2016

Black Rails in North Carolina

M. D. Wilson
The Center for Conservation Biology

B D. Watts
The Center for Conservation Biology, bdwatt@wm.edu

D Poulton
The Center for Conservation Biology

Black Rail Status Survey in North Carolina

This study was funded by the North Carolina Wildlife Resources Commission through a Federal Aid in Wildlife Restoration Grant from the United States Fish and Wildlife Service

Center for Conservation Biology
College of William and Mary
&
Virginia Commonwealth University

Black Rail Status Survey in North Carolina

Michael D. Wilson
Bryan D. Watts
Daniel Poulton

Center for Conservation Biology
College of William and Mary & Virginia Commonwealth University
Williamsburg, VA 23187-8975

Recommended Citation:

Wilson, M.D., B. D. Watts, and D. Poulton. Black Rail Status Survey in North Carolina. Center for Biology Technical Report Series, CCBTR-16-01. College of William and Mary and Virginia Commonwealth University. 21 pp.

Cover Photo of Black Rail by Greg Lavaty used with permission.

This publication was completed by funds from the North Carolina Wildlife Resources Commission through a Federal Aid in Wildlife Restoration Grant from the United States Fish and Wildlife Service.

The Center for Conservation Biology is an organization dedicated to discovering innovative solutions to environmental problems that are both scientifically sound and practical within today's social context. Our philosophy has been to use a general systems approach to locate critical information needs and to plot a deliberate course of action to reach what we believe are essential information endpoints.

Executive Summary

The Black Rail (*Laterallus jamaicensis*) is one of the most imperiled bird species along the Atlantic Coast. The species has undergone a range reduction, loss of breeding sites, and a loss of individuals from several known strongholds. Reasons for the decline are unclear but may include marsh loss and degradation, poor reproduction, changes in adult survival, and incompatible management practices.

North Carolina has long been known to be an important stronghold for Black Rail populations in the mid-Atlantic region. However, most of what has been known about population abundance and distribution has been pieced together from a scattering of anecdotal observations. The objective of this study was to conduct a broad, systematic survey of the Black Rail along the coast of North Carolina to provide information on the species' status and distribution.

We established a network of survey points within areas historically known to support Black Rails and other areas with appropriate habitat. The results of this effort were the detection of Black Rails at 15 of 153 locations surveyed in 2014 and 5 of 109 locations surveyed in 2015. The population of Black Rails in North Carolina appears to be broadly distributed along the coast with detections across many locations of the survey network. However, population numbers appear to be very low. Most detections involved single, calling individuals. Moreover, the number of birds detected at the state's largest known population at Cedar Island National Wildlife Refuge was much lower compared to historical observations. A high count of at least 80 calling Black Rails was conducted at Cedar Island NWR in May of 1973. Surveys through the late 1980s and 1990s documented about 20 birds. Our survey effort only yielded a maximum of 8 individuals.

All detections of Black Rails were in the high marsh zone. These habitat patches are characterized by the presence of salt meadow hay (*Spartina patens*) and saltgrass (*Distichlis spicata*), and are often interspersed with lower wet areas of black needlerush (*Juncus roemerianus*).

This project helped identify areas important for Black Rail conservation and management. The Cedar Island NWR and peninsula of Carteret County it inhabits remains the most important area for focal management based on the concentration of birds in several marshes. This survey effort also serves as an important benchmark to compare future survey and monitoring efforts.

Introduction

The Black Rail (*Laterallus jamaicensis*) is one of the most imperiled bird species along the Atlantic Coast. This species has undergone a range reduction, a loss of historical breeding sites, and a decline in numbers within recognized strongholds. Recent surveys have shown a dramatic (90%) loss of breeding sites in the Chesapeake Bay over the short span of 15 years (Wilson et al. 2015). It is very possible that the Black Rail will become extirpated in many portions of its range without timely and appropriate management intervention.

The Black Rail is taxonomically divided into five subspecies with two that are distributed in North America. The California Black Rail (*L. j. couturniculus*) is found throughout portions of California and Arizona (Eddleman et al. 1994), whereas the eastern Black Rail *(L. j. jamaicensis*) breeds in scattered locations in Kansas and the Midwest and along the Atlantic and Gulf coastal states (Eddleman et al. 1994). Eastern coastal populations breed from New York to Florida along the Atlantic Coast and in Florida and Texas along the Gulf Coast. Historically, the northern edge of this breeding range may have once extended as far as Massachusetts but contracted south to New York sometime in the early twentieth century (Eddleman et al. 1994). Eastern Black rails spend the winter along the Atlantic Coast from New Jersey to Florida, and along the Gulf Coast from Florida to Texas. Breeding populations of the eastern United States may also winter in Cuba and the West Indies.

The core of the Black Rail population in the Mid-Atlantic region is found within tidal salt marshes. Specifically, Black Rails occupy the upper elevational zone of salt marshes known as the high marsh (Davidson 1992, Eddleman et al. 1994). The high marsh is only inundated during lunar and extreme high tide events and is dominated by plants such as salt meadow hay (*Spartina patens*), saltgrass (*Distichlis spicata*), and often interspersed with shrubs such as marsh elder (*Iva frutescens*) or saltbush (*Baccharis hamilifolia*) (Cowardin 1977). In general, the character of the high marsh is a short-grass savannah. The high marsh forms as isolated hummocks on elevated portions within marshes or more frequently, along the upland-marsh edge. The ecotone between the upland and marsh sometimes includes stunted pine trees (*Pinus* spp.) and red cedar (*Juniperus virginiana*). Additional features of Black Rail habitats may include the presence of salt pannes (higher saline patches dominated by *Salicornia* sp.) and patches of needlerushes (*Juncus* spp.) in wetter zones. In lower salinity marshes and non–tidal marshes, Black Rails are found in vegetation communities that are a mix of rushes (*Juncus* spp.), sedges (*Carex* spp.), sawgrass (*Cladium* sp.), and cattails (*Typha* spp.).

Reasons for the dramatic decline of the Black Rail are not completely understood. Contributing factors may include habitat loss and degradation, predation, low reproductive rates, poor overwinter survival, and environmental contaminants. Habitat degradation may include direct take, transformation by ditching for mosquito control, and/or loss or transformation by rising sea levels. High marsh habitats that Black Rails rely upon are particularly vulnerable to loss and transformation as a result of sea-level rise. The rate of sea-level rise in the mid-Atlantic is two times greater than the global average within some locations and has been accelerating over recent decades (Zervas 2001). In many areas, large portions of

marshes are already being submerged where the sea is rising faster than marshes can accumulate sediments to maintain elevation. As the sea level rises, increased flooding of marshes will convert many areas of high marsh to low marsh even if the total area of marsh remains constant. Over a regional scale, changes in the composition in marshes resulting from sea-level rise may be enough to affect the entire system state and habitat availability for Black Rails. Recent evidence suggests that marshes where Black Rails have declined or disappeared in Virginia have undergone significant transformations by losing portions of high marsh to low marsh (Wilson et al. 2014A). In addition to direct habitat loss, Black Rails may be negatively influenced by higher than usual tidal heights that destroy nests and reduce annual productivity.

North Carolina has long been recognized as a stronghold for Black Rails within the immediate region. Most of what we know about the distribution and abundance of Black Rails in the state is based on scattered anecdotal reports or site specific surveys. These reports have documented a number of tidal marsh breeding locations and a well-known larger population at the Cedar Island National Wildlife Refuge (NWR). In the late 1800s and early 1900s Black Rails were documented in the western part of the state using agricultural fields but have not had consistent records since that time (Lee 1999). However, before this project a comprehensive status assessment for Black Rails in North Carolina had not been conducted, nor are there any existing monitoring programs in place to assess the health of populations. The purpose of this project was to gain a systematic view of the distribution of Black Rails in coastal North Carolina to help determine their status. Furthermore, we designed a broad survey so sampling locations could be used for monitoring purposes into the future.

Methods

Black Rails are logistically difficult to survey because their habitats are often in remote locations and they are most reliably detected at night. We used a combination of boat and road travel to access high marsh patches that appeared to have the potential to support Black Rails. Marshes were surveyed from the water or road edge; we did not attempt to traverse marshes by foot at night.

Survey sites were selected by reviewing historical locations where Black Rails were detected, examining National Wetlands Inventory maps, and inspecting aerial and satellite photos for habitat characters. Marshes with a known history of supporting Black Rails were automatically included. We also targeted significant high marsh patches (composed of a mixture of salt-meadow hay, saltgrass, and black needlerush) that appeared to be accessible by boat or vehicle travel. We also focused on oligohaline marshes of the northern back-barrier sounds of Currituck and Pamlico. Most of these marshes were dominated by sawgrass and needlerush. In most cases, we concentrated several survey points close to target marshes so many points could be surveyed in succession along boat or road routes. All survey points were ≥350 m from one another.

All survey points were visited 3 times between 21 April and 11 June in 2014, and between 7 May and 7 July in 2015. We chose a later starting date in 2015 because all

detections in 2014 were made after mid-May. We concentrated surveys in the southern coastal counties of North Carolina in 2014 and the northern coastal counties in 2015. The only exception were survey points on Cedar Island NWR that were surveyed in both years and visited 5 times each year to provide an indication of calling frequency, because we expected birds to be detected there each year.

Black Rail surveys were conducted at night (30 min after sunset until 1 hr before sunrise) using a pre-determined call-response technique. The call-response survey consisted of a 10-min sequence of alternating silent listening periods and species playback in the following order: 1) 2 min silence, 2) 4 min Black Rail calls, 3) 1 min silence, 4) 2 min Virginia Rail calls, 5) 1 min silence. Rail calls were broadcast with a Foxpro game caller at approximately 100-110 decibels. All marsh obligate bird species encountered during surveys were counted.

Results

Black Rails were detected at 15 of 153 (9%) points surveyed in 2014 (Figure 1), and 5 of 109 (5%) points surveyed in 2015 (Figure 2; Appendix I and II). In 2014, 9 of the 15 points where Black Rails were detected were clustered within Cedar Island NWR. Additional Black Rails detected in 2014 were at 2 locations on James Creek, 2 locations in Jones Bay, 1 location on the South River, and 1 location on Willis Creek near Stacy, NC. Twenty-eight Black Rails were detected among all survey visits to these points. We conservatively estimate that there were 22 individuals at these locations based on maximum counts from the three survey visits.

In 2015, Black Rails were detected at 3 locations on the North River, 1 location on the Currituck Sound near Coinjock (specifically, Wolf House Point), and 1 location on the Swanquarter NWR. Due to the fact that detections were made in different survey rounds, it is possible that 2 of the 3 positive locations on the North River were the same bird detected at two points. All new survey point detections for Black Rails in 2015 were of a single bird and each was only detected from one of three visits to any point. In addition, the survey of Cedar Island NWR in 2015 detected Black Rails at 3 of the 15 survey points along Highway 12 that bisects the refuge marsh lands. These 3 positive detections overlapped with locations where Black Rails were detected in 2014. However, only a maximum of 3 birds on a single night were detected in 2015 compared to a maximum of 8 birds for one night in 2014.

Figure 1. Locations of 153 Black Rail Survey points and 15 positive detections in 2014.

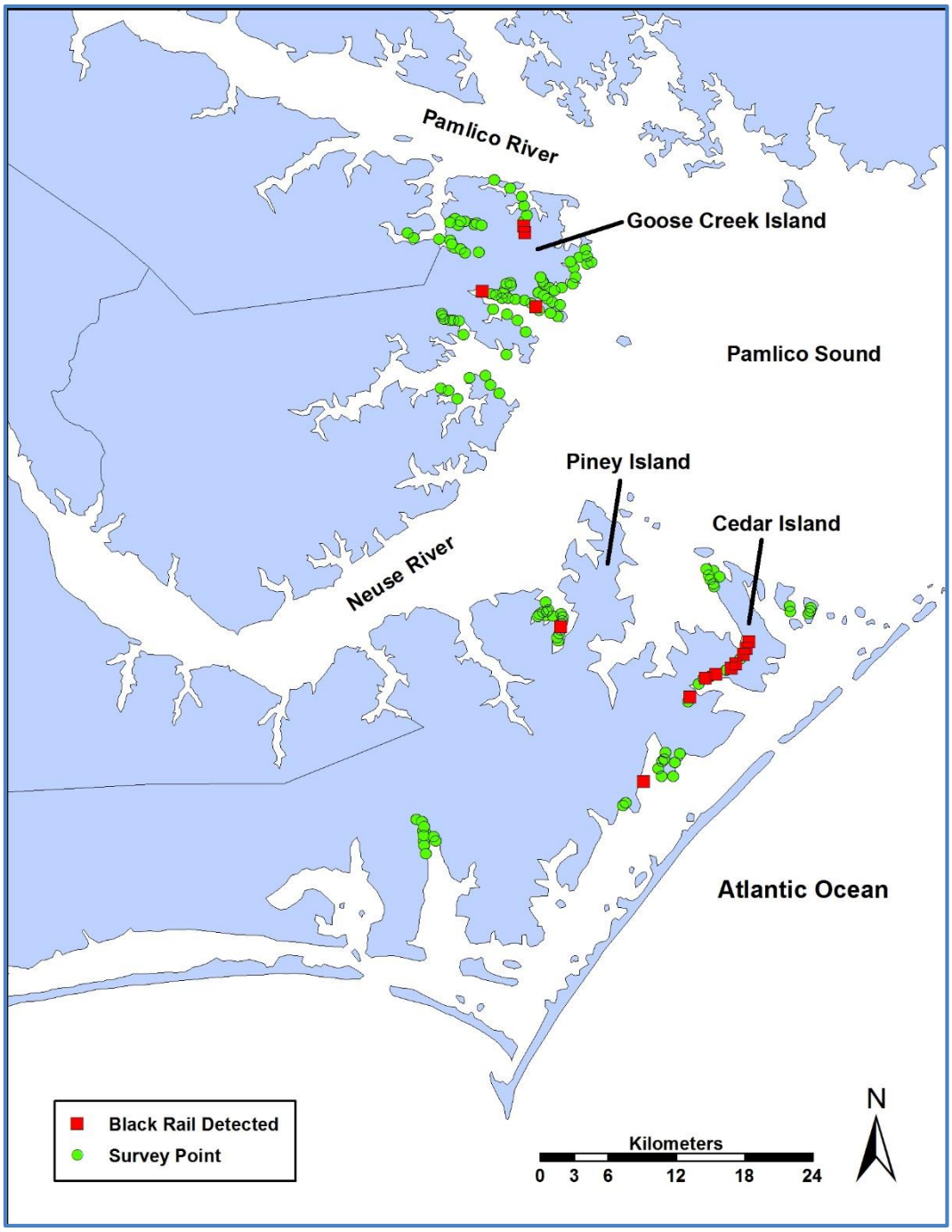
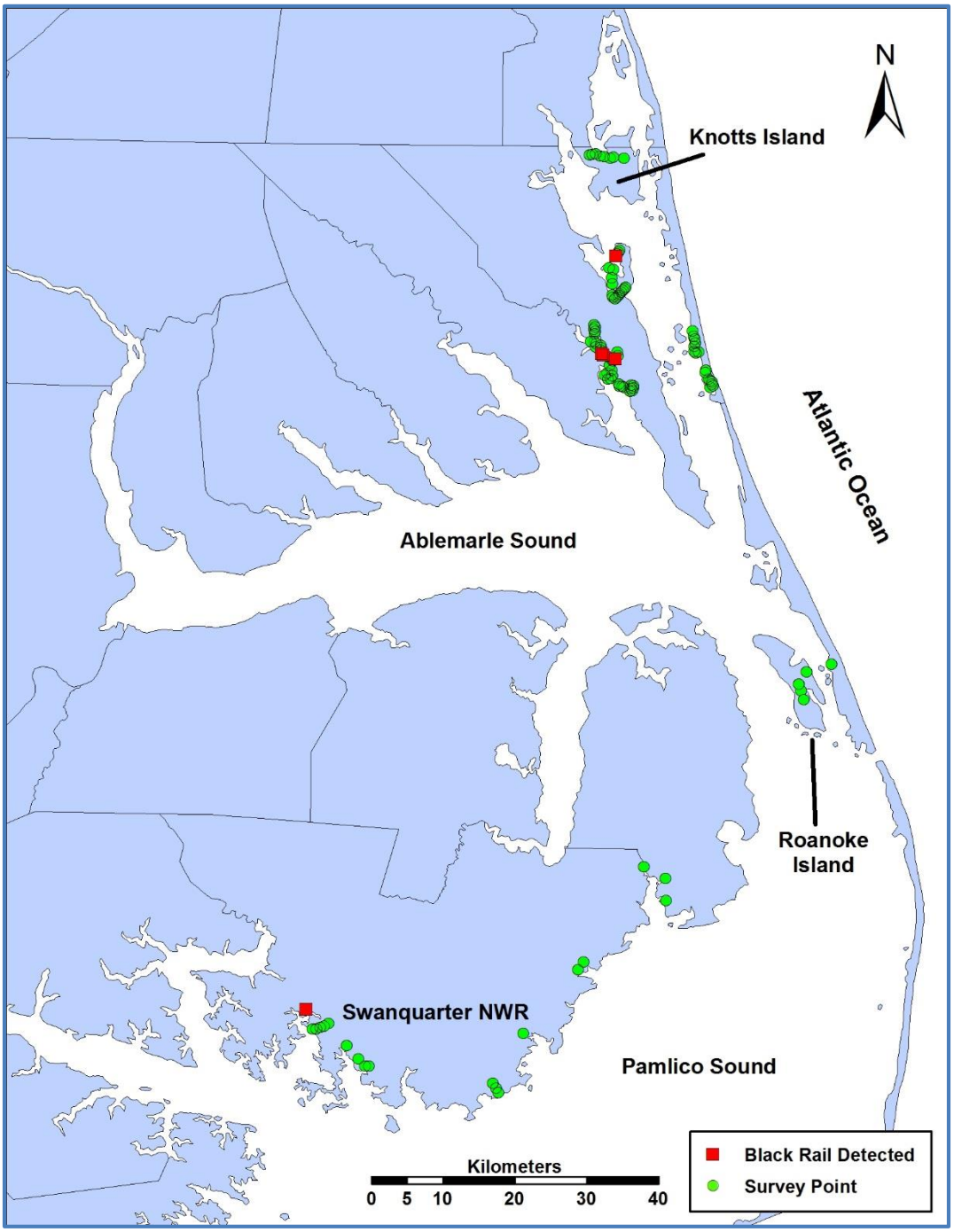


Figure 2. Location of 109 Black Rail survey points and 5 positive detections in 2015.



Discussion

The population of Black Rails in North Carolina appears to be broadly distributed along the coast with detections across several locations of the survey network. However, population numbers appear to be low. Most detections involved single individuals. Moreover, the number of birds detected at the state's largest known population at Cedar Island NWR was lower than historical observations. Anecdotal observations from single-night visits to Cedar Island NWR in the 1980s and 1990s by J. Fussell included counts of Black Rails in the mid-20s (J. Fussell, personal comm.). Records from a roadside survey of Cedar Island NWR in 1974 by J. Fussell and D. McCrimmon included 74 calling Black Rails (Teulings 1974). The maximum single-night survey result for 2014 and 2015 over 8 visits to Cedar Island NWR yielded only 8 individuals.

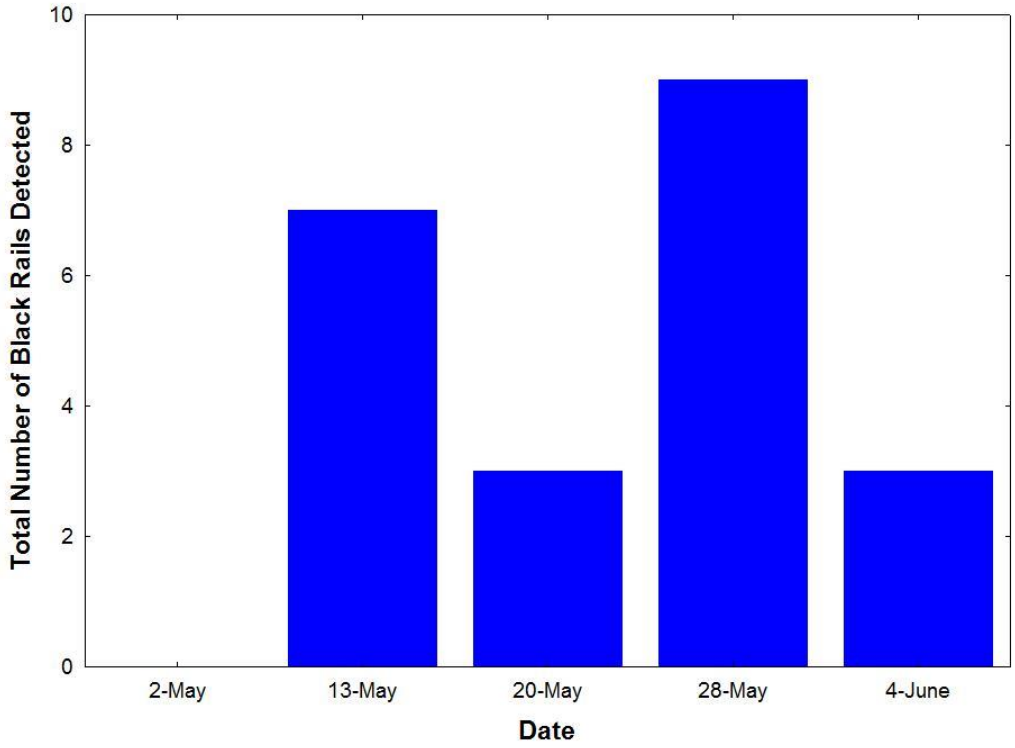
The geographical distribution of Black Rails from this survey effort matched several historical occurrences for the species. For instance, there are several reports of Black Rails in the Hobucken Marshes and the Jones Bay area (LeGrand 1987, LeGrand 1988) with only a few birds detected per visit. We also only detected single birds at two locations within this area. We detected one Black Rail at Swanquarter NWR in the same marsh where another survey effort in 2002 detected a Black Rail (Paxton and Watts 2002). Similarly, personal communication from J. Fussell indicated that there was a small number of Black Rails detected a few years earlier in the same portion of the North River where we encountered Black Rails in this survey.

We did not detect Black Rails in several areas where we expected them based on past occurrences. We were suprissed to find no birds along the North River marshes (near Beaufort) where several records from 2002 included 7 birds (B. Carlson, unpublished data) and 6 birds in 1972 (Teulings 1975). We placed 11 survey points in the North River marshes, all north of I-70, to overlap locations of older records, but we detected no Black Rails. Likewise, we did not detect birds on Roanoke Island nor Pine Island on the Currituck Sound despite past records of Black Rails during the breeding season. There were a few areas on the Outer Banks with historical records that were not surveyed. There have been regular detections at several locations on the Outer Banks including Bodie Light House and Ocracoke Island that were not surveyed in 2015. These areas should be included in future surveys.

Black Rails are notoriously difficult to survey because of their inconsistent calling and secretive nature. These behaviors make it difficult to determine if Black Rails are actually absent or just not calling during a survey visit. We used 3 survey visits to each point to increase the detection probability of birds at each location and 5 visits at Cedar Island NWR in 2014 to help assess detection rates. Black Rails were detected during 4 of 5 visits to Cedar Island with the only missed detection being early in the survey period (Figure 3). Over the two years of surveys, Black Rails were rarely detected using their typical *ki-ki-kerr* call, but rather were detected more often responding to the broadcast playback with growling and "pow" calls. In fact, the *ki-ki-kerr* call was only observed at Cedar Island NWR and nowhere else. The *ki-ki-kerr*

call is often repeated many times during a calling bout and can go on for several minutes making them easily detected even without species playback. Conversely, growls and the "pow" call were only heard in response to playback and were short in duration. The reason for the lack of regular calling at locations away from Cedar Island NWR is not known. However, *ki-ki-kerr* calls were being detected at Cedar Island NWR at the same time birds were only being detected using growls elsewhere, so time of season does not appear to be a primary influence. It is possible that the larger population of Black Rails at Cedar Island NWR promotes more calling between birds compared to what appeared to be single birds that did not vocalize as readily elsewhere.

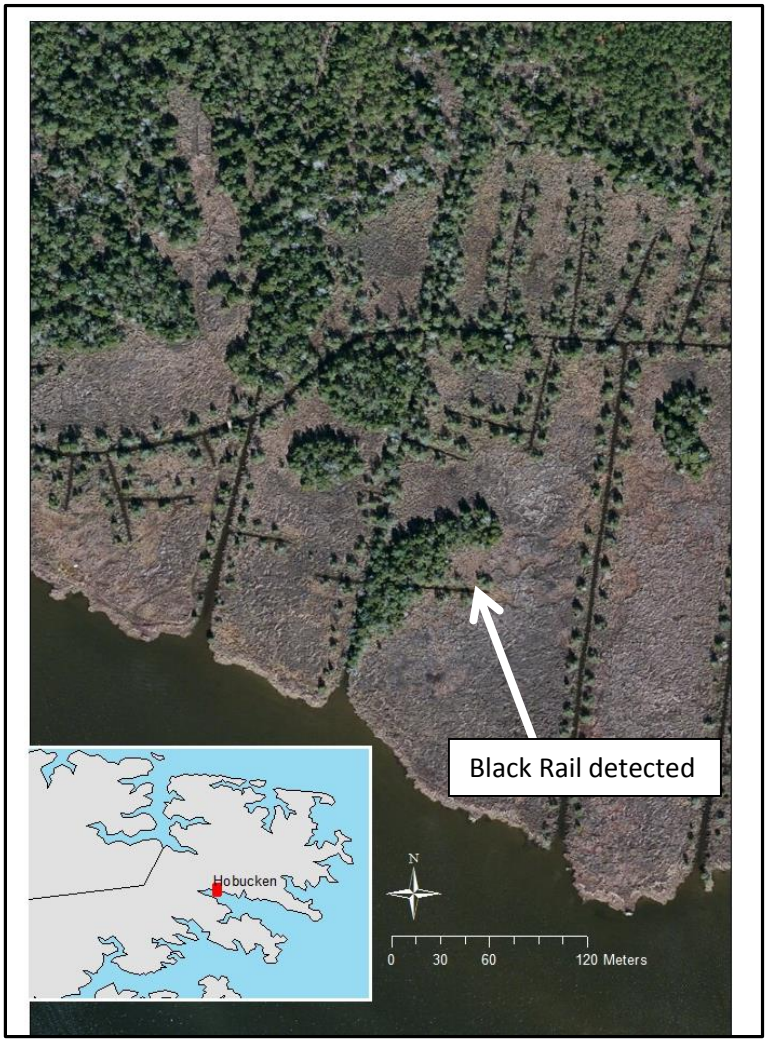
Figure 3. Detection of Black Rails within Cedar Island National Wildlife Refuge across 5 survey visits in 2014.



Habitats used by Black Rails during this survey effort varied by geography and salinity. Black Rails in higher saline tidal zones in Carteret, Pamlico, and Hyde counties occupied high marsh areas that were embedded in larger amounts of low marsh dominated by smooth cordgrass (*S. alterniflora*). The high marsh patches where Black Rails were detected were dominated by salt-meadow hay and salt grass, combined with many wetter areas of black needlerush. The marshes where Black Rails were detected in Hobucken, Jones Bay, and Oyster Bay (Pamlico County) were heavily ditched for mosquito control, termed Open Water Marsh Management. Black Rails were detected using the high marsh vegetation centered along these

ditch lanes (e.g., Fig. 4). Ditching is used to drain surface water off a marsh into canals so fish have greater access to mosquito larvae. Ditches in this area were constructed in the late 1980s as a semi-open system with deep ditches that penetrate the marsh from the water to the landward edge and lateral ditches that connect tidal flow between ditches (Pope 1993). The marsh adjacent to each ditch has been raised, presumably when excavated, to create a series of long, high locations that slope downwards to the marsh. These high areas harbor most of the high marsh vegetation, whereas most of the intervening areas between ditches are lower and inundated more frequently and are dominated by black needlerush and smooth cordgrass. The marsh area around many ditches is high enough in elevation to act as dryer hammocks and therefore is able to support trees such as loblolly pine and red cedar. The high marsh areas of this ditch system could provide habitat for Black Rails. However, we surveyed 75 points within Pamlico County in ditched marshes and only detected birds at 4 locations.

Figure 4. A "mosquito-ditched" Hobucken marsh where a Black Rail was detected in 2014. Black Rails require high marsh habitats which appear as the lighter tan color in this image. High marsh zones form around higher elevation edges of ditches and upland hammocks.



The capaticy of ditched marshes to support Black Rails needs to be investigated further, as well as differences in amounts of high marsh zones of these areas before and after Open Water Marsh Management.

Habitat used by Black Rails in Currituck County included marshes in brackish and oligohaline saline conditions (1-3 ppt salinity). The high marsh components of this region's marshes are dominated by saltmeadow hay, saltgrass, and interspersed black needle rush. The low marsh portion of northern marshes include large portions of smooth cordgrass, and have increased composition of plant forms adapted to lower salinity such of big cordgrass (*S. cynusoroides*) and sawgrass. Like other areas to the south, locations of Black Rails in Currituck County were embedded within large marsh complexes with many more survey points that did not contain Black Rails. For instance, Black Rails were detected at only 3 of 38 survey points along the North River. This effort covered over 16 km of that river's length.

There did not appear to be any major difference in the structure of marshes between those occupied by Black Rails and not occupied by Black Rails. Most of the marshes surveyed were extensive and ranged from hundreds to thousands of hectares in size. The high marsh component of these complexes was often a very small fraction compared to the much larger low-marsh portion. High marshes often appear along elevated terraces directly adjacent to the uplands as thin ribbons of habitat. High marshes can also be interspersed within high elevation pockets and hammocks within the interior of large marsh complexes. There were survey points not occupied by Black Rails clustered around survey points that contained Black Rails, including those that appeared similar in both the composition of vegetation and patch size. In general, there was a bias in the marsh sampling to survey larger patches because most small fringing and pocket marshes (<3 ha) are located up narrow, shallow creeks that were not navigable by boat.

Black Rail conservation efforts in North Carolina should be geographically widespread. Based on the broad geographic distribution of Black Rail detections along the coast, including areas we did not detect birds but recent records exist, it appears that many locations may be required to help maintain population levels. However, special focus should be given to the Cedar Island NWR and surrounding area of this peninsula of Carteret County. The refuge has long supported the largest population of Black Rails in North Carolina but the population may be declining. Moreover, the entire peninsula where the refuge is located may have the largest concentration of Black Rails in the state. Piney Island, a U.S. military training base which is located just west of the refuge, has had single night records of up to 19 birds by J. Fussell as recent as 1992 (LeGrand 1993). We did not survey Piney Island Bombing Range in the 2014 and 2015 effort because an approach to the shoreline is not permitted by the U.S. Military. However, we did detect a bird at another location on the western shoreline of Turnagain Bay, just opposite of the Piney Island Bombing Range. In addition a detection of a Black Rail near the town of Stacy and previous evidence on the North River indicate a large portion of marshes in this area have been recently used by Black Rails during the breeding season.

There appears to be a substantial amount of available habitat that remains unoccupied by Black Rails in North Carolina, including areas where birds historically occurred. In general, landscapes supporting seemingly suitable habitat that are not filled to capacity by individuals may be an indication of underlying demographic problems. This notion suggests that the low percentage of occupied marshes by Black Rails in North Carolina may also be a result of poor demographic rates such as low breeding productivity or adult survival. Rising sea levels not only reduce the amount of habitat for Black Rails, but also lower the demographic value of existing patches as well. An increase of tidal flooding above historic tide lines can inundate areas used for nesting and drown eggs. Black Rails likely have evolved behaviors that have shaped their current timing and placement of nests above high tide lines within high marshes. The amount and duration of flooding across the marsh surface has continued to increase and is expected to accelerate as water continues to rise relative to the land (Donnelly and Bertness 2001. Episodic flooding of high marshes at heights greater than historic values is not likely to produce noticeable changes in marsh composition over the short-term, but its effect on Black Rail breeding should be assessed. The possibility of the "silent killing" of Black Rail populations by an increase of tidal flooding suggests that populations will continue to decline faster than we would expect due to habitat loss alone. Conservation tools that investigate recent changes in tidal heights and forecast the effect of increasing tidal heights and penetration across the marsh surface into the future are needed to understand the exposure risk of Black Rails and other high marsh nesting birds to flooding of nesting habitat.

Another factor that can limit Black Rail demographic rates is nest predation. Black Rails using high marshes for breeding are highly susceptible to nest predators (Wilson et al. 2014B). High marshes allow easy access to predators because of their low water levels and proximity to the upland. A recent study on the Delmarva Peninsula of Virginia investigated the nesting potential of high marsh nesting birds by investigating predation rates on artificial nests placed in high marsh (Wilson et al. 2014B). Results of this study indicated that 90% of artificial nests were predated within 20 days of exposure with raccoon being the most common predator within the study areaThe incubation period of the Black Rail is estimated at 20-21 days, suggesting that this species is at high risk of nest predation at a level that could cause poor breeding productivity at the population level.

Understanding the influence on mosquito control on Black Rail habitat and demography is critical for their conservation. Management practices associated with mosquito control can degrade marshes for Black Rails both physically and demographically. Black Rails occupied a low percentage of survey locations within ditched marshes during this study. These marshes were ditched more than 15 years ago. Black Rails were detected in Hobucken during the breeding season in 1987, prior to some of the ditching (Pope 1993). However, it is not known whether ditching was a positive influence by creating high areas or a negative influence that has impacted Black Rails by decreasing populations in those marshes. Historically the practice of ditching marshes for mosquito control has been pervasive throughout the Northeast. Marsh ditching severely impacts marsh hydrology by altering tidal patterns. Although specific techniques vary between open, semi-open, and closed systems, all forms of Open Marsh Water Management (OMWM) for mosquito control alter natural hydrology and have specifically been

used to target high marsh habitats that Black Rails rely on and perhaps the specific patches which they were known to inhabit. In addition, mosquito control using insecticides has been prevalent for decades but is being used more prevalently in recent time. Insecticides have sometimes been chosen as an alternative to OMWM more recently, just as OMWM once was chosen as an alternative to insecticides (Floore 2006). The influence that mosquito control may have on decreasing Black Rail populations is recommended as a priority research action where it occurs in their range.

It is also possible that the decline of eastern Black Rails may be due to events occurring on the wintering grounds. The influence of the non-breeding season on Black Rail population levels and adult survival remains unknown. A number of potential factors such as marsh loss, habitat change, predation or others may impact overwinter survival and should be considered research priorities moving forward. For example, prescribed burning during the winter has been implicated in direct mortality of rails and other species that are reluctant to fly long distances or indirectly to increase their vulnerability to predators (Grace et al. 2005).

Overall, the dramatic population loss of Black Rails throughout the mid-Atlantic provides an indication that the ecosystem they rely on is no longer suitable. Emergency management actions are required to prevent further population loss and begin restoration. However, some of the limiting factors on Black Rails are so pervasive that they are beyond management control. For instance, halting the loss of high marsh from sea-level rise may be considered unfathomable. Furthermore, nest predators may be distributed too widely and exist in greater numbers than could be controlled through management and marshes are too large to undergo predator exclusion. However, basic management actions in the face of sea-level rise should include preventing any shoreline armoring that may contribute to natural marsh transgression into the upland. Similarly, management actions such as water control, prescribed fire, or mosquito control should be made compatible with Black Rail conservation within selected focal areas.

A critical management need for the Black Rail is to protect, create, and manage habitats that are not influenced by sea-level rise. Artificial habitats such as managed impoundments offer the best opportunity to fit these demands. Impoundments could be placed inland to avoid rising seas and could be fenced to reduce predator visitation. A broad strategy and site-specific recommendations for managing impoundments to benefit Black Rails are still in need of development through experimentation. Black Rails respond positively to impoundments that are managed under proper conditions. For example, Black Rails appear to be maintained in a number of sites and number of individuals over time in managed impoundments in South Carolina (Roach and Barret 2015). Basic requirements for impoundments would be a cover of dense grasses and very low water levels (i.e., centimeters in depth). This management would require specific flooding and draw down events timed specifically to produce optimal conditions for Black Rails.

We recommend continual monitoring of the Black Rail population of North Carolina into the future using the same protocol used for this study to maintain consistency. This protocol is

also being used by other state surveys along the Atlantic Coast. Monitoring of Cedar Island NWR should occur annually and the remaining survey locations with positive detections and a subset of locations without detections should be visited every 4 to 5 years. Survey points with no rail detections should be rotated between survey efforts to assess whether or not birds are moving in the landscape between monitoring benchmarks. New locations should be added over time including areas in the inner coastal fringe with oligohaline and freshwater marshes, and managed impoundments.

Acknowledgments

This study was made possible by funding from the North Carolina Wildlife Resources Commission (NCWRC) and the United States Fish and Wildlife Service (USFWS). We thank Sara Schweitzer and David Allen of the NCWRC for administrative and logistical support throughout the project. We also thank Katie Rittenhouse and Dan McAuley for conducting all surveys in 2014 and 2015, respectively. We are grateful to John Stanton of the USFWS Migratory Bird Program for conducting additional surveys at the Cedar Island NWR. Robert Fearn at the Audubon Pine Island Sanctuary helped by providing housing at the sanctuary in 2015. Erica Lawler and Jane Lopez provided important administrative support from the sponsored programs office at the College of William and Mary. We also would like to thank John Fussell for conversations on the history and location of Black Rails that assisted in selecting areas for survey.

Literature Cited

Davidson, L. M. 1992. Black rail, Laterallus jamaicensis. Pages 119-134 in K. J. Schneider and D. M. Pence, editors. Migratory nongame birds of management concern in the Northeast. U.S. Fish and Wildlife Service, Newton Corner, Massachusetts. 400 pp.

Donnelly, J. P. and M. D. Bertness. 2001. Rapid shoreward encroachment of salt marsh cordgrass in response to accelerated sea-level rise. Proceedings of the National Academy of Sciences 98:14218-14223.

Eddleman, W. R., R. E. Flores, and M. L. Legare. 1994. Black Rail (*Laterallus jamaicensis*). *In* The Birds of North America, No. 123 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union

Floore, T. G. 2006. Mosquito larval control practices: Past and present. Journal of the American Mosquito Control Association 22:527-533.

Grace, J.B., Allain, L.K., Baldwin, H.Q., Billock, A.G., Eddleman, W.R., Given, A.M., Jeske, C.W., and Moss, R., 2005, Effects of Prescribed Fire in the Coastal Prairies of Texas: USGS Open File Report 2005-1287.

Lee, D. S. 1999. Extinction, extirpation, and range reduction of breeding birds in North Carolina: what can be learned? Chat 63: 103-122.

LeGrand, H. E., 1987. Briefs for the files. Chat 51: 78-83.

LeGrand, H.E., 1988. Briefs for the files. Chat 53: 43-50.

LeGrand, H. E. 1993. Briefs for the files. Chat 57: 77-85.

Paxton, B. J. and B. D. Watts. 2002. Marshbird callback surveys of highmarsh patches along the southeastern shore of the Albemarle-Pamlico Peninsula, North Carolina. Center for Conservation Biology Technical Report Series, CCBTR-02-09. College of William and Mary,Williamsburg, VA. 11 p.

Pope, B. F. 1993. Hydrology of two tidal marshes in North Carolina where open-marsh water Management modifications have been implemented. U.S. Geologic Survey, Water-Resources Investigations Report 93-4051. Raleigh, NC. 46 p.

Teulings, R. P. 1974. Briefs for the files. Chat 38: 78-81.

Teulings, R. P. 1975. Briefs for the files. Chat 38: 95-98.

Roach, N. S., and K. Barret. 2015. Managed habitats increase occupancy of black rails (*Laterallus Jamaicensis*) and may buffer impacts from sea-level rise. Wetlands 35: 1065-1076.

Wilson, M. D., C. Turrin, and B. D. Watts. 2014A. Assessing the role of marsh habitat change on The distribution and decline of Black Rails in Virginia. Center for Conservation Biology Technical Report Series, CCBTR-14-009. College of William and Mary and Virginia Commonwealth University, Williamsburg, VA. 14 pp.

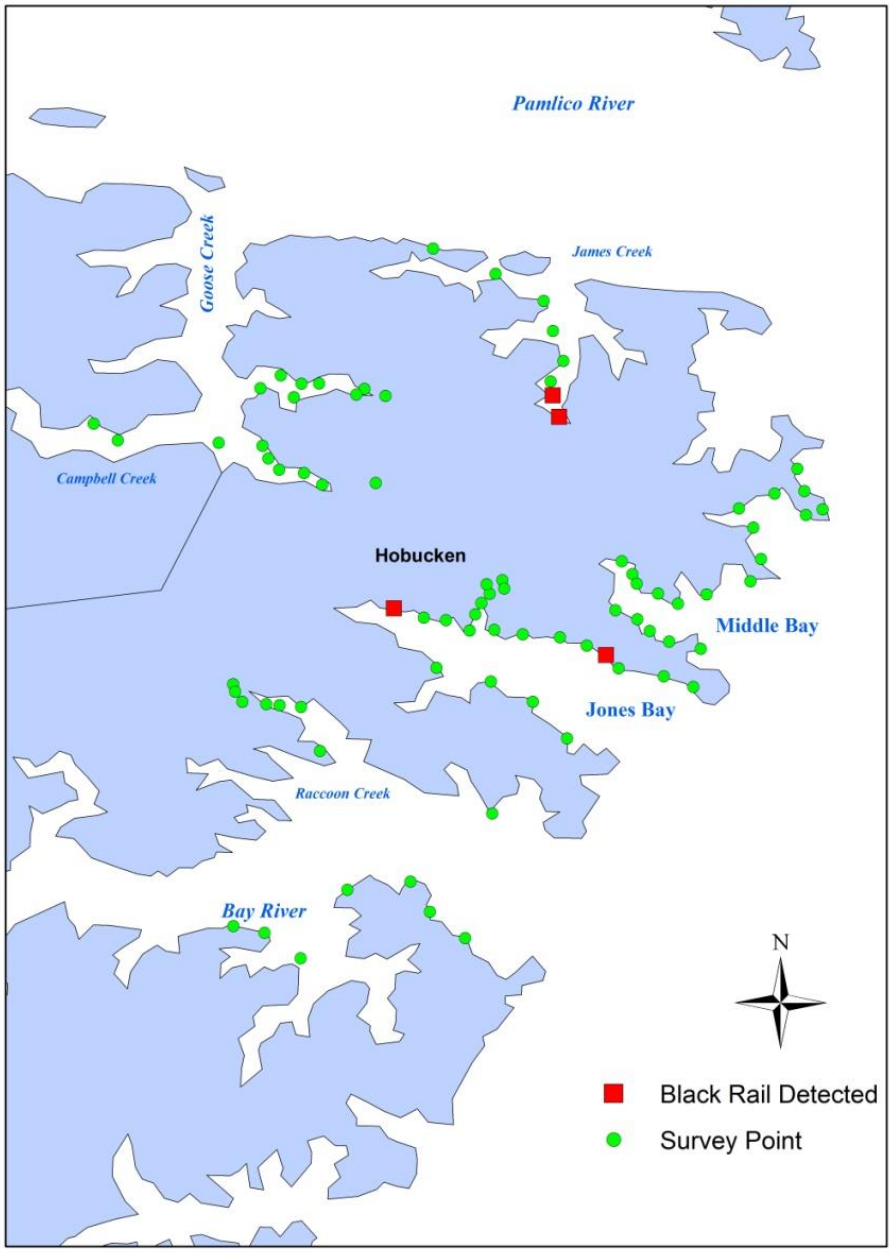
Wilson, M. D., and B. D. Watts. 2014B. Nesting potential of high marsh nesting birds in tidal marshes of Virginia Center for Conservation Biology Technical Report Series, CCBTR-14-006. College of William and Mary and Virginia Commonwealth University. Williamsburg, VA. 13 pp.

Wilson, M. D., F. M. Smith, and B. D. Watts. 2015. Re-survey and Population Status Update of the Black Rail in Virginia. Center for Conservation Biology Technical Report Series,CCBTR-15-004. College of William and Mary and Virginia Commonwealth University. Williamsburg, VA. 15pp.

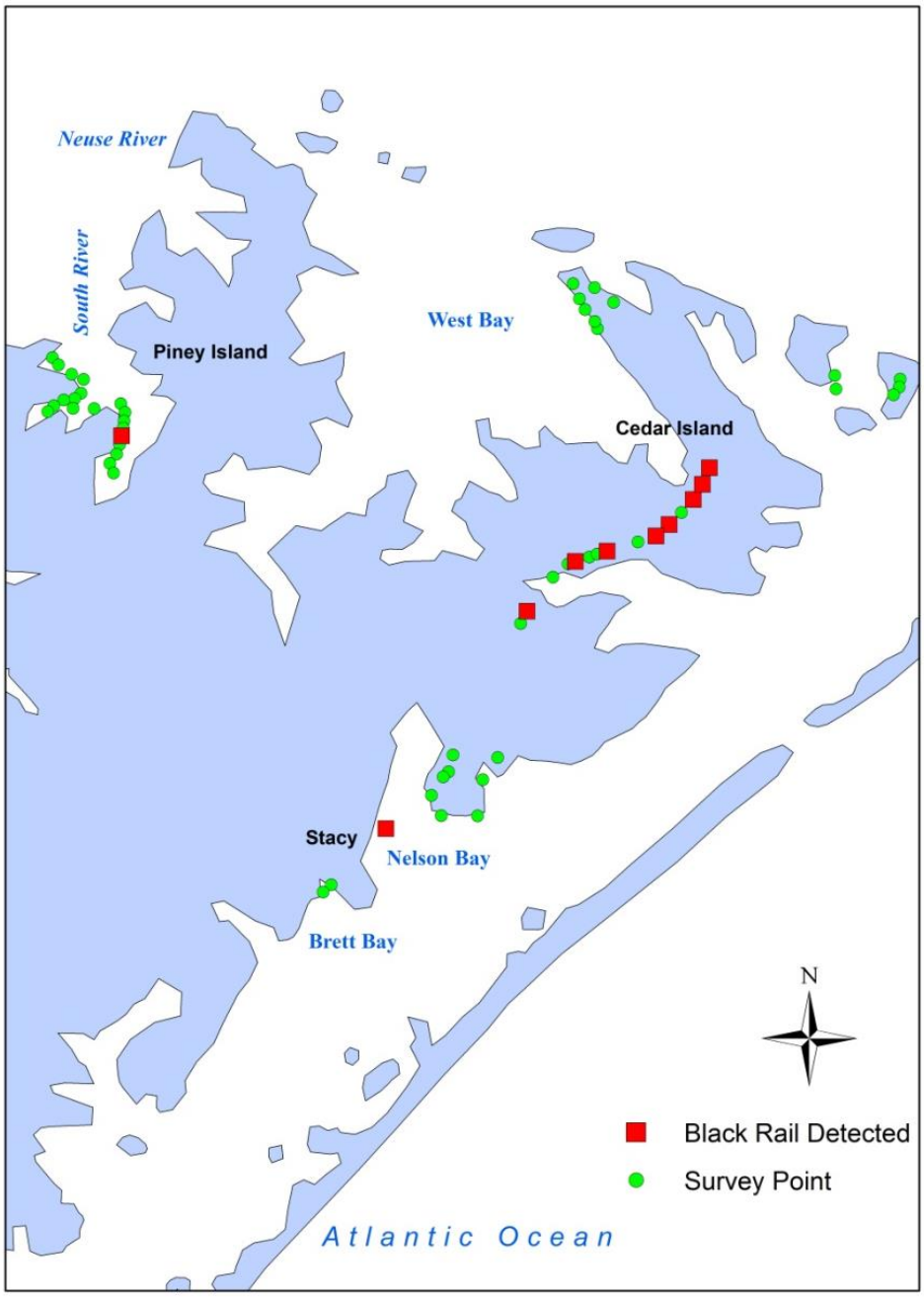
Zervas C. 2001. Sea level variations of the United States. NOAA Technical Report 403 NOS CO-OPS 36. Silver Spring, MD.

Appendix I. Location of survey points and black rail detections in 2014 (A&B)

A) Hobucken, Jones Bay, Goose Creek, and Raccoon Creek vicinity

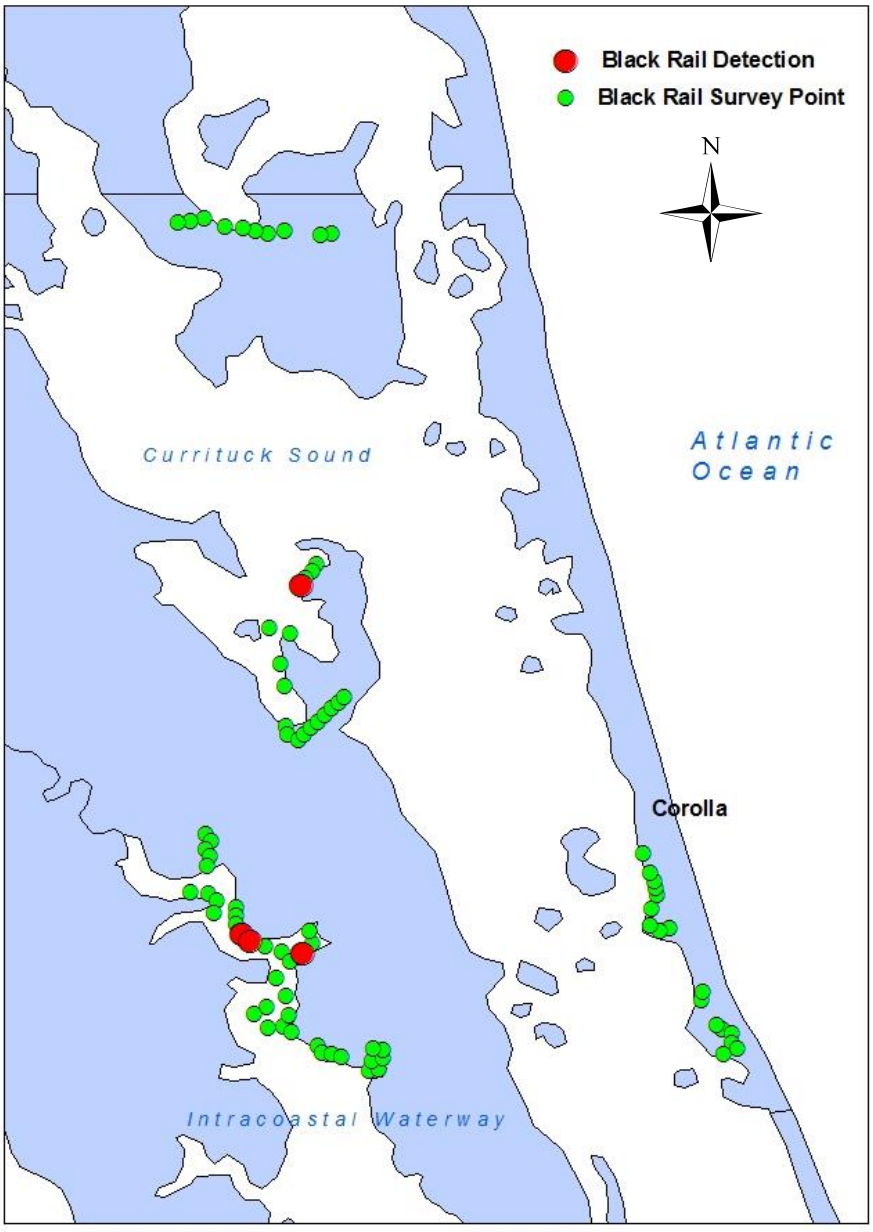


B) Cedar Island, South River, and Stacy, NC vicinity

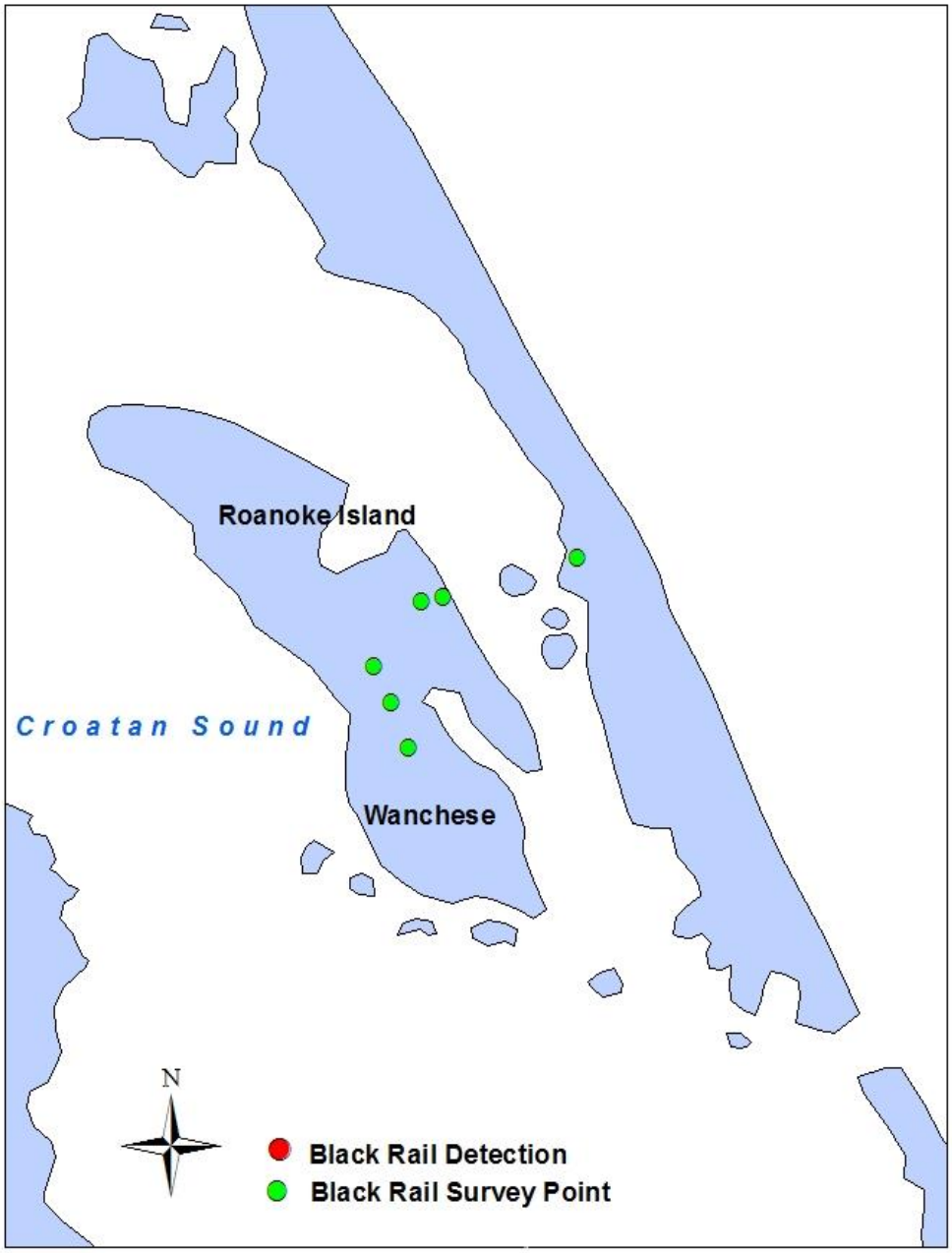


Appendix II. Location of survey points and Black Rail detections from 2015 (A through C)

A) Currituck Sound, Mackay Island, and North River (Intracoastal Waterway) and Pine Island vicinity.



B) Roanoke Island and vicinity.



C) Swanquarter, Wysocking Bay, Far Creek, Long Shoal River vicinity.