National Park Service
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Natural Resource Stewardship and Science

Landbird Community Monitoring at Fort Frederica National Monument

2014 Data Summary

Natural Resource Data Series NPS/SECN/NRDS—2016/1058



ON THE COVER
Pine Warbler (*Dendroica pinus*)
Photo courtesy of Rachel Holzman

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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.

Data in this report were collected and analyzed using methods based on established peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Executive Summary

Birds are an important component of park ecosystems. Due to their high body temperature, rapid metabolism, and high ecological position in most food webs, birds are also good indicators of the effects of local and regional ecosystem changes. Patterns in the community composition, distribution, and occurrence of breeding birds provide a metric for assessing ecological integrity and sustainability in southeastern U. S. ecosystems. Further, the responses of these community characteristics to various management actions (e.g., fire, invasive-species treatments), natural disturbances, and other stressors will improve our understanding of their effects on the condition of park resources.

This report summarizes data collected during implementation of the SECN landbird community monitoring protocol (Byrne et al. 2014) at Fort Frederica National Monument in 2014.

- Automated recording devices collected bird detection/non-detection data (i.e., presence/absence) from eight spatially balanced random locations at the monument.
- Approximately 480 minutes of recordings were collected May–June, to represent a closed population, and were evaluated for the presence of vocalizing birds.
- Fifty-one native species of birds were detected during the sampling effort.
- Monitoring efforts provided the first documented occurrences of ten new species at the monument and additions to the official species list: Acadian flycatcher, least tern, marsh wren, northern rough-winged swallow, ovenbird, painted bunting, pine warbler, red-tailed hawk, song sparrow, and yellow-throated warbler.
- One non-native species, the house finch, was detected during the sampling effort.
- The brown-headed cowbird, Carolina wren, fish crow, great-crested flycatcher, mourning dove, northern cardinal, northern parula, pine warbler, red-bellied woodpecker, and tufted titmouse were detected at all sampling locations, and were the most widely distributed species in the monument.
- The full dataset, and associated metadata, can be acquired from the NPS data store at the Integrated Resource Management Applications portal (https://irma.nps.gov/App/Portal/Home).

Introduction

Overview

Birds play several critical roles in park ecosystems. They occupy and interact with several trophic levels of the food web, including their role as both predator and prey. Among their many functions, birds regulate rodent populations (Ims and Andreassen 2000), regulate insect populations (Mols and Visser 2002), and scavenge dead animals (Pain et al. 2003). Some avian species aid in pollination of wild and cultivated crop plants (Stiles 1978) and provide mechanisms for seed dispersal (Howe and Smallwood 1982). Bird guano contains nutrients necessary for many vegetation communities (Wootton 1991). Management activities aimed at preserving habitat for bird populations (e.g., neotropical migrants) frequently have the added benefit of preserving entire ecosystems and their attendant ecosystem services (Karr 1991, Maurer and Heywood 1993).

A wide range of stressors affect bird communities, and birds often respond quickly to environmental stressors, perturbations, or changes. Therefore, characteristics of the bird community at a park are good indicators of the extent of the impact of those stressors on park lands. Many bird species have been extensively studied; their biology and life histories are well defined, and their habitat-use patterns have been identified. Consequently, the composition, species richness, species diversity, and distribution of bird communities provide substantial insight into the ecological condition of park resources. Information about the landbird community also provides derivative information about other characteristics of the park and surrounding area (e.g., vegetation community types, extent of fragmentation).

Because many birds are primarily diurnal, visible and vocal, and attractive, they are a major point of interest for many park visitors and for the general public. Birds have a strong public appeal and are the recreational focus for many park visitors. Birdwatching has a substantial and positive impact on the U.S. economy, contributing well over $100 billion annually (Carver 2013), and it is one of the most popular recreational activities pursued by Americans (Cordell et al. 2002).

Over 400 species of birds, representing 61 families, use Southeast Coast Network (SECN) parks annually for breeding, wintering, or as a migratory stopover area. The high bird diversity in the Southeast Coast Network exists because of the concentration of SECN parks within the Atlantic Flyway. Many SECN parks occur in a highly fragmented landscape. However, because the network encompasses inland and coastal areas, it provides a wide range of bird habitat types.

This report summarizes data collected with the SECN landbird community monitoring protocol (Byrne et al. 2014). Protocol objectives that are addressed in this report include:

a) Determine the species richness and diversity of the landbird community at each park,

b) Determine the frequency of detection of selected landbirds, and

c) Determine the distribution of landbirds within park lands.

Study Area

Established on St. Simons Island in 1736 to protect South Carolina and Georgia from the Spanish, the town of Frederica was the southernmost post of the British colonies in North America. Today, Fort Frederica National Monument (FOFR) encompasses three land units totaling 99 hectares (ha; 244 acres [ac]) on St. Simons Island in southeastern Georgia (Figure 1). The monument is divided by the Frederica River, one of the primary salt marsh rivers in the Brunswick area, with 40 ha (99 ac) of salt marsh at the Frederica site on the west side of the river and approximately 55 ha (137 ac) of uplands adjacent to the east side of the river. The separate Bloody Marsh site consists of three ha (8 ac), of which approximately five acres are tidal marsh. The salt marsh is dominated by cordgrass (*Spartina* spp.), and the uplands are a mix of coastal maritime hammock dominated by Virginia live oak (Quercus virginiana) and loblolly pine (Pinus taeda).

Fort Frederica National Monument has 107 known bird species (Table A-1; NPSpecies 2015).

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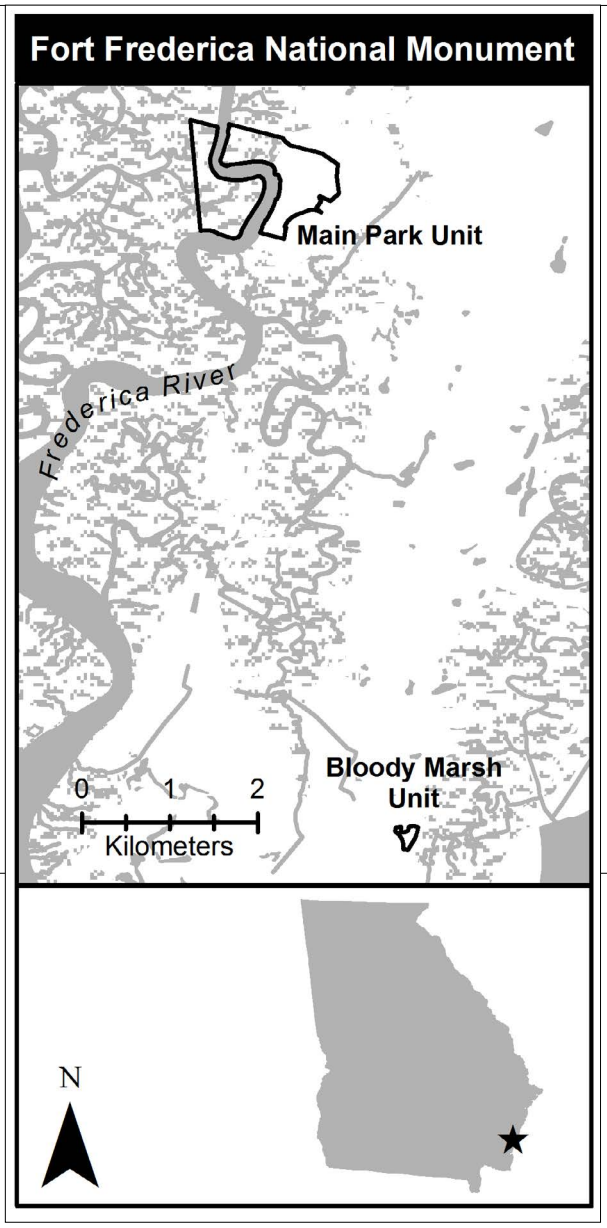


Figure 1. Location of Fort Frederica National Monument.

Methods

Sampling Design

The sampling design and sampling-location selection is detailed in Appendix B of the SECN landbird community monitoring protocol (Byrne et al. 2014) and in the sampling-location selection standard operating procedure 1.1.01 (Byrne 2012). In summary, the administrative boundary was used as the sampling frame to allow for park-wide inference. The sampling frame was divided into a systematic 0.5-hectare grid superimposed over the entire sampling frame (i.e., monument boundary); the center point of each grid cell served as the potential sampling location. 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 specified selection criteria (e.g., safety issues, accessibility) were not met. A sample size of 11 was chosen based on consideration of park size, hypothesized variability, and logistical issues (Figure 2); however, the final sample size was 8 due to the failure of three devices.

Taxonomic Standards

Taxonomy and nomenclature follow that set forth in the Integrated Taxonomic Information System (ITIS; http://www.itis.gov/). The National Park Service uses the online application NPSpecies (https://irma.nps.gov/npspecies) to document "our knowledge about the occurrence and status of species on National Park Service lands," including maintenance of species lists for NPS properties. The taxonomy and nomenclature in NPSpecies is periodically updated with the most current ITIS catalog. As noted on the ITIS webpage, the system intends not to serve as a forum for cutting-edge taxonomic classifications, but rather to use classifications that have gained broad acceptance in the taxonomic literature and by professionals who work with the taxa.

All bird vocalizations are identified to the finest resolution possible in the taxonomic hierarchy. Only vocalizations identified to the species level are used in the analyses presented herein.

Data Collection

Automatic recording devices (ARDs) were deployed at all sampling locations March–June, 2012. ARDs are deployed at the center point of each 0.5-hectare grid cell (i.e., the sampling location) and are programmed to record from 08:00–08:12 (i.e., 12 minutes) every other day for a period of 77 days (Byrne et al. 2014). This schedule results in the collection of 39 discrete sampling events across the spring migratory period and breeding season for each sampling location. Currently, however, our analysis efforts focus on the time period that most accurately approximates a closed population of breeding birds. Therefore, species occurrences are derived from analyzing five recordings collected from May–June at each sampling location.

Manual Evaluation of Recordings

Ambient / background noise influences detectability in auditory avian surveys (Alldredge et al. 2007, Simons et al. 2007, Pacifici et al. 2008, Simons et al. 2009). To minimize the impact of background noise on detectability, three strategies are applied to all recordings: (1) omit recordings with a background noise level above approximately 45dB, if possible, (2) quantify background noise categorically, and (3) use existing software tools to remove or minimize the influence of frequency ranges that are exclusive to the background noise and outside the frequency range of target vocalizations (Byrne et al. 2014). In general, sounds with a sound pressure level greater than 45 dB preclude hearing birds located over 100 meters (328 ft) from the observer. To provide a frame of reference, the approximate loudness of a watch or clock ticking is 20 dB, a quiet whisper is 30 dB, a steady and heavy rain is 50 dB, and normal conversation is 60 dB.

High levels of background noise can make it difficult to discern vocalizations, and this limits the researcher's ability to adequately detect and classify bird vocalizations. Therefore, the background noise level for each recording was classified a priori, and an index score ranging from one (low) to three (high) was assigned. Each three-minute segment (i.e., 0–3, 3–6, 6–9, and 9–12) of the recordings was a priori categorized according to background noise level (i.e., 1=low, 2=moderate, and 3=high), and an average noise score was calculated for the entire 12-minute recording. In general, the background noise level of the recording was defined as follows: (a) "low" characterizes a recording in which the vocalizations are clear and distinct, the vocalizations are the primary source of sound, and background noise is a low-volume muffle; (b) "moderate" characterizes a recording with uniform loudness of less than 45dB, in which vocalizations are identifiable and some are clear and distinct while others

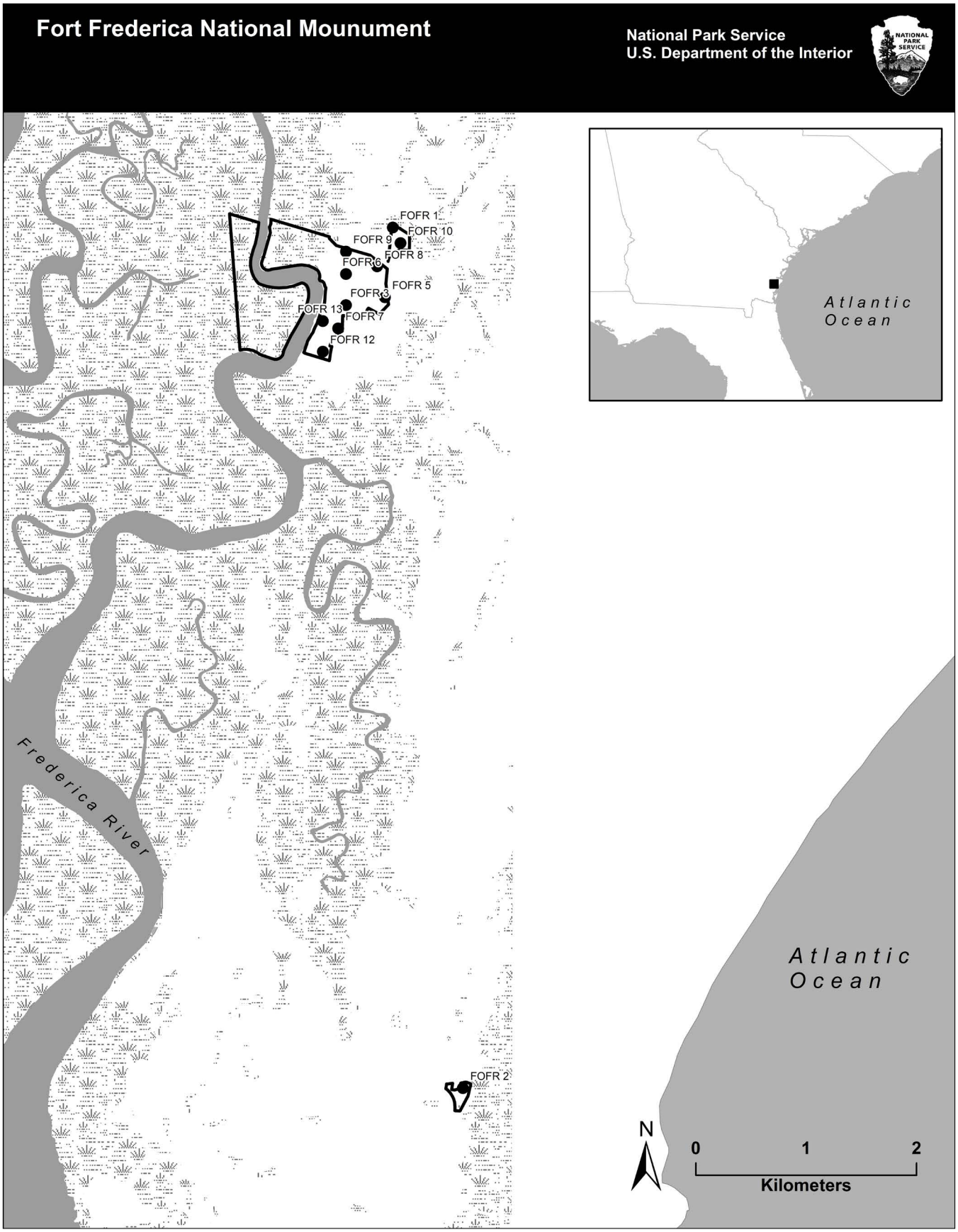


Figure 2. Landbird community monitoring sampling locations at Fort Frederica National Monument in 2014.

blend into the background noise, which may contain a low- to medium-speed wind or light rain, distant traffic, or rustling vegetation; or (c) "high" characterizes a recording in which background noise is the dominant sound, above 45dB, and some vocalizations are difficult to separate from the background noise.

Examples of background noise in recordings in the "high" category include proximate automobile traffic, high winds in vegetation, insects (e.g., cicadas), frog choruses, trains, heavy rain, or thunderstorms. If both the alternate and primary recordings have similar background noise issues, then the next consecutive sampling event (i.e., next day) is reviewed. This process continues until five monitoring events within the May to mid-June window with the lowest noise levels are selected for evaluation for each sampling location. If all recordings from a sampling location have a substantial amount of background noise, the required number of recordings to meet our analysis objectives will continue to be analyzed such that sample size and replicates are not lost, and background noise is categorized as previously mentioned to be later used as an explanatory variable when modeling detectability. The methodology, implemented as part of Byrne et al. (2014), was designed specifically to create an alternate recording for each day of monitoring. This facilitates the screening process and minimizes the influence of anomalous sound events that could impede or preclude species detection.

All recordings were evaluated by one trained observer, with several years of birding experience, astute at vocalization identification, whose skills were reviewed and tested. The observer performed the evaluation by listening to the recordings while simultaneously examining spectrograms in Song Scope software (Wildlife Acoustics, Inc.). The observer spent approximately one hour analyzing each 12-minute recording, including the time spent clarifying uncertain identifications with a digital library of vocalizations, online resources, or confirmation with other expert birders. All identifiable birds in each recording were documented. Some vocalizations were unidentifiable due to background noise or distance from the sampling location.

Data Analysis

Data in this report represent one year and are summarized in three general but closely linked categories: composition, richness, and distribution. Appendix B depicts all species detected by sampling location, and Appendix C depicts individual-species distribution maps. These results were derived from the manual evaluation of 480 minutes from 40 recordings.

Composition

Measures of community composition are often good indicators of abiotic variability, disturbance, or other stressors. Summaries related to composition include the total number of species detected (i.e., species richness) and naïve occupancy. Species richness is simply the number of native species detected and is presented for the ARD method. Naïve occupancy is the percentage of the sampling locations where a species was detected at least once, without adjusting for probability of detection (i.e., detectability). Naïve occupancy is also referred to as frequency of occurrence. Naïve occupancy provides insight into the distribution of a species across a park and whether the species can be considered common or uncommon. Species with high values occur at more locations than those with low values.

Richness

Species richness is a major component of species diversity. Magurran (2004) defines diversity as "the variety and abundance of species in a defined unit of study." 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 (i.e., species richness) and the relative abundance of those species (i.e., species evenness/dominance) within a defined community (Margalef 1958, Lloyd and Ghelardi 1964, Pielou 1966). The methodology implemented by the Southeast Coast Network does not collect abundance data; therefore, the analysis focuses on species richness estimation of the landbird community. Further, the term community refers to the assemblage of species populations that occur together in space and time (Begon et al. 1986), as per the conceptual ecological models presented in our monitoring plan (see Chapter 2 in DeVivo et al. 2008).

Species richness and diversity is presented in the form of indices. Because richness and diversity indices respond differently to various mechanisms that influence community change, several indices must be used to adequately characterize richness and diversity in SECN parks (Haedrick 1975, Boyle et al. 1984). Based on characteristics of the SECN dataset and careful appraisal of the advantages and disadvantages of several richness indices, the selected richness indices are presented in Table 1, including notes on value interpretation. Because observed species richness (i.e., $\mathbf{S}_{obs}$) is an underestimate (i.e., influenced by detectability, observer error) of true species richness, richness indices more closely approximate true species richness for a defined area. In this analysis, richness estimates are based only on landbird observations identified to the species level, and detections/occurrences of non-native species were not included in the calculations.

Distribution

Understanding changes in the distribution of landbirds is integral to informed management of species and their requisite habitats. Changes in species distributions over time provide useful information at both the local and landscape scale regarding how species respond to large-scale influences such as changing land use, climate, hydrology, or habitat availability and condition. Shifting species distributions alter species interactions and the food-web structure, thereby producing cascading effects on ecosystem processes (Montoya and Raffaelli 2010). Distribution maps for all bird species detected are presented in Appendix C.

Table 1. Incidence-based species richness indices used in this analysis, corresponding symbol, community attribute that the index reflects, range of index values, and notes on each index.

Index	Symbol	Community Attribute	Index Citation	Notes
Native Species Richness	$\mathbf{S}_{obs}$	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 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.
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) Heltshe 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.

Results

Composition

The brown-headed cowbird, Carolina wren, fish crow, great-crested flycatcher, mourning dove, northern cardinal, northern parula, pine warbler, red-bellied woodpecker, and tufted titmouse had the highest naïve occupancy of all bird species at the monument, occurring at 100% of the sampling locations (Table 2).

One non-native species was detected, the house finch. The occurrences of ten species, Acadian flycatcher, least tern, marsh wren, northern rough-winged swallow, ovenbird, painted bunting, pine warbler, red-tailed hawk, song sparrow, and yellow-throated warbler, were new records for the monument (Table 3) and will be added to the park species list and NPSpecies.

Table 2. Naïve occupancy estimates (i.e., proportion of sampling locations in which a species was detected) for birds at Fort Frederica National Monument in 2014.

Common Name	Scientific Name	Naïve Occupancy
Brown-headed cowbird	*Molothrus ater*	1.00
Carolina wren	*Thryothorus ludovicianus*	1.00
Fish crow	*Corvus ossifragus*	1.00
Great crested flycatcher	*Myiarchus crinitus*	1.00
Mourning dove	*Zenaida macroura*	1.00
Northern cardinal	*Cardinalis cardinalis*	1.00
Northern parula	*Setophaga americana*	1.00
Pine warbler	*Setophaga pinus*	1.00
Red-bellied woodpecker	*Melanerpes carolinus*	1.00
Tufted titmouse	*Baeolophus bicolor*	1.00
Blue jay	*Cyanocitta cristata*	0.88
Carolina chickadee	*Poecile carolinensis*	0.88
Chimney swift	*Chaetura pelagica*	0.88
House finch	*Haemorhous mexicanus*	0.88
Northern mockingbird	*Mimus polyglottos*	0.75
Pileated woodpecker	*Dryocopus pileatus*	0.75
Yellow-throated warbler	*Setophaga dominica*	0.75
Blue-gray gnatcatcher	*Polioptila caerulea*	0.63
Downy woodpecker	*Picoides pubescens*	0.63
Eastern towhee	*Pipilo erythrophthalmus*	0.63
Red-winged blackbird	*Agelaius phoeniceus*	0.63
Boat-tailed grackle	*Quiscalus major*	0.50
Brown thrasher	*Toxostoma rufum*	0.50
Summer tanager	*Piranga rubra*	0.50
White-eyed vireo	*Vireo griseus*	0.50
American crow	*Corvus brachyrhynchos*	0.38
Barn swallow	*Hirundo rustica*	0.38
Common yellowthroat	*Geothlypis trichas*	0.38
Eastern bluebird	*Sialia sialis*	0.38
Ovenbird	*Seiurus aurocapilla*	0.38
Common grackle	*Quiscalus quiscula*	0.25
Laughing gull	*Leucophaeus atricilla*	0.25
Red-eyed vireo	*Vireo olivaceus*	0.25
Red-headed woodpecker	*Melanerpes erythrocephalus*	0.25

Table 2 (continued). Naïve occupancy estimates (i.e., proportion of sampling locations in which a species was detected) for birds at Fort Frederica National Monument in 2014.

Common Name	Scientific Name	Naïve Occupancy
Royal tern	*Thalasseus maximus*	0.25
Acadian flycatcher	*Empidonax virescens*	0.13
American redstart	*Setophaga ruticilla*	0.13
American robin	*Turdus migratorius*	0.13
Barred owl	*Strix varia*	0.13
Cedar waxwing	*Bombycilla cedrorum*	0.13
Eastern wood-pewee	*Contopus virens*	0.13
Hooded warbler	*Setophaga cyanea*	0.13
Least tern	*Sternula antillarum*	0.13
Marsh wren	*Cistothorus palustris*	0.13
Northern flicker	*Colaptes auratus*	0.13
Northern rough-winged swallow	*Stelgidopteryx serripennis*	0.13
Painted bunting	*Passerina ciris*	0.13
Red-shouldered hawk	*Buteo lineatus*	0.13
Red-tailed hawk	*Buteo jamaicensis*	0.13
Ruby-throated hummingbird	*Archilochus colubris*	0.13
Song sparrow	*Melospiza melodia*	0.13
Yellow-throated vireo	*Vireo flavifrons*	0.13

Table 3. New bird species detected at Fort Frederica National Monument in 2014 and recommended NPSpecies classifications.

Common Name	Abundance	Residency	Nativity	Pest	Management Priority	Exploitation Concerns
Acadian flycatcher	Unknown	Breeder	Native	No	No	No
Least tern	Unknown	Breeder	Native	No	No	No
Marsh wren	Unknown	Vagrant	Native	No	No	No
Northern rough-winged swallow	Unknown	Breeder	Native	No	No	No
Ovenbird	Unknown	Vagrant	Native	No	No	No
Painted bunting	Unknown	Breeder	Native	No	Yes	Yes
Red-tailed hawk	Unknown	Resident	Native	No	No	No
Song sparrow	Unknown	Vagrant	Native	No	No	No
Yellow-throated vireo	Unknown	Breeder	Native	No	No	No

Richness

The native species richness (S_{obs}) for landbirds at Fort Frederica National Monument in 2014 was 51. Species richness indices were based only on native species, and confidence intervals for each index were estimated with a bootstrap procedure. Richness indices varied, ranging from 57.5 to 76.3 (Table 4), likely attributable to properties of the dataset. The mean of the species richness estimates differs from S_{obs} by over 20%, suggesting that the loss of three sampling locations (i.e., replicates) to device failure had an impact on richness estimation.

The first documented occurrence of the painted bunting at the monument is notable due to its very specific habitat requirements and national conservation status as a species of concern.

Distribution

Distribution maps for all detected species are presented in Appendix C and indicate the sampling location(s) in which each species occurred. The brown-headed cowbird, Carolina wren, fish crow, great-crested flycatcher, mourning dove, northern cardinal, northern parula, pine warbler, red-bellied woodpecker, and tufted titmouse were the most widely distributed species in the monument, occurring at all sampling locations. Painted bunting was only detected at one sampling location.

Table 4. Species richness indices for birds at Fort Frederica National Monument in 2014 and recommended NPSpecies classifications.

Index	Symbol	Value	Lower 95% CI	Upper 95% CI	Value Interpretation
Native Spp. Richness	**S_{obs}**	51.0	42.9	59.1	Number of native species detected; species richness at the monument is considered to be moderate
Chao 2	**Chao2**	76.3	58.5	136.8	Estimated true species richness; considered to be moderate, very large CI
Incidence-based Coverage	**ICE**	66.1	63.3	68.8	Estimated true species richness; considered to be moderate
Jackknife 1	**Jack1**	65.9	63.1	68.7	Estimated true species richness; considered to be moderate
Jackknife 2	**Jack2**	75.4	72.2	78.6	Estimated true species richness; considered to be moderate
Bootstrap	**Boot**	57.5	56.0	59.0	Estimated true species richness; considered to be moderate

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Appendix A—Species List

Table A-1. Birds known to occur at Fort Frederica National Monument based upon records in NPSpecies (2015) and those detected during this sampling effort.

Order	Family	Scientific Name	Common Name	NPSpecies	ARD 2014
Accipitriformes	Accipitridae	*Buteo jamaicensis*	Red-tailed Hawk		X
Accipitriformes	Accipitridae	*Buteo lineatus*	Red-shouldered hawk	X	X
Accipitriformes	Accipitridae	*Haliaeetus leucocephalus*	Bald eagle	X	
Accipitriformes	Cathartidae	*Cathartes aura*	Turkey vulture	X	
Accipitriformes	Cathartidae	*Coragyps atratus*	Black vulture	X	
Accipitriformes	Pandionidae	*Pandion haliaetus*	Osprey	X	
Anseriformes	Anatidae	*Lophodytes cucullatus*	Hooded merganser	X	
Apodiformes	Apodidae	*Chaetura pelagica*	Chimney swift	X	X
Apodiformes	Trochilidae	*Archilochus colubris*	Ruby-throated hummingbird	X	X
Charadriiformes	Laridae	*Larus delawarensis*	Ring-billed gull	X	
Charadriiformes	Laridae	*Leucophaeus atricilla*	Laughing gull	X	X
Charadriiformes	Laridae	*Sterna antillarum*	Least tern		X
Charadriiformes	Laridae	*Sterna forsteri*	Forster's tern	X	
Charadriiformes	Laridae	*Thalasseus maximus*	Royal tern	X	X
Ciconiiformes	Ciconiidae	*Mycteria americana*	Wood stork	X	
Columbiformes	Columbidae	*Zenaida macroura*	Mourning dove	X	X
Coraciiformes	Alcedinidae	*Megaceryle alcyon*	Belted kingfisher	X	
Cuculiformes	Cuculidae	*Coccyzus americanus*	Yellow-billed cuckoo	X	
Cuculiformes	Cuculidae	*Coccyzus erythropthalmus*	Black-billed cuckoo	X	
Gaviiformes	Gaviidae	*Gavia immer*	Common loon	X	
Gruiformes	Rallidae	*Rallus longirostris*	Clapper rail	X	
Passeriformes	Bombycillidae	*Bombycilla cedrorum*	Cedar waxwing	X	X
Passeriformes	Cardinalidae	*Cardinalis cardinalis*	Northern cardinal	X	X
Passeriformes	Cardinalidae	*Passerina ciris*	Painted bunting		X
Passeriformes	Cardinalidae	*Passerina cyanea*	Indigo bunting	X	
Passeriformes	Corvidae	*Corvus brachyrhynchos*	American crow	X	X
Passeriformes	Corvidae	*Corvus ossifragus*	Fish crow	X	X
Passeriformes	Corvidae	*Cyanocitta cristata*	Blue jay	X	X
Passeriformes	Emberizidae	*Ammodramus maritimus*	Seaside sparrow	X	
Passeriformes	Emberizidae	*Junco hyemalis*	Dark-eyed junco	X	
Passeriformes	Emberizidae	*Melospiza melodia*	Song Sparrow		X
Passeriformes	Emberizidae	*Passerella iliaca*	Fox sparrow	X	
Passeriformes	Emberizidae	*Pipilo erythrophthalmus*	Eastern Towhee	X	X
Passeriformes	Emberizidae	*Spizella passerina*	Chipping sparrow	X	
Passeriformes	Emberizidae	*Zonotrichia albicollis*	White-throated sparrow	X	
Passeriformes	Emberizidae	*Zonotrichia leucophrys*	White-crowned sparrow	X	
Passeriformes	Fringillidae	*Carduelis tristis*	American goldfinch	X	
Passeriformes	Fringillidae	*Carpodacus mexicanus*	House finch	X	X
Passeriformes	Fringillidae	*Carpodacus purpureus*	Purple finch	X	
Passeriformes	Hirundinidae	*Hirundo rustica*	Barn swallow	X	X
Passeriformes	Hirundinidae	*Stelgidopteryx serripennis*	Northern rough-winged swallow		X
Passeriformes	Hirundinidae	*Tachycineta bicolor*	Tree swallow	X	
Passeriformes	Icteridae	*Agelaius phoeniceus*	Red-winged blackbird	X	X

Table A-1 (continued). Birds known to occur at Fort Frederica National Monument based upon records in NPSpecies (2015) and those detected during this sampling effort.

Order	Family	Scientific Name	Common Name	NPSpecies	ARD 2014
Passeriformes	Icteridae	*Icterus spurius*	Orchard oriole	X	
Passeriformes	Icteridae	*Molothrus ater*	Brown-headed cowbird	X	X
Passeriformes	Icteridae	*Quiscalus major*	Boat-tailed grackle	X	X
Passeriformes	Icteridae	*Quiscalus quiscula*	Common grackle	X	X
Passeriformes	Icteridae	*Sturnella magna*	Eastern meadowlark	X	
Passeriformes	Laniidae	*Lanius ludovicianus*	Loggerhead shrike	X	
Passeriformes	Mimidae	*Dumetella carolinensis*	Gray catbird	X	
Passeriformes	Mimidae	*Mimus polyglottos*	Northern mockingbird	X	X
Passeriformes	Mimidae	*Toxostoma rufum*	Brown thrasher	X	X
Passeriformes	Paridae	*Baeolophus bicolor*	Tufted titmouse	X	X
Passeriformes	Paridae	*Poecile carolinensis*	Carolina chickadee	X	X
Passeriformes	Parulidae	*Geothlypis trichas*	Common yellowthroat	X	X
Passeriformes	Parulidae	*Mniotilta varia*	Black-and-white warbler	X	
Passeriformes	Parulidae	*Seiurus aurocapilla*	Ovenbird		X
Passeriformes	Parulidae	*Setophaga americana*	Northern parula	X	X
Passeriformes	Parulidae	*Setophaga caerulescens*	Black-throated blue warbler	X	
Passeriformes	Parulidae	*Setophaga citrina*	Hooded warbler	X	X
Passeriformes	Parulidae	*Setophaga coronata*	Yellow-rumped warbler	X	
Passeriformes	Parulidae	*Setophaga discolor*	Prairie warbler	X	
Passeriformes	Parulidae	*Setophaga dominica*	Yellow-throated warble	X	X
Passeriformes	Parulidae	*Setophaga palmarum*	Palm warbler	X	
Passeriformes	Parulidae	*Setophaga petechia*	American yellow warbler	X	
Passeriformes	Parulidae	*Setophaga pinus*	Pine warbler	X	X
Passeriformes	Parulidae	*Setophaga ruticilla*	American redstart	X	X
Passeriformes	Parulidae	*Vermivora cyanoptera*	Blue-winged warbler	X	
Passeriformes	Polioptilidae	*Polioptila caerulea*	Blue-gray gnatcatcher	X	X
Passeriformes	Regulidae	*Regulus calendula*	Ruby-crowned kinglet	X	
Passeriformes	Regulidae	*Regulus satrapa*	Golden-crowned kinglet	X	
Passeriformes	Sittidae	*Sitta carolinensis*	White-breasted nuthatch	X	
Passeriformes	Sittidae	*Sitta pusilla*	Brown-headed nuthatch	X	
Passeriformes	Thraupidae	*Piranga rubra*	Summer tanager	X	X
Passeriformes	Troglodytidae	*Cistothorus palustris*	Marsh Wren		X
Passeriformes	Troglodytidae	*Thryothorus ludovicianus*	Carolina wren	X	X
Passeriformes	Turdidae	*Hylocichla mustelina*	Wood thrush	X	
Passeriformes	Turdidae	*Sialia sialis*	Eastern bluebird	X	X
Passeriformes	Turdidae	*Turdus migratorius*	American robin	X	X
Passeriformes	Tyrannidae	*Contopus virens*	Eastern wood-pewee	X	X
Passeriformes	Tyrannidae	*Empidonax minimus*	Least flycatcher	X	
Passeriformes	Tyrannidae	*Empidonax virescens*	Acadian flycatcher		X
Passeriformes	Tyrannidae	*Myiarchus crinitus*	Great crested flycatcher	X	X
Passeriformes	Tyrannidae	*Sayornis phoebe*	Eastern phoebe	X	
Passeriformes	Tyrannidae	*Tyrannus tyrannus*	Eastern kingbird	X	
Passeriformes	Vireonidae	*Vireo flavifrons*	Yellow-throated vireo		X
Passeriformes	Vireonidae	*Vireo griseus*	White-eyed vireo	X	X
Passeriformes	Vireonidae	*Vireo olivaceus*	Red-eyed vireo	X	X

Table A-1 (continued). Birds known to occur at Fort Frederica National Monument based upon records in NPSpecies (2015) and those detected during this sampling effort.

Order	Family	Scientific Name	Common Name	NPSpecies	ARD 2014
Pelecaniformes	Ardeidae	*Ardea alba*	Great egret	X	
Pelecaniformes	Ardeidae	*Ardea herodias*	Great blue heron	X	
Pelecaniformes	Ardeidae	*Botaurus lentiginosus*	American bittern	X	
Pelecaniformes	Ardeidae	*Bubulcus ibis*	Cattle egret	X	
Pelecaniformes	Ardeidae	*Butorides virescens*	Green heron	X	
Pelecaniformes	Ardeidae	*Egretta caerulea*	Little blue heron	X	
Pelecaniformes	Ardeidae	*Egretta thula*	Snowy egret	X	
Pelecaniformes	Pelecanidae	*Pelecanus occidentalis*	Brown pelican	X	
Piciformes	Picidae	*Colaptes auratus*	Northern flicker	X	X
Piciformes	Picidae	*Dryocopus pileatus*	Pileated woodpecker	X	X
Piciformes	Picidae	*Melanerpes carolinus*	Red-bellied woodpecker	X	X
Piciformes	Picidae	*Melanerpes erythrocephalus*	Red-headed woodpecker	X	X
Piciformes	Picidae	*Picoides pubescens*	Downy woodpecker	X	X
Piciformes	Picidae	*Picoides villosus*	Hairy woodpecker	X	
Piciformes	Picidae	*Sphyrapicus varius*	Yellow-bellied sapsucker	X	
Podicipediformes	Podicipedidae	*Podilymbus podiceps*	Pied-billed grebe	X	
Strigiformes	Strigidae	*Bubo virginianus*	Great horned owl	X	
Strigiformes	Strigidae	*Strix varia*	Barred owl	X	X
Suliformes	Phalacrocoracidae	*Phalacrocorax auritus*	Double-crested cormorant	X	

Appendix B—Species Detection Matrix

Table B-1. Species detected at each sampling location at Fort Frederica National Monument in 2014. Refer to Figure 2 for labeled sampling locations.

Species	01	02	06	07	08	09	12	13
Acadian flycatcher				X				
American crow				X		X	X	
American redstart							X	
American robin			X					
Barn swallow			X	X		X		
Barred owl		X						
Blue jay	X	X	X	X	X		X	X
Blue-gray gnatcatcher	X	X	X	X				X
Boat-tailed grackle		X	X	X		X		
Brown thrasher			X	X		X	X	
Brown-headed cowbird	X	X	X	X	X	X	X	X
Carolina chickadee	X	X	X	X	X	X	X	
Carolina wren	X	X	X	X	X	X	X	X
Cedar waxwing	X							
Chimney swift	X	X	X		X	X	X	X
Common grackle					X		X	
Common yellowthroat	X		X					X
Downy woodpecker	X			X	X		X	X
Eastern bluebird			X	X			X	
Eastern towhee	X	X	X		X		X	
Eastern wood-pewee	X							
Fish crow	X	X	X	X	X	X	X	X
Great crested flycatcher	X	X	X	X	X	X	X	X
Hooded warbler						X		
House finch	X	X	X		X	X	X	X
Laughing gull						X		X
Least tern								X
Marsh wren								X
Mourning dove	X	X	X	X	X	X	X	X
Northern cardinal	X	X	X	X	X	X	X	X
Northern flicker	X							
Northern mockingbird	X	X	X	X		X	X	
Northern parula	X	X	X	X	X	X	X	X
Northern rough-winged swallow			X					
Ovenbird					X	X		X
Painted bunting								X
Pileated woodpecker	X		X	X	X	X	X	
Pine warbler	X	X	X	X	X	X	X	X
Red-bellied woodpecker	X	X	X	X	X	X	X	X
Red-eyed vireo				X			X	
Red-headed woodpecker	X	X						
Red-shouldered hawk		X						
Red-tailed hawk	X							

Table B-1 (continued). Species detected at each sampling location at Fort Frederica National Monument in 2014. Refer to Figure 2 for labeled sampling locations.

Species	01	02	06	07	08	09	12	13
Red-winged blackbird		X	X	X		X		X
Royal tern		X						X
Ruby-throated hummingbird					X			
Song sparrow								X
Summer tanager	X		X				X	X
Tufted titmouse	X	X	X	X	X	X	X	X
White-eyed vireo	X			X	X			X
Yellow-throated vireo			X					
Yellow-throated warbler	X		X		X	X	X	X
Yellow-billed cuckoo	X			X				
Yellow-throated vireo		X		X				X
Yellow-throated warbler	X	X	X	X		X	X	X

Appendix C—Species Distribution Maps

Ordered alphabetically by common name

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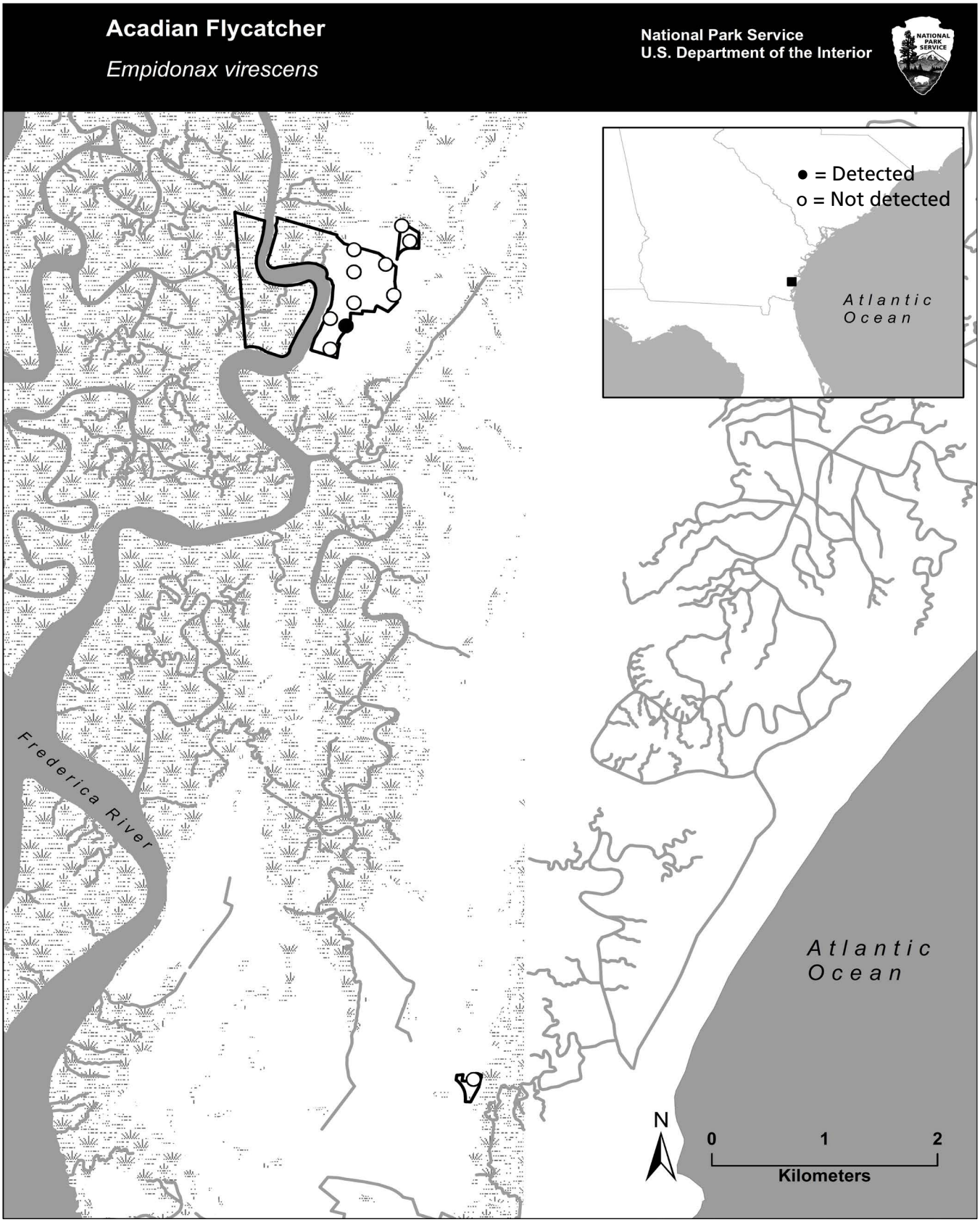


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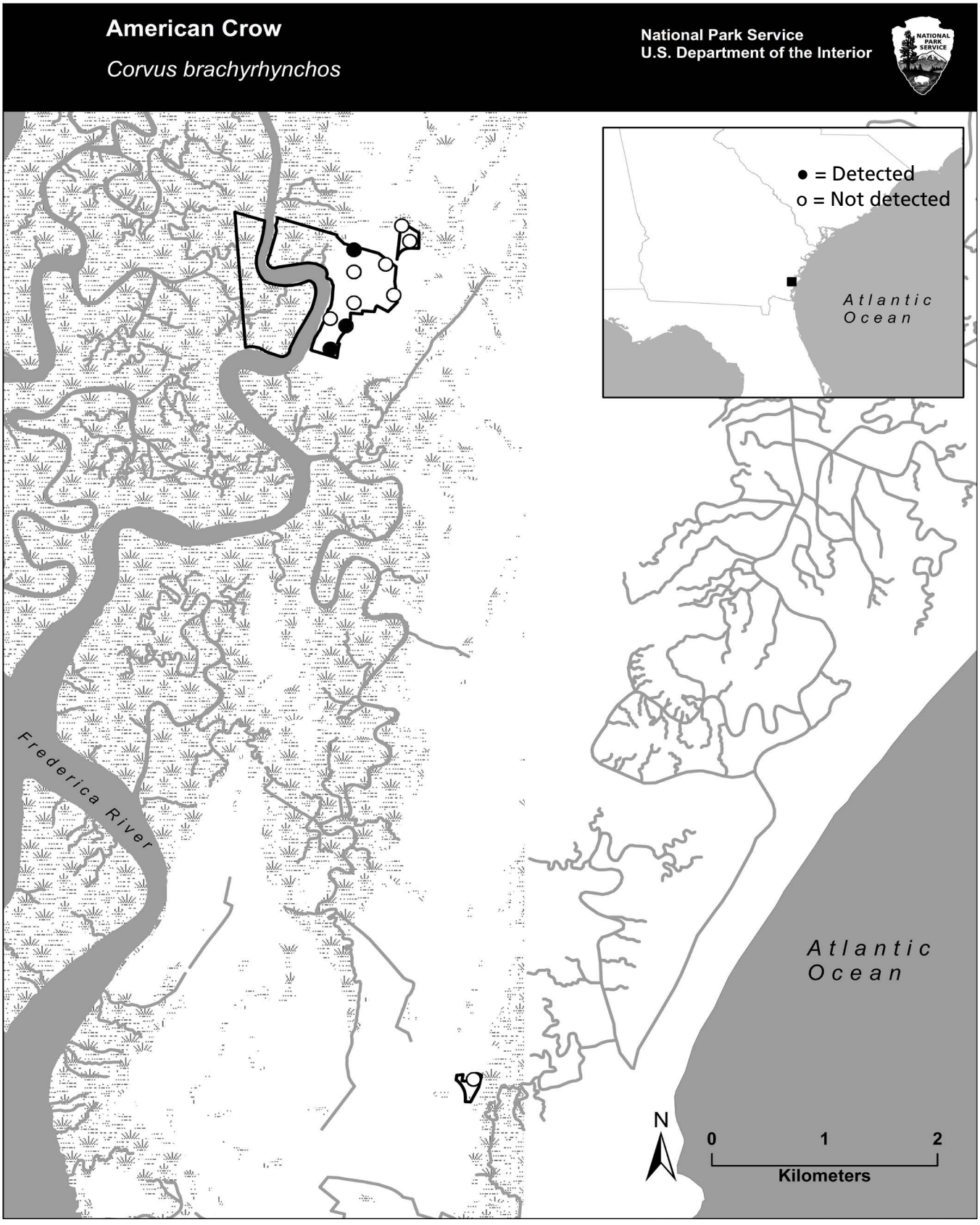


Figure C-2. Sampling locations where American crow (*Corvus brachyrhynchos*) was detected at Fort Frederica National Monument, 2014.

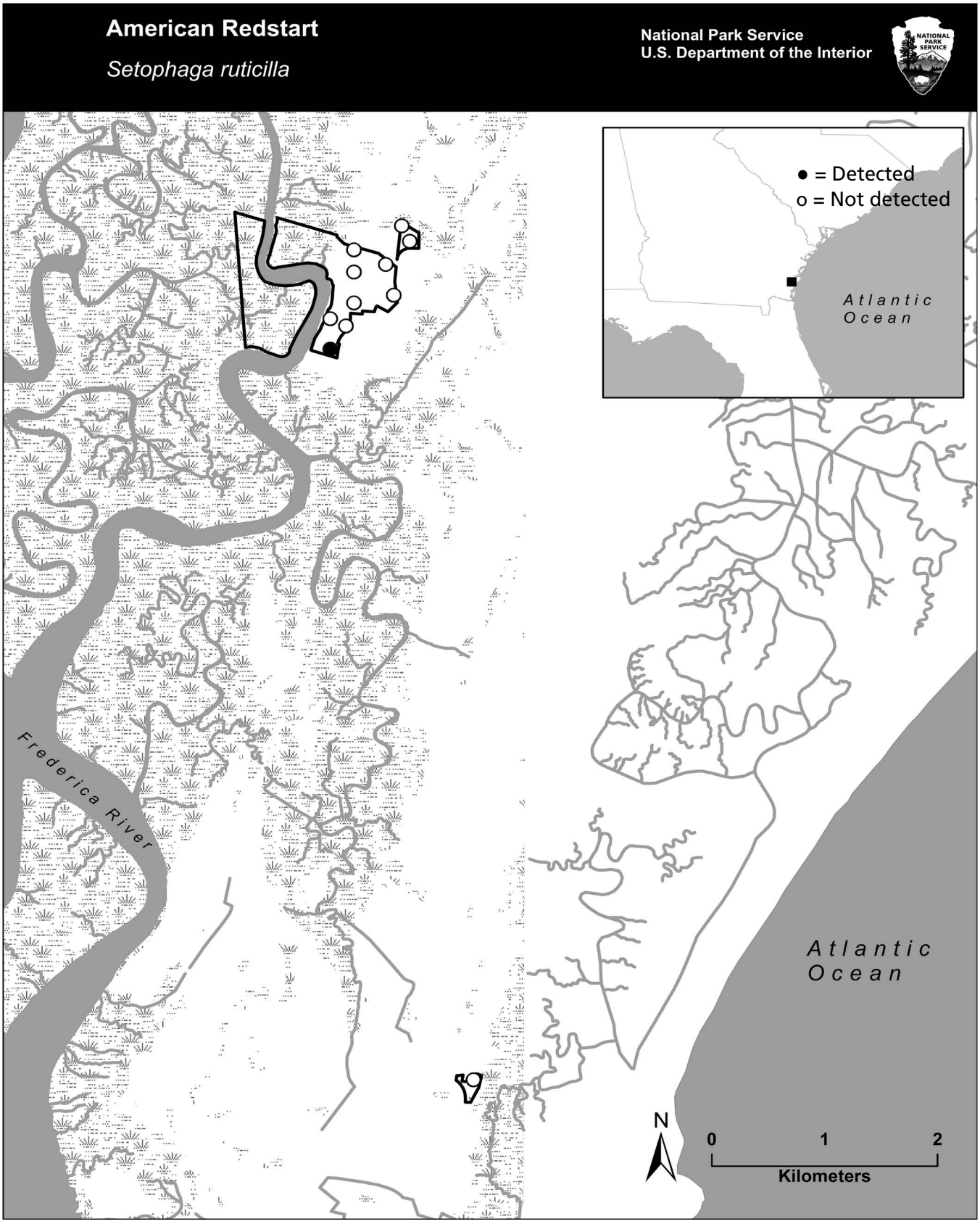


Figure C-3. Sampling locations where American redstart (*Setophaga ruticilla*) was detected at Fort Frederica National Monument, 2014.

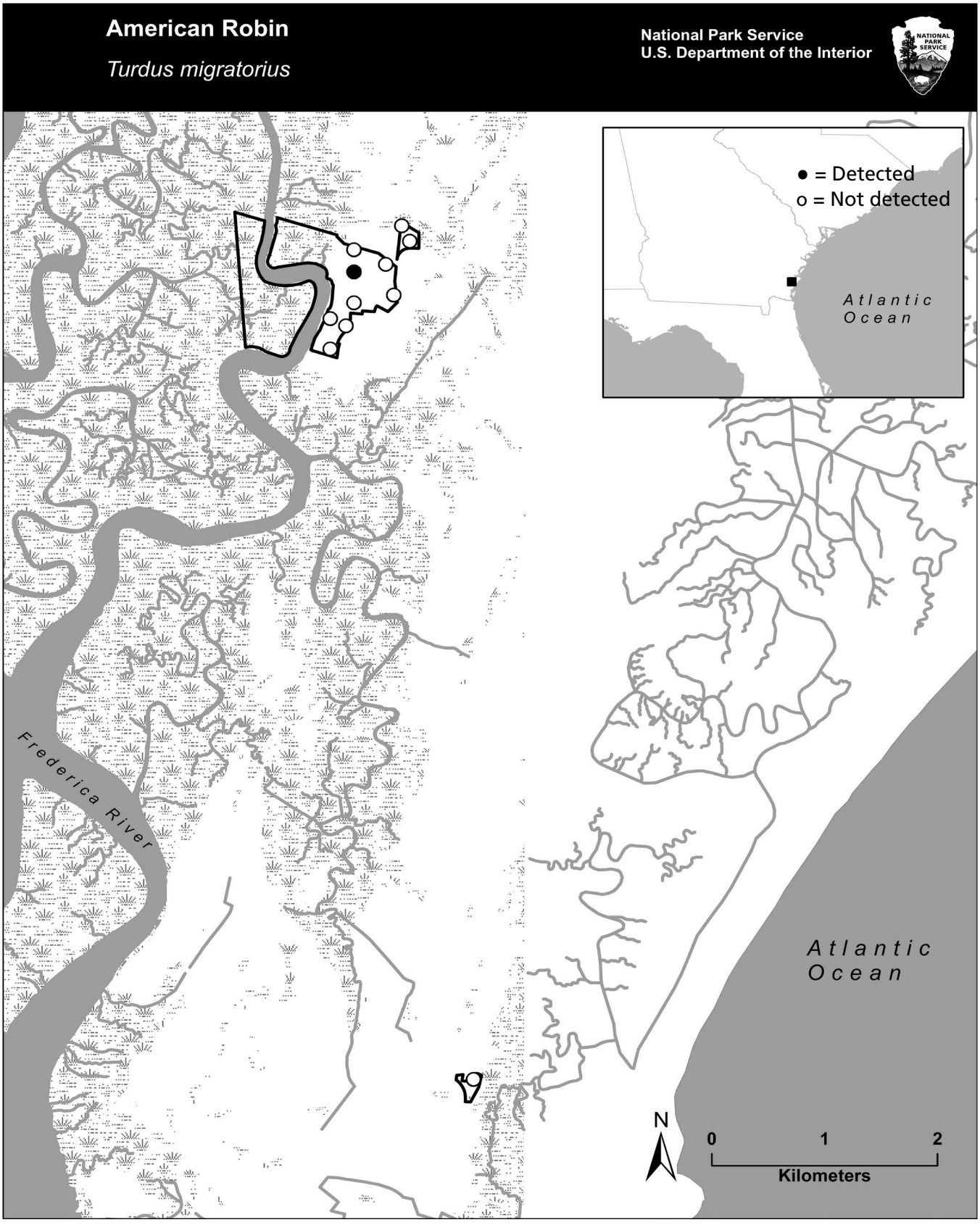


Figure C-4. Sampling locations where American robin (*Turdus migratorius*) was detected at Fort Frederica National Monument, 2014.

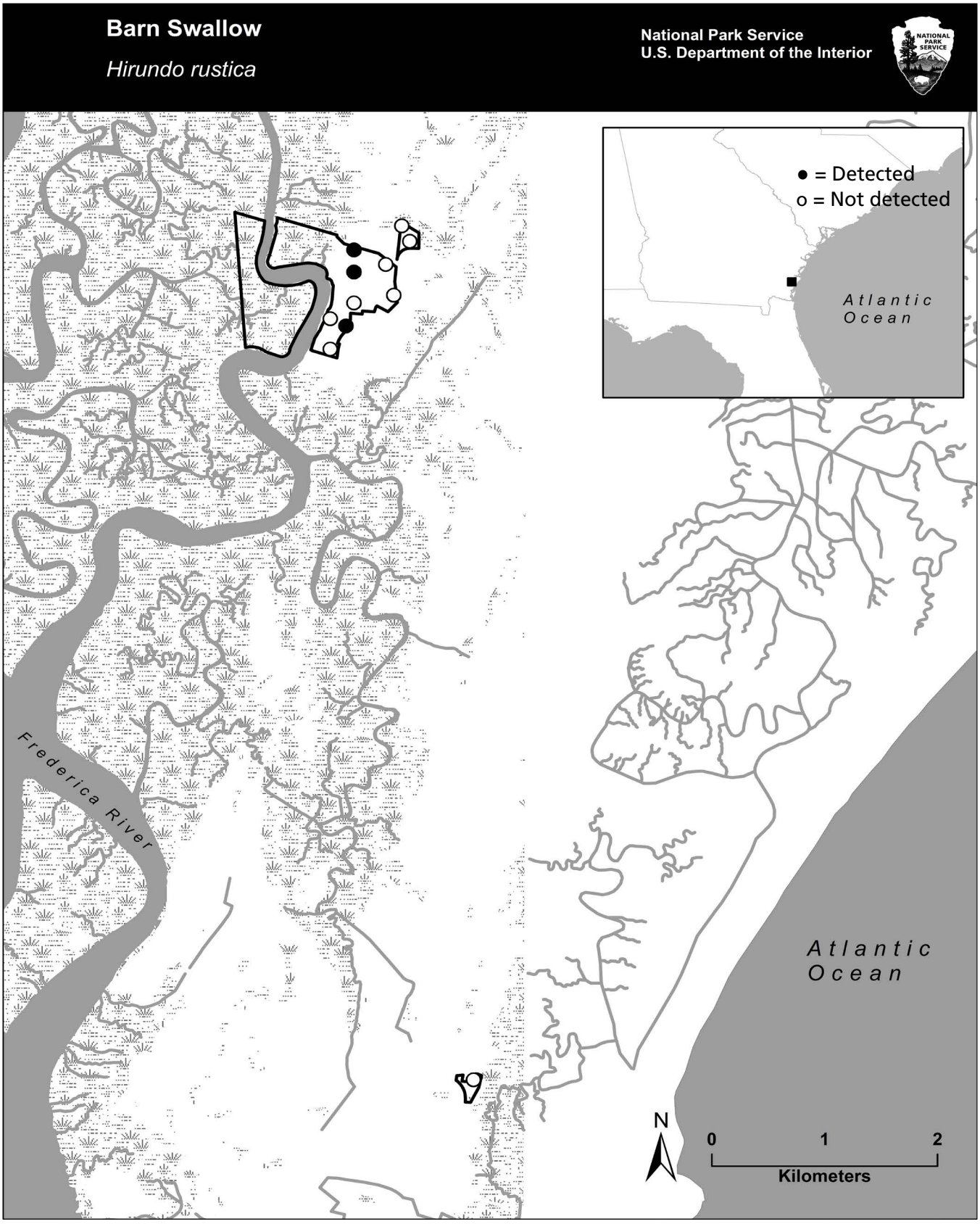


Figure C-5. Sampling locations where barn swallow (*Hirundo rustica*) was detected at Fort Frederica National Monument, 2014.

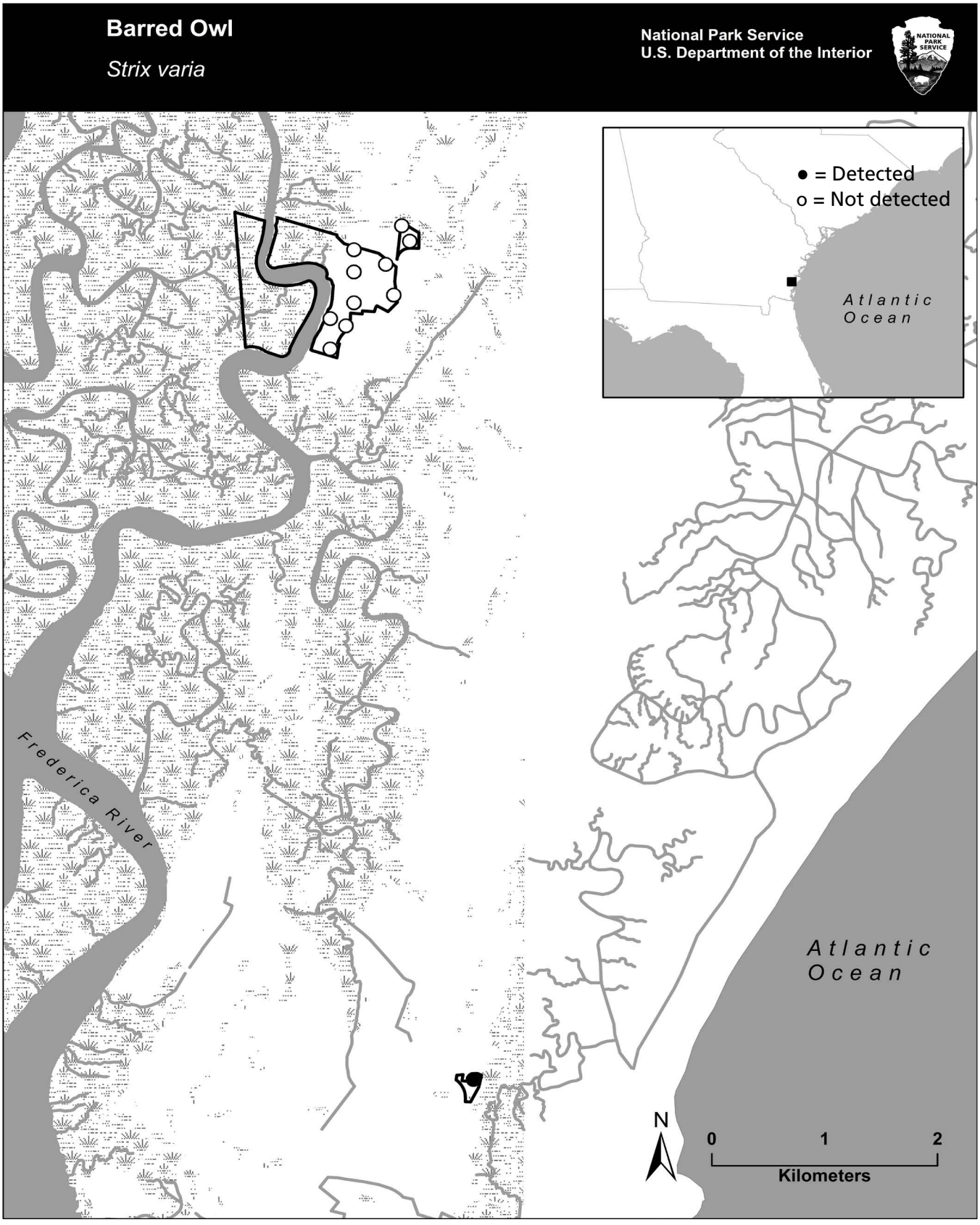


Figure C-6. Sampling locations where barred owl (*Strix varia*) was detected at Fort Frederica National Monument, 2014.

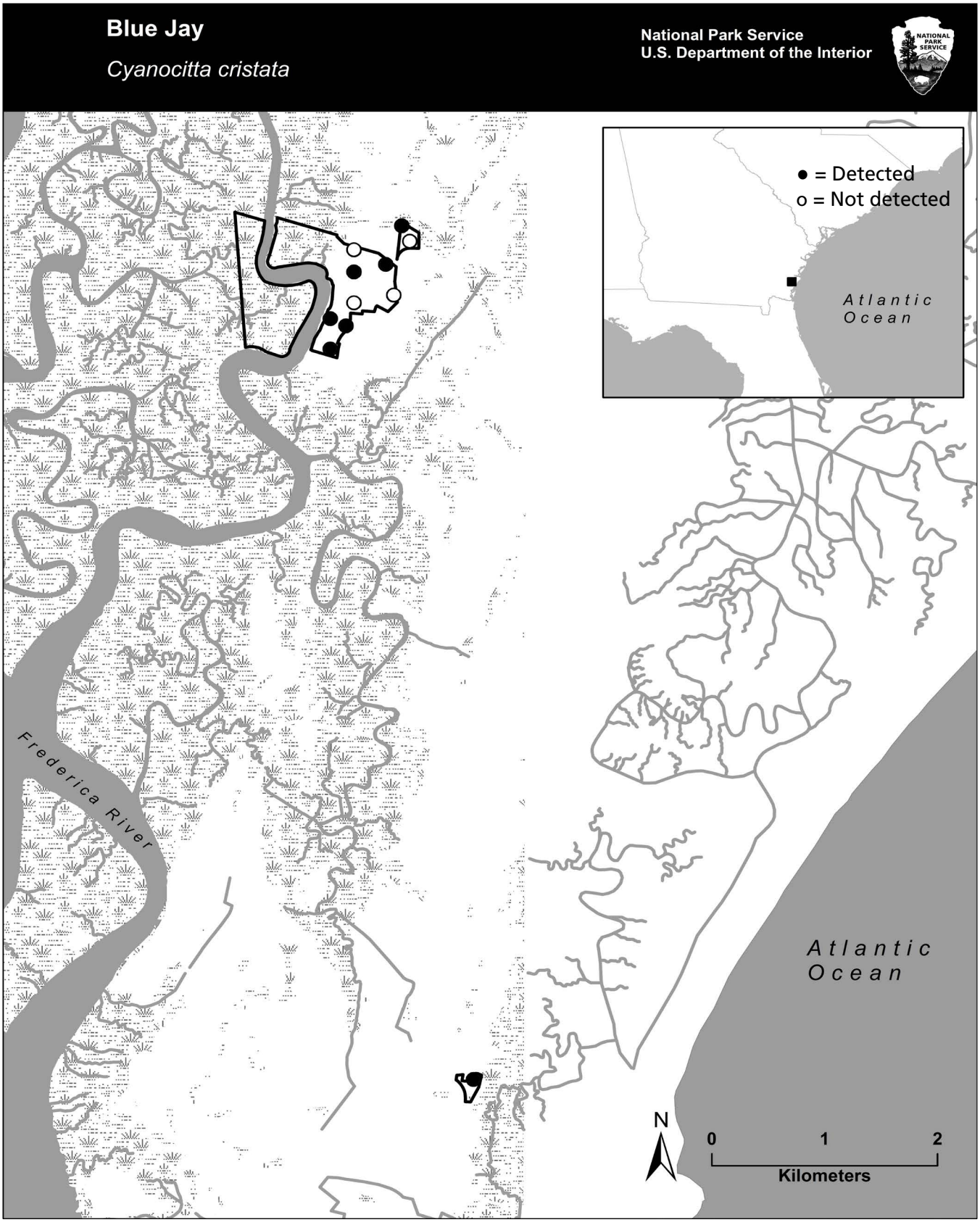


Figure C-7. Sampling locations where blue jay (*Cyanocitta cristata*) was detected at Fort Frederica National Monument, 2014.

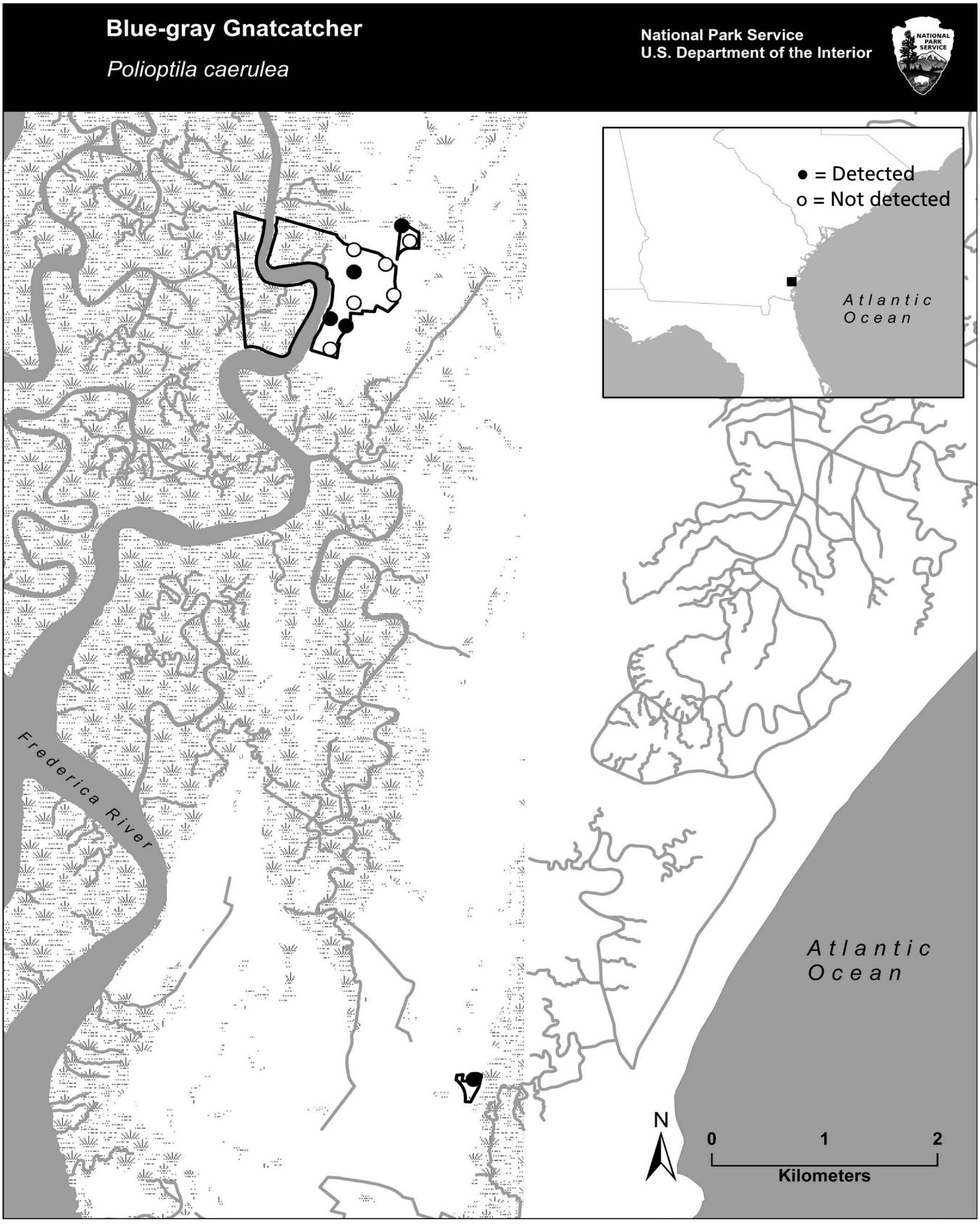


Figure C-8. Sampling locations where blue-gray gnatcatcher (*Polioptila caerulea*) was detected at Fort Frederica National Monument, 2014.

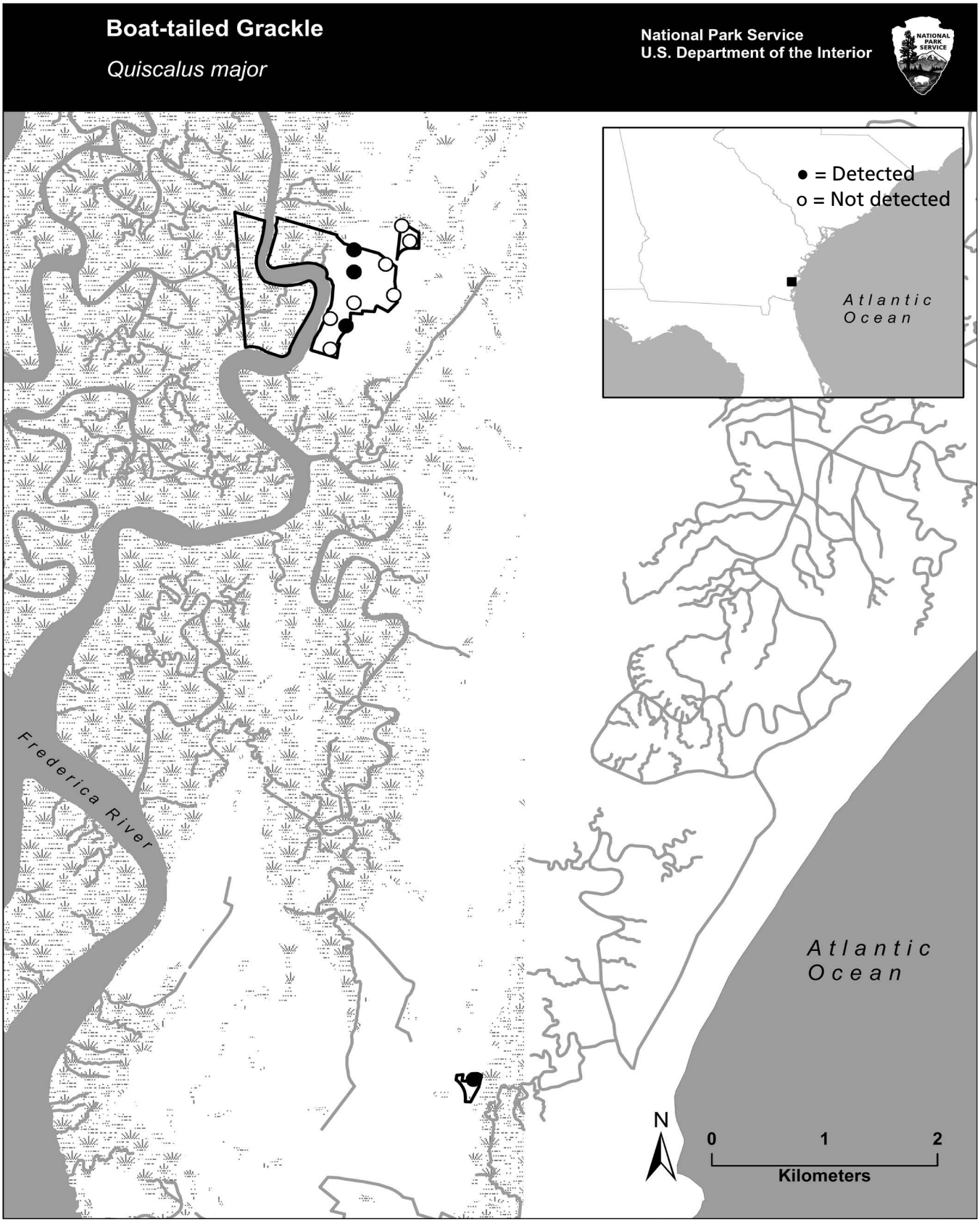


Figure C-9. Sampling locations where boat-tailed grackle (*Quiscalus major*) was detected at Fort Frederica National Monument, 2014.

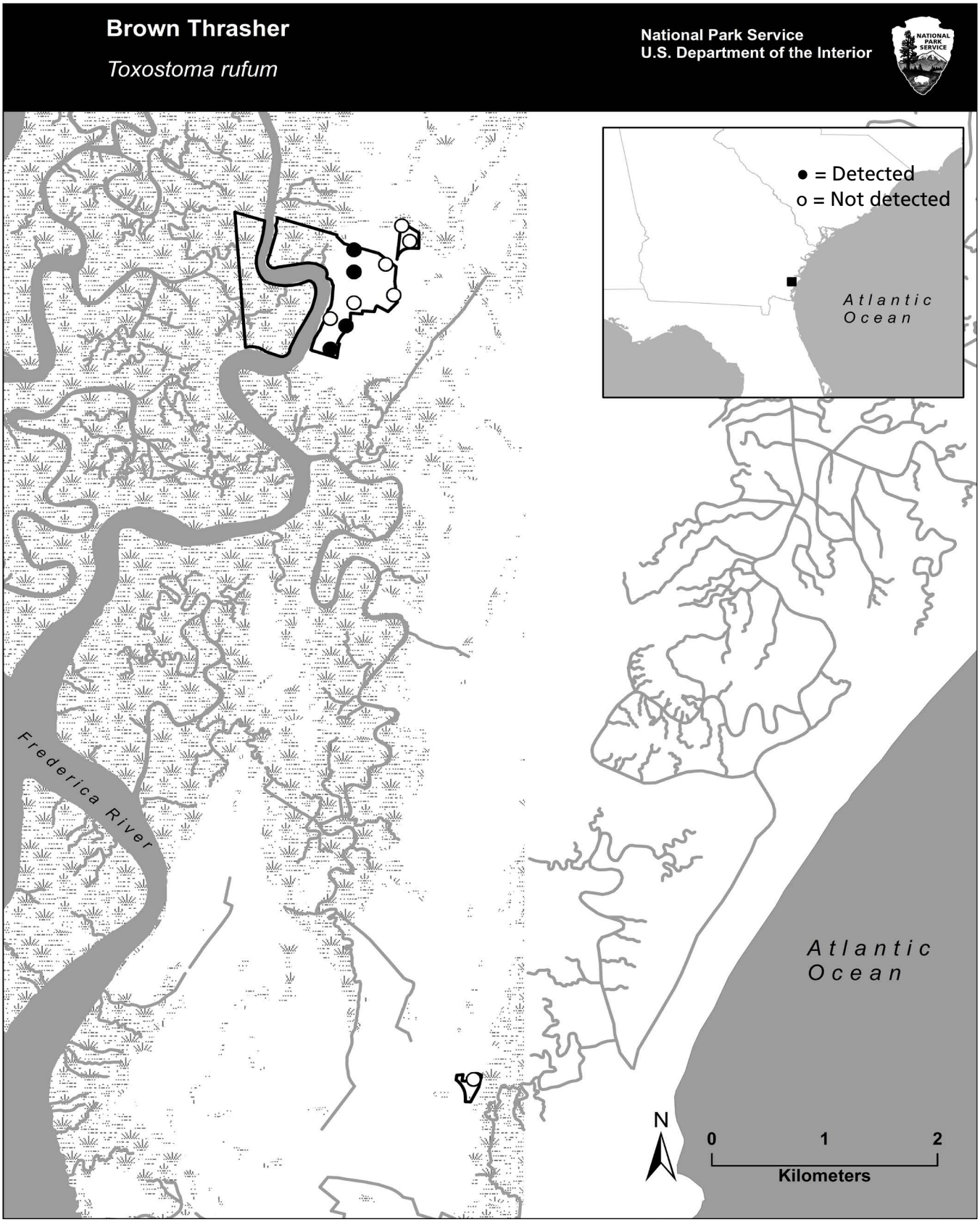


Figure C-10. Sampling locations where brown thrasher (*Toxostoma rufum*) was detected at Fort Frederica National Monument, 2014.

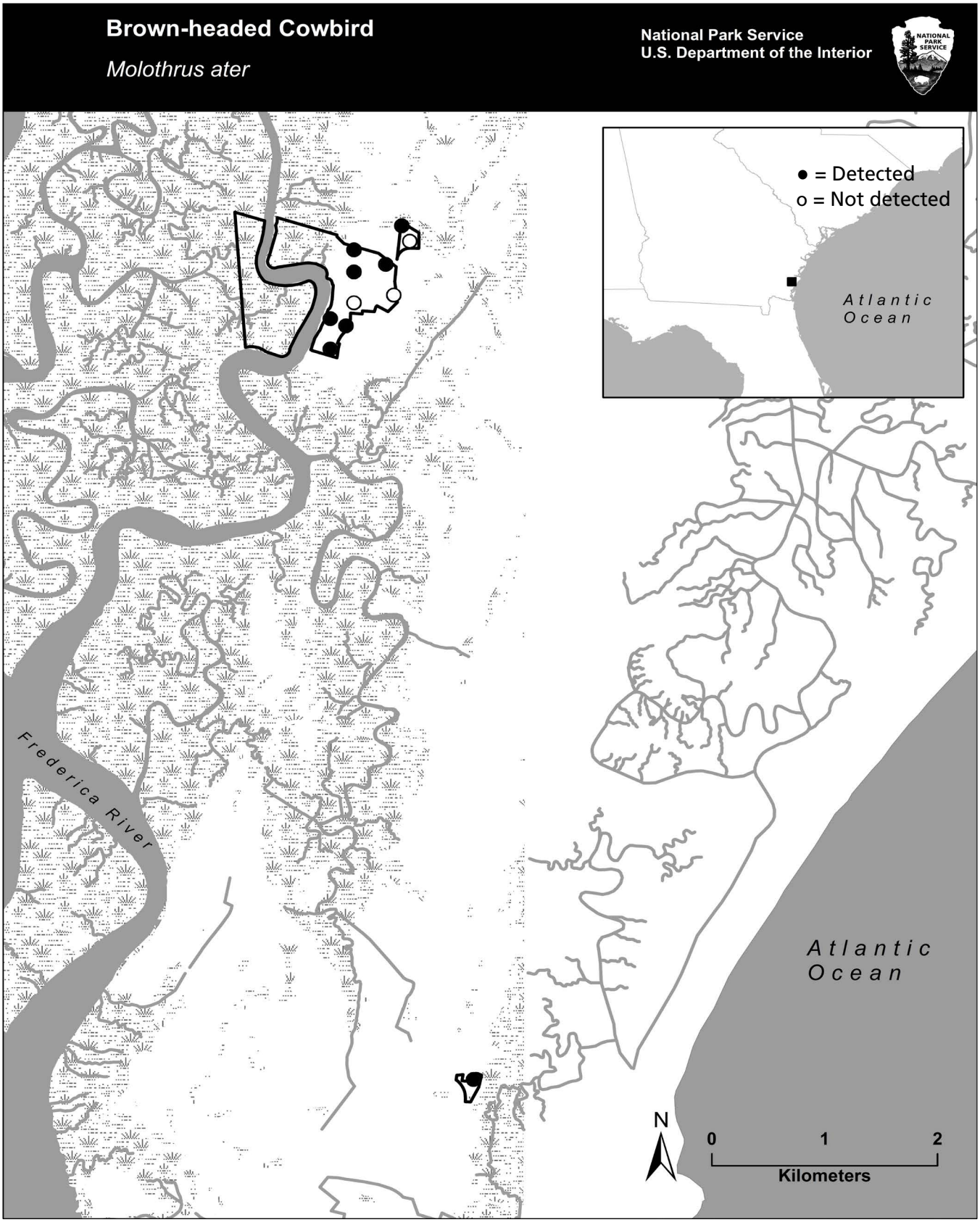


Figure C-11. Sampling locations where brown-headed cowbird (*Molothrus ater*) was detected at Fort Frederica National Monument, 2014.

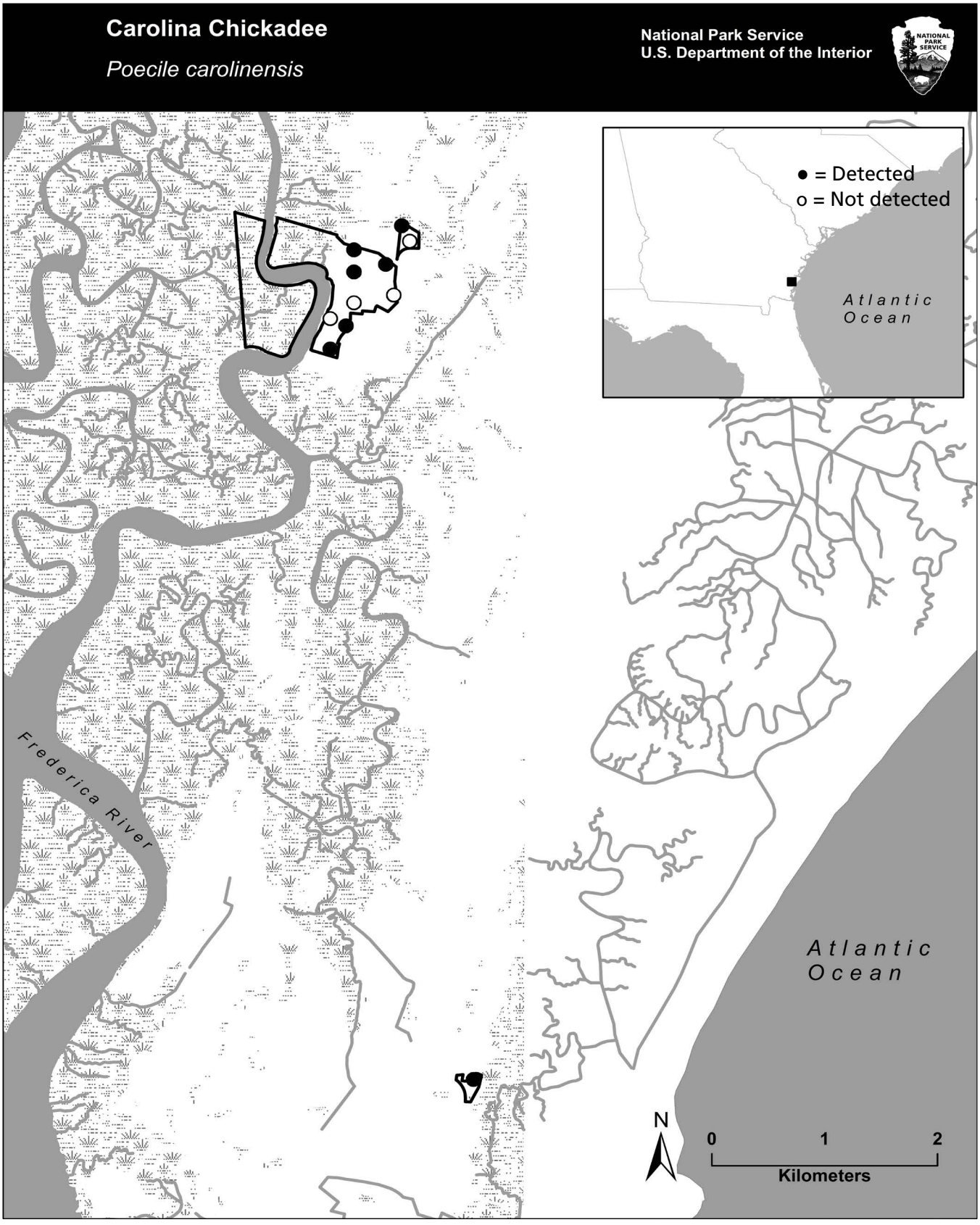


Figure C-12. Sampling locations where Carolina chickadee (*Poecile carolinensis*) was detected at Fort Frederica National Monument, 2014.

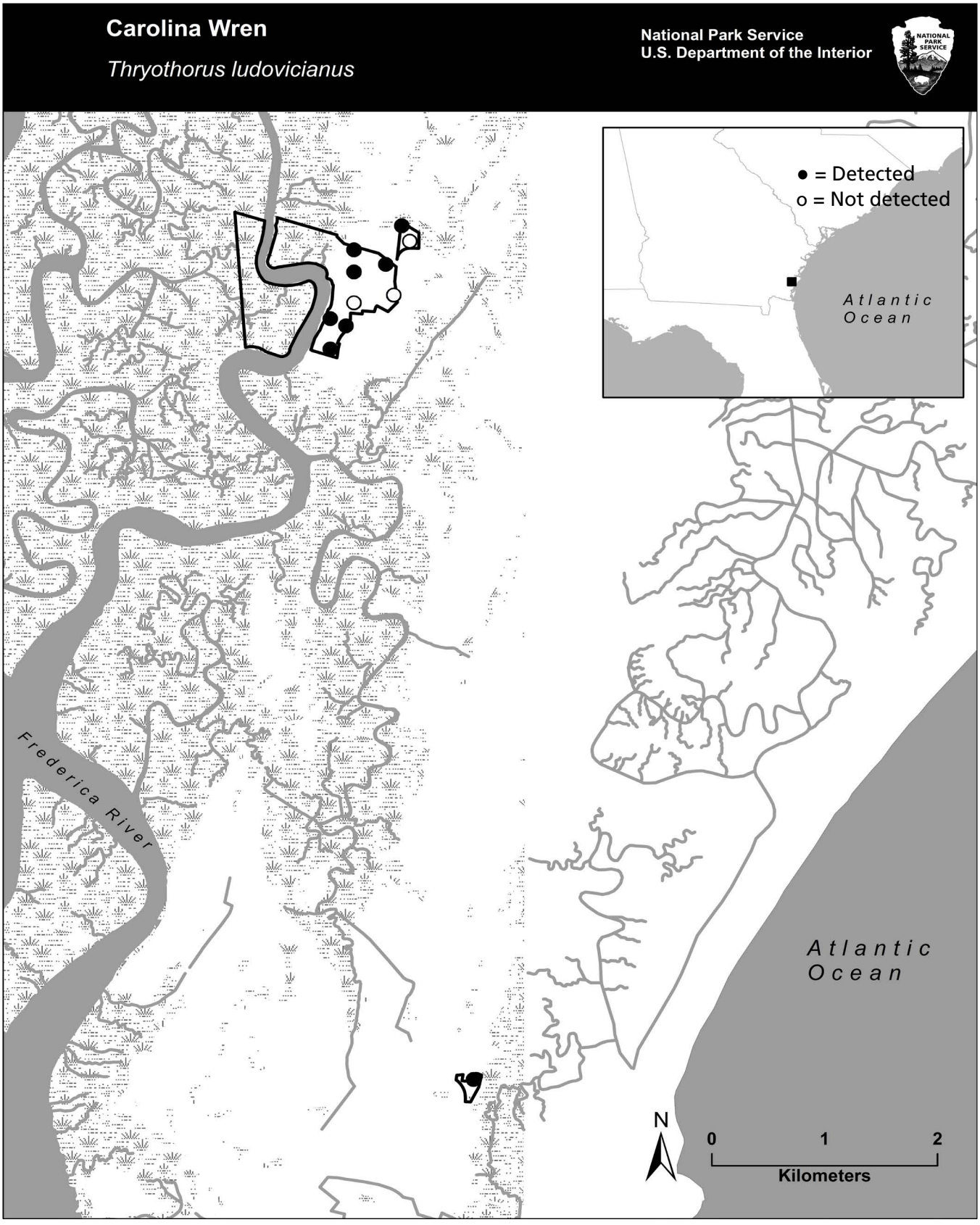


Figure C-13. Sampling locations where Carolina wren (*Thryothorus ludovicianus*) was detected at Fort Frederica National Monument, 2014.

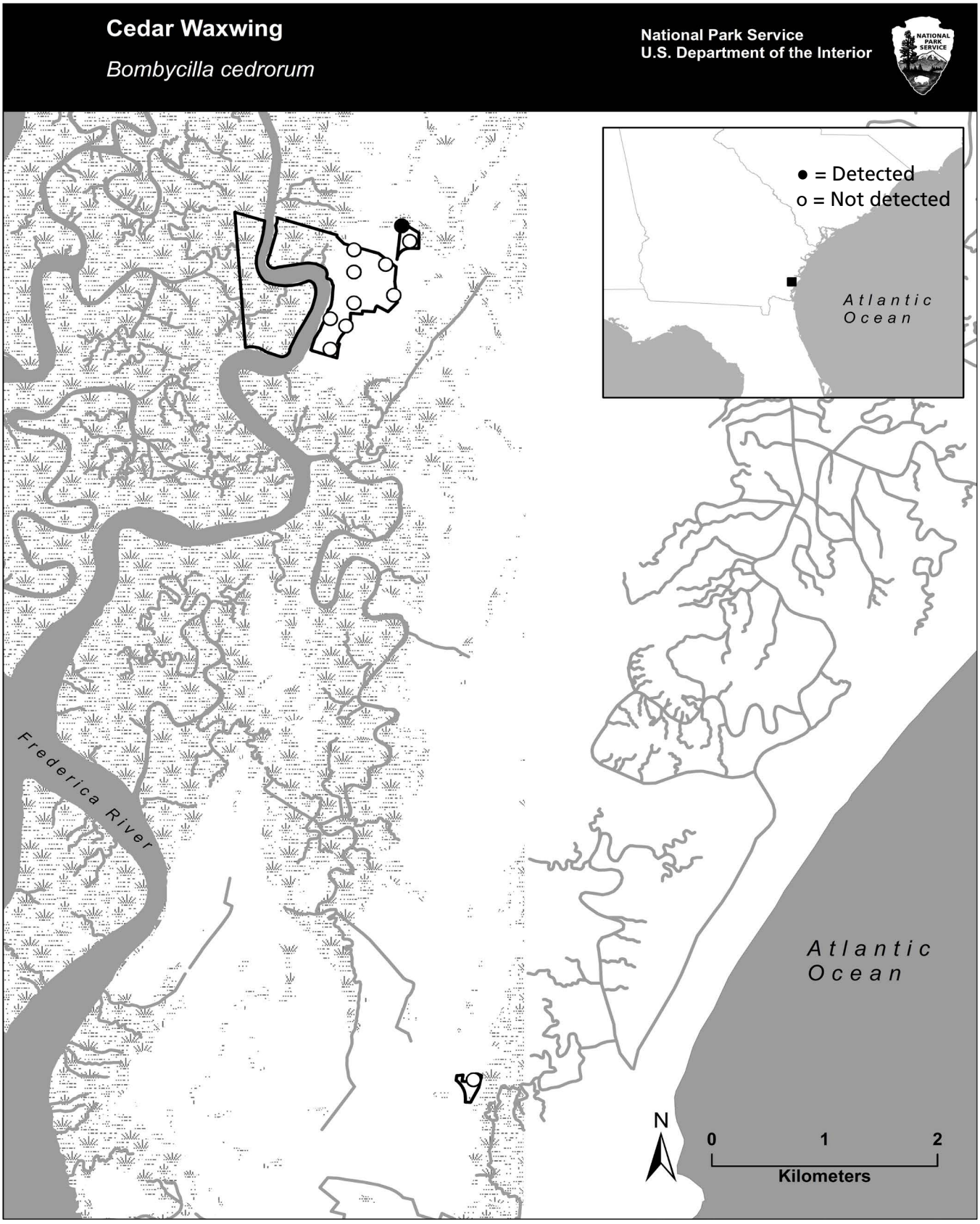


Figure C-14. Sampling locations where cedar waxwing (*Bombycilla cedrorum*) was detected at Fort Frederica National Monument, 2014.

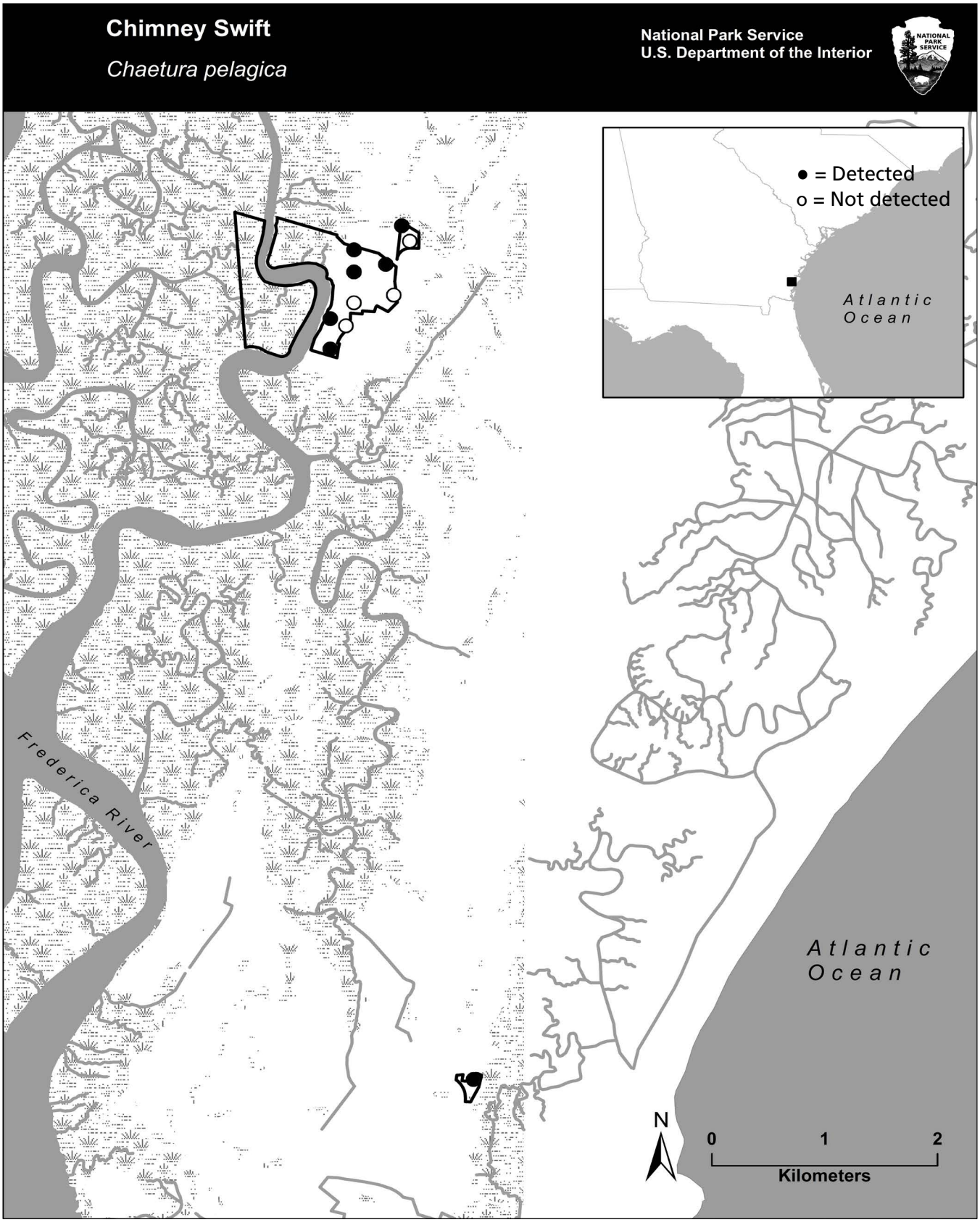


Figure C-15. Sampling locations where chimney swift (*Chaetura pelagica*) was detected at Fort Frederica National Monument, 2014.

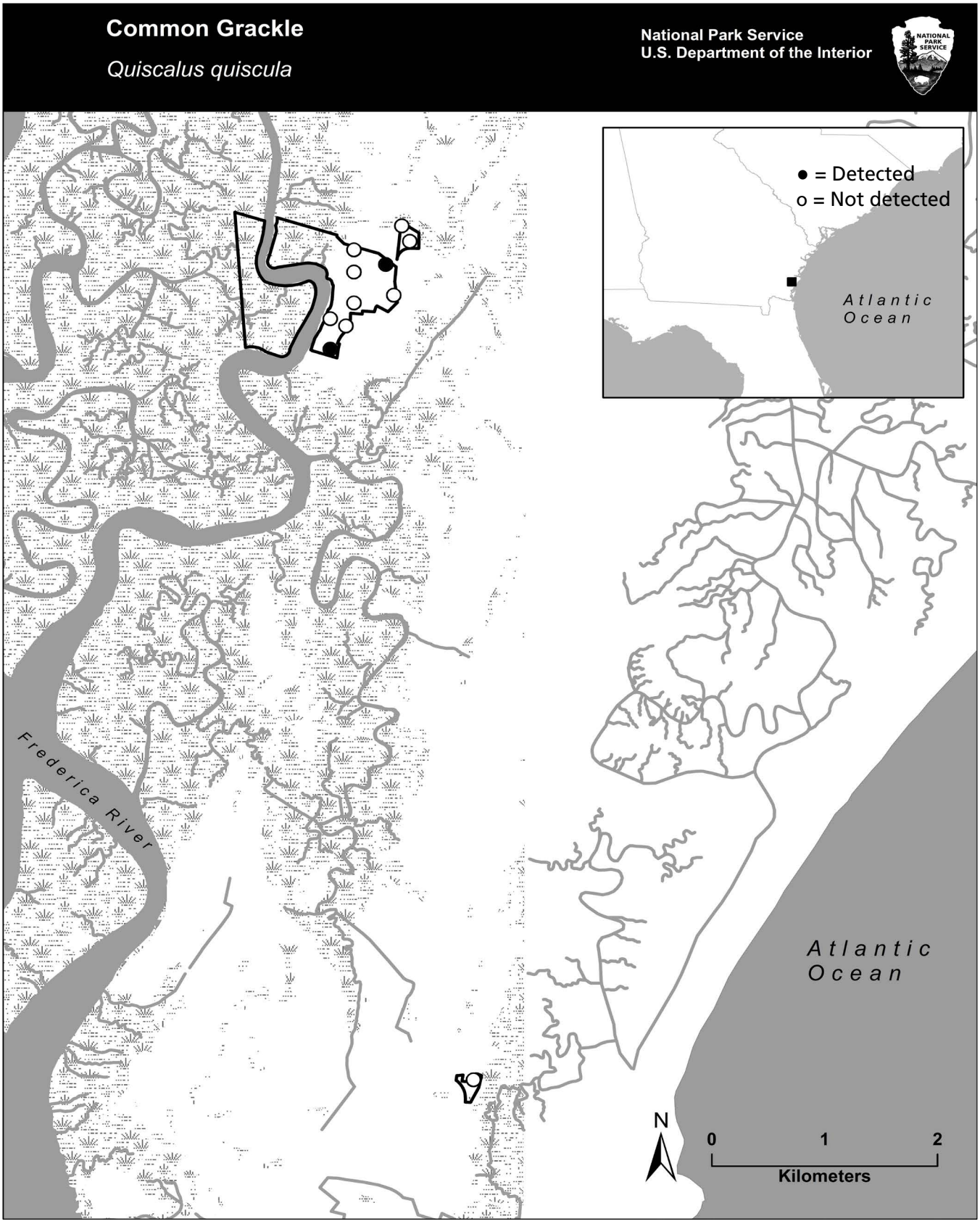


Figure C-16. Sampling locations where common grackle (*Quiscalus quiscula*) was detected at Fort Frederica National Monument, 2014.

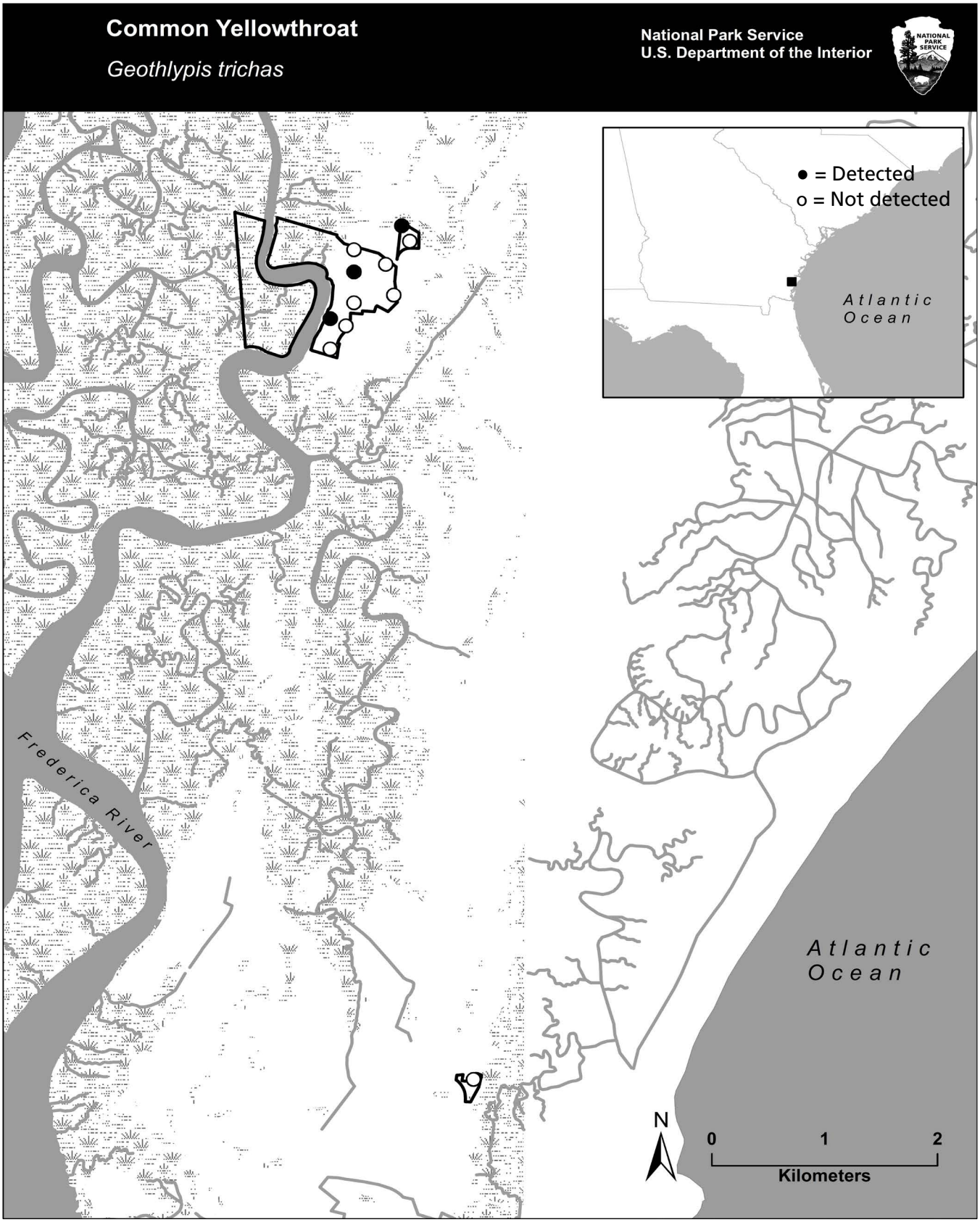


Figure C-17. Sampling locations where common yellowthroat (*Geothlypis trichas*) was detected at Fort Frederica National Monument, 2014.

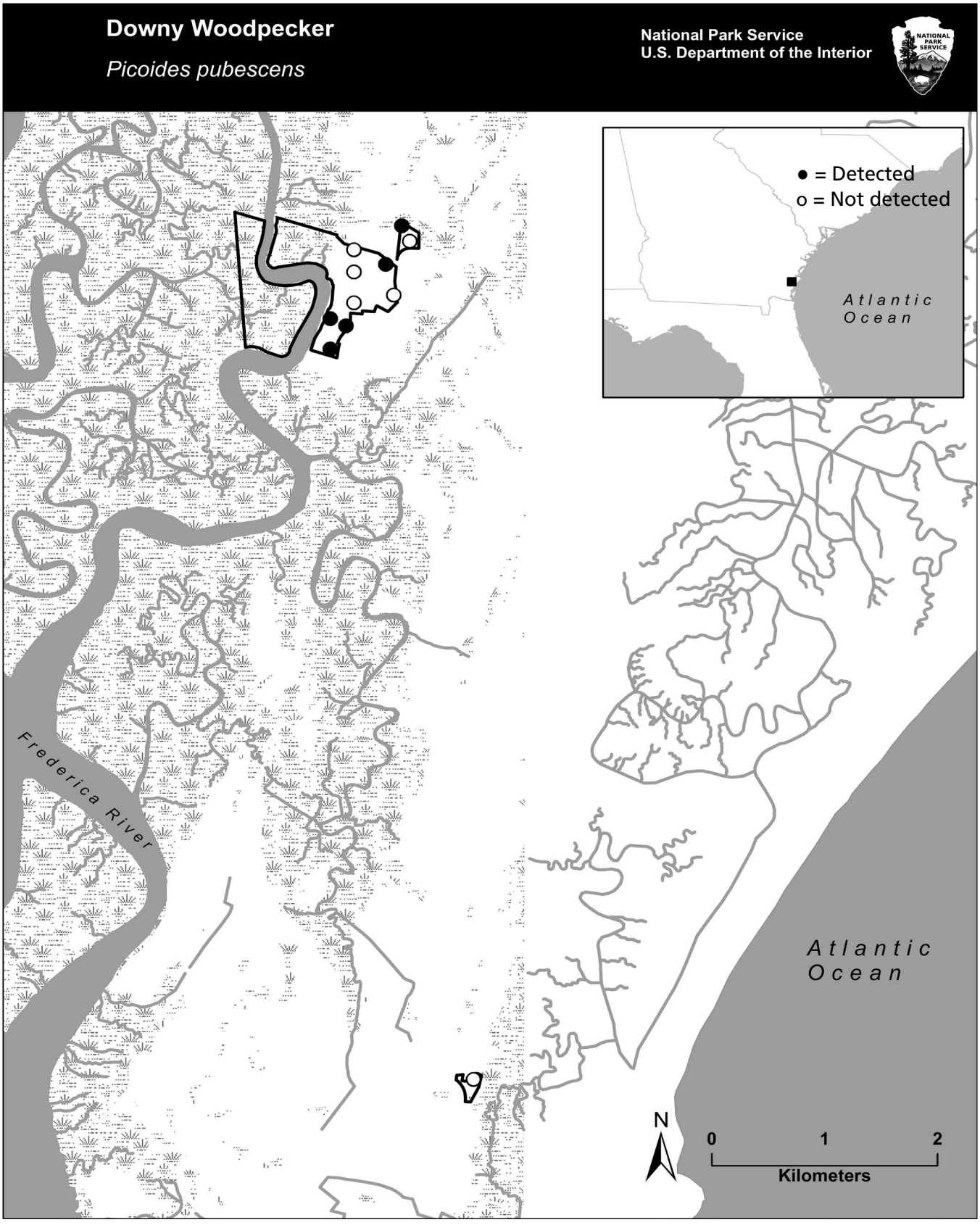


Figure C-18. Sampling locations where downy woodpecker (*Picoides pubescens*) was detected at Fort Frederica National Monument, 2014.

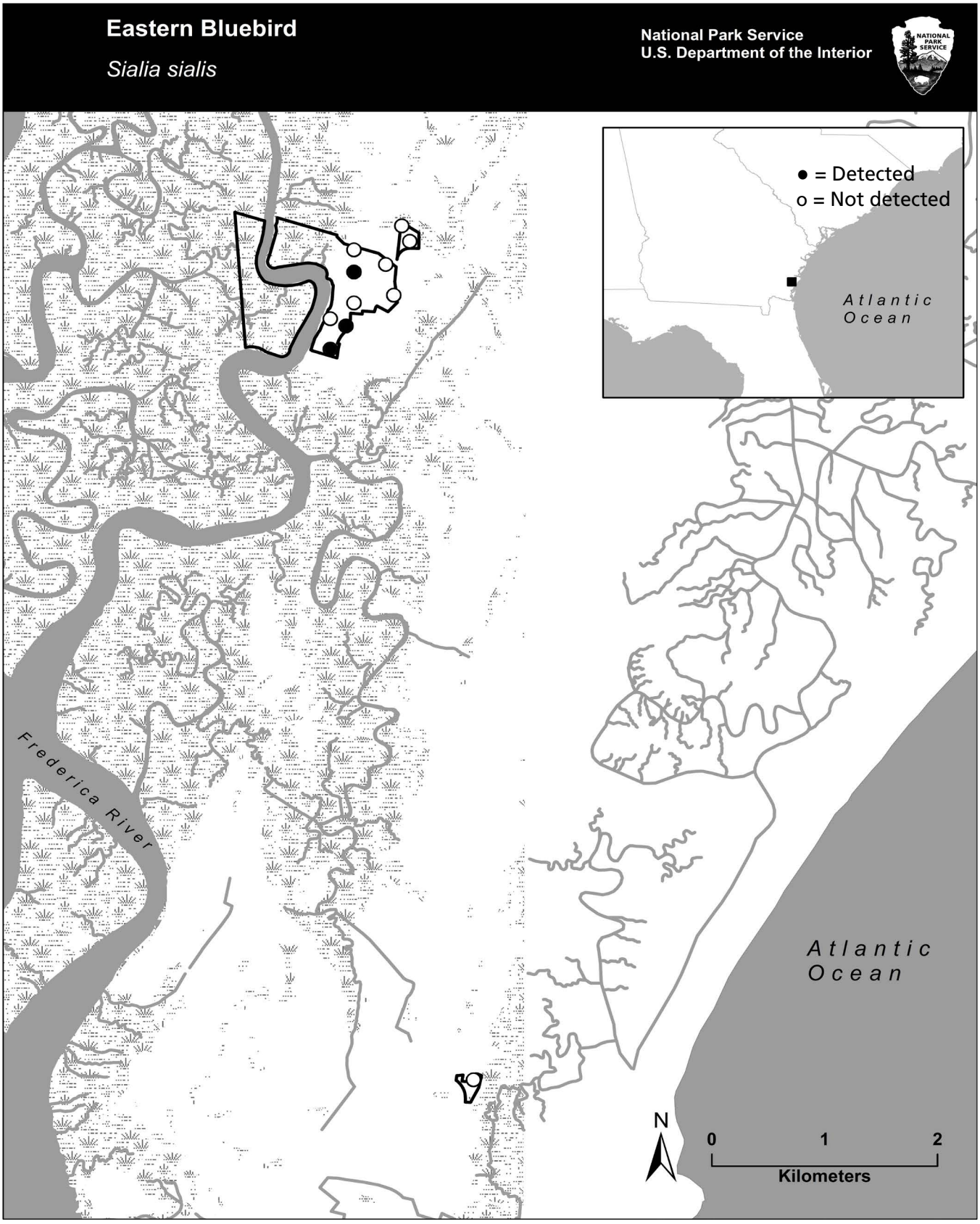


Figure C-19. Sampling locations where eastern bluebird (*Sialia sialis*) was detected at Fort Frederica National Monument, 2014.

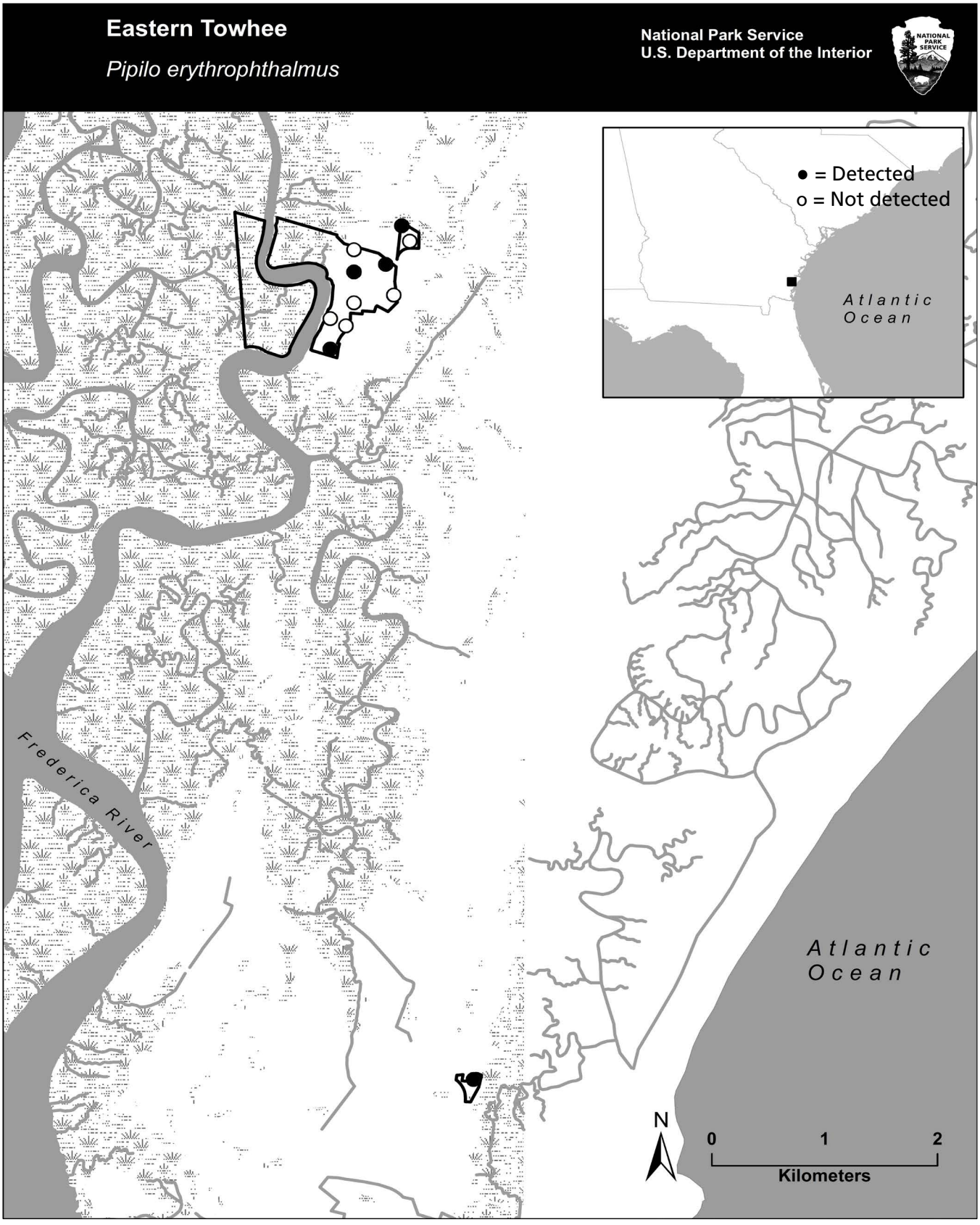


Figure C-20. Sampling locations where eastern towhee (*Pipilo erythrophthalmus*) was detected at Fort Frederica National Monument, 2014.

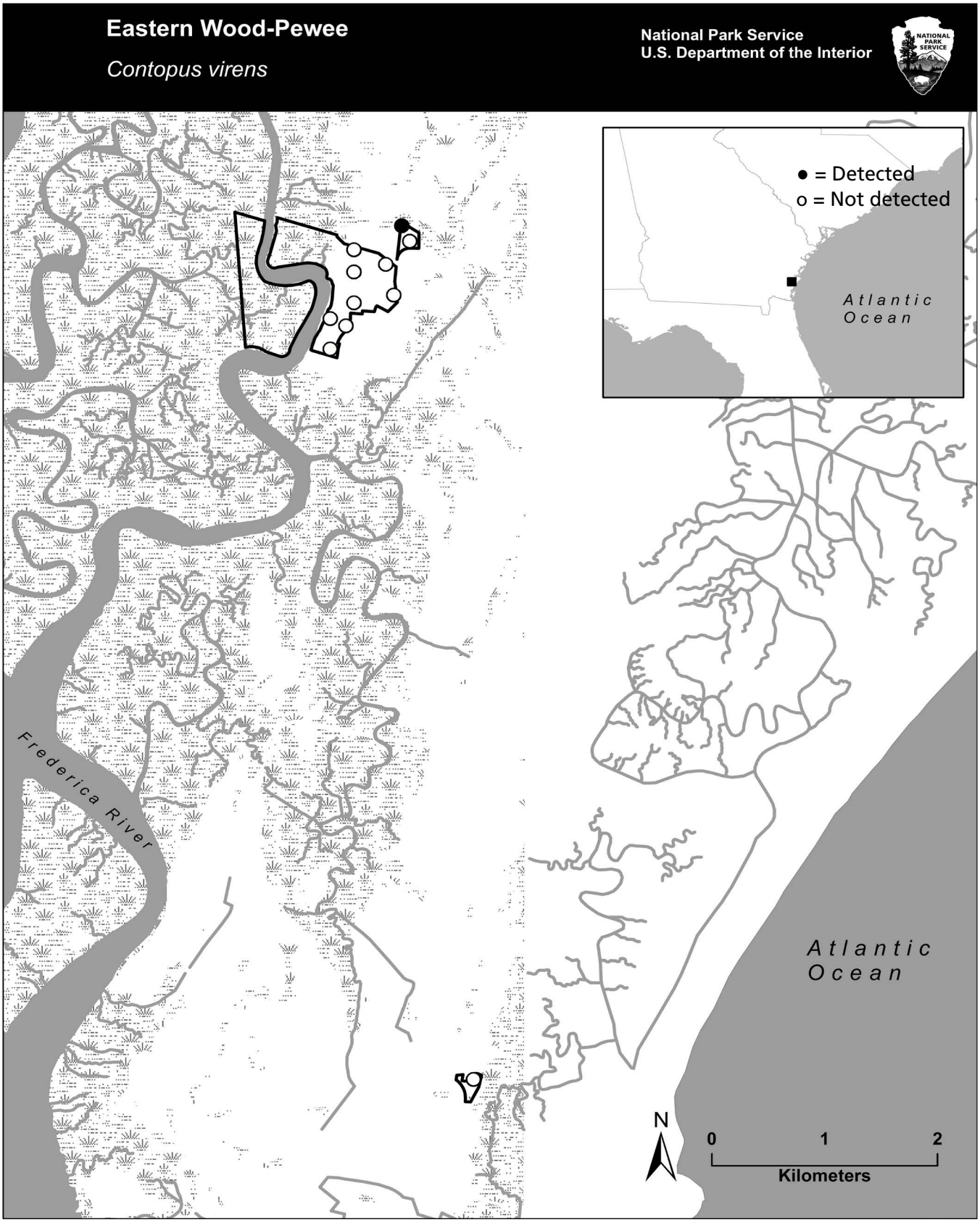


Figure C-21. Sampling locations where eastern wood-pewee (*Contopus virens*) was detected at Fort Frederica National Monument, 2014.

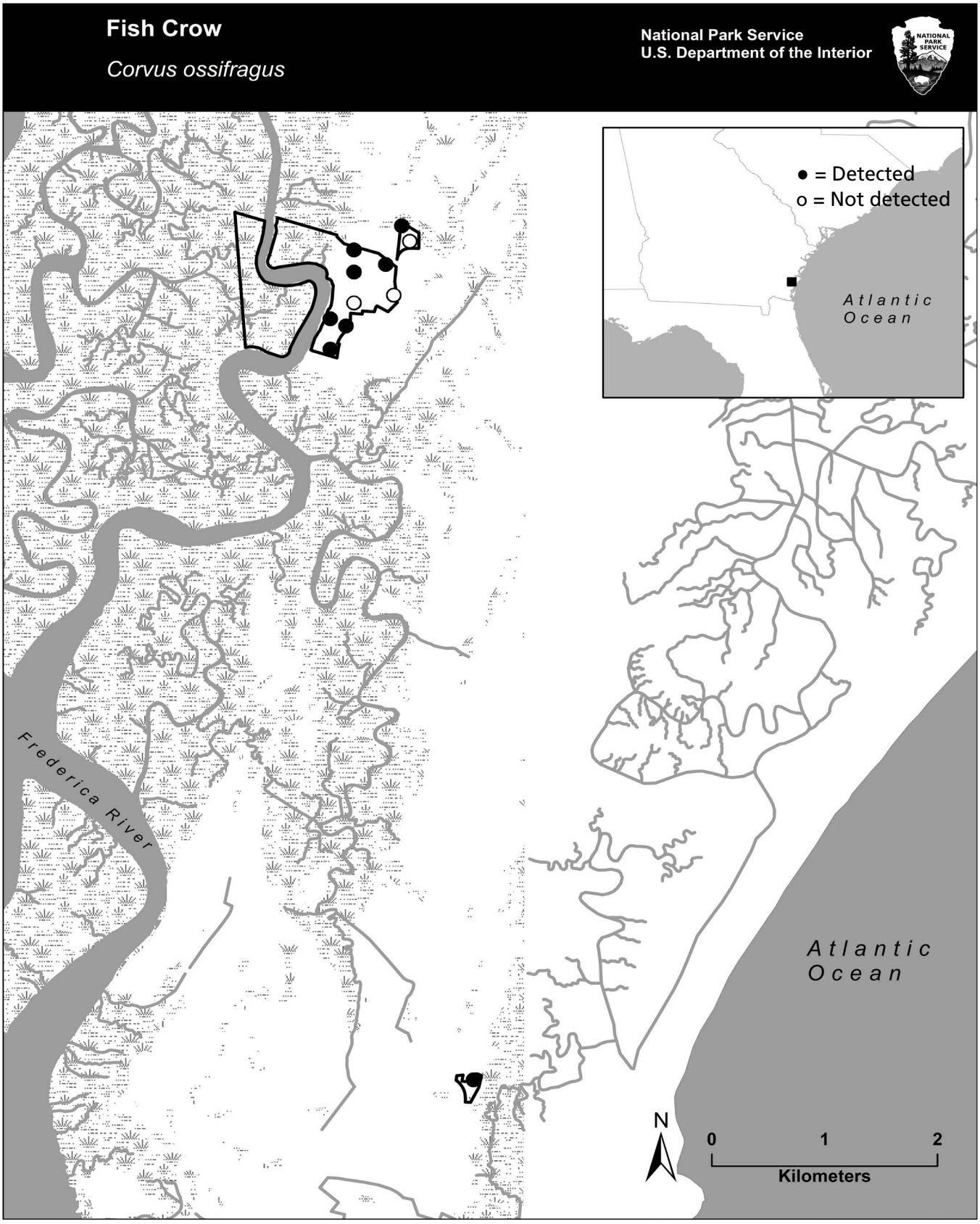


Figure C-22. Sampling locations where fish crow (*Corvus ossifragus*) was detected at Fort Frederica National Monument, 2014.

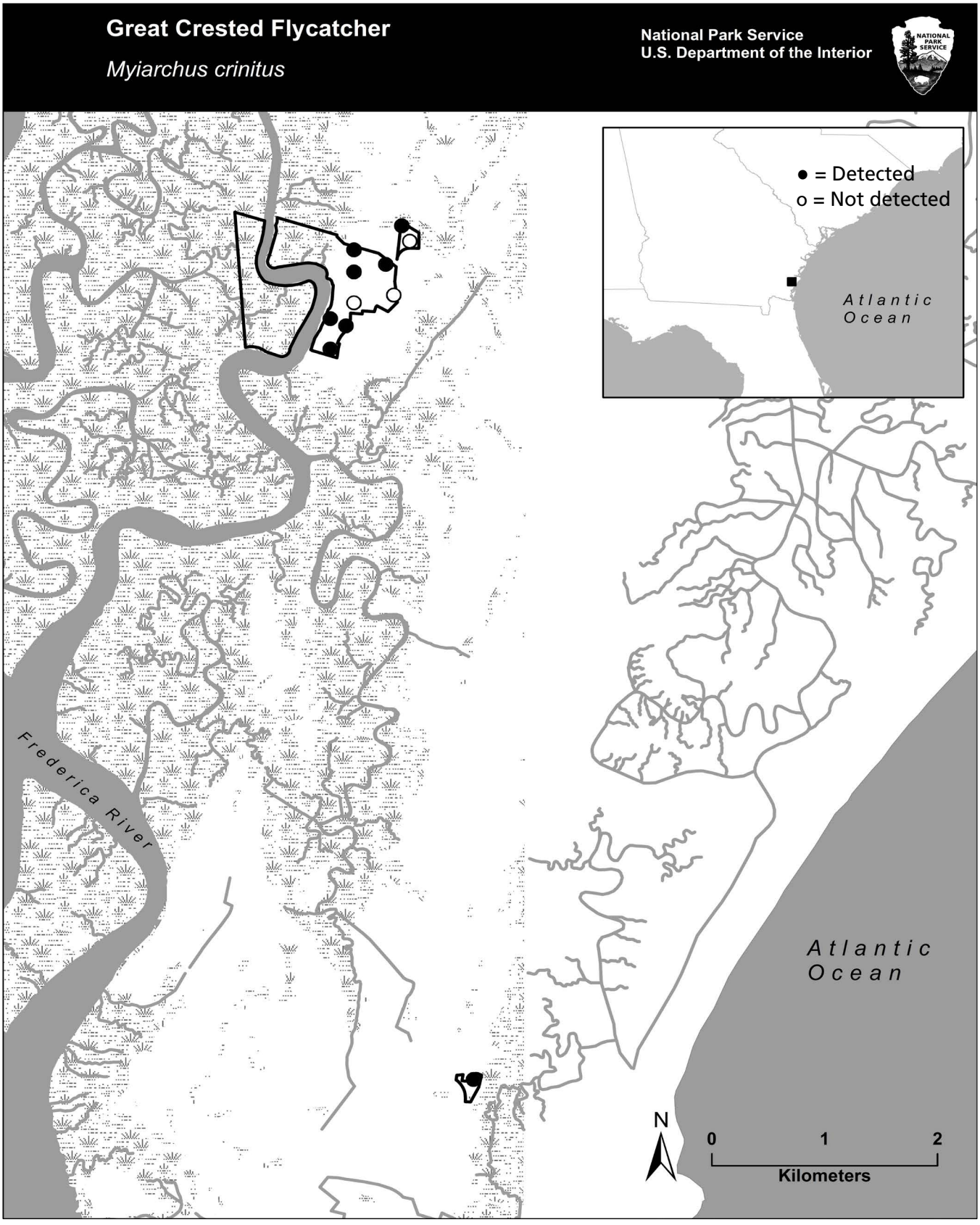


Figure C-23. Sampling locations where great crested flycatcher (*Myiarchus crinitus*) was detected at Fort Frederica National Monument, 2014.

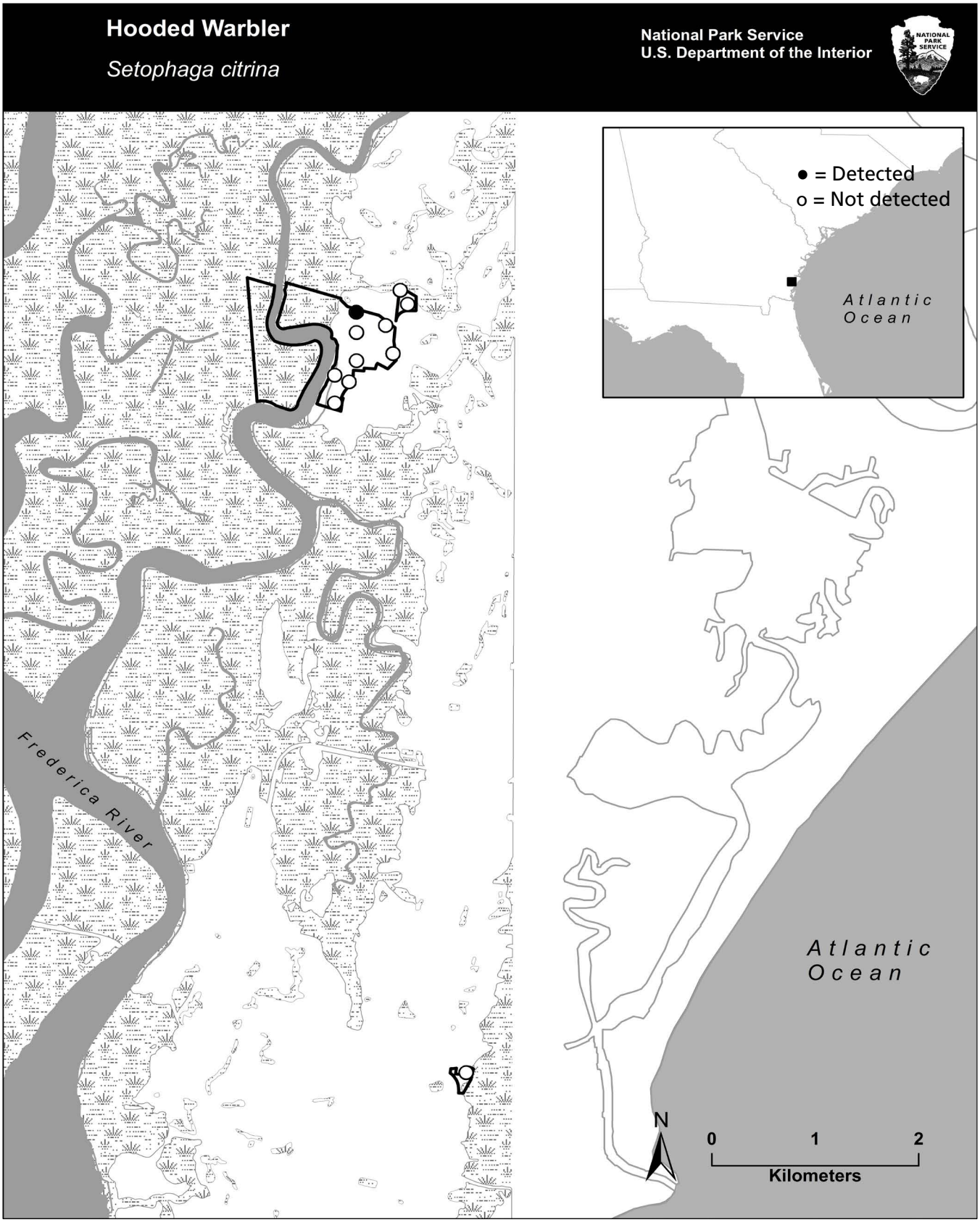


Figure C-24. Sampling locations where hooded warbler (*Setophaga cyanea*) was detected at Fort Frederica National Monument, 2014.

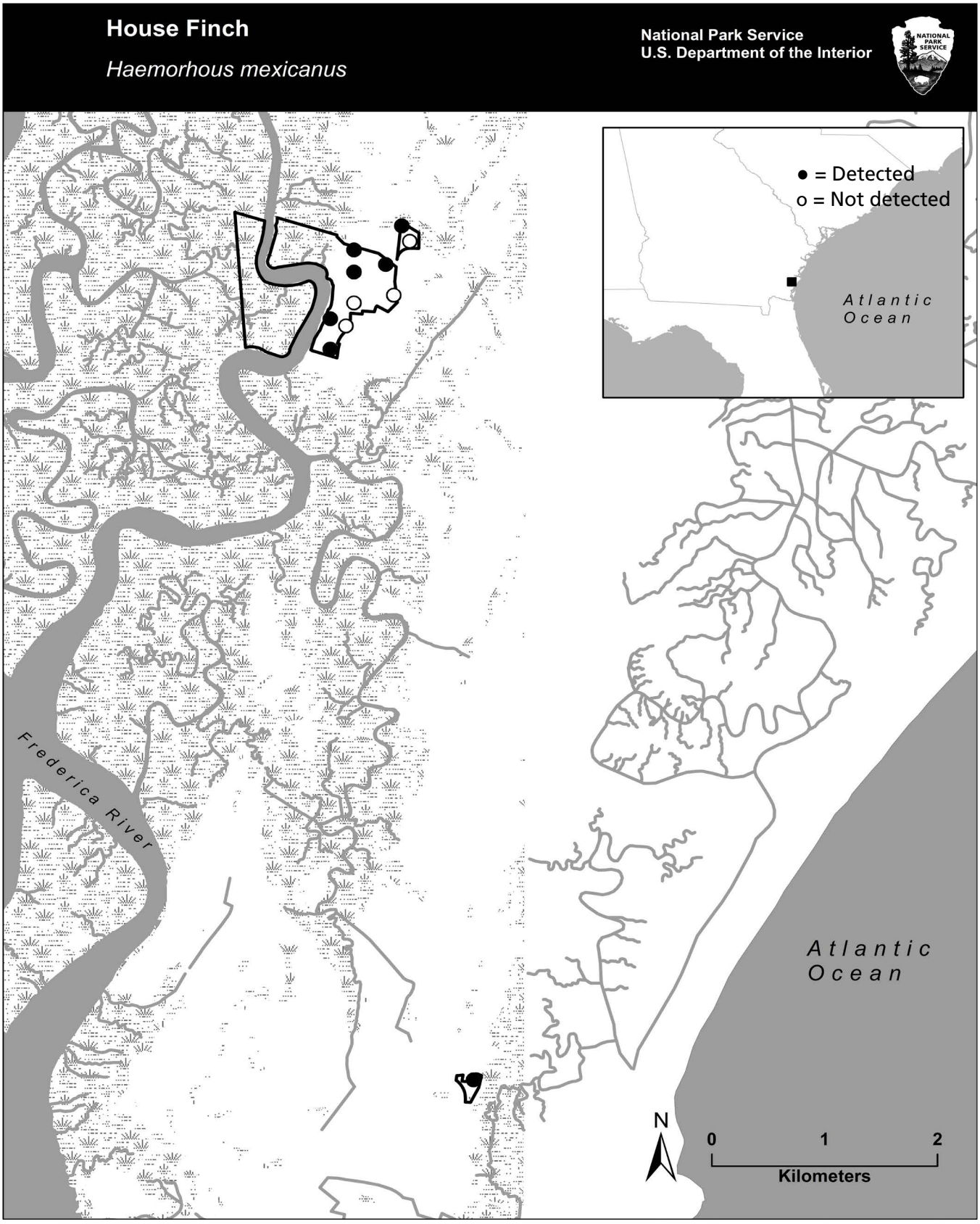


Figure C-25. Sampling locations where house finch (*Haemorhous mexicanus*) was detected at Fort Frederica National Monument, 2014.

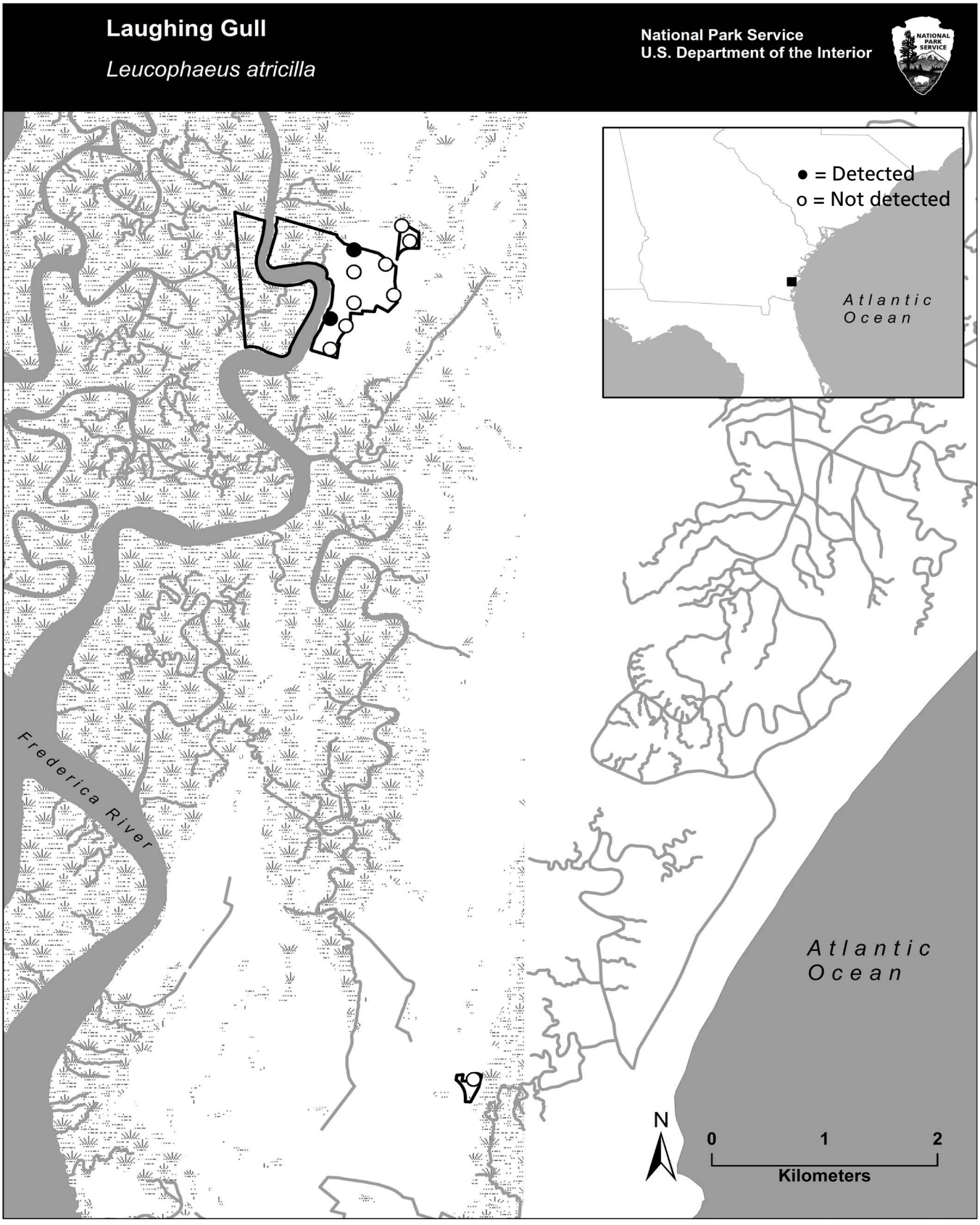


Figure C-26. Sampling locations where laughing gull (*Leucophaeus atricilla*) was detected at Fort Frederica National Monument, 2014.

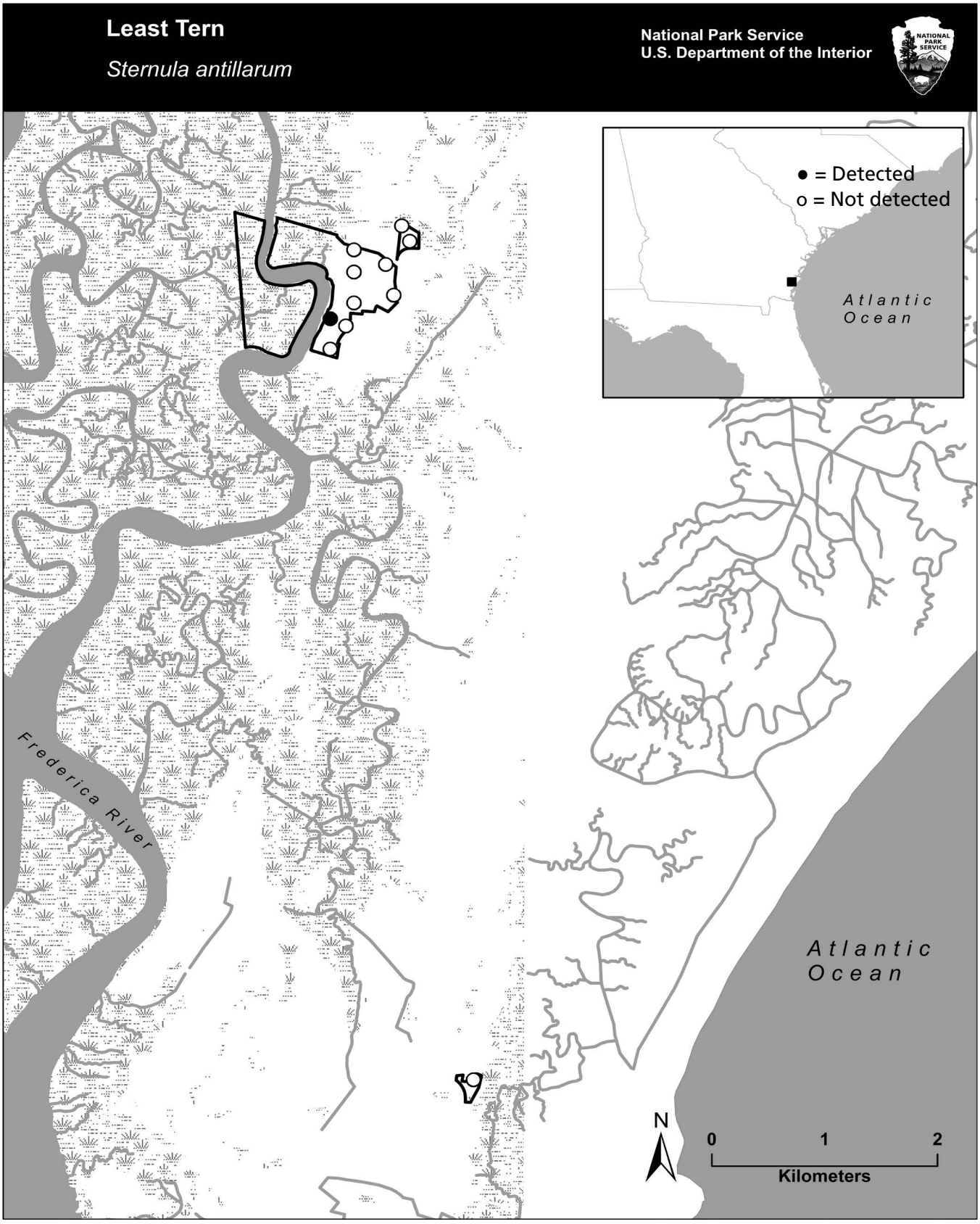


Figure C-27. Sampling locations where least tern (*Sternula antillarum*) was detected at Fort Frederica National Monument, 2014.

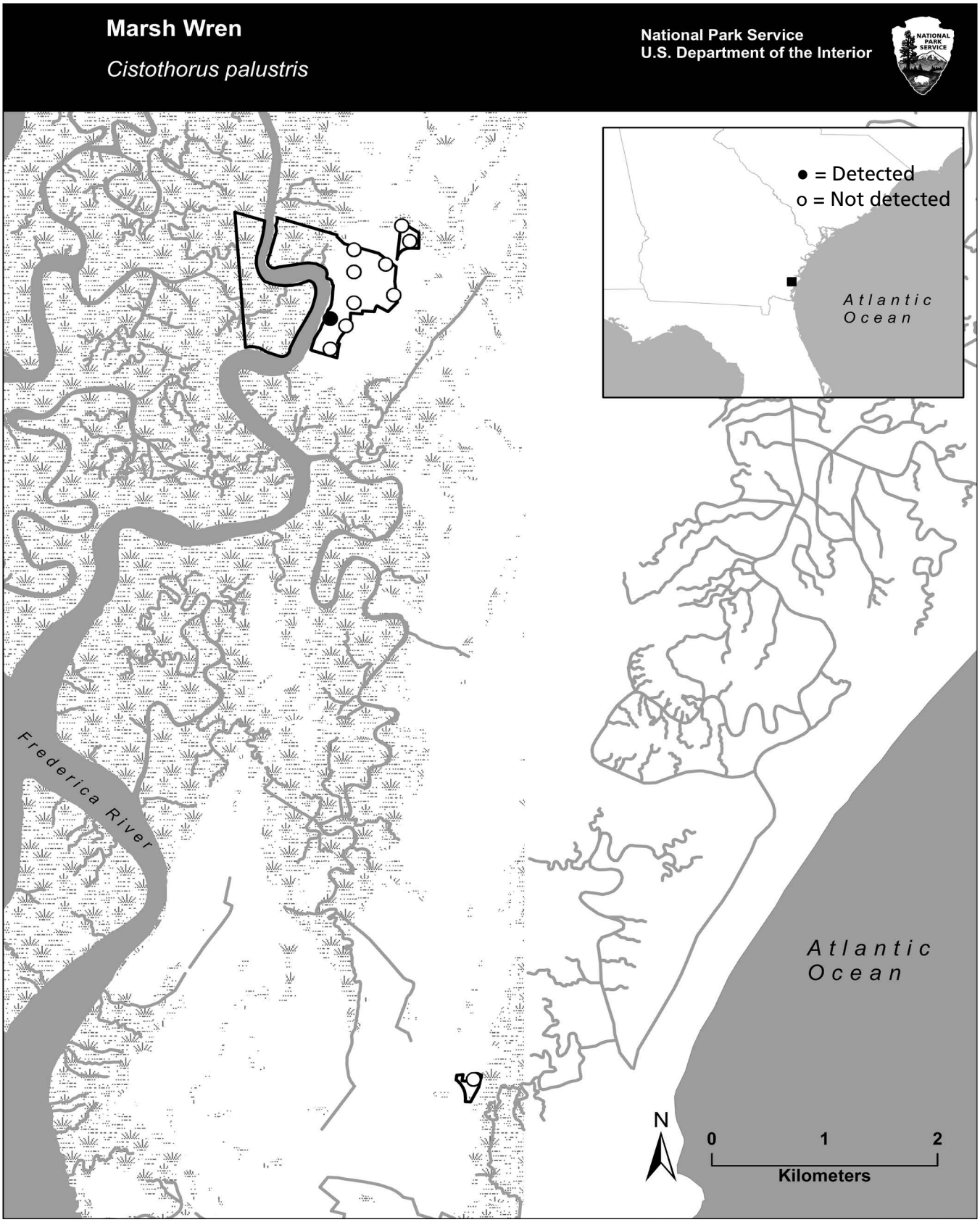


Figure C-28. Sampling locations where marsh wren (*Cistothorus palustris*) was detected at Fort Frederica National Monument, 2014.

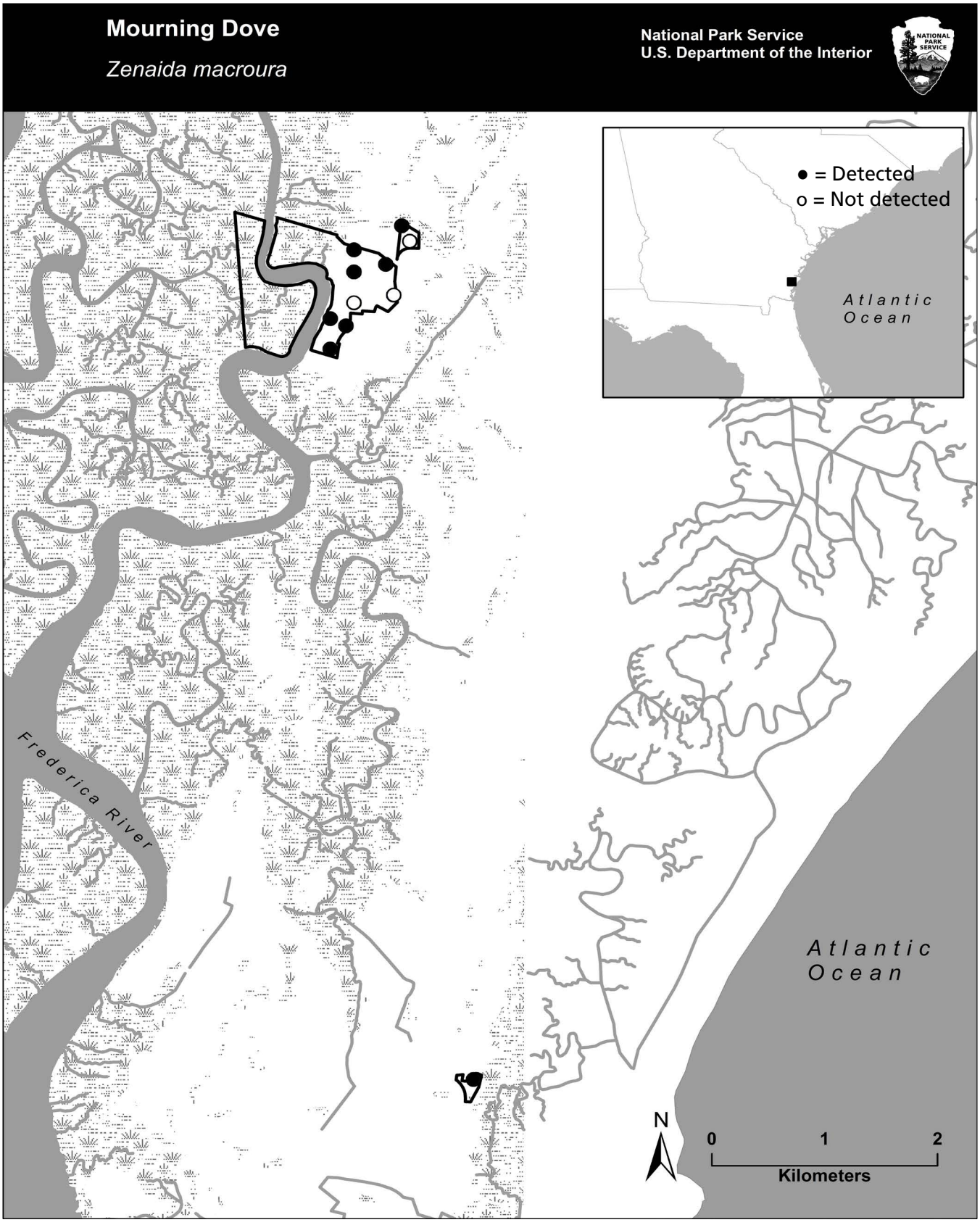


Figure C-29. Sampling locations where mourning dove (*Zenaida macroura*) was detected at Fort Frederica National Monument, 2014.

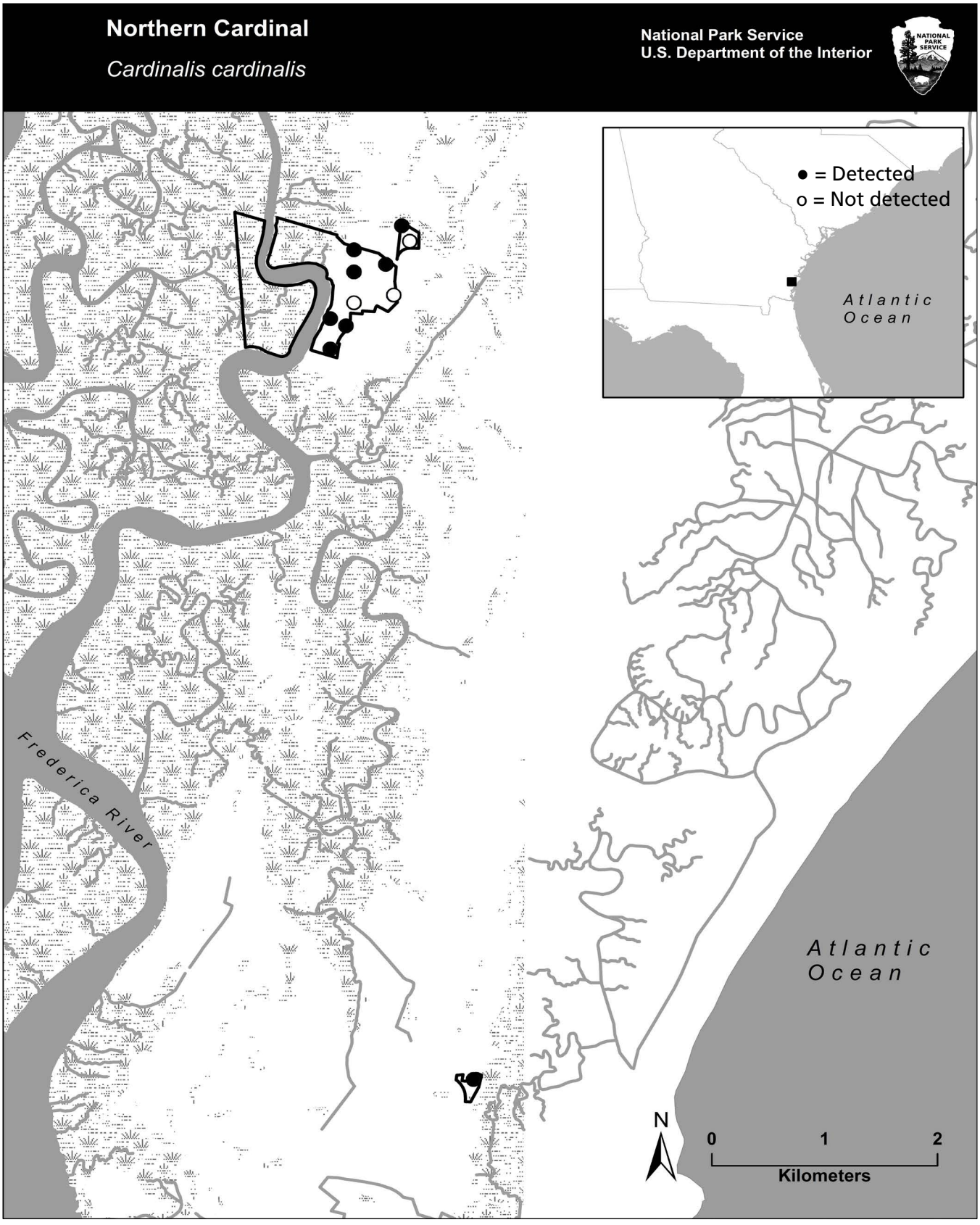


Figure C-30. Sampling locations where northern cardinal (*Cardinalis cardinalis*) was detected at Fort Frederica National Monument, 2014.

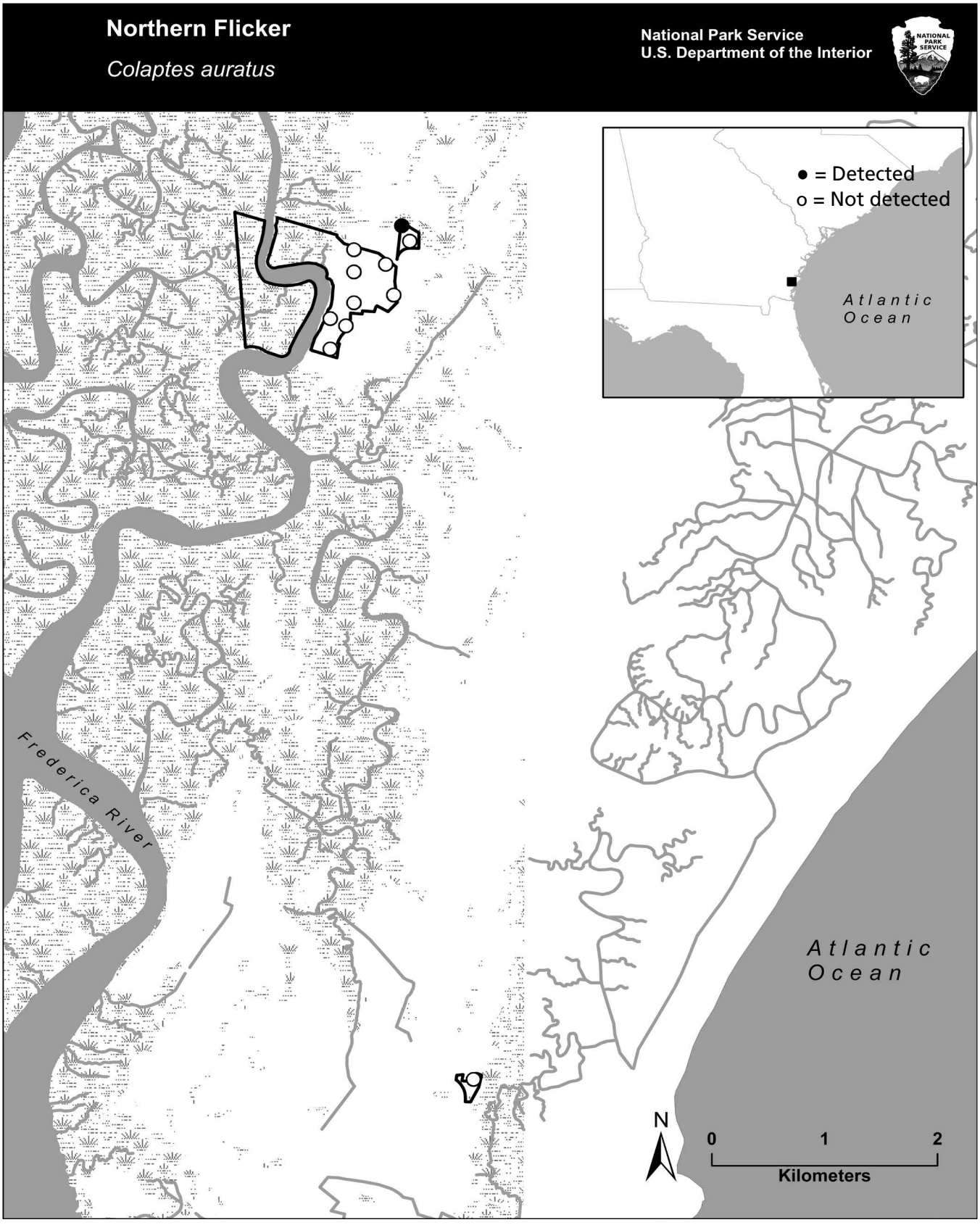


Figure C-31. Sampling locations where northern flicker (*Colaptes auratus*) was detected at Fort Frederica National Monument, 2014.

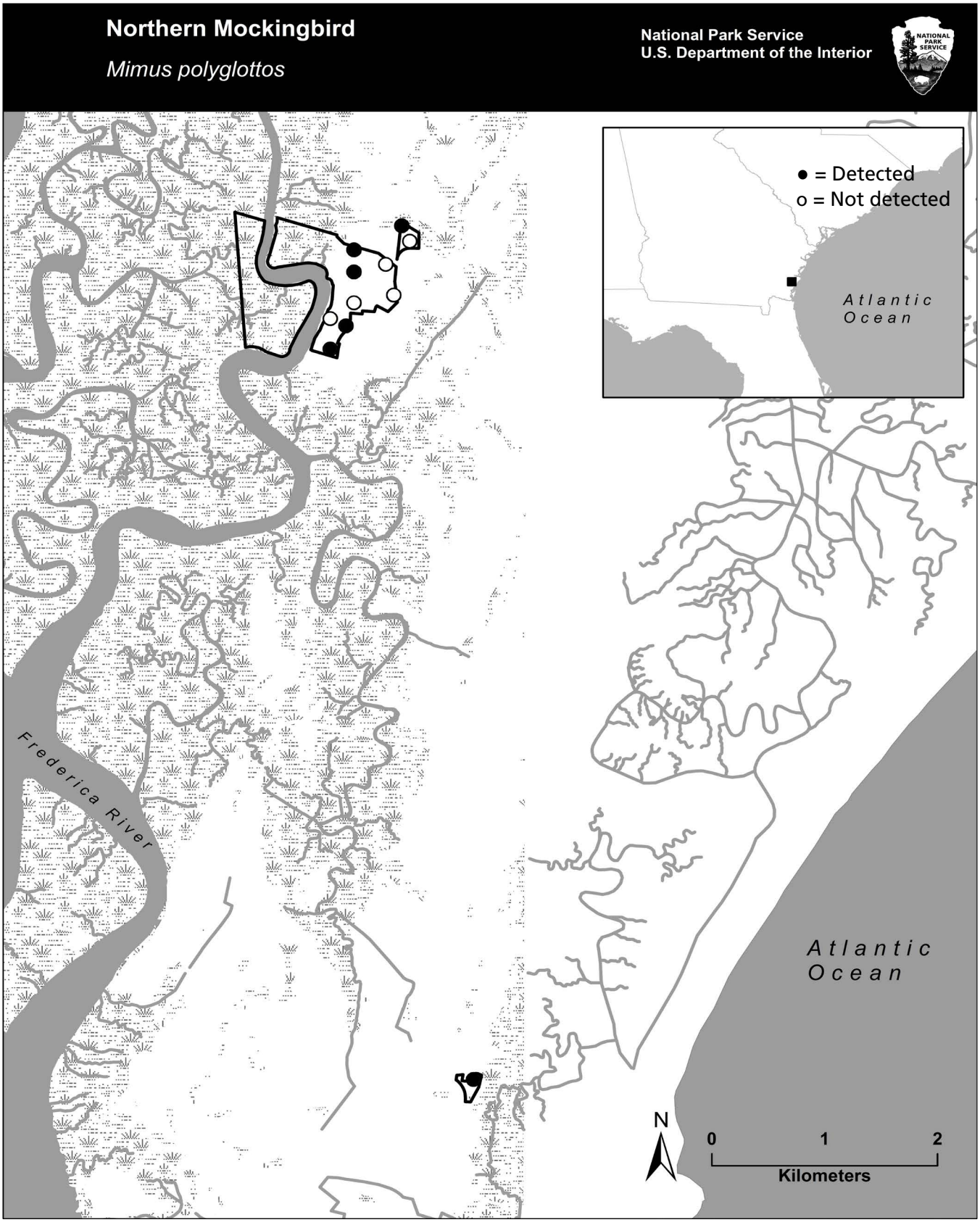


Figure C-32. Sampling locations where northern mockingbird (*Mimus polyglottos*) was detected at Fort Frederica National Monument, 2014.

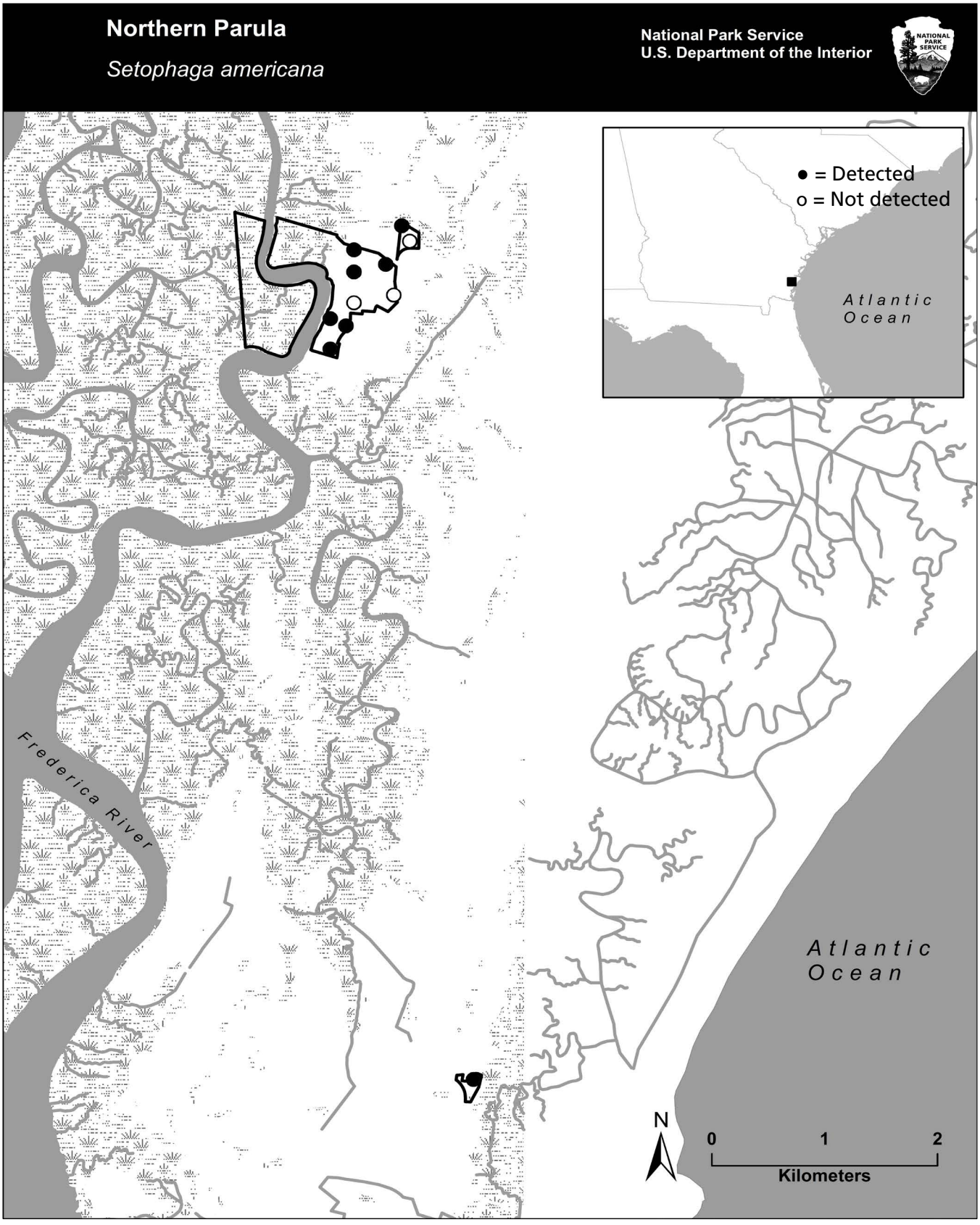


Figure C-33. Sampling locations where northern parula (*Setophaga americana*) was detected at Fort Frederica National Monument, 2014.

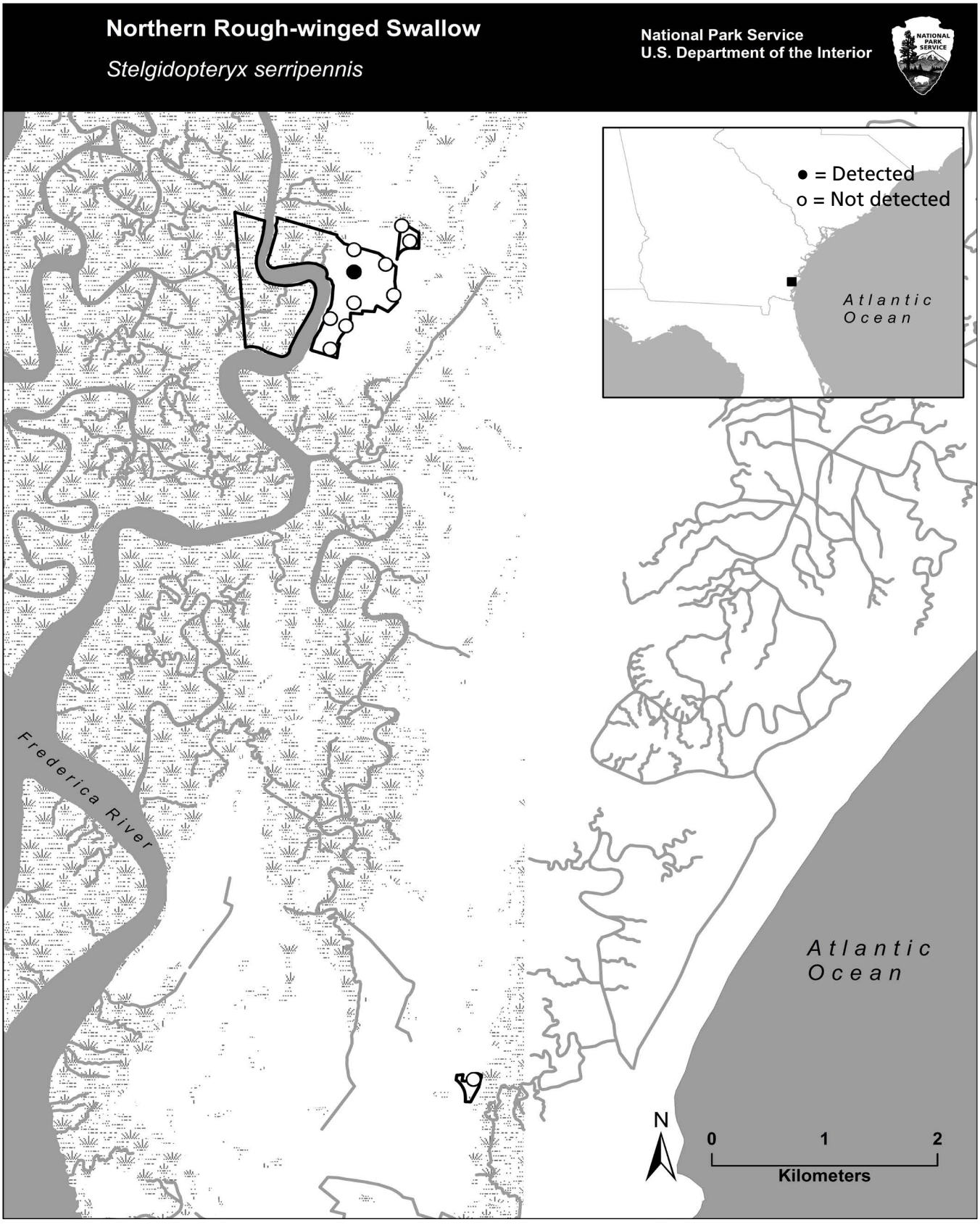


Figure C-34. Sampling locations where northern rough-winged swallow (*Stelgidopteryx serripennis*) was detected at Fort Frederica National Monument, 2014.

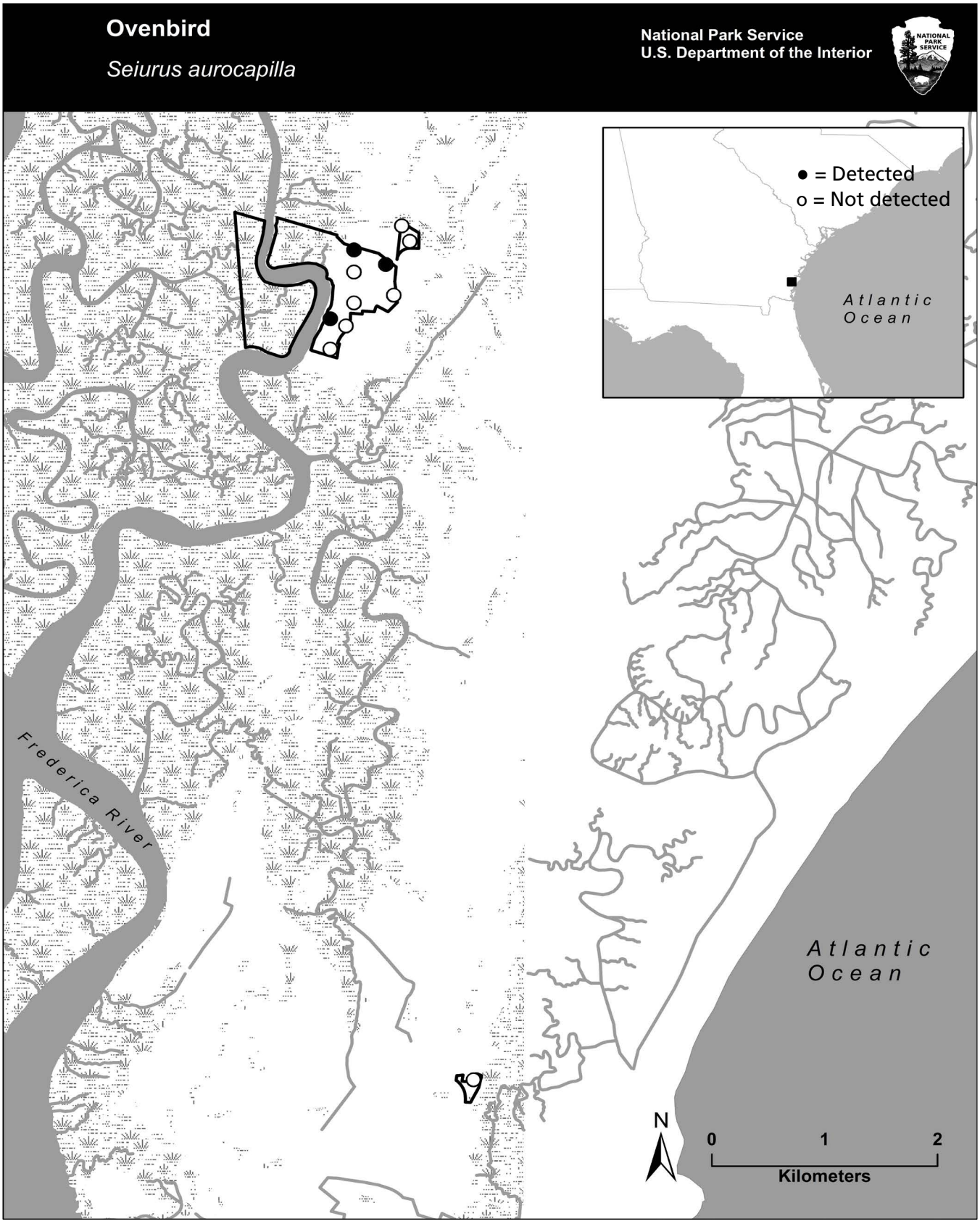


Figure C-35. Sampling locations where ovenbird (*Seiurus aurocapilla*) was detected at Fort Frederica National Monument, 2014.

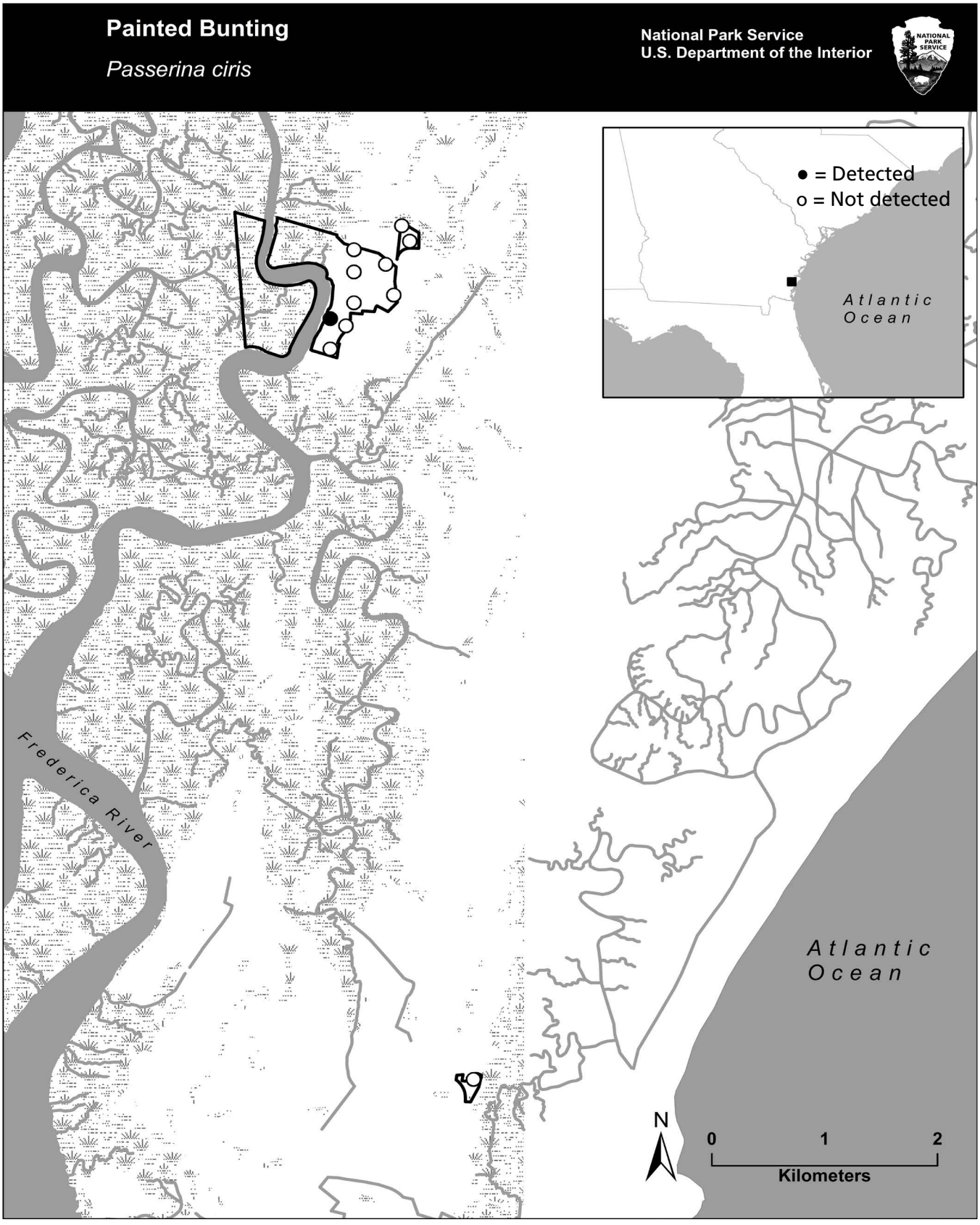


Figure C-36. Sampling locations where painted bunting (*Passerina ciris*) was detected at Fort Frederica National Monument, 2014.

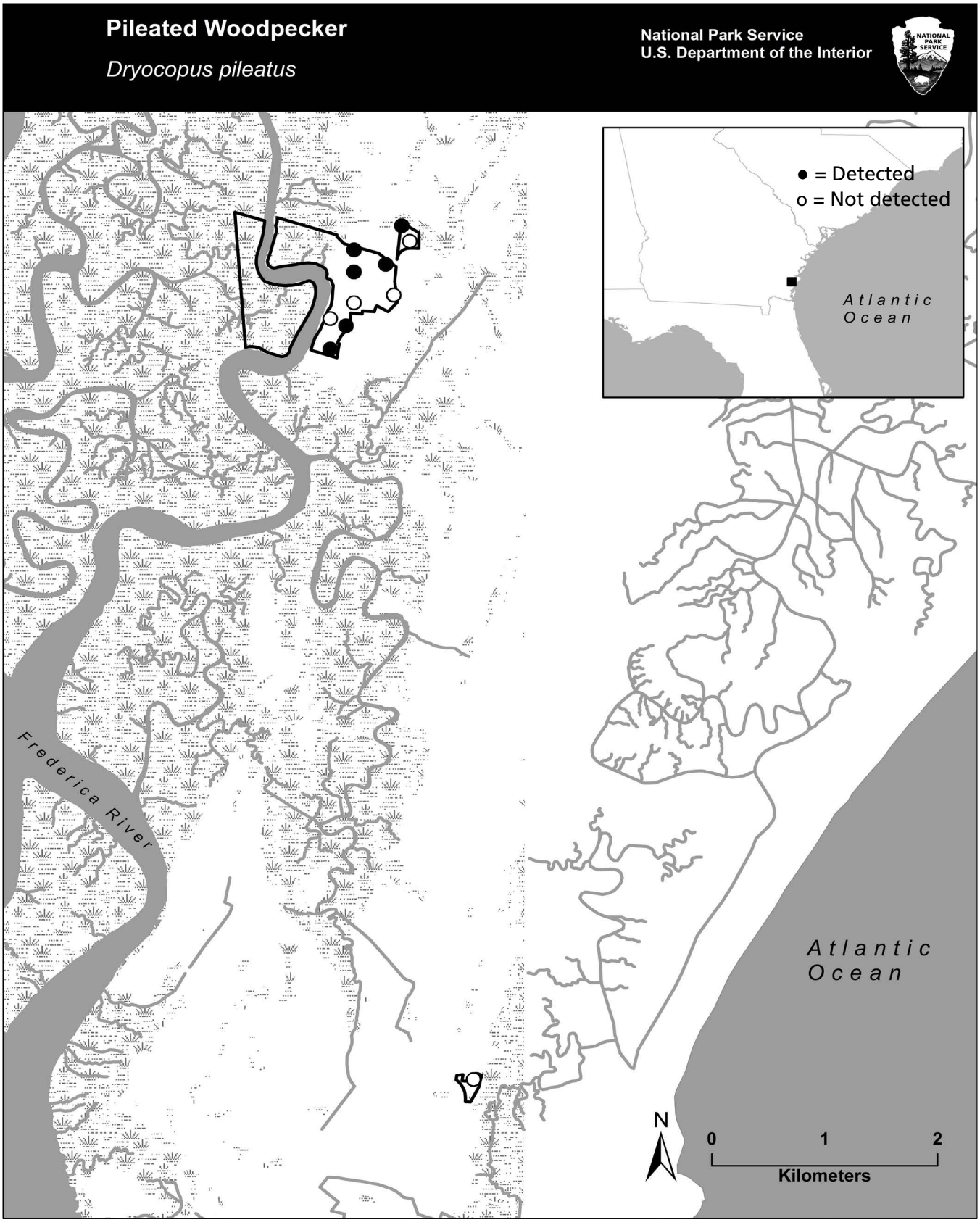


Figure C-37. Sampling locations where pileated woodpecker (*Dryocopus pileatus*) was detected at Fort Frederica National Monument, 2014.

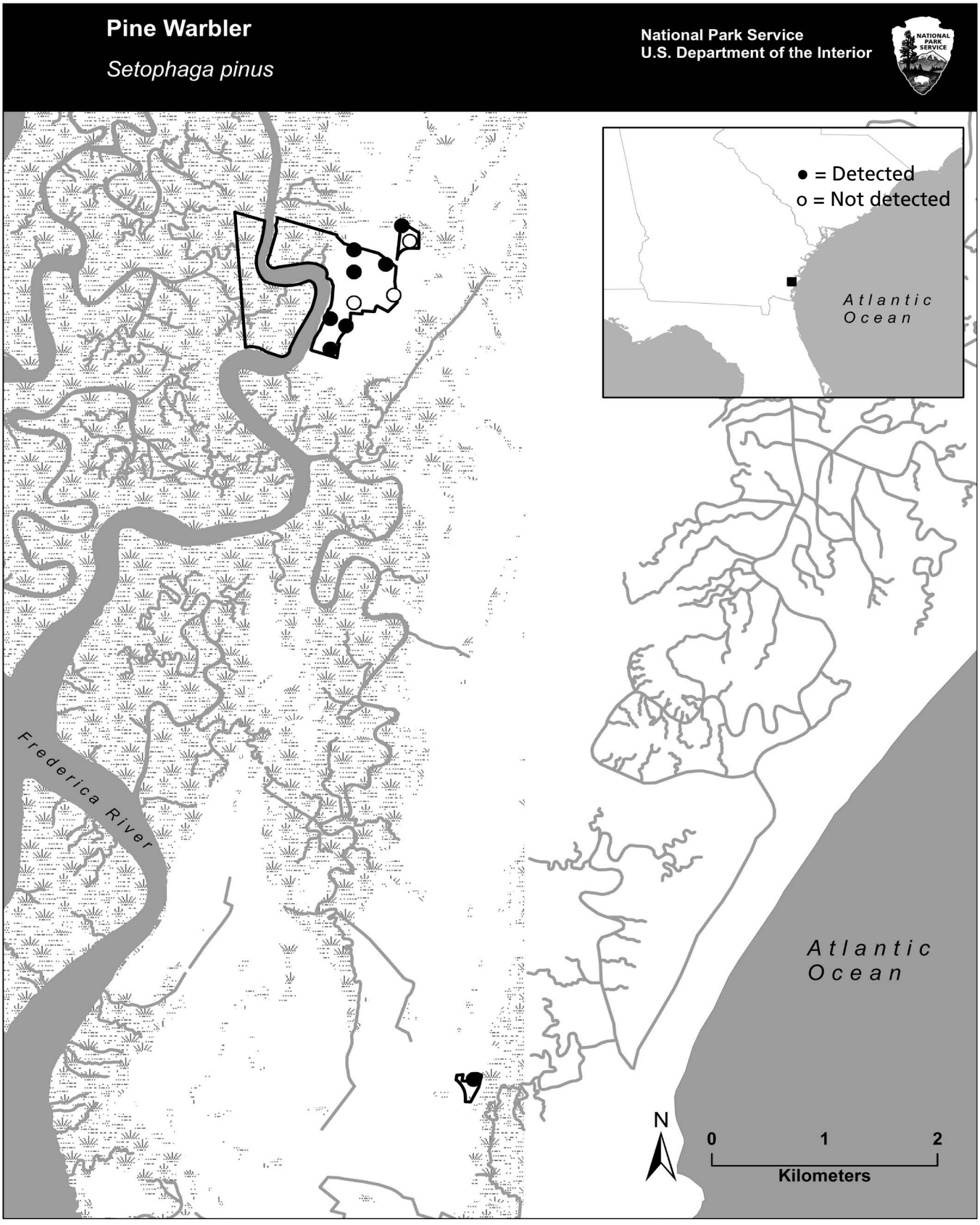


Figure C-38. Sampling locations where pine warbler (*Setophaga pinus*) was detected at Fort Frederica National Monument, 2014.

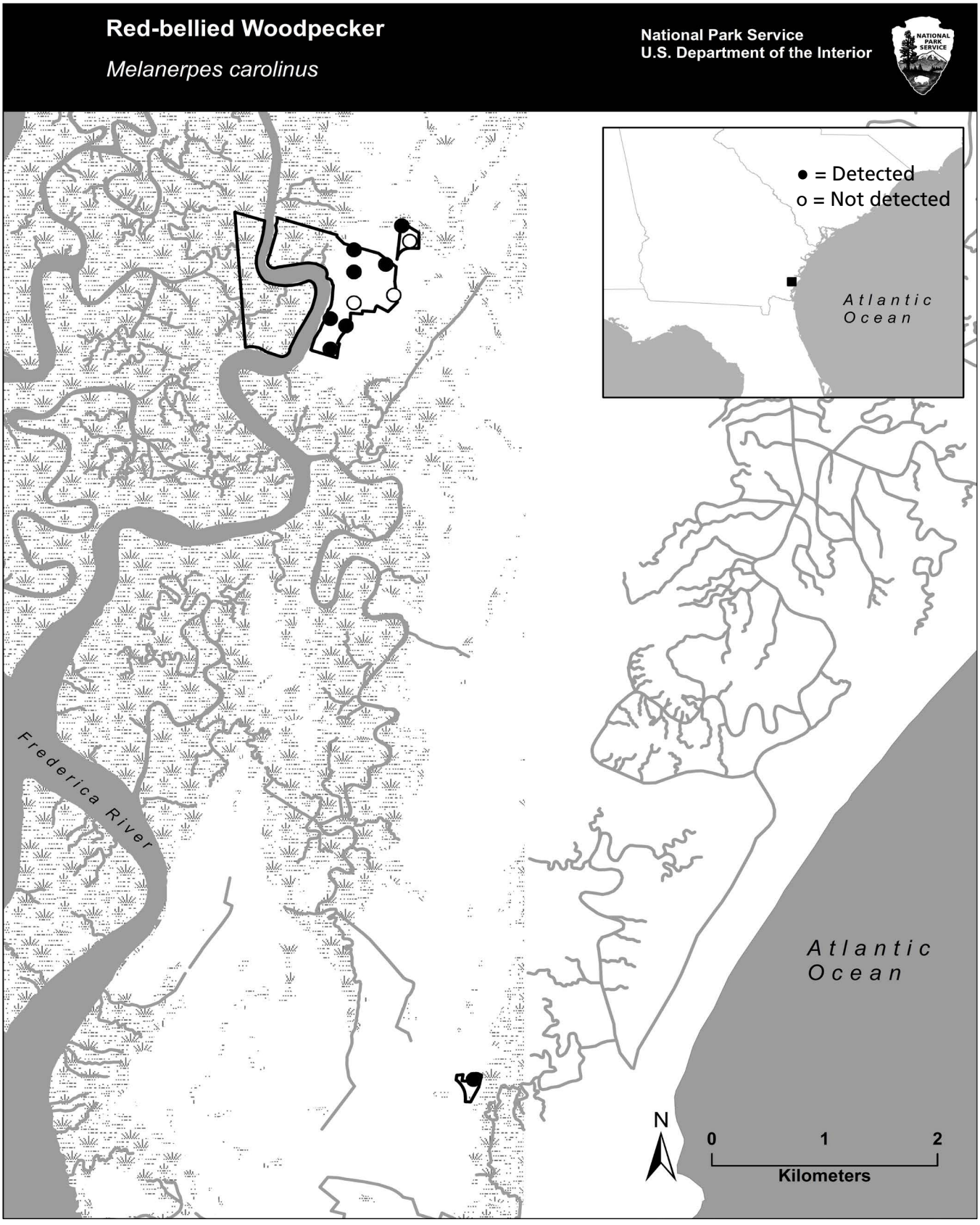


Figure C-39. Sampling locations where red-bellied woodpecker (*Melanerpes carolinus*) was detected at Fort Frederica National Monument, 2014.

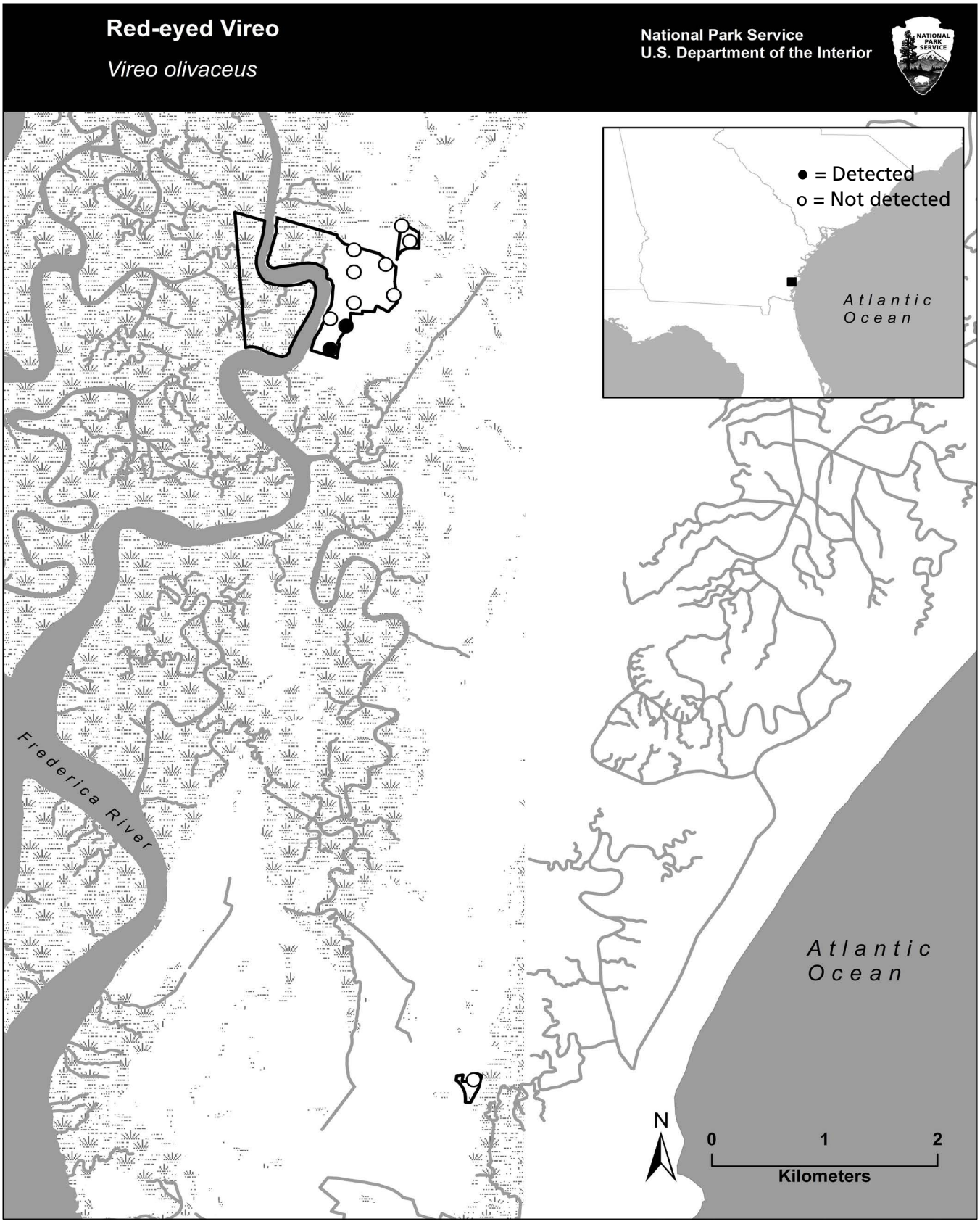


Figure C-40. Sampling locations where red-eyed vireo (*Vireo olivaceus*) was detected at Fort Frederica National Monument, 2014.

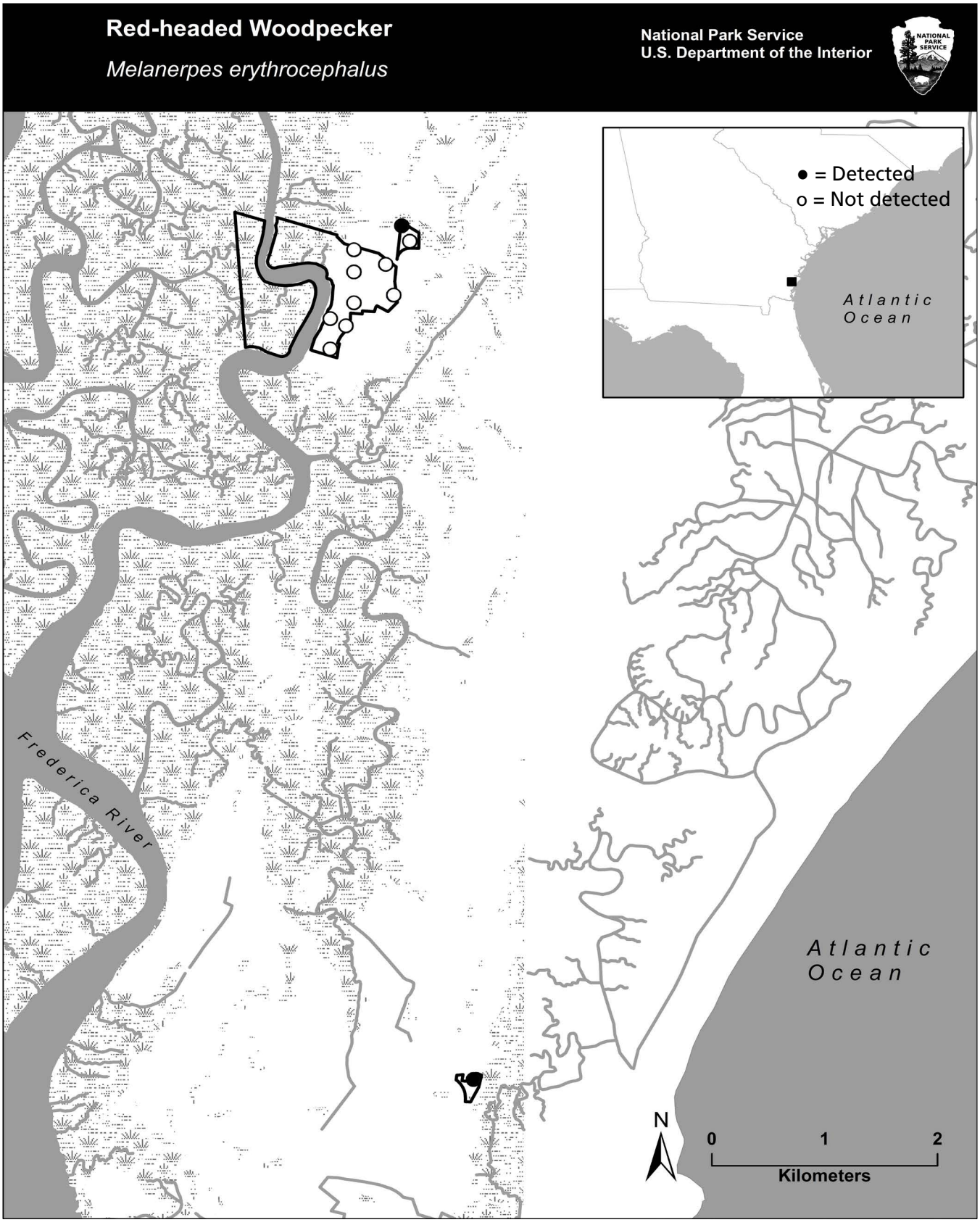


Figure C-41. Sampling locations where red-headed woodpecker (*Melanerpes erythrocephalus*) was detected at Fort Frederica National Monument, 2014.

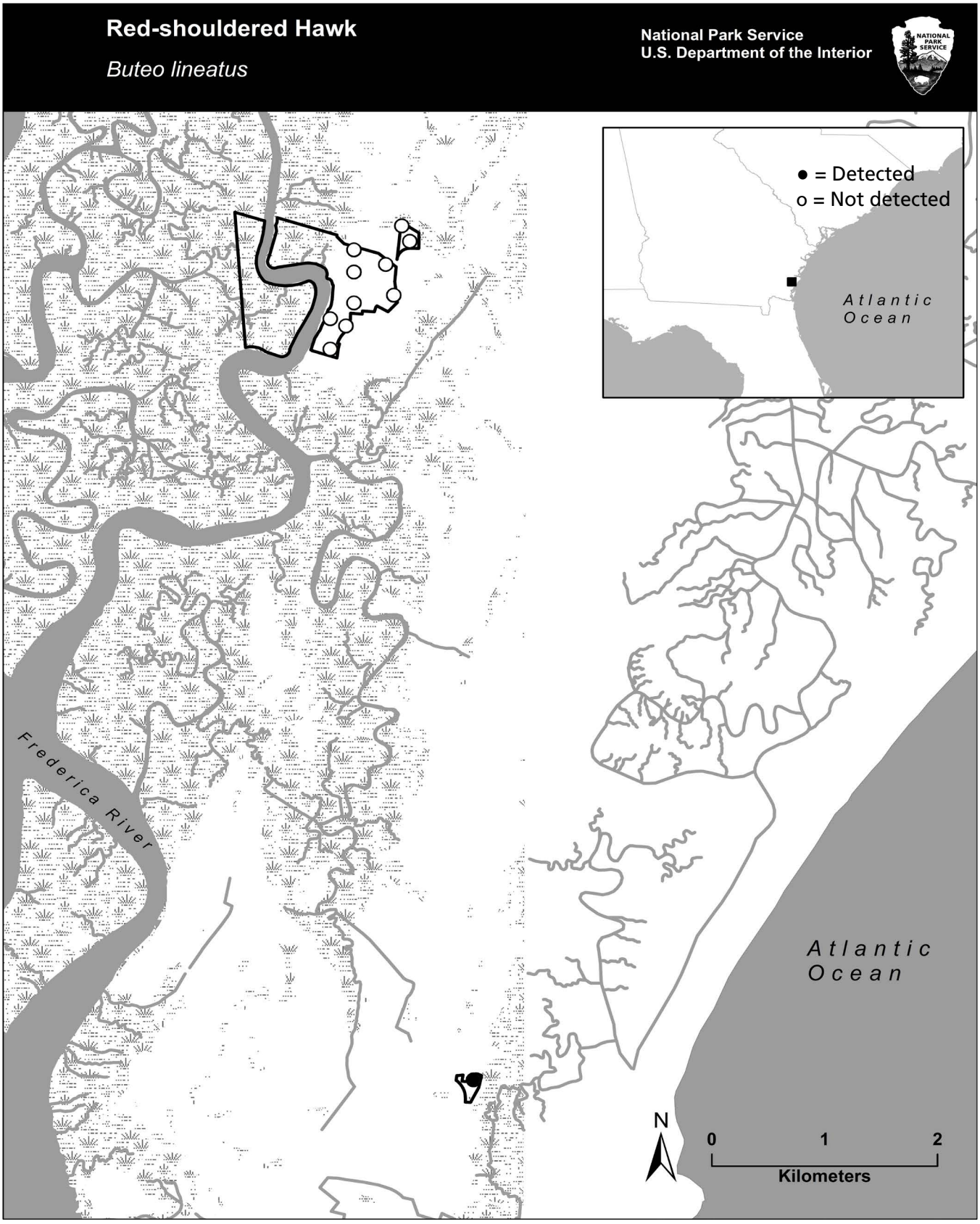


Figure C-42. Sampling locations where red-shouldered hawk (*Buteo lineatus*) was detected at Fort Frederica National Monument, 2014.

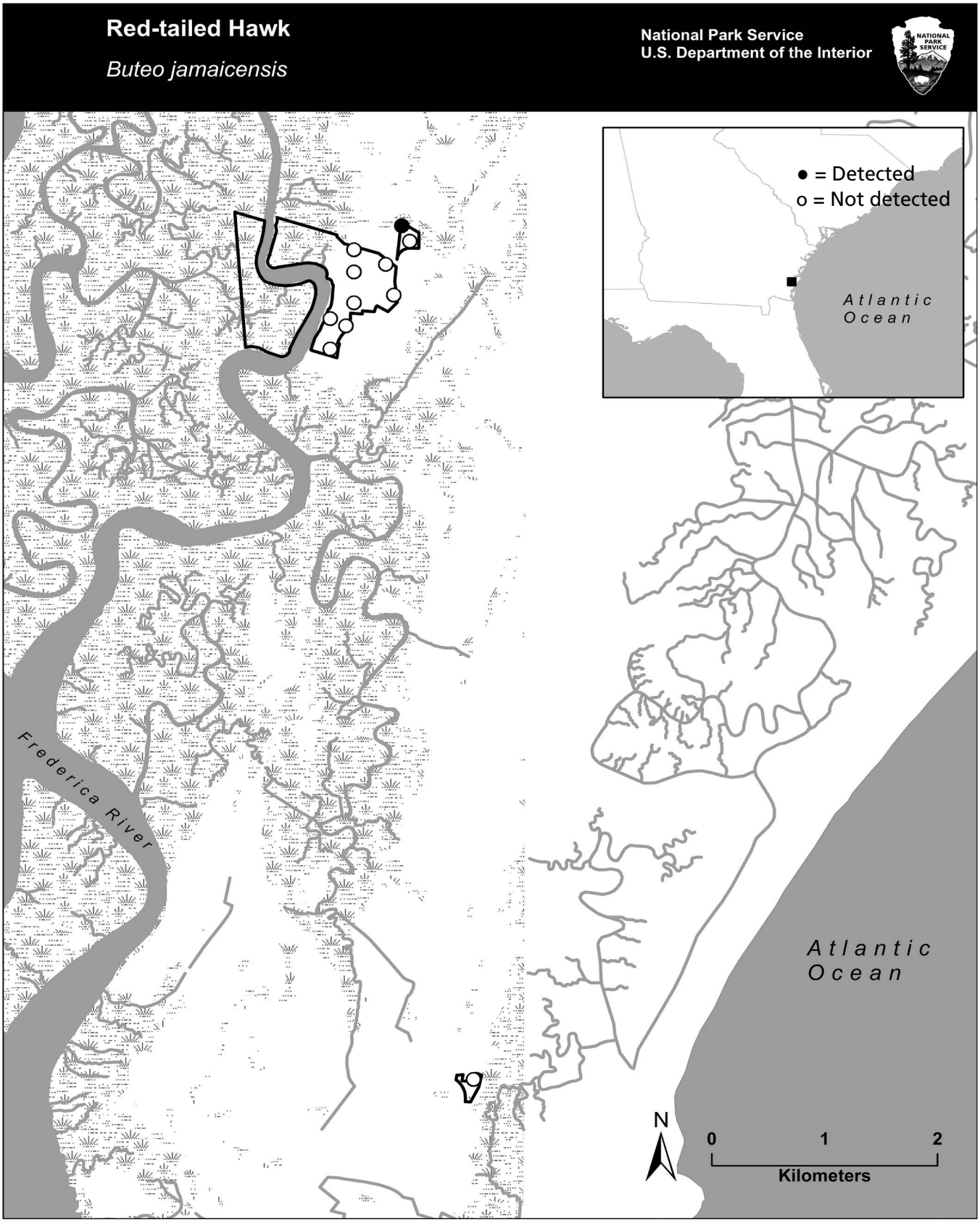


Figure C-43. Sampling locations where red-tailed hawk (*Buteo jamaicensis*) was detected at Fort Frederica National Monument, 2014.

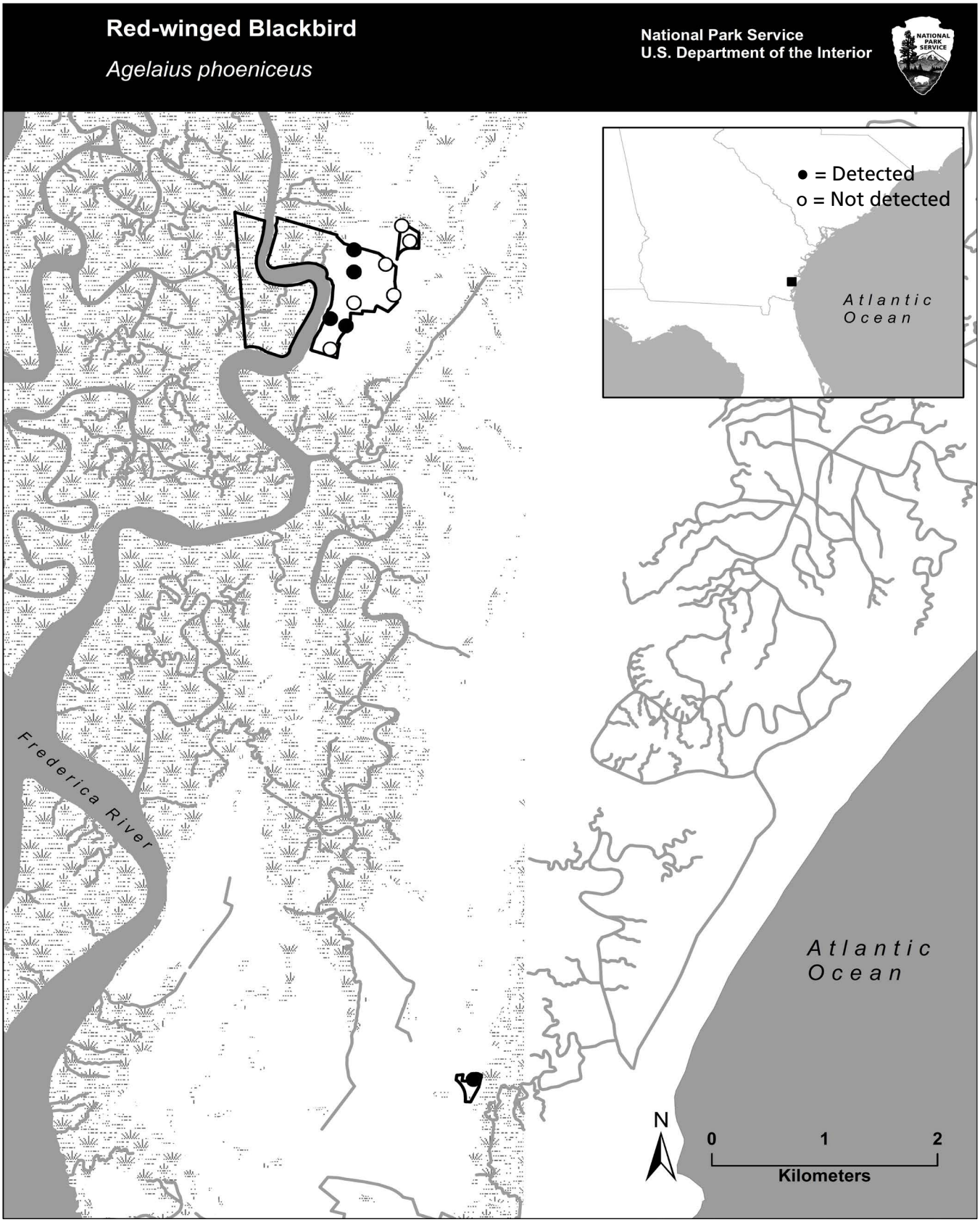


Figure C-44. Sampling locations where red-winged blackbird (*Agelaius phoeniceus*) was detected at Fort Frederica National Monument, 2014.

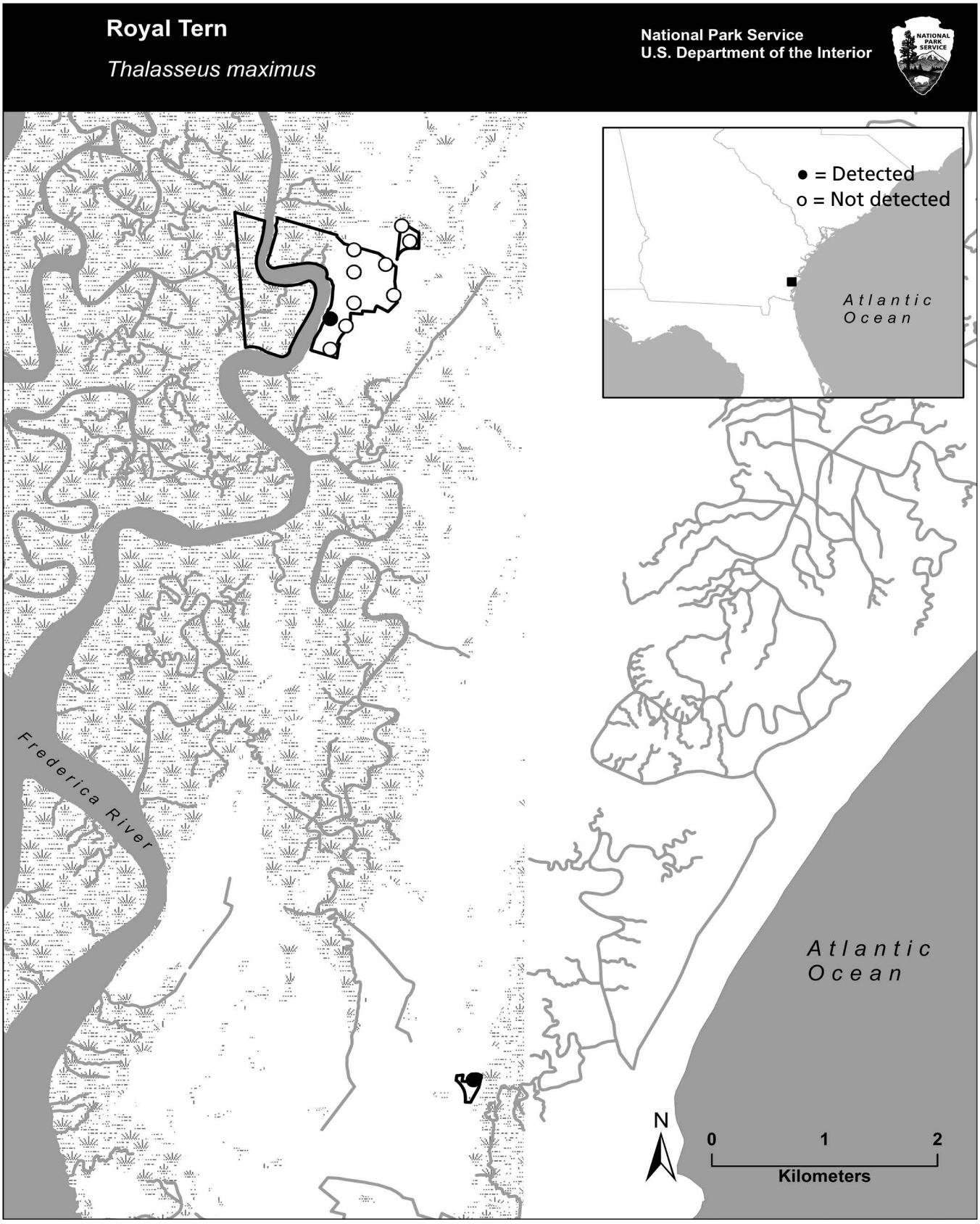


Figure C-45. Sampling locations where royal tern (*Thalasseus maximus*) was detected at Fort Frederica National Monument, 2014.

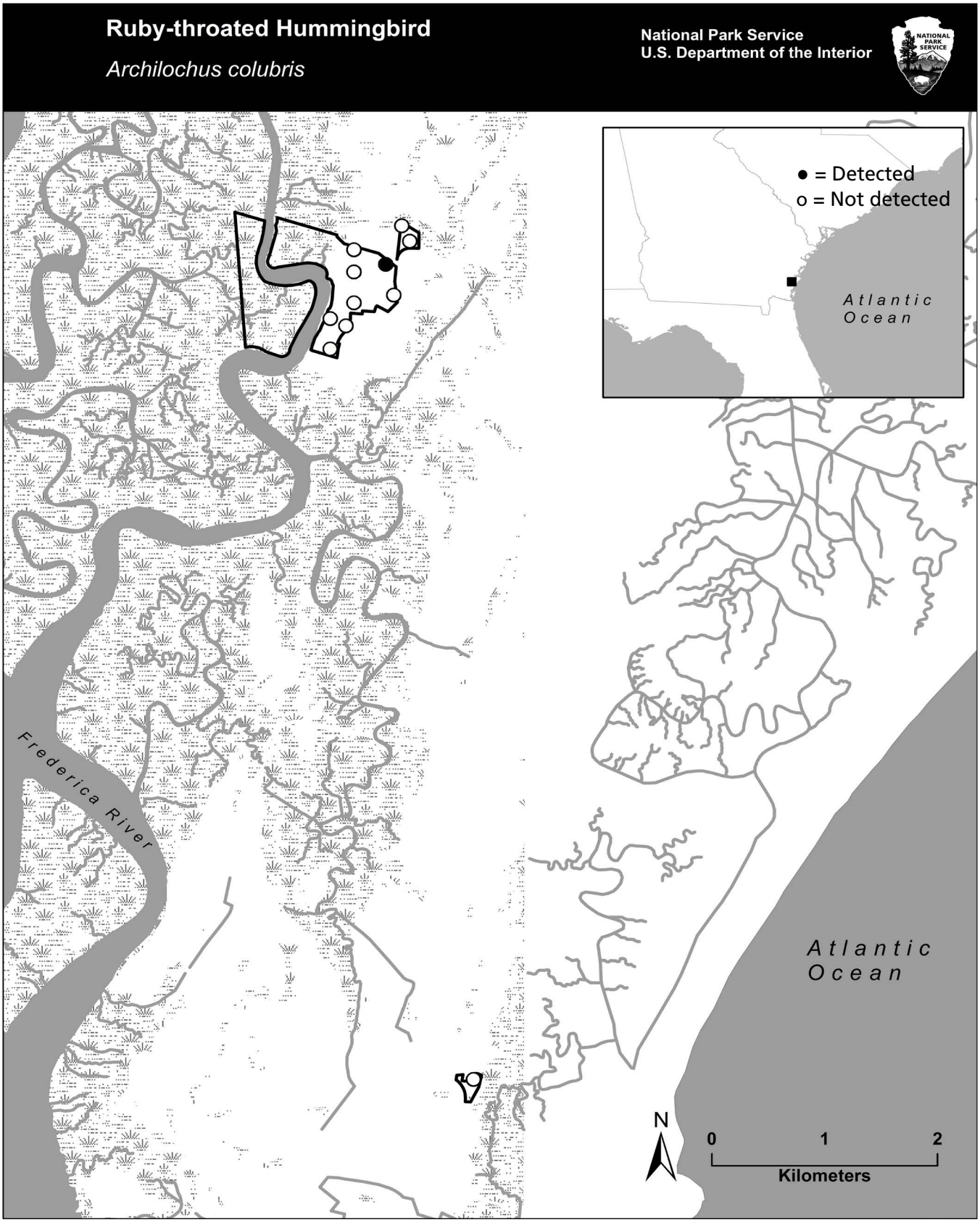


Figure C-46. Sampling locations where ruby-throated hummingbird (*Archilochus colubris*) was detected at Fort Frederica National Monument, 2014.

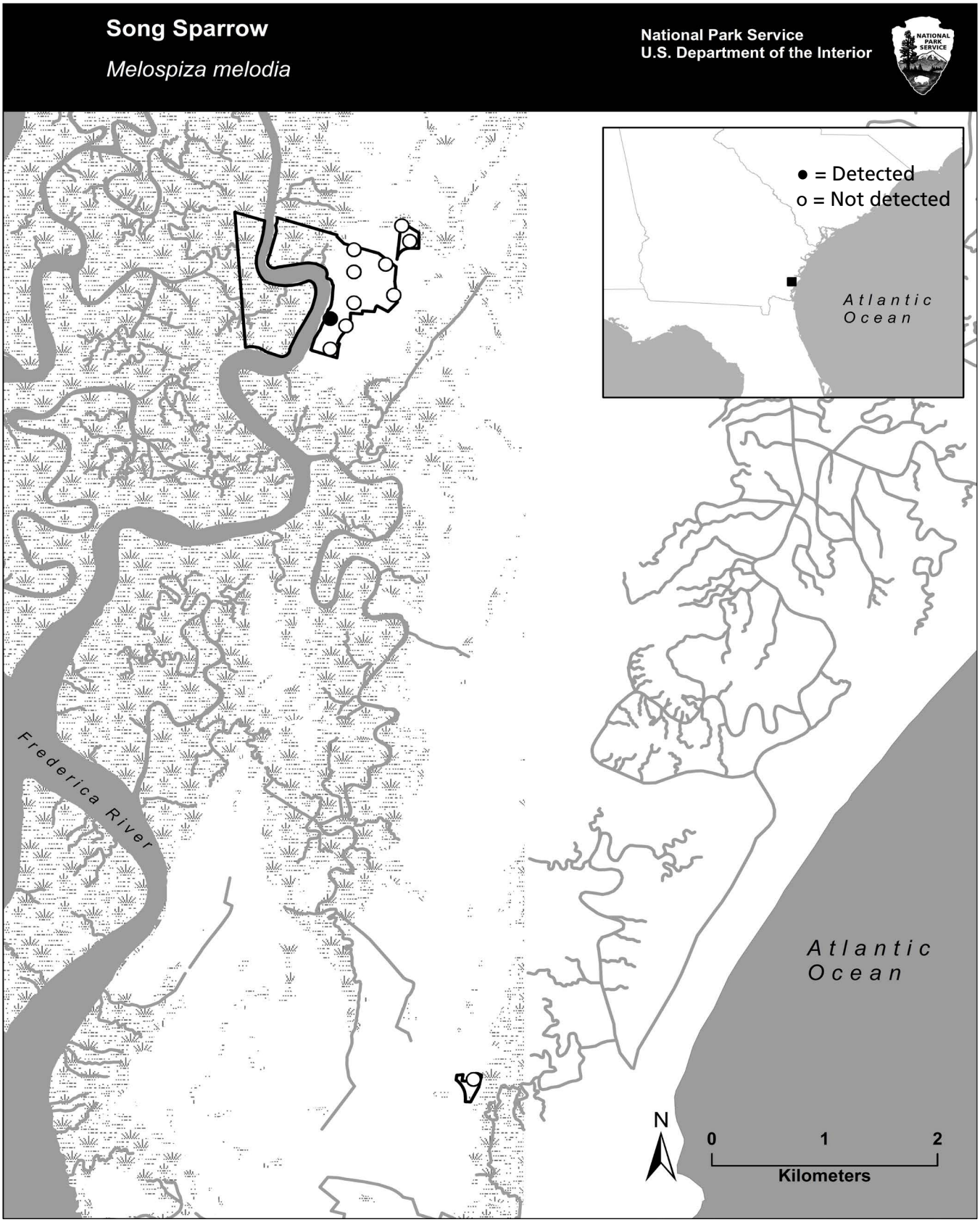


Figure C-47. Sampling locations where song sparrow (*Melospiza melodia*) was detected at Fort Frederica National Monument, 2014.

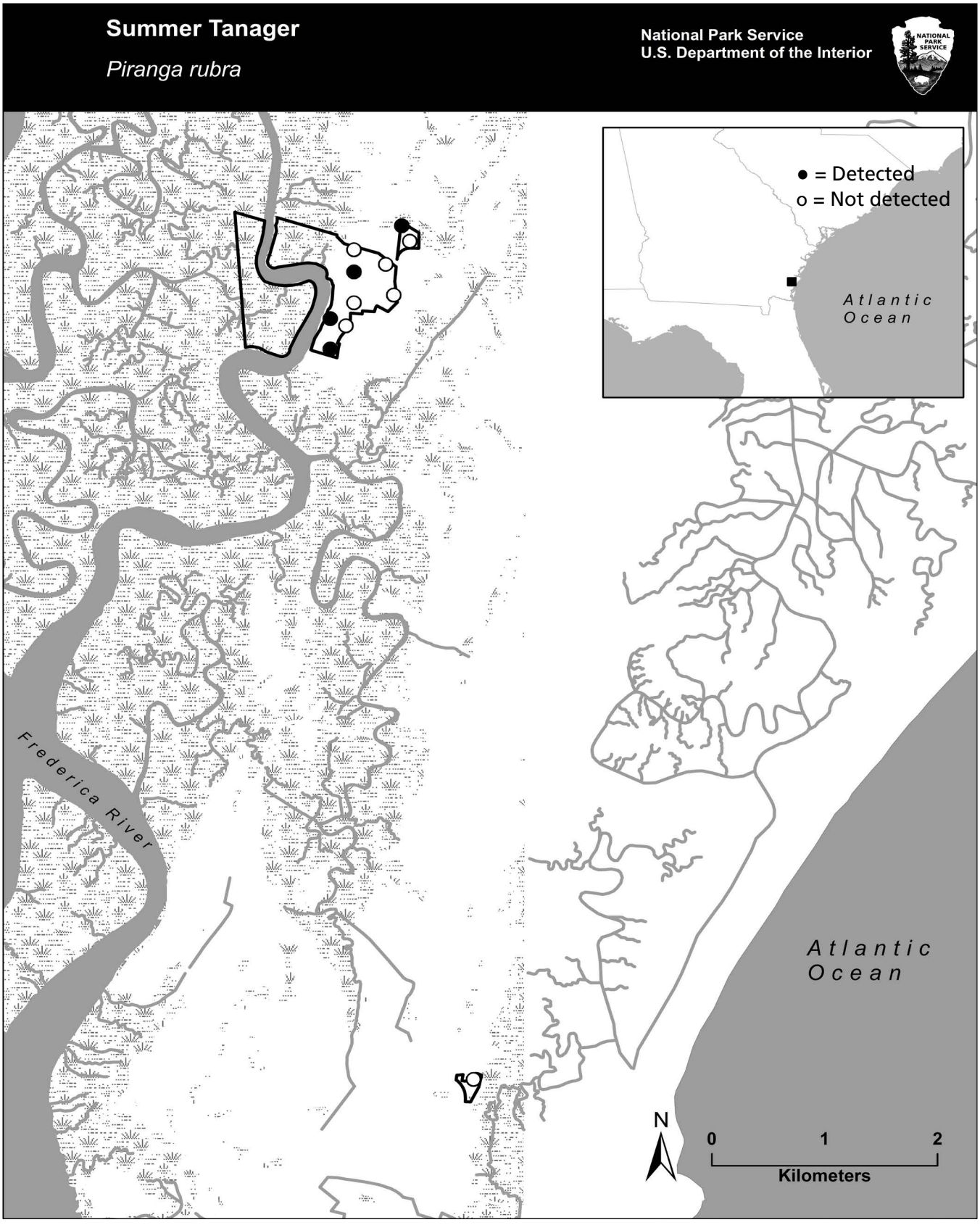


Figure C-48. Sampling locations where summer tanager (*Piranga rubra*) was detected at Fort Frederica National Monument, 2014.

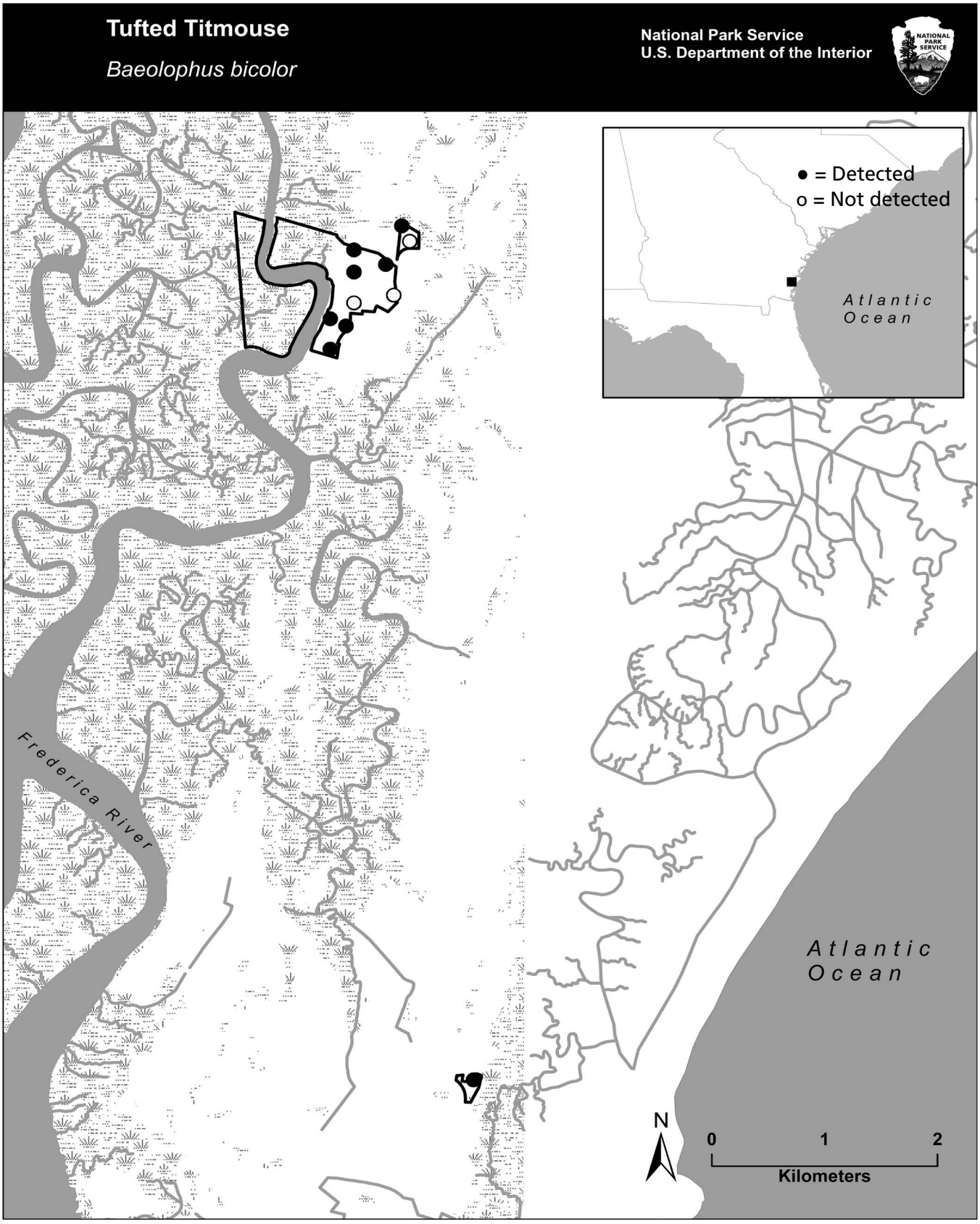


Figure C-49. Sampling locations where tufted titmouse (*Baeolophus bicolor*) was detected at Fort Frederica National Monument, 2014.

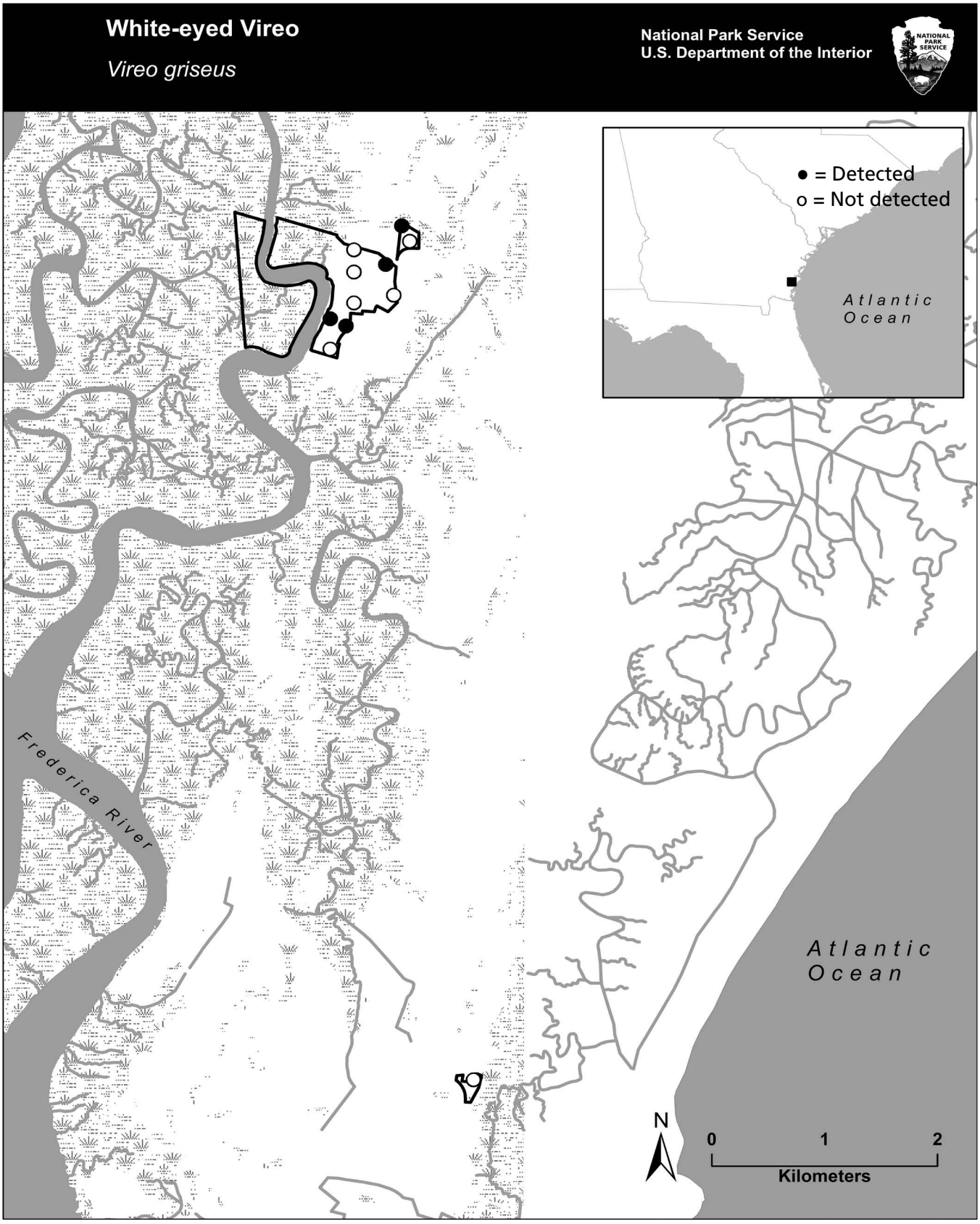


Figure C-50. Sampling locations where white-eyed vireo (*Vireo griseus*) was detected at Fort Frederica National Monument, 2014.

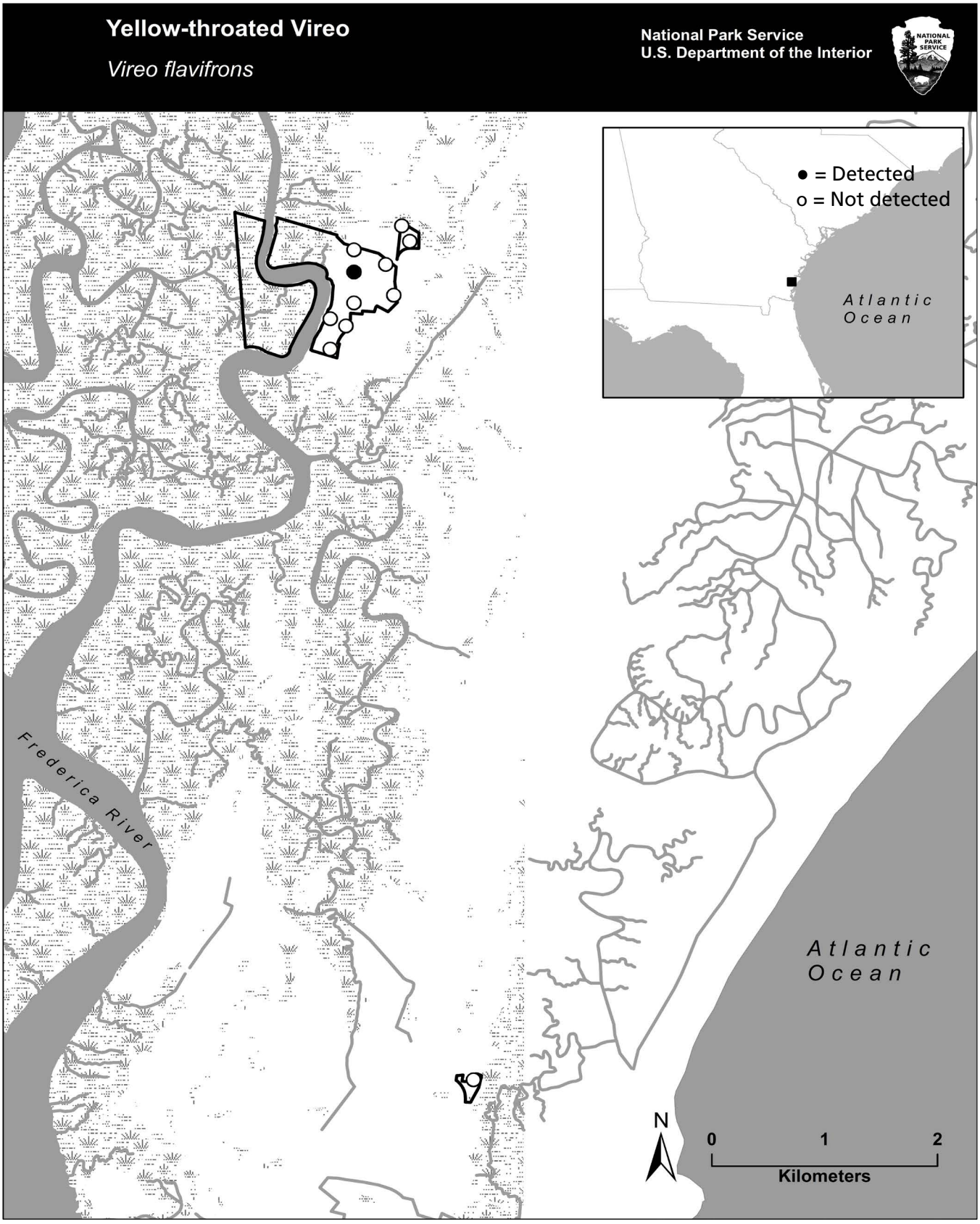


Figure C-51. Sampling locations where yellow-throated vireo (*Vireo flavifrons*) was detected at Fort Frederica National Monument, 2014.

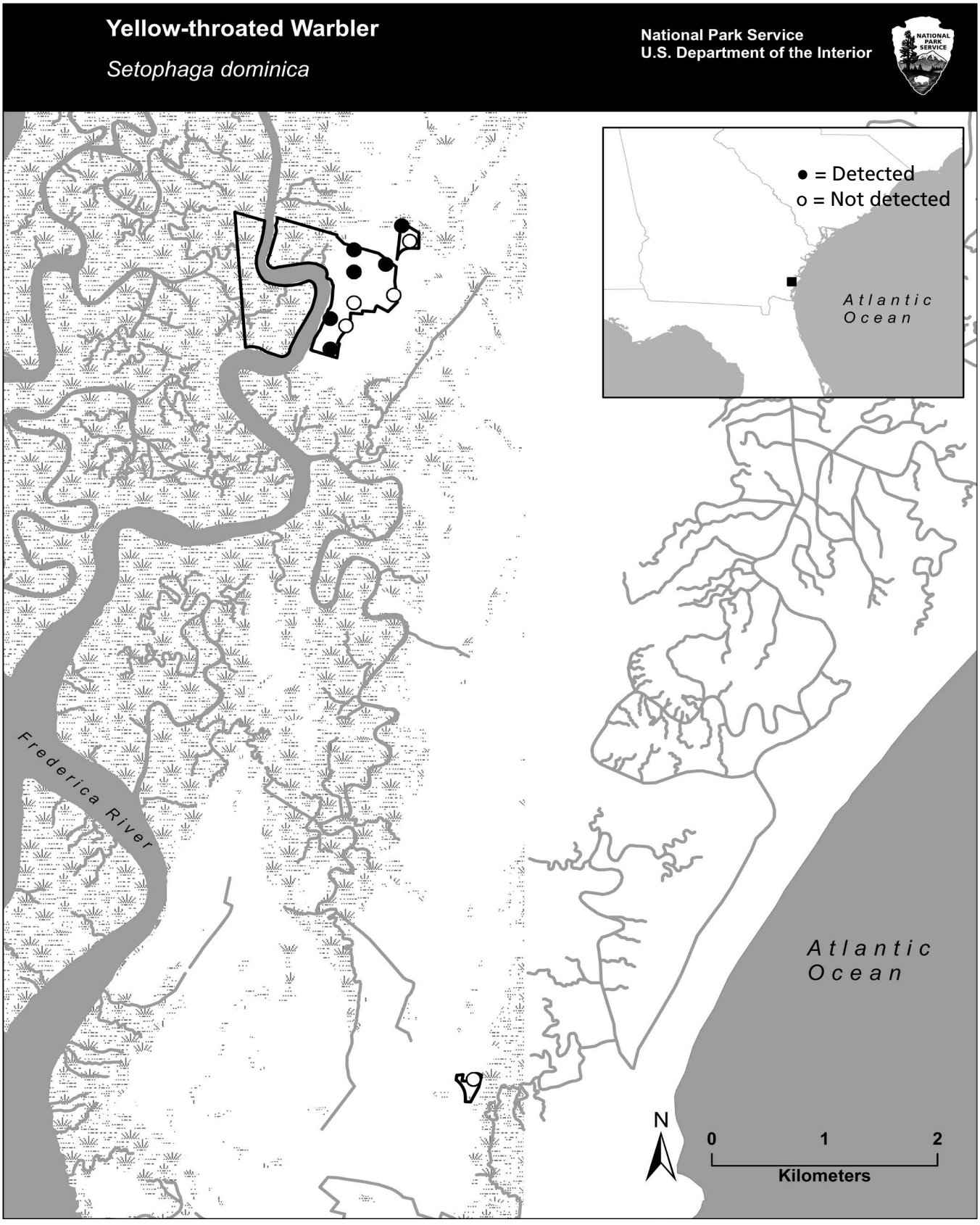


Figure C-52. Sampling locations where yellow-throated warbler (*Setophaga dominica*) was detected at Fort Frederica National Monument, 2014.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 369/134563, September 2016

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
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