



Summary of Amphibian Community Monitoring at Canaveral National Seashore, 2009

Natural Resource Data Series NPS/SECN/NRDS—2010/098



ON THE COVER

Clockwise from top left, *Hyla chrysoscelis* (Cope's grey treefrog), *Hyla gratiosa* (barking treefrog), *Scaphiopus holbrookii* (Eastern spadefoot), and *Hyla cinerea* (Green treefrog).

Photographs by J.D. Willson.

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Executive Summary

This report summarizes data collected with the Draft SECN Amphibian Community Monitoring Protocol (Byrne et al. *in preparation*) at Canaveral National Seashore in 2009.

- Data were collected at 22 spatially-balanced random locations at the park with two techniques: automated recording devices and visual-encounter surveys.
- Surveys were conducted at three additional non-random locations; one at the request of CANA management and two chosen by SECN staff.
- Sampling activities occurred at the park from 4/14/2009 to 4/24/2009, and again from 8/12/2009 to 9/17/2009.
- We detected 830 amphibians in 17 species, including two non-natives, and 365 reptiles and reptile signs in 11 species, including one non-native.
- Three of the amphibians detected were the first recorded occurrences at the park and additions to the species list: the non-native Cuban treefrog, and the native spring peeper and green frog.
- The ratio of the counts of native to non-native reptiles was approximately 2.5 to 1; attributable to the non-native brown anole. We consider this ratio high.
- Observed native species richness is 15 (95% CI: 11.41, 18.58) and the sample was not dominated by any one species.
- Squirrel treefrog and green treefrog were the most widely distributed amphibians at the park.
- This monitoring protocol will be implemented again at the park in 2012.
- The full dataset, and associated metadata, can be acquired from the data store at <http://science.nature.nps.gov/nrdata/>

Introduction

Overview

Amphibian populations have exhibited declines in North America and many other areas around the world. Several factors are attributable to population declines and localized extinctions. Among these factors are disease and anthropogenic stressors such as habitat loss and degradation, non-native predators, acid precipitation, altered hydrology and hydroperiod, ultraviolet radiation, and chemical contaminants (Collins and Storfer 2003). Although diseases and parasites naturally occur in amphibian populations, the effects of these influences can be exacerbated when combined with other anthropogenic stressors.

Amphibians have complex life cycles, where the immature phase often consists of an aquatic larval stage, followed by a post-metamorphic adult terrestrial stage. Slight alterations in the aquatic or terrestrial communities upon which amphibians are dependent upon can have substantial impacts on the survival, reproduction, and persistence of a species. Given their habitat requirements, anatomy, and physiology, amphibians are considered good indicators of ecological condition.

The southeastern U.S. is host to one of the most diverse amphibian communities in the world. With an estimated 140 amphibian species, more than half of which are salamanders, the Southeast accounts for about half of the total number of amphibians in the U.S (Echternacht & Harris 1993, Petranka 1998). The Southeast Coast Network (SECN) has 61 known amphibian species; 26 in Caudata (salamanders, newts, amphiumas, sirens), and 35 in Anura (frogs and toads) (NPSpecies 2010).

Given their known population declines, sensitivity to anthropogenic stressors, and the diversity of amphibians in the southeastern U.S., amphibian communities are a priority for SECN monitoring efforts.

The National Park Service Omnibus Management Act of 1998, and other reinforcing policies and regulations, require park managers “to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources” (Title II, Sec. 204). The amphibian-community monitoring data summarized herein is a tool to assist park managers in fulfilling this mandate.

This report summarizes data collected under the draft SECN Amphibian Community Monitoring Protocol (Byrne et al. *in preparation*).

Objective

- Determine trends in amphibian-species occupancy, distribution, diversity, and community composition in SECN parks.

Methods

Study Area

Canaveral National Seashore (CANA) is located on the east coast of central Florida (Figure 1). The park is approximately 57,000 acres, including Mosquito Lagoon, and the southern portion is jointly managed by the NPS and the U.S. Fish and Wildlife Service's (USFWS) Merritt Island National Wildlife Refuge. The park's natural resources include a diverse assemblage of wildlife, plant communities, geophysical features and natural processes reflecting the complexity of the land/lagoon/sea interface of east-central Florida. Mosquito Lagoon, extending along the backside of Canaveral's barrier island, is the northernmost part of the Indian River Lagoon and has been designated as an Estuary of National Significance by the Environmental Protection Agency and an Outstanding Florida Water by the State of Florida. The lagoon acts as an important nursery area for a wide variety of game and non-game species. Unlike many barrier islands, CANA has a less complex dune system separating the lagoon from the ocean and generally consists of a single primary dune, averaging 12 ft in height. The uplands consist of live-oak (*Quercus virginiana*) / sabal palm (*Sabal palmetto*) hammocks and pine flatwoods interspersed with freshwater wetlands forming a unique and diverse mosaic. The park provides habitat for 15 federally-listed species. Between 3,000 and 4,500 sea turtle nests are recorded on CANA's 24 miles of beach each year. CANA also sustains nationally-renown recreational and commercial fisheries, including finfish, oysters and clams. The park has a rich Native American occupational history and several shell middens occur at the park. Park managers work cooperatively with the USFWS to implement a prescribed-fire management plan to maintain the integrity of the fire-adapted communities at CANA.

CANA has 22 known amphibian species and 55 known reptile species (Appendix A); which includes three amphibians added to the Park's species list as a result of SECN 2009 monitoring efforts. The amphibians consist of 18 species in Anura (frogs and toads) and four species in Caudata (e.g. salamanders, newts, amphiumas, sirens). The reptiles consist of one species of Crocodilia, 38 species in Squamata (e.g. lizards, snakes, geckos, and skinks), and 16 species in Testudines (turtles).

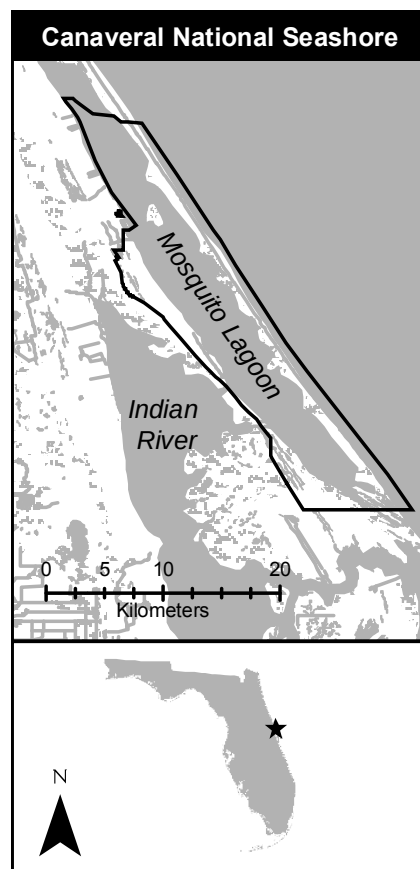


Figure 1. Location of Canaveral National Seashore

Sampling Design

A detailed explanation of the sampling design and site selection can be found in the SECN Draft Amphibian Monitoring Protocol (Byrne et al. *in preparation*) and sample site selection SOP (Byrne 2009). In summary, to allow for park-wide inference, the park's administrative boundary was used as the sampling frame. The sampling frame was divided into a systematic 0.5-ha grid; the center point of each grid cell served as the potential sampling site. A spatially-balanced sample was drawn from this grid using the Reversed Randomized Quadrant-Recursive Raster (RRQRR) algorithm (Theobald et al. 2007). Alternate points were used when selection criteria (i.e., including safety and access issues) were not met. A sample size of 30 was chosen after consideration of park size, hypothesized variability, and logistical issues regarding travel time and conducting monitoring activities in five to six park units per year. Only 22 of the 30 planned sampling points, however, were sampled in 2009 (Figure 2) due to closures related to the delayed launch of the Space Shuttle Discovery, STS-128. Therefore, three non-randomly located sites were included in the sample that targeted areas of personal and management interest. Sampling locations are presented in Figure 2.

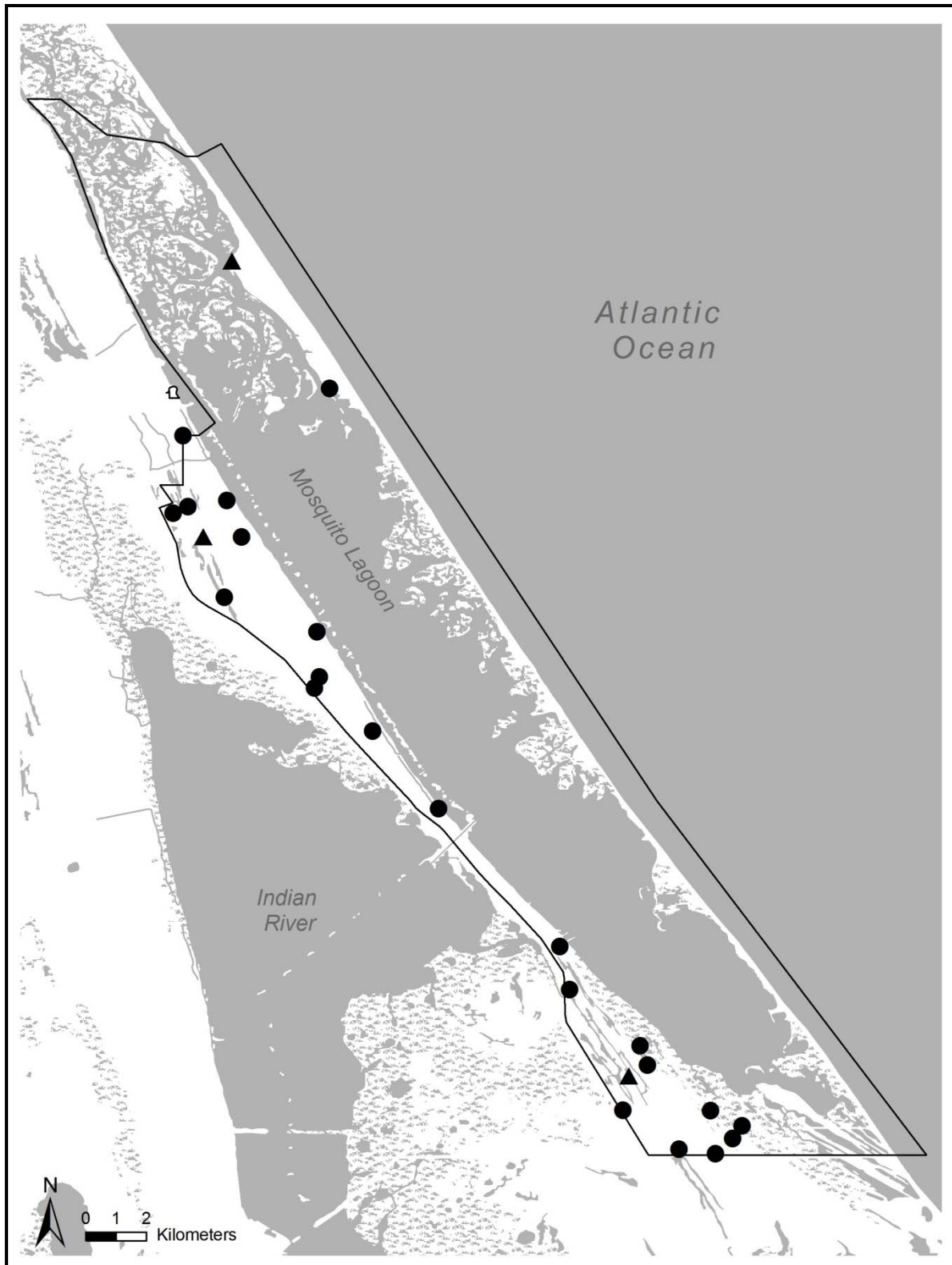


Figure 2. Spatially-balanced random (●) and non-random (▲) sampling locations at CANA, 2009.

Sampling Methodology

Three sampling techniques are used as part of SECN amphibian monitoring; a combination of active and passive sampling techniques. The active technique is a time- and area-constrained medium-intensity visual encounter survey (VES) that incorporates dip-net techniques in sampling locations with aquatic communities. All species or species sign detected by sight or sound are recorded as part of the VESs. The passive technique is an automated-recording device (ARD) programmed to record one minute every ten minutes from dusk to dawn once every three days. Use of multiple techniques, as a “toolbox” approach (Olson et al. 1997), is generally agreed to be the most effective means to monitor amphibian communities (Hutchens and DePerno 2009). These sampling techniques are described in detail in Byrne (2007a) and Byrne (2007b).

ARDs were deployed from 4/14/2009 to 4/24/2009. Of the 22 ARDs deployed, one malfunctioned and failed to record data. A total of 7040 minutes were recorded by all of the devices deployed the park. VESs were conducted from 08/12/2009 to 09/17/2009.

Data Analysis

Because this is the first year of this protocol’s implementation at the park, only the status of the elements presented in the aforementioned monitoring objective are presented; except occupancy. The data in this report are summarized and presented in three general categories: diversity, composition, and distribution. Sampling locations are presented in Figure 2, labeled locations are presented in Appendix B, and species detected at each location are presented in Appendix C.

Despite a well-trained and dedicated field crew, complete identification of all individuals encountered was not always possible due to the quick and evasive nature of many species. Species were, however identified to most refined taxonomic level possible. For example, while the surveyors are approaching a small pool surrounded by dense vegetation they catch brief glimpses of and hear several frogs dive into the pool prior to completing a full visual inspection of the individuals necessary for identification. Although the majority of these species could most likely be identified to the genus or family level (i.e., Unknown Rana or Ranidae in this instance) based upon knowledge of the site and the local fauna, a conservative estimation is used and these species are identified to Order as “Unknown Anuran”.

Although the primary purpose for implementing the aforementioned monitoring techniques as part of SECN monitoring efforts was to detect amphibians, reptiles were also encountered. It is important to note that neither VESs nor ARDs are not effective tools to survey for many reptile species, nor was the intent of VES implementation to target reptiles, but all reptile, and reptile sign detections are presented.

Diversity

Diversity is defined as “the variety and abundance of species in a defined unit of study” (Magurran 2004, p. 8). Diversity is a community property that is related to trophic structure, productivity, stability, (McIntosh 1967, McNaughton 1977), immigration / emigration (Colwell and Lees 2000), and ecological condition (i.e., ecological integrity as defined by Karr and Chu 1995). Species diversity consists of two components, the number of species (species richness) and the relative abundance of those species (species evenness / dominance) within a defined community (Margalef 1958, Lloyd and Ghelardi 1964, Pielou 1996). Species diversity is often

communicated in the form of diversity indices. The term community refers to the assemblage of species populations that occur together in space and time (Begon et al. 1986), and we consider the Park as a whole community as per the conceptual ecological models presented in our monitoring plan (see Chapter 2 in DeVivo et al. 2008).

Because diversity indices respond differently to various mechanisms that influence community change, several indices must be used to adequately characterize diversity in SECN parks (Haedrick 1975, Boyle et al. 1984). After careful appraisal of advantages and disadvantages of the many diversity indices, a suite of alpha diversity indices were selected to summarize these data (Table 1), where alpha diversity is the diversity of species within a defined area, community, or ecosystem (Whittaker 1972).

Species diversity estimates are based only on amphibian observations identified to the species level, as they were the primary target of this monitoring effort. Non-native amphibians were not included in diversity estimates. As previously mentioned, the methodologies used for amphibians are inadequate for the reptile community; therefore diversity indices generated for reptiles would be biased and were not calculated.

Composition

Measures of community composition are often good indicators of abiotic variability, disturbance, or other stressors. Summaries related to sample composition include the total number of individuals and species detected, and proportional abundances of each species in the overall sample. Frequency of occurrence estimates are calculated for all species detected. Counts were also pooled across non-native species to generate frequency of occurrence estimates for all non-natives. Ratios of the individual counts of native to non-native species are also presented. Summaries of composition are presented for all amphibians, reptiles, and reptile sign (e.g., snake skin) detected.

Distribution

The distribution of species on Park lands is integral to informed management. Further, changes in species distributions over time provides useful information regarding possible unseen influences that alter wildlife-habitat use and may be indicative of other issues. This section presents maps of all sampling locations where each amphibian, reptile, and reptile sign was detected.

Table 1. Diversity indices used, corresponding symbol, community attribute the index reflects, the range of index values, and notes on each index.

Index	Symbol	Community Attribute	Index Citation	Notes
Native Spp. Richness	S_{obs}	Richness	n/a	Value is a positive integer that indicates the number of native species in the sample. Intuitive. Good discriminant ability if sampling effort is comparable; sensitive to sample size, the occurrence of rare species, or those with low detectability; does not account for relative abundances.
Chao 1	Chao1	Richness	Chao (1984) Chao (1987)	Values indicate an estimate of species richness; abundance-based estimate; works well with dataset containing several infrequent observations ^a .
Chao 2	Chao2	Richness	Chao (1984) Chao (1987)	Values indicate an estimate of total species richness (including species not present in the sample); incidence-based estimate; works well with dataset containing several infrequent observations ^a .
Abundance-based Coverage	ACE	Richness	Chao and Lee (1992) Chazdon et al. (1998)	Values indicate an estimate of species richness; abundance-based estimate.
Incidence-based Coverage	ICE	Richness	Lee and Chao (1994) Chazdon et al. (1998)	Values indicate an estimate of total species richness (including species not present in the sample); incidence-based estimate.
Jackknife 1	Jack1	Richness	Burnham and Overton (1978) Burnham and Overton (1979) Heltsh and Forrester (1983)	Values indicate an estimate of total species richness (including species not present in the sample); incidence-based estimate; The higher the value the higher the species richness. This procedure requires no assumptions regarding the data distribution.
Jackknife 2	Jack2	Richness	Smith and van Bell (1984)	Values indicate an estimate of species richness; incidence-based estimate.
Bootstrap	Boot	Richness	Smith and van Bell (1984)	Values indicate an estimate of species richness; incidence-based estimate.
Fisher's α	α	Richness	Fisher et al. (1943)	Value is a positive integer and indicates a relative estimate of species richness; good discriminant ability, low sensitivity to sample size, and robust to deviations in the assumed distribution ^{b, c, d, e} ; abundance-based estimate.

Index	Symbol	Community Attribute	Index Citation	Notes
Q Statistic	Q	Richness	Kempton and Taylor (1976) Kempton and Taylor (1978)	Value is a positive integer and indicates a relative estimate of species richness. Good discriminant ability and low bias with small samples ^f , model fit is irrelevant to index performance ^g ; value is not weighted towards abundant or rare species; abundance-based estimate.
Smith and Wilson	E_{var}	Evenness	Smith and Wilson (1996)	Values range from 0 (no evenness) to 1 (perfectly even and all species exists in relatively equal abundance); weighs common species more heavily than rare species (desirable in certain cases).
Smith and Wilson 1/D	E_{1/D}	Evenness	Smith and Wilson (1996) Simpson (1949)	Values range from 0 (no evenness) to 1 (perfectly even and all species exists in relatively equal abundance); weighs rare and abundant species equally (desirable in certain cases).
Camargo	E'	Evenness	Camargo (1992)	Values range from 0 (no evenness) to 1 (perfectly even and all species exists in relatively equal abundance); performs well estimating intermediate values of evenness than the other indices; weighs rare and abundant species equally (desirable in certain cases).
Gini	E_G	Evenness	Gini (1912)	Values range from 0 (no evenness) to 1 (perfectly even and all species exists in relatively equal abundance); Good discriminant ability and low sensitivity to sample size ^h ;
Berger-Parker	D_{BP}	Dominance	Berger and Parker (1970)	Values range from 0 (no single-species dominance) to 1 (sample is strongly dominated by a single species); describes the proportional dominance of the single most abundant species; low sensitivity to sample size but poor discriminant ability ⁱ – not used for across year or site comparisons.

^a(Chao 1984), ^b(Kempton 2002), ^c(Kempton and Taylor 1974), ^d(Hayek and Buzas 1997), ^e(Wolda 1983), ^f(Kempton and Wedderburn 1978), ^g(Magurran 1988),
^h(Lexerød and Eid 2006), ⁱ(Magurran 2004)

Results

Diversity

Diversity indices calculated for these data were selected to reflect community composition (i.e., number of species) and structure (i.e., number of individuals), which include species richness and evenness estimates (Table 2). Confidence intervals for each of the diversity index were estimated with a bootstrap procedure. A brief explanation of interpreting the value is presented in Table 1.

Rank-abundance plots, frequency distributions, and other descriptive approaches were used to explore the abundance distributions and patterns in the dataset, and evaluate the utility of select indices and abundance equitability among species. The data are fit well by both log-series and log-normal abundance models; $\chi^2=0.1669$, $df=3$, $p=0.9828$ and $\chi^2=0.1903$, $df=3$, $p=0.9791$, respectively. The species accumulation curve generated from the data asymptotes at approximately 19 samples (i.e., less than the total number of samples collected of 22), validating the sample size as effective in characterizing amphibian diversity at the park.

Estimates of amphibian species richness across indices are consistent with one another (i.e., 15.00 – 19.73) and species richness is moderate ($\alpha=2.66$, $Q=2.69$) (Table 2). The amphibian community does not appear to be even (E_{var} , $E_{1/D}$, E' , E_G), nor is it dominated by one species (D_{BP}). Because 2009 monitoring efforts were the first for this vital sign, these values will serve as a baseline to which to compare when the park is sampled again.

Table 2. Amphibian alpha-diversity estimates at CANA, 2009.

Index	Symbol	Value	Lower 95% CI	Upper 95% CI	Value Interpretation
Native Spp. Richness	S_{obs}	15.00	na	na	Number of native species detected
Chao 1	Chao1	15.33	15.01	20.96	Estimated true species richness
Chao 2	Chao2	16.43	15.14	29.48	Estimated true species richness
Abundance-based Coverage	ACE	15.93	14.70	17.16	Estimated true species richness
Incidence-based Coverage	ICE	16.90	15.37	18.43	Estimated true species richness
Jackknife 1	Jack1	17.86	14.78	20.94	Estimated true species richness
Jackknife 2	Jack2	19.72	16.78	22.66	Estimated true species richness
Bootstrap	Boot	16.30	15.26	17.34	Estimated true species richness
Fisher's α	α	2.66	2.09	3.23	Baseline value, suggests medium diversity
Q Statistic	Q	2.69	1.80	3.19	Baseline value, suggests medium diversity
Smith and Wilson	E_{var}	0.189	0.164	0.243	Species occur in a variety of relative abundances – low evenness
Smith and Wilson 1/D	E_{1/D}	0.251	0.238	0.315	Species occur in a variety of relative abundances – low evenness
Camargo	E'	0.267	0.256	0.326	Species occur in a variety of relative abundances – low evenness
Gini	E_G	0.265	0.249	0.331	Species occur in a variety of relative abundances – low evenness
Berger-Parker	D_{BP}	0.424	0.390	0.454	Sample is not dominated by a single species

Composition

Amphibians

We detected 830 amphibians in 22 species or genera, including two non-natives (Appendix A). The ARDs detected 14 amphibian species at CANA, including two new additions to the CANA species list (Appendix A), *Osteopilus septentrionalis* (Cuban treefrog) and *Pseudacris crucifer* (spring peeper). The VESs detected 15 amphibian species, 11 reptile species, and were responsible for adding one new amphibian species to the CANA species list (Appendix A), *Rana clamitans* (green frog). *Osteopilus septentrionalis* (Cuban treefrog) was also detected with this technique.

The majority of the overall sample was composed of squirrel treefrog, Eastern narrow-mouthed toad, and green treefrog (Figure 3). The frequency of occurrence for amphibians detected during 2009 sampling effort is presented in Table 3. Frequency of occurrence provides insight into the abundance of detected species across the park and whether a species is commonly or uncommonly encountered; however this is strongly influenced by a species' detectability as more-easily detected species may be more frequently encountered (and vice versa). Squirrel treefrog and green treefrog were the most frequently encountered species (i.e., 0.86 and 0.73, respectively), followed by Southern toad (0.45), Eastern narrow-mouthed toad (0.41), pine woods treefrog (0.41), and oak toad (Table 3). The least frequently encountered species were green frog, barking treefrog, and spring peeper (i.e., all at 0.05) (Table 3). The frequency of occurrence of non-native amphibians at CANA is 0.64 (Cuban treefrog and greenhouse frog) (Table 3). The ratio of the total counts of native amphibians to non-native amphibians is 415:28.

Reptiles

We detected 365 reptiles and reptile signs in 16 species or genera, including one non-native. The majority of the sample was composed of green anole, brown anole, and active/inactive gopher tortoise burrows (Figure 4). The frequency of occurrence for reptiles detected during 2009 sampling effort is presented in Table 4. The frequency of occurrence of non-native reptiles (brown anole) is 0.36. The ratio of the total counts of native reptiles to non-native reptiles is 261:104.

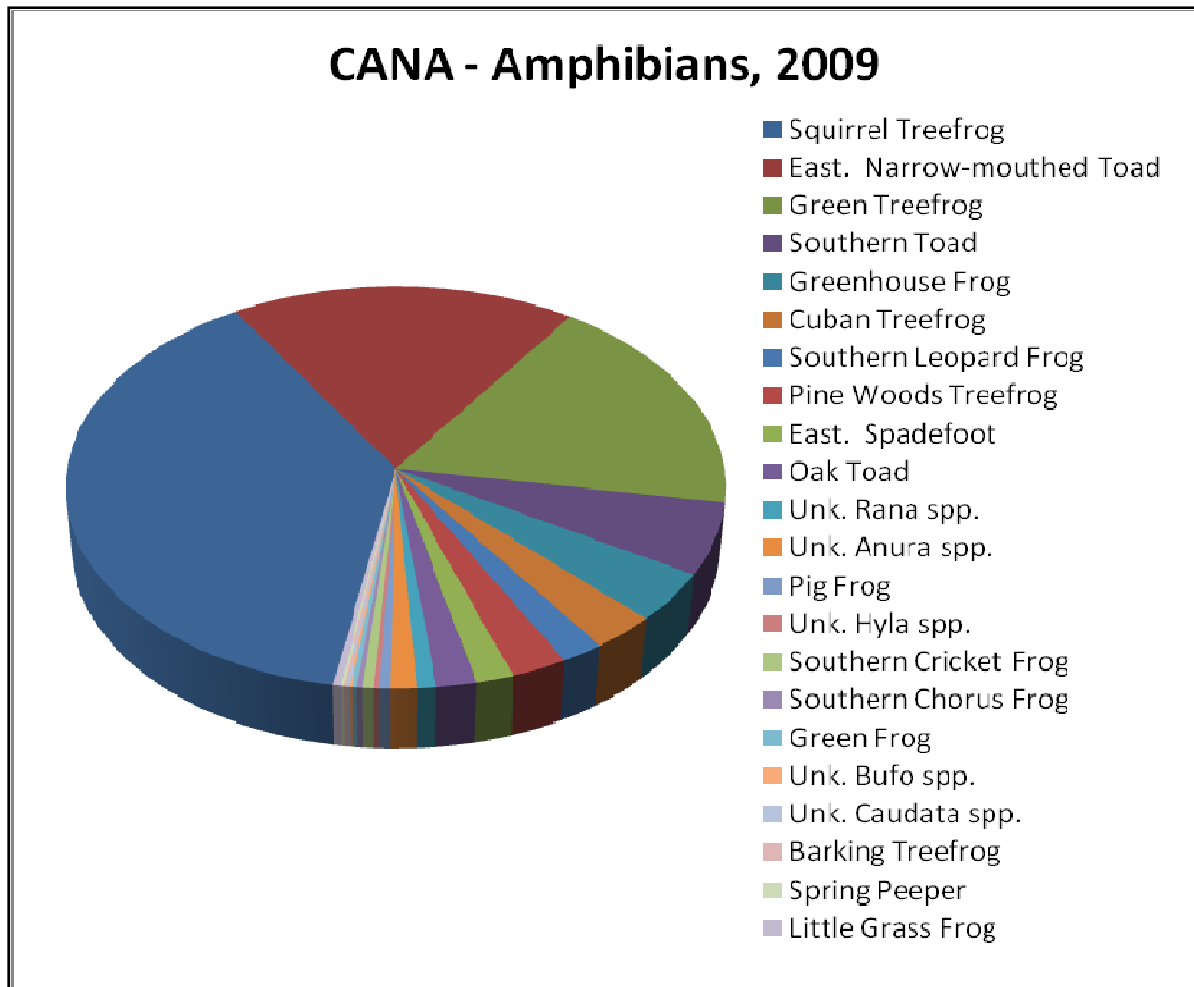


Figure 3. Proportions of amphibian species in the 2009 CANA sample.

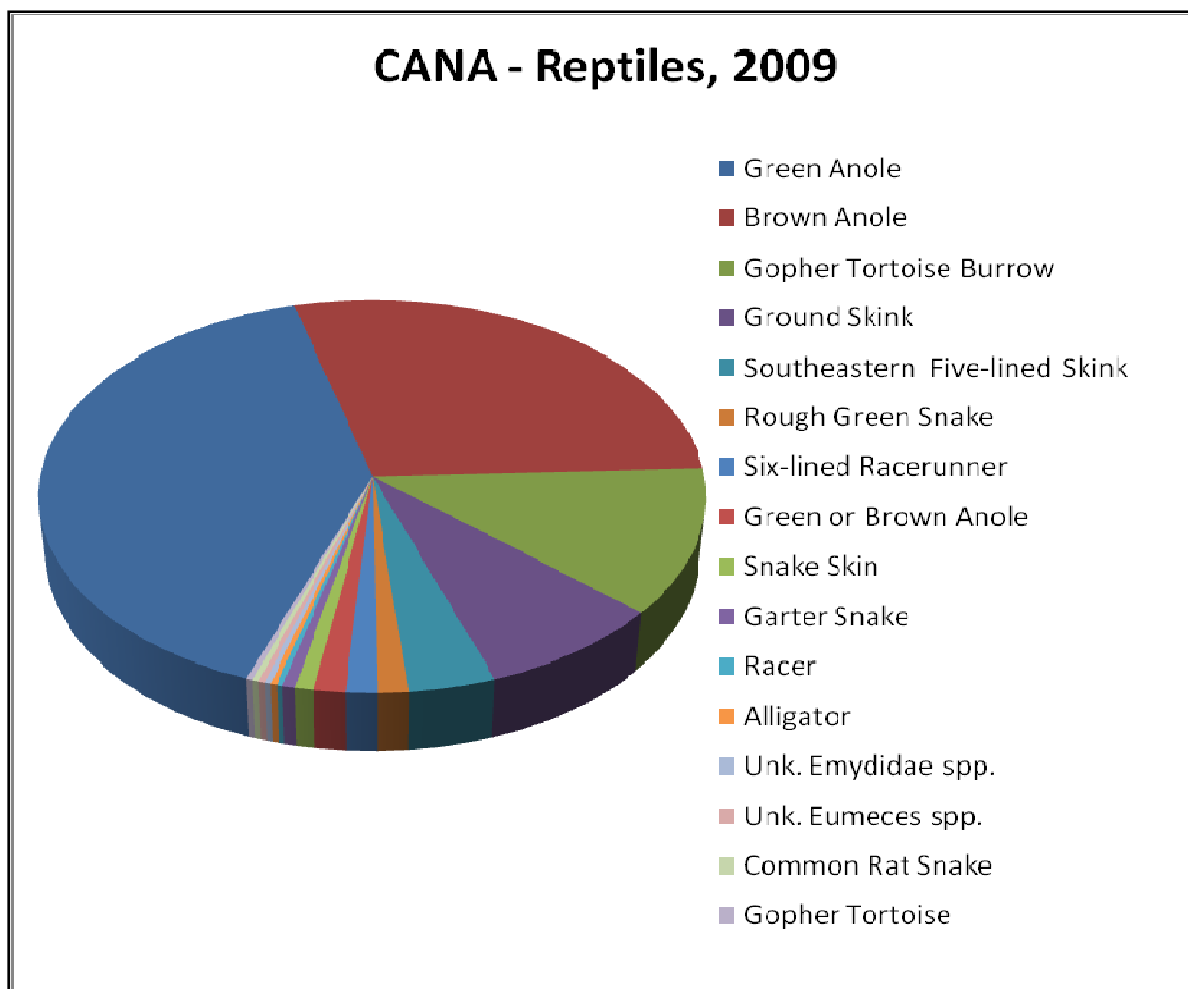


Figure 4. Proportion of reptile species and reptile signs in the 2009 CANA sample.

Table 3. Frequency of occurrence of amphibians at CANA, 2009.

Common Name	Frequency of Occurrence
Squirrel Treefrog	0.86
Green Treefrog	0.73
Southern Toad	0.45
Eastern Narrow-mouthed Toad	0.41
Pine Woods Treefrog	0.41
Oak Toad	0.41
Greenhouse Frog	0.36
Cuban Treefrog	0.27
Eastern Spadefoot	0.27
Unk. Anura spp.	0.27
Southern Leopard Frog	0.18
Pig Frog	0.18
Unk. <i>Rana</i> spp.	0.14
Southern Cricket Frog	0.14
Little Grass Frog	0.14
Unk. <i>Hyla</i> spp.	0.09
Southern Chorus Frog	0.09
Green Frog	0.05
Unk. <i>Bufo</i> spp.	0.05
Unk. Caudata spp.	0.05
Barking Treefrog	0.05
Spring Peeper	0.05

Table 4. Frequency of occurrence of reptiles and reptile sign at CANA, 2009.

Common Name	Frequency of Occurrence
Green Anole	0.91
Brown Anole	0.36
Southeastern Five-lined Skink	0.36
Gopher Tortoise Burrow	0.27
Ground Skink	0.23
Green or Brown Anole	0.23
Rough Green Snake	0.14
Six-lined Racerunner	0.14
Snake Skin	0.09
Garter Snake	0.05
Racer	0.05
Alligator	0.05
Unk. <i>Emydidae</i> spp.	0.05
Unk. <i>Eumeces</i> spp.	0.05
Common Rat Snake	0.05
Gopher Tortoise	0.05

Distribution

Amphibians

Squirrel treefrog was the most widely distributed native species (Figure 12), followed by green treefrog (Figure 7) and Southern toad (Figure 5). Barking treefrog was only encountered in the northwest part of the park (Figure 9), while green frog was only detected at one location in the eastern portion of the park south of Eldora (Figure 17). Although spring peeper (Figure 14) and little grass frog (Figure 16) were only encountered in the southern part of the park, most the remaining species appear distributed across the park. Greenhouse frog was the most widely distributed non-native species (Figure 15). Species lists for each sampling location are in Appendix C.

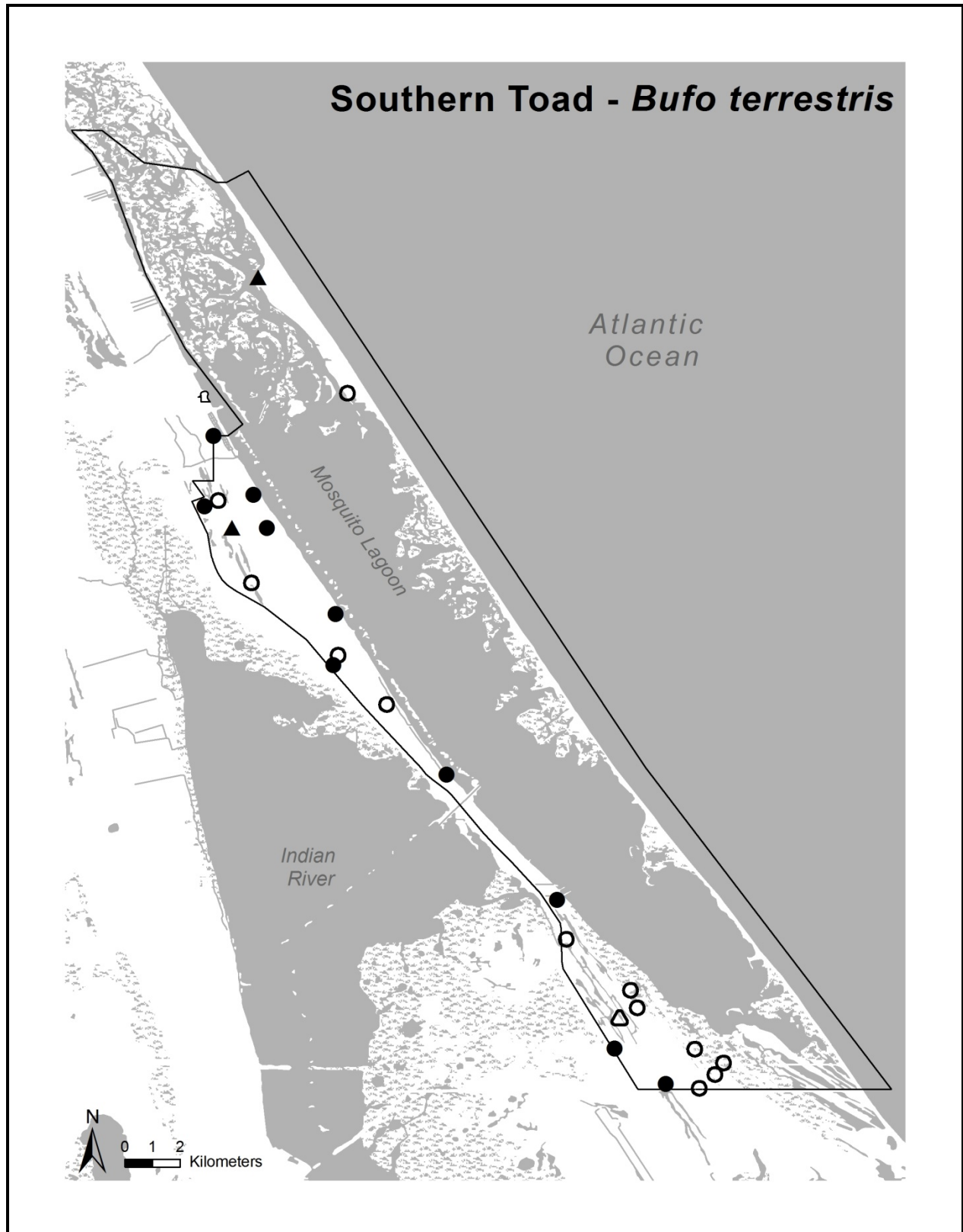


Figure 5. Sampling locations where Southern toad (*Bufo terrestris*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

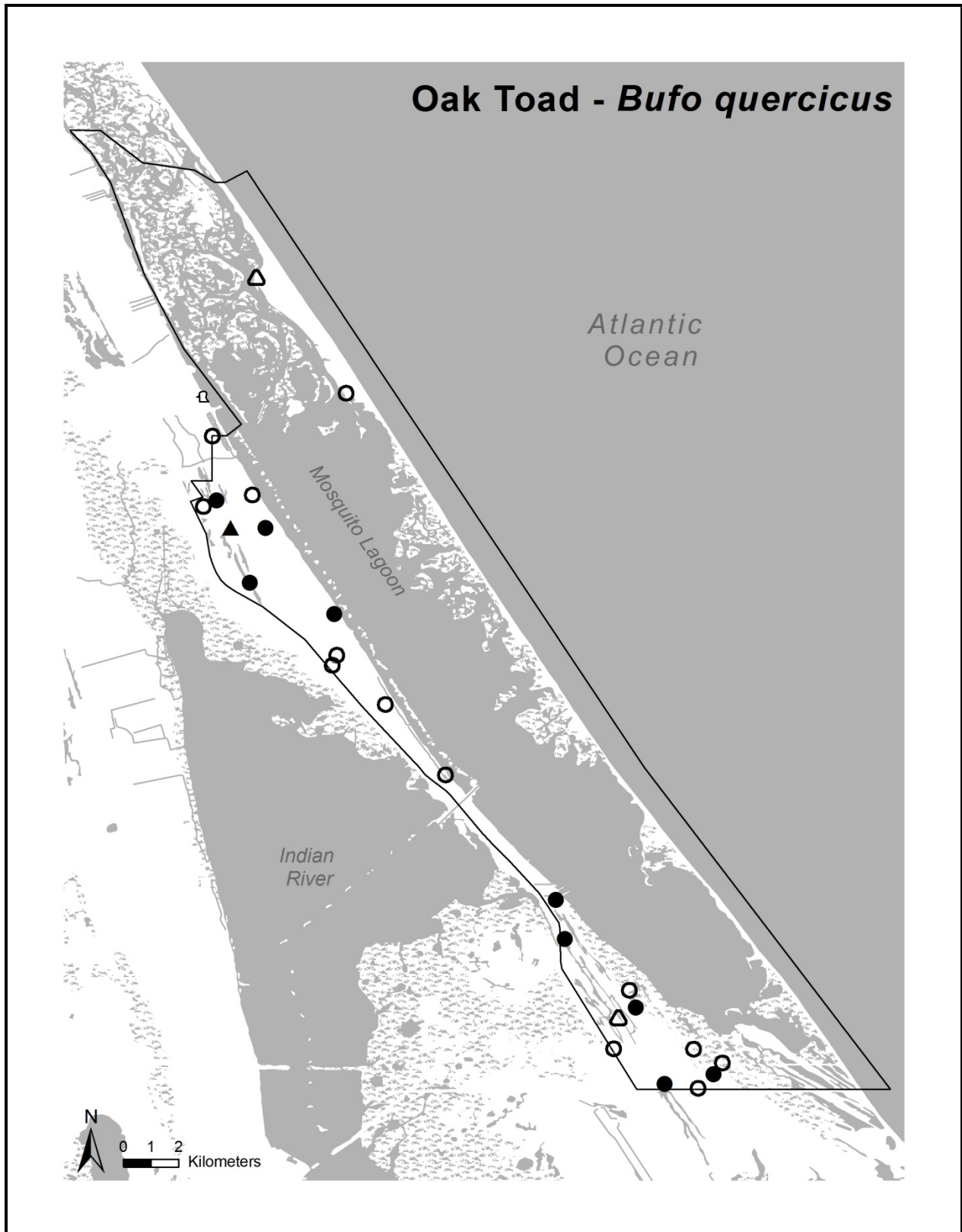


Figure 6. Sampling locations where oak toad (*Bufo quercicus*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

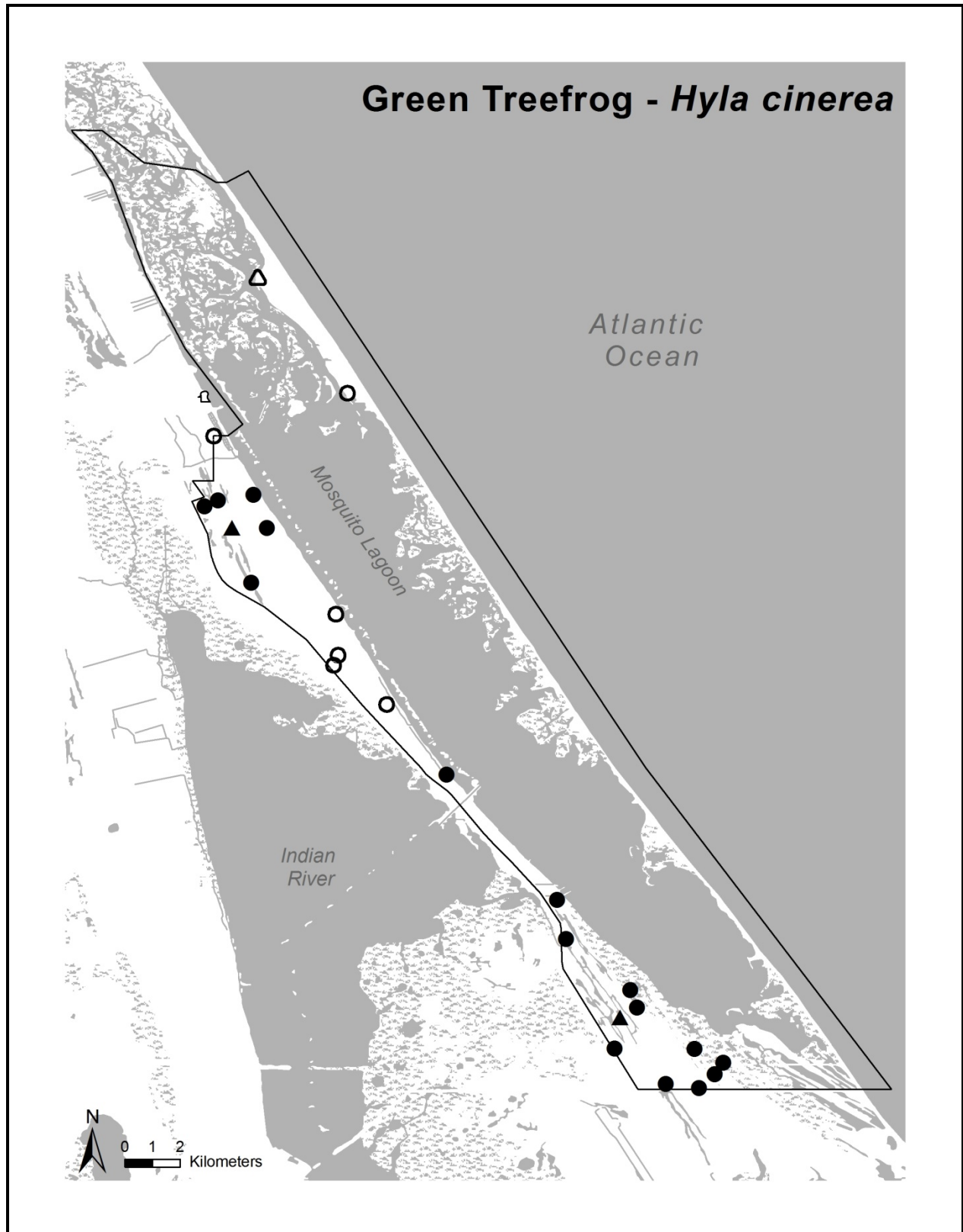


Figure 7. Sampling locations where green treefrog (*Hyla cinerea*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

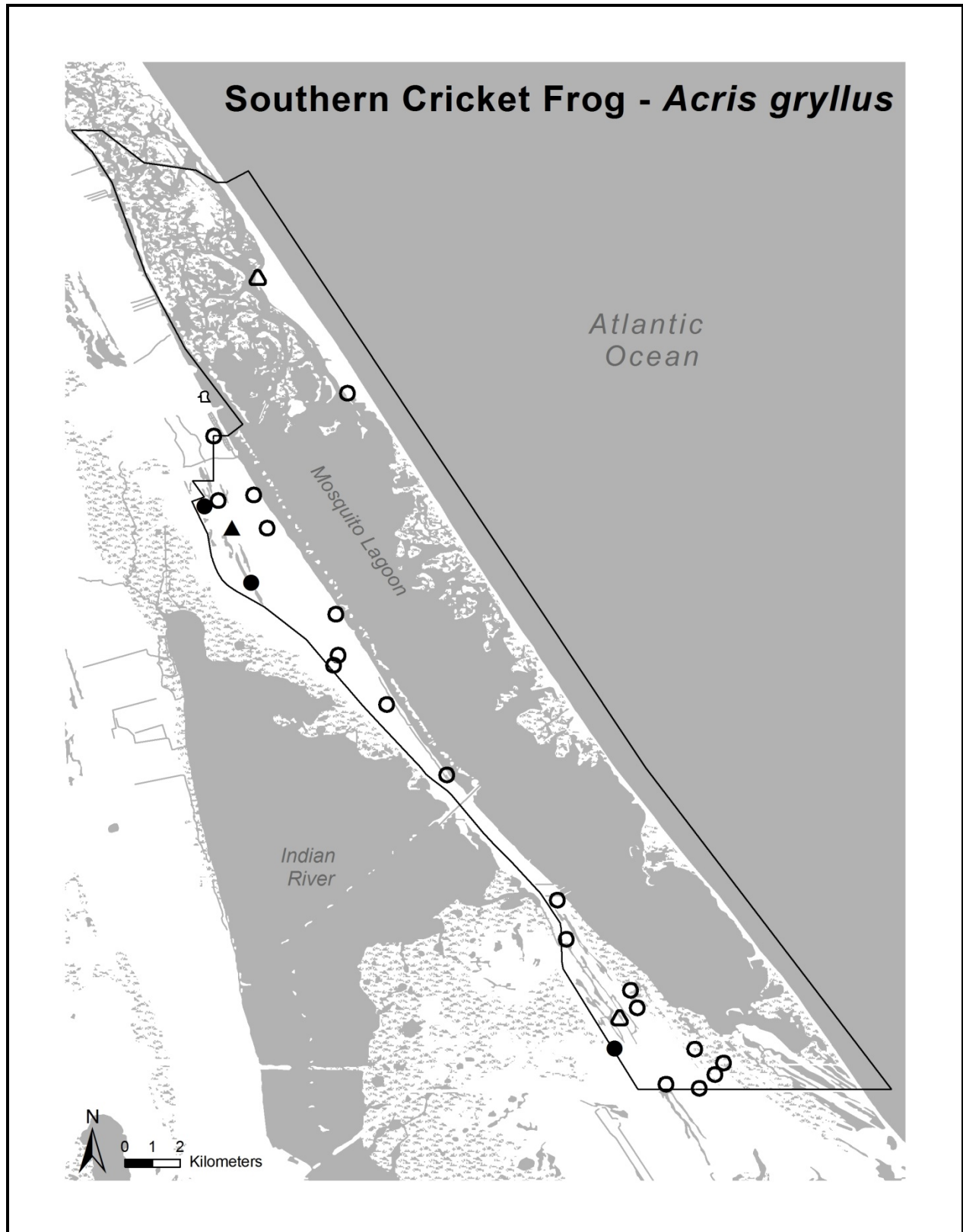


Figure 8. Sampling locations where Southern cricket frog (*Acris gryllus*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

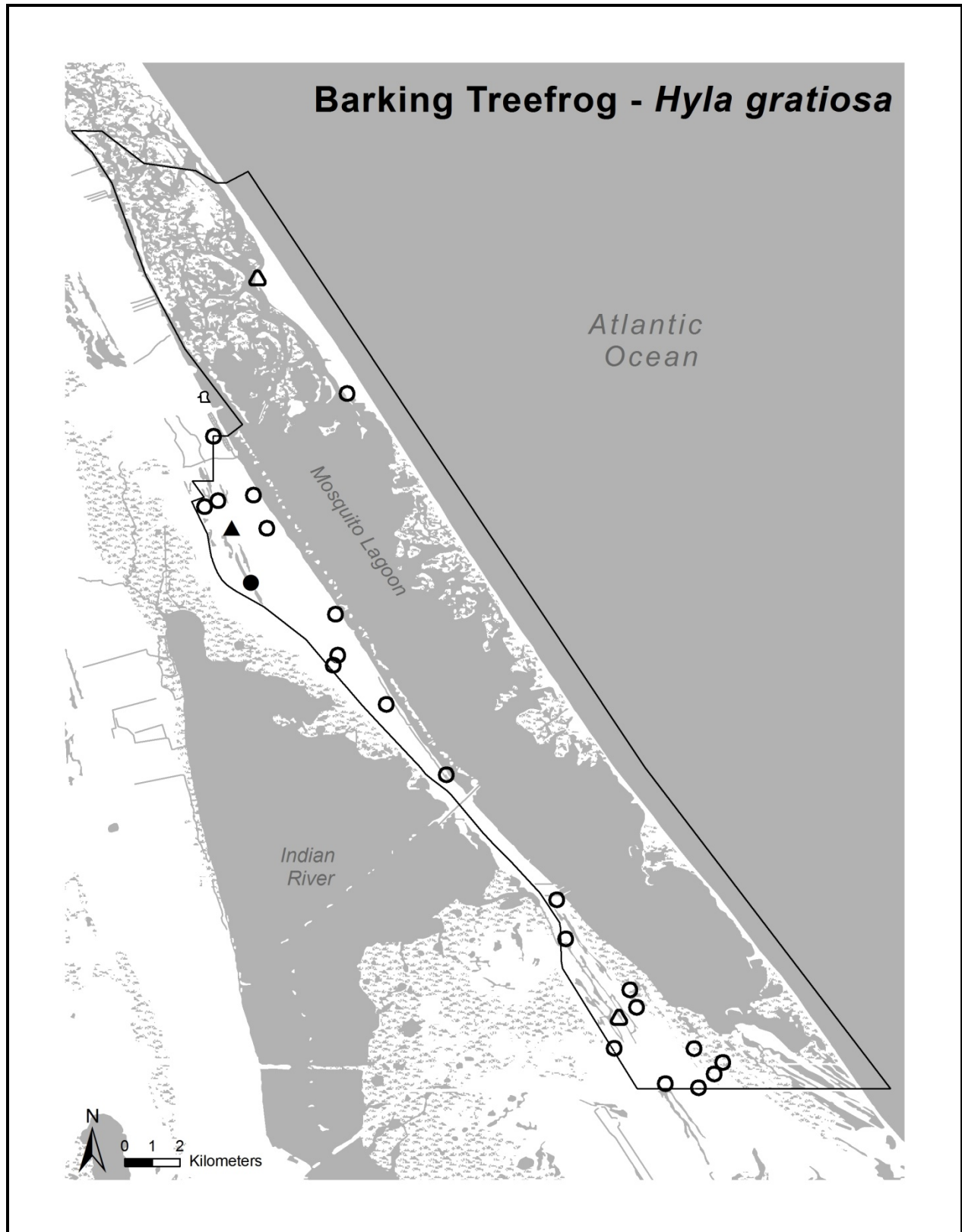


Figure 9. Sampling locations where barking treefrog (*Hyla gratiosa*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

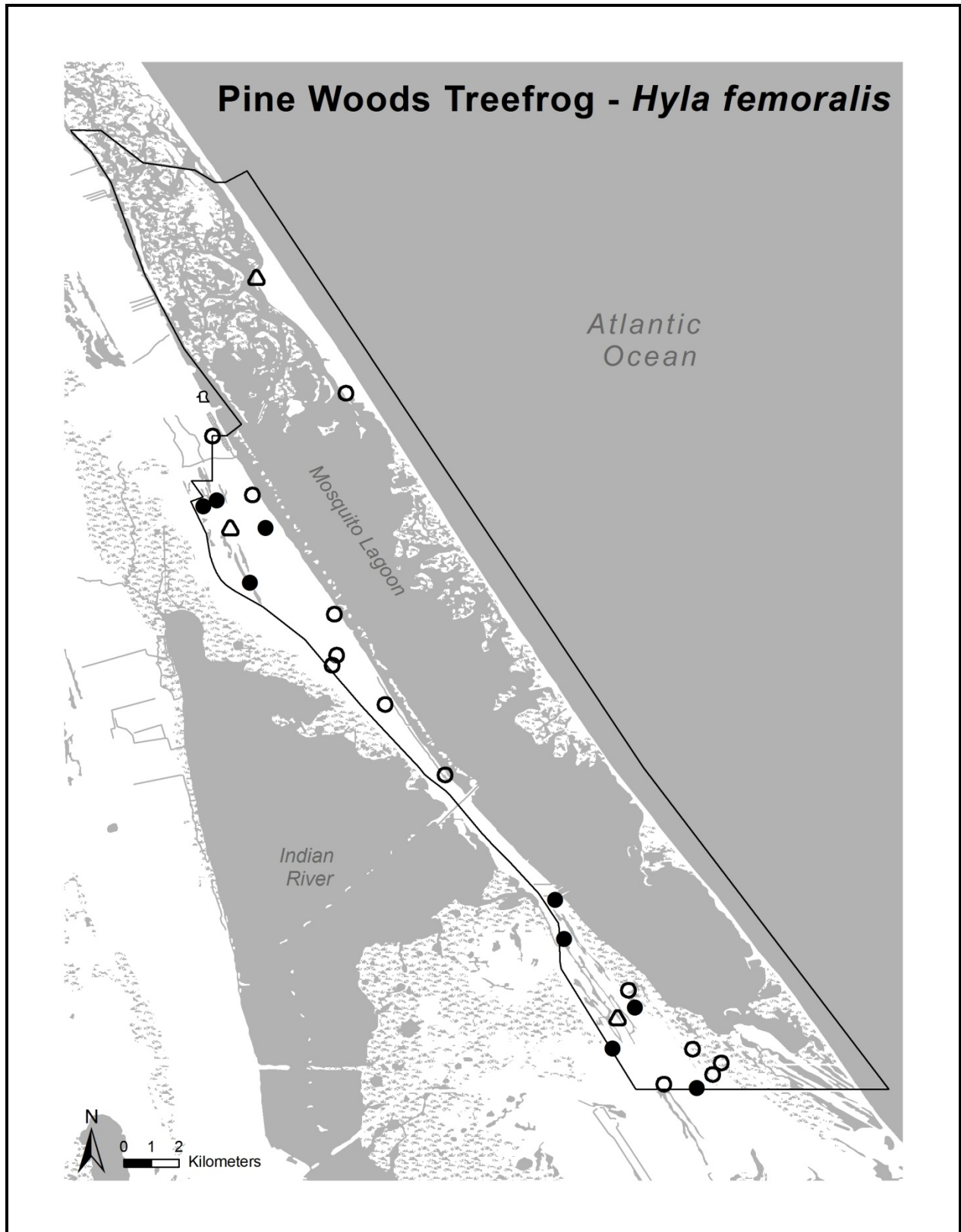


Figure 10. Sampling locations where pine woods treefrog (*Hyla femoralis*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

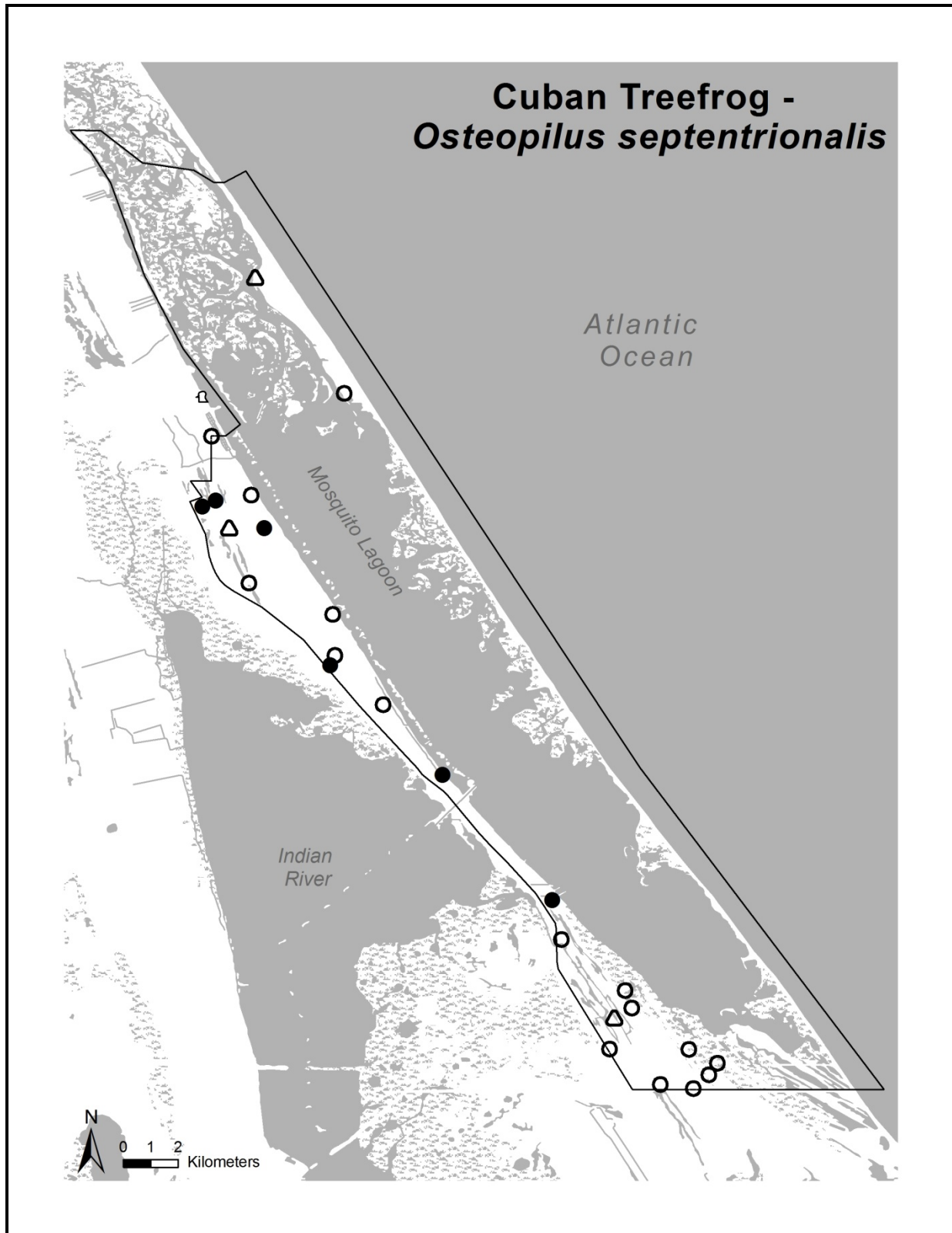


Figure 11. Sampling locations where Cuban treefrog (*Osteopilus septentrionalis*) was detected at Canaveral National Seashore, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

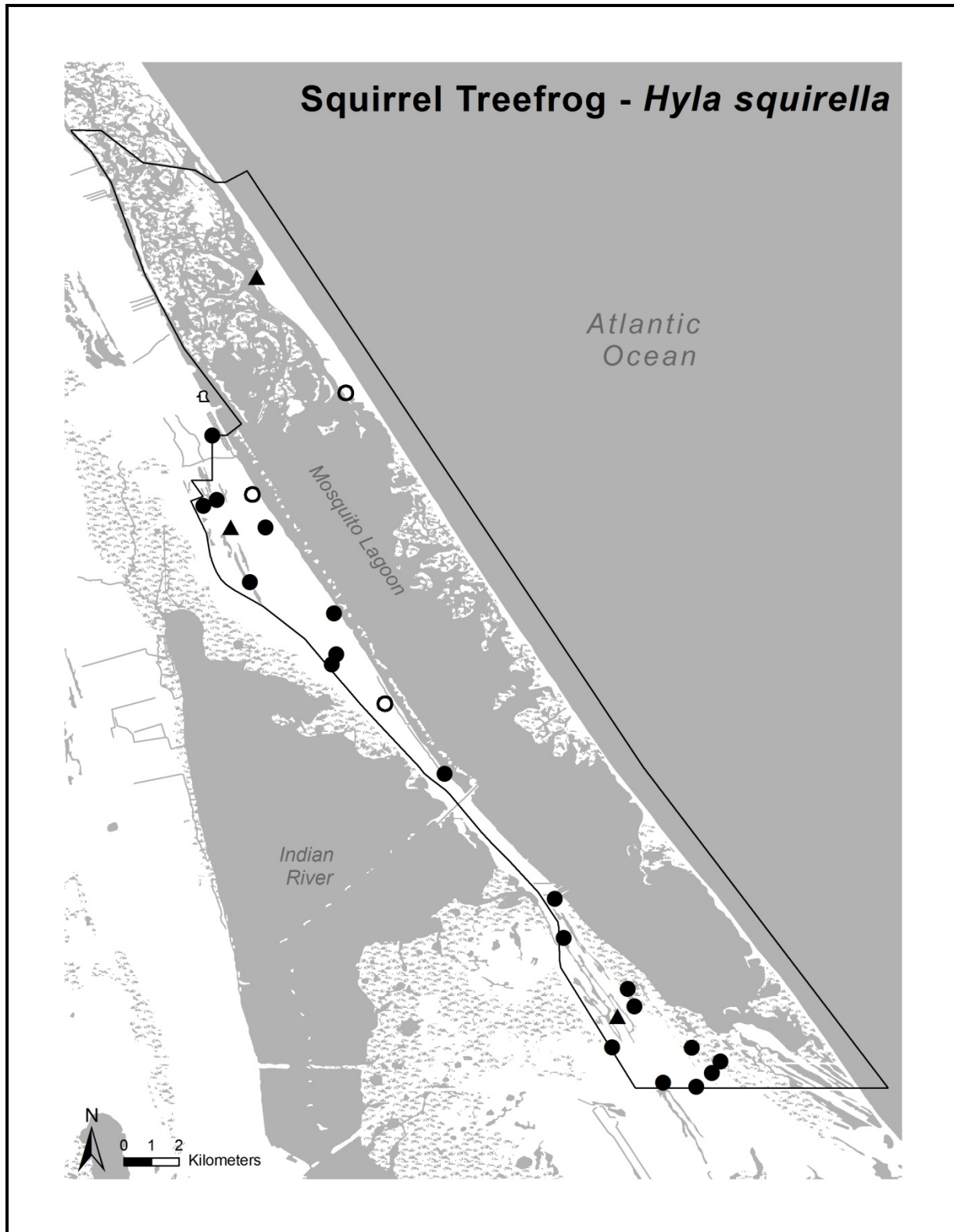


Figure 12. Sampling locations where squirrel treefrog (*Hyla squirella*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

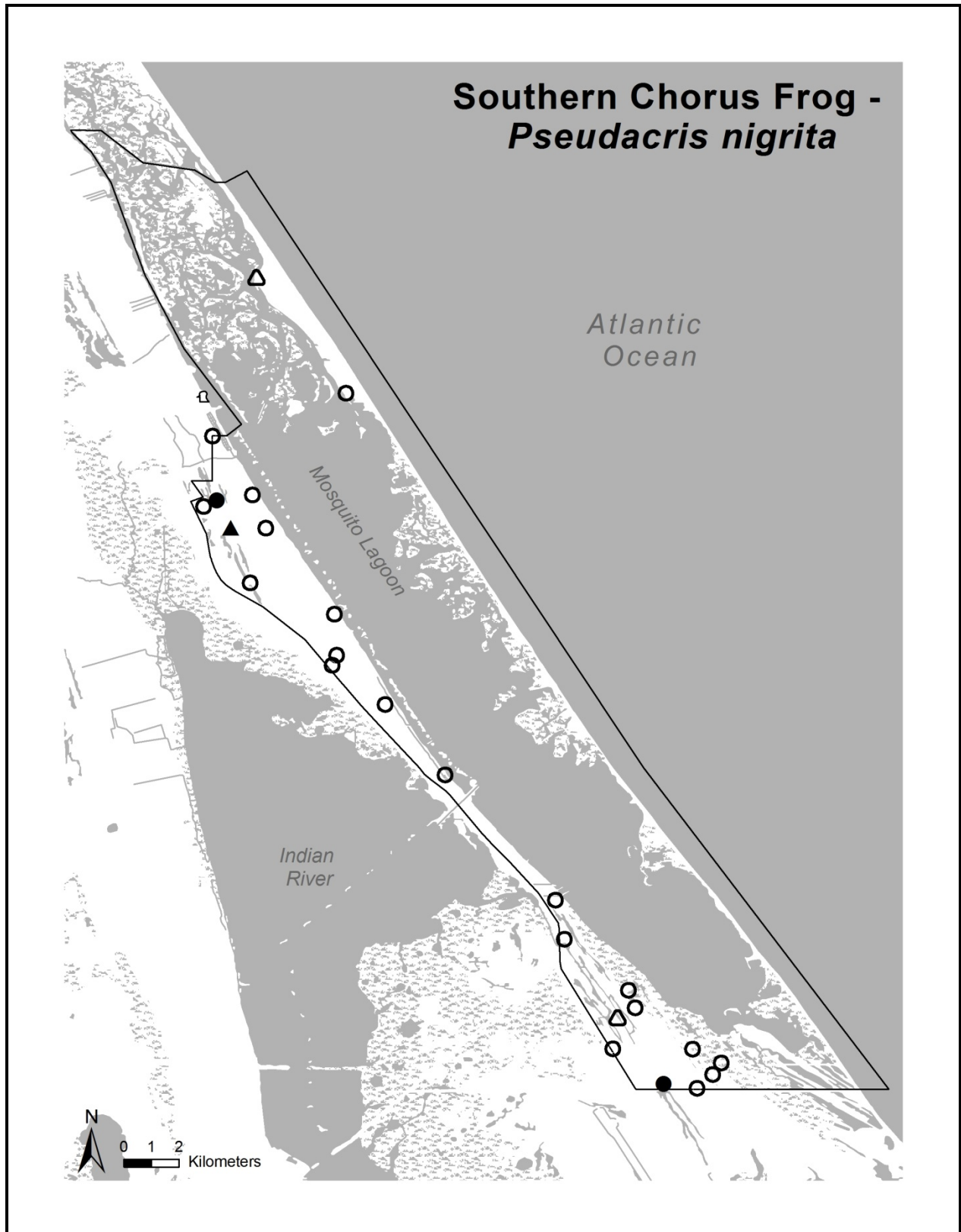


Figure 13. Sampling locations where Southern chorus frog (*Pseudacris nigrita*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

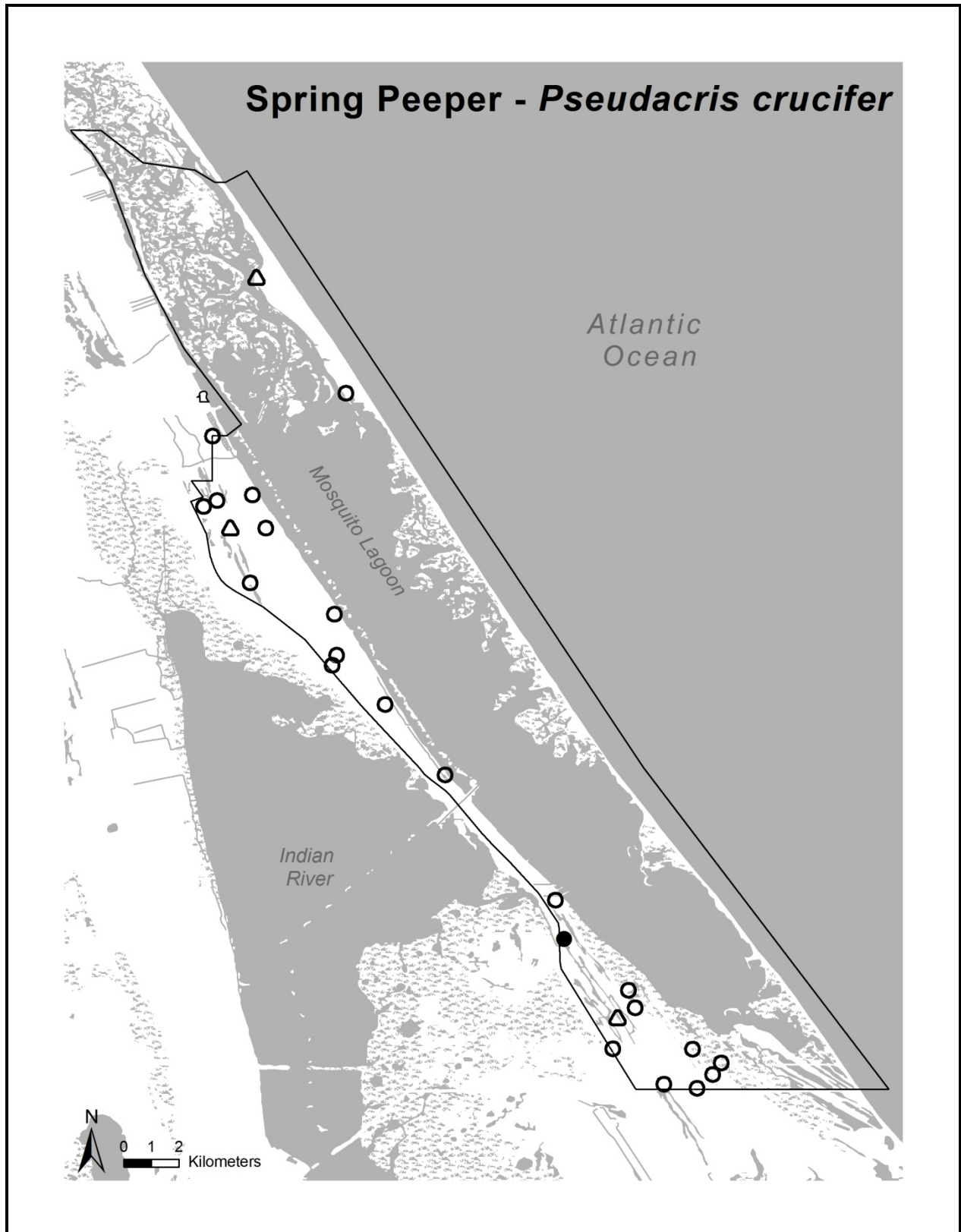


Figure 14. Sampling locations where spring peeper (*Pseudacris crucifer*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

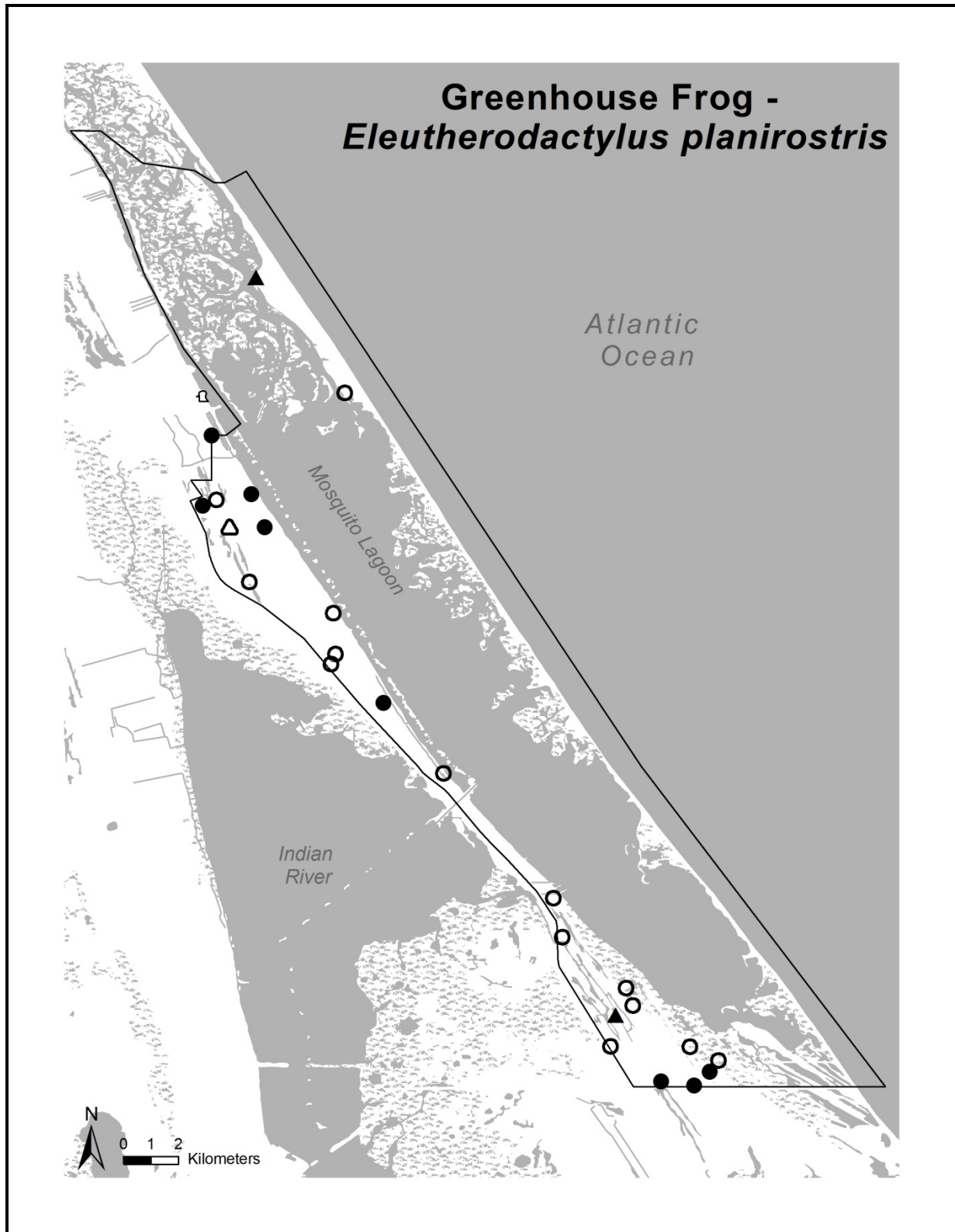


Figure 15. Sampling locations where greenhouse frog (*Eleutherodactylus planirostris*) was detected at Canaveral National Seashore, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

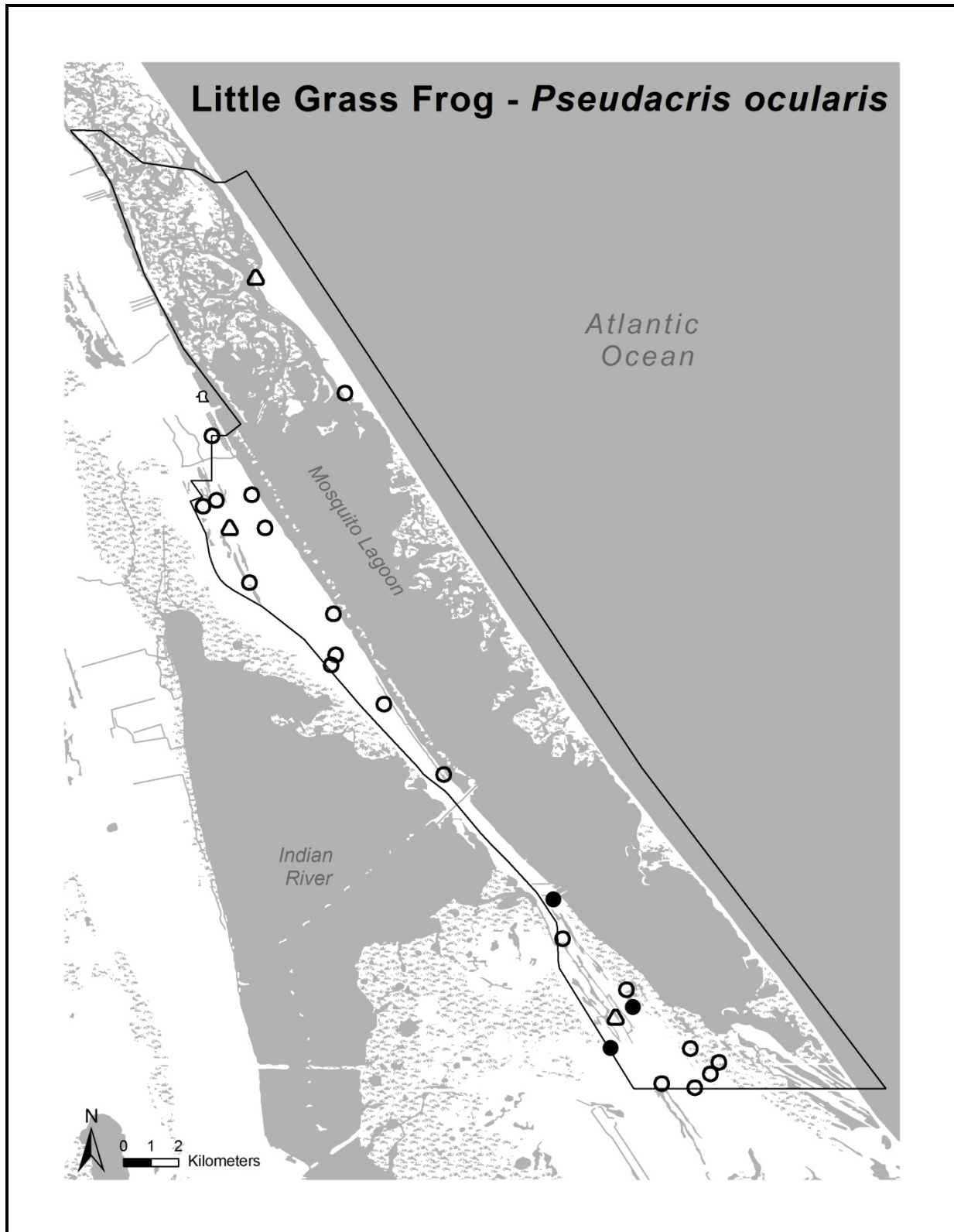


Figure 16. Sampling locations where little grass frog (*Pseudacris ocularis*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

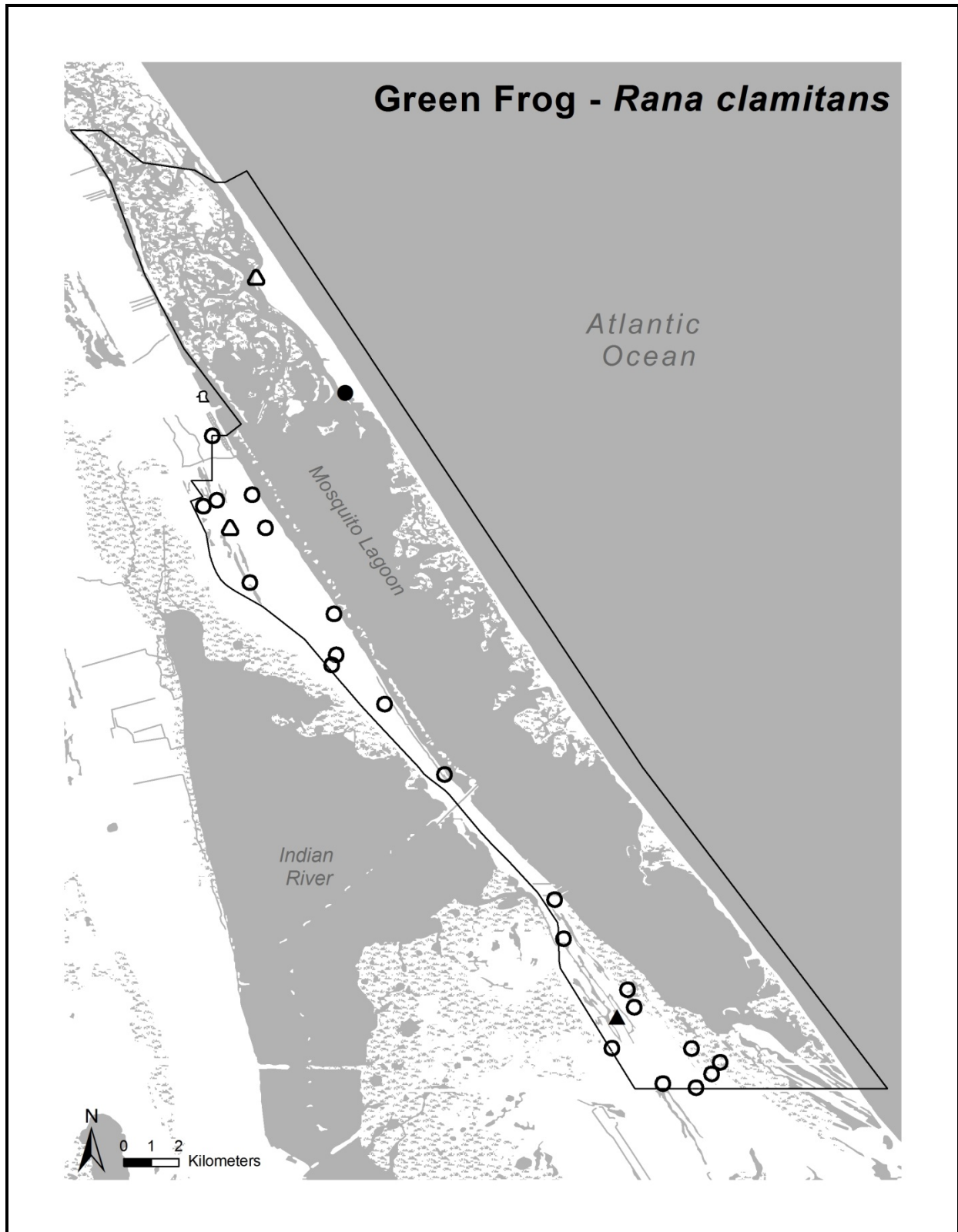


Figure 17. Sampling locations where green frog (*Rana clamitans*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

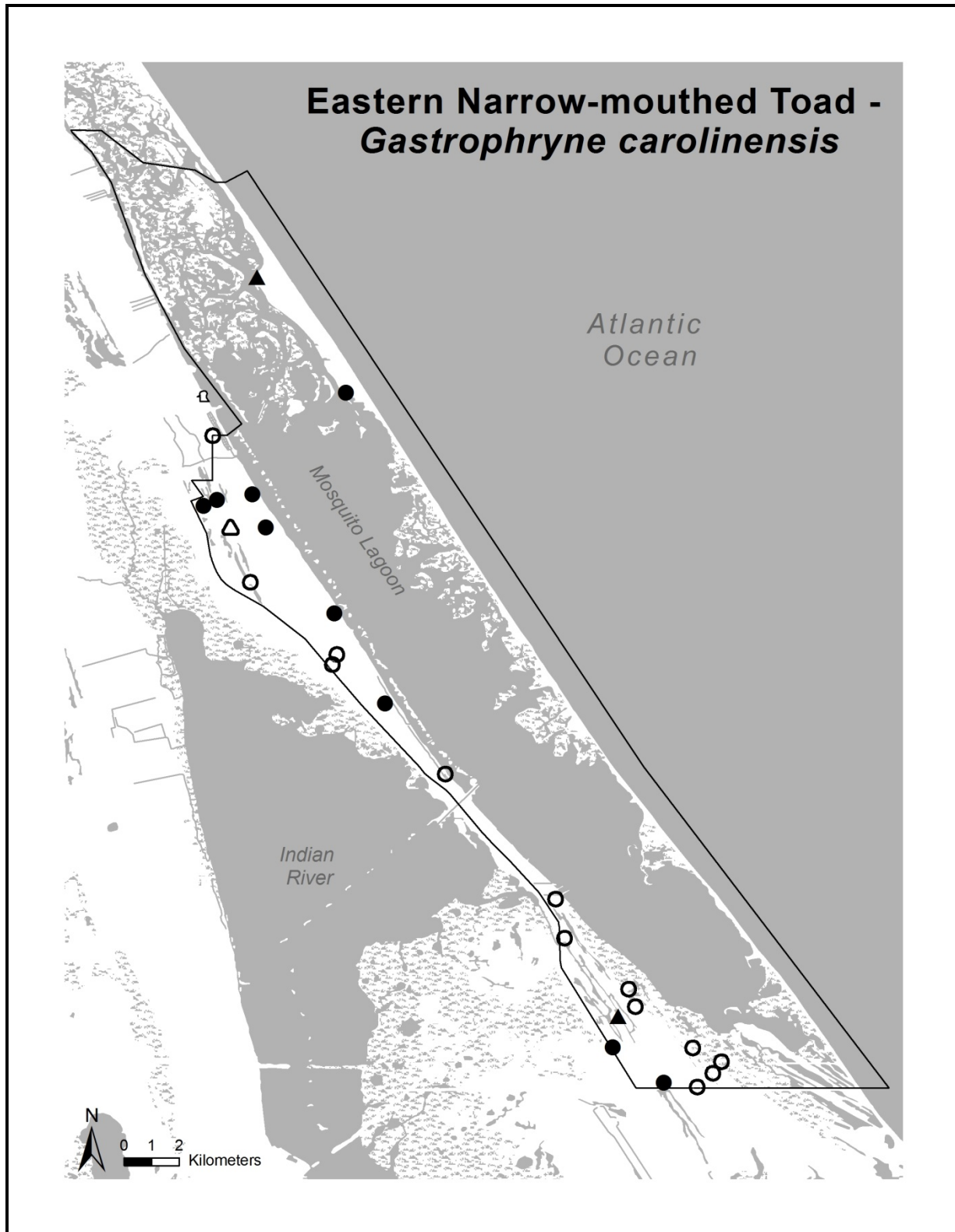


Figure 18. Sampling locations where Eastern narrow-mouthed toad (*Gastrophryne carolinensis*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

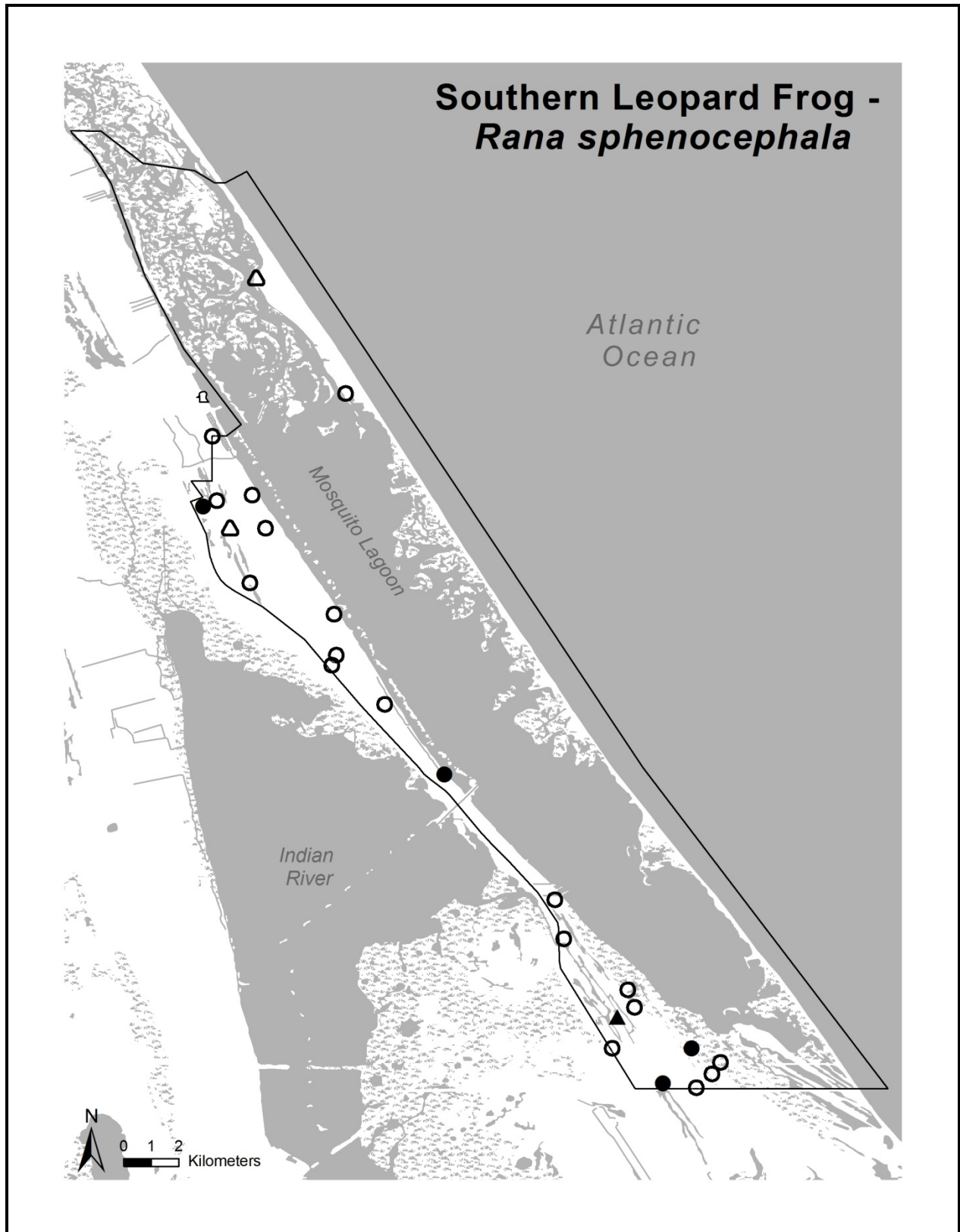


Figure 19. Sampling locations where Southern leopard frog (*Rana sphenocephala*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

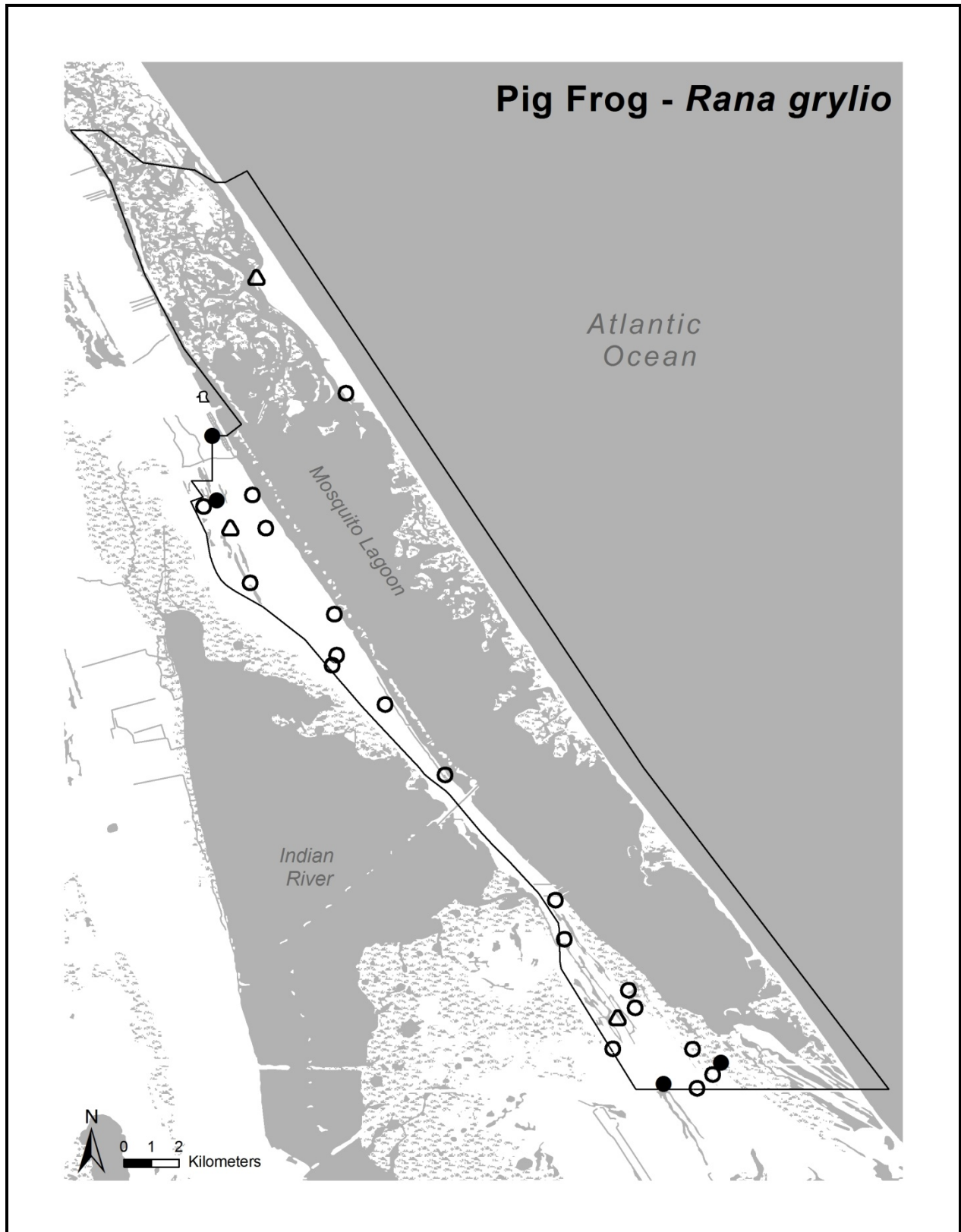


Figure 20. Sampling locations where pig frog (*Rana grylio*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

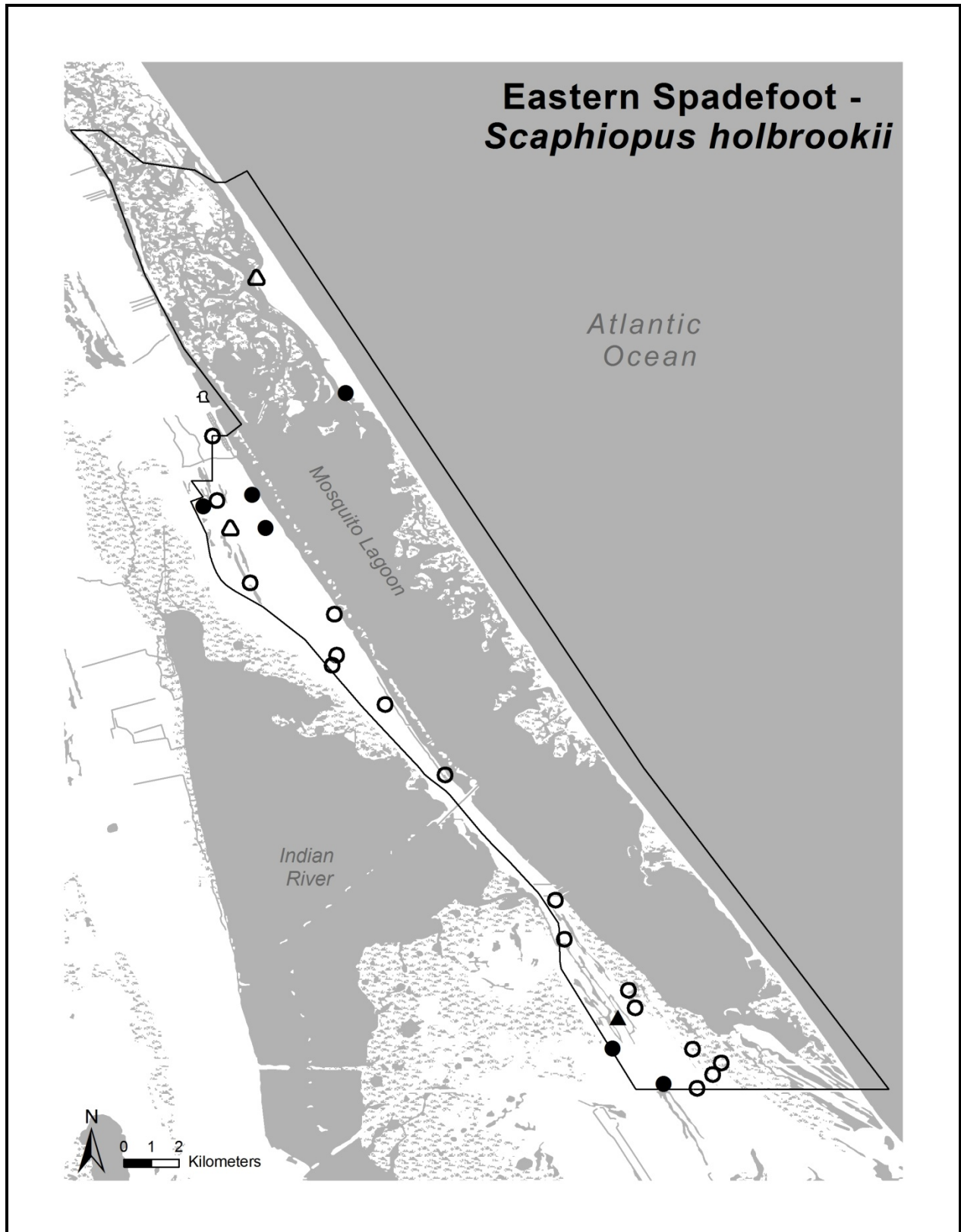


Figure 21. Sampling locations where Eastern spadefoot (*Scaphiopus holbrookii*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

Reptiles

Green anole was the most widely encountered native species (Figure 28), followed by Southeastern five-lined skink (Figure 30). Brown anole was the only non-native species encountered (Figure 31). Species lists for each sampling location are in Appendix C.

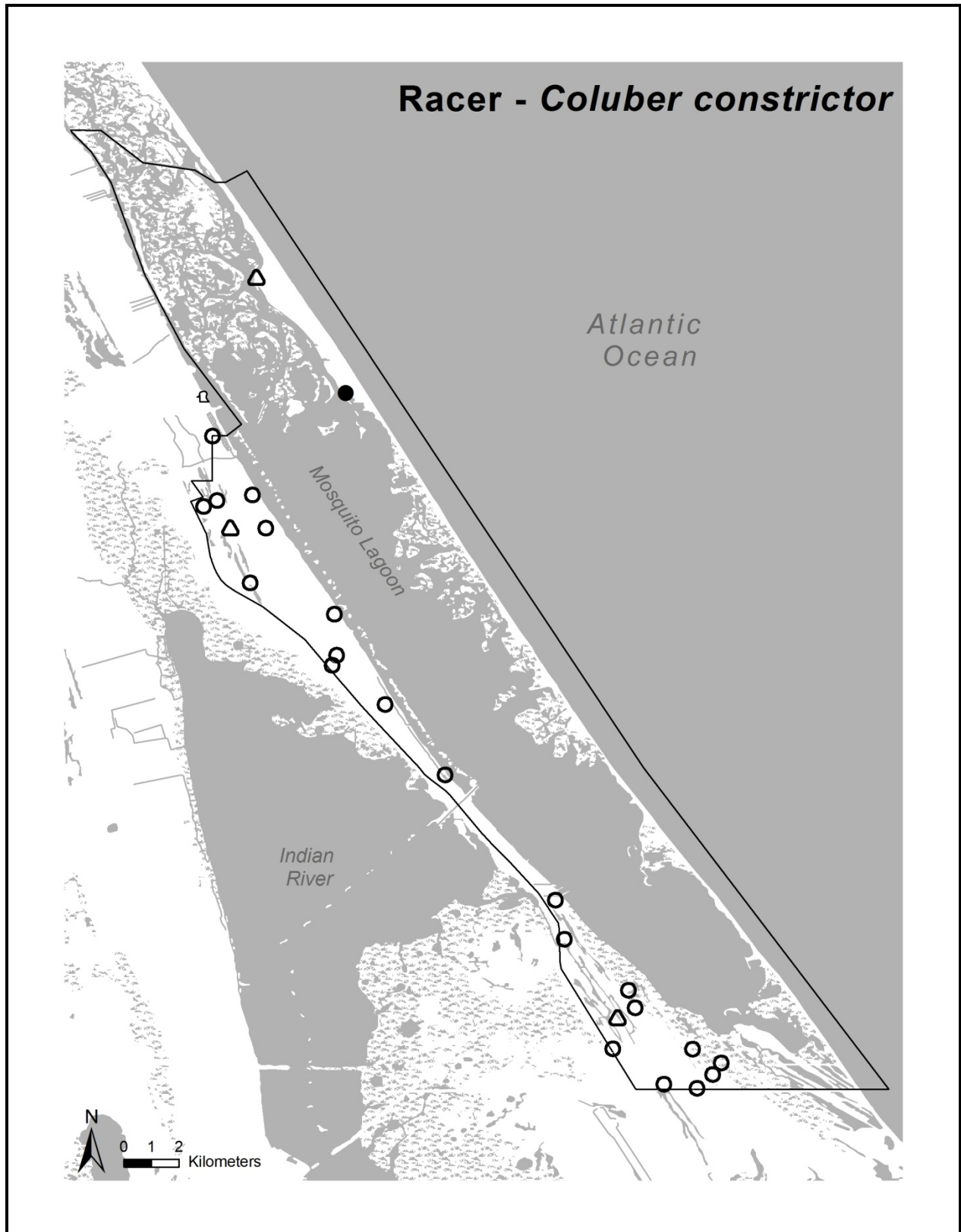


Figure 22. Sampling locations where racer (*Coluber constrictor*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

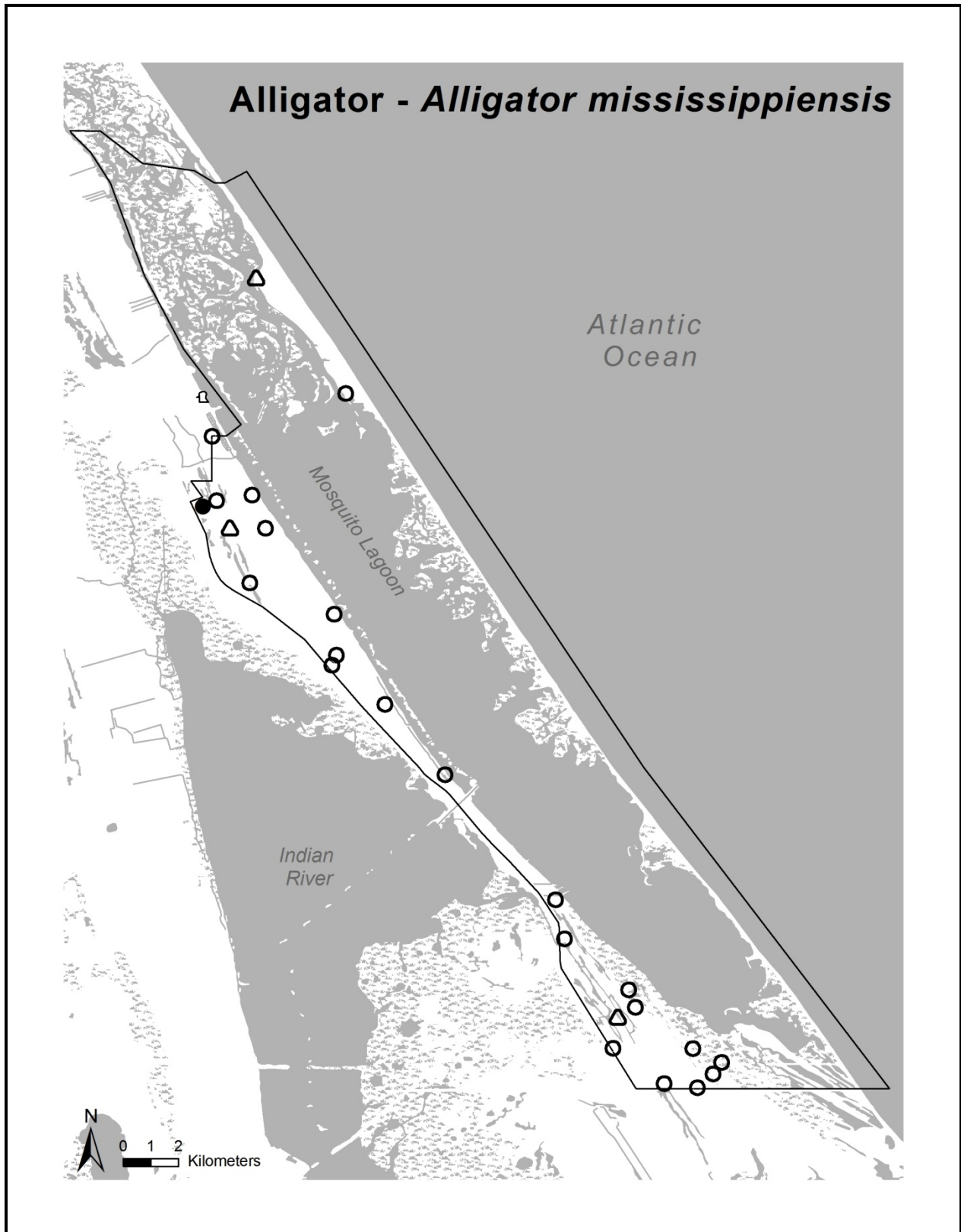


Figure 23. Sampling locations where alligator (*Alligator mississippiensis*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

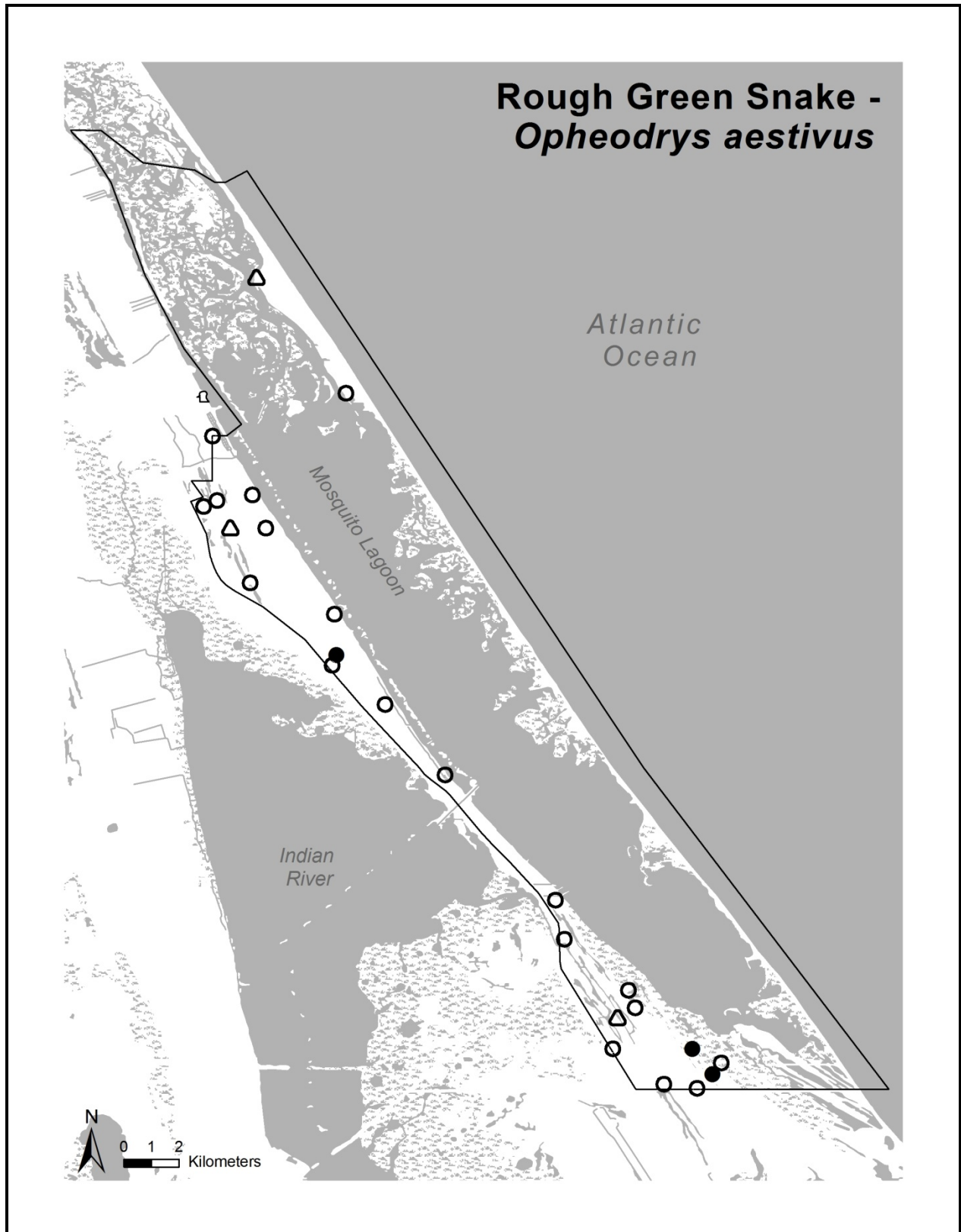


Figure 24. Sampling locations where rough green snake (*Opheodrys aestivus*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

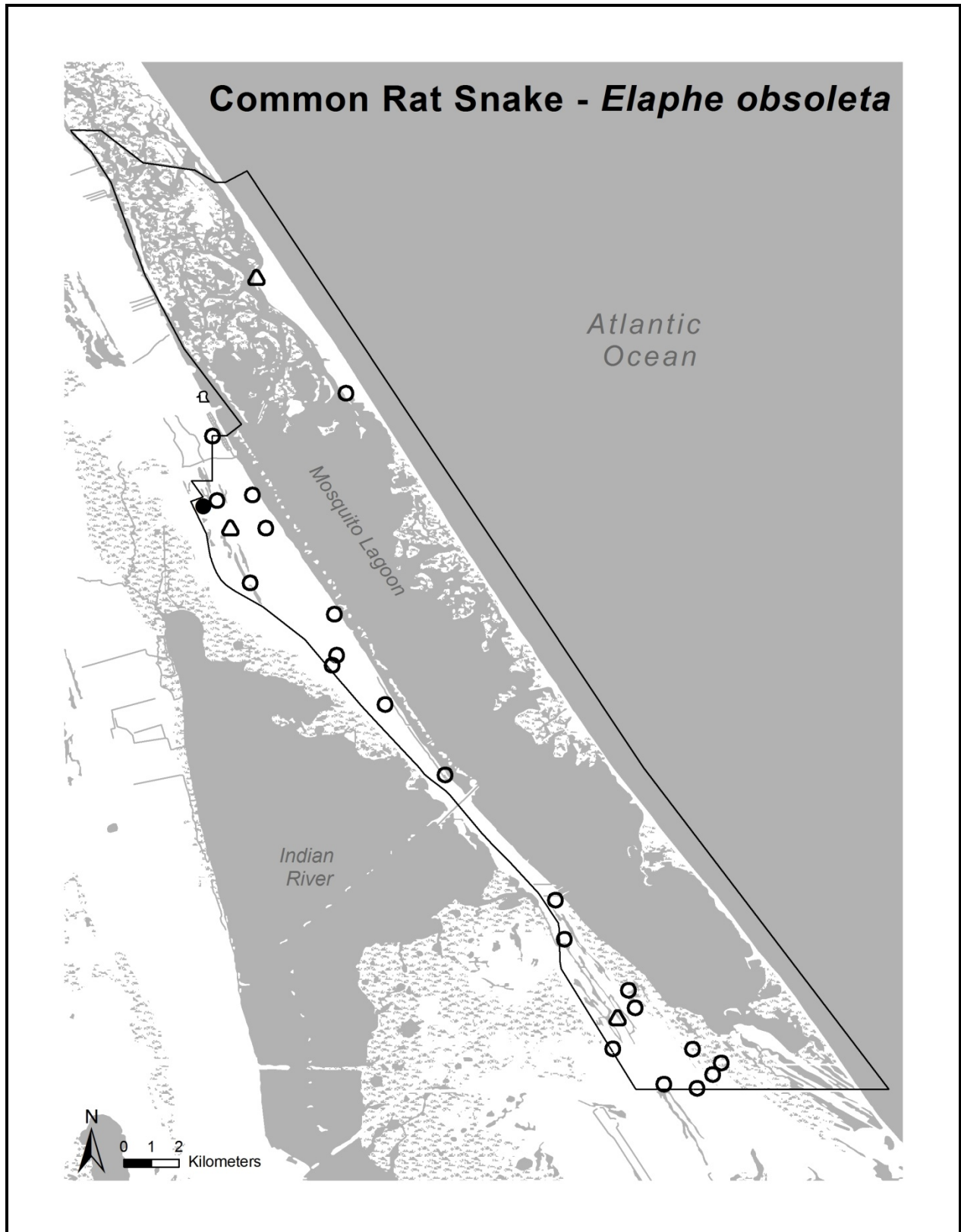


Figure 25. Sampling locations where common rat snake (*Elaphe obsoleta*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

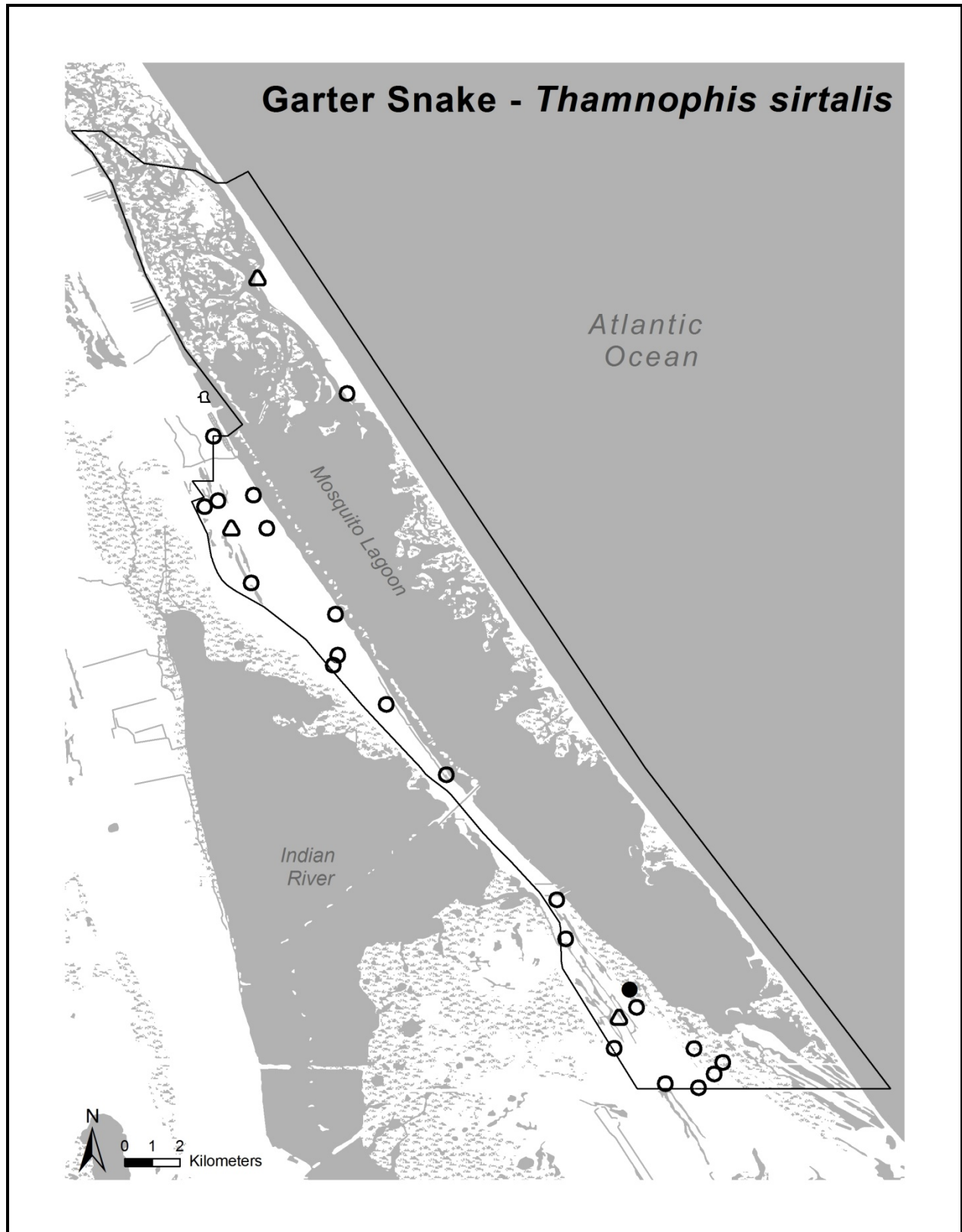


Figure 26. Sampling locations where garter snake (*Thamnophis sirtalis*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

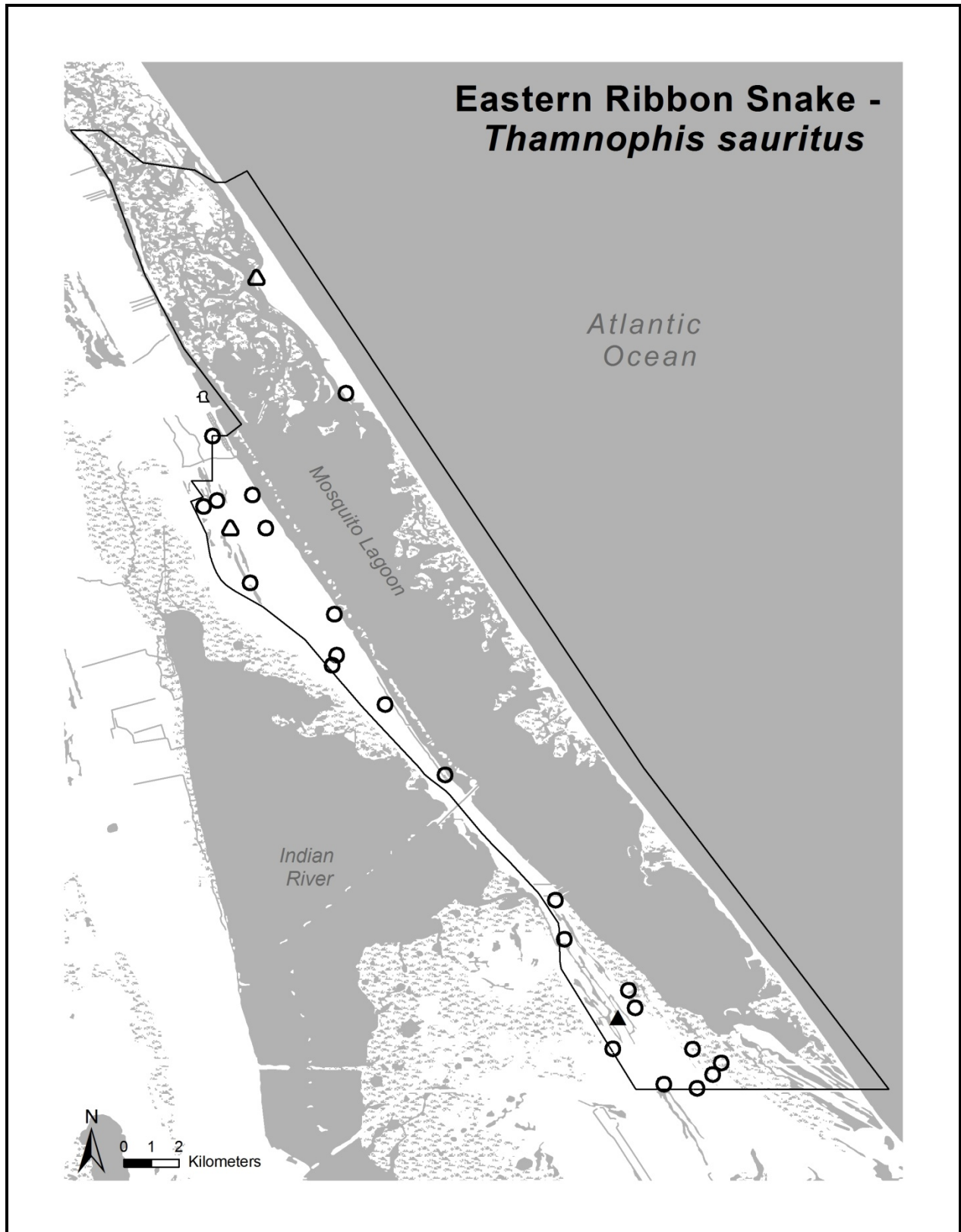


Figure 27. Sampling locations where Eastern ribbon snake (*Thamnophis sauritus*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

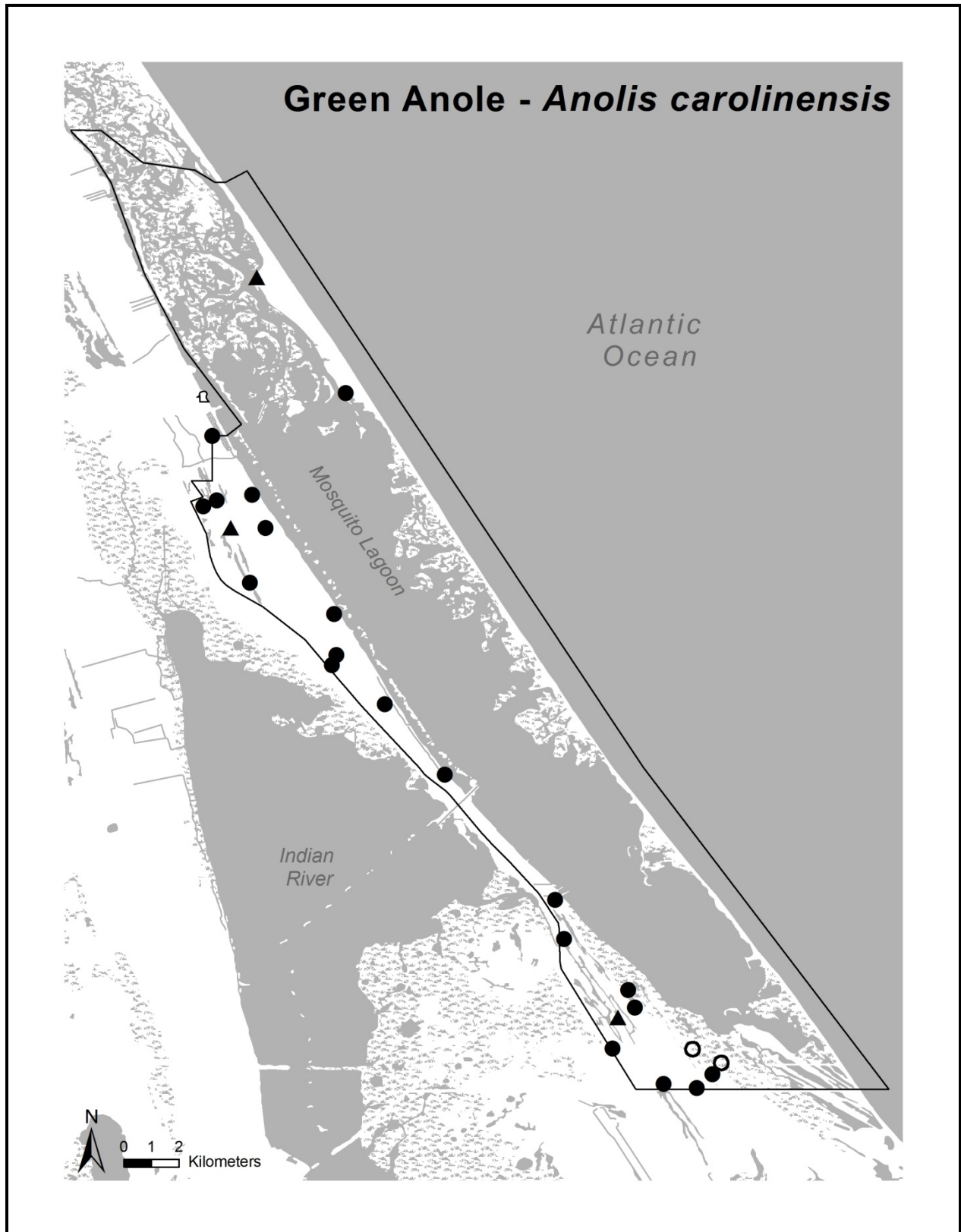


Figure 28. Sampling locations where green anole (*Anolis carolinensis*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

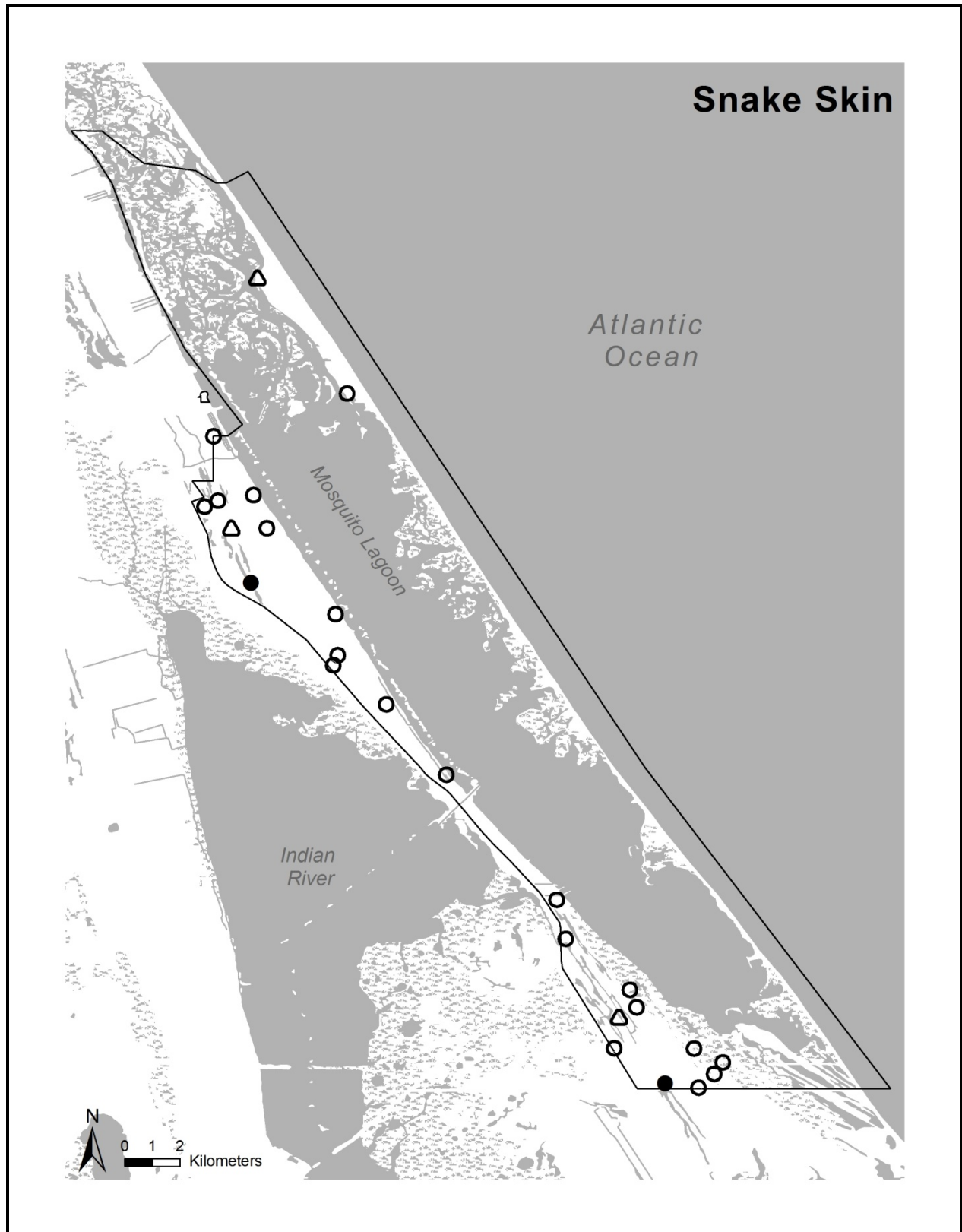


Figure 29. Sampling locations where snake skin was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

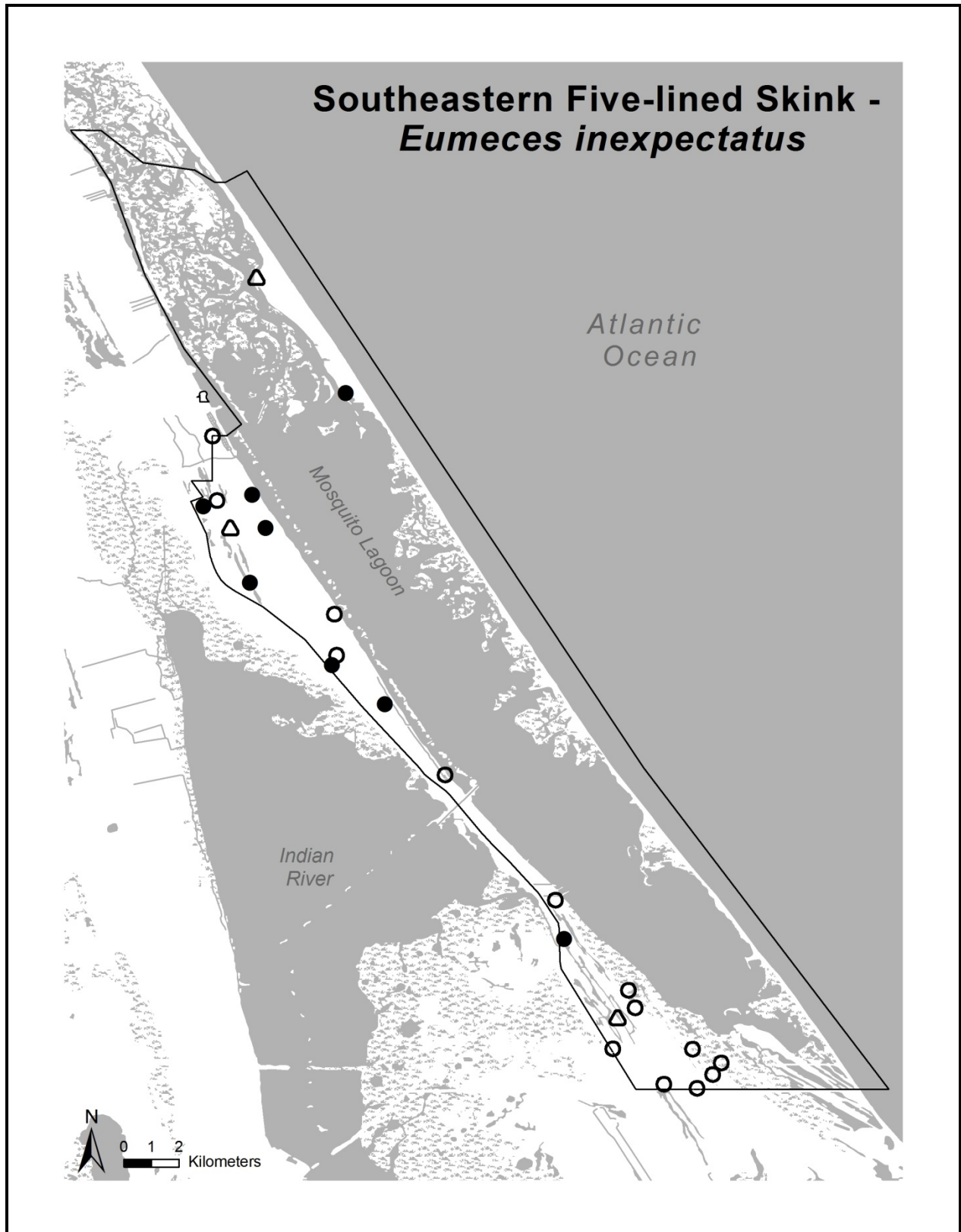


Figure 30. Sampling locations where Southeastern five-lined skink (*Eumeces inexpectatus*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

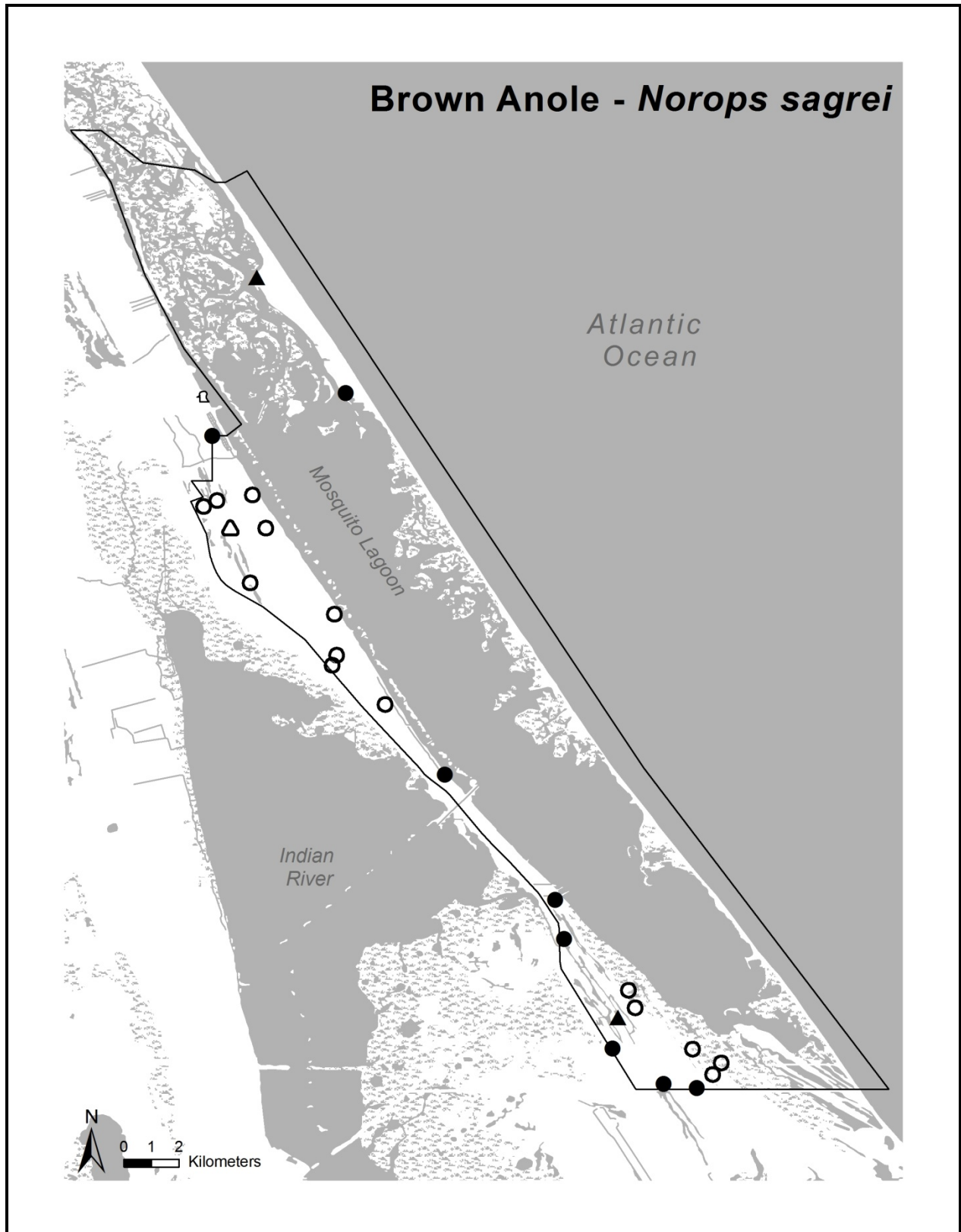


Figure 31. Sampling locations where brown anole (*Norops sagrei*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

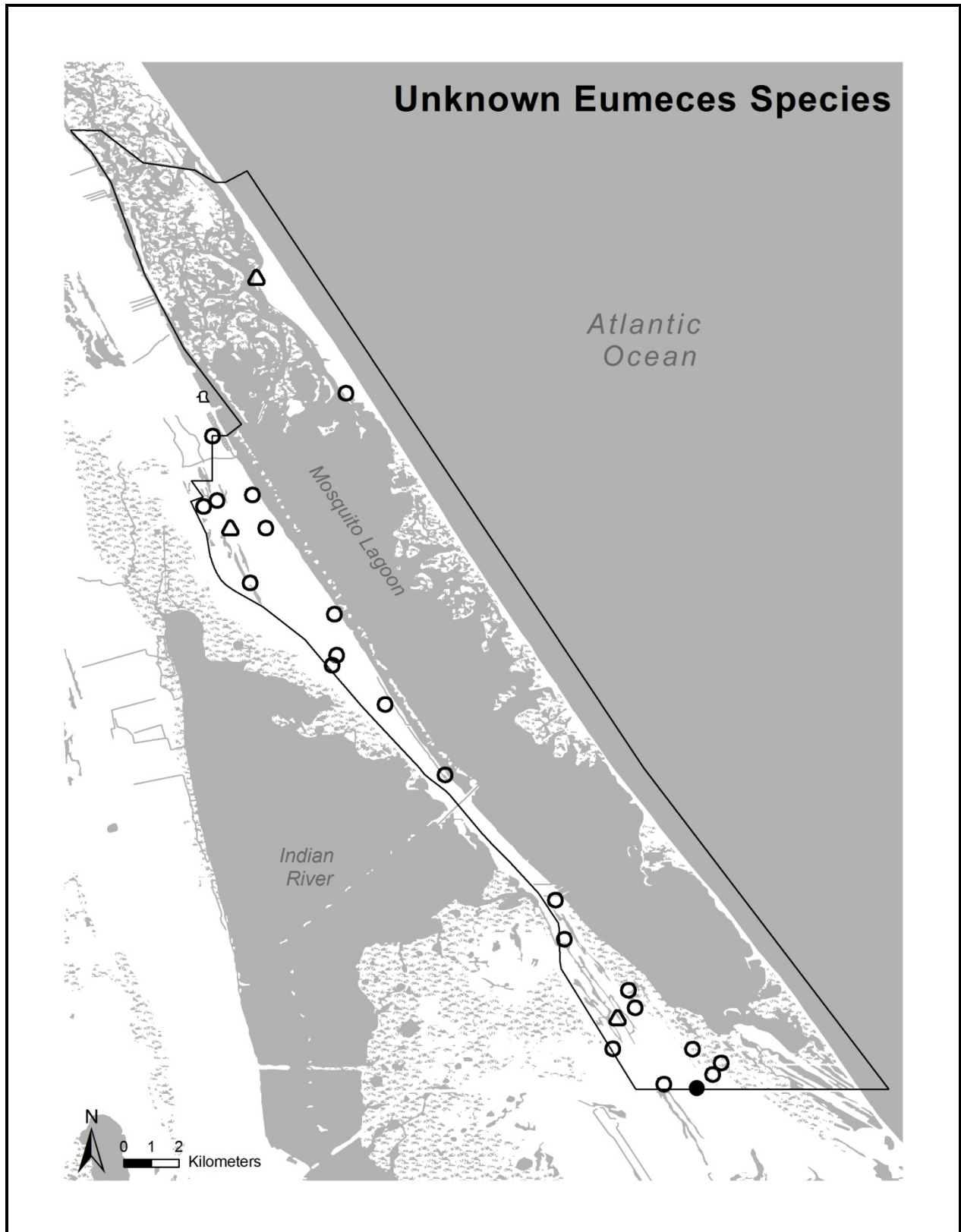


Figure 32. Sampling locations where unknown *Eumeces* species was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

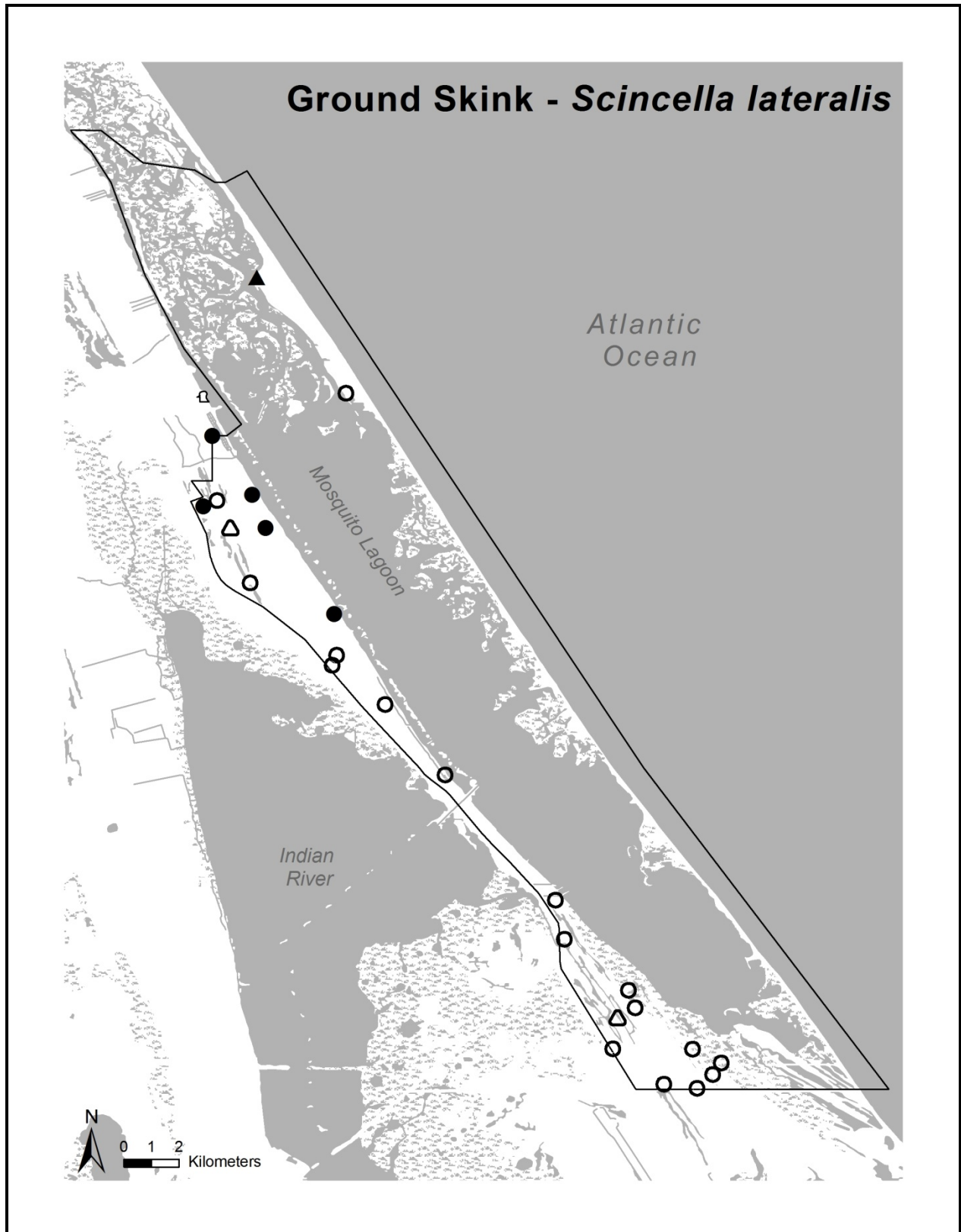


Figure 33. Sampling locations where ground skink (*Scincella lateralis*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

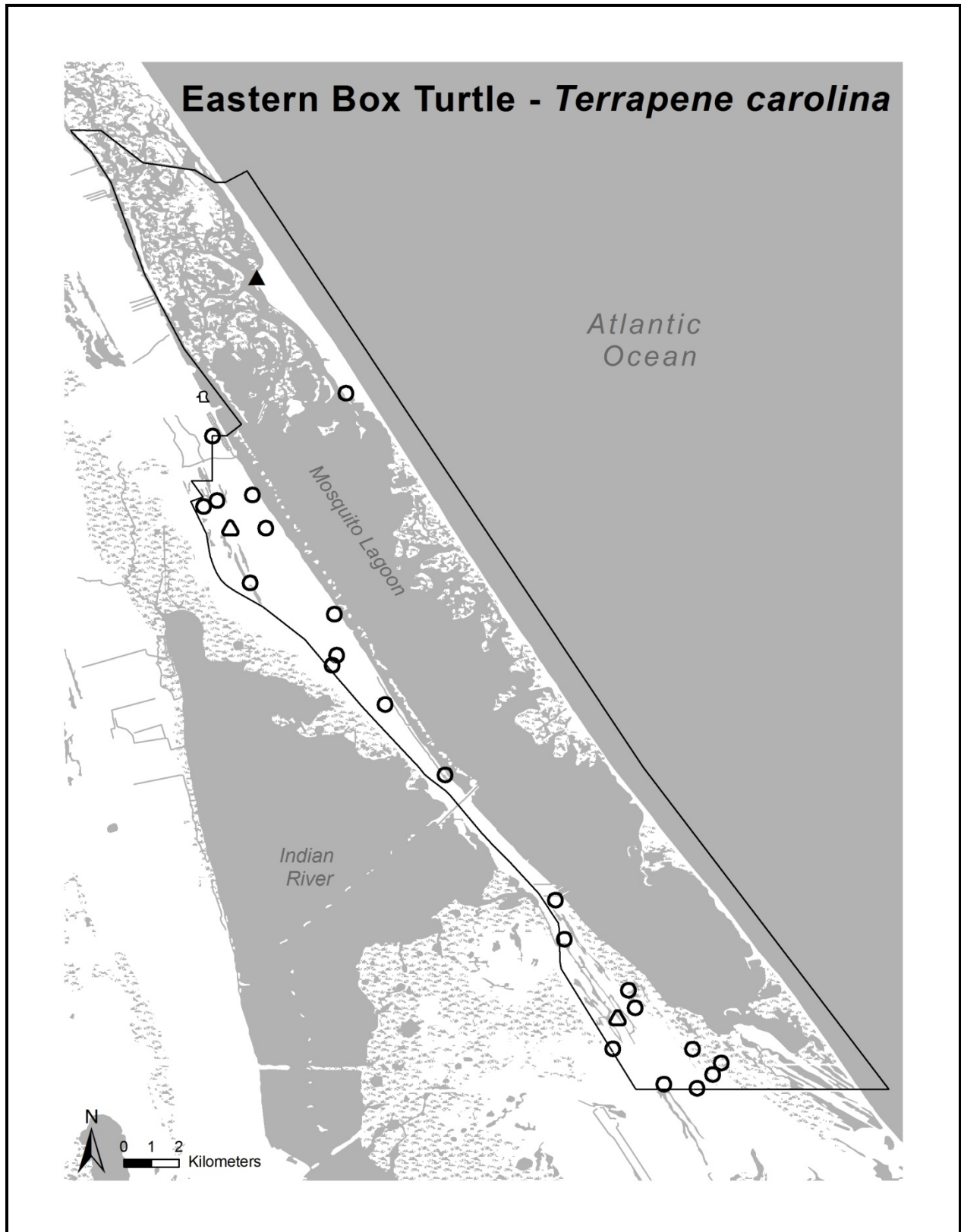


Figure 34. Sampling locations where Eastern box turtle (*Terrapene carolina*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

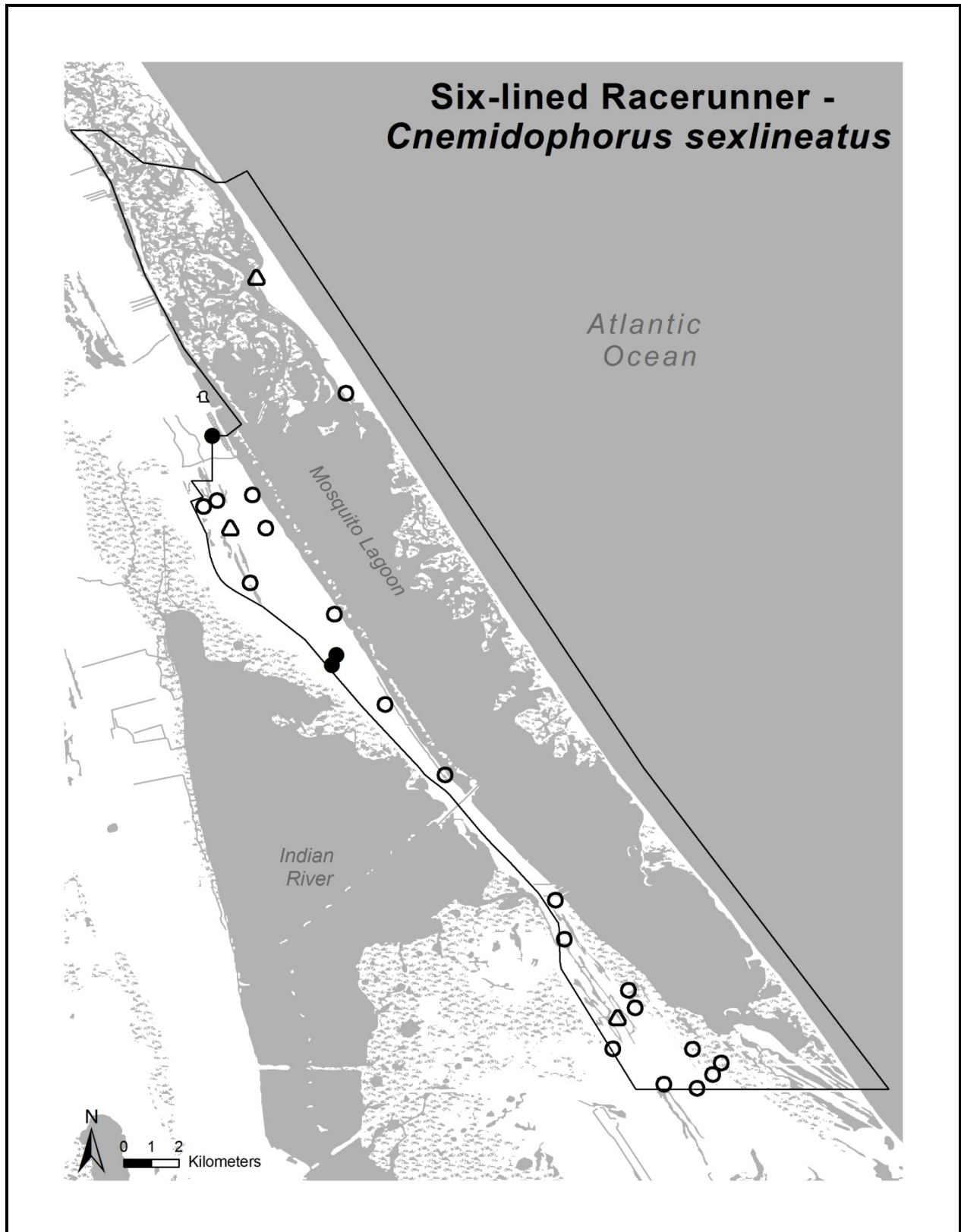


Figure 35. Sampling locations where six-lined racerunner (*Cnemidophorus sexlineatus*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

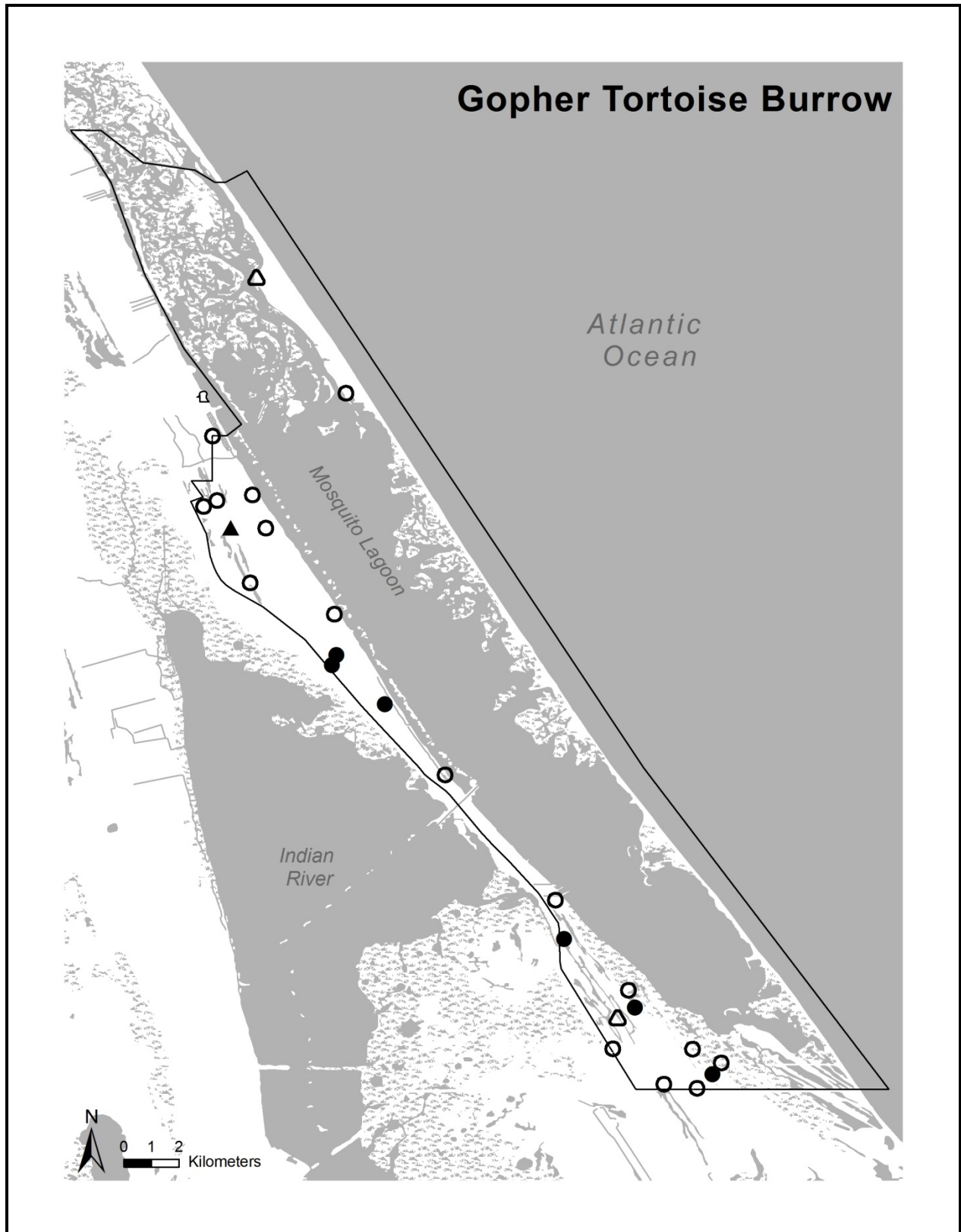


Figure 36. Sampling locations where gopher tortoise burrow was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

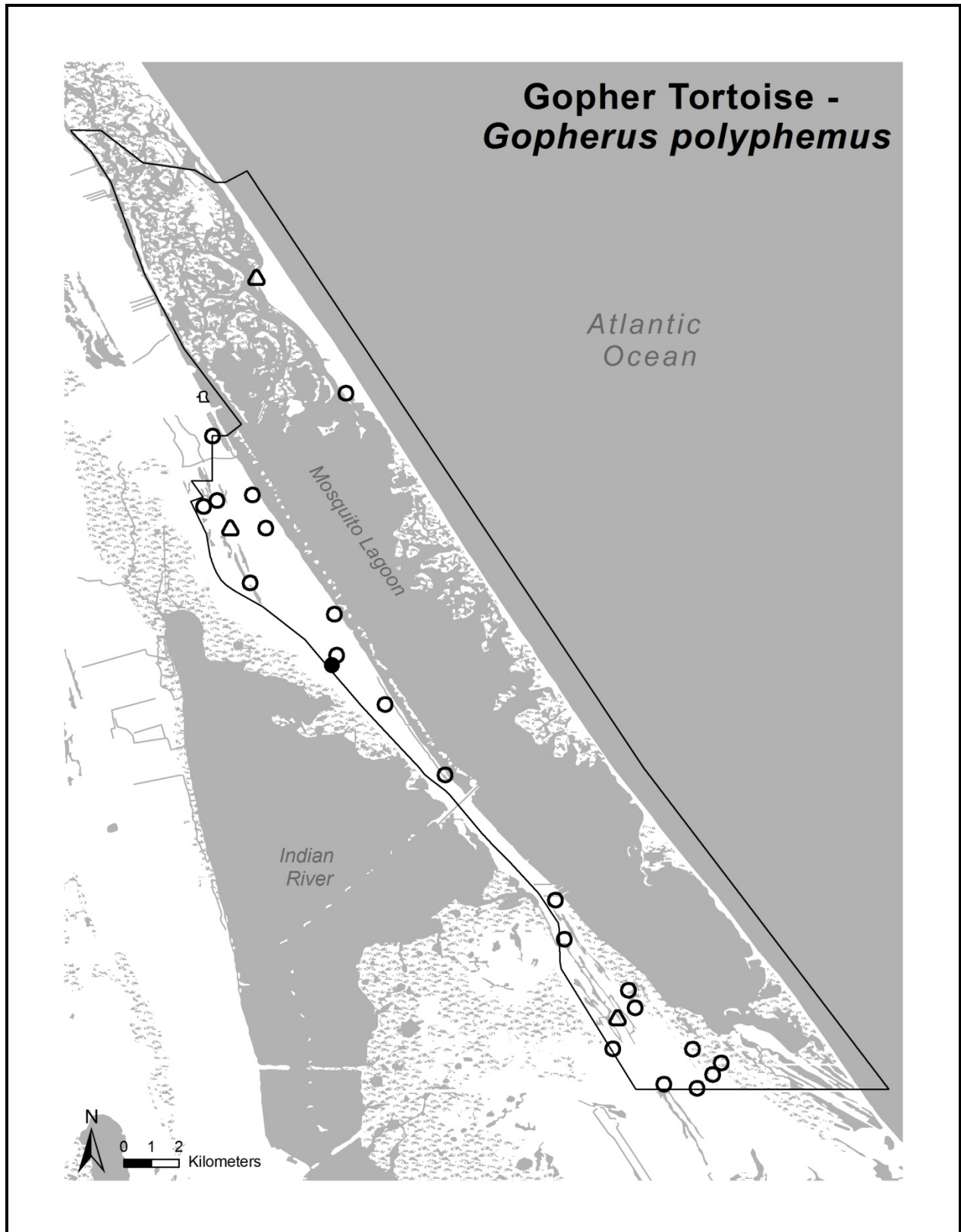


Figure 37. Sampling locations where gopher tortoise (*Gopherus polyphemus*) was detected at CANA, 2009. Circles = random, triangles = non-random, solid = detected, hollow = not detected.

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Appendix A. Amphibians and Reptiles Known to Occur at CANA

Table A-1. Amphibians and reptiles known to occur at CANA based upon records in NPSpecies or from current monitoring efforts presented herein.

Order	Family	Scientific Name	Common Name	NPSpecies	ARD	VES
Anura	Bufo	<i>Bufo quercicus</i>	Oak Toad	X	X	X
Anura	Bufo	<i>Bufo terrestris</i>	Southern Toad	X	X	X
Anura	Hyla	<i>Acris gryllus</i>	Southern Cricket Frog	X		X
Anura	Hyla	<i>Hyla cinerea</i>	Green Treefrog	X	X	X
Anura	Hyla	<i>Hyla femoralis</i>	Pine Woods Treefrog	X	X	X
Anura	Hyla	<i>Hyla gratiosa</i>	Barking Treefrog	X		X
Anura	Hyla	<i>Hyla squirella</i>	Squirrel Treefrog	X	X	X
Anura	Hyla	<i>Osteopilus septentrionalis</i>	Cuban Treefrog		X	X
Anura	Hyla	<i>Pseudacris crucifer</i>	Spring Peeper		X	
Anura	Hyla	<i>Pseudacris nigrita</i>	Southern Chorus Frog	X	X	X
Anura	Hyla	<i>Pseudacris ocularis</i>	Little Grass Frog	X	X	
Anura	Leptodactylidae	<i>Eleutherodactylus planirostris</i>	Greenhouse Frog	X	X	X
Anura	Microhylidae	<i>Gastrophryne carolinensis</i>	Eastern Narrow-mouthed Toad	X	X	X
Anura	Rana	<i>Rana capito</i>	Gopher Frog	X		
Anura	Rana	<i>Rana clamitans</i>	Green Frog			X
Anura	Rana	<i>Rana grylio</i>	Pig Frog	X		X
Anura	Rana	<i>Rana sphenoccephala</i>	Southern Leopard Frog	X	X	X
Anura	Scaphiopodidae	<i>Scaphiopus holbrookii</i>	Eastern Spadefoot	X	X	X
Caudata	Amphiumidae	<i>Amphiuma means</i>	Two-toed Amphiuma	X		
Caudata	Salamandridae	<i>Notophthalmus viridescens</i>	Eastern Newt	X		
Caudata	Sirenidae	<i>Siren intermedia</i>	Dwarf Siren, Lesser Siren	X		
Caudata	Sirenidae	<i>Siren lacertina</i>	Greater Siren	X		
Crocodylia	Alligatoridae	<i>Alligator mississippiensis</i>	Alligator	X		X
Squamata	Anguidae	<i>Ophisaurus attenuatus</i>	Slender Glass Lizard	X		
Squamata	Anguidae	<i>Ophisaurus compressus</i>	Island Glass Lizard	X		
Squamata	Anguidae	<i>Ophisaurus ventralis</i>	Eastern Glass Lizard	X		
Squamata	Colubridae	<i>Cemophora coccinea</i>	Scarlet Snake	X		
Squamata	Colubridae	<i>Coluber constrictor</i>	Racer	X		X
Squamata	Colubridae	<i>Diadophis punctatus</i>	Ring-necked Snake	X		
Squamata	Colubridae	<i>Drymarchon corais</i>	Indigo Snake	X		
Squamata	Colubridae	<i>Elaphe guttata</i>	Corn Snake, Red Rat Snake	X		
Squamata	Colubridae	<i>Elaphe obsoleta</i>	Common Rat Snake	X		X

Table A-1. (Continued).

Order	Family	Scientific Name	Common Name	NPSpecies	ARD	VES
Squamata	Colubridae	<i>Farancia abacura</i>	Mud Snake	X		
Squamata	Colubridae	<i>Heterodon platirhinos</i>	Eastern Hog-nosed Snake	X		
Squamata	Colubridae	<i>Lampropeltis getula</i>	Common Kingsnake	X		
Squamata	Colubridae	<i>Lampropeltis triangulum</i>	Milk Snake	X		
Squamata	Colubridae	<i>Masticophis flagellum</i>	Coachwhip	X		
Squamata	Colubridae	<i>Nerodia clarkii taeniata</i>	Salt Marsh Snake	X		
Squamata	Colubridae	<i>Nerodia fasciata</i>	Southern Water Snake	X		
Squamata	Colubridae	<i>Nerodia floridana</i>	Florida Green Water Snake	X		
Squamata	Colubridae	<i>Opheodrys aestivus</i>	Rough Green Snake	X		X
Squamata	Colubridae	<i>Pituophis melanoleucus</i>	Pine Snake	X		
Squamata	Colubridae	<i>Regina alleni</i>	Striped Crayfish Snake	X		
Squamata	Colubridae	<i>Rhadinaea flavilata</i>	Pine Woods Snake	X		
Squamata	Colubridae	<i>Seminatrix pygaea</i>	Black Swamp Snake	X		
Squamata	Colubridae	<i>Storeria dekayi</i>	Dekay's Brown Snake	X		
Squamata	Colubridae	<i>Tantilla relicta</i>	Florida Crowned Snake	X		
Squamata	Colubridae	<i>Thamnophis sauritus</i>	Eastern Ribbon Snake	X		X
Squamata	Colubridae	<i>Thamnophis sirtalis</i>	Garter Snake	X		X
Squamata	Elapidae	<i>Micrurus fulvius</i>	Eastern Coral Snake	X		
Squamata	Gekkonidae	<i>Hemidactylus garnotii</i>	Indo-Pacific Gecko	X		
Squamata	Gekkonidae	<i>Hemidactylus turcicus</i>	Mediterranean Gecko	X		
Squamata	Polychrotidae	<i>Anolis carolinensis</i>	Green Anole	X		X
Squamata	Polychrotidae	<i>Norops sagrei</i>	Brown Anole	X		X
Squamata	Scincidae	<i>Eumeces egregius</i>	Mole Skink	X		
Squamata	Scincidae	<i>Eumeces inexpectatus</i>	Southeastern Five-lined Skink	X		X
Squamata	Scincidae	<i>Scincella lateralis</i>	Ground Skink	X		X
Squamata	Teiidae	<i>Cnemidophorus sexlineatus</i>	Six-lined Racerunner	X		X
Squamata	Viperidae	<i>Agkistrodon piscivorus</i>	Cottonmouth	X		
Squamata	Viperidae	<i>Crotalus adamanteus</i>	Eastern Diamondback Rattlesnake	X		
Squamata	Viperidae	<i>Sistrurus miliarius</i>	Pygmy Rattlesnake	X		
Testudines	Cheloniidae	<i>Caretta caretta</i>	Loggerhead Sea Turtle	X		
Testudines	Cheloniidae	<i>Chelonia mydas</i>	Green Sea Turtle	X		
Testudines	Cheloniidae	<i>Eretmochelys imbricata</i>	Hawksbill Sea Turtle	X		
Testudines	Cheloniidae	<i>Lepidochelys kempii</i>	Kemp's Ridley Sea Turtle	X		

Table A-1. (Continued).

Order	Family	Scientific Name	Common Name	NPSpecies	ARD	VES
Testudines	Chelydridae	<i>Chelydra serpentina</i>	Common Snapping Turtle	X		
Testudines	Dermochelyidae	<i>Dermochelys coriacea</i>	Leatherback Sea Turtle	X		
Testudines	Emydidae	<i>Deirochelys reticularia</i>	Chicken Turtle	X		
Testudines	Emydidae	<i>Malaclemys terrapin</i>	Diamondback Terrapin	X		
Testudines	Emydidae	<i>Pseudemys nelsoni</i>	Florida Red-bellied Cooter	X		
Testudines	Emydidae	<i>Pseudemys peninsularis</i>	Peninsular Cooter	X		
Testudines	Emydidae	<i>Terrapene carolina</i>	Eastern Box Turtle			X
Testudines	Kinosternidae	<i>Kinosternon baurii</i>	Striped Mud Turtle	X		
Testudines	Kinosternidae	<i>Kinosternon subrubrum</i>	Common Mud Turtle	X		
Testudines	Kinosternidae	<i>Sternotherus odoratus</i>	Common Musk Turtle	X		
Testudines	Testudinidae	<i>Gopherus polyphemus</i>	Gopher Tortoise	X		X
Testudines	Trionychidae	<i>Apalone ferox</i>	Florida Softshell Turtle	X		

Appendix B. Map of Sampling Locations with Point Labels.

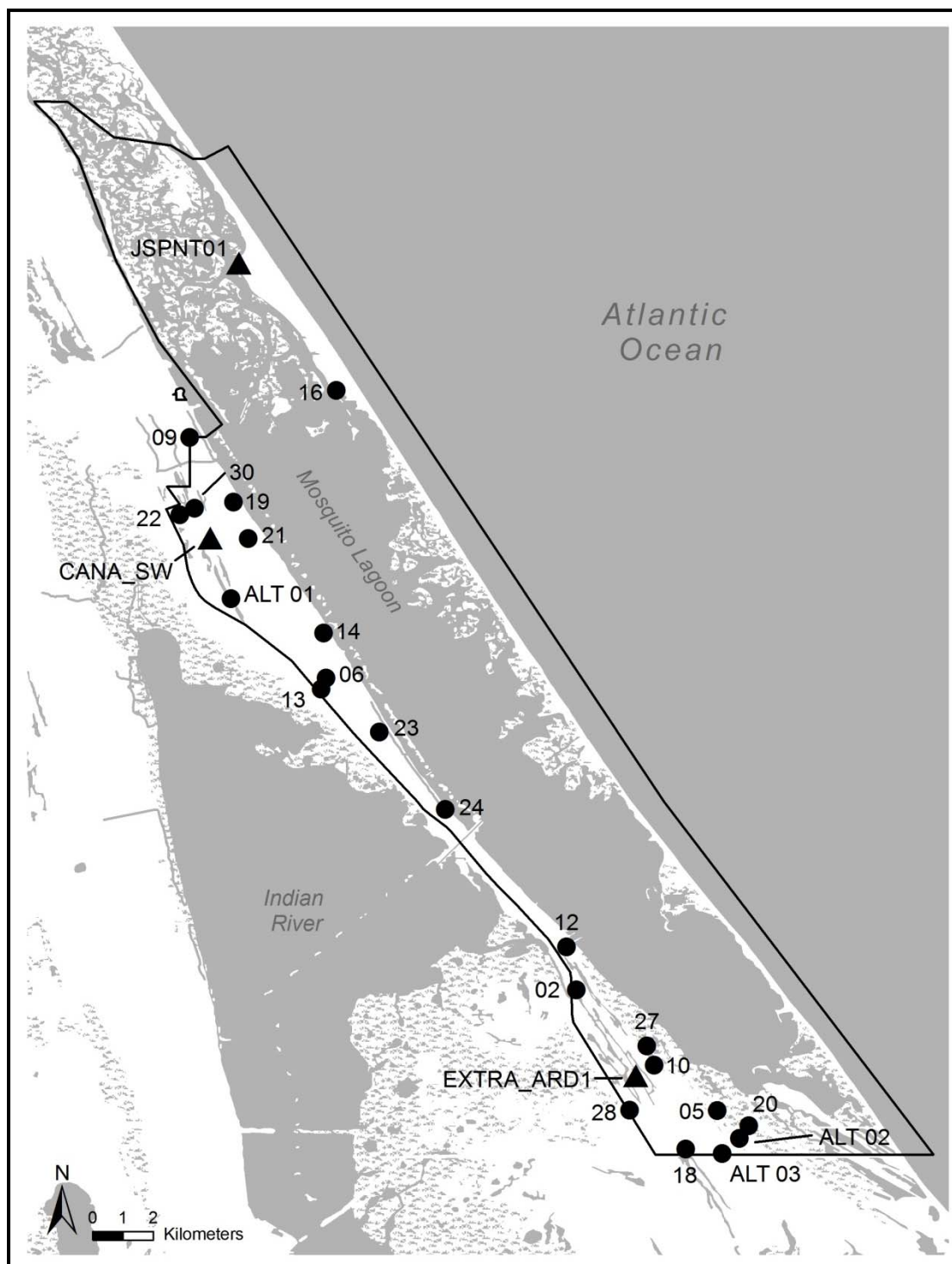


Figure B-1. Spatially-balanced random (●) and non-random (▲) sampling locations with labels at CANA, 2009.

Appendix C. Species Detections by Sampling Location.

Table C-1. Species or species sign detected at each sampling location at CANA, 2009. Refer to Appendix B for labeled sampling-locations.

Species	Sampling Location																								
	2	5	6	9	10	12	13	14	16	18	19	20	21	22	23	24	27	28	30	A1	A2	A3	SW	XARD1	PNT1
Oak Toad	X				X	X		X		X			X						X	X	X		X		
Southern Toad				X		X	X	X		X	X		X	X		X		X					X		X
Unk. <i>Bufo</i> spp.										X															
Southern Cricket Frog														X				X		X			X		
Green Treefrog	X	X			X	X				X	X	X	X	X		X	X	X	X	X	X	X	X	X	
Pine Woods Treefrog	X				X	X							X	X				X	X	X		X			
Barking Treefrog																				X			X		
Squirrel Treefrog	X	X	X	X	X	X	X	X		X		X	X	X		X	X	X	X	X	X	X	X	X	X
Cuban Treefrog						X	X						X	X		X			X						
Spring Peeper	X																								
Southern Chorus Frog										X									X				X		
Little Grass Frog					X	X												X							
Unk. <i>Hyla</i> spp.					X																	X			
Greenhouse Frog				X						X	X		X	X	X						X	X		X	X
East. Narrow-mouthed Toad								X	X	X	X		X	X	X			X	X					X	X
Green Frog									X															X	
Pig Frog				X						X		X							X						
Southern Leopard Frog		X								X				X		X								X	
Unk. <i>Rana</i> spp.										X				X					X				X		
East. Spadefoot									X	X	X		X	X				X						X	
Unk. <i>Anura</i> spp.	X									X						X		X	X			X	X	X	
Unk. <i>Caudata</i> spp.														X											
Alligator														X											
Racer									X																
Common Rat Snake														X											
Rough Green Snake		X	X																		X				
Eastern Ribbon Snake																								X	
Garter Snake																	X								
Snake Skin										X										X					
Green Anole	X		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Brown Anole	X			X		X			X	X						X		X				X		X	X
Green or Brown Anole	X					X				X					X			X							
Southeast. Five-lined Skink	X						X		X		X		X	X	X					X					
Ground Skink				X				X			X		X	X											X
Unk. <i>Eumeces</i> spp.																						X			
Six-lined Racerunner			X	X			X																		
Unk. <i>Emydidæ</i> spp.										X															
Gopher Tortoise							X																		
Gopher Tortoise Burrow	X		X		X		X								X						X		X		
Eastern Box Turtle																									X