



Summary of Amphibian Community Monitoring at Cumberland Island National Seashore, 2009

Natural Resource Data Series NPS/SECN/NRDS—2010/094



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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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data.

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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 Cumberland Island National Seashore in 2009.

- Data were collected at 30 spatially-balanced random locations at the park with two techniques: automated recording devices and visual-encounter surveys.
- Sampling activities occurred at the park from 4/6/2009 to 4/16/2009, and again from 9/9/2009 to 10/2/2009.
- We detected 1240 amphibians in 14 species, genera, families, or orders, and 452 reptiles and reptile signs in 13 species, genera, families, or orders.
- No non-native amphibians or reptiles were detected.
- Two of the amphibians detected were the first recorded occurrences at the park and additions to the species list; Cope's gray treefrog and Southern chorus frog.
- Three of the reptiles detected were the first recorded occurrences at the park and additions to the species list; Southern water snake, banded water snake, and pine woods snake.
- Observed native species richness is 11, the sample very adequately characterized species richness, and the sample was not dominated by any one species.
- Green treefrog and squirrel treefrog are 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

Cumberland Island National Seashore (CUIS), a 26-km (17 ½ mile) long barrier island, is one of the larger and more diverse islands on the Atlantic Coast (Figure 1). Located off the southern Georgia coast adjacent to the Georgia-Florida border, it totals 14,743 ha (36,415 acres), of which 6,821 ha (16,850 acres) are estuarine. A cordgrass (*Spartina* spp.) dominated salt-marsh, oyster mud flats, and tidal creeks provide habitat for a diverse assemblage of fish and wildlife. The terrestrial areas of the park consist of Virginia live oak (*Quercus virginiana*) / palmetto (*Sabal palmetto*) maritime forests, extensive dune systems, interdunal wetlands, freshwater ponds and wetlands, and mixed-pine / hardwood forests in the northern part of the park. Approximately 4000 ha (9886 acres) of the island's northern portion are designated a Wilderness area. The coastal maritime hammock at CUIS is a pristine example of this community type and is host to a variety of resident and migratory species. Although many of the freshwater wetlands and pine communities on the island evolved with frequent fires that maintained an open and highly diverse understory community, the island has experienced substantial anthropogenic-influenced fire suppression over the last century resulting in woody-encroached and drying freshwater wetlands and a reduction in the diversity of the herbaceous understory in the fire-adapted uplands.

The island is known as one of the primary loggerhead sea turtle nesting sites and provides key habitat for nesting and migratory shorebirds and landbirds. The island is also host to an actively controlled feral hog population and a feral horse population. The island has a long history of Native American inhabitants and a brief occupancy by 19th century American aristocracy. The island is sparsely developed and many of the structures occur in the island's five historic districts listed on the National Register of Historic Places.

CUIS has 19 known amphibian species and 43 known reptiles (Appendix A); which includes the two amphibians and two reptiles added to the Park's species list as a result of these 2009 monitoring efforts summarized herein. The amphibians consist of 14 species in Anura (frogs and toads) and five species in Caudata (e.g. salamanders, newts, amphiumas, sirens). The reptiles consist of one species of Crocodilia, 28 species in Squamata (e.g. lizards, snakes, geckos, and skinks), and 14 species in Testudines (turtles and tortoises).

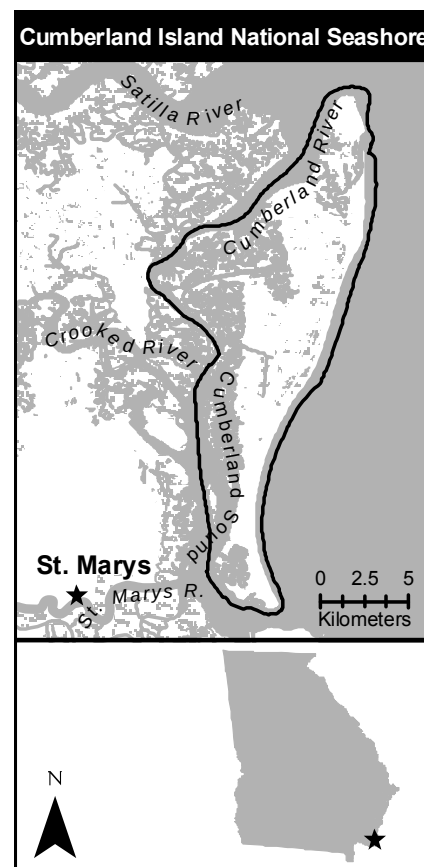


Figure 1. Location of Cumberland Island National

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. Sampling locations are presented in Figure 2.

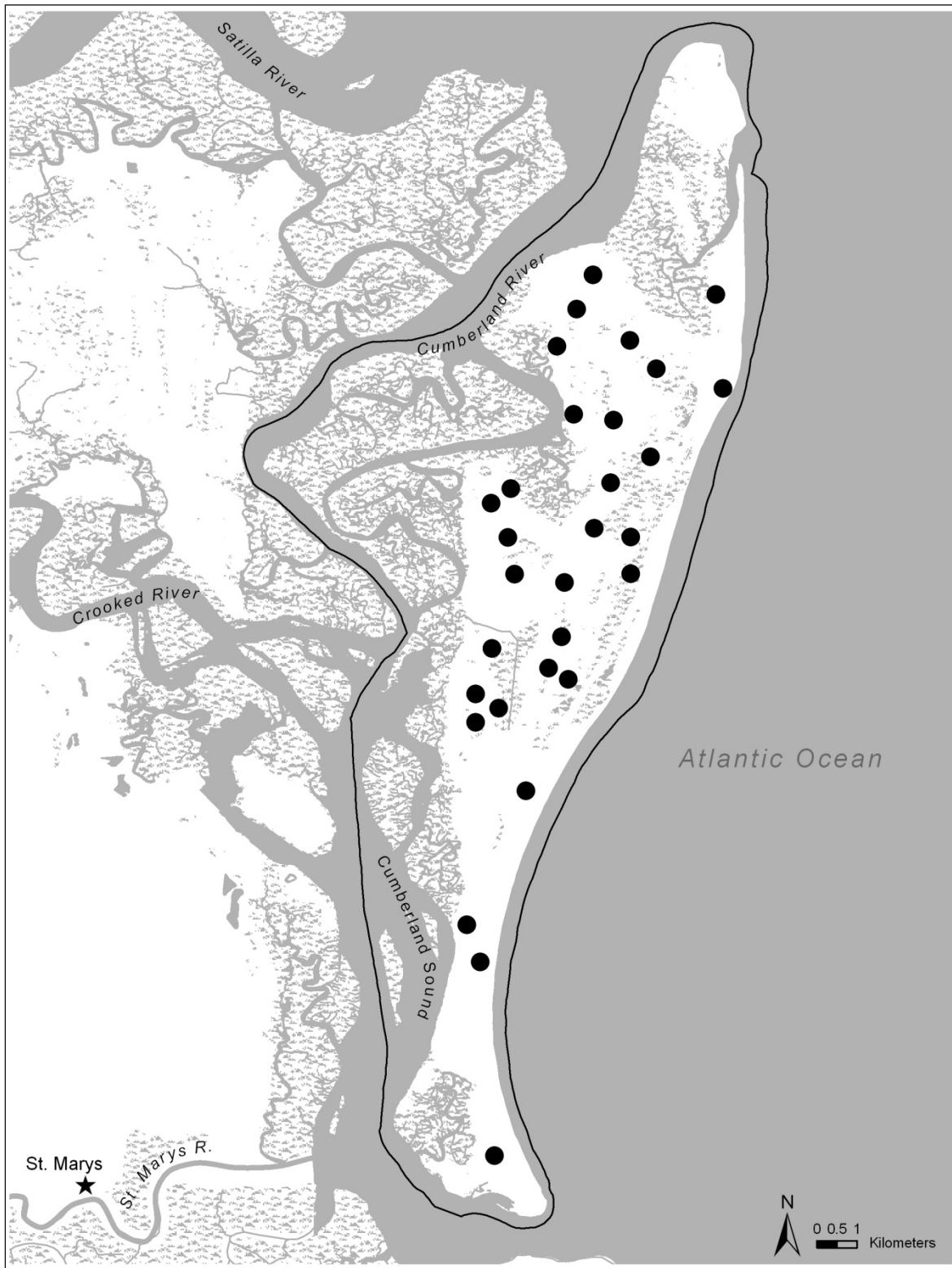


Figure 2. Spatially-balanced random sampling locations at CUIS, 2009.

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).

ARD’s were deployed from 4/6/2009 to 4/16/2009. Of the 30 ARDs deployed, one malfunctioned and failed to record data. A total of 9280 minutes were recorded by all of the devices deployed the park. VESs were conducted from 09/09/2009 to 10/02/2009.

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 best fit by a log-series abundance model; $\chi^2=2.91$, $df=2$, $p=0.233$. The species accumulation curve generated from the data asymptotes at approximately 21 samples (i.e., less than the total number of samples collected of 30), validating the sample size as effective in characterizing amphibian diversity at the park.

Estimates of amphibian species richness across indices are very consistent with one another (i.e., 9.97 – 11.44) with most richness indices resulting in value equal to that of observed species richness (i.e., S_{obs}) (Table 2). Although very seldom seen, computation procedures of many indices with the CUIS amphibian data resulted in miniscule measures of variability, thereby resulting in no meaningful confidence interval (or 99% confidence that species richness is the reported value). Species diversity is moderate ($\alpha=1.67$, $Q=2.75$) (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 CUIS, 2009.

Index	Symbol	Value	Lower 95% CI	Upper 95% CI	Value Interpretation
Native Spp. Richness	S_{obs}	11.00	11.00	11.00	Number of native species detected; 95% CI unavailable because resampling variance was miniscule meaning sampling effort characterized species richness very well.
Chao 1	Chao1	11.00	11.00	11.00	Estimated true species richness
Chao 2	Chao2	11.00	11.00	11.11	Estimated true species richness
Abundance-based Coverage	ACE	11.00	11.00	11.00	Estimated true species richness
Incidence-based Coverage	ICE	11.00	11.00	11.00	Estimated true species richness
Jackknife 1	Jack1	11.00	11.00	11.00	Estimated true species richness
Jackknife 2	Jack2	9.97	7.54	12.40	Estimated true species richness
Bootstrap	Boot	11.44	11.22	11.66	Estimated true species richness
Fisher's α	α	1.67	1.30	2.04	Baseline value, suggests medium diversity
Q Statistic	Q	2.75	2.15	3.52	Baseline value, suggests medium diversity
Smith and Wilson	E_{var}	0.226	0.169	0.257	Species occur in a variety of relative abundances – low evenness
Smith and Wilson 1/D	E_{1/D}	0.240	0.229	0.256	Species occur in a variety of relative abundances – low evenness
Camargo	E'	0.284	0.270	0.303	Species occur in a variety of relative abundances – low evenness
Gini	E_G	0.260	0.170	0.350	Species occur in a variety of relative abundances – low evenness
Berger-Parker	D_{BP}	0.491	0.461	0.518	Sample is not dominated by a single species

Composition

Amphibians

We detected 1240 amphibians in 17 species, genera, or order. The majority of the sample was composed of green treefrog, squirrel treefrog, and little grass frog (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). Green treefrog and squirrel treefrog were the most frequently encountered species (0.80 and 0.77, respectively), followed by pine woods treefrog (0.30), little grass frog (0.30), and Southern cricket frog (0.27) (Table 3). Southern chorus frog, Cope's gray treefrog, and Eastern spadefoot toad (i.e., all at 0.07) were the least frequently encountered species (Table 3). No non-native amphibians were detected.

Reptiles

We detected 452 reptiles and reptile signs in 13 species or genera. The majority of the sample was composed of green anole, ground skink, and Eastern fence lizard (Figure 4). The frequency of occurrence for reptiles detected during 2009 sampling effort is presented in Table 4. No non-native reptiles were detected.

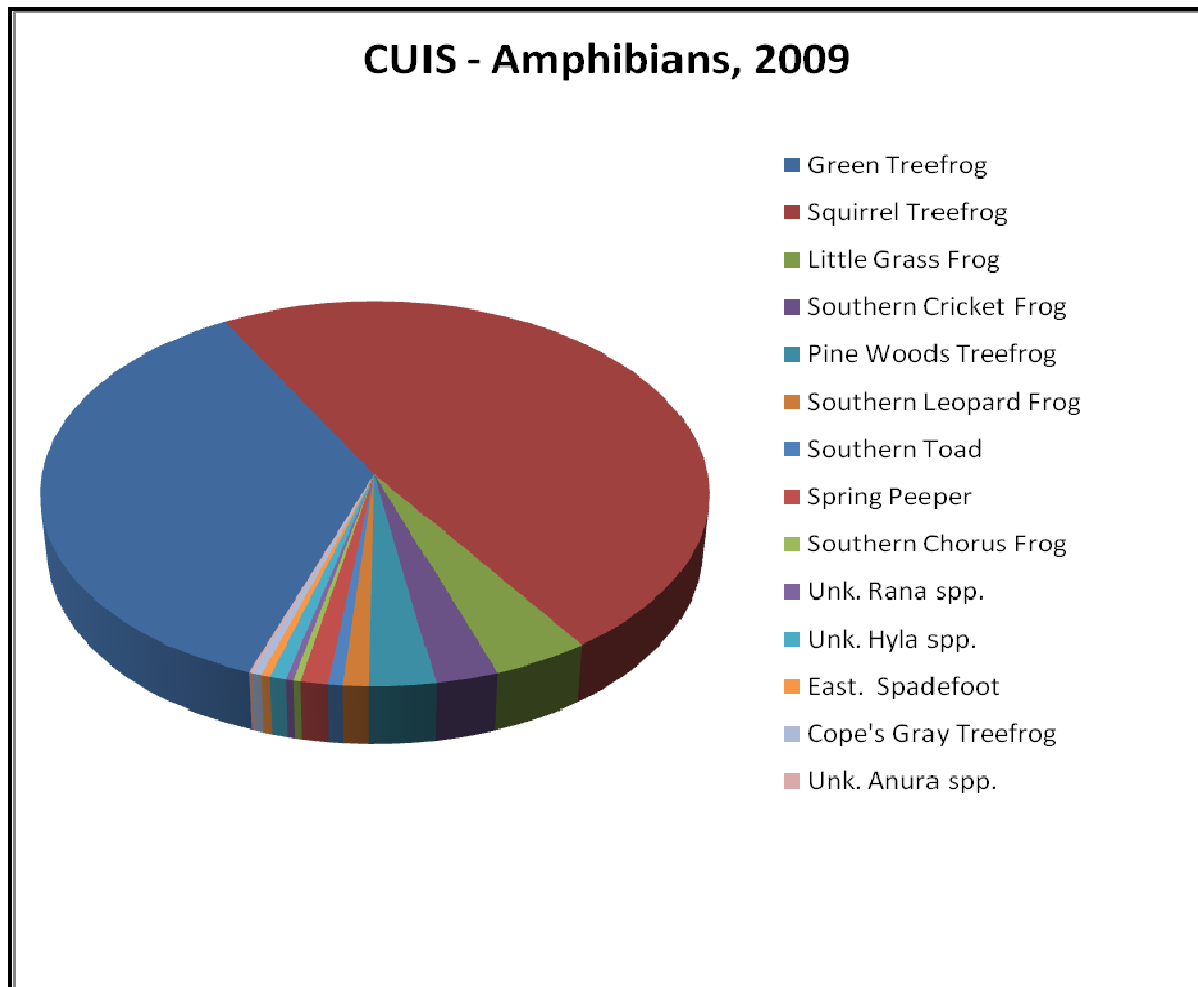


Figure 3. Proportions of amphibian species in the 2009 CUIS sample.

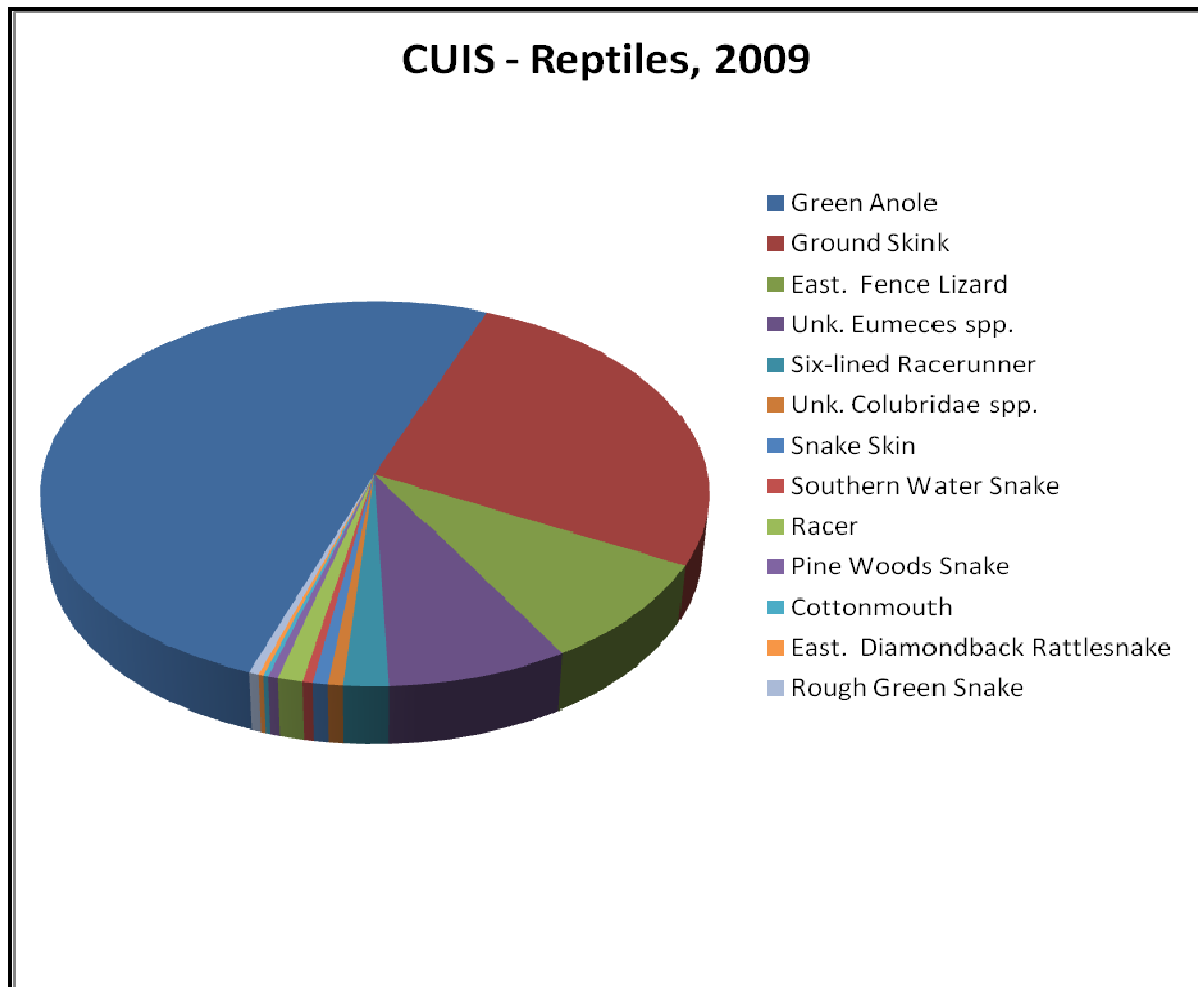


Figure 4. Proportion of reptile species and reptile signs in the 2009 CUIS sample.

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

Common Name	Frequency of Occurrence
Squirrel Treefrog	0.80
Green Treefrog	0.77
Pine Woods Treefrog	0.30
Little Grass Frog	0.27
Southern Cricket Frog	0.27
Southern Toad	0.17
Spring Peeper	0.13
Southern Leopard Frog	0.10
Unk. <i>Hyla</i> spp.	0.10
Southern Chorus Frog	0.07
Eastern Spadefoot	0.07
Cope's Gray Treefrog	0.07
Unk. <i>Anura</i> spp.	0.07
Unk. <i>Rana</i> spp.	0.03

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

Common Name	Frequency of Occurrence
Green Anole	0.70
Ground Skink	0.67
Unk. <i>Eumeces</i> spp.	0.47
Eastern Fence Lizard	0.33
Six-lined Racerunner	0.10
Snake Skin	0.10
Unk. <i>Colubridae</i> spp.	0.07
Southern Water Snake	0.07
Racer	0.07
Pine Woods Snake	0.03
Cottonmouth	0.03
East. Diamondback	0.03
Rattlesnake	0.03
Rough Green Snake	0.03

Distribution

Amphibians

Green treefrog (Figure 8) and squirrel treefrog (Figure 10) were the most widely distributed species. Cope's gray treefrog (Figure 7) and Eastern spadefoot toad (Figure 15) were only detected in the northwest portion of the park. Southern chorus frog, while only detected in two locations, do not appear to be aggregated in any specific region of the park (Figure 12). Species lists for each sampling location are in Appendix C.

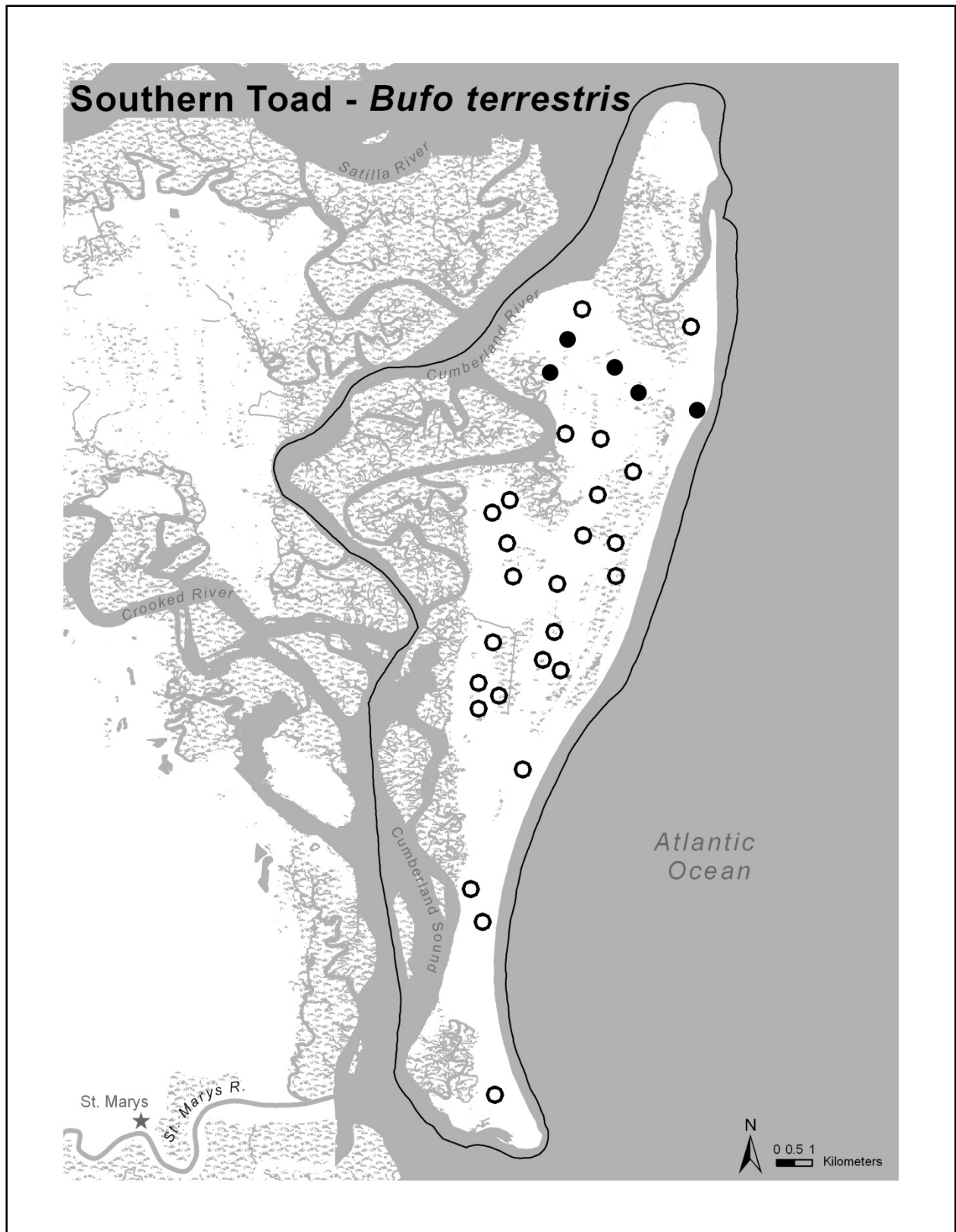


Figure 5. Sampling locations where Southern toad (*Bufo terrestris*) was detected at CUIS, 2009.
● = detected, ○ = not detected.

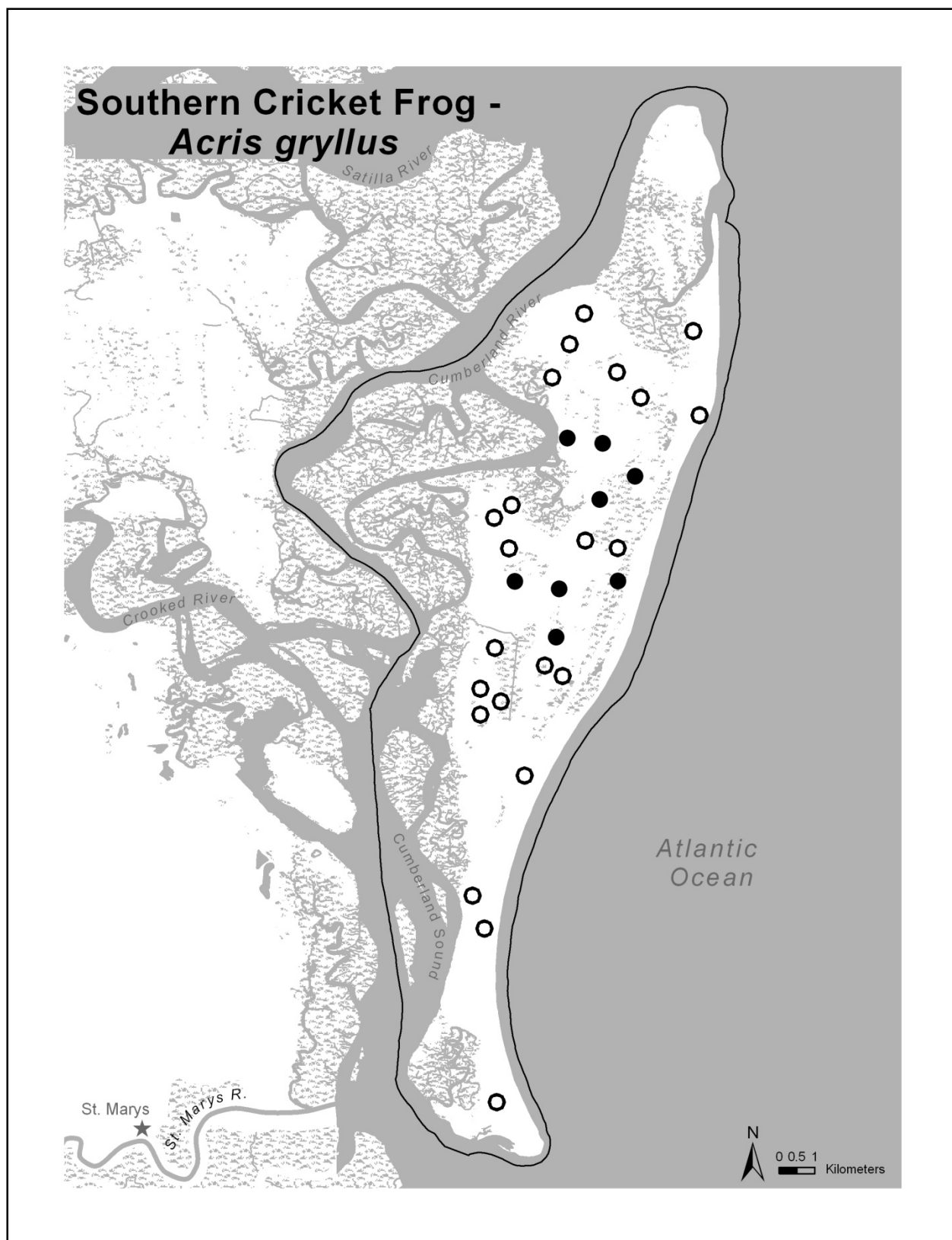


Figure 6. Sampling locations where Southern cricket frog (*Acris gryllus*) was detected at CUIS, 2009.
● = detected, ○ = not detected.

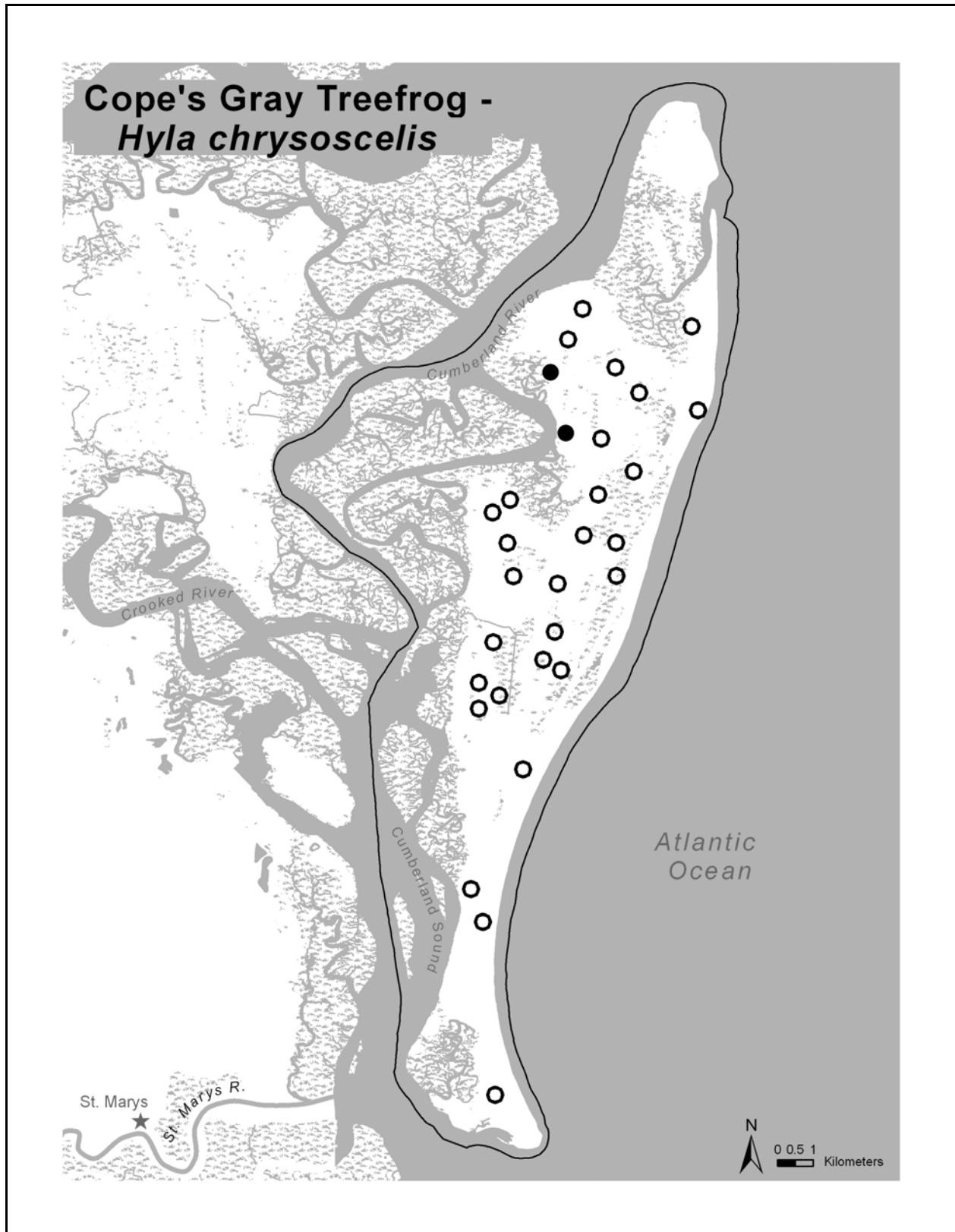


Figure 7. Sampling locations where Cope's gray treefrog (*Hyla chrysoscelis*) was detected at CUIS, 2009. ● = detected, ○ = not detected.

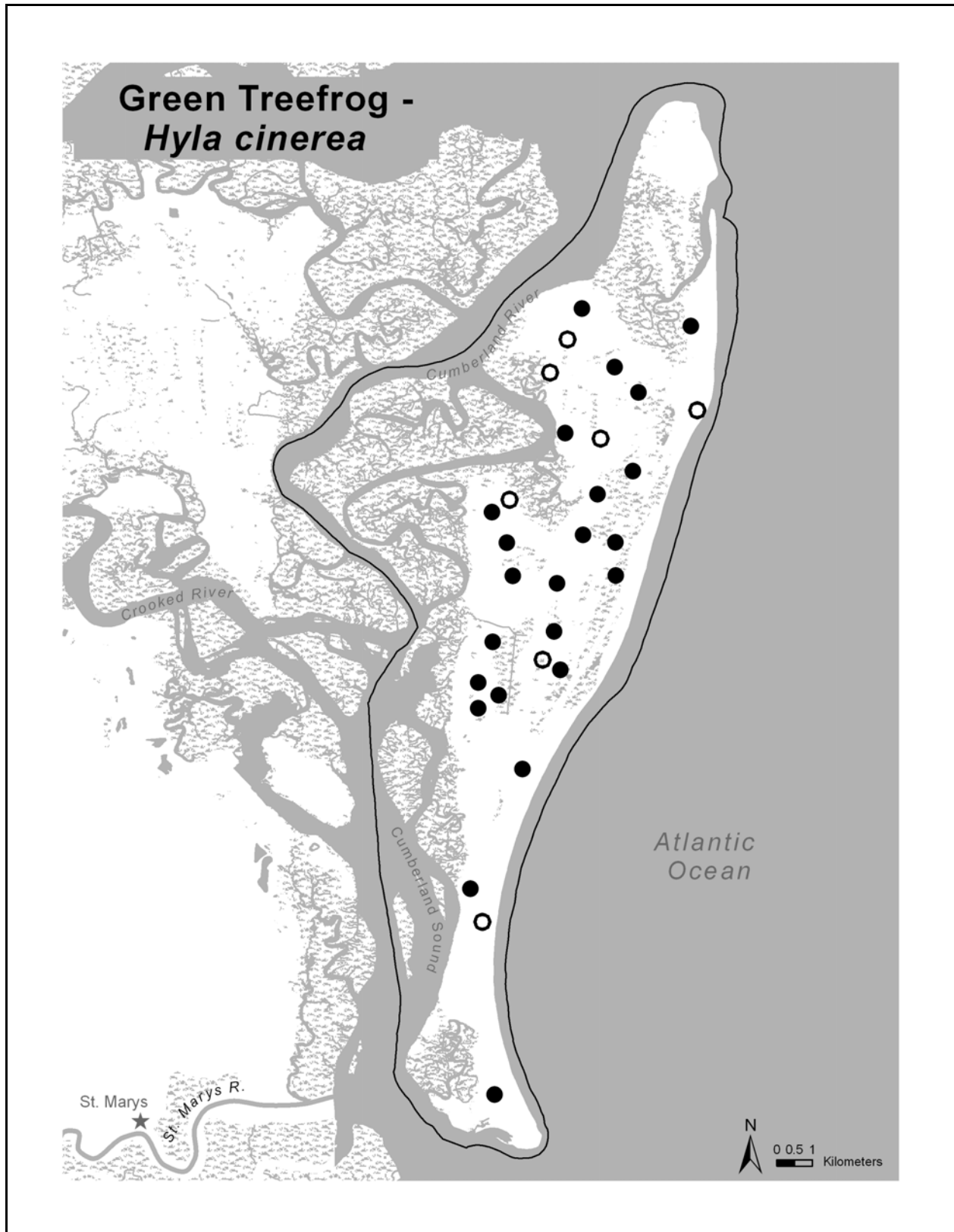


Figure 8. Sampling locations where green treefrog (*Hyla cinerea*) was detected at CUIS, 2009.
● = detected, ○ = not detected.

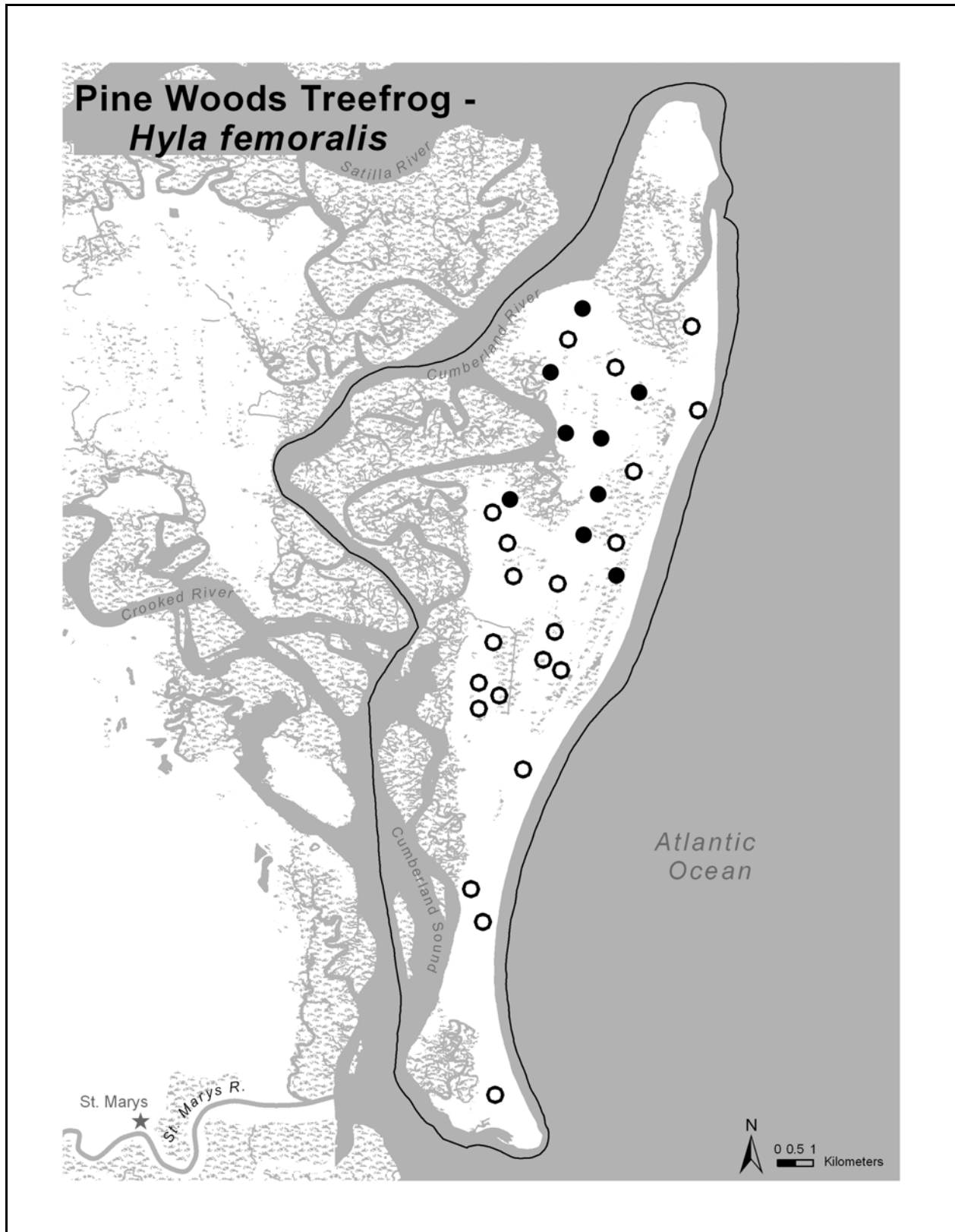


Figure 9. Sampling locations where pine woods treefrog (*Hyla femoralis*) was detected at CUIS, 2009.
● = detected, ○ = not detected.

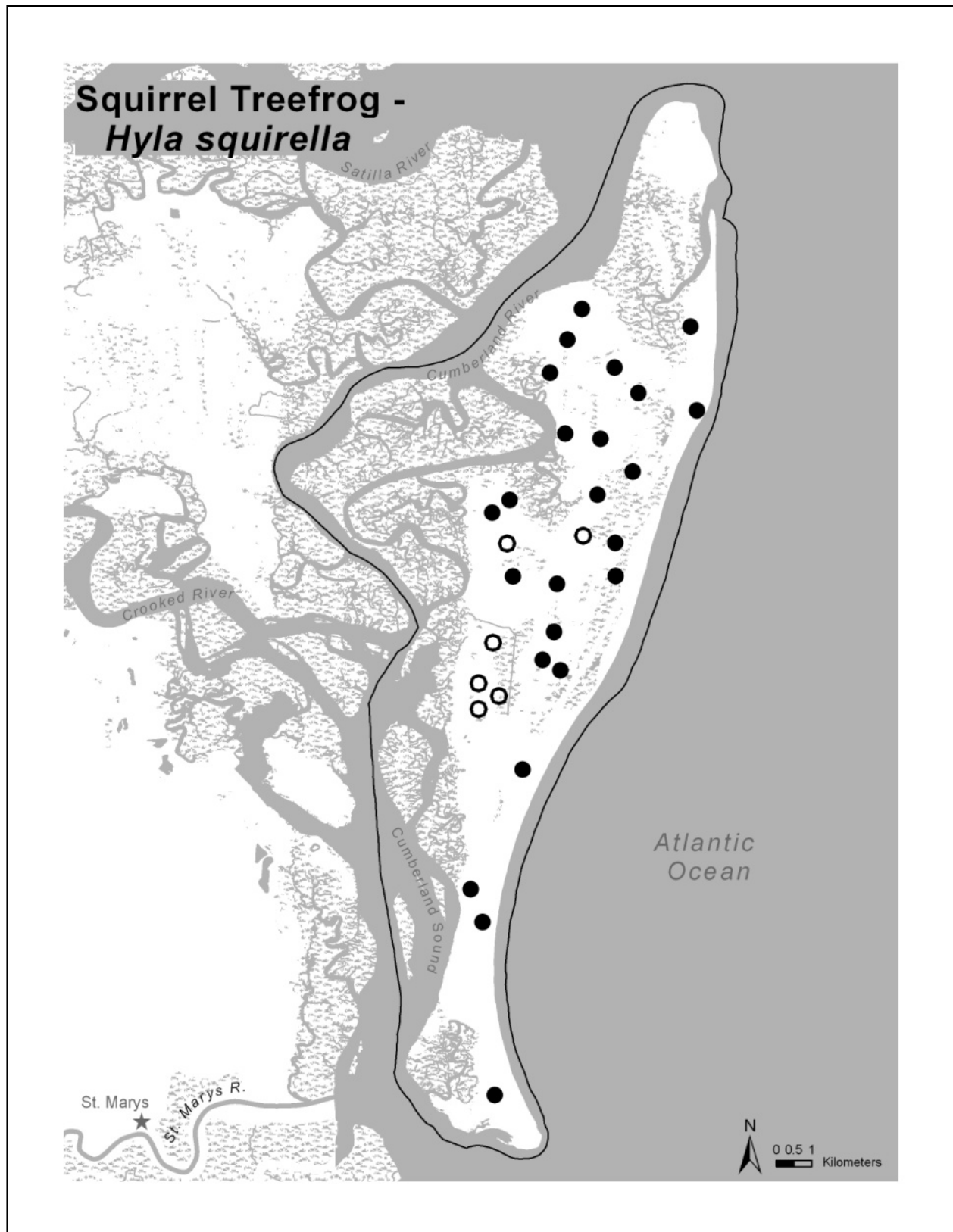


Figure 10. Sampling locations where squirrel treefrog (*Hyla squirella*) was detected at CUIS, 2009.
● = detected, ○ = not detected.

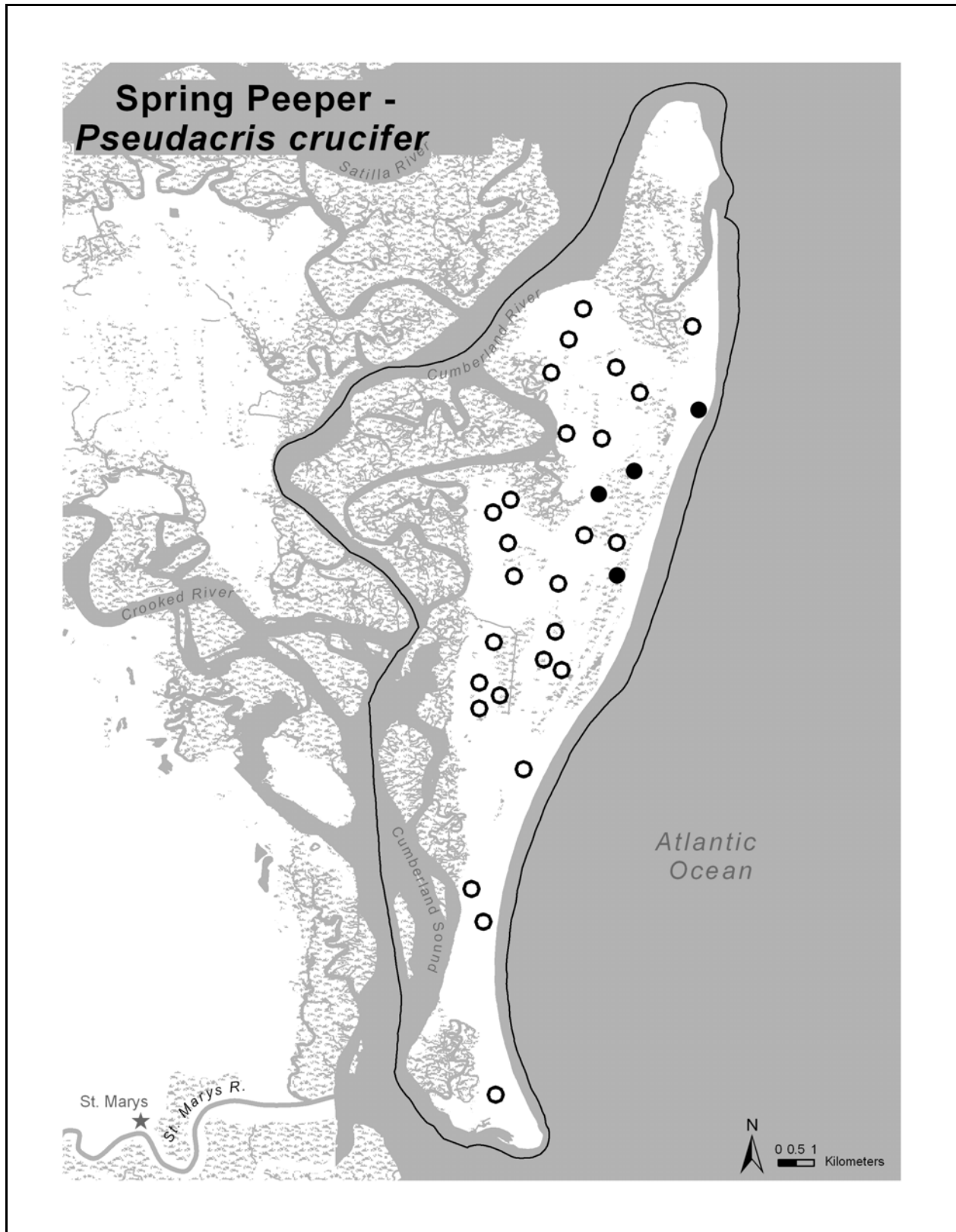


Figure 11. Sampling locations where spring peeper (*Pseudacris crucifer*) was detected at CUIS, 2009.
● = detected, ○ = not detected.

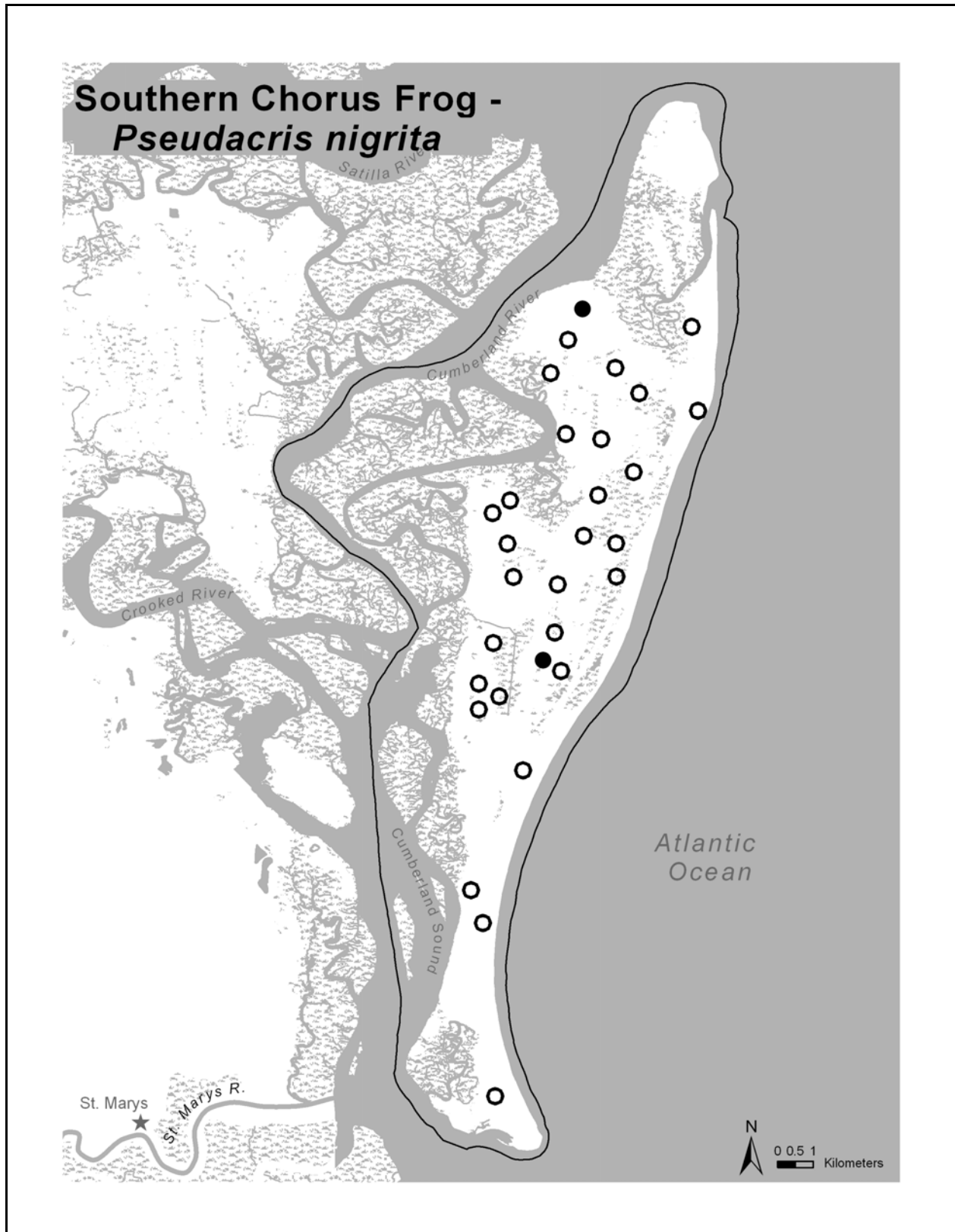


Figure 12. Sampling locations where Southern chorus frog (*Pseudacris nigrita*) was detected at CUIS, 2009. ● = detected, ○ = not detected.

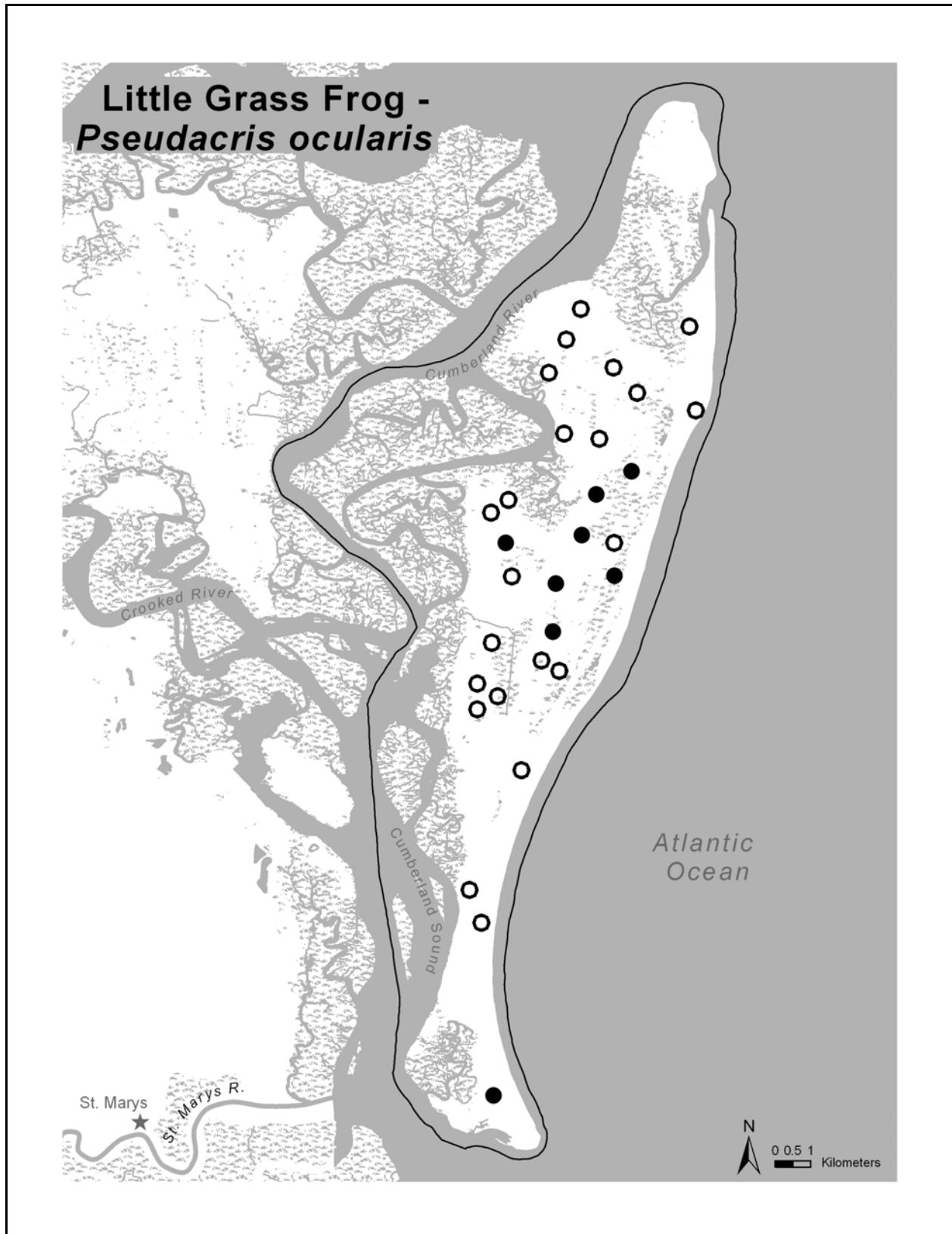


Figure 13. Sampling locations where little grass frog (*Pseudacris ocularis*) was detected at CUIS, 2009.
● = detected, ○ = not detected.

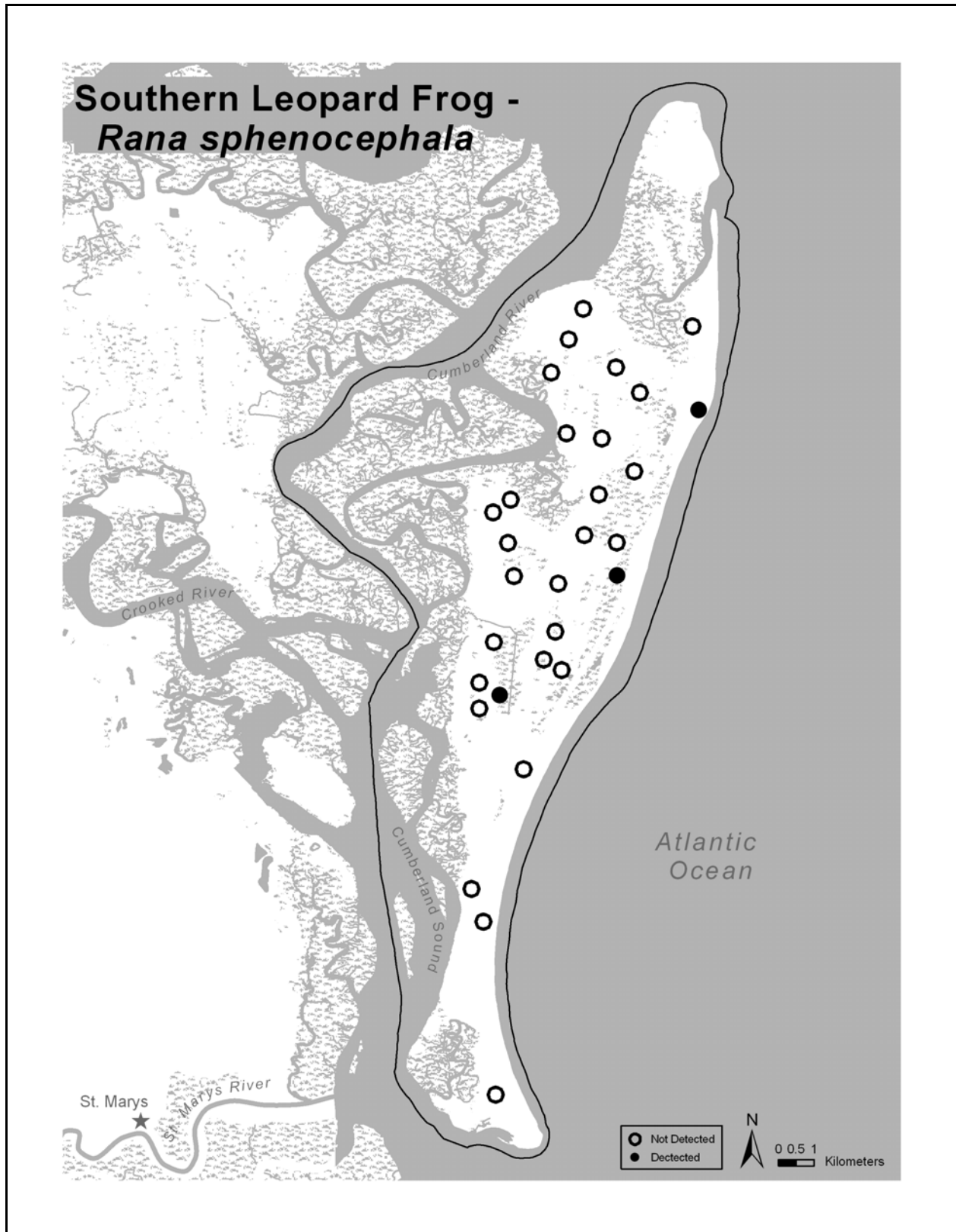


Figure 14. Sampling locations where Southern leopard frog (*Rana sphenocephala*) was detected at CUIS, 2009. ● = detected, ○ = not detected.

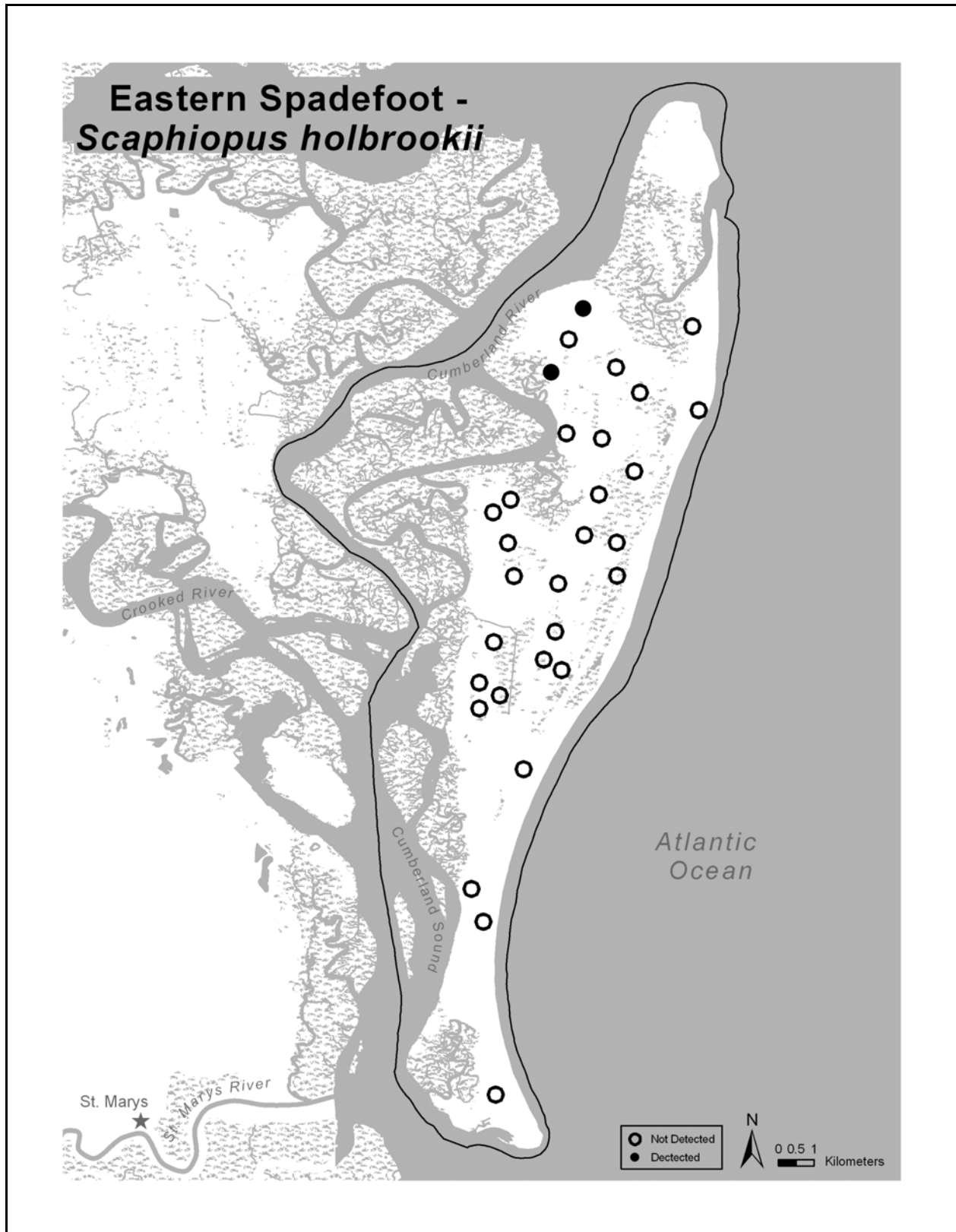


Figure 15. Sampling locations where Eastern spadefoot toad (*Scaphiopus holbrookii*) was detected at CUIS, 2009. ● = detected, ○ = not detected.

Reptiles

Green anole (Figure 21) and ground skink (Figure 23) were the most widely distributed reptiles detected, followed by Eastern fence lizard (Figure 20). Species lists for each sampling location are in Appendix C.

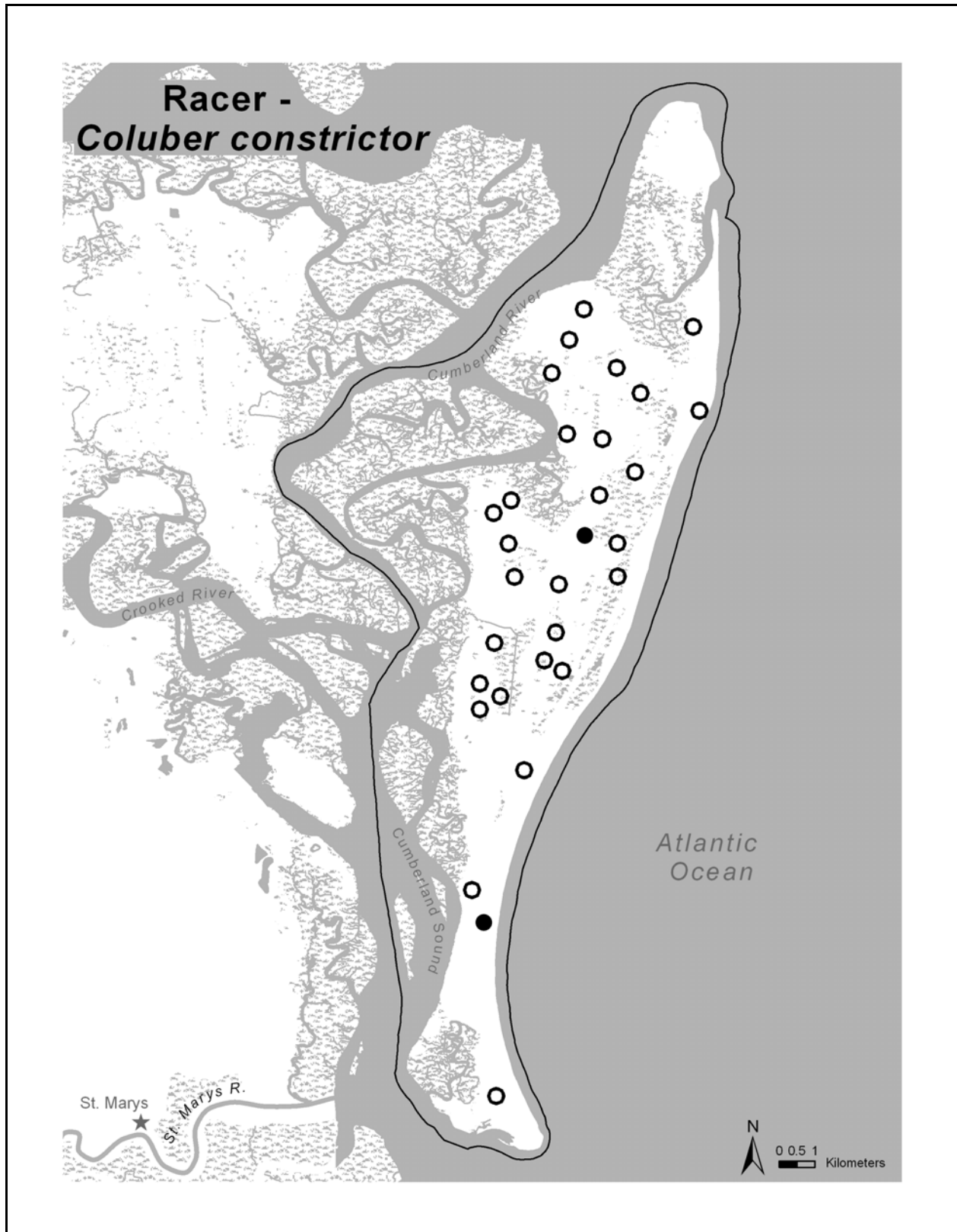


Figure 16. Sampling locations where racer (*Coluber constrictor*) was detected at CUIS, 2009.
● = detected, ○ = not detected.

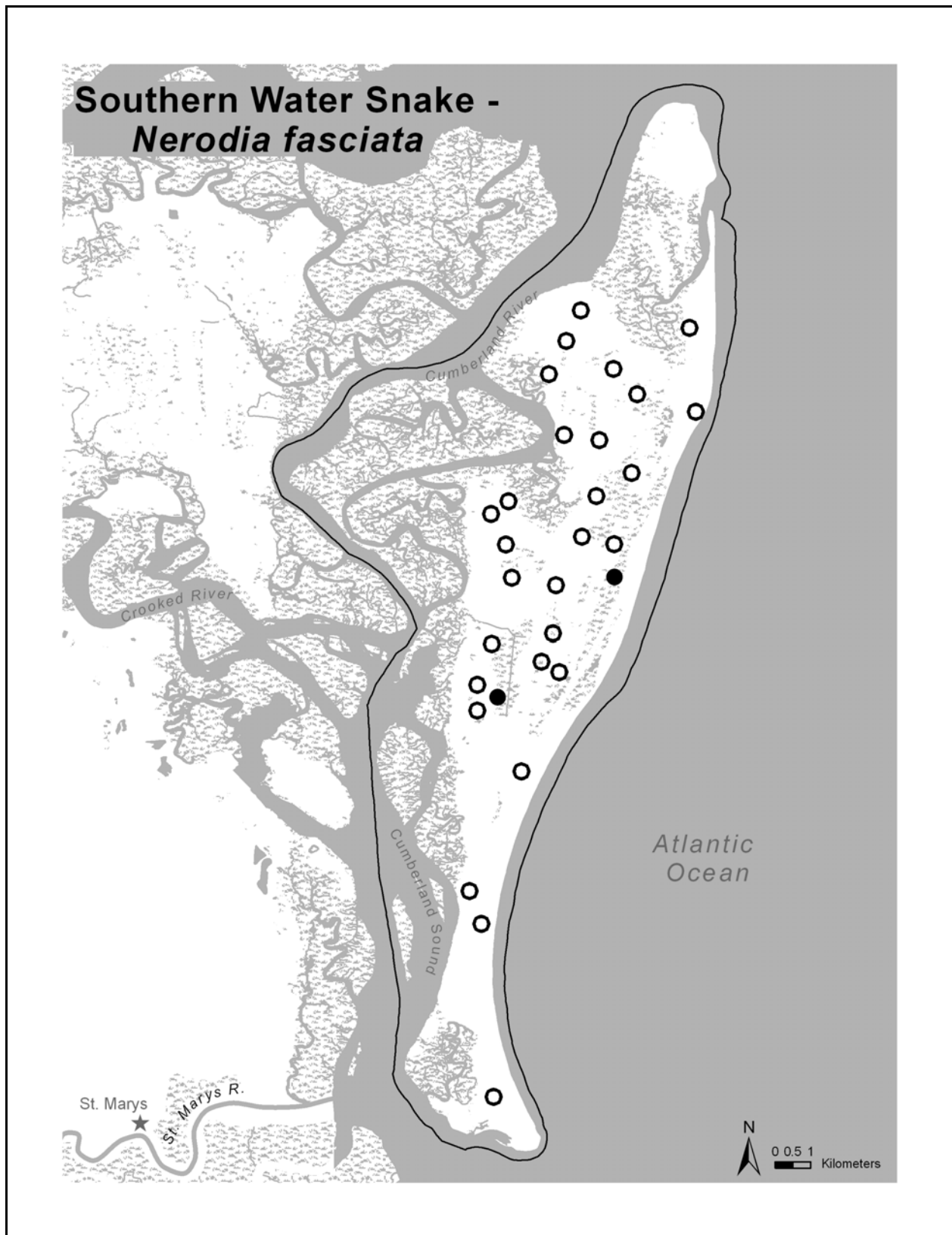


Figure 17. Sampling locations where Southern water snake (*Nerodia fasciata*) was detected at CUIS, 2009. ● = detected, ○ = not detected.

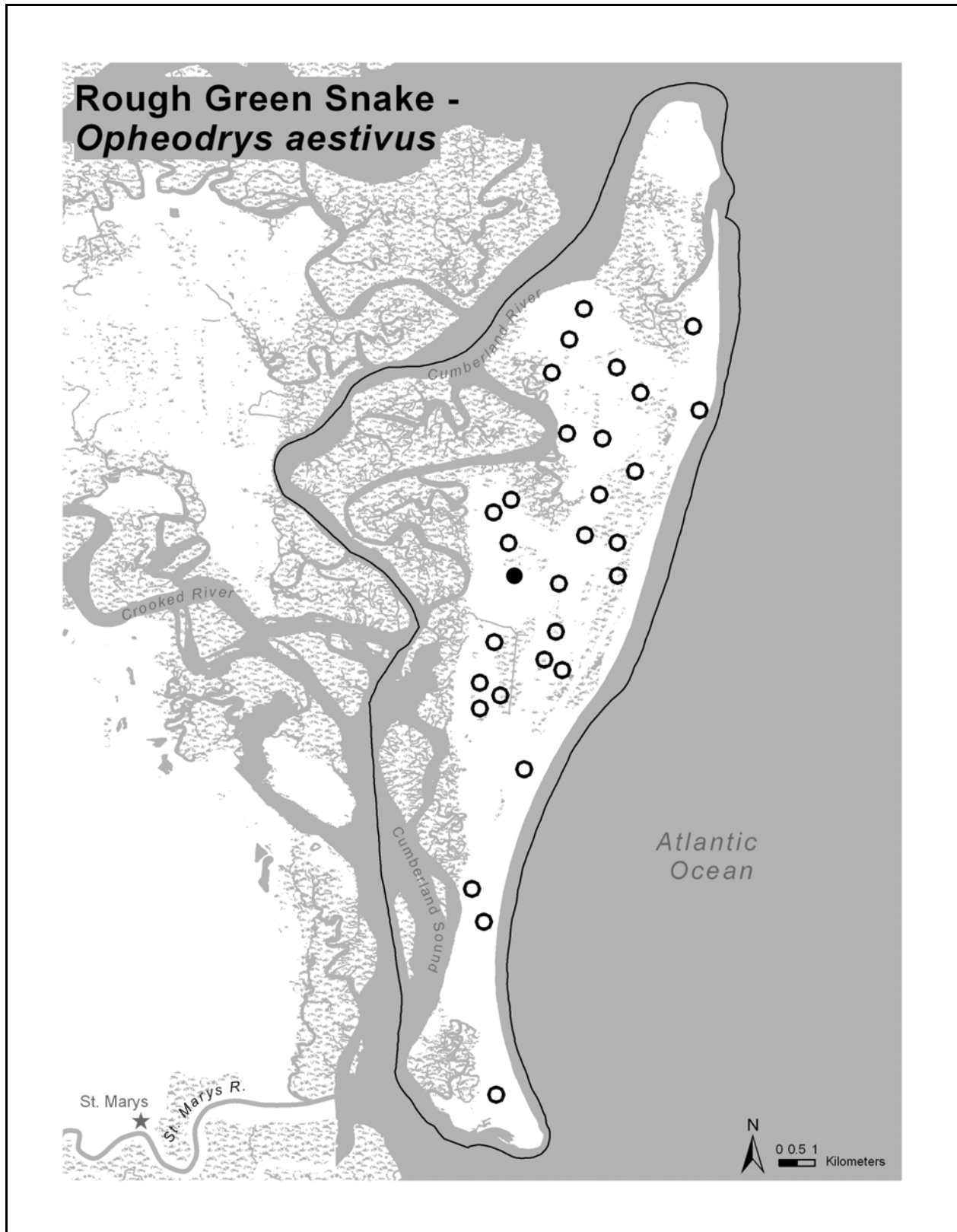


Figure 18. Sampling locations where rough green snake (*Opheodrys aestivus*) was detected at CUIS, 2009. ● = detected, ○ = not detected.

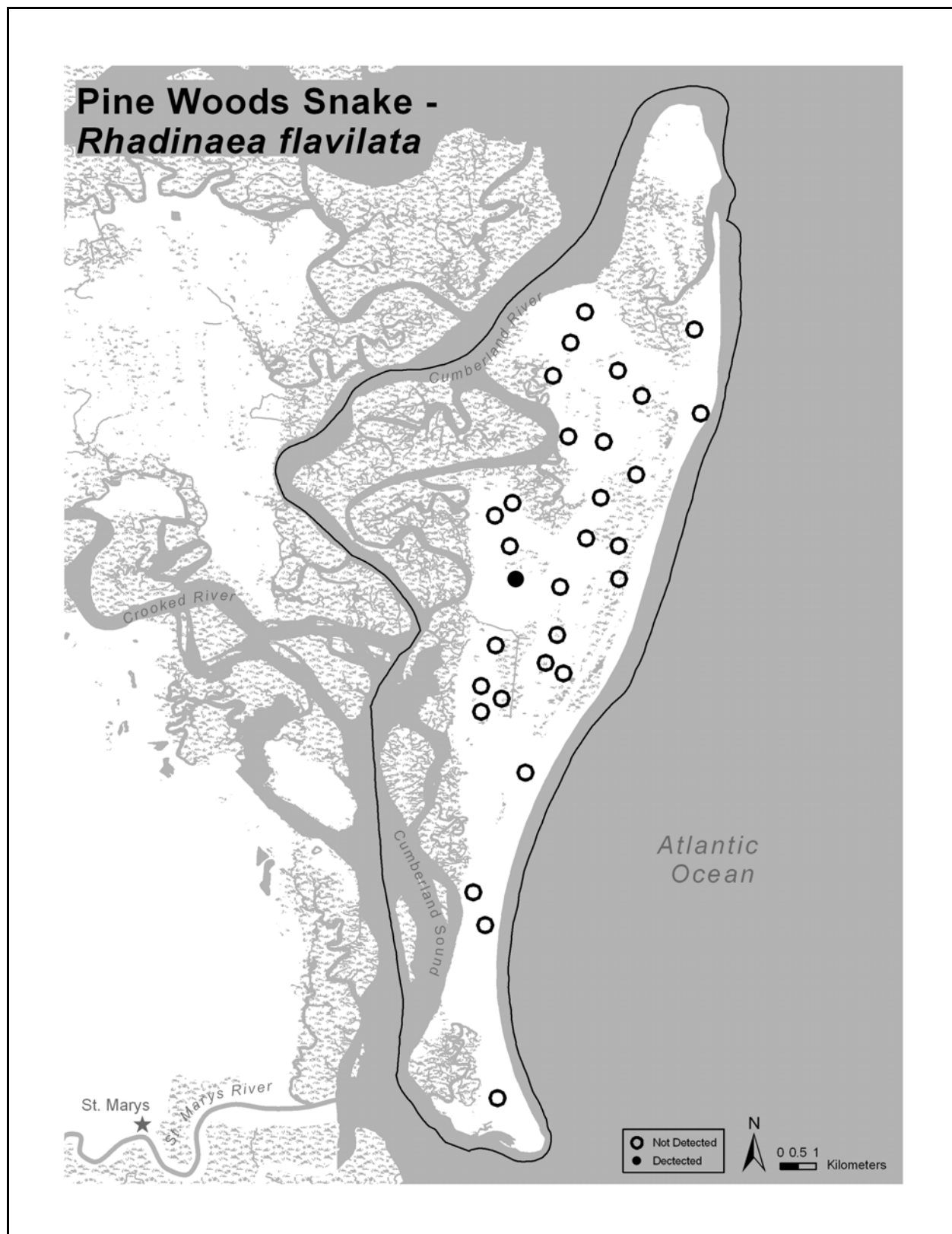


Figure 19. Sampling locations where pine woods snake (*Rhadinaea flavilata*) was detected at CUIS, 2009. ● = detected, ○ = not detected.

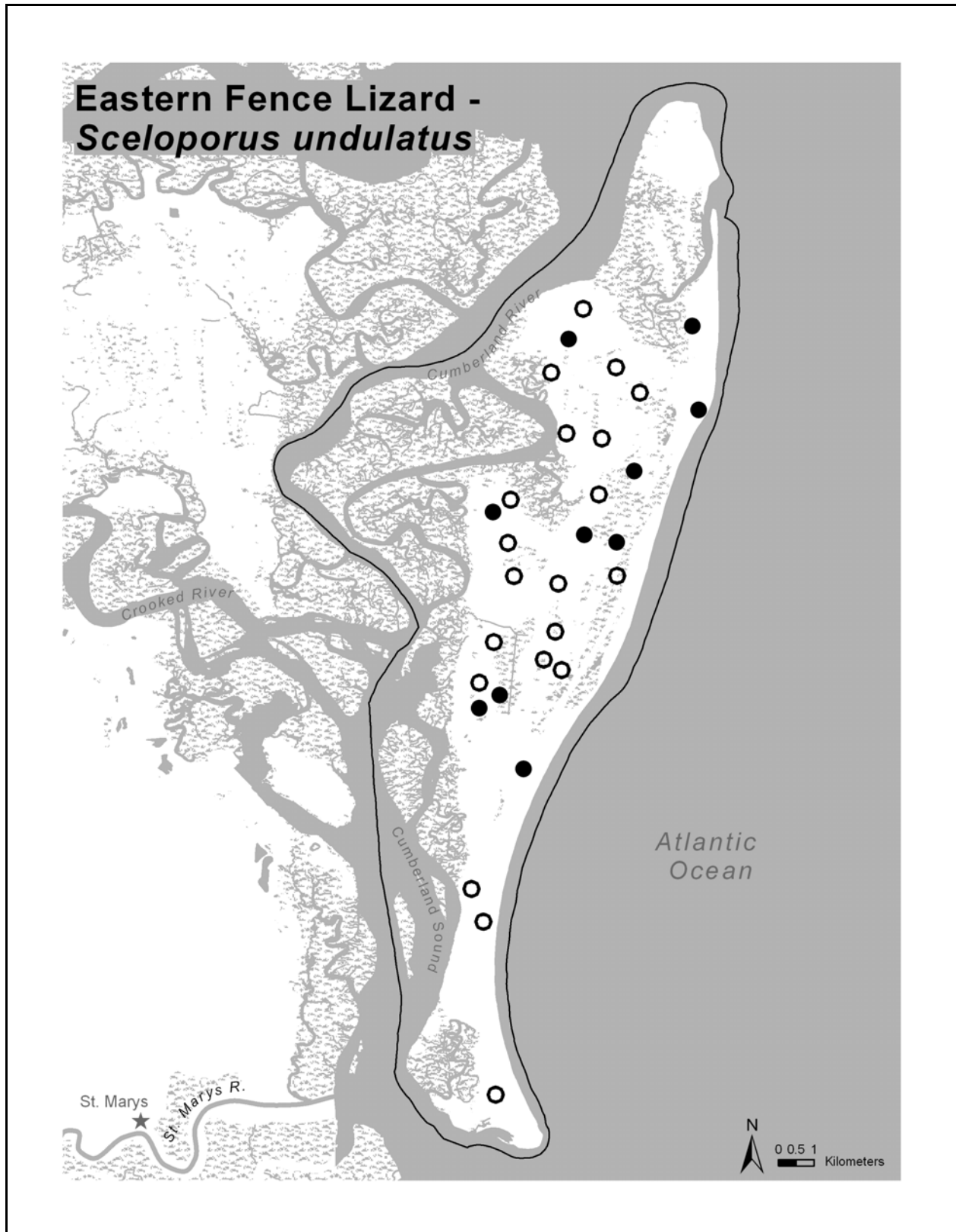


Figure 20. Sampling locations where Eastern fence lizard (*Sceloporus undulatus*) was detected at CUIS, 2009. ● = detected, ○ = not detected.

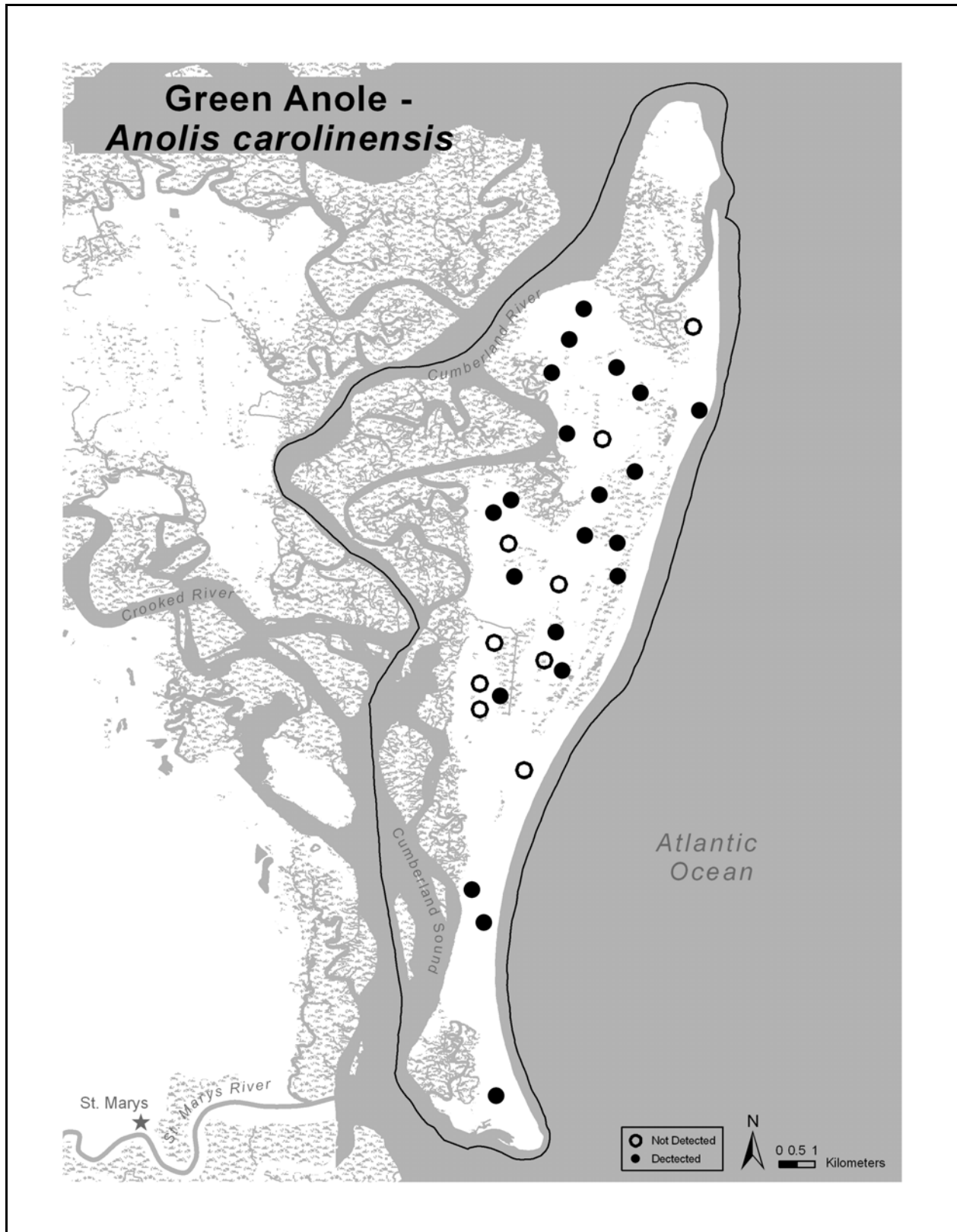


Figure 21. Sampling locations where green anole (*Anolis carolinensis*) was detected at CUIS, 2009.
● = detected, ○ = not detected.

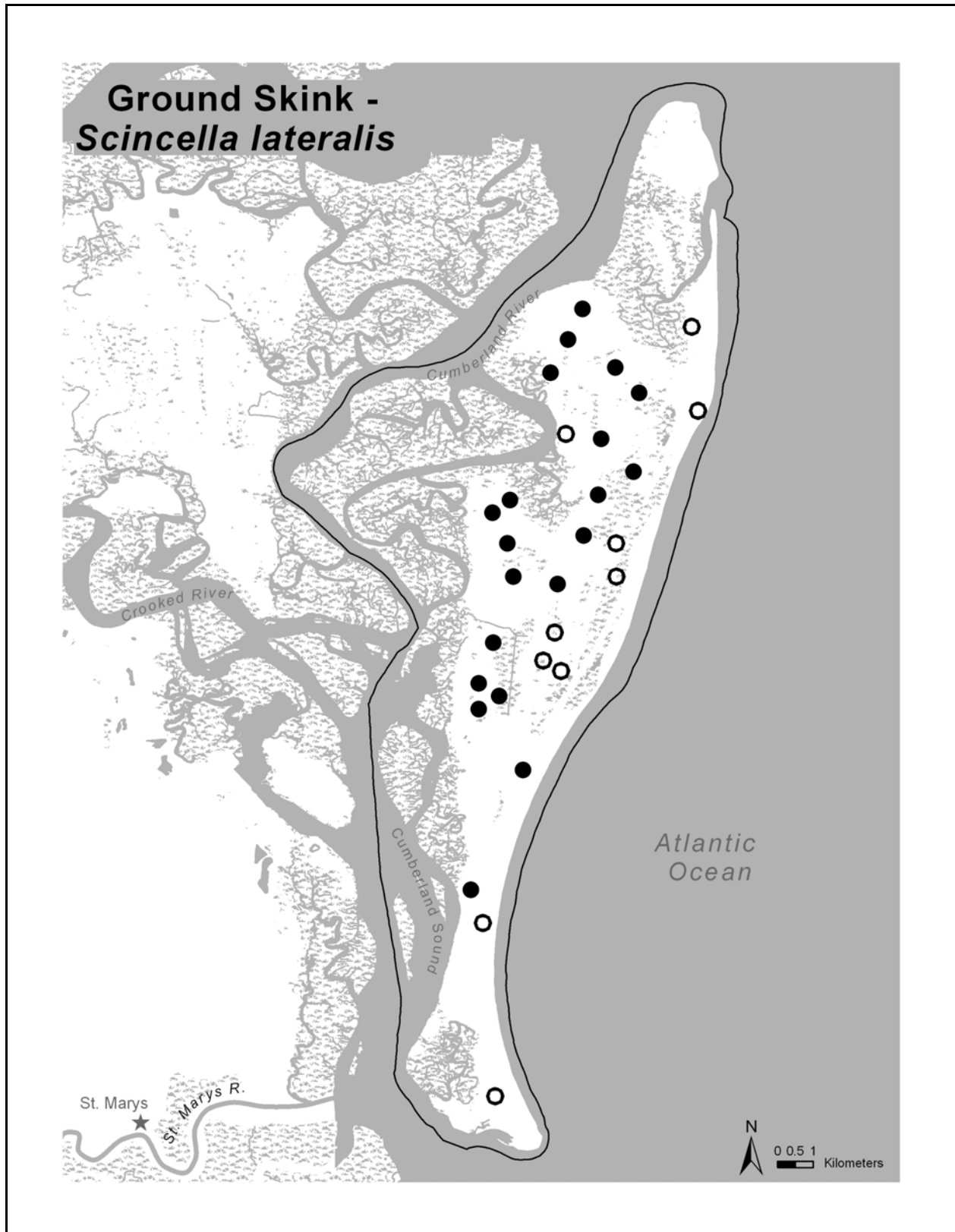


Figure 23. Sampling locations where ground skink (*Scincella lateralis*) was detected at CUIS, 2009.
● = detected, ○ = not detected.

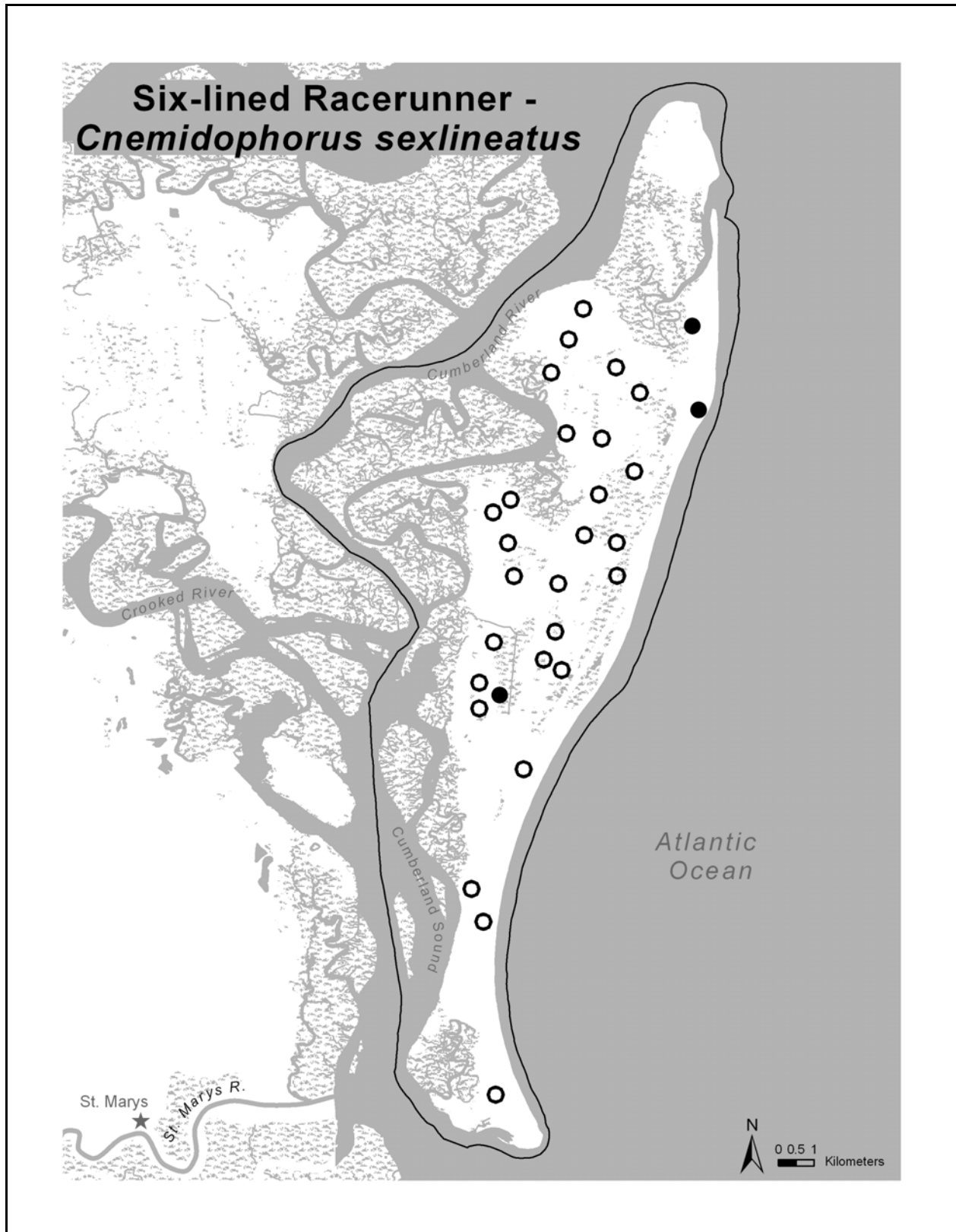


Figure 24. Sampling locations where six-lined racerunner (*Cnemidophorus sexlineatus*) was detected at CUIS, 2009. ● = detected, ○ = not detected.

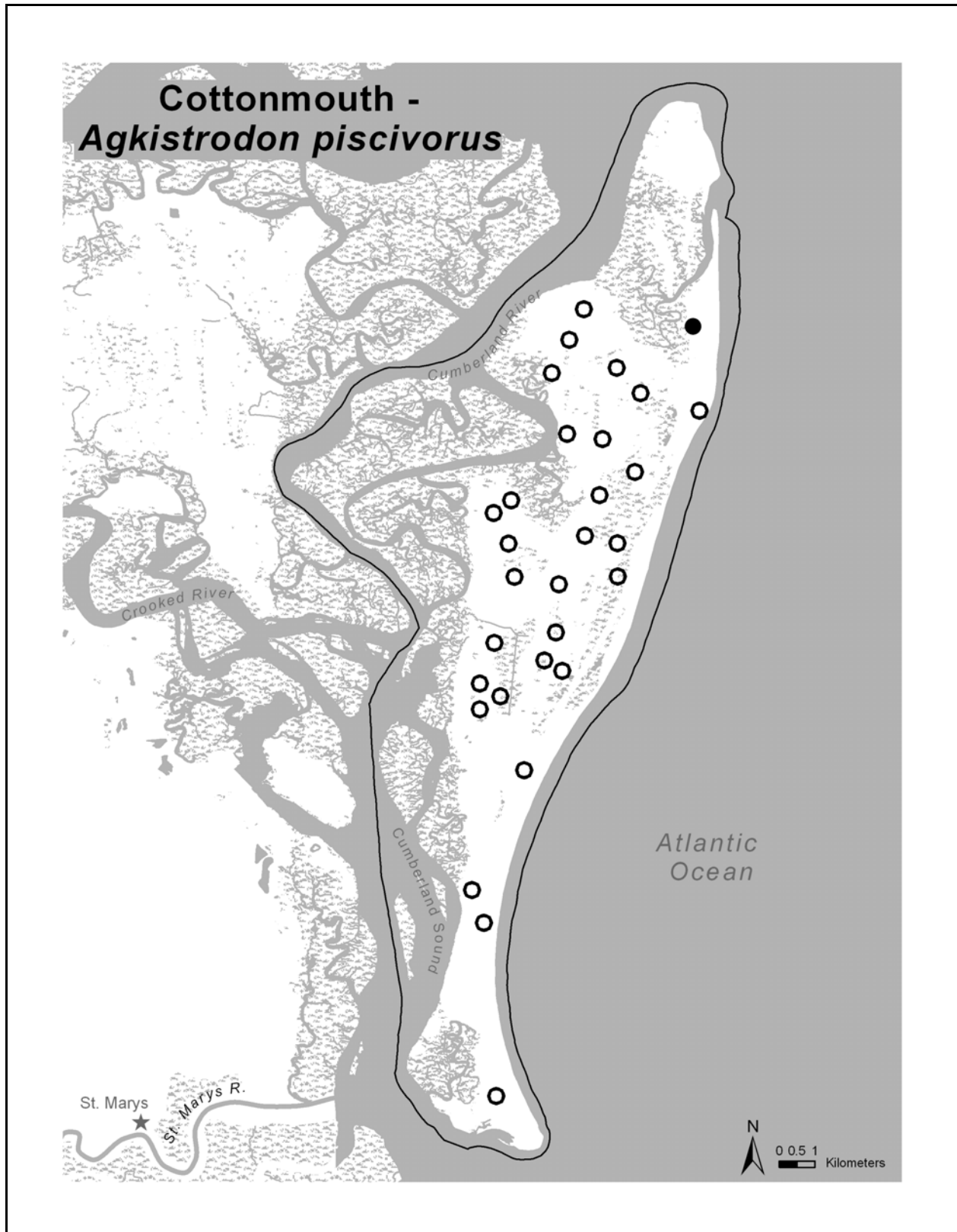


Figure 25. Sampling locations where cottonmouth (*Agkistrodon piscivorus*) was detected at CUIS, 2009.
● = detected, ○ = not detected.

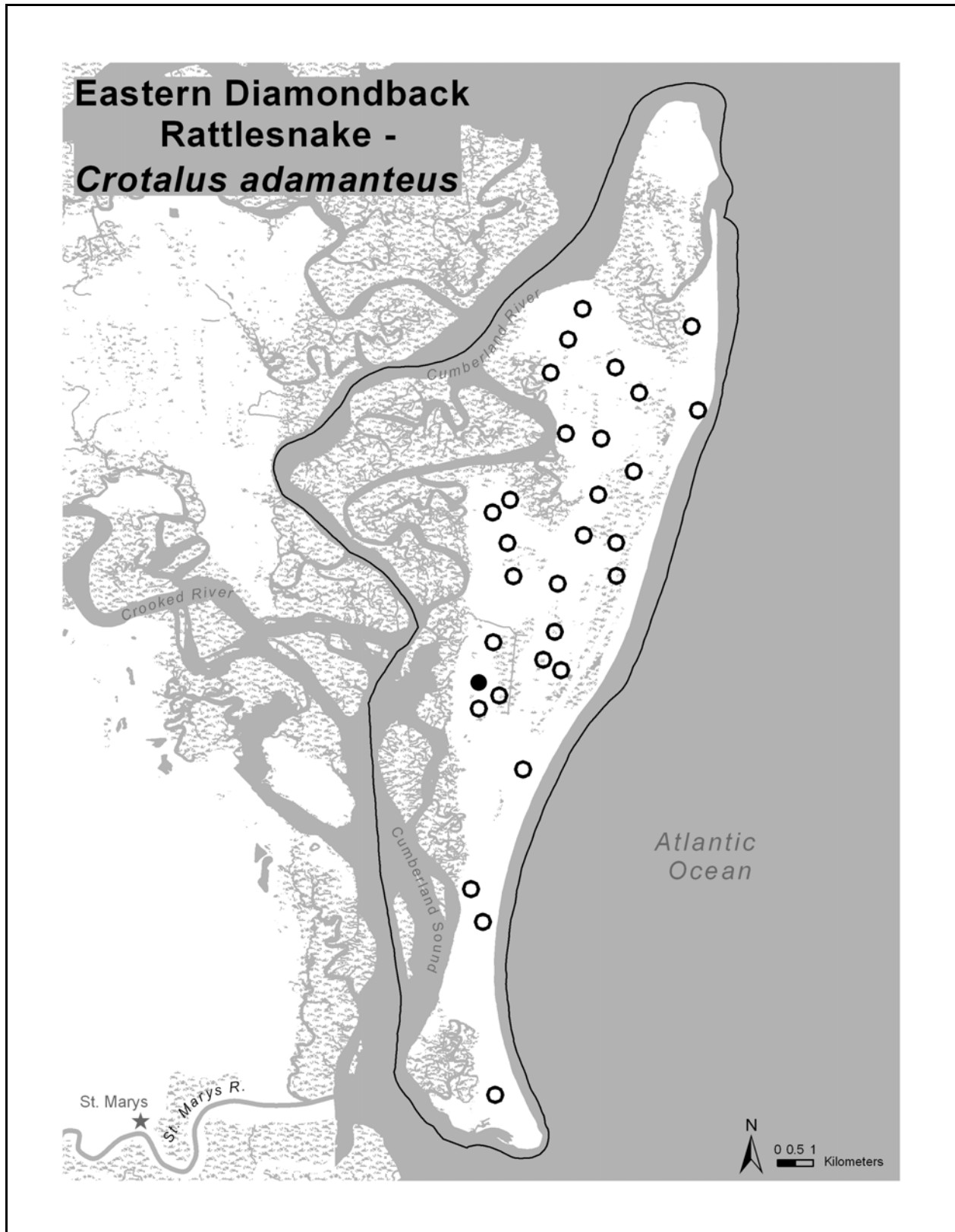


Figure 26. Sampling locations where Eastern diamondback rattlesnake (*Crotalus adamanteus*) was detected at CUIS, 2009. ● = detected, ○ = not detected.

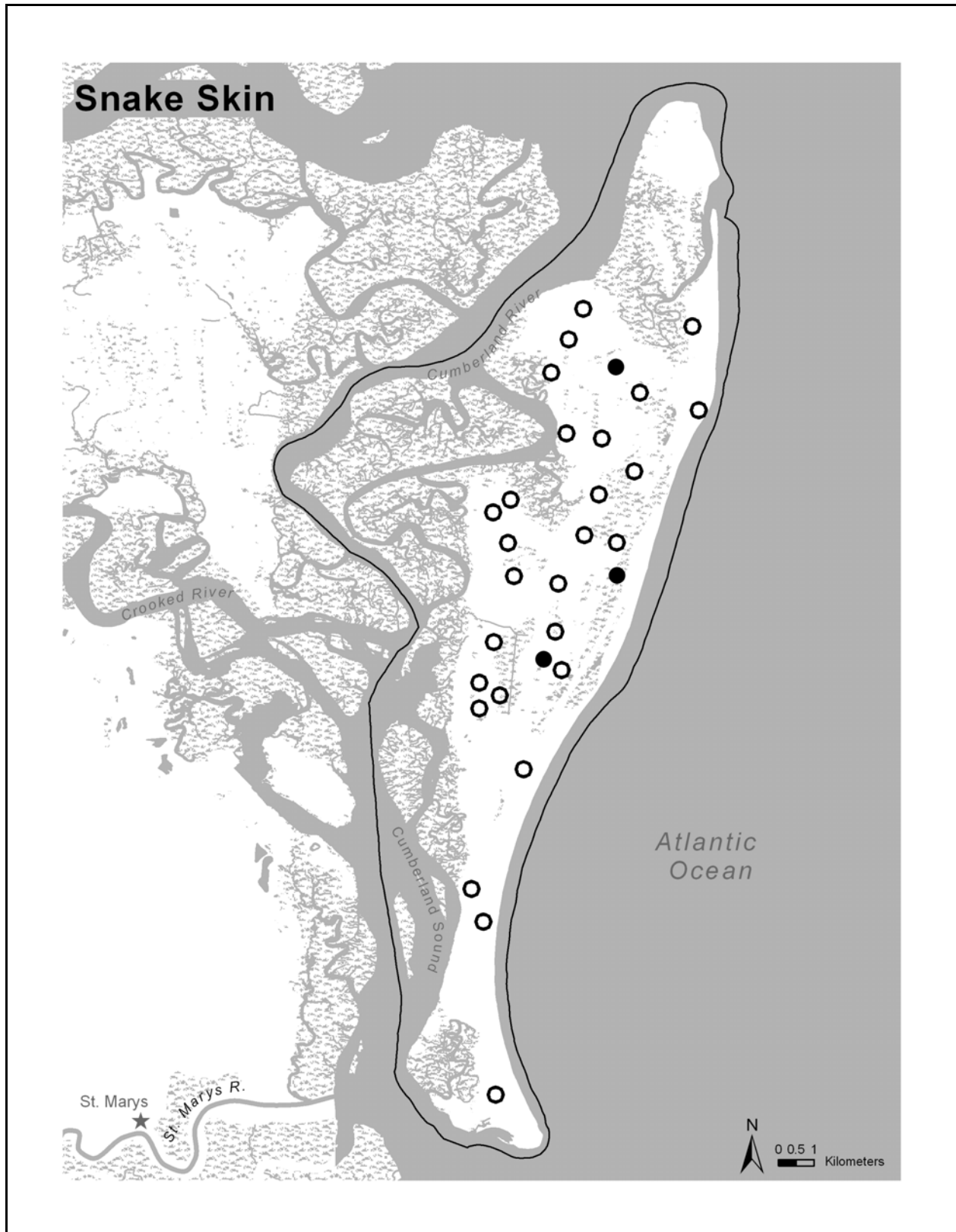


Figure 27. Sampling locations where snake skin was detected at CUIS, 2009.
● = detected, ○ = not detected.

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Appendix A. Amphibians and reptiles known to occur at CUIS.

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

Order	Family	Scientific Name	Common Name	NPSpecies	ARD	VES
Anura	Bufonidae	<i>Bufo terrestris</i>	Southern Toad	X		X
Anura	Hylidae	<i>Acris gryllus</i>	Southern Cricket Frog	X		X
Anura	Hylidae	<i>Hyla chrysoscelis</i>	Cope's Gray Treefrog			X
Anura	Hylidae	<i>Hyla cinerea</i>	Green Treefrog	X	X	X
Anura	Hylidae	<i>Hyla femoralis</i>	Pine Woods Treefrog	X		X
Anura	Hylidae	<i>Hyla gratiosa</i>	Barking Treefrog	X		
Anura	Hylidae	<i>Hyla squirella</i>	Squirrel Treefrog	X	X	X
Anura	Hylidae	<i>Pseudacris crucifer</i>	Spring Peeper	X	X	X
Anura	Hylidae	<i>Pseudacris nigrita</i>	Southern Chorus Frog			X
Anura	Hylidae	<i>Pseudacris ocularis</i>	Little Grass Frog	X	X	X
Anura	Microhylidae	<i>Gastrophryne carolinensis</i>	Eastern Narrow-mouthed Toad	X		
Anura	Ranidae	<i>Rana grylio</i>	Pig Frog	X		
Anura	Ranidae	<i>Rana sphenoccephala</i>	Southern Leopard Frog	X	X	X
Anura	Scaphiopodidae	<i>Scaphiopus holbrookii</i>	Eastern Spadefoot	X		X
Caudata	Ambystomatidae	<i>Ambystoma talpoideum</i>	Mole Salamander	X		
Caudata	Amphiumidae	<i>Amphiuma means</i>	Two-toed Amphiuma	X		
Caudata	Plethodontidae	<i>Desmognathus auriculatus</i>	Southern Dusky Salamander	X		
Caudata	Plethodontidae	<i>Eurycea quadridigitata</i>	Dwarf Salamander	X		
Caudata	Salamandridae	<i>Notophthalmus viridescens</i>	Eastern Newt	X		
Crocodylia	Alligatoridae	<i>Alligator mississippiensis</i>	Alligator	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>Elaphe guttata</i>	Corn Snake, Red Rat Snake	X		
Squamata	Colubridae	<i>Elaphe obsoleta</i>	Common Rat Snake	X		
Squamata	Colubridae	<i>Farancia abacura</i>	Mud 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 fasciata</i>	Southern Water Snake			X

Table A-1. (Continued)

Order	Family	Scientific Name	Common Name	NPSpecies	ARD	VES
Squamata	Colubridae	<i>Nerodia fasciata fasciata</i>	Banded Water Snake			X
Squamata	Colubridae	<i>Opheodrys aestivus</i>	Rough Green Snake	X		X
Squamata	Colubridae	<i>Rhadinaea flavilata</i>	Pine Woods Snake			X
Squamata	Colubridae	<i>Storeria occipitomaculata</i>	Red-bellied Snake	X		
Squamata	Colubridae	<i>Thamnophis sauritus</i>	Eastern Ribbon Snake	X		
Squamata	Colubridae	<i>Thamnophis sirtalis</i>	Garter Snake	X		
Squamata	Phrynosomatidae	<i>Sceloporus undulatus</i>	Eastern Fence Lizard	X		X
Squamata	Polychrotidae	<i>Anolis carolinensis</i>	Green Anole	X		X
Squamata	Scincidae	<i>Eumeces egregius</i>	Mole Skink	X		
Squamata	Scincidae	<i>Eumeces inexpectatus</i>	Southeastern Five-lined Skink	X		
Squamata	Scincidae	<i>Eumeces laticeps</i>	Broad-headed Skink	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		X
Squamata	Viperidae	<i>Crotalus adamanteus</i>	Eastern Diamondback Rattlesnake	X		X
Squamata	Viperidae	<i>Crotalus horridus</i>	Timber 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		
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>Trachemys scripta</i>	Common Slider	X		
Testudines	Kinosternidae	<i>Kinosternon baurii</i>	Striped Mud Turtle	X		
Testudines	Kinosternidae	<i>Kinosternon subrubrum</i>	Common Mud Turtle	X		
Testudines	Testudinidae	<i>Gopherus polyphemus</i>	Gopher Tortoise	X		
Testudines	Trionychidae	<i>Apalone ferox</i>	Florida Softshell Turtle	X		

Appendix B. Map of sampling locations with point labels.

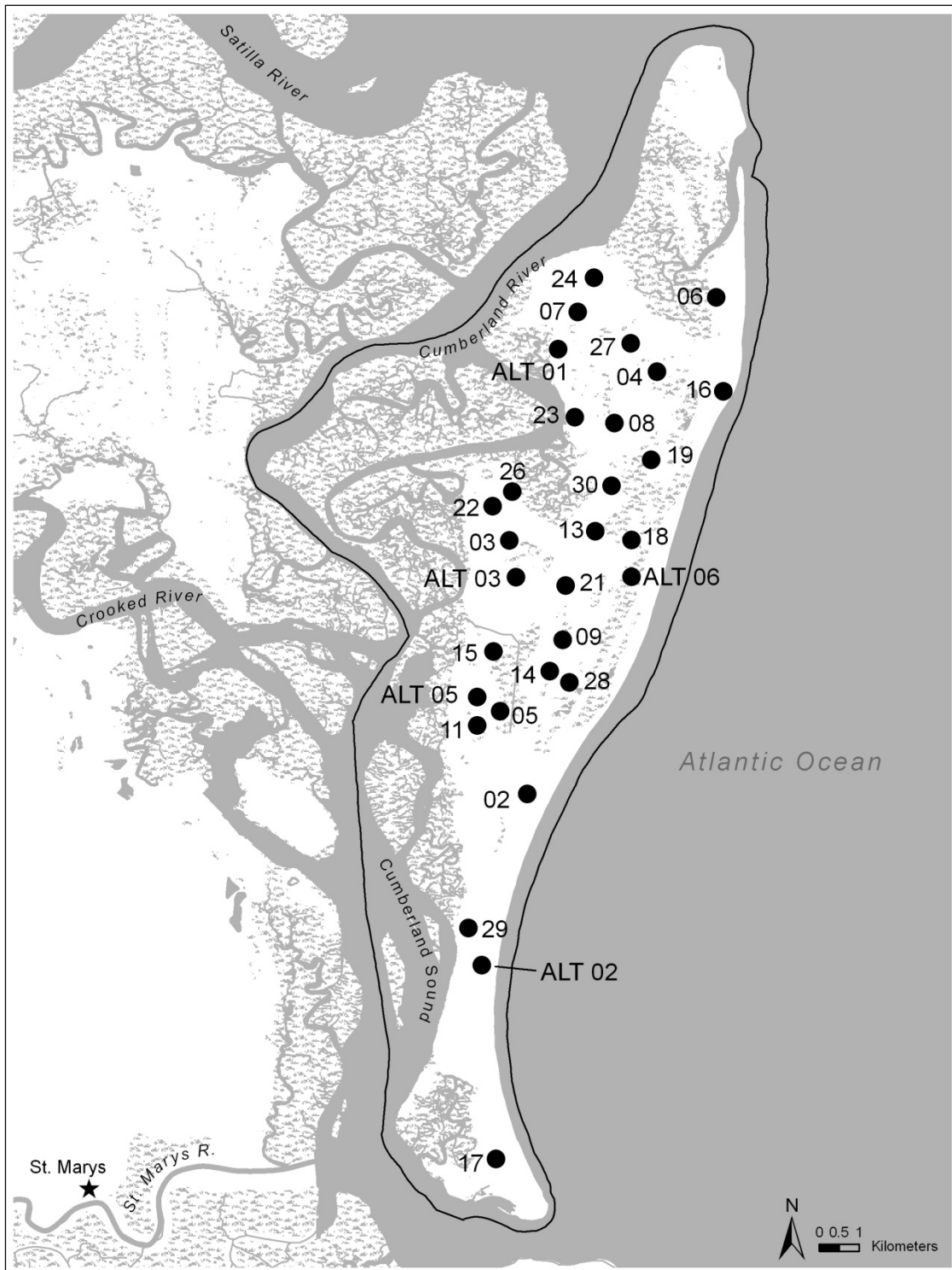


Figure B-1. Spatially-balanced random sampling locations at CUIS with labels, 2009.

Appendix C. Table of species detections by sampling location.

Table C-1. Species or species sign detected at each sampling location at CUIS, 2009. Refer to Appendix 2 for labeled sampling-locations.

[illegible]