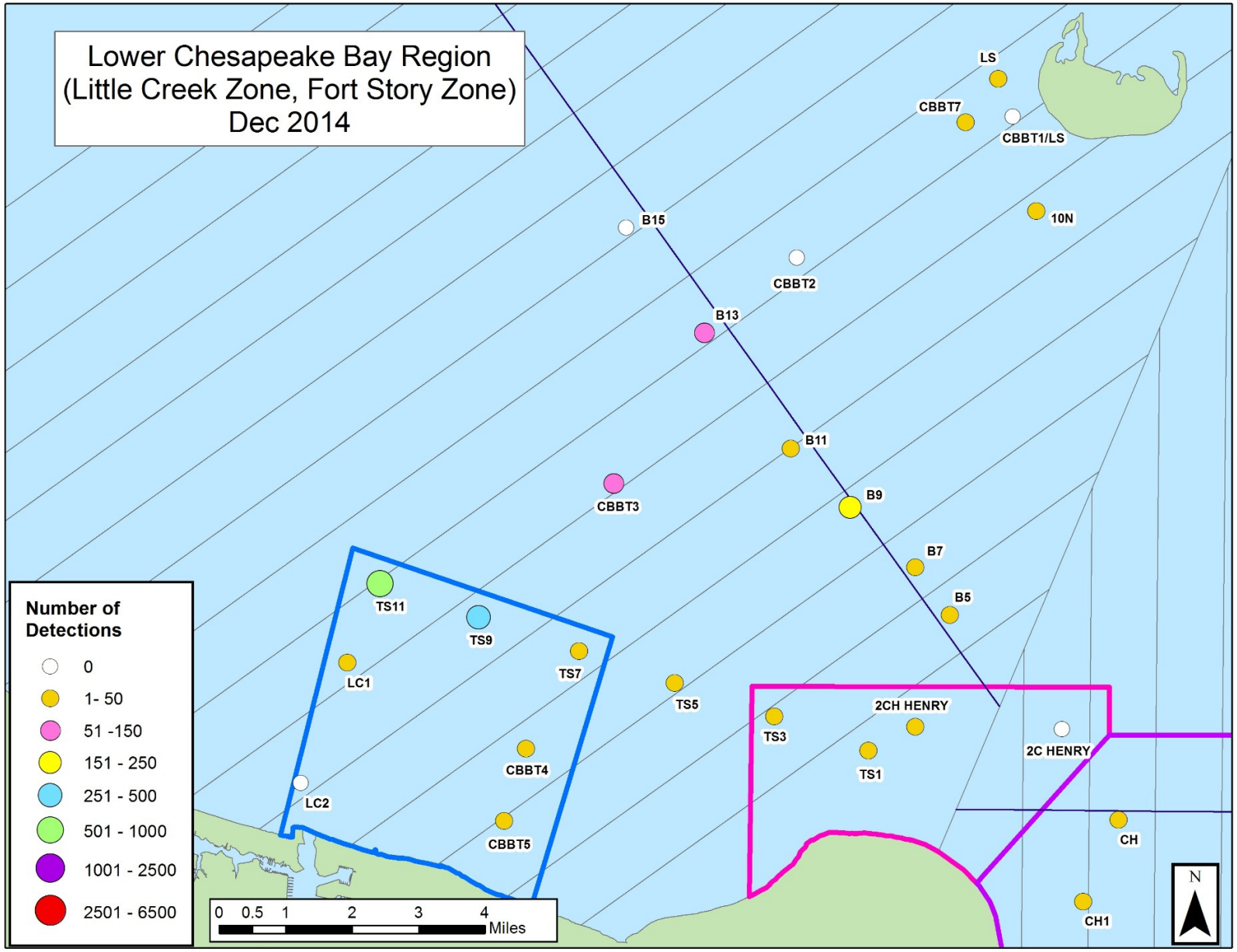

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Jul 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

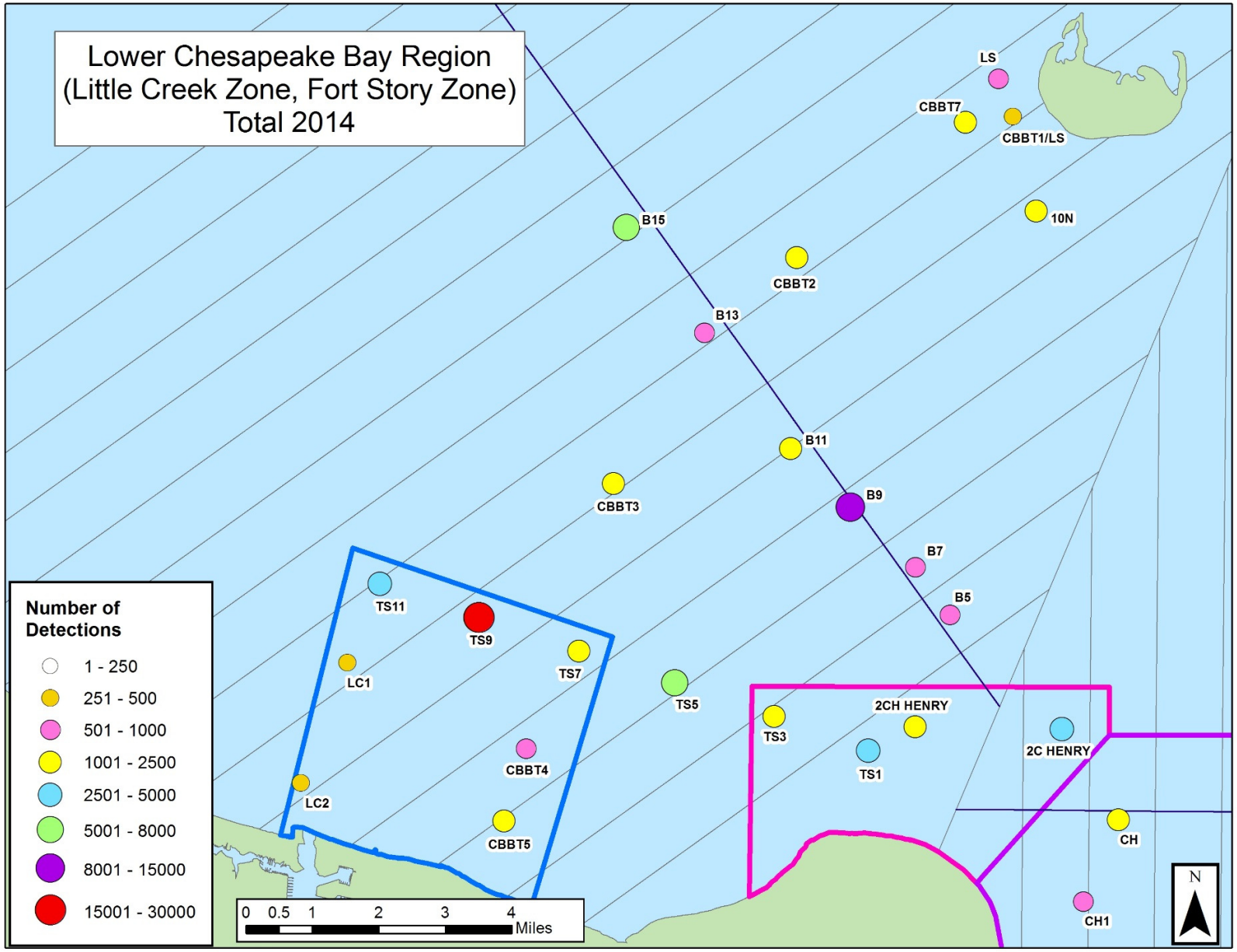

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Aug 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
B9
CBBT3
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

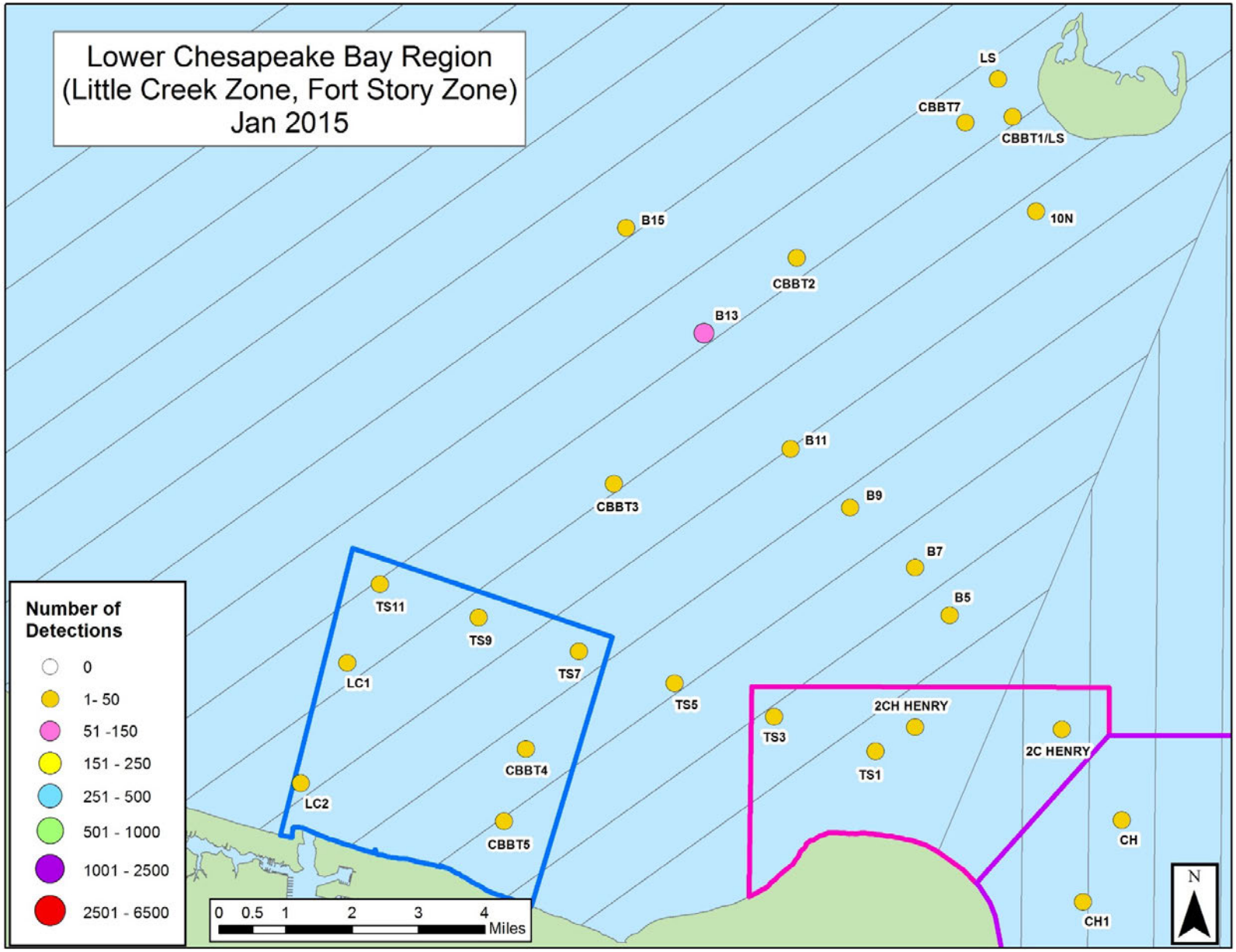

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Sep 2014
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N

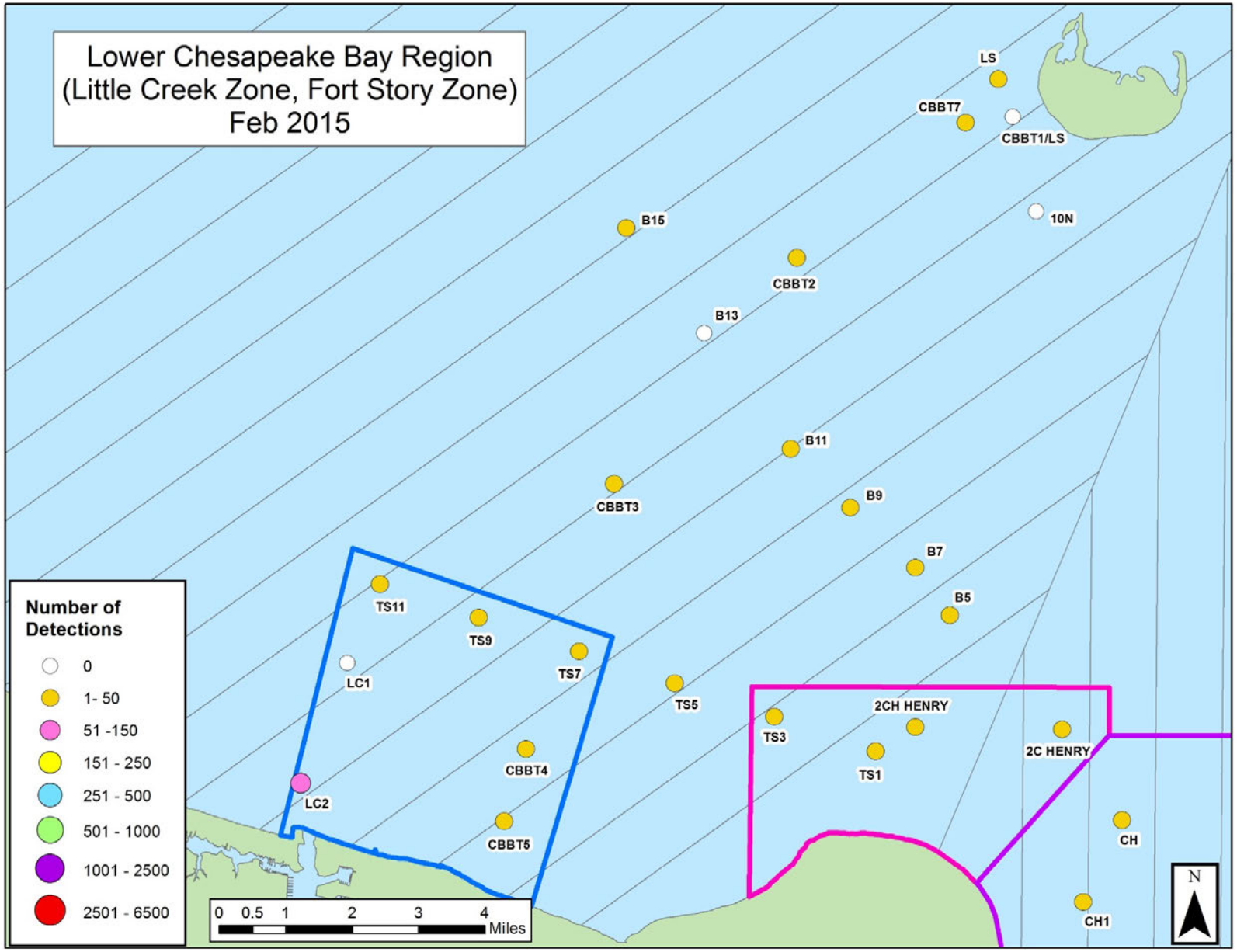

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Oct 2014
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N

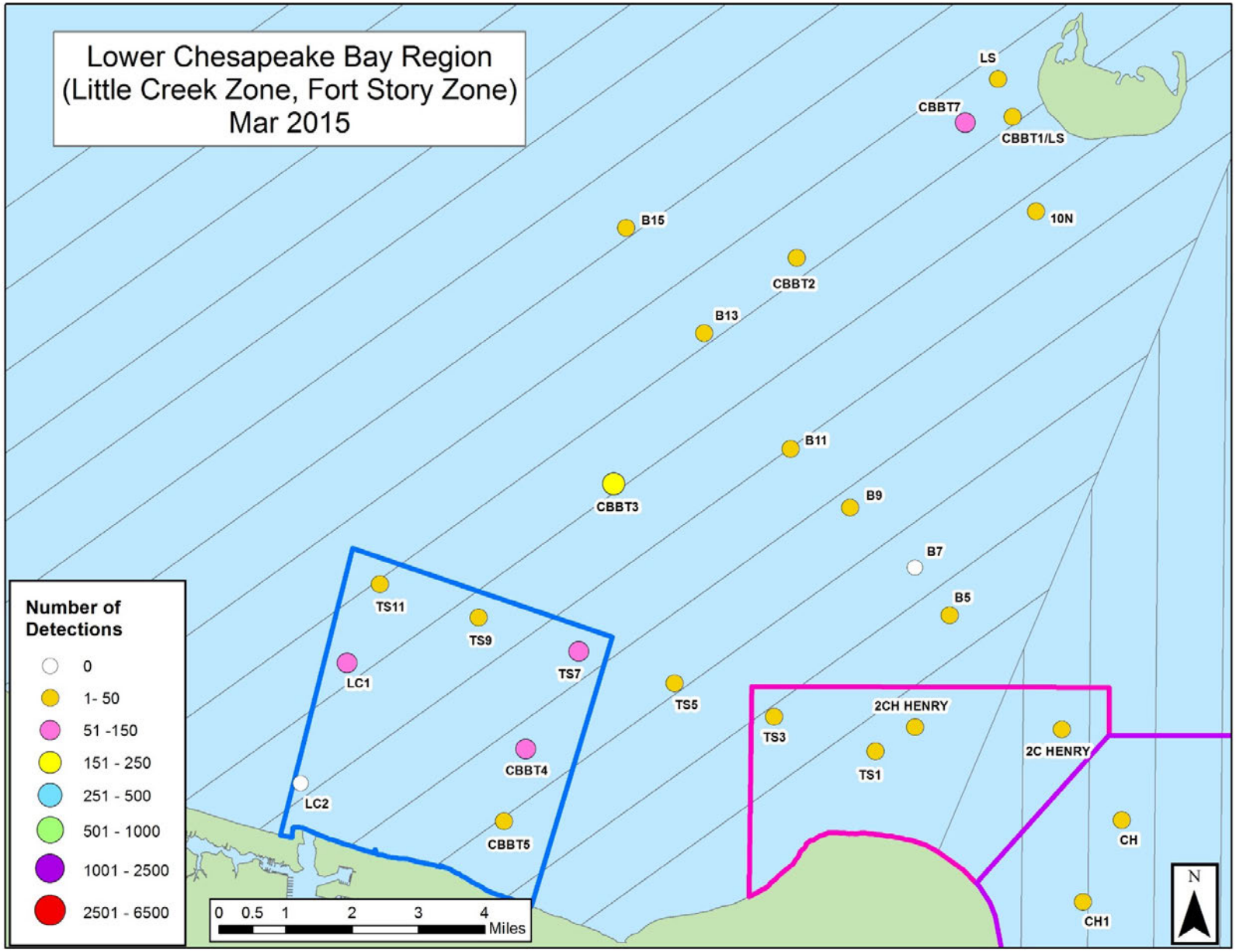

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Nov 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

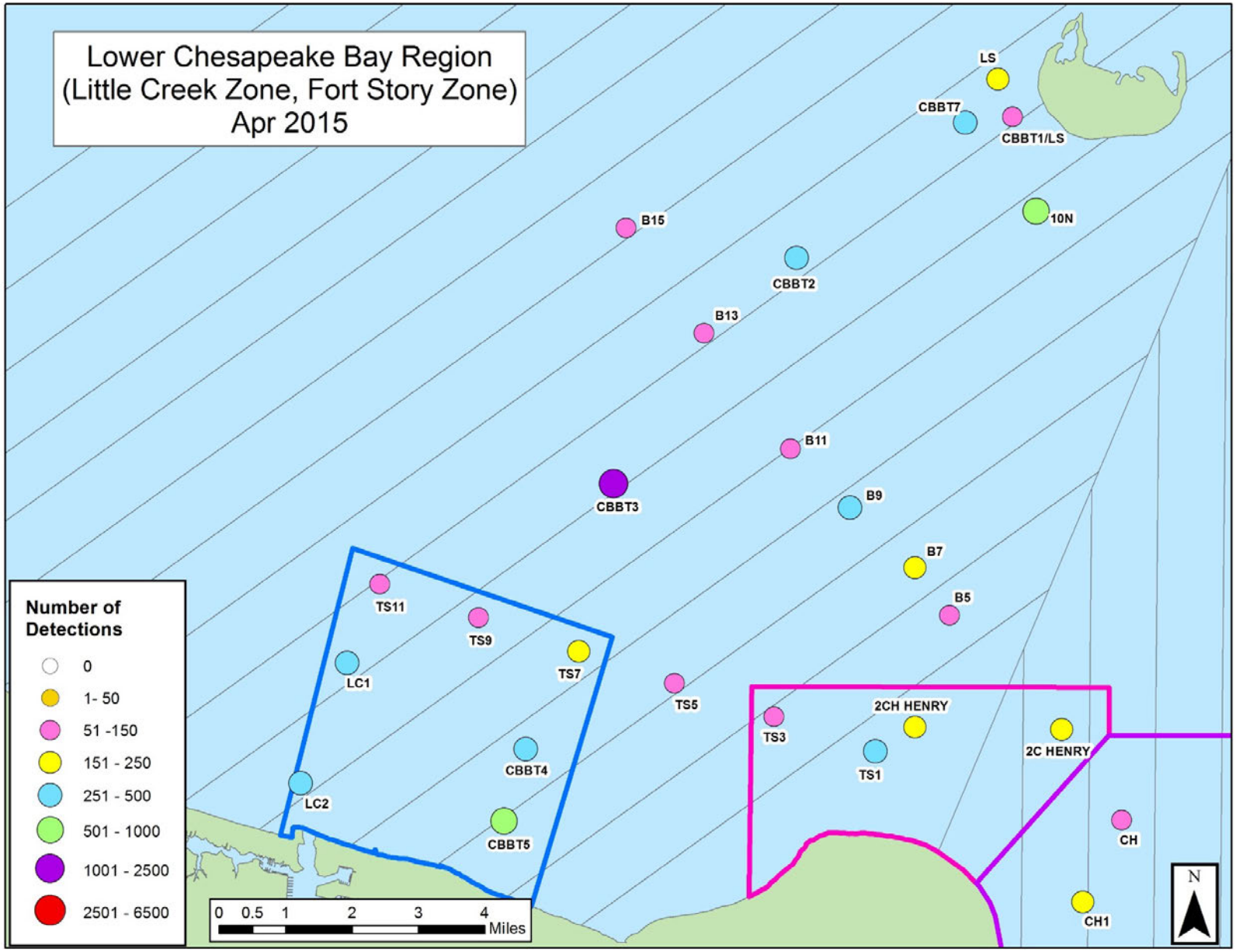

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Dec 2014
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
B9
CBBT3
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

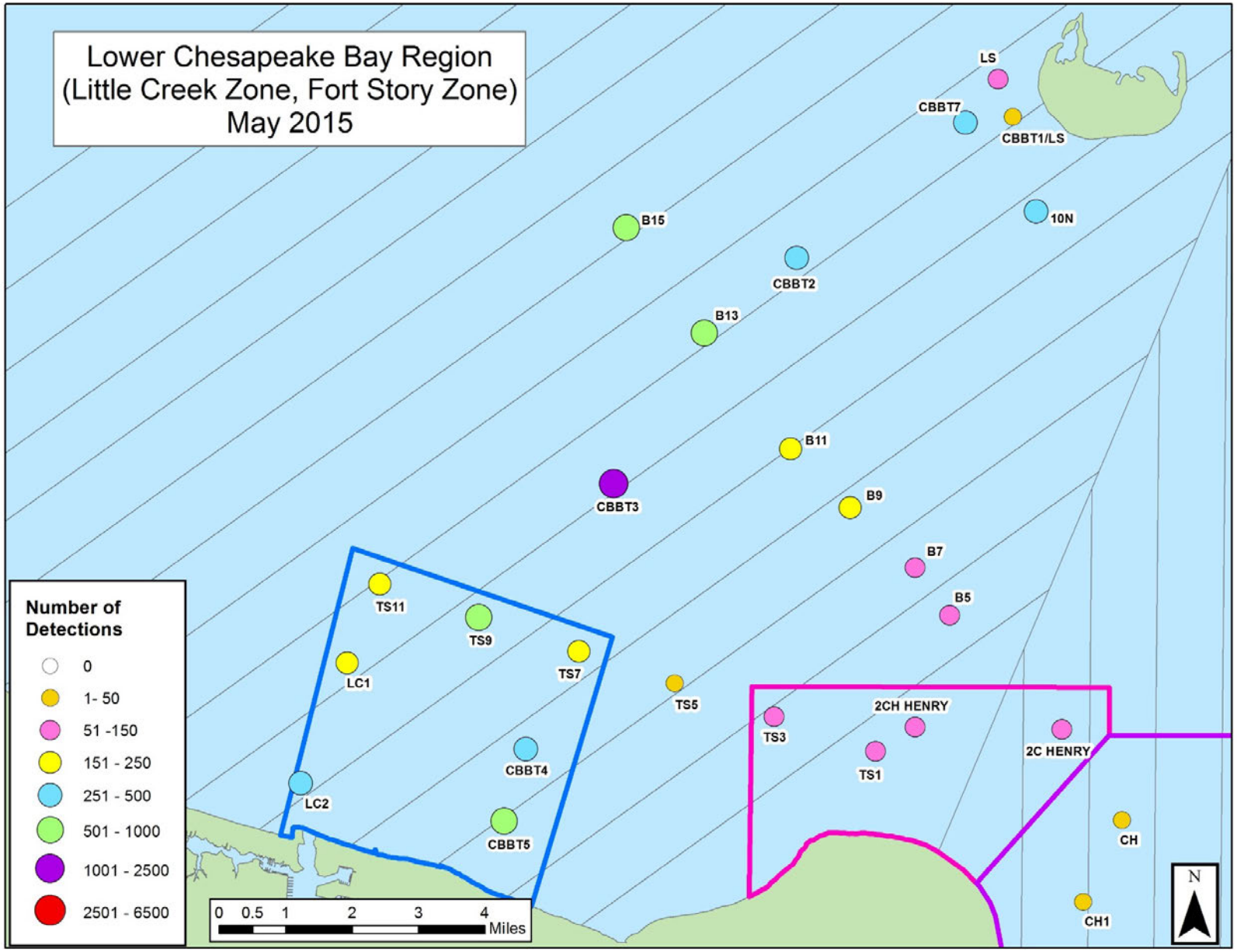

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Total 2014
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
B9
CBBT3
B7
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
2C HENRY
TS1
CBBT4
LC2
CBBT5
CH
CH1

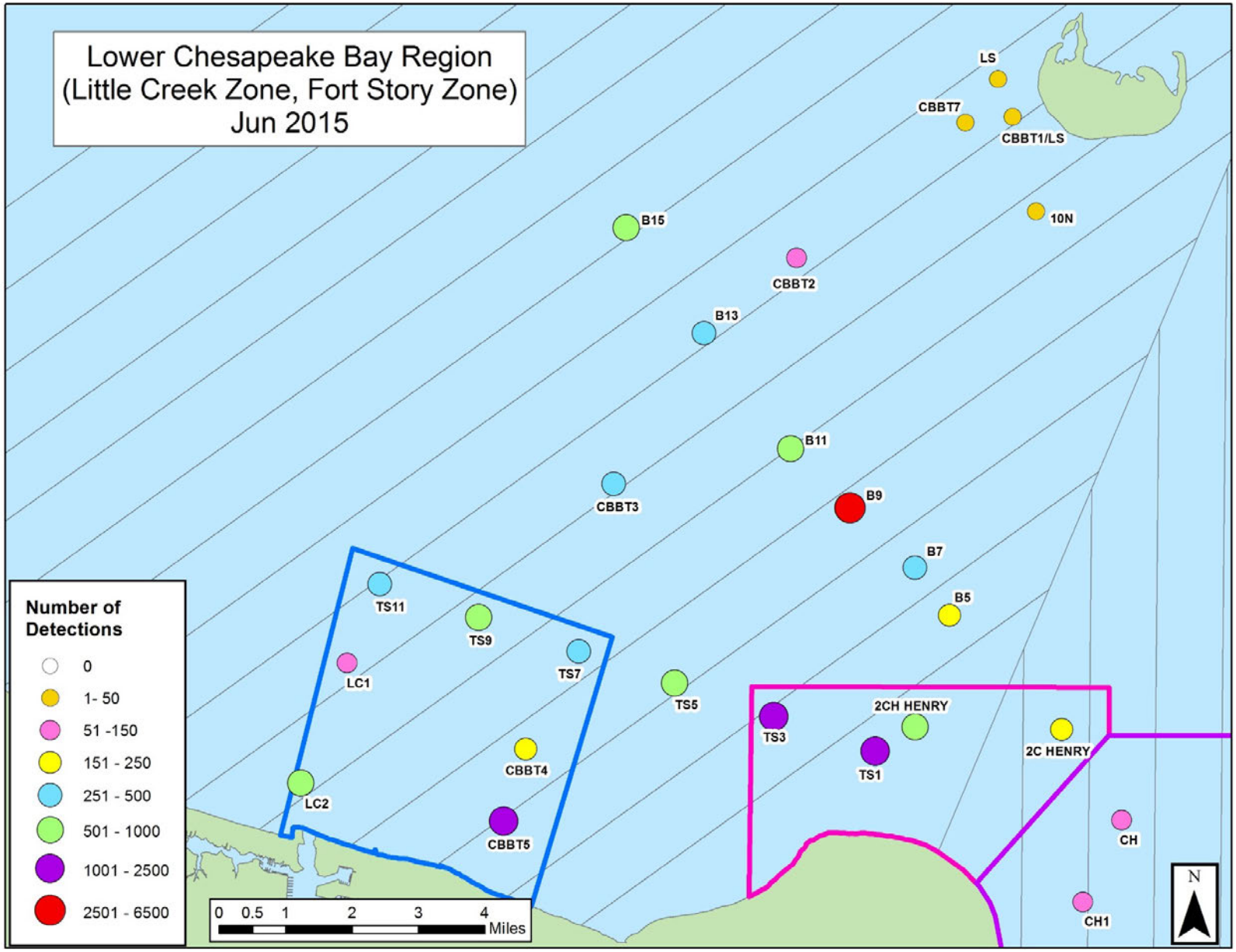

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Jan 2015
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N

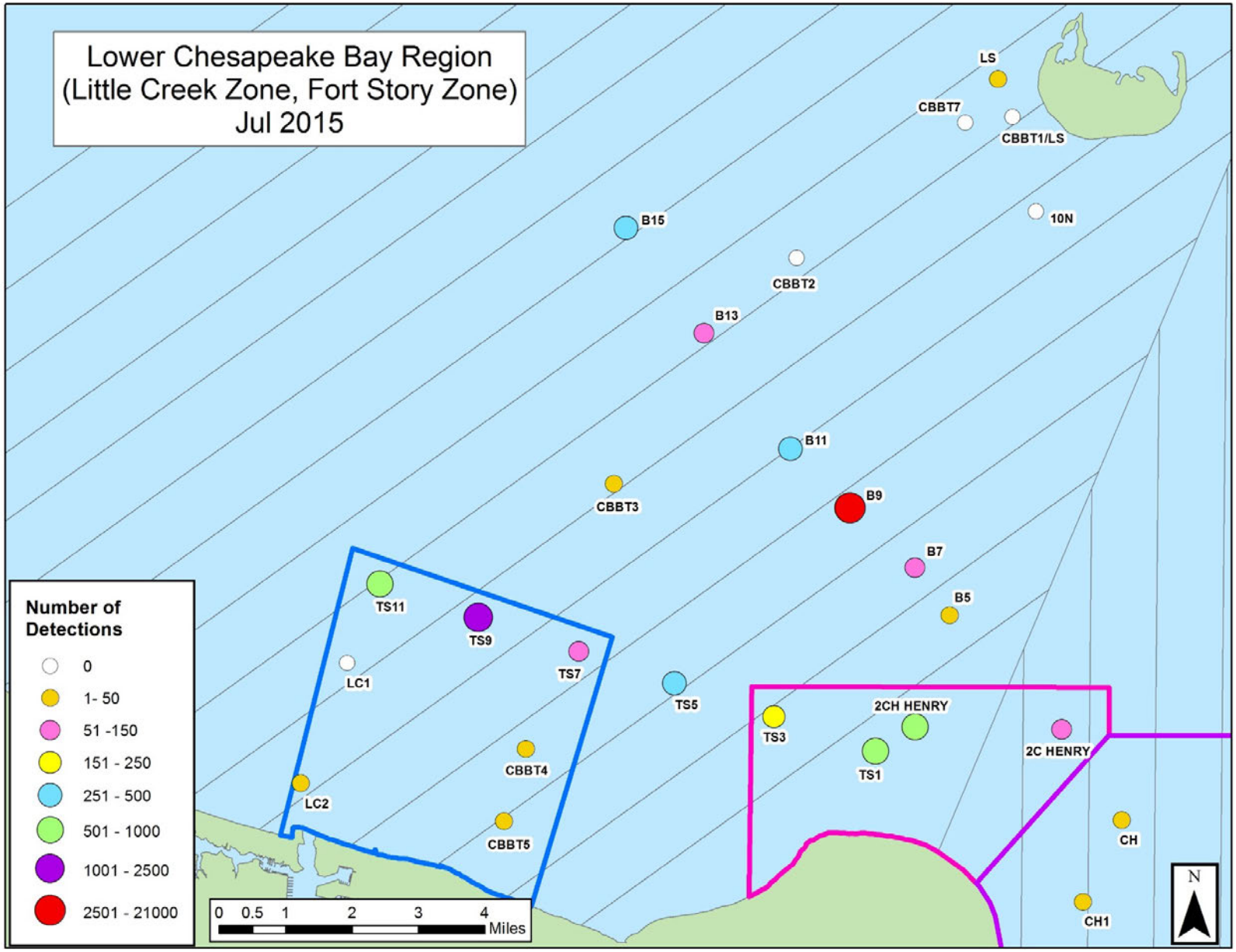

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Feb 2015
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N

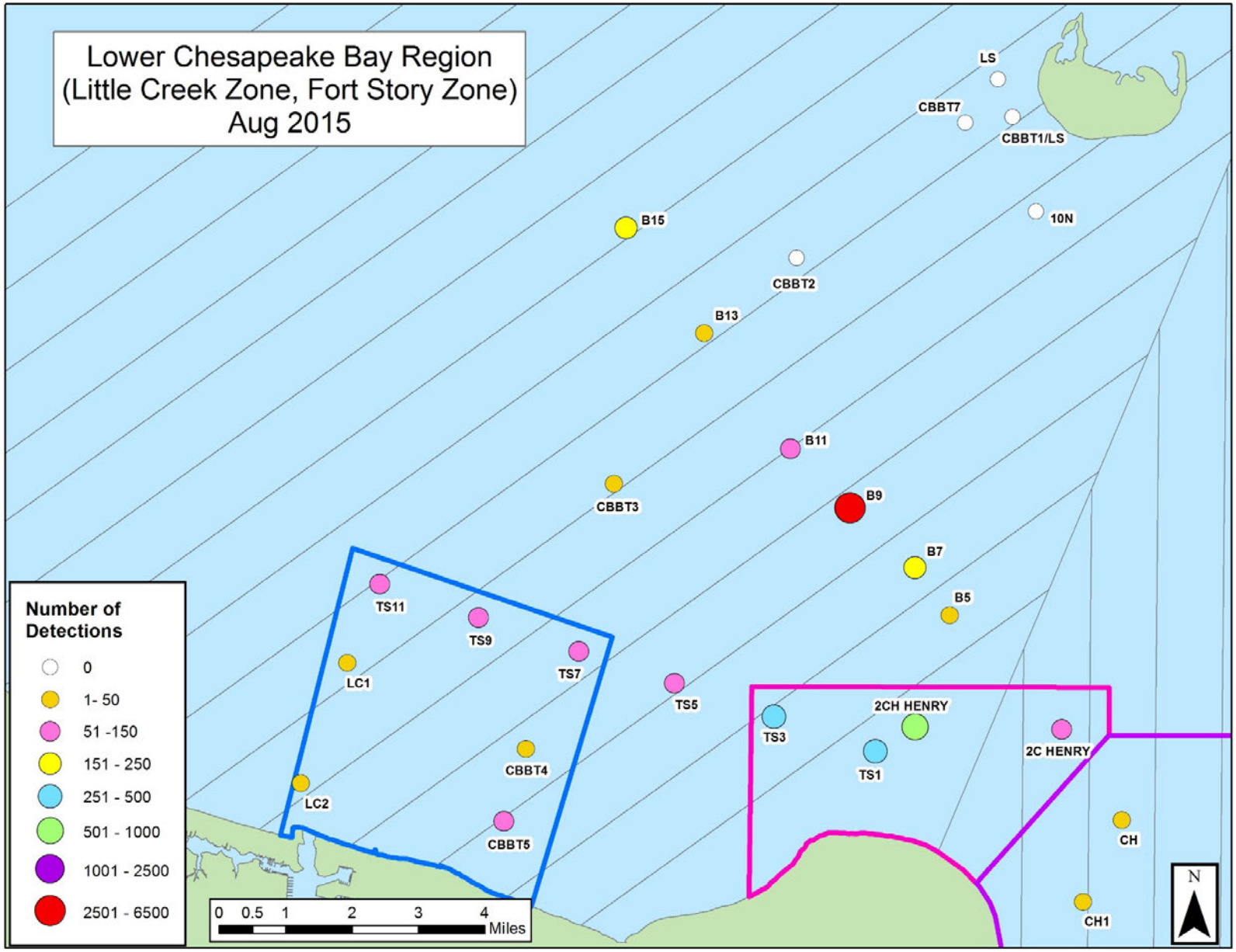

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Mar 2015
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

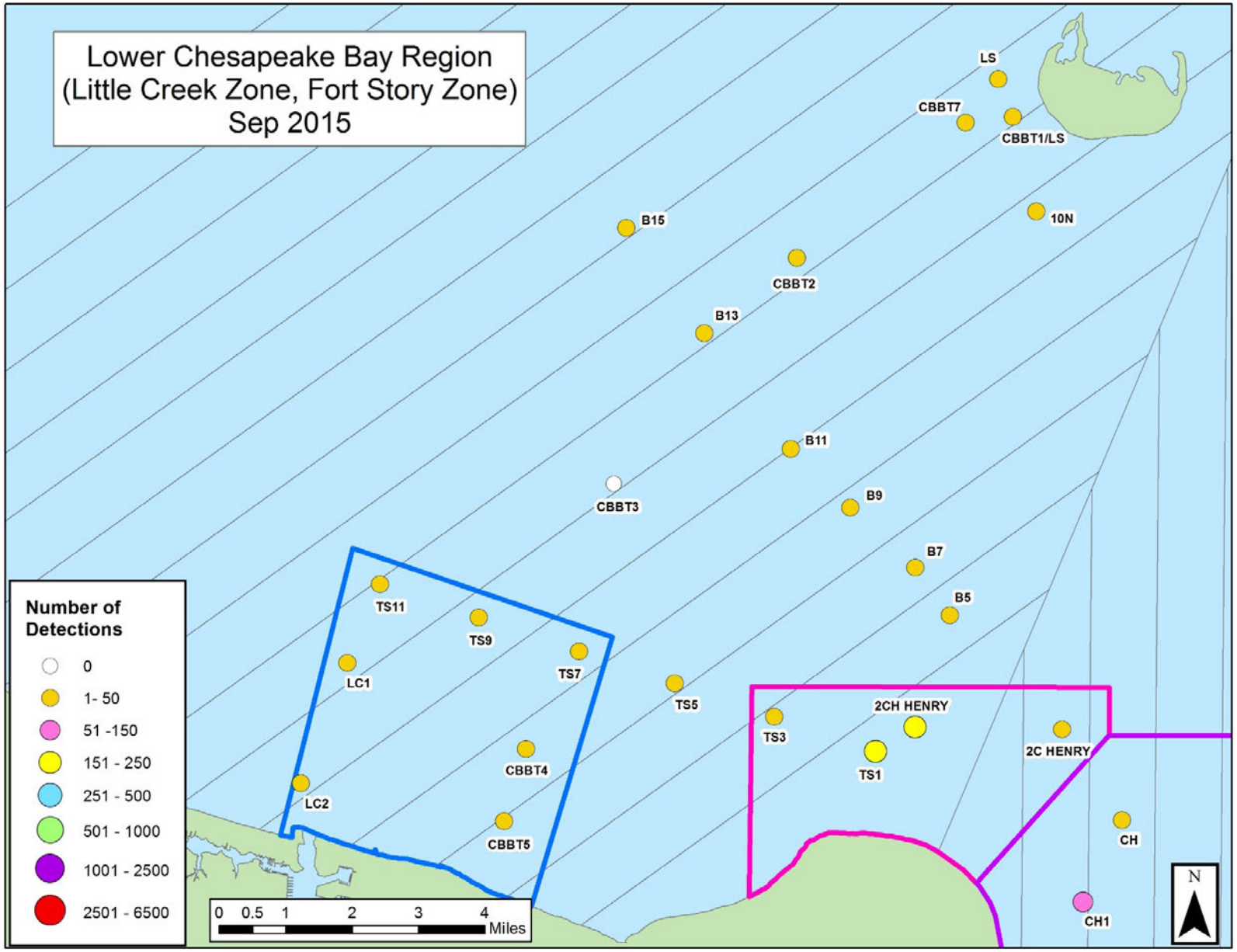

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Apr 2015
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
2C HENRY
TS1
CBBT4
LC2
CBBT5
CH
CH1

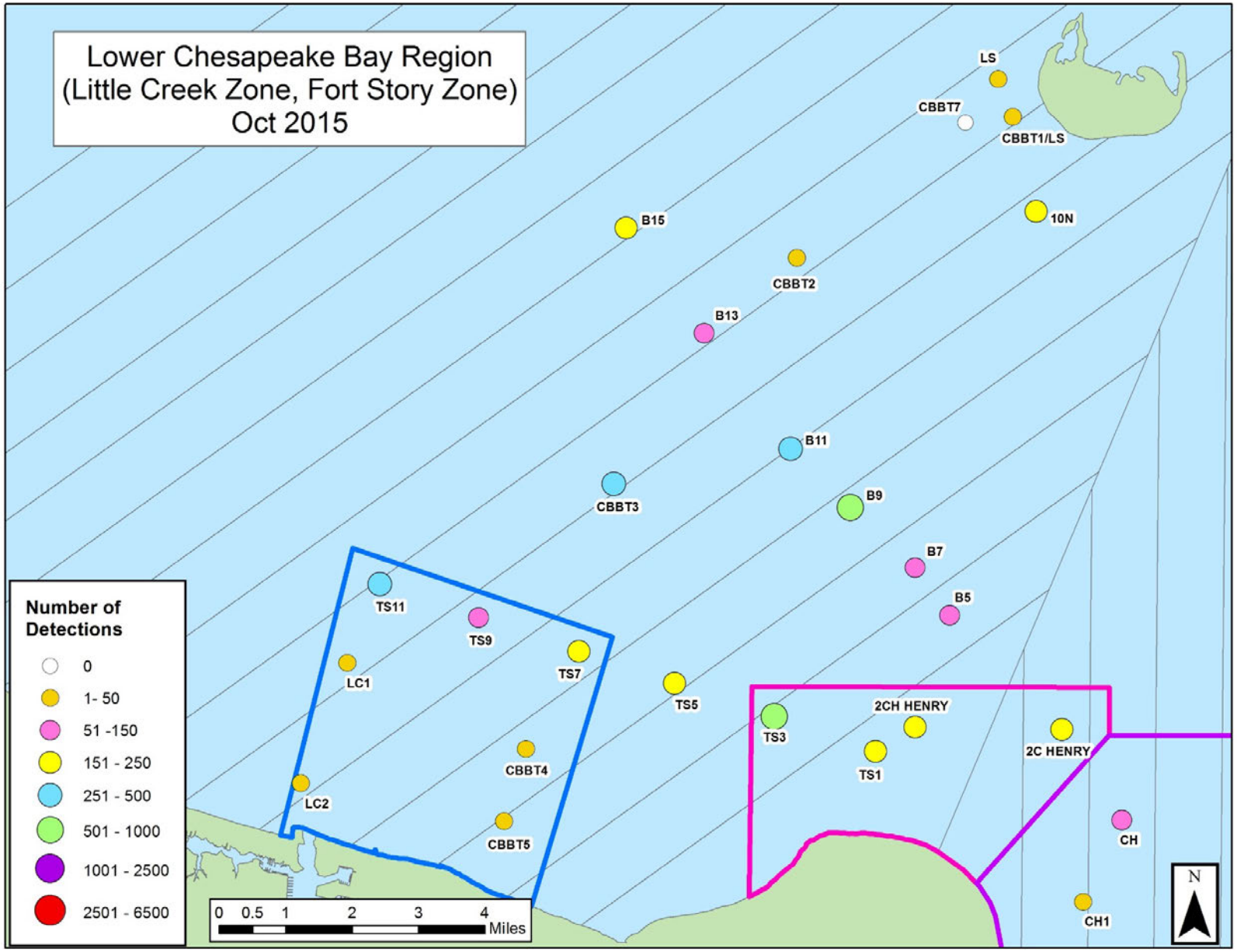

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
May 2015
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

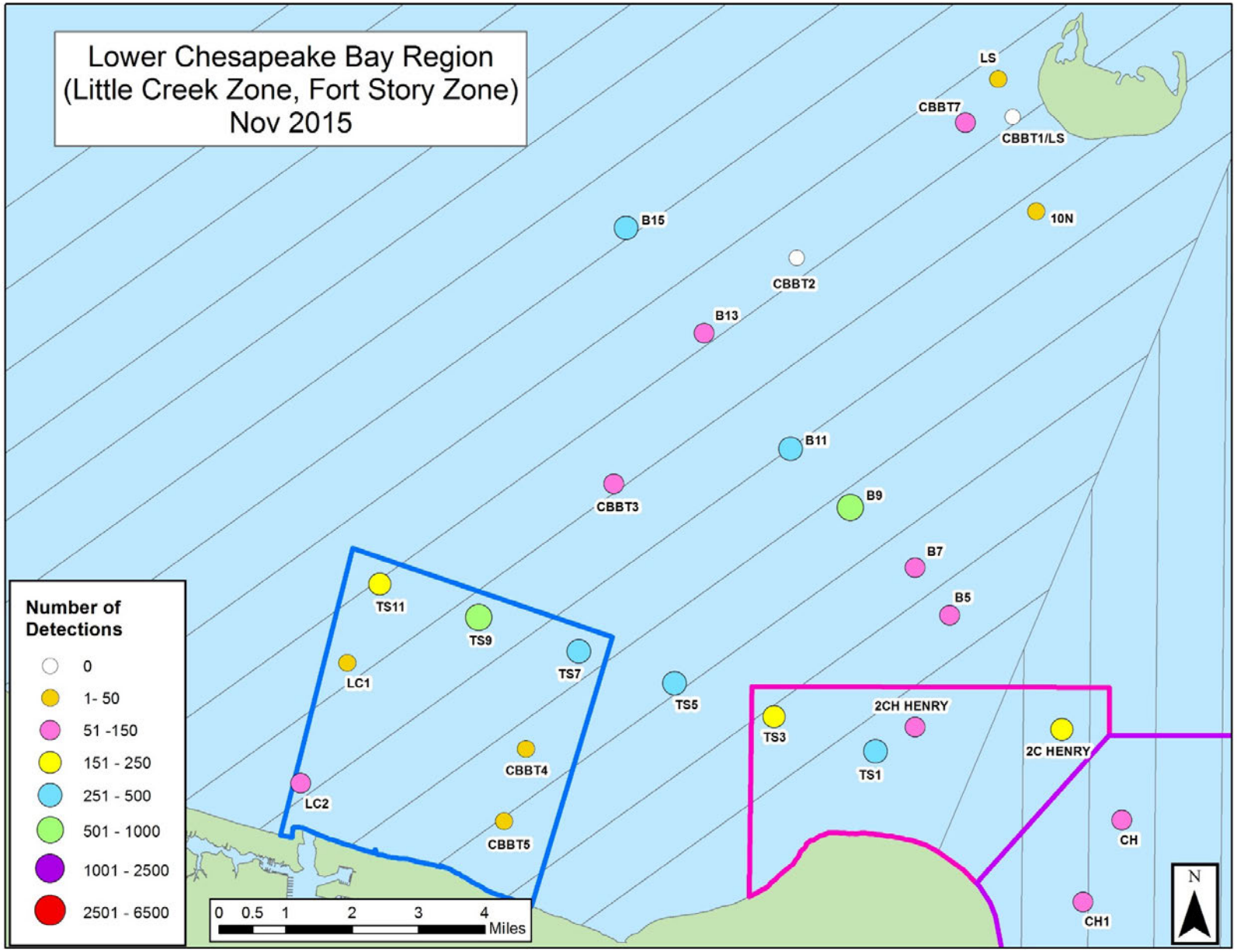

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Jun 2015
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N

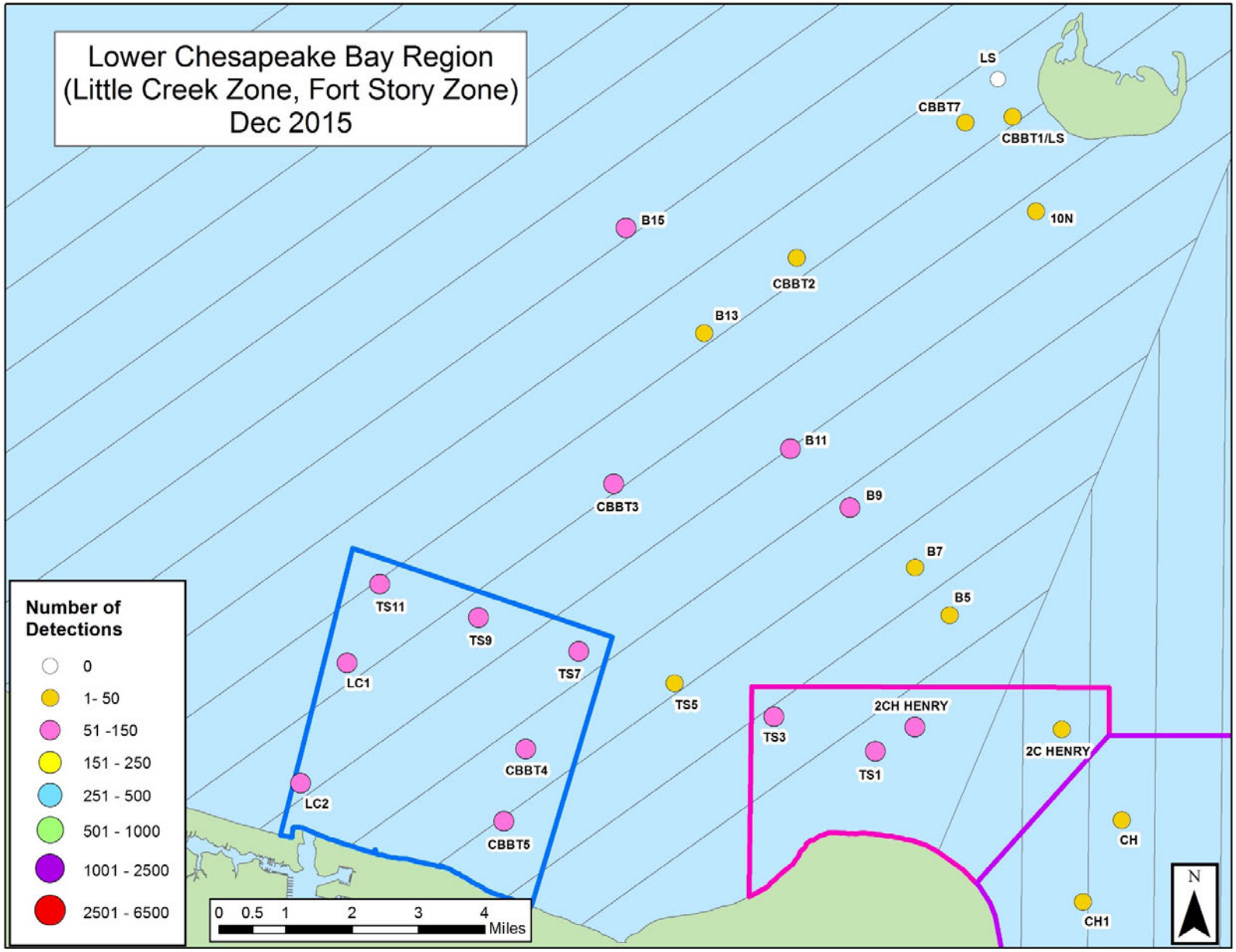

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Jul 2015
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 21000
0 0.5 1 2 3 4
Miles
N

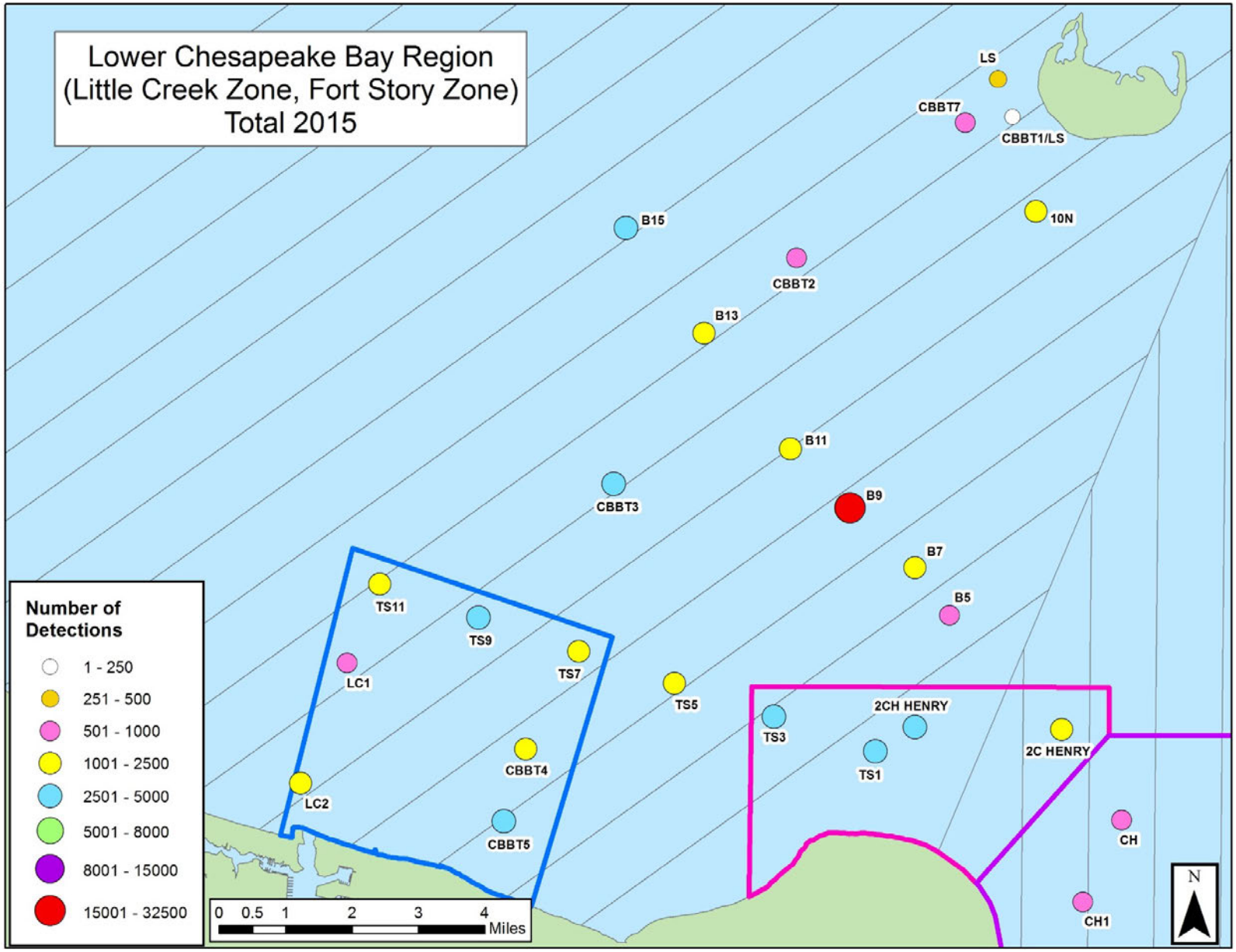

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Aug 2015
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N

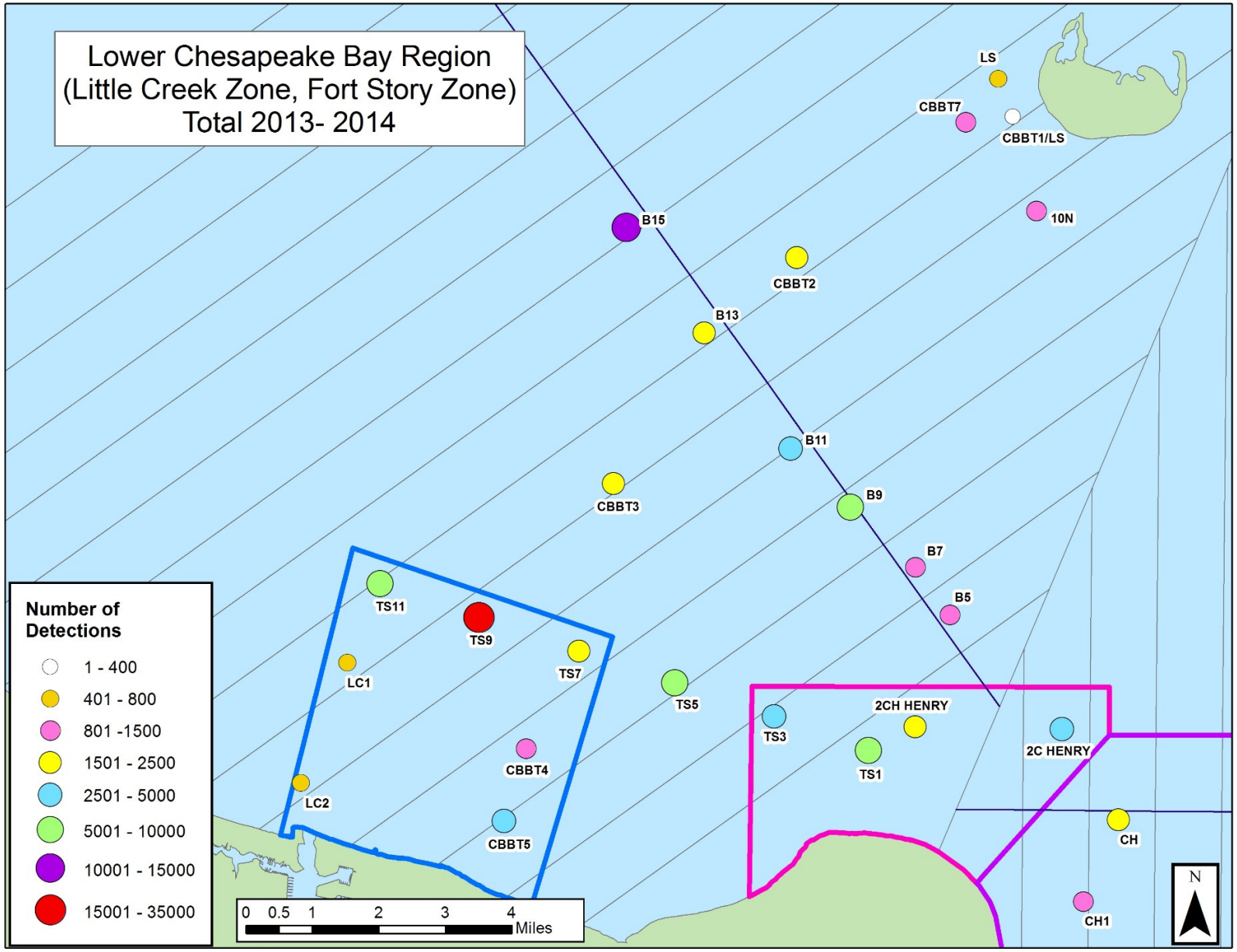

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Sep 2015
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N

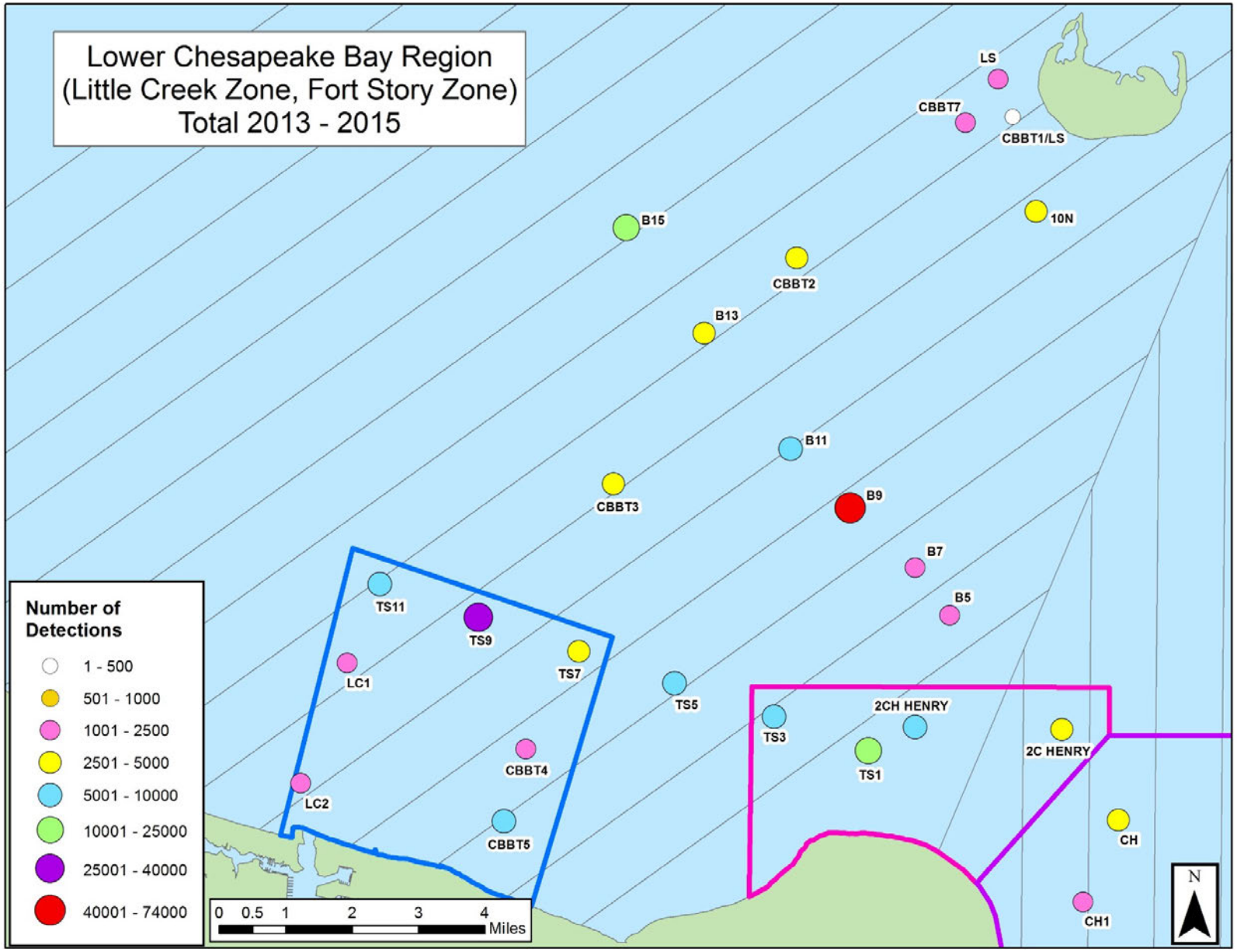

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Oct 2015
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
TS3
2CH HENRY
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N


Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Nov 2015
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
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N

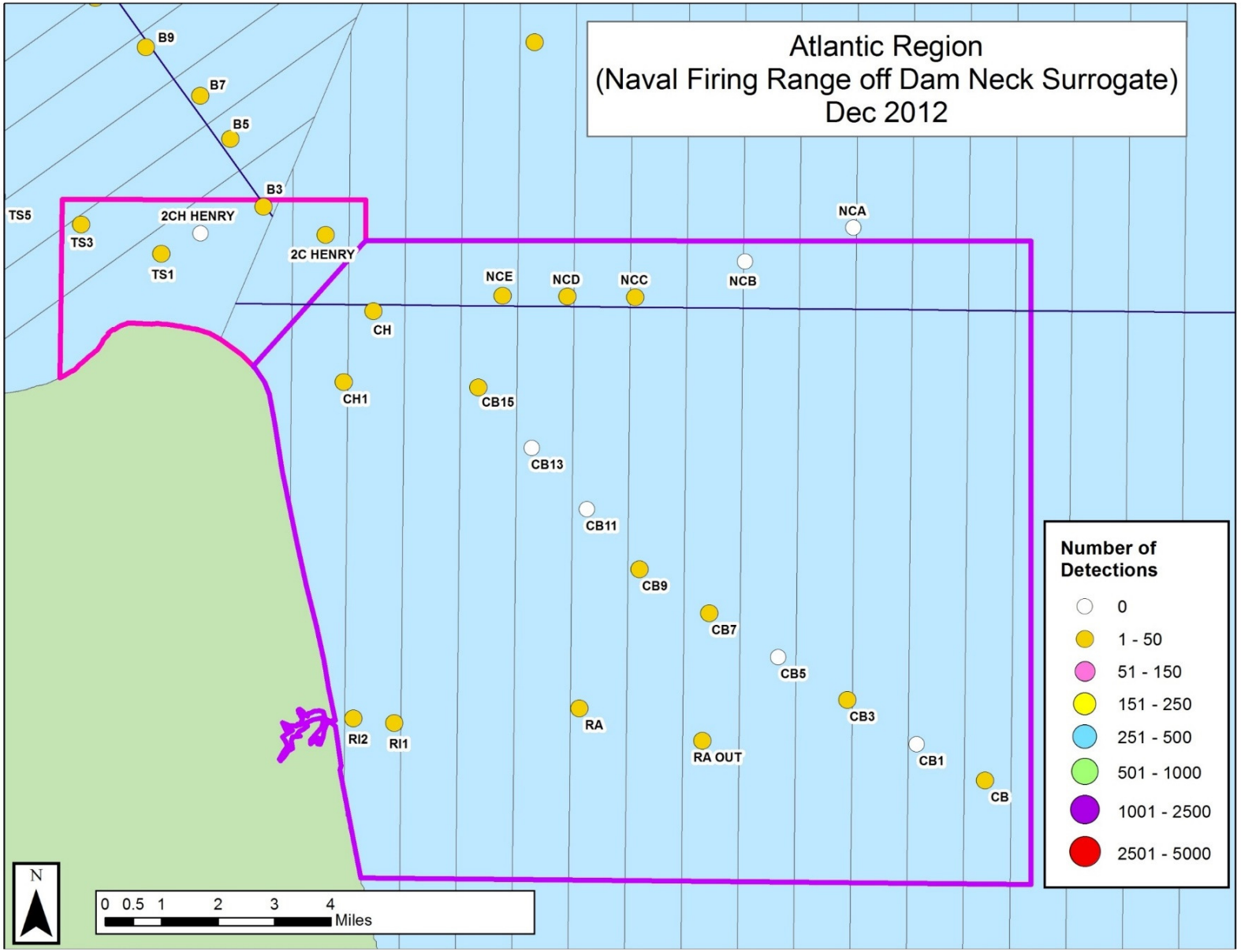

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Dec 2015
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1
Number of Detections
0
1- 50
51 -150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 6500
0 0.5 1 2 3 4
Miles
N

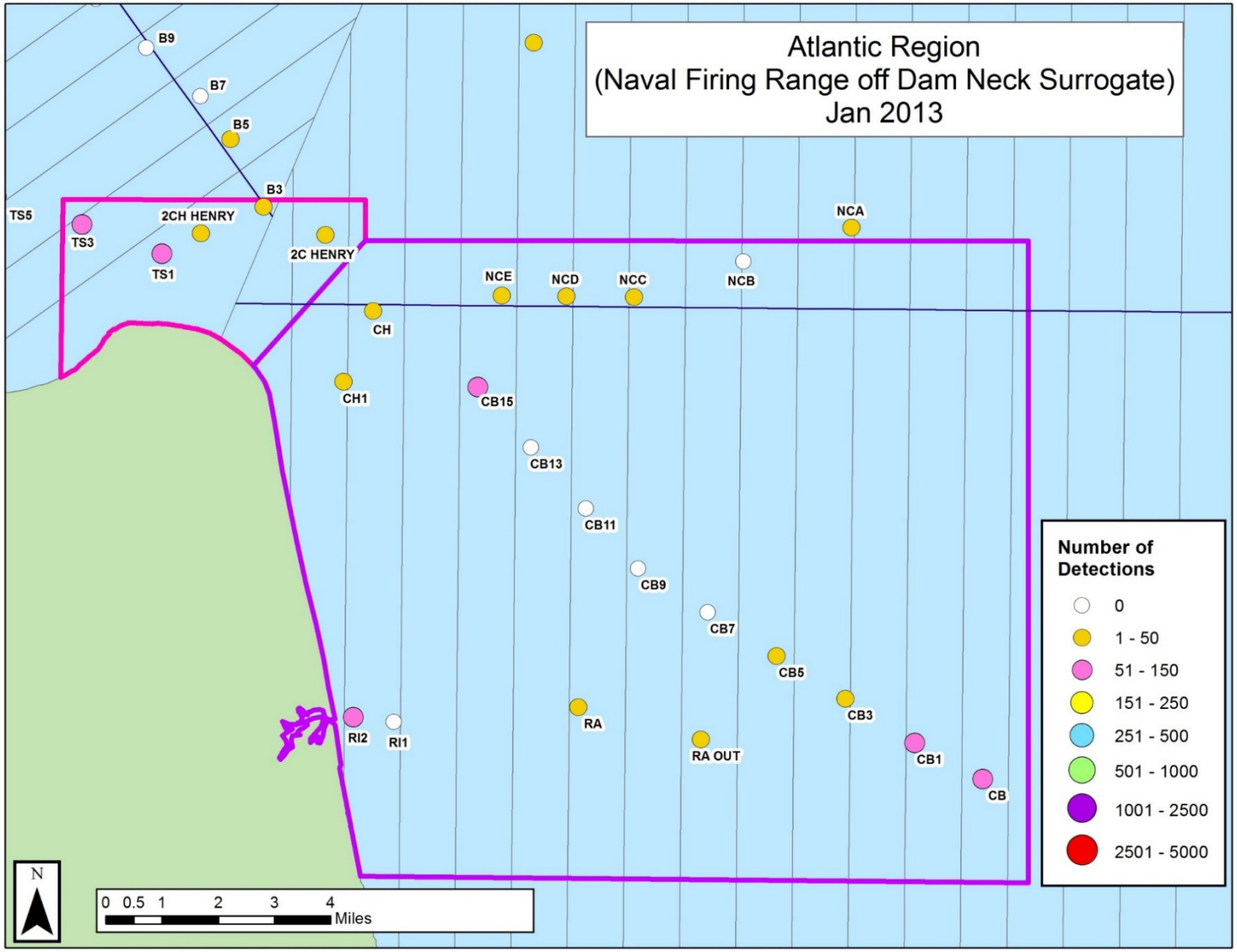

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Total 2015
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 32500
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

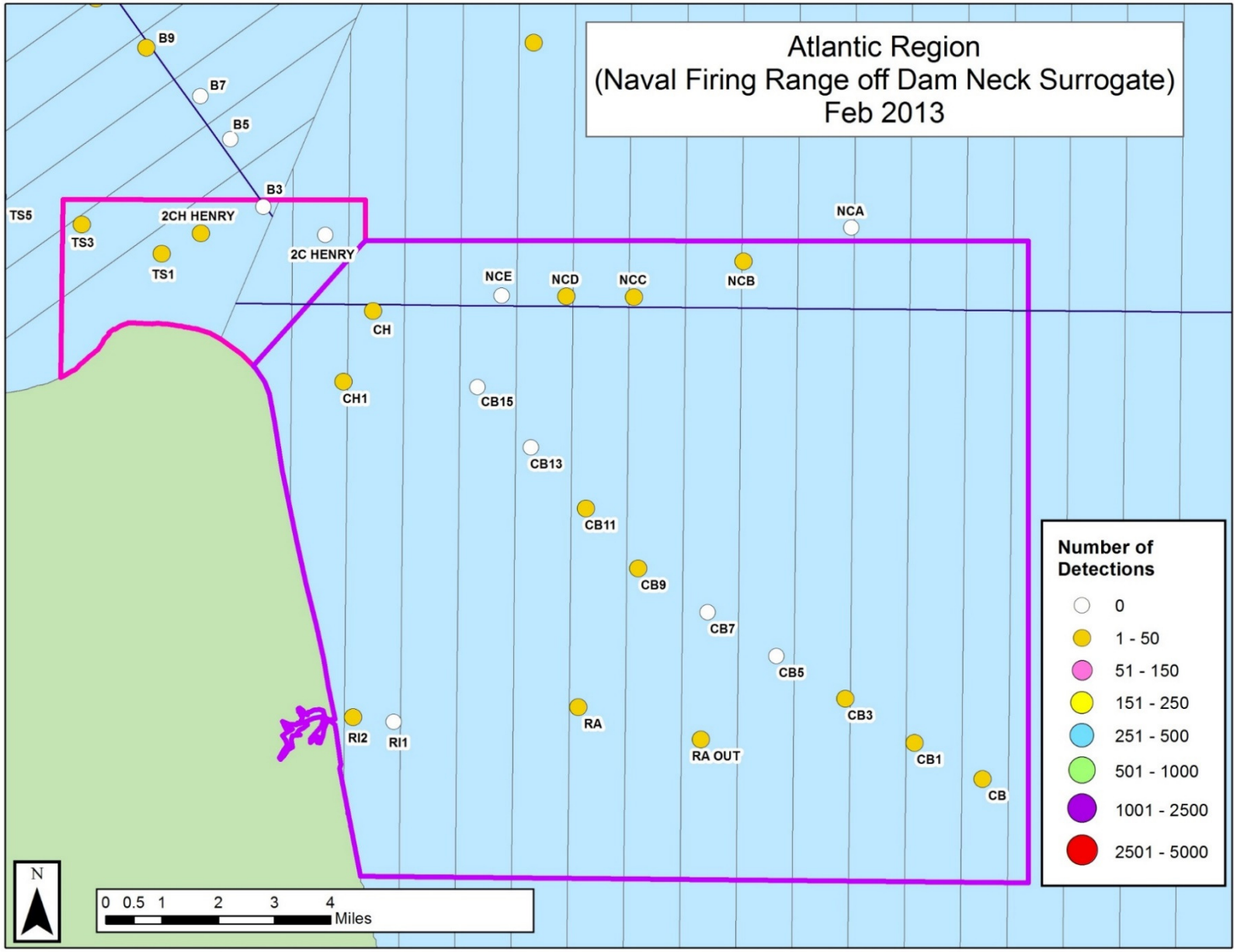

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Total 2013- 2014
Number of Detections
1 - 400
401 - 800
801 -1500
1501 - 2500
2501 - 5000
5001 - 10000
10001 - 15000
15001 - 35000
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

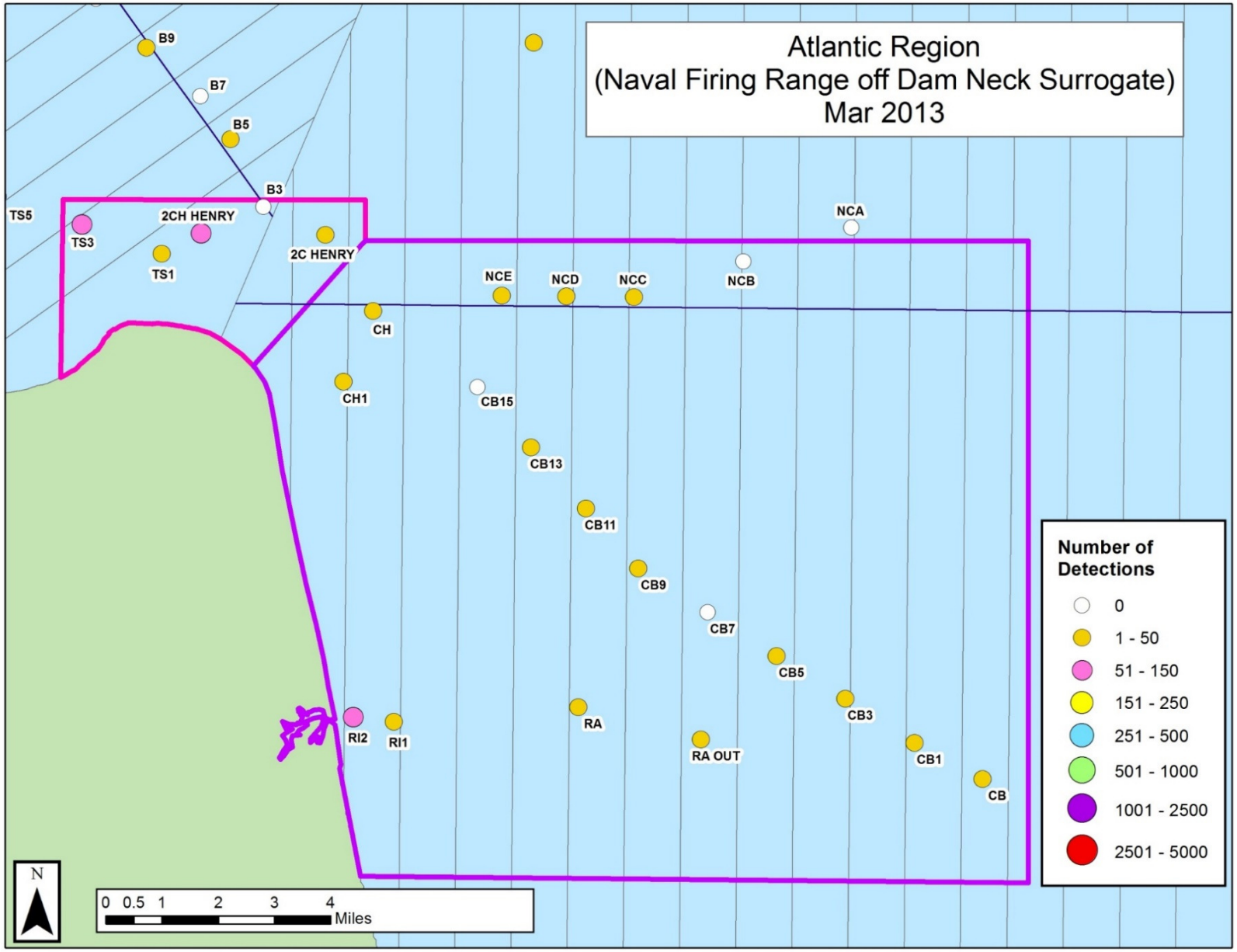

Lower Chesapeake Bay Region
(Little Creek Zone, Fort Story Zone)
Total 2013 - 2015
Number of Detections
1 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 10000
10001 - 25000
25001 - 40000
40001 - 74000
0 0.5 1 2 3 4
Miles
N
LS
CBBT7
CBBT1/LS
10N
B15
CBBT2
B13
B11
CBBT3
B9
B7
B5
TS11
TS9
TS7
LC1
TS5
2CH HENRY
TS3
TS1
2C HENRY
CBBT4
LC2
CBBT5
CH
CH1

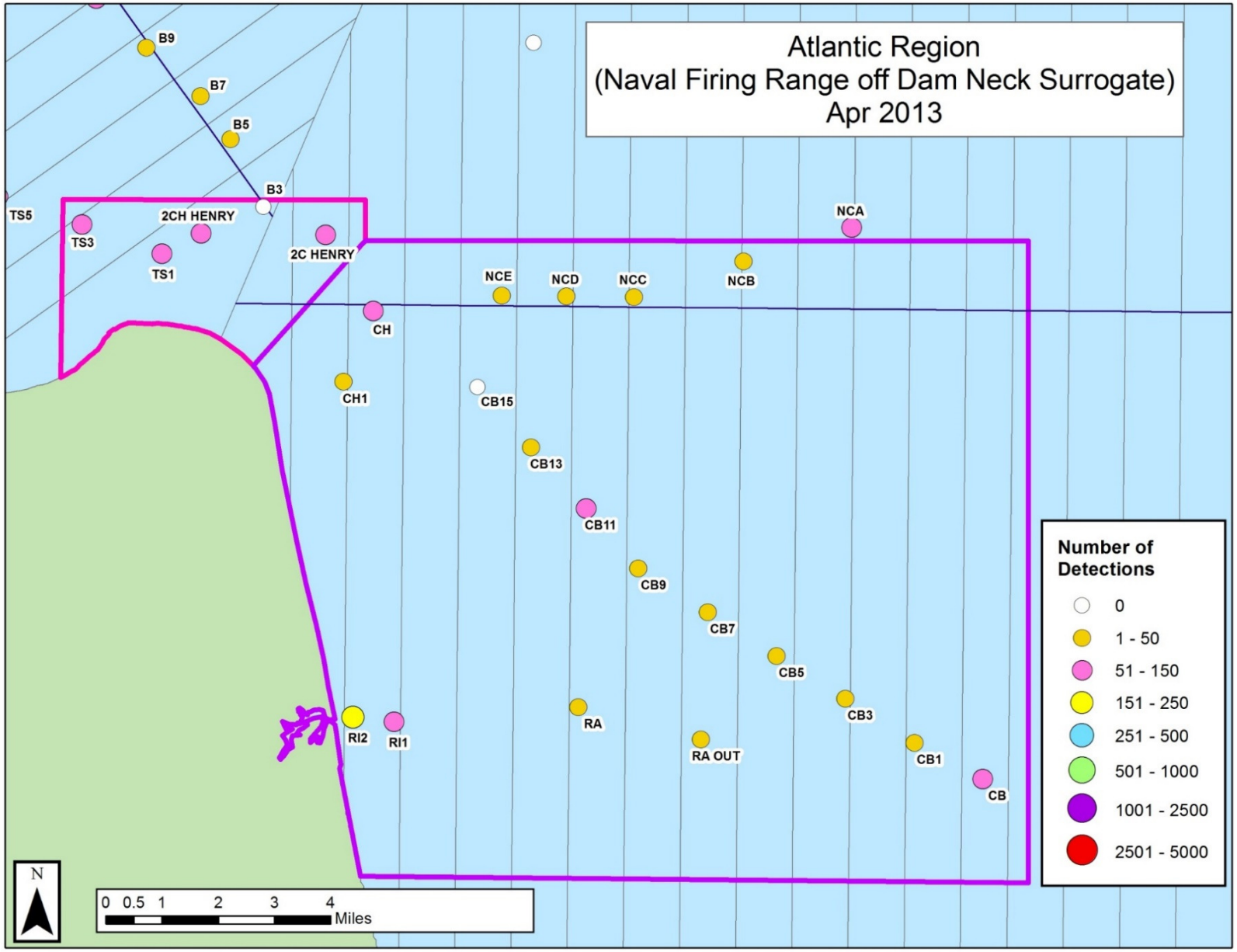
## 9.8 APPENDIX 4.4.6: ATLANTIC REGION (NAVAL FIRING RANGE OFF DAM NECK SURROGATE)

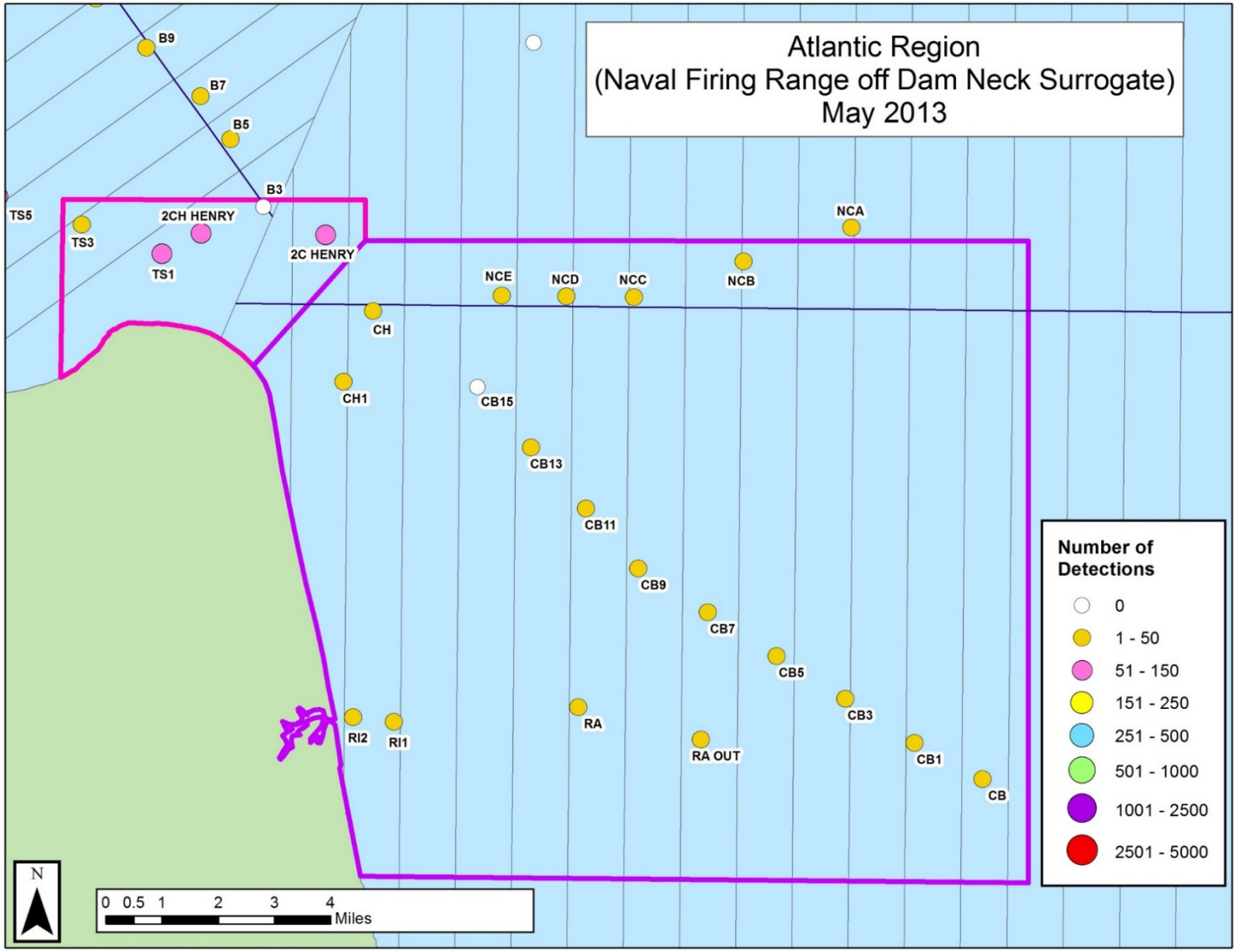


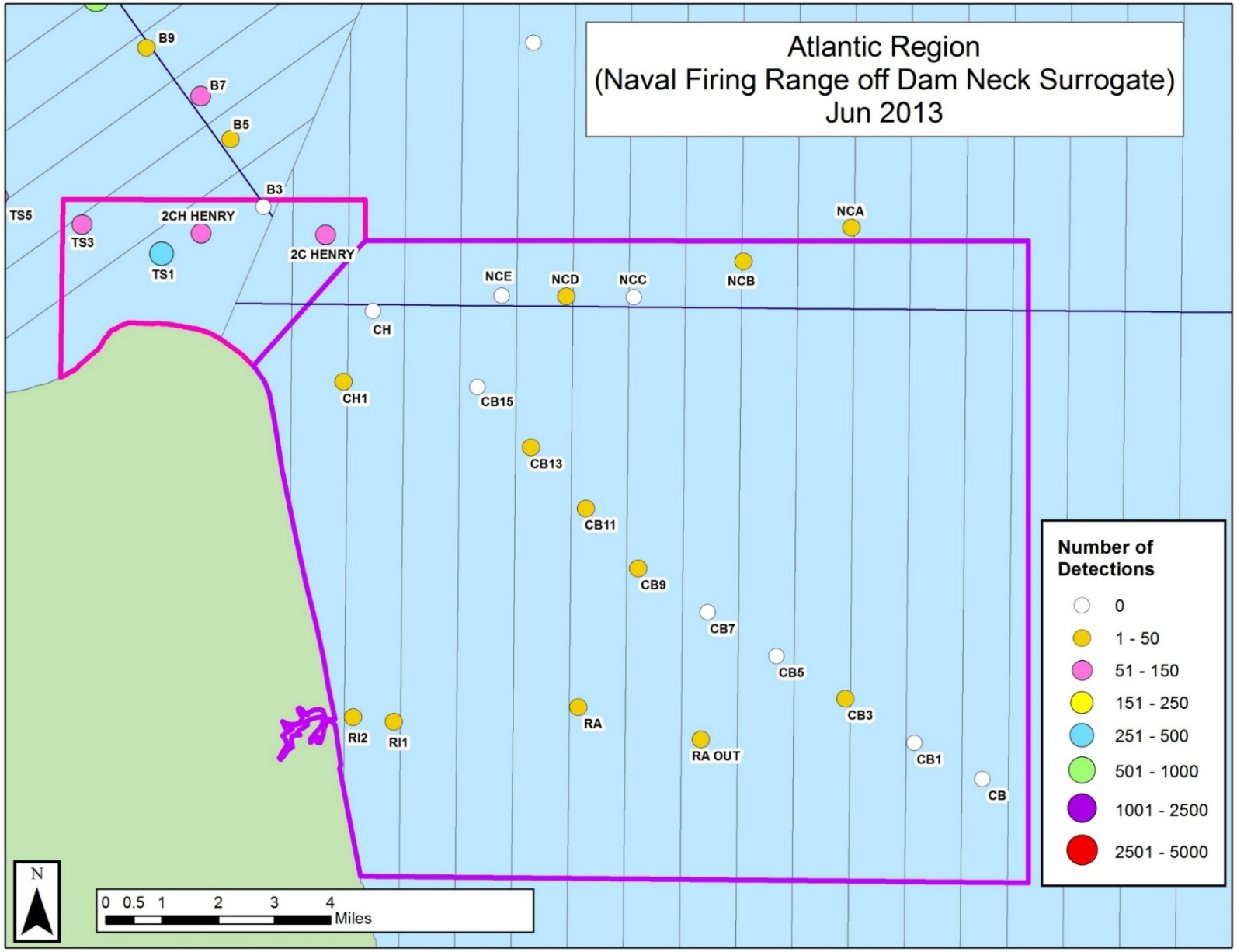

Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Jan 2013
B9
B7
B5
B3
TS5
TS3
TS1
2CH HENRY
2C HENRY
NCA
NCE
NCD
NCC
NCB
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

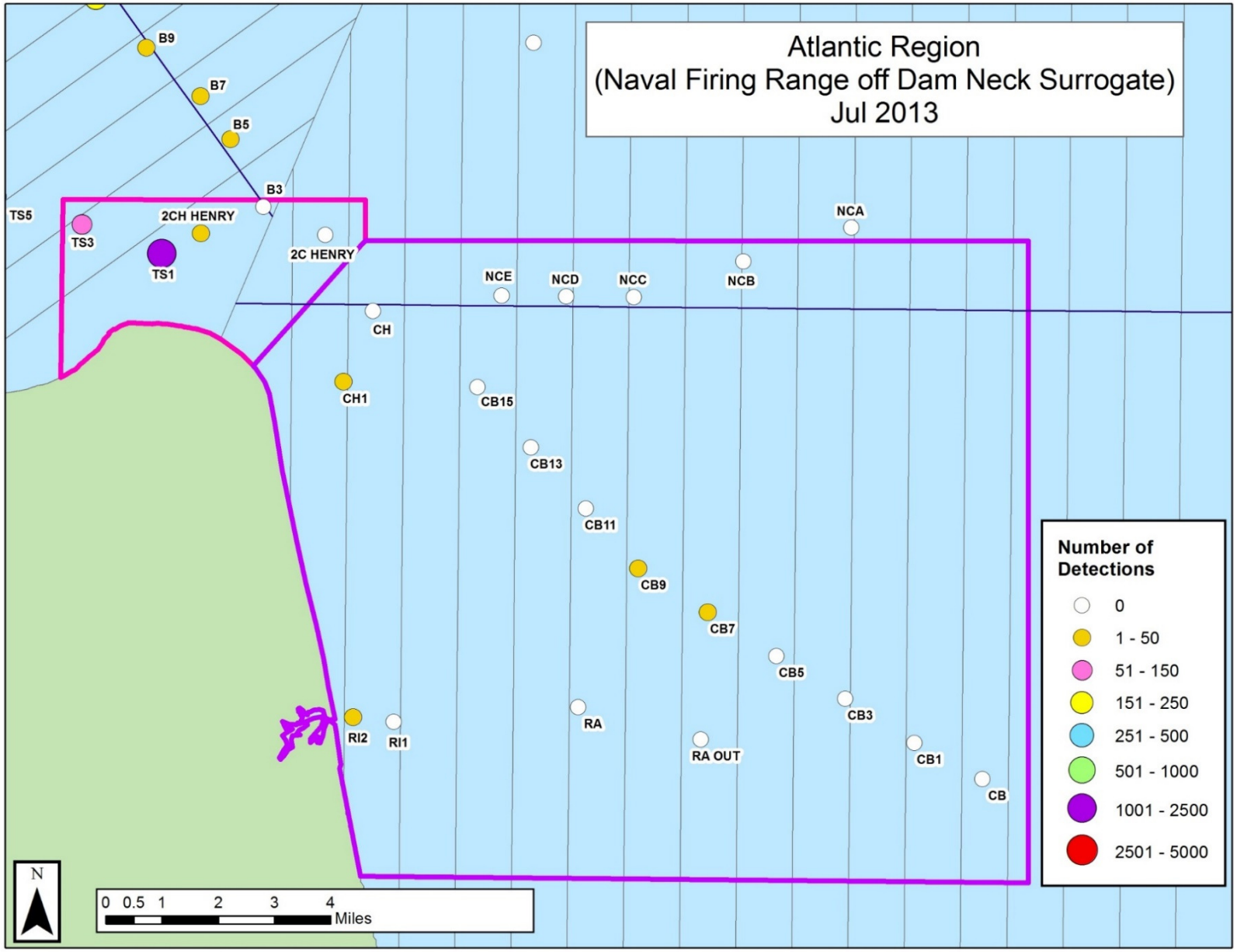

Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Feb 2013
B9
B7
B5
B3
TS5
TS3
TS1
2CH HENRY
2C HENRY
NCA
NCE
NCD
NCC
NCB
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

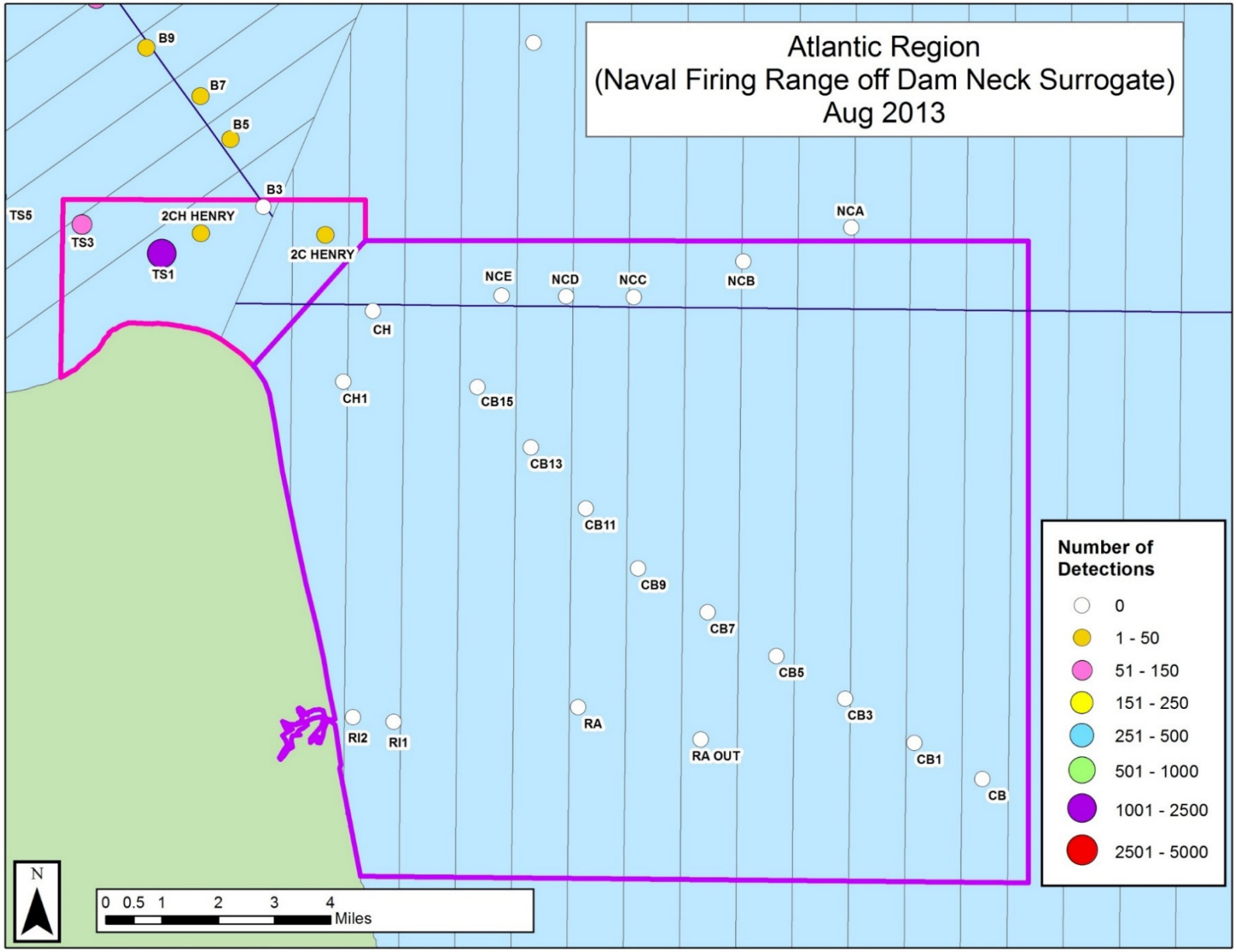

Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Mar 2013
B9
B7
B5
B3
TS5
TS3
2CH HENRY
TS1
2C HENRY
NCA
NCE
NCD
NCC
NCB
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

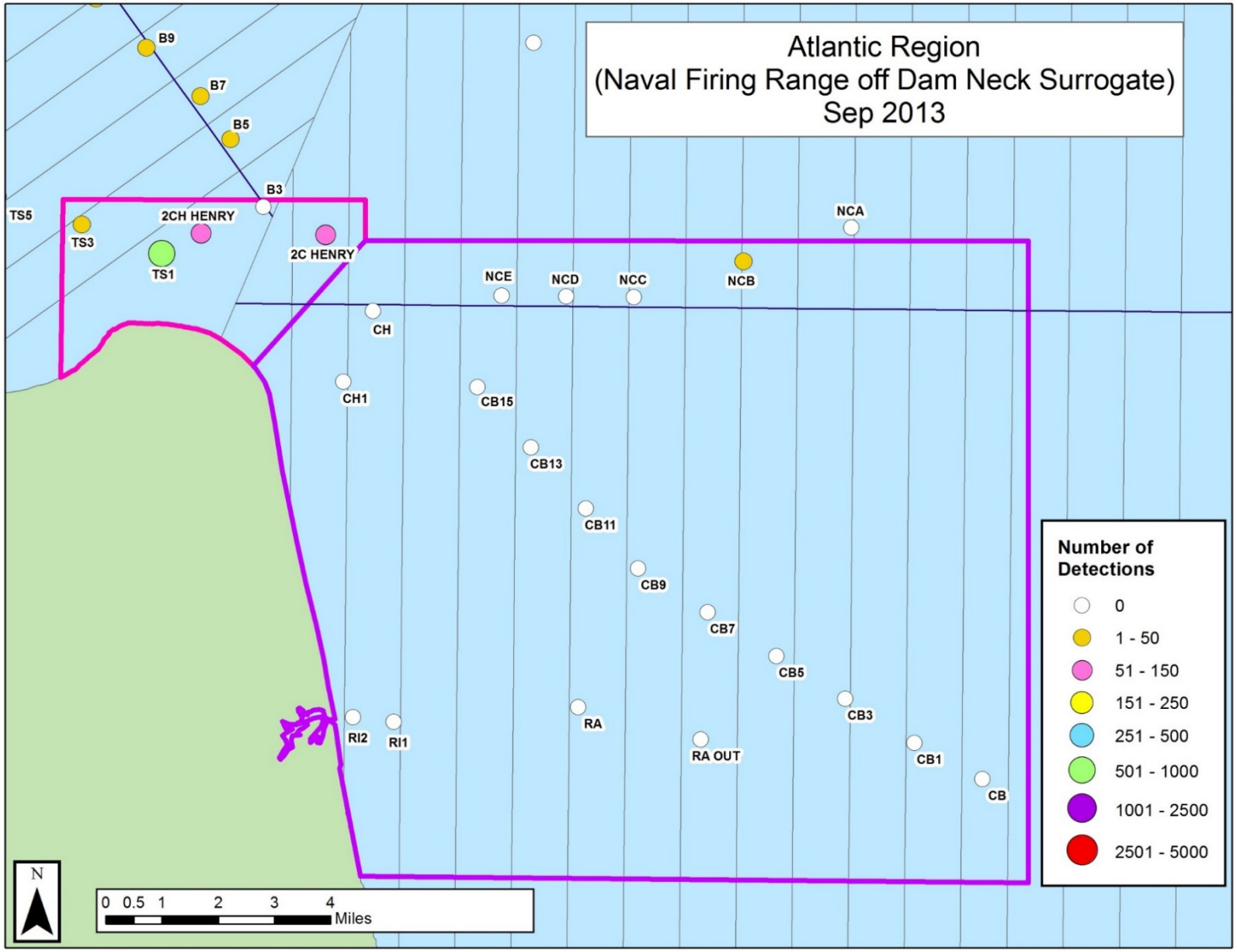

Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Apr 2013
B9
B7
B5
B3
TS5
TS3
TS1
2CH HENRY
2C HENRY
NCA
NCE
NCD
NCC
NCB
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

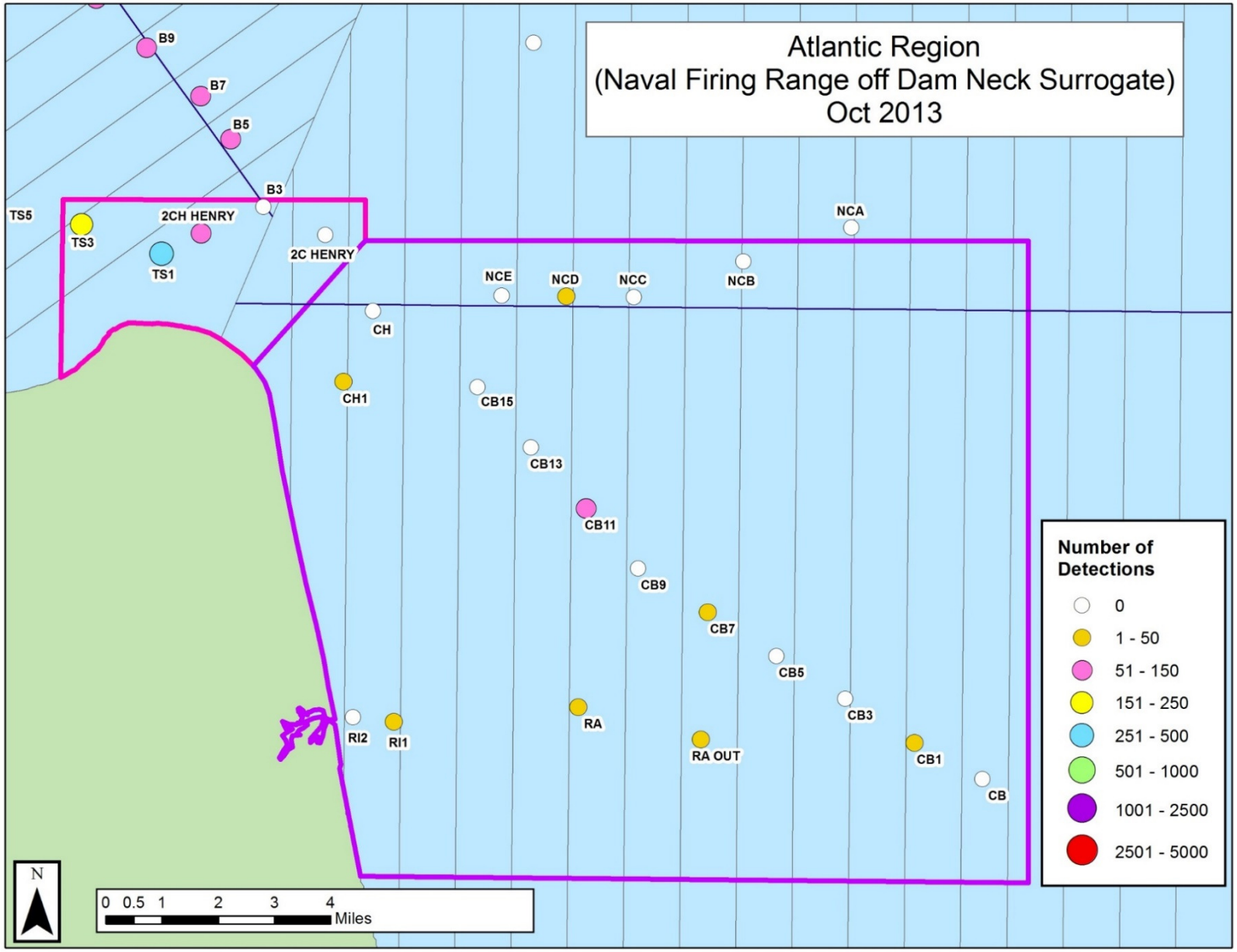

Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
May 2013
B9
B7
B5
B3
TS5
TS3
TS1
2CH HENRY
2C HENRY
NCA
NCE
NCD
NCC
NCB
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

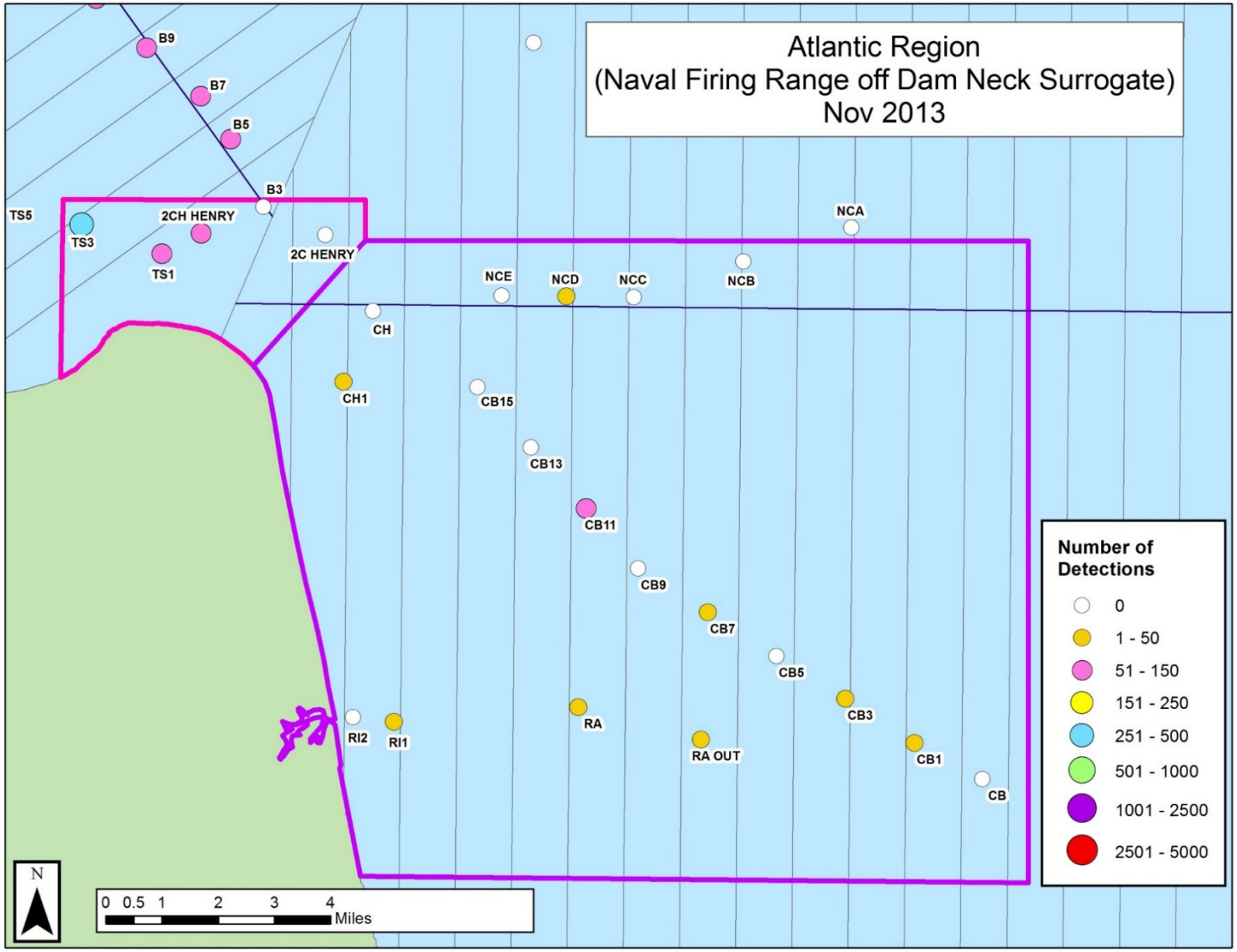

Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Jun 2013
B9
B7
B5
B3
TS5
TS3
2CH HENRY
TS1
2C HENRY
NCA
NCE
NCD
NCC
NCB
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

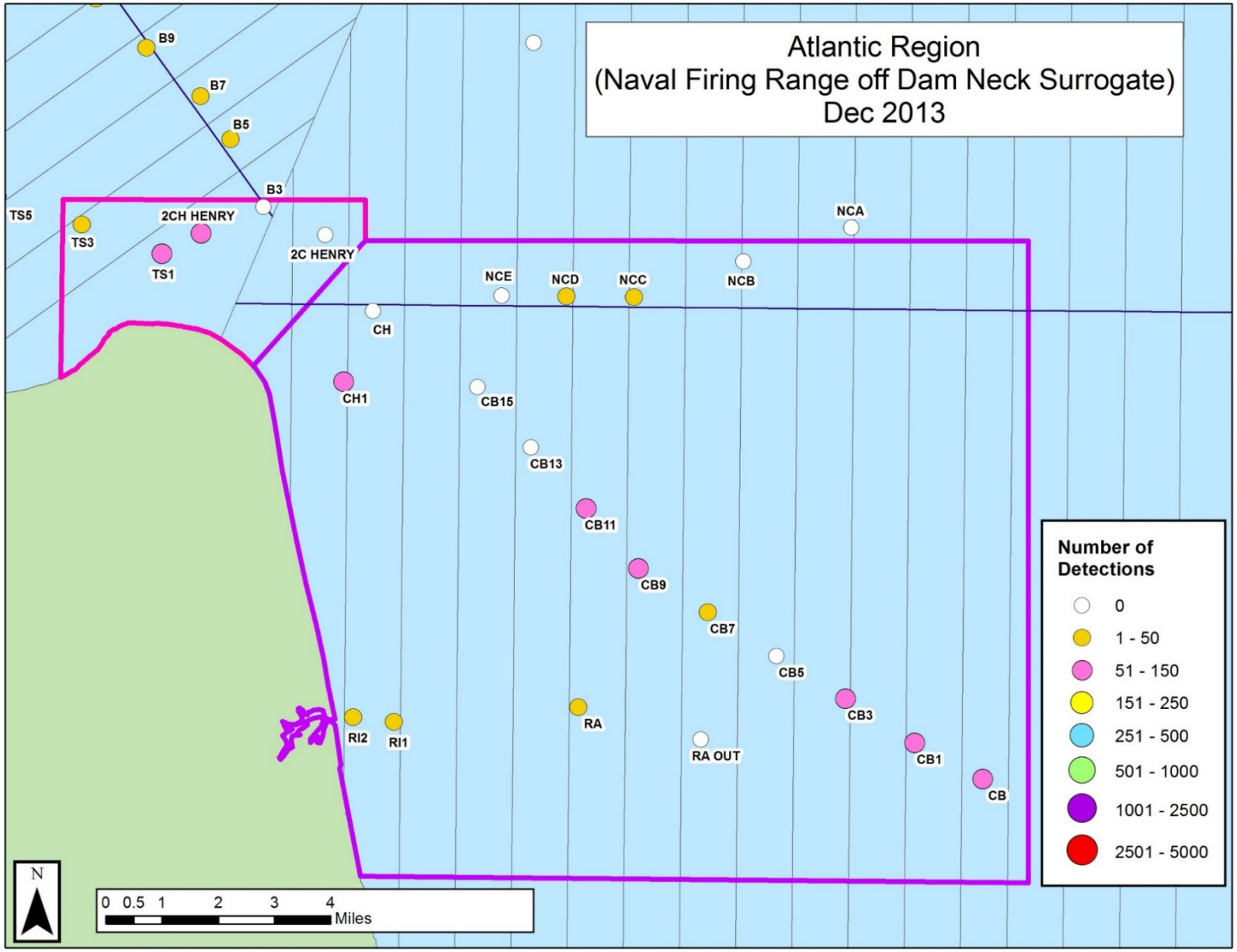

Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Jul 2013
B9
B7
B5
B3
TS5
TS3
2CH HENRY
TS1
2C HENRY
NCA
NCE
NCD
NCC
NCB
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

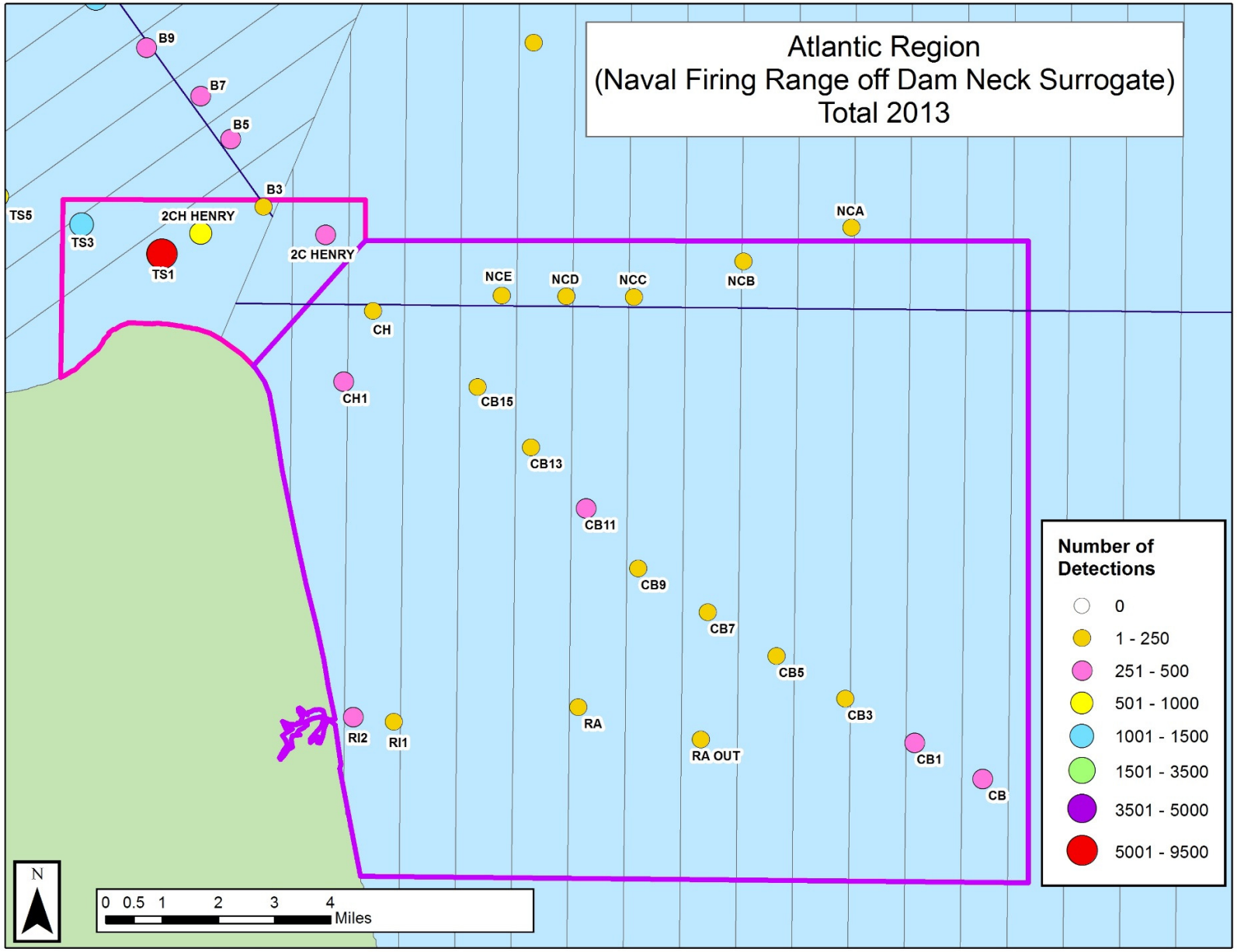

Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Aug 2013
B9
B7
B5
B3
TS5
TS3
TS1
2CH HENRY
2C HENRY
NCA
NCE
NCD
NCC
NCB
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles

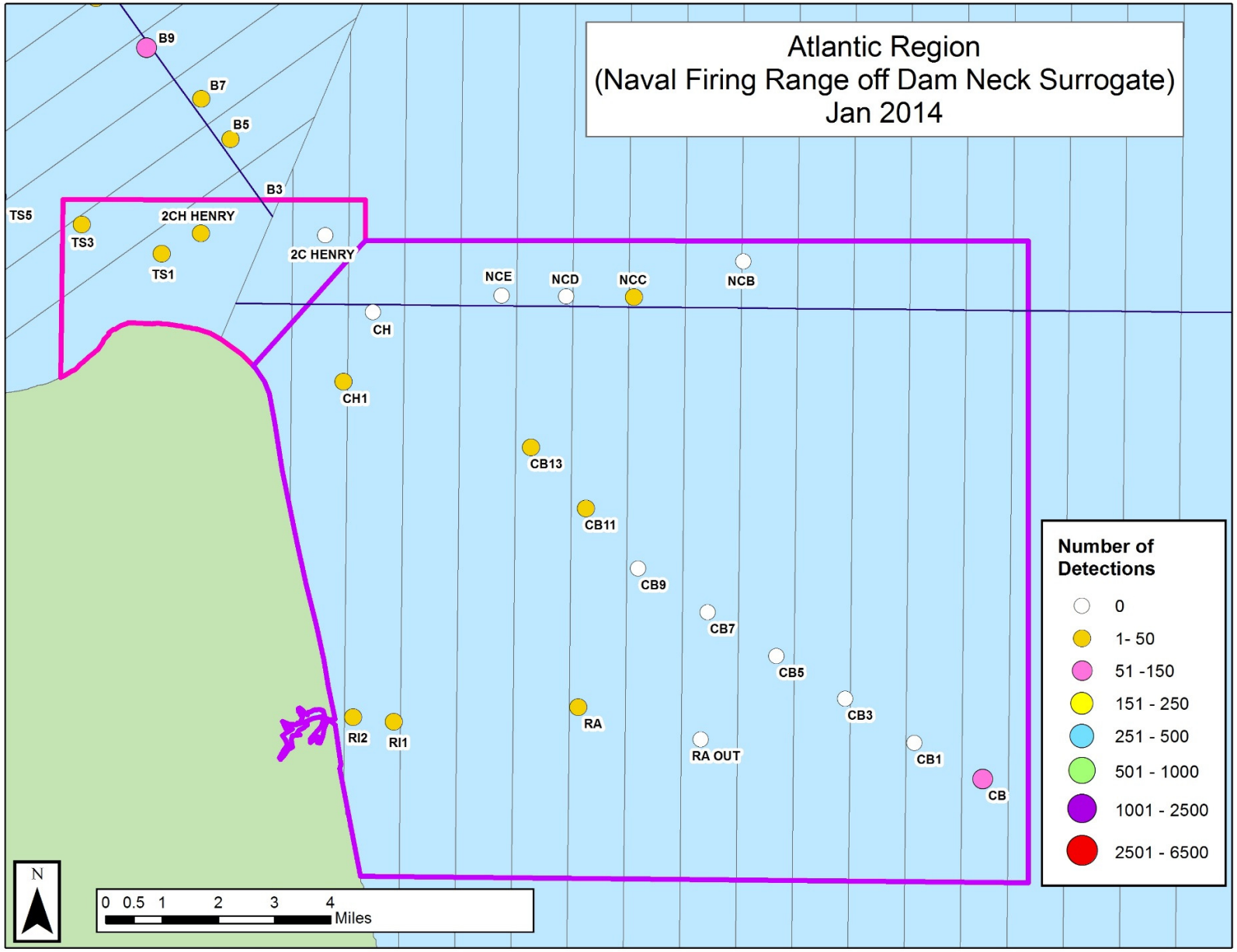

Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Sep 2013
B9
B7
B5
B3
TS5
TS3
TS1
2CH HENRY
2C HENRY
NCA
NCE
NCD
NCC
NCB
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Oct 2013
B9
B7
B5
B3
TS5
TS3
2CH HENRY
TS1
2C HENRY
NCA
NCE
NCD
NCC
NCB
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Nov 2013
B9
B7
B5
B3
TS5
TS3
TS1
2CH HENRY
2C HENRY
NCA
NCE
NCD
NCC
NCB
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Dec 2013
B9
B7
B5
B3
TS5
TS3
2CH HENRY
TS1
2C HENRY
NCA
NCE
NCD
NCC
NCB
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Number of Detections
0
1 - 50
51 - 150
151 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
N
0 0.5 1 2 3 4
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Total 2013
B9
B7
B5
B3
TS5
TS3
TS1
2CH HENRY
2C HENRY
NCA
NCE
NCD
NCC
NCB
CH
CH1
CB15
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Number of Detections
0
1 - 250
251 - 500
501 - 1000
1001 - 1500
1501 - 3500
3501 - 5000
5001 - 9500
N
0 0.5 1 2 3 4
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Jan 2014
B9
B7
B5
B3
TS5
TS3
TS1
2CH HENRY
2C HENRY
NCE
NCD
NCC
NCB
CH
CH1
CB13
CB11
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CB3
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CB
RA
RA OUT
RI2
RI1
Number of Detections
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251 - 500
501 - 1000
1001 - 2500
2501 - 6500
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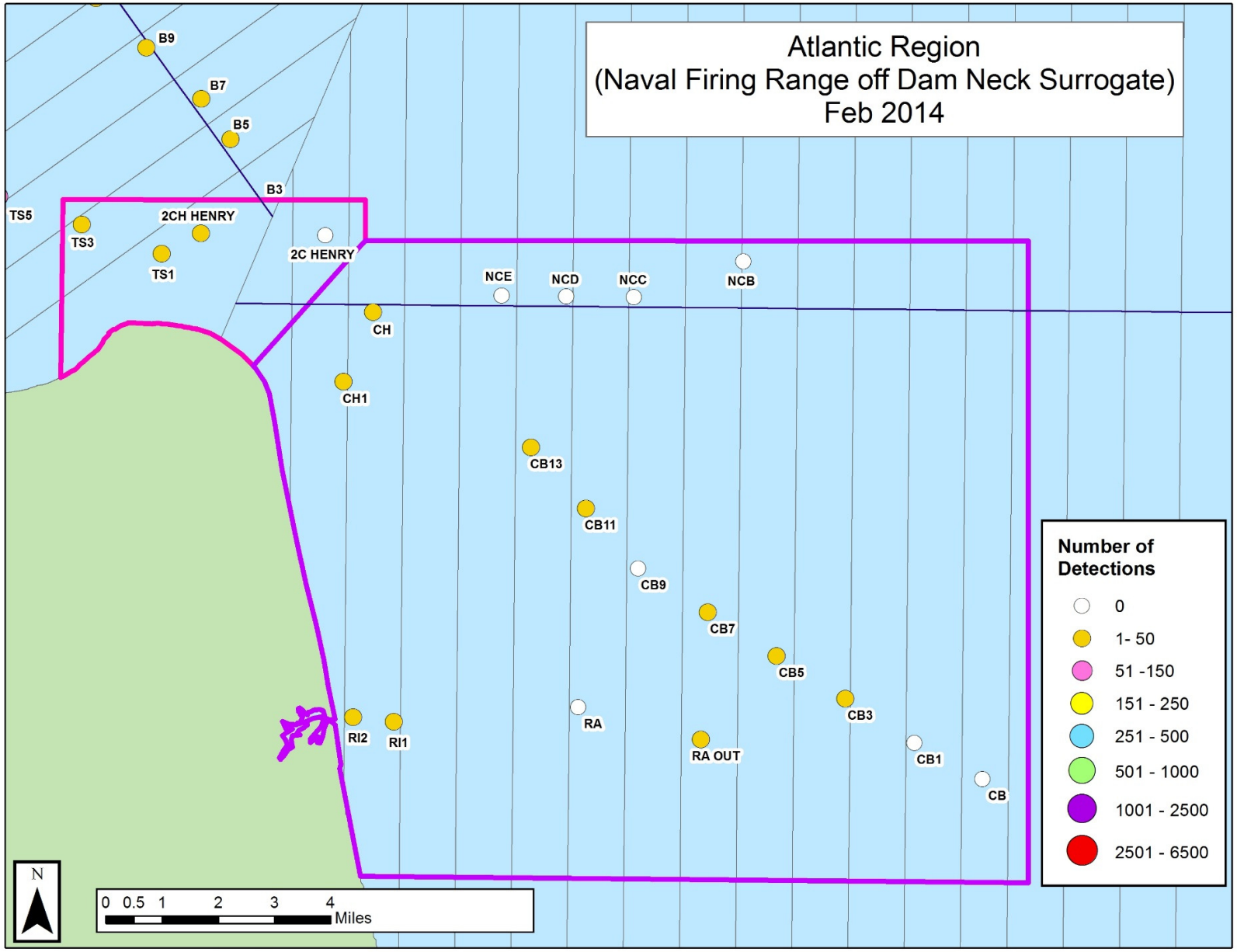
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Feb 2014
B9
B7
B5
B3
TS5
TS3
TS1
2CH HENRY
2C HENRY
NCE
NCD
NCC
NCB
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CB13
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CB
RA
RA OUT
RI2
RI1
Number of Detections
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2501 - 6500
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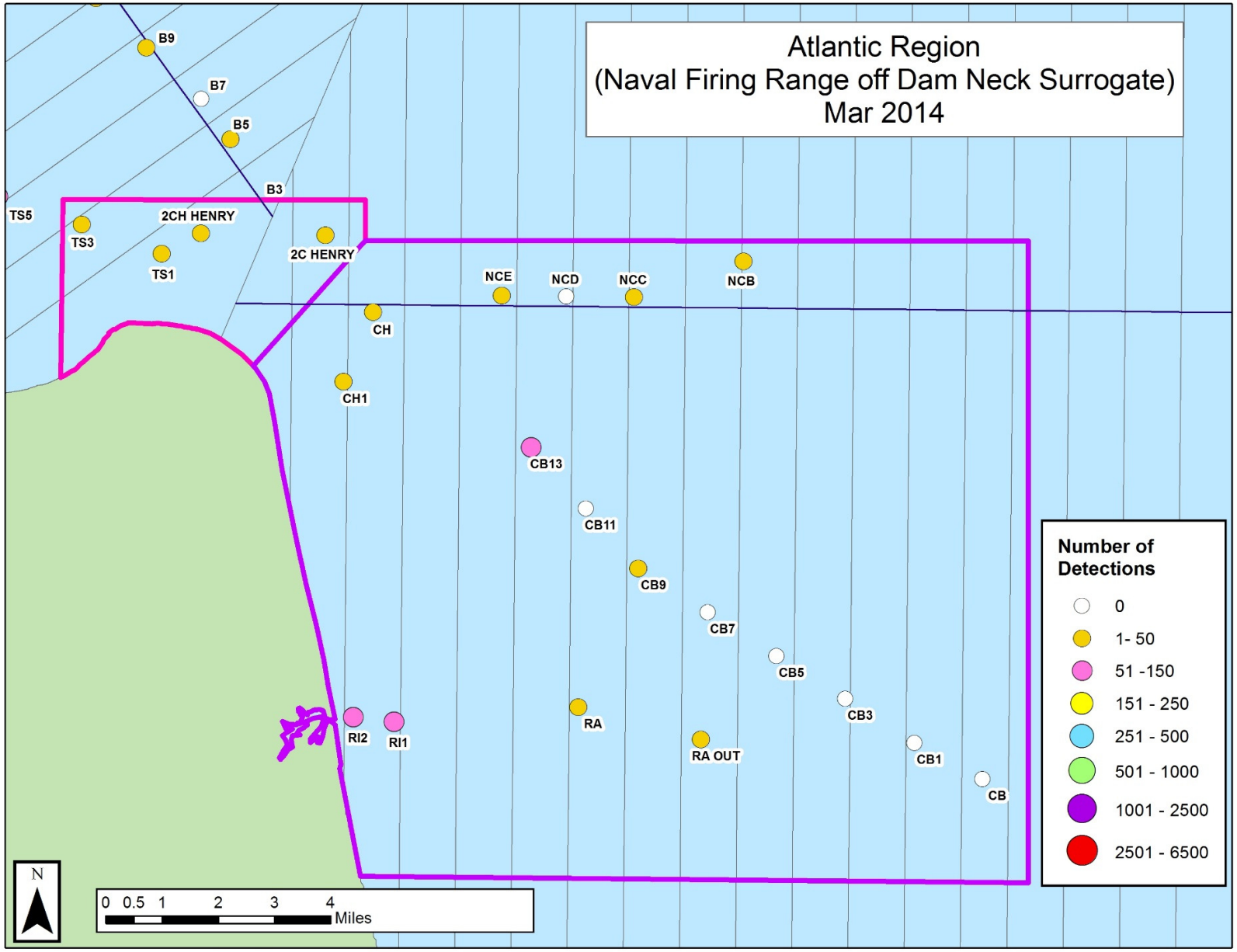
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Mar 2014
B9
B7
B5
B3
TS5
TS3
TS1
2CH HENRY
2C HENRY
NCE
NCD
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RA
RA OUT
RI2
RI1
Number of Detections
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151 - 250
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2501 - 6500
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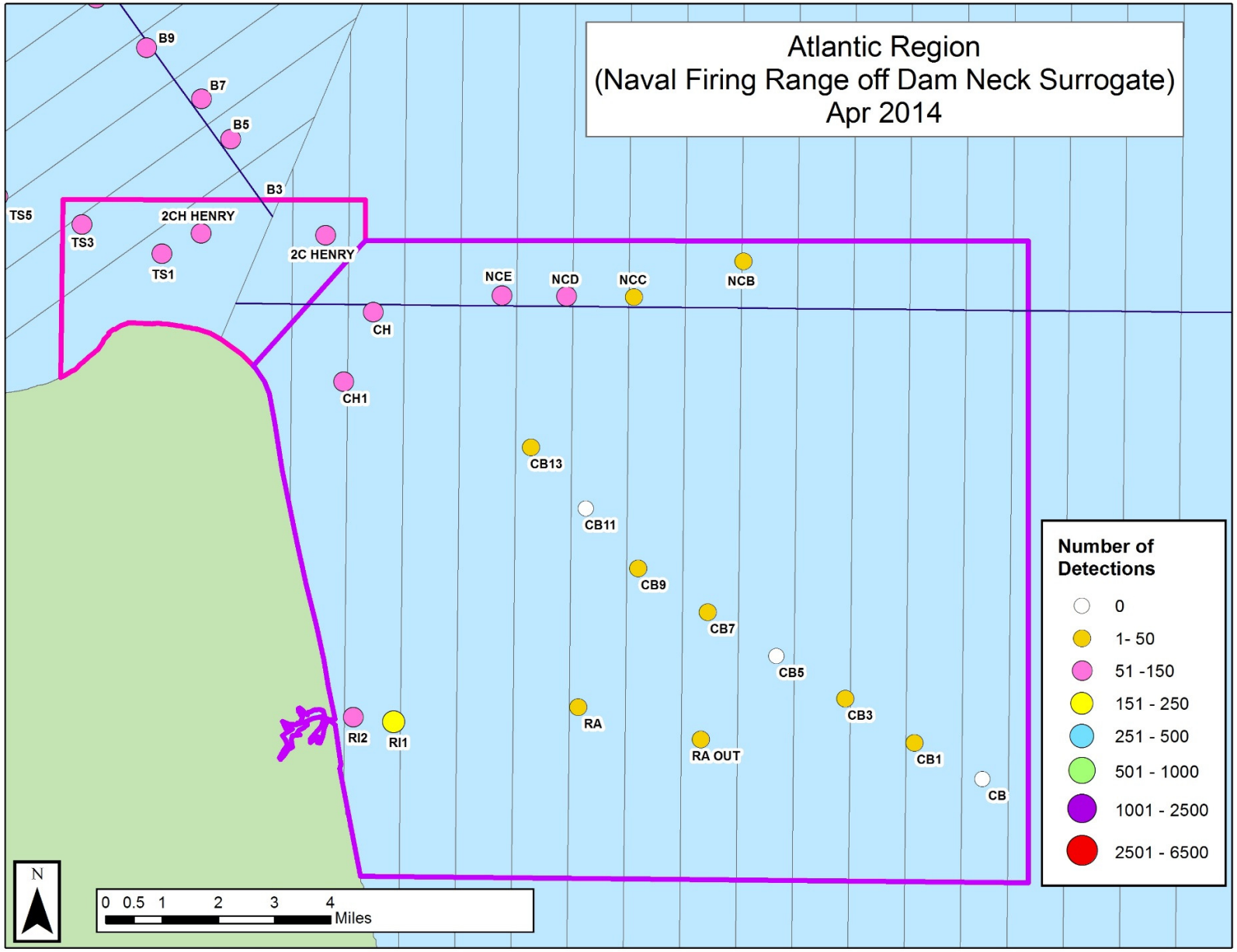
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Apr 2014
B9
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B3
TS5
TS3
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2CH HENRY
2C HENRY
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Number of Detections
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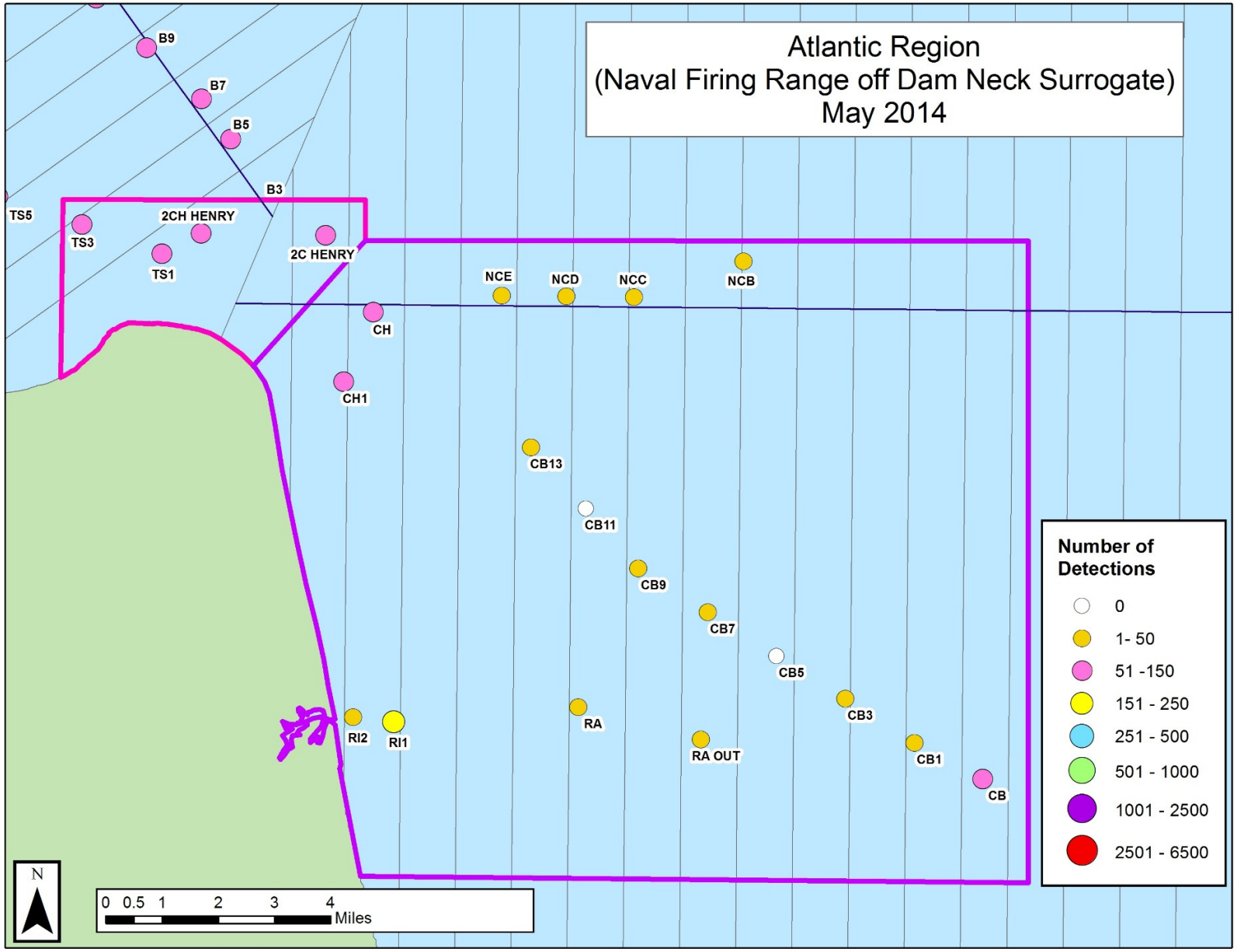
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
May 2014
B9
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2C HENRY
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CH1
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RI1
Number of Detections
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2501 - 6500
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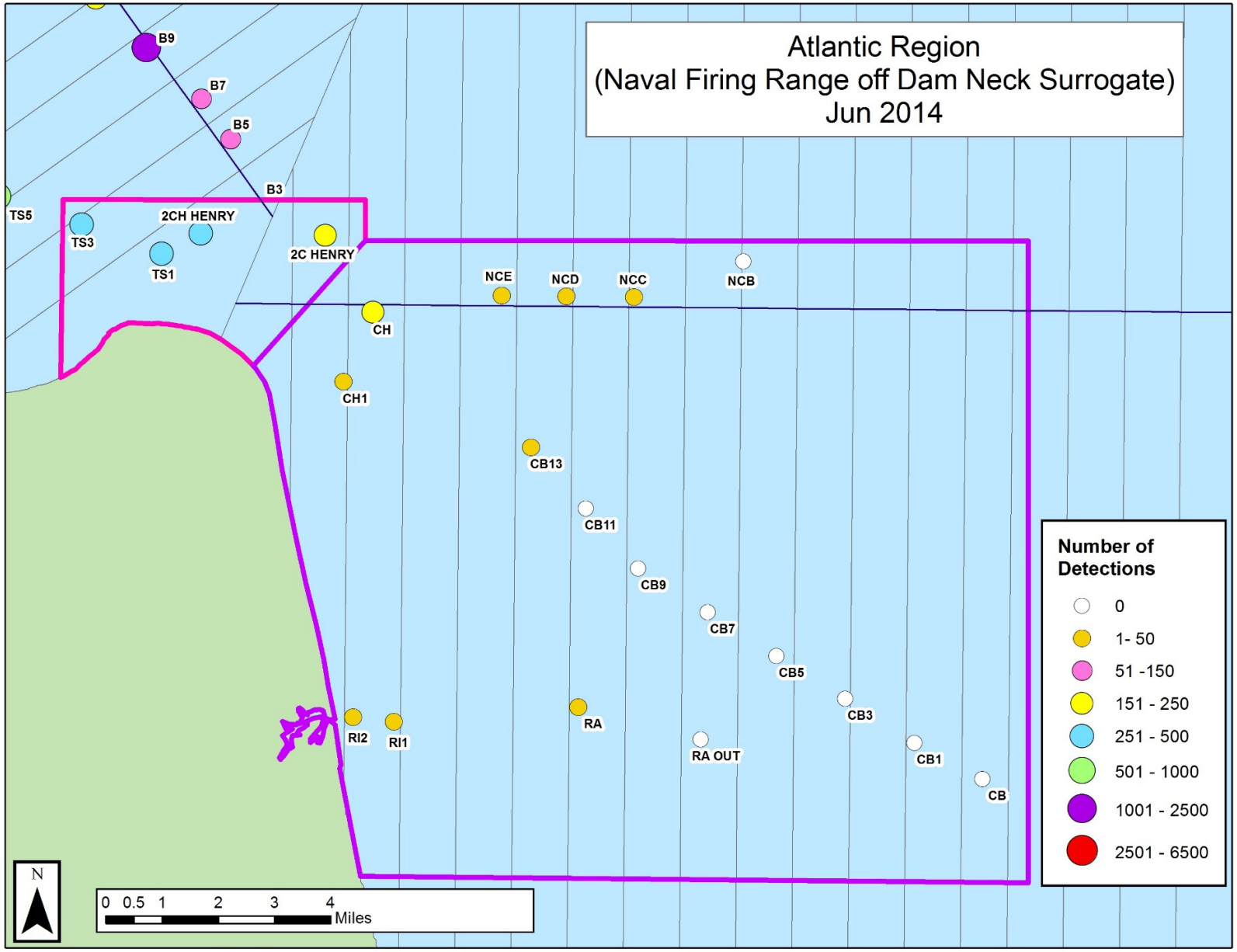
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Jun 2014
B9
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TS5
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TS1
2CH HENRY
2C HENRY
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CB13
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RA OUT
RI2
RI1
Number of Detections
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2501 - 6500
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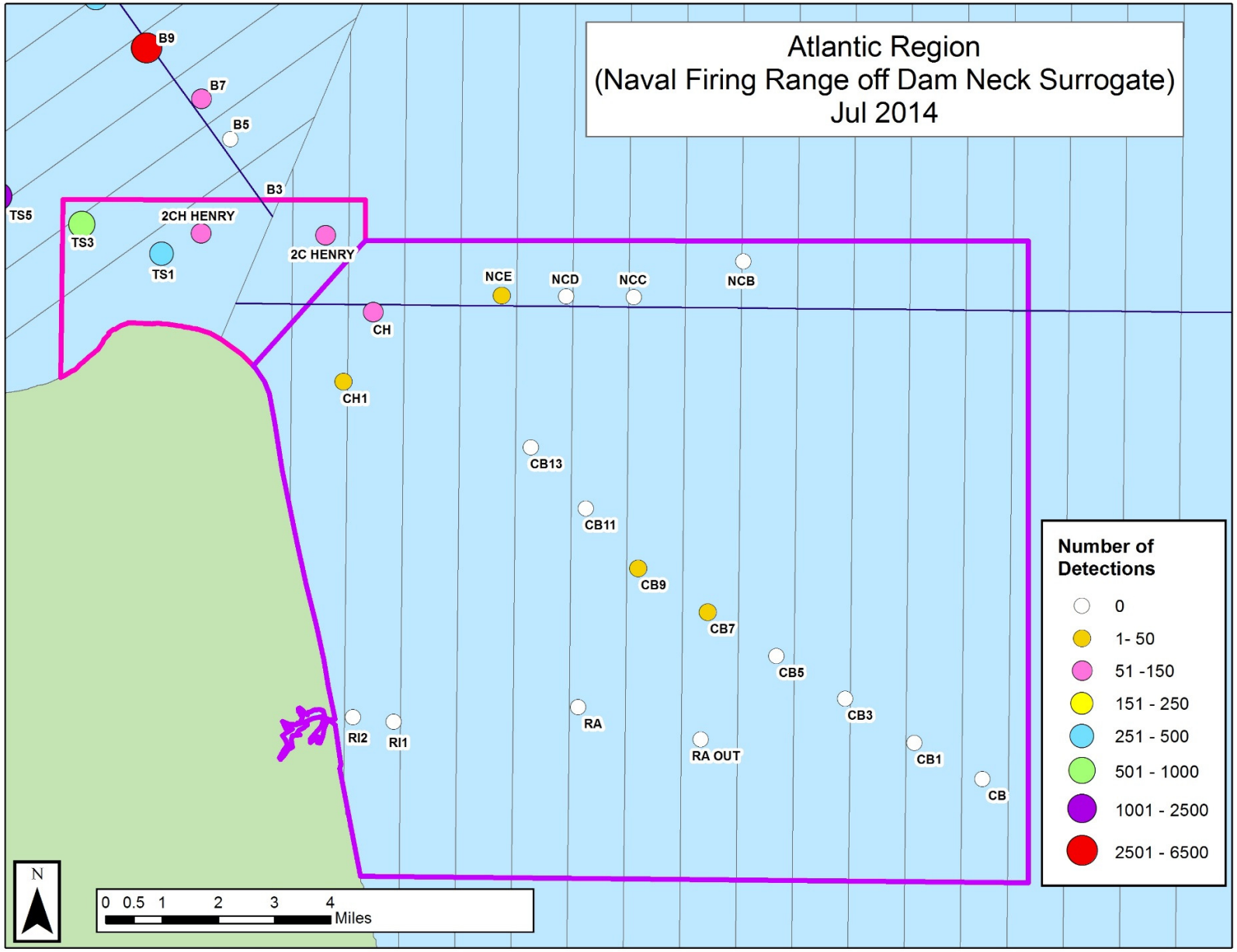
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Jul 2014
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2C HENRY
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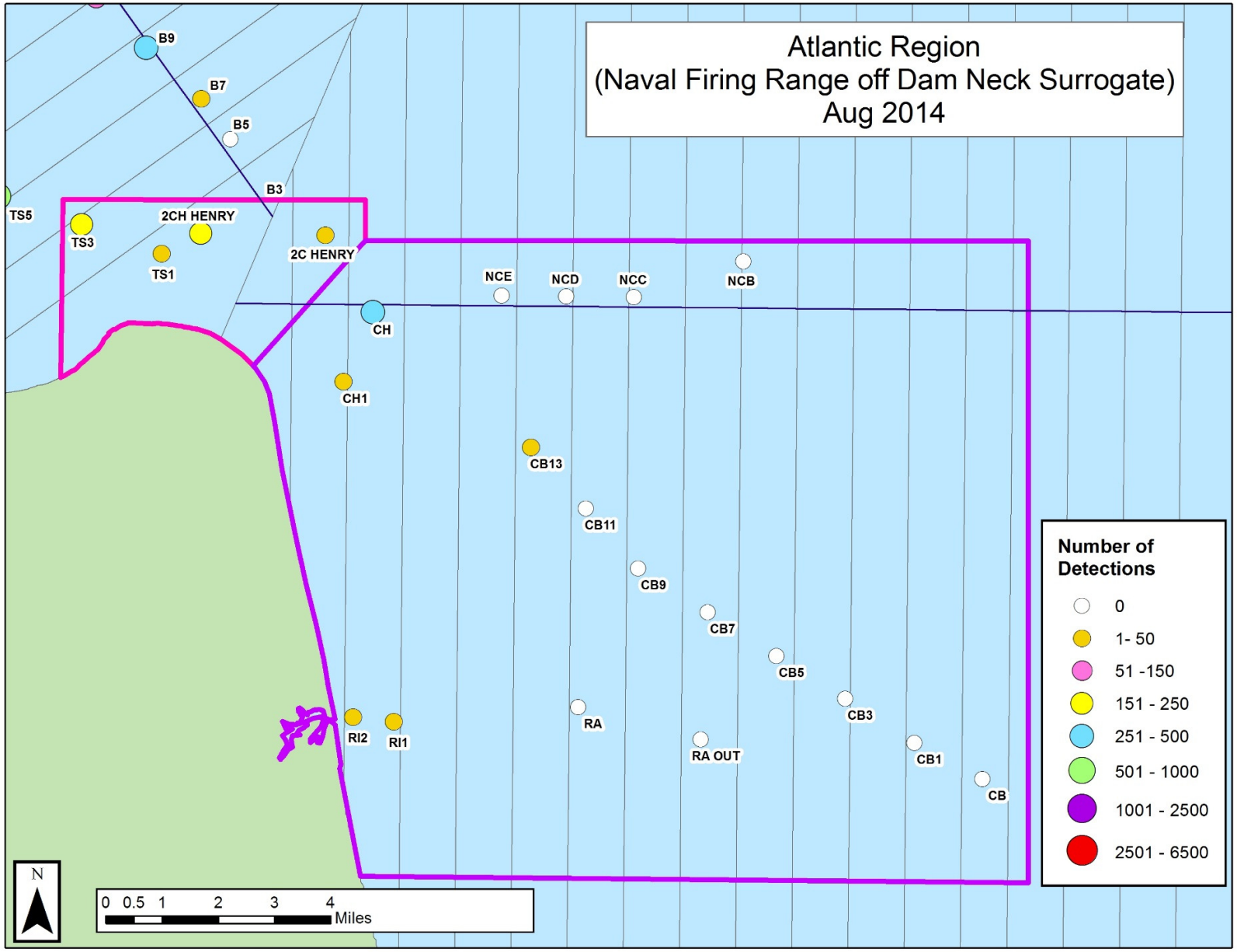
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Aug 2014
B9
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2CH HENRY
2C HENRY
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Number of Detections
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151 - 250
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1001 - 2500
2501 - 6500
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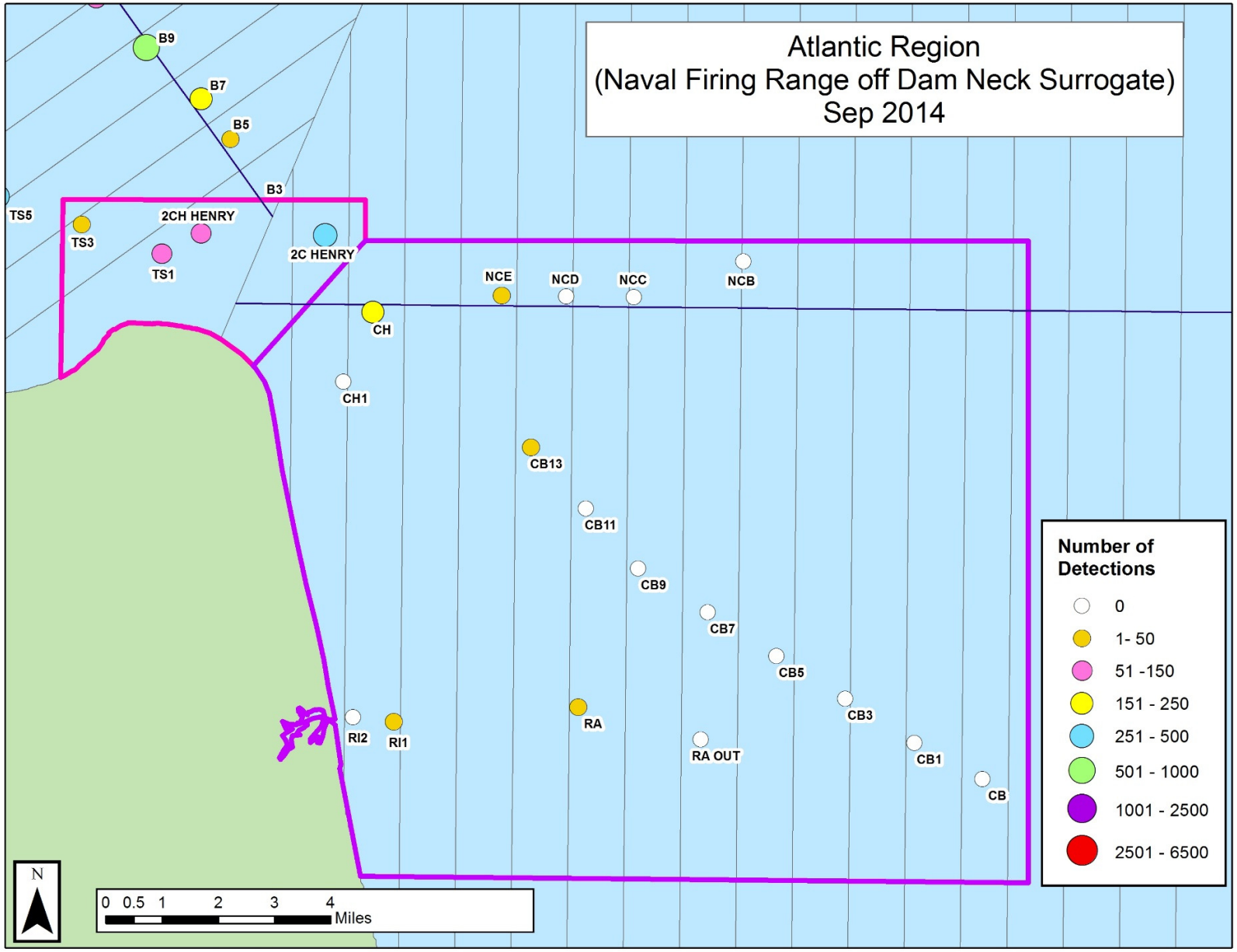
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Sep 2014
B9
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2C HENRY
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Number of Detections
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1001 - 2500
2501 - 6500
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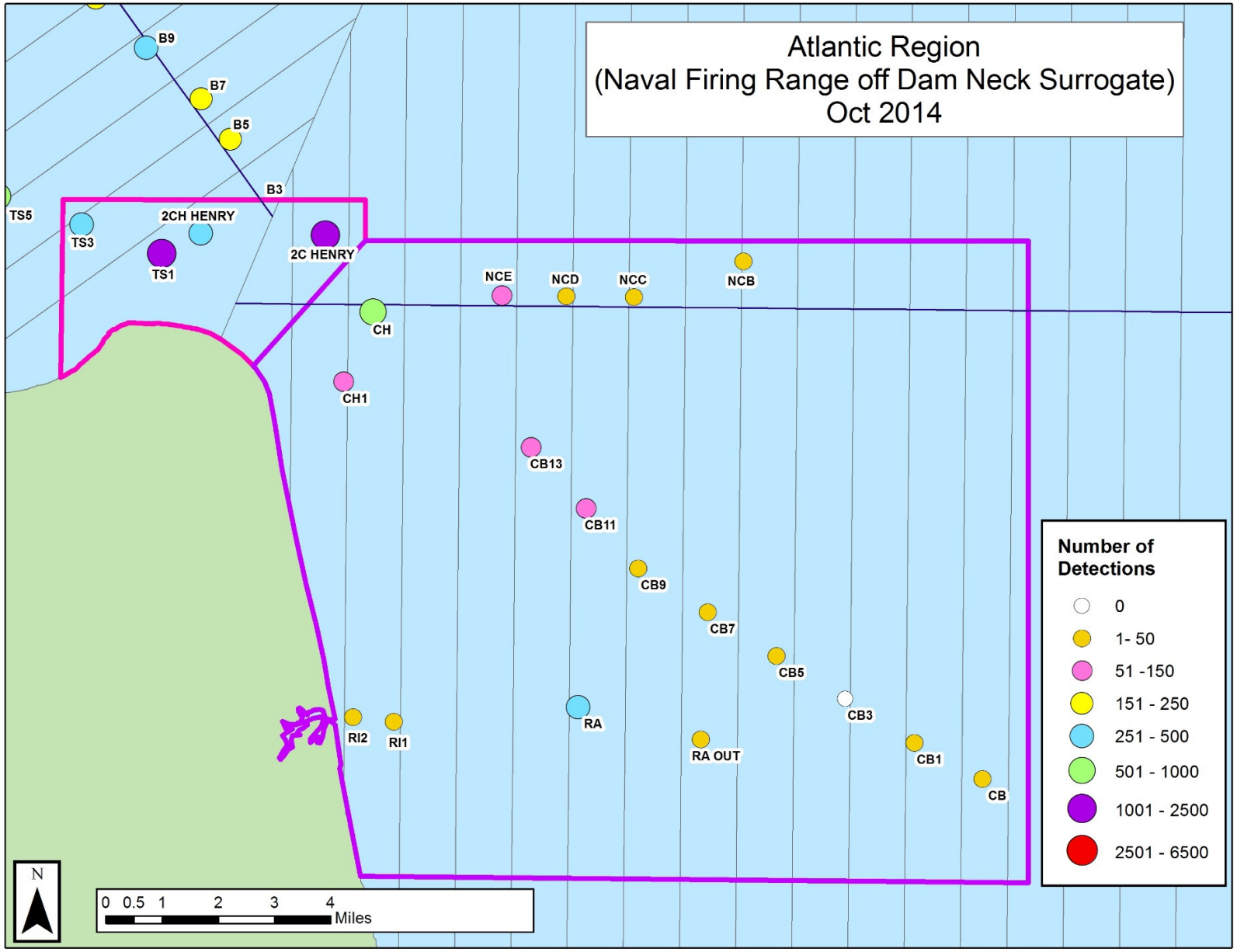
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Oct 2014
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2CH HENRY
TS1
2C HENRY
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RI2
RI1
Number of Detections
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501 - 1000
1001 - 2500
2501 - 6500
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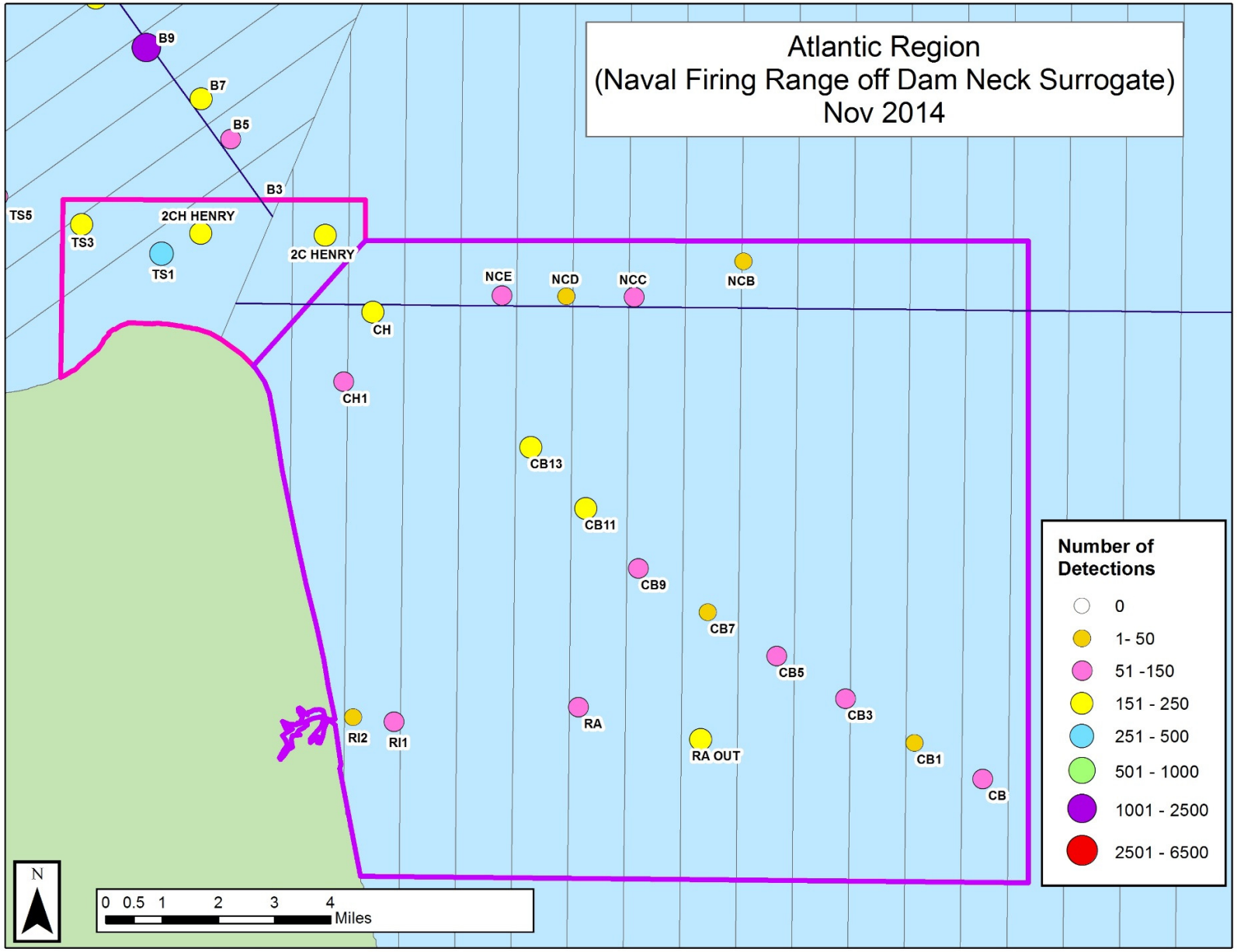
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Nov 2014
B9
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2CH HENRY
2C HENRY
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RA OUT
RI2
RI1
Number of Detections
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151 - 250
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2501 - 6500
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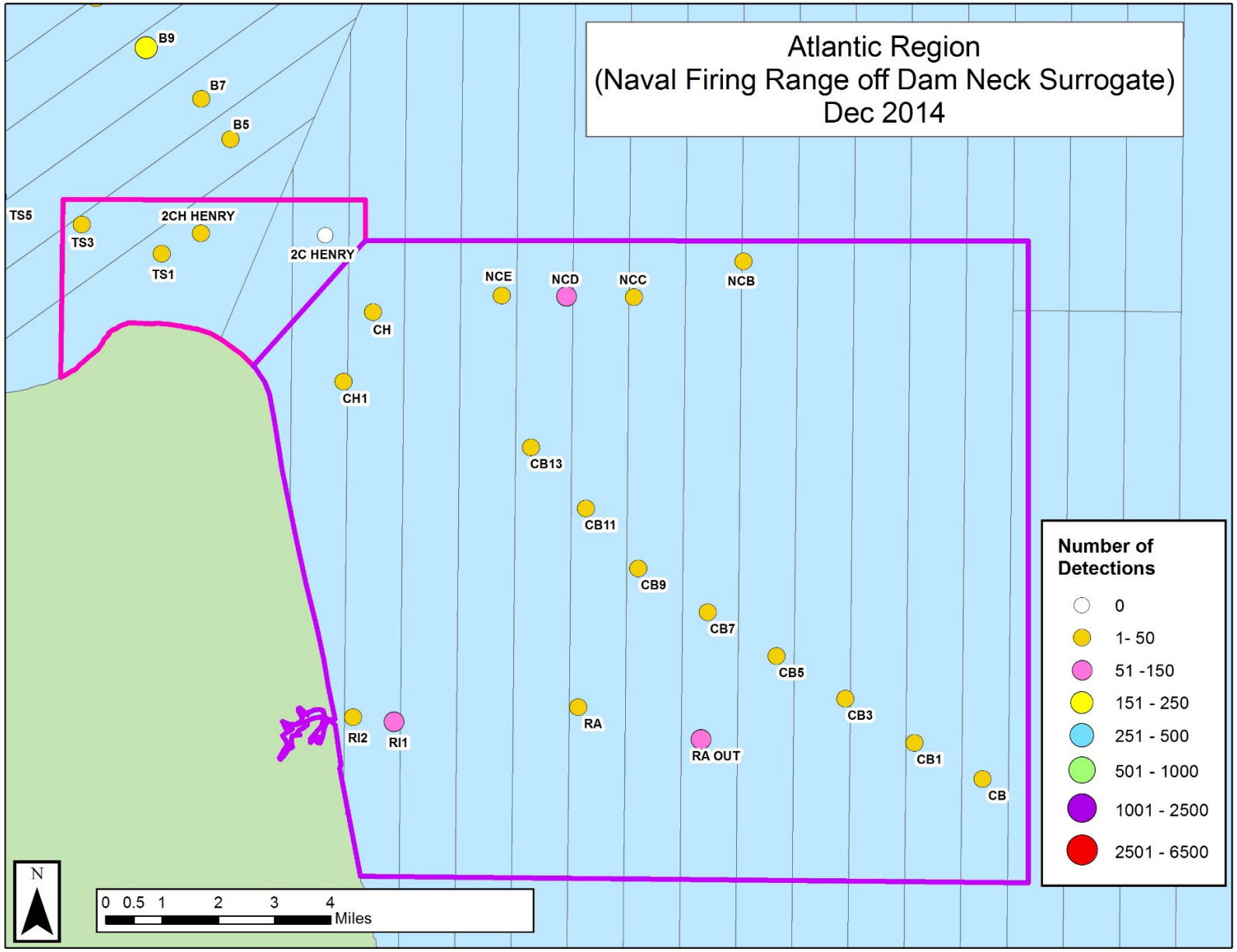
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Dec 2014
B9
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TS5
TS3
2CH HENRY
TS1
2C HENRY
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CB1
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RA
RA OUT
RI2
RI1
Number of Detections
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2501 - 6500
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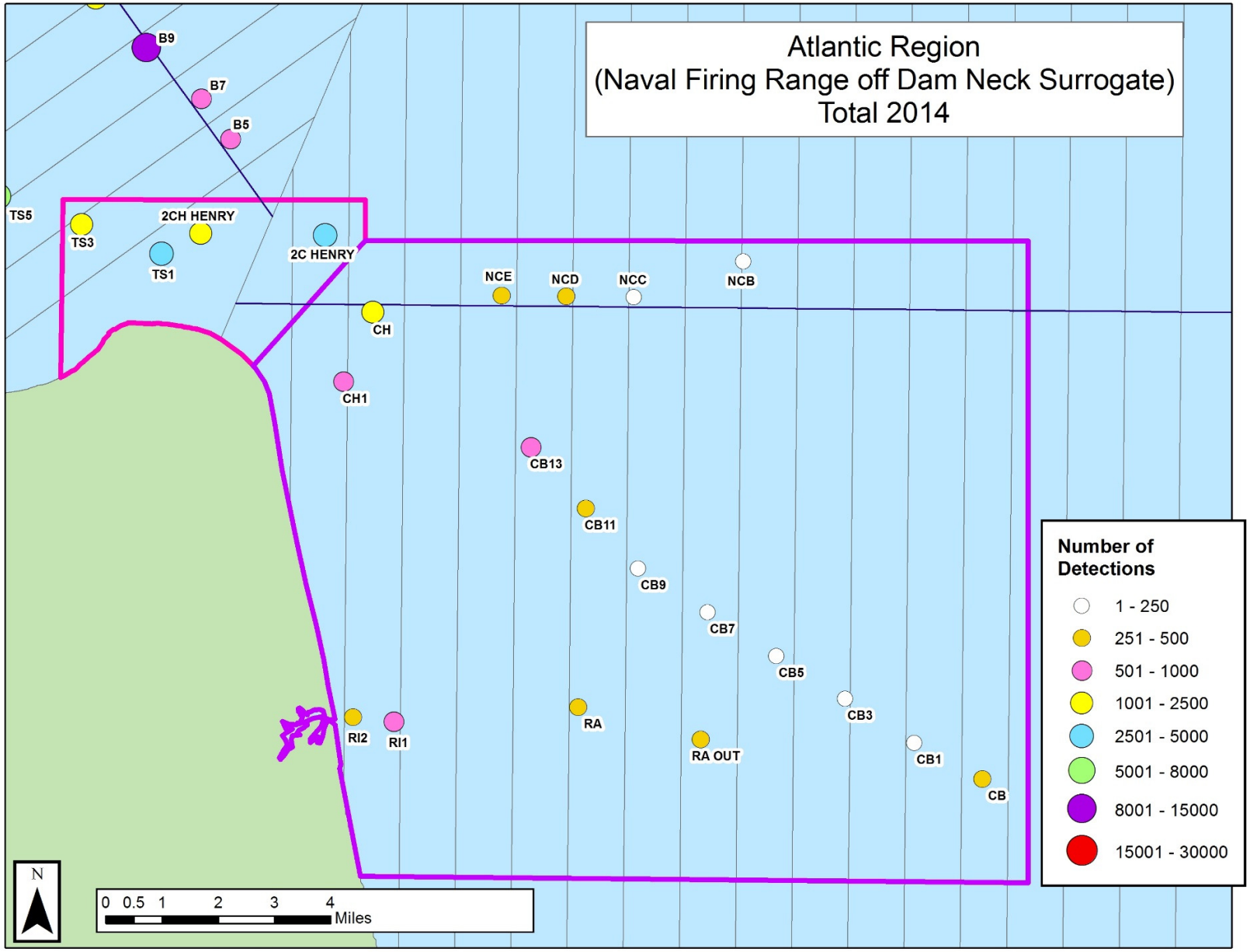
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Total 2014
B9
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TS5
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2CH HENRY
TS1
2C HENRY
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NCB
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CH1
CB13
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CB3
CB1
CB
RA
RA OUT
RI2
RI1
Number of Detections
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251 - 500
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1001 - 2500
2501 - 5000
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15001 - 30000
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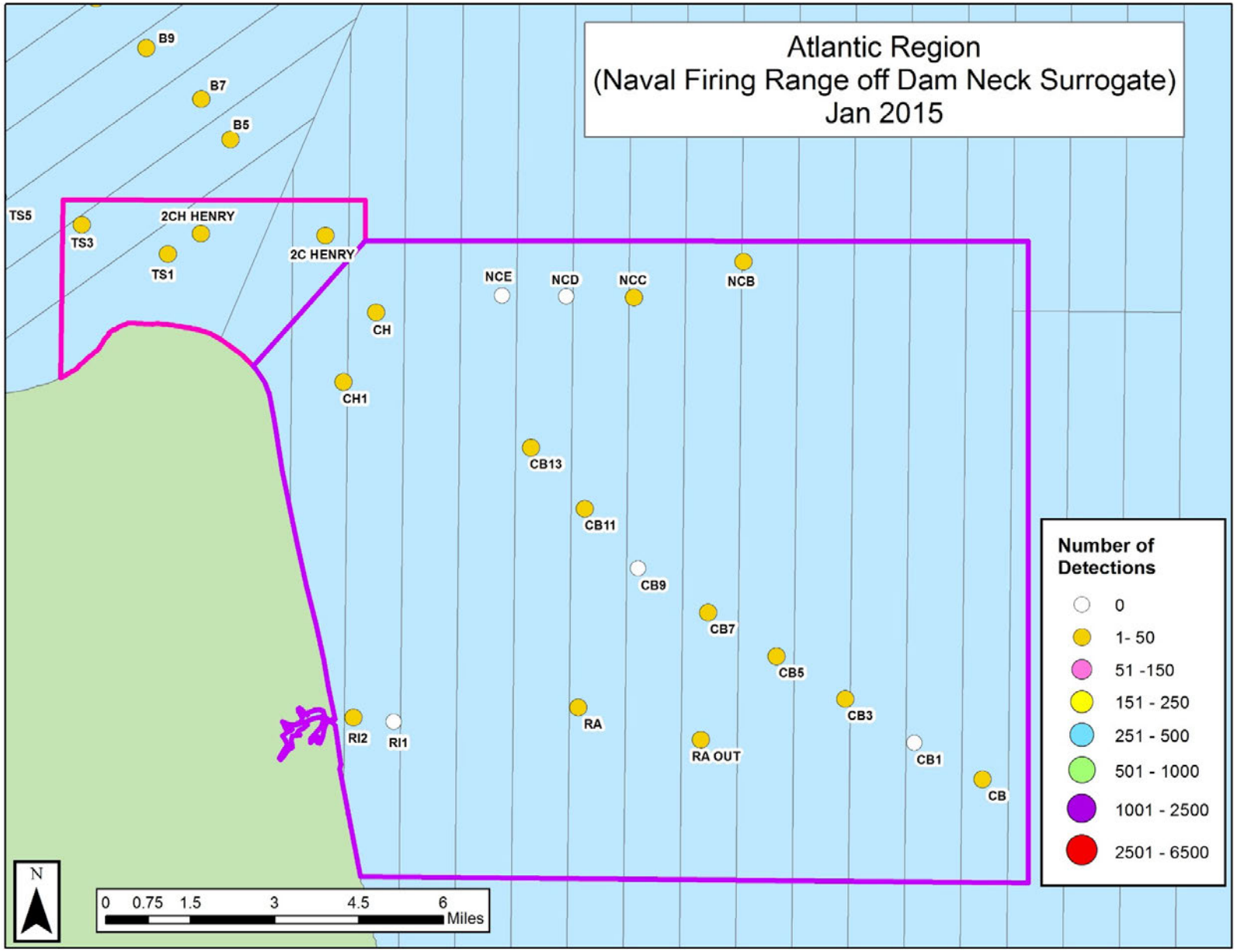
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Jan 2015
B9
B7
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TS5
TS3
2CH HENRY
TS1
2C HENRY
NCE
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NCB
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CB3
CB1
CB
RA
RA OUT
RI2
RI1
Number of Detections
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151 - 250
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501 - 1000
1001 - 2500
2501 - 6500
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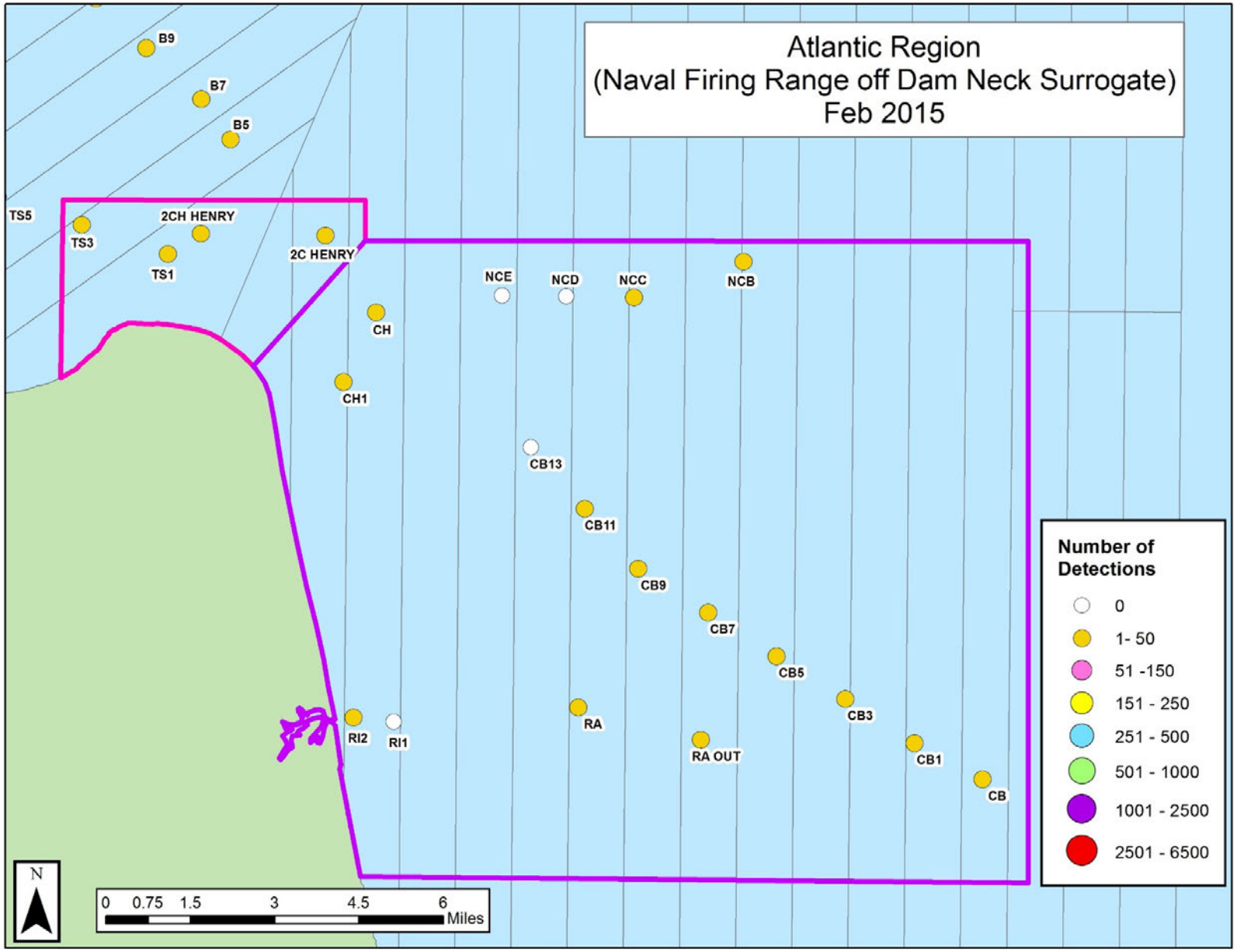
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Feb 2015
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TS5
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TS1
2C HENRY
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RA OUT
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RI1
Number of Detections
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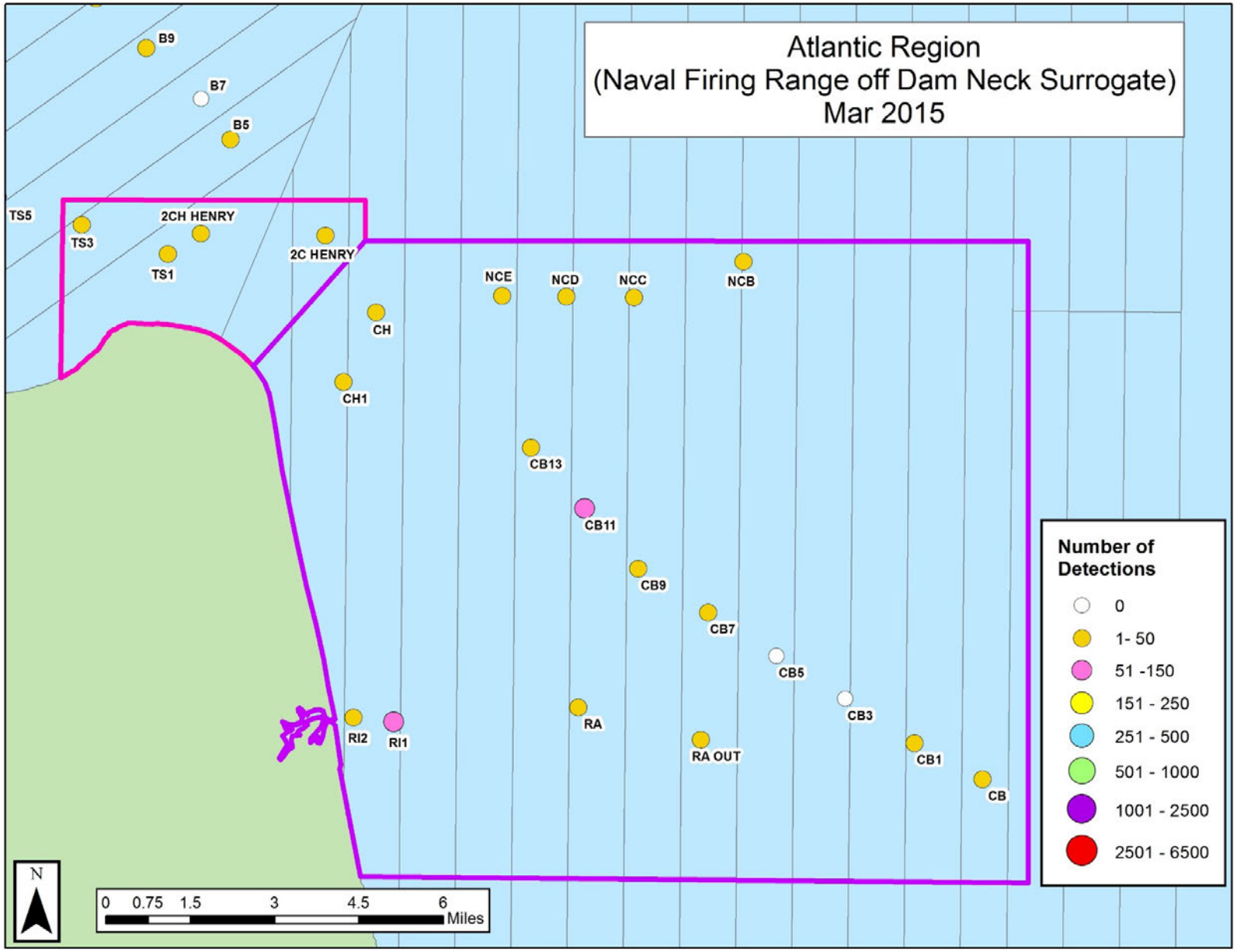
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Mar 2015
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2C HENRY
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RA OUT
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Number of Detections
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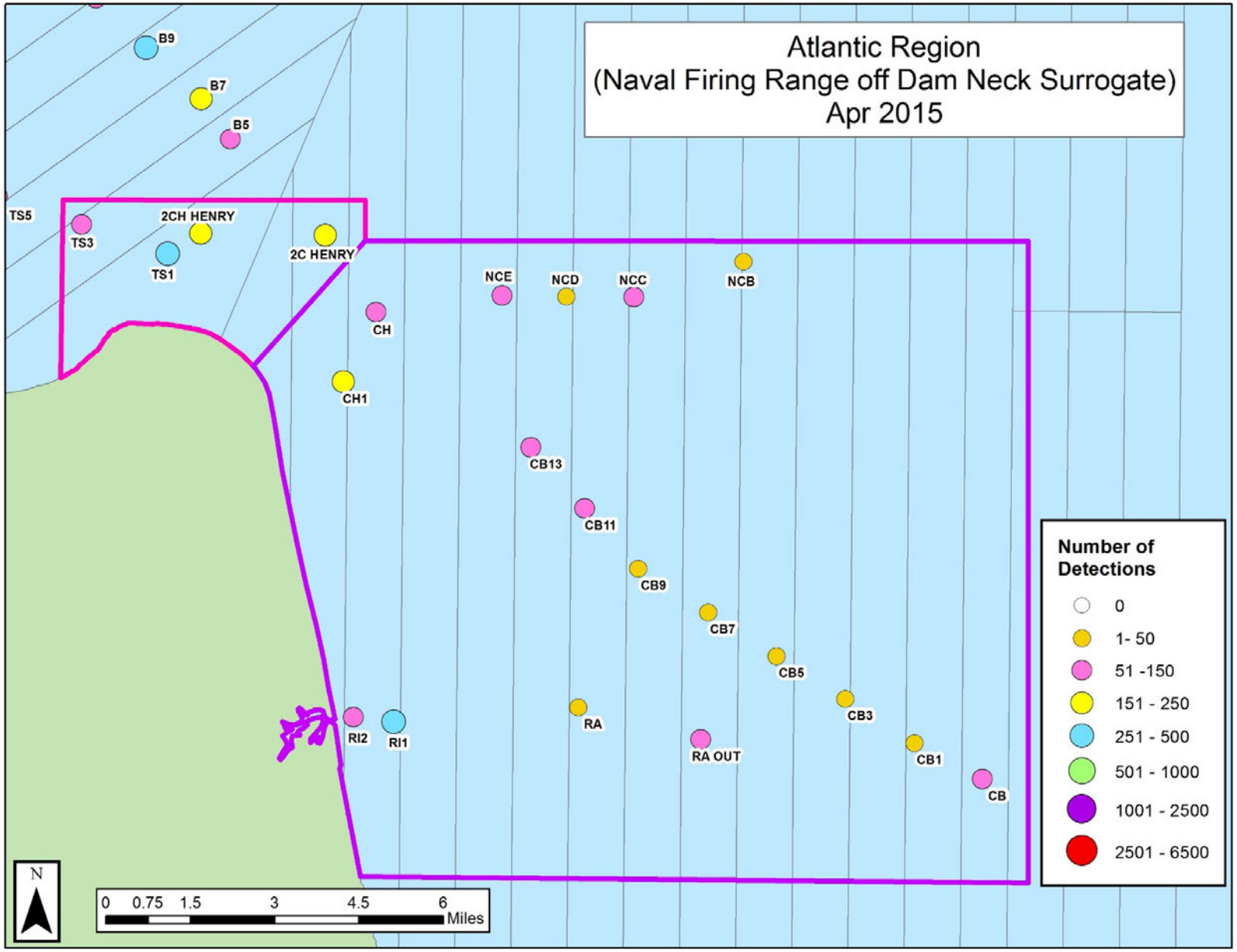
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Apr 2015
B9
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Number of Detections
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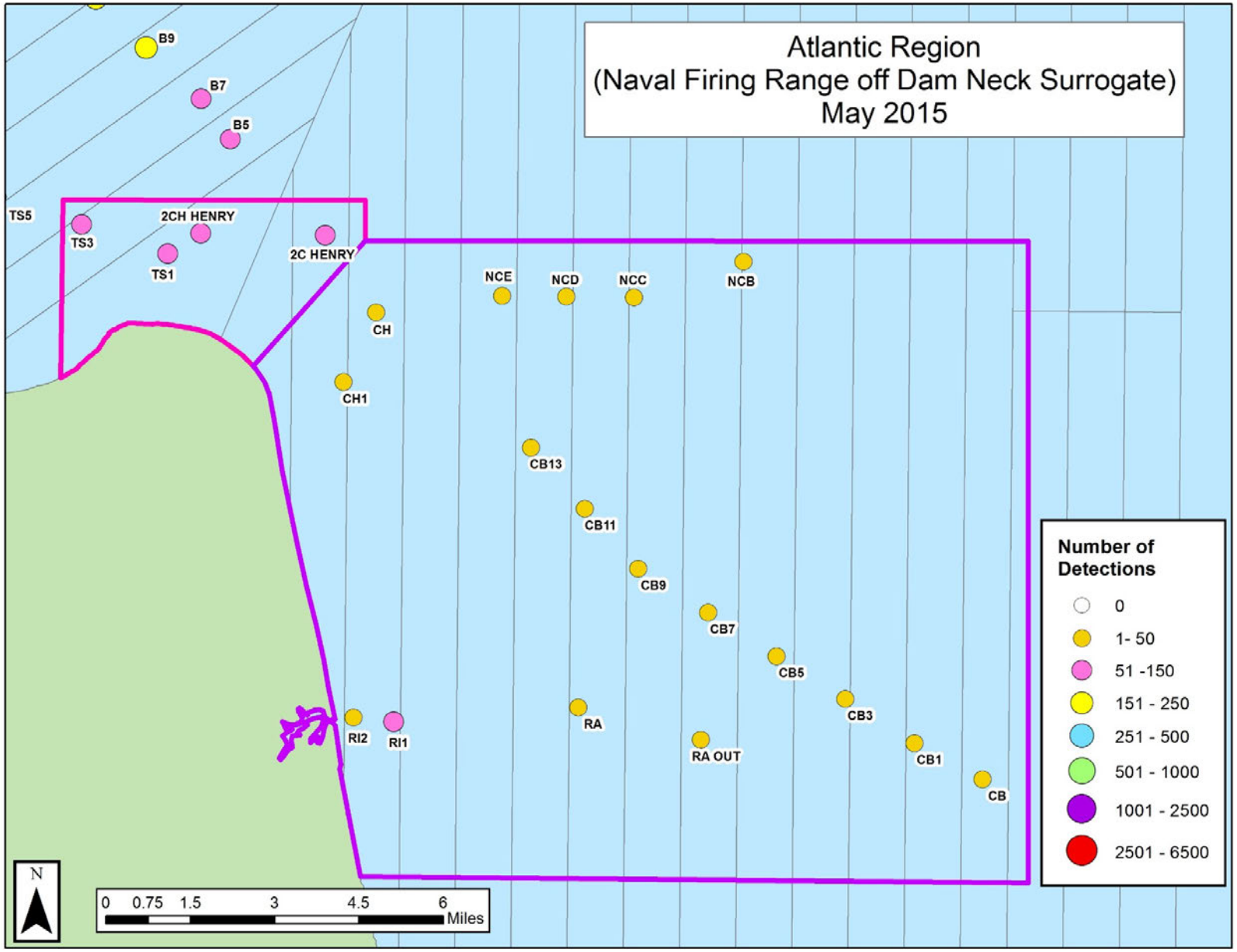
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
May 2015
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Number of Detections
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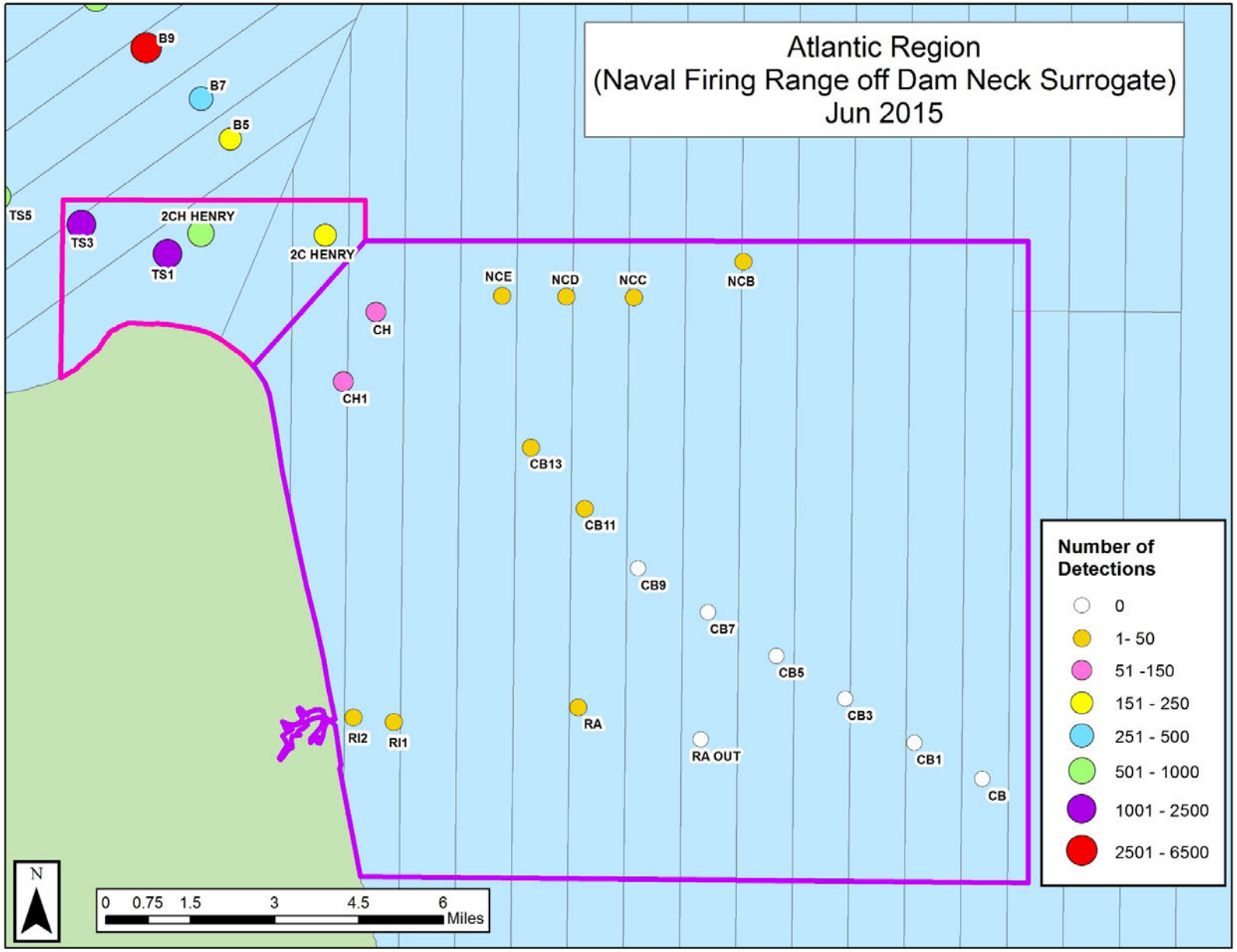
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Jun 2015
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TS5
TS3
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2C HENRY
NCE
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Number of Detections
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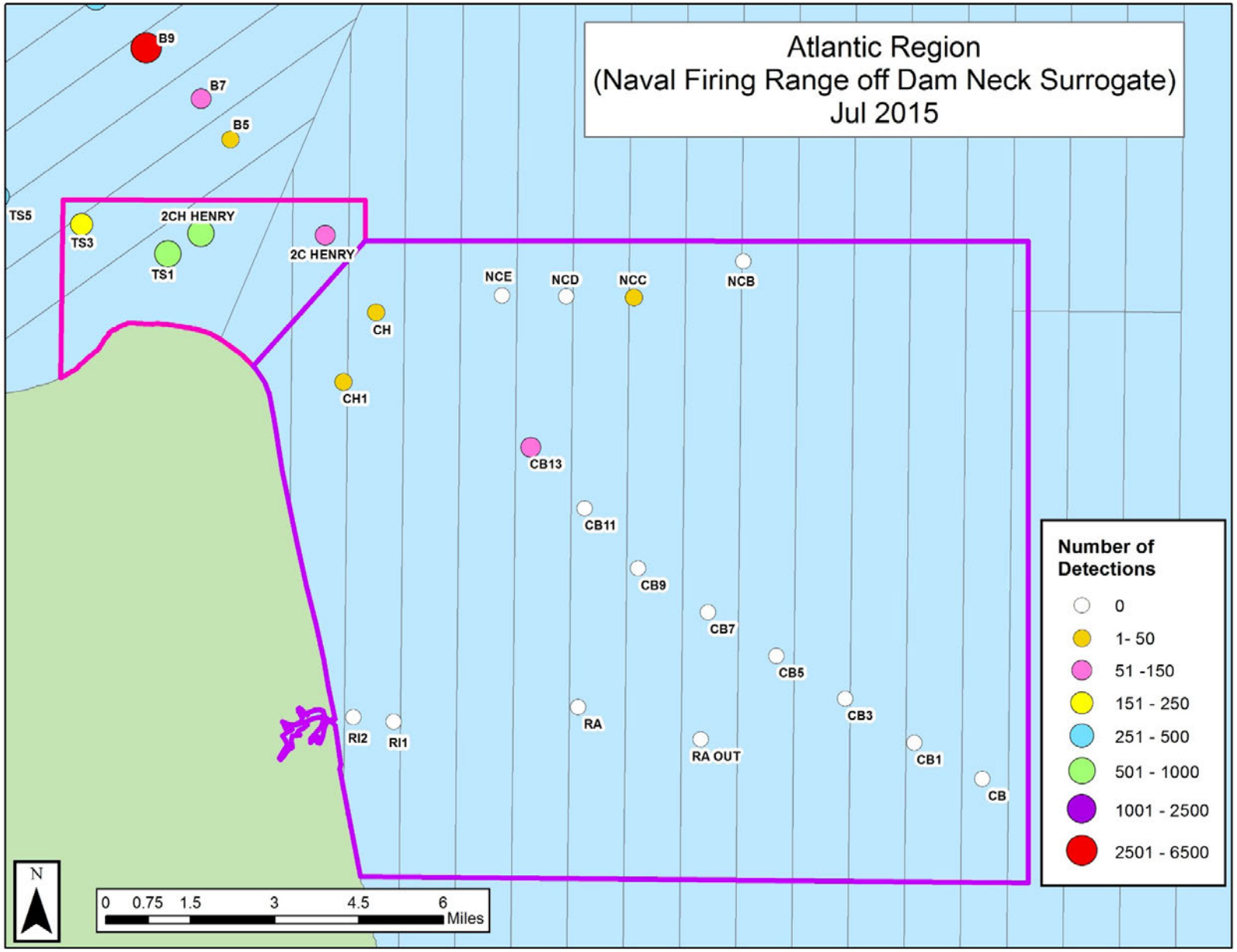
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Jul 2015
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TS5
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Number of Detections
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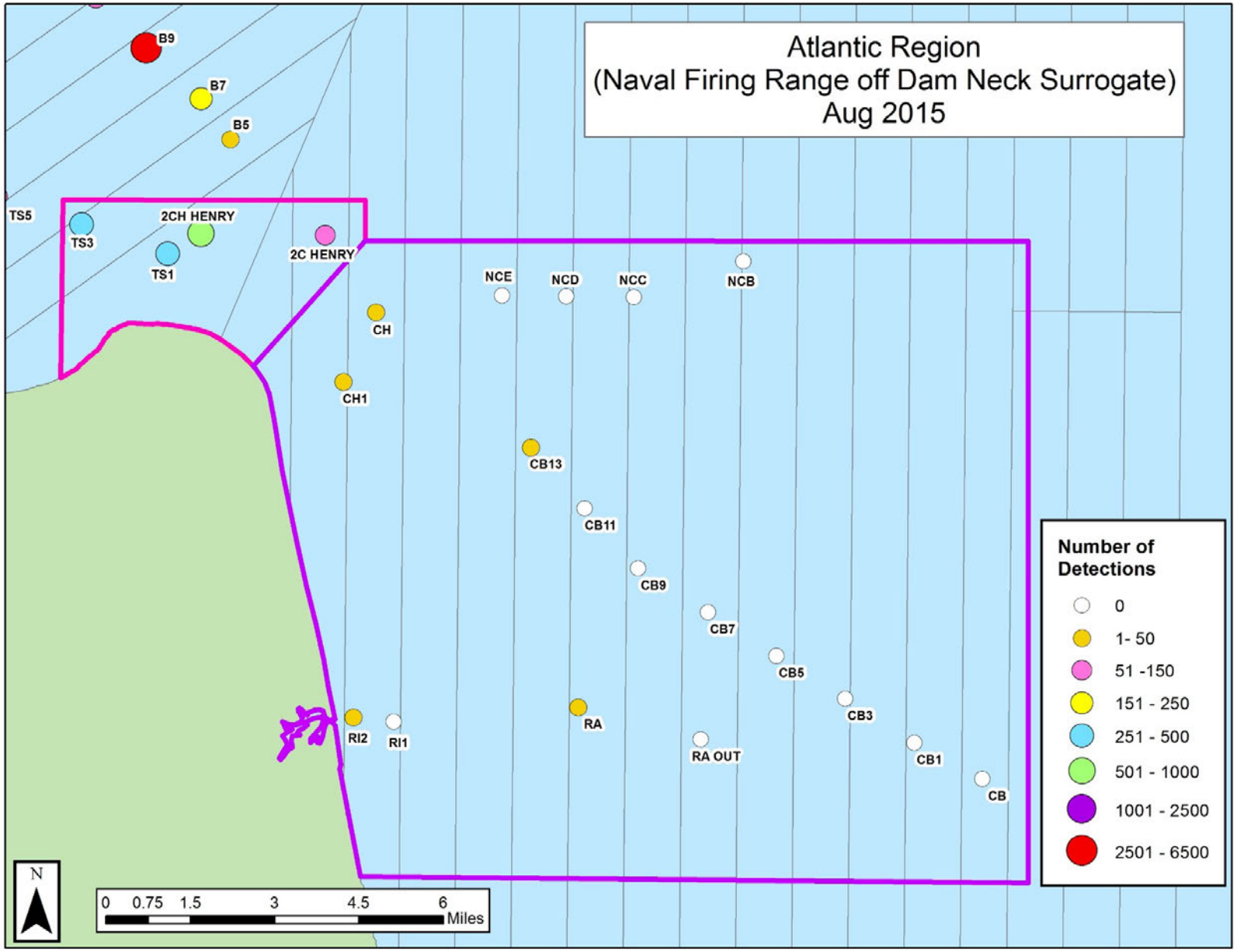
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Aug 2015
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TS5
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2C HENRY
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Number of Detections
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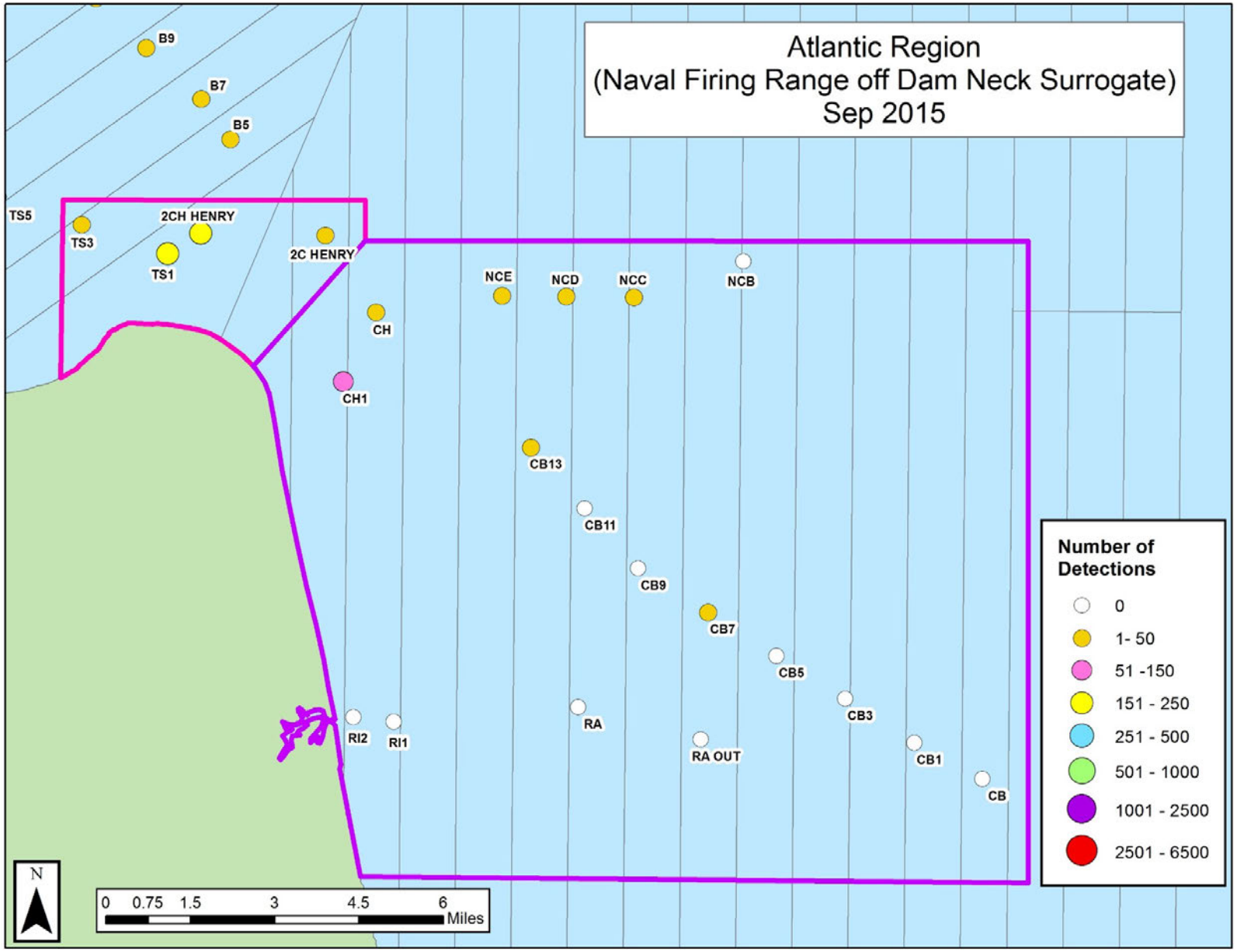
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Sep 2015
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Number of Detections
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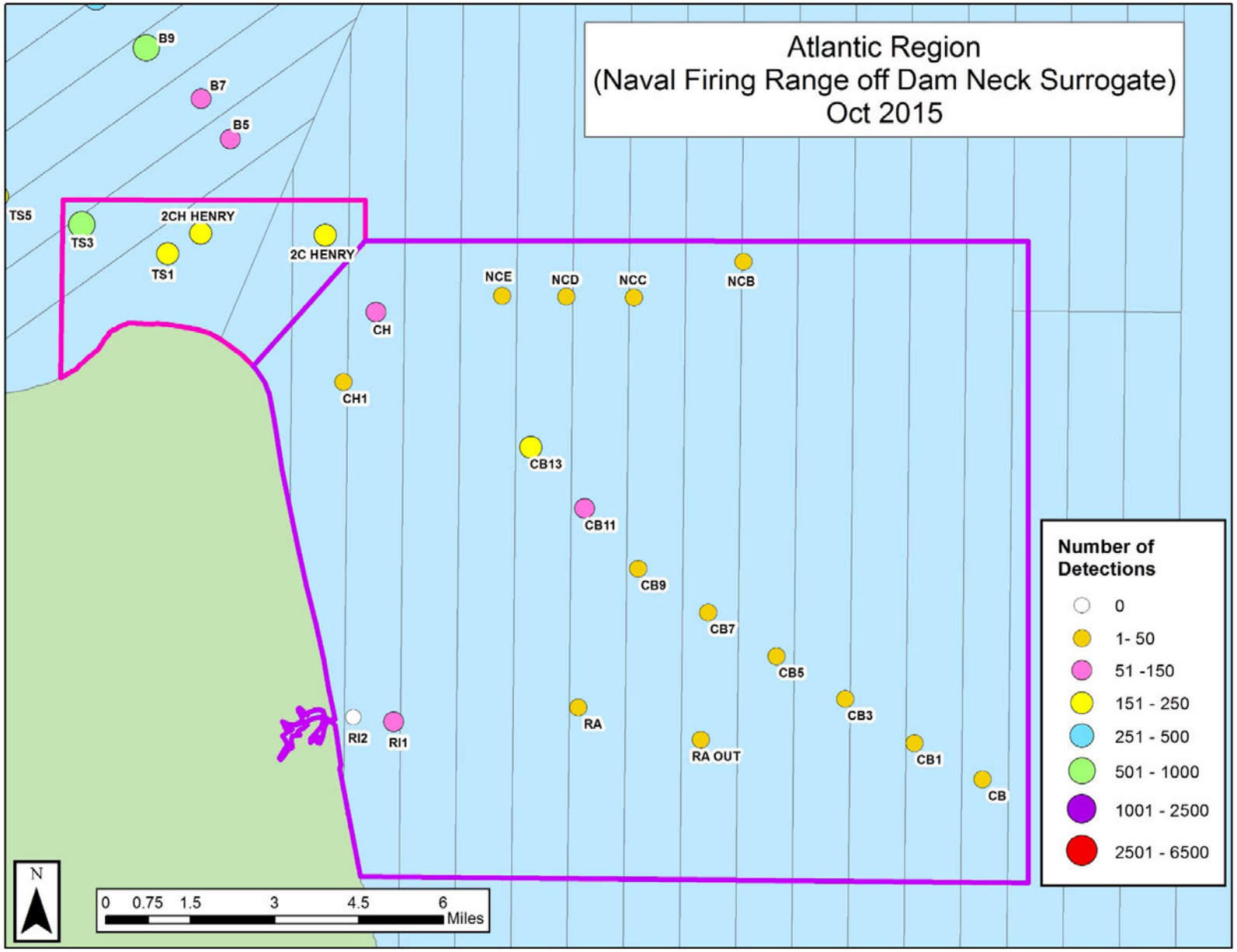
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Oct 2015
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Number of Detections
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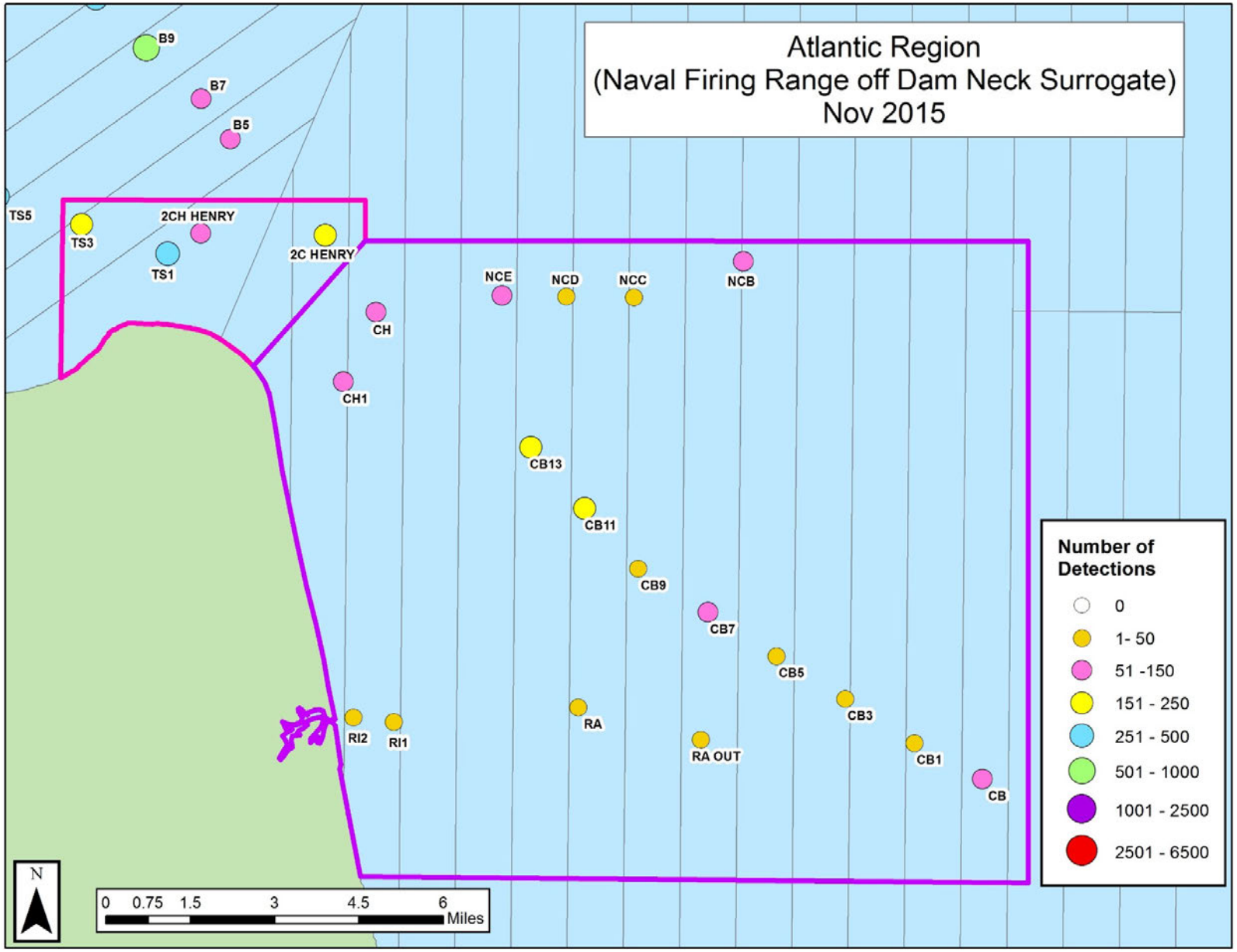
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Nov 2015
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Number of Detections
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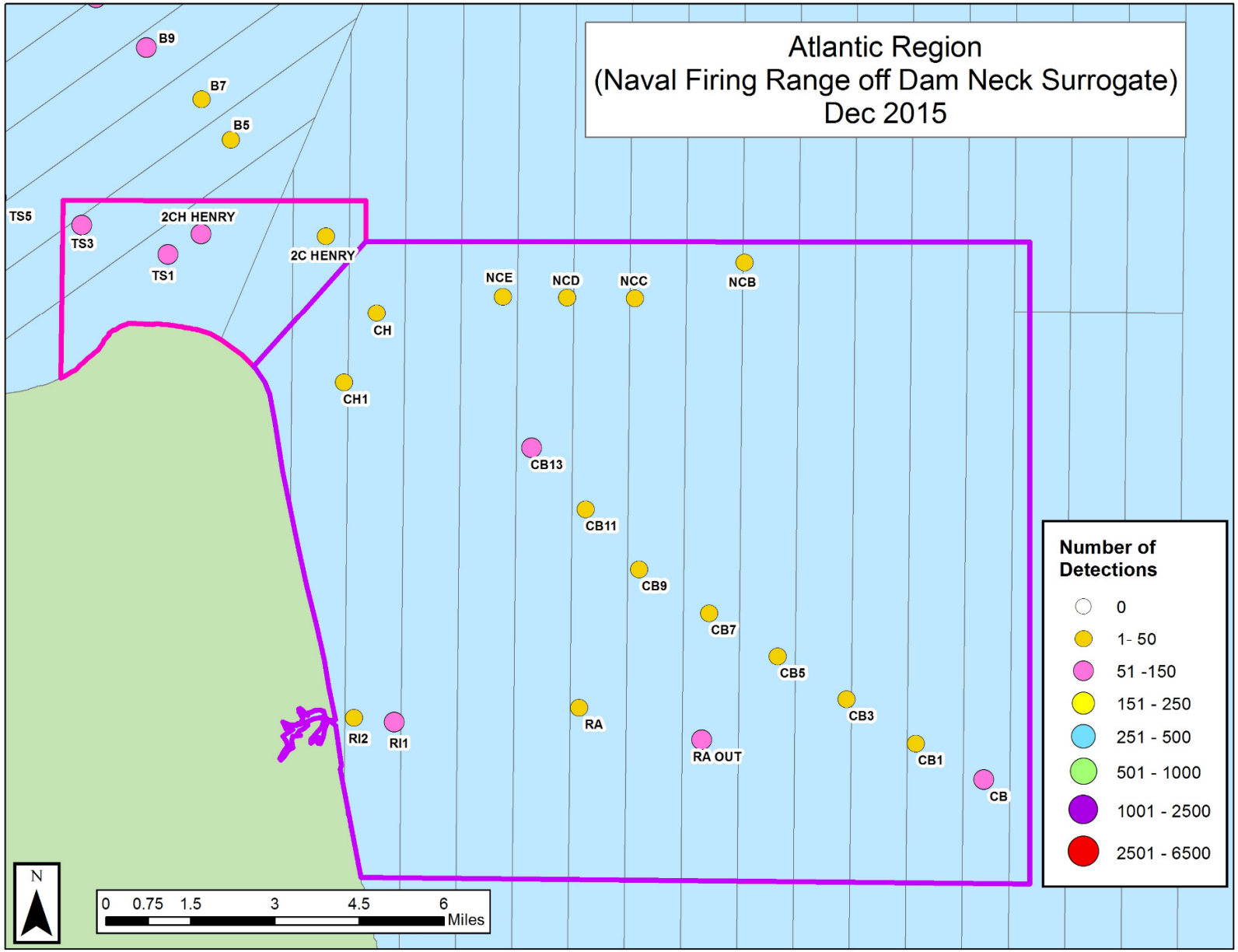
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Dec 2015
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Number of Detections
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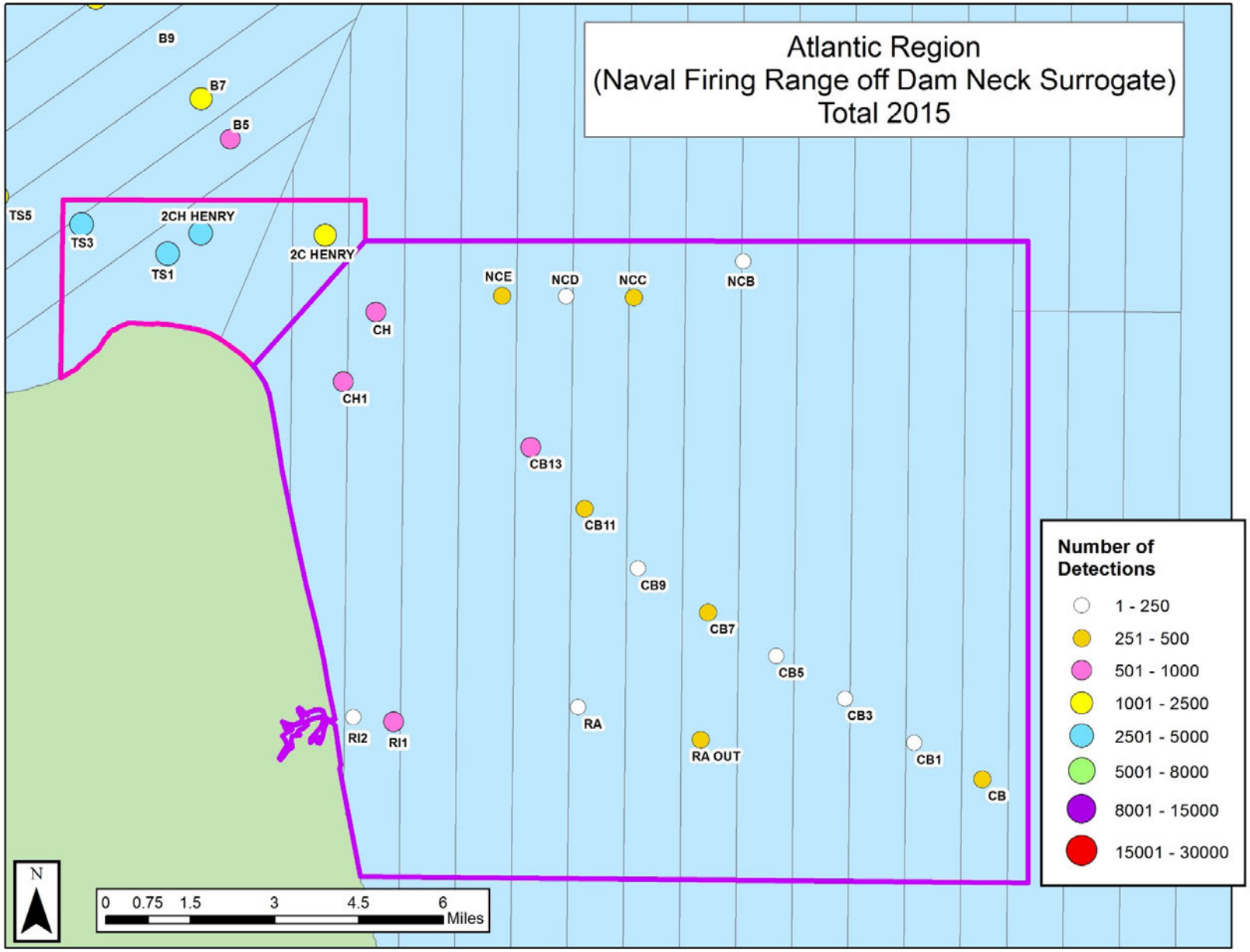
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Total 2015
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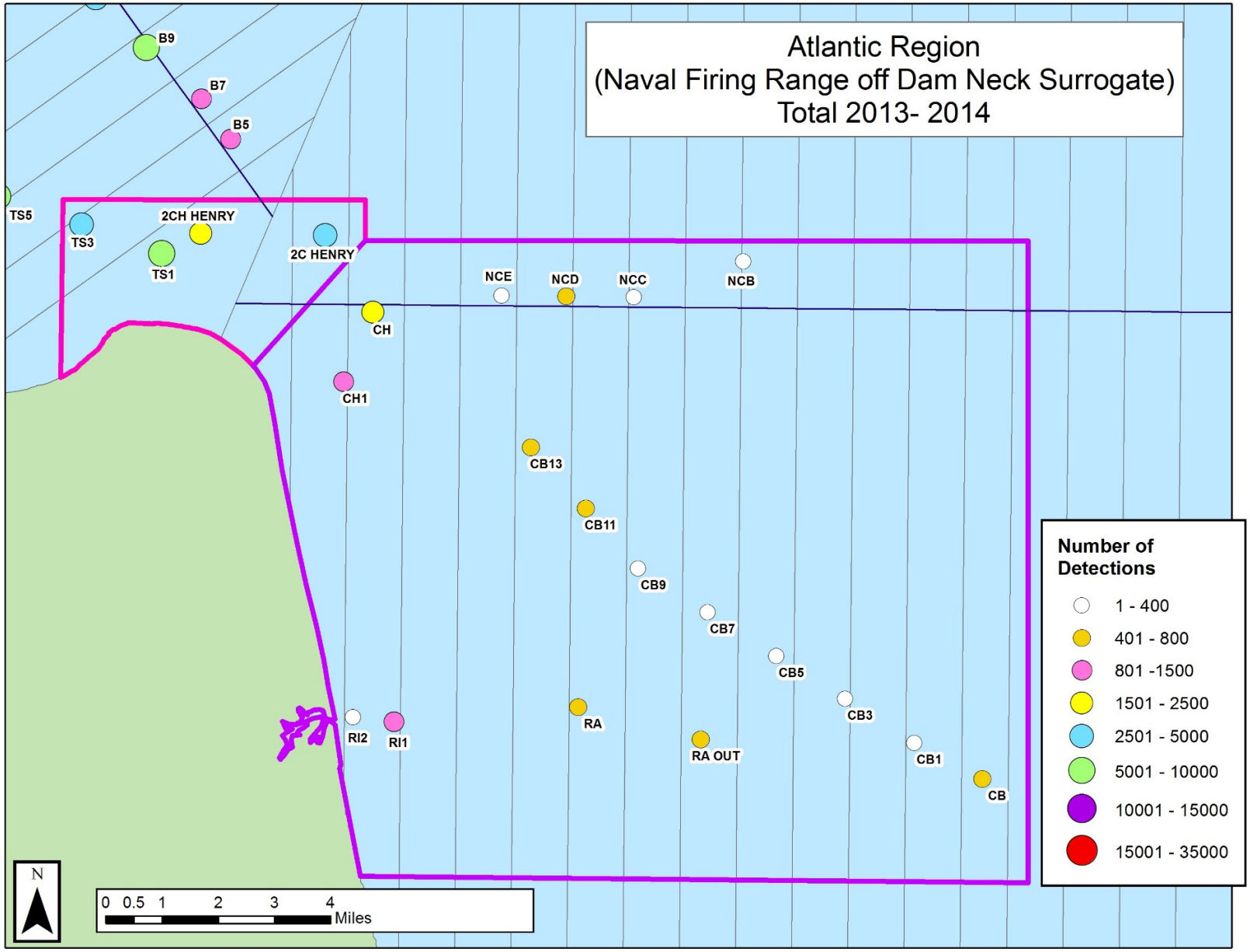
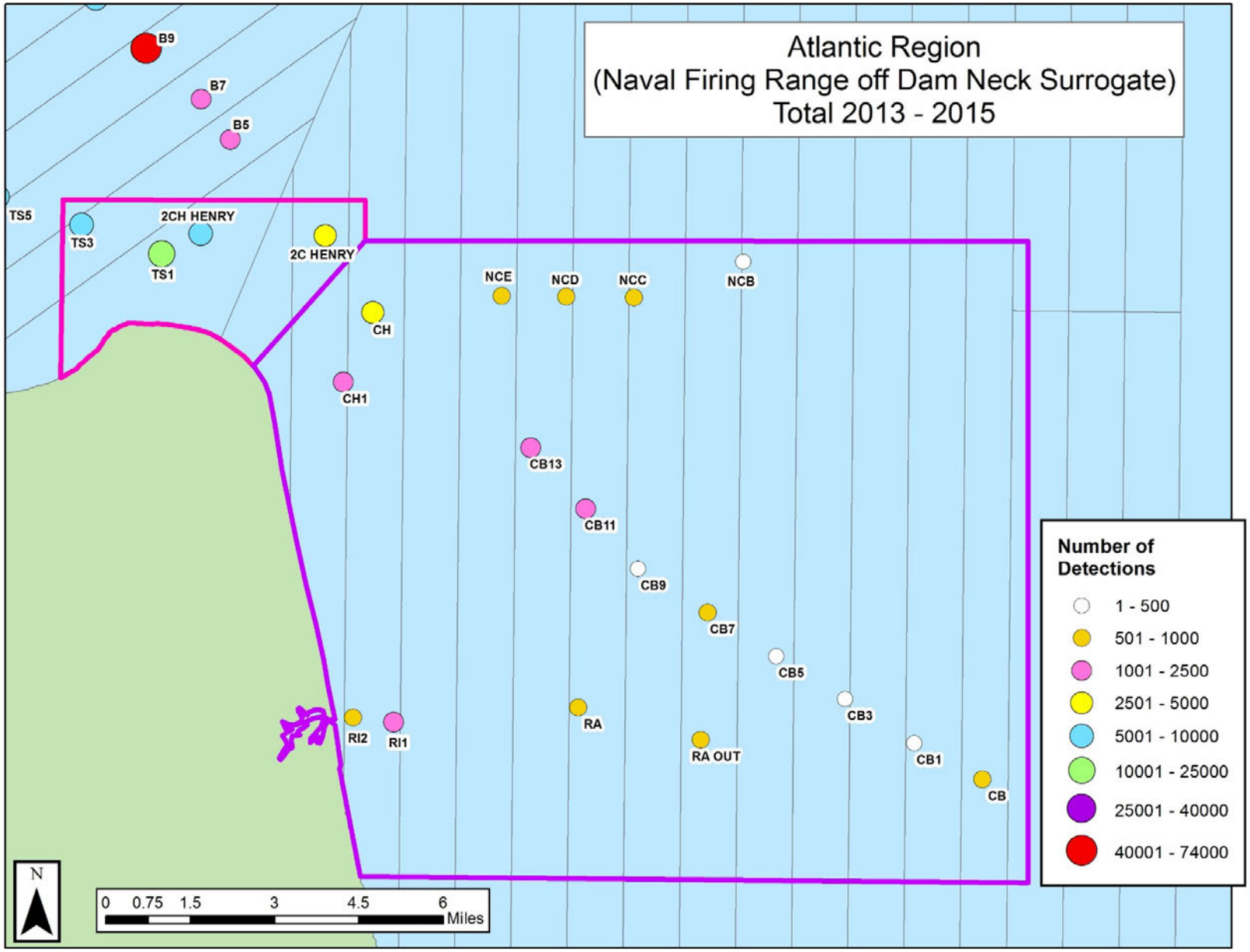
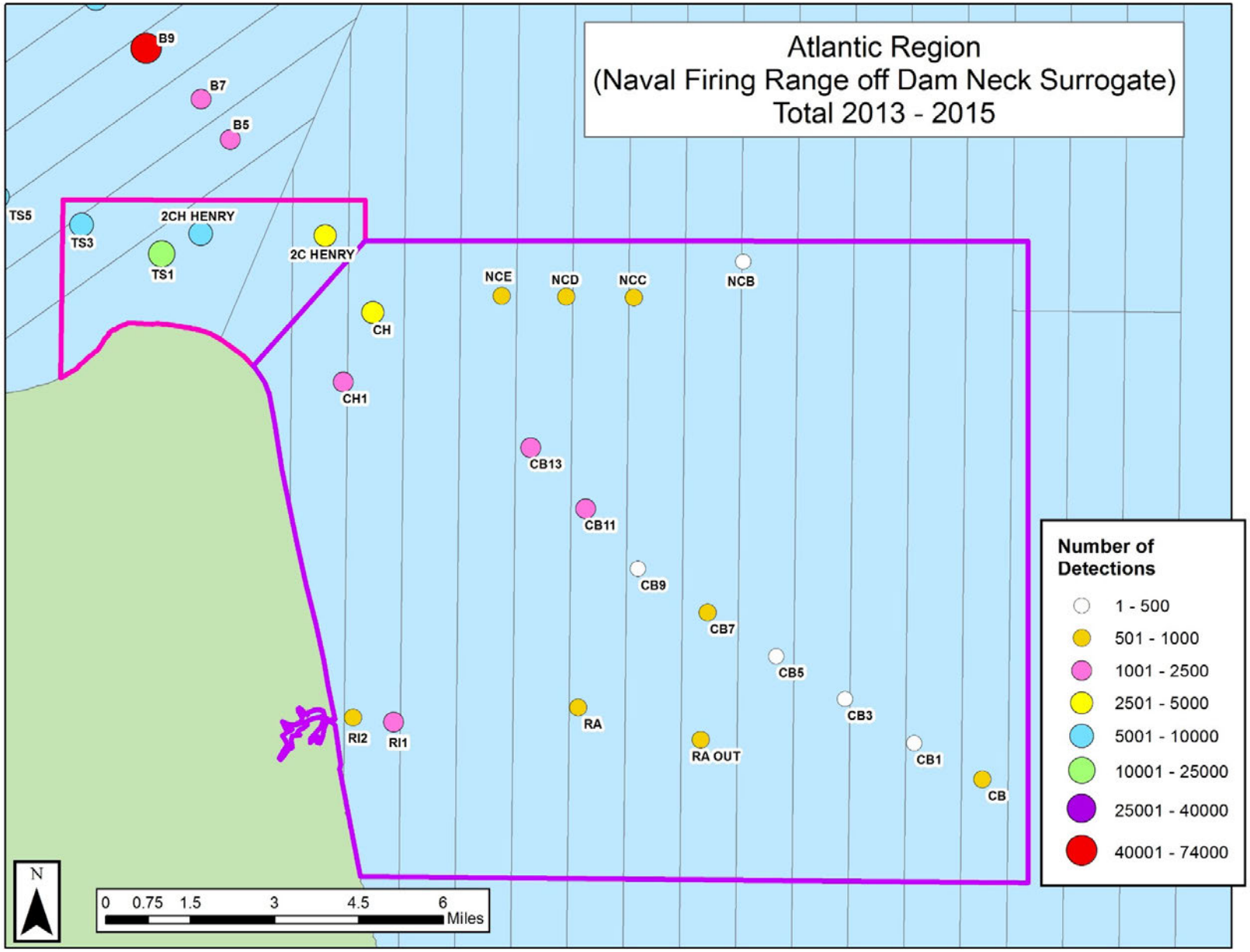
RA
RA OUT
RI2
RI1
Number of Detections
1 - 250
251 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 8000
8001 - 15000
15001 - 30000
N
0 0.75 1.5 3 4.5 6
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Total 2013- 2014
B9
B7
B5
TS5
TS3
TS1
2CH HENRY
2C HENRY
NCE
NCD
NCC
NCB
CH
CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Number of Detections
1 - 400
401 - 800
801 -1500
1501 - 2500
2501 - 5000
5001 - 10000
10001 - 15000
15001 - 35000
N
0 0.5 1 2 3 4
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Total 2013 - 2015
B9
B7
B5
TS5
TS3
2CH HENRY
TS1
2C HENRY
NCE
NCD
NCC
NCB
CH
CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Number of Detections
1 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 10000
10001 - 25000
25001 - 40000
40001 - 74000
N
0 0.75 1.5 3 4.5 6
Miles


Atlantic Region
(Naval Firing Range off Dam Neck Surrogate)
Total 2013 - 2015
B9
B7
B5
TS5
TS3
2CH HENRY
TS1
2C HENRY
NCE
NCD
NCC
NCB
CH
CH1
CB13
CB11
CB9
CB7
CB5
CB3
CB1
CB
RA
RA OUT
RI2
RI1
Number of Detections
1 - 500
501 - 1000
1001 - 2500
2501 - 5000
5001 - 10000
10001 - 25000
25001 - 40000
40001 - 74000
N
0 0.75 1.5 3 4.5 6
Miles

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# 10. TABLE APPENDIX

### Summary of monitoring for sonic-tagged sturgeon, January 2014–December 2014

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 number in the month columns is the date of maintenance. An R following this date denotes that the receiver was retrieved, D denotes deployment, B denotes broken unknown cause, W receiver wet internally, C indicates clock failure and USCG means that the buoy was replaced by the USCG and the receiver removed. The 10/1 in the September column indicates the receiver was read on October 1. Abbreviations are as follows. For regions: Pam. is Pamunkey; Chick. is Chickahominy; Eliz. is Elizabeth; and Ches. is Chesapeake and for military zones: NW/Ch. is Naval Weapons/Cheatham Annex; NSN is Naval Station Norfolk and Range Sur. is the surrogate for the Naval Firing Range Surrogate off of Dam Neck

| 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 | 9/20/2013LD10/12 | 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 | 3/29/2013/R | 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 |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| 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 | NSN | 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 | NSN | 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 | NSN | 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 | NSN | 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 | NSN | 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 | NSN | 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 | NSN | 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 | NSN | 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 | NSN | 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 | NSN | 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 | NSN | 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 | NSN | 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 360 | Pam. River | | | | | | | | | | | 9/10/2013 | 10/4/2013 | 11/5/2013 | 12/10/2013 |
| PAM [redacted] UPPER | Pam. River | | | | | | | | | | 8/20/2013 | 9/10/2013 | 10/4/2013 | 11/5/2013 | 12/10/2013 |
| PAM [redacted] | 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 BRICK WALL | Pam. River | | | | | | | | | | | 9/13/2013 | 10/4/2013 | 11/5/2013 | 12/10/2013 |
| 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 [redacted] | 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 [redacted] | 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 |

| 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 |
| CB15 | Atlantic | Range Sur. | not deployed | | | | | | | | | | | | |
| CB3 | Atlantic | Range Sur. | 1/31/2014RD | 2/20/14RCD | 3/12/2014 | 4/25/2014 | 5/7/2014 | 6/18/2014 | 7/30/2014 USCGRD | 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 | 7/30/2014 USCGRD | 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 | 7/30/2014 USCGRD | 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 | |
| NCA | Atlantic | | not deployed | | | | | | | | | | | | |
| 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 |
| B3 | Ches. Bay | Fort Story | not deployed | | | | | | | | | | | | |
| 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 |
| 11N | Ches. Bay | | not deployed | | | | | | | | | | | | |
| 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 | 7/23/2014 USCGRD | 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 | 7/23/2014 USCGRD | 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 | 7/31/2014USCGRD | 9/3/2014 | 10/3/2014USCGRD | 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 |
| NH5 | James River | NSN | not deployed | | | | | | | | | | | | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NN 1ER FWS | James River | NSN | 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 | NSN | 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 | NSN | 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 | NSN | 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 | NSN | 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 | NSN | 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 | NSN | 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 | NSN | 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 | NSN | 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 | NSN | 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 | NSN | 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. 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 | | seasonal | | | | | | | 8/11/2014D | 9/11/2014 | 10/6/2014 | 11/4/2014 | | |
| Pam. TOP 1 | Pam. River | | seasonal | | | | | | 7/26/2014D | 8/12/2014 | 9/11/2014CRD | 10/6/2014 | 11/4/2014 | | |
| Pam. rootball | Pam. River | | seasonal | | | | | | | 8/11/2014D | 9/11/2014 | 10/6/2014 | 11/4/2014 | | |
| Pam. hickory | Pam. River | | seasonal | | | | | | 7/21/2014D | 8/12/2014 | 9/11/2014 | 10/6/2014 | 11/4/2014 | | |
| Pam. farm H2O | Pam. River | | seasonal | | | | | | 7/21/201D | 8/14/2014 | 9/11/2014 | 10/6/2014 | 11/4/2014 | | |
| Pam. [redacted] 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 [redacted] | Pam. River | | seasonal | | | | | | 7/26/2014D | 8/12/2014 | 9/11/2014 | 10/6/2014 | 11/4/2014 | | |
| Pam Fossil Cliff | Pam. River | | seasonal | | | | | | 7/26/2014D | 8/12/2014 | 9/11/2014 | 10/6/2014 | 11/4/2014 | | |
| Pam. [redacted] | 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 [redacted] lower | Pam. River | | seasonal | | | | | | 7/26/2014D | 8/12/2014 | 9/11/2014 | 10/6/2014 | 11/4/2014 | | |
| Pam. [redacted] | Pam. River | | seasonal | | | | | | | | 9/5/2014D | 10/6/2014 | 11/4/2014 | | |
| Pam. poles | Pam. River | | 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 | | |
| 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. [redacted] | 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. [redacted] | 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 |
| Chick. Bridge | Chick. River | | seasonal | | | 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 |