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Status and Distribution of Black Rails in Virginia

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This study was made possible by funds provided by the State Wildlife Grants Program through the Virginia Department of Game and Inland Fisheries, Nongame and Environmental Program

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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.

Table of Contents

Executive Summary……………………………….……….. 1
Introduction…………………………………….………….. 2
Methods…………………………………………….……………. 3
Results……………………………………………….…………. 6
Discussion………………………………………….……….. 10
Acknowledgements……………………………………... 15
Literature Cited……………………………………..…… 16
Appendix I…………………………………………………… 18
Appendix II………………………………………………… 19

Executive Summary

The Black Rail (*Laterallus jamaicensis*) may be the most endangered bird along the Atlantic Coast. Over the past 10-20 years, populations in Virginia and Maryland have declined more than 75% and have become dangerously low. There has been a reduction in both the number of breeding locations and a loss of individuals from historical strongholds. Recent evidence suggests that Black Rails may only breed in a dozen or fewer places in each state along the Atlantic coast. The reasons for the dramatic decline of the Black Rail are not completely understood but may be attributed to factors such as habitat loss and degradation, predation, low reproductive rates, overwinter survival, and environmental contaminants.

Until this study, the status of the Black Rail in coastal Virginia had never been systematically determined. Information on the species occurrence only existed in the form of anecdotal accounts and a small collection of unpublished historical records. These accounts generally characterize Black Rails being patchily distributed within tidal salt marshes on the eastern shore of Virginia but its overall distribution within this region was poorly known. Basic abundance and distribution information are central to the development of an effective conservation strategy. The objective of this study was to determine the status and distribution of Black Rails in Virginia using a systematic, targeted survey effort.

We established a network of 328 survey points throughout coastal Virginia within marshes containing historical occurrence records, and marshes with appropriate habitat. Surveys were conducted at night during the Black Rail breeding season in 2007 and 2008. Black Rails were only detected at 12 survey points (< 4 % of total). All detections were restricted to the bayside marshes of Accomack County on the Delmarva Peninsula. No Black Rails were detected on the seaside of the Delmarva Peninsula, the western shore of the Chesapeake Bay, along the James –York-or-Nansemond rivers, or Back Bay. The location of all Black Rail detections shared 4 primary characteristics; 1) being within the high marsh zone, 2) near the upland edge, 3) within a zone of scattered Red Cedars or pines, 4) and only where the upland matrix was composed of a block of pine forest. Black Rails use the highest elevation areas of salt marshes composed primarily of a cover Salt-meadow hay (*Spartina alternifolora*), salt-grass (*Distichilis spicata*), and black needlerush (*Juncus romerianus*).

Black Rails appear to have retracted completely from their historical distribution along the seaside of the Delmarva Peninsula. Moreover, known population strongholds at locations such as the Saxis Wildlife Management area have been dramatically reduced compared to past accounts. Black Rails are only occupying a small fraction of the available habitat. Overall populations appear to be dangerously low and may be at a risk of extirpation in the Commonwealth of Virginia. The future of this species is uncertain because Black Rails occupy habitats that are vulnerable to land-use change, in close proximity to upland nest predators, and sensitive to changes in climate and sea-level rise.

Introduction

The Black Rail (*Laterallus jamaicensis*) is one of the most threatened bird species in Virginia and throughout the Mid-Atlantic region. Black Rail populations have been declining in the eastern United States for over a century resulting in a retraction of its breeding range, an overall reduction in the number of breeding locations within its core range, and a loss of individuals within historic strongholds. Over the past 10-20 years, populations have appeared to decline more than 75% in Virginia and Maryland and have become dangerously low. Recent evidence suggests that Black Rails may only breed in a dozen or fewer places in each state along the Atlantic and Gulf coasts. The 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, overwinter survival, and environmental contaminants.

The outlook for the Black Rail is uncertain. Within the Atlantic and Gulf coastal regions, Black Rails occupy habitats that are vulnerable to land-use change or sensitive to changes in climate. Because of the low elevational position within the landscape, salt marshes will be among the first habitats consumed by sea-level rise. The extensive patches of high marsh required for breeding are projected to be lost or converted to low marsh (Glick et al. 2008). Moreover, the position of Black Rail habitats along the marsh-upland interface makes this species particularly vulnerable to terrestrial nest predation.

The Black Rail is taxonomically divided into two subspecies. The California Black Rail (L. j. couturniculus) is distributed 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 Atlantic coasts 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 in 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 extreme high tide events and dominated by plants such as salt meadow hay (*S. 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, grassy savannah. The high marsh generally forms as isolated hummocks in elevated portions within marshes or more frequently along the upland-marsh edge. The ecotone between the upland and marsh can sometimes include stunted pine trees (Pinus sp.) and red cedar (*Juniperus virginiana*). Additional features of Black Rail habitats can be the presence of salt pannes (higher saline patches dominated by Salicornia sp.) and patches of needlerushes (Juncus sp.) in wetter zones. Away from tidal areas, Black Rails are found in freshwater marshes composed of a mix of rushes (Juncus sp.), sedges (Carex sp.), and cattails (Typha sp.).

The status of the Black Rail in Virginia has never been systematically determined. Information on its general occurrence during the breeding season only exists in the form anecdotal accounts (Bailey 1927, Grey 1938) and a small collection of unpublished historical records (Rottenborn and Brinkley 2005). These records generally characterize its patchy occurrence within high elevation areas of tidal marshes on the eastern shore of Virginia as well as scattered records in the Piedmont or southwestern Virginia (Handley 1941, Stevenson 1947) but its overall distribution is poorly known. The lack of information on Black Rails is mostly due to the difficulty in surveying remote marsh areas at night when Black Rails are most active and have a higher probability of detection. The objective of this study is to determine the status and distribution of Black Rails in Virginia using a targeted survey effort. Because basic abundance and distribution information are central to the development of an effective conservation strategy for Black Rails we hope this study will help gain a more systematic view of their management.

Methods

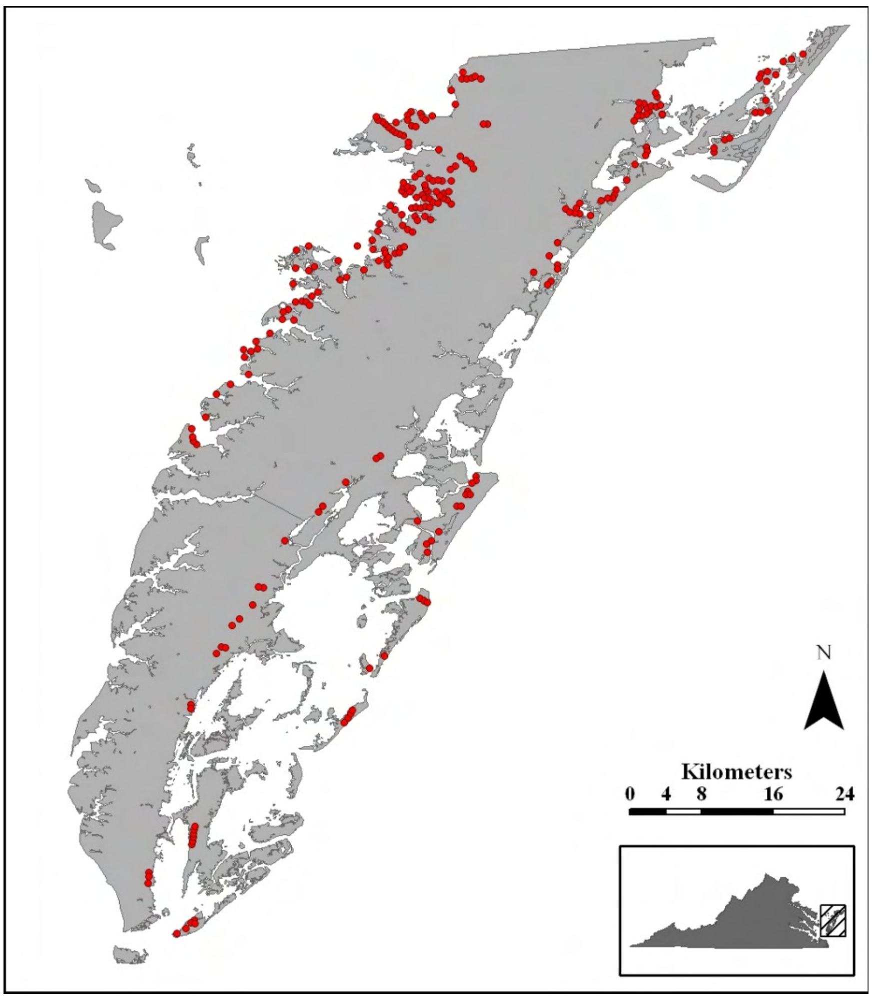
We conducted field work on Virginia's eastern shore (i.e., the lower Delmarva Peninsula) in 2007 and on the western shore of the Chesapeake Bay and Back Bay in 2008. We selected appropriate high marsh patches for survey that contained either historical records of occurrence for Black Rails or that contained appropriate vegetation and topography. On the eastern shore this included marshes along the bayside of the Delmarva Peninsula from the Virginia/Maryland border south to Hyslop Marsh in Accomack County, marshes along the mainland edge of the seaside of the peninsula from Chincoteague Bay south to Magothy Bay, and marshes on the backside of the Barrier Islands. Along the western Shore we selected marshes from Matthew County south to Ragged Island Wildlife Management Area (Isle of Wight County), along the tributaries of the James York, and Nansemond rivers, and on managed impoundments within the Back Bay National Wildlife Refuge.

We established a network 328 unlimited radius point counts within target marshes. This included 242 points on the Delmarva Peninsula (Figure 1) and 86 points on the western shore of the Chesapeake Bay and tributaries (Figure 2). Point count stations were visited by either boat or road depending on access. On the bayside of the Delmarva Peninsula, 52 points were surveyed by vehicle and 80 points were surveyed by boat. On the seaside, 28 points were surveyed by vehicle and 82 points were surveyed by boat. On the western shore, 32 of 86 points were visited by boat and the remaining 54 points by road. Survey points were separated by a minimum of 250 m but were most often separated by much greater distances.

All surveys were conducted at night, 30 min after sunset and before sunrise, between May 4 and June 22, 2007 and between May 12 and June 30, 2008. All points were surveyed using a call-response technique (Gibbs and Melvin 1993). All rail detections were registered with respect to distance from the observer, orientation of detection, time of first detection, and mapped to produce an estimated location in the marsh.

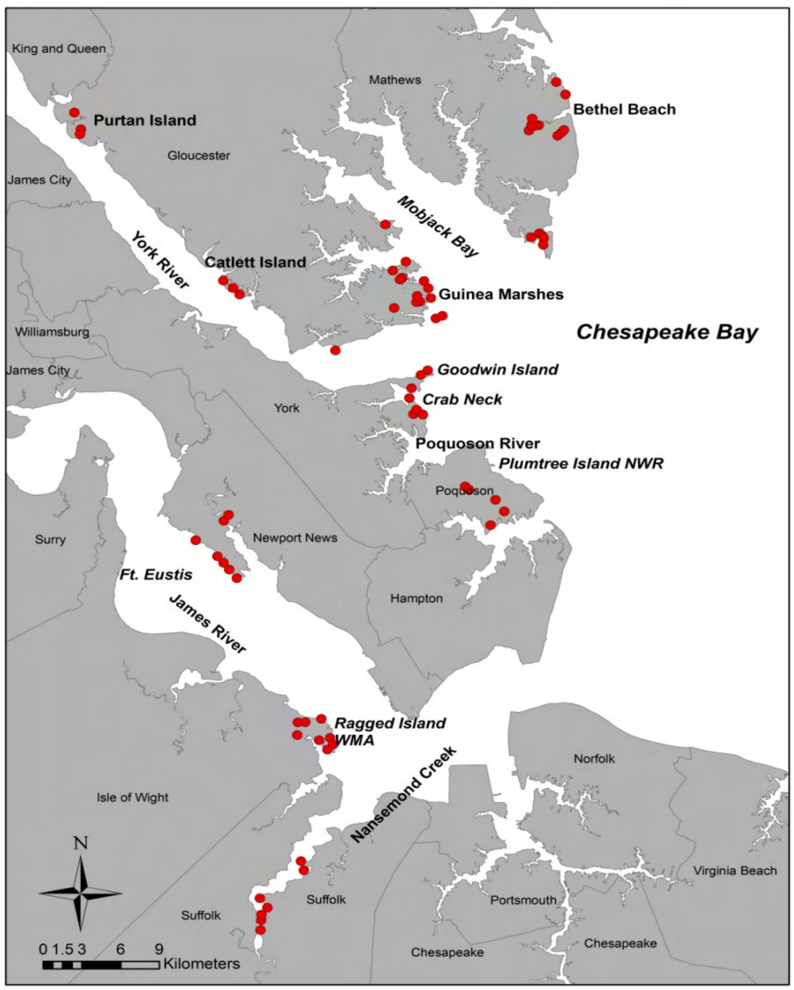
We used the call-response technique used for Black Rail surveys by the Maryland Department of Natural Resources (DNR), Wildlife and Heritage Service during 1991-1992 and 2007 (D. Brinker, pers. comm.) so regional comparisons could be made. The call-response survey consisted of a 10-min sequence of alternating silent listening periods and species playback in the following order; 1) 2 minutes of silence, 2) 4 minutes of Black Rail calls (Ki-Ki-Ker, growls, Ki-Ki doo); 3) 1 minute of silence; 3) 2 minutes Virginia Rail calls; 4) 1 minute of silence. The species playback sequence also had

Figure 1. An overview of all 242 points surveyed on the Delmarva Peninsula during the 2007 breeding season.



interstitial moments of silence to allow detection of calling birds. This protocol was used to specifically target Black Rails and differs from the National Marshbird Survey Protocol (Conway 2008) by devoting a greater amount of time for the broadcast of species calls. The Maryland DNR used the National Marshbird Survey Protocol in 2006 and had no Black Rail detections in areas they are known to occur so the more intense 1991-1992 protocol was re-used for 2007. They subsequently had detections with the 1991-1992 protocol in 2007 at places where birds were not detected in 2006.

Figure 2. Overview of all points surveyed on the western shore and Chesapeake Bay tributaries.



Black rails have low detection rates that can vary greatly according to changes in breeding disposition, time of year, and weather (Brinker 1997, Legare et al. 1999). Legare et al. (1999) estimated that only 23-38 % of radio-tagged individuals responded to call-playbacks during evening and morning trials. To incorporate the influence of detection on point use we applied a site occupancy model (MacKenzie et al. 2002) that incorporates detection probability using the program Presence ver. 2.4 (Hines 2006). This method allows us to compare the proportion of points where birds were detected during surveys to an estimated proportion of points (p) adjusted for detection probability (Ψ). The assumptions of this model are: 1) the sites remain occupied during the study period, no extinction, emigration or colonization occurs, 2) the detection probability of Black Rails is greater than zero, and 3) the detection of a Black Rail at a point is not influenced by the detection at other points. In order to meet the third assumption we changed the detection history of 2 survey points from "detected" to "not detected" for the analysis because it was obvious all detections from 3 survey points were of the same individual Black Rail heard at all the three locations. We also eliminated 8 points that were surveyed only one time because occupancy models require at least two visits to calculate detection probability. We ran one model for equal detection probability over both survey visits and one model for visit-specific (1^{st} and 2^{nd} visit) detection probabilities. Because all points were visited one time before any point was visited a second time, the visit-specific model reflects an early and late period of survey. The site occupancy model was only applied to points within the Delmarva Peninsula study area. Having a value for detection probability also allows us to calculate the probability of not detecting a Black Rail that is present (F) using the following equation: $F = (1-p)^N$; where p is the detection probability and N is the number of visits.

In addition, two autonomous recording units (ARUs) were deployed in marshes where Black Rails were observed to help determine calling rates and detection patterns (Appendix I). ARUs were designed to collect acoustical bird data over long time periods when no human observer is present. ARUs were comprised of a microphone, amplifier, programmable computer, and software that schedules, records, and stores data on a hard drive. Subsequently, these ARUs did not detect calling Black Rails. However, the ARU units did detect our call-response broadcasts during survey visits, including visits that resulted in Black Rail detections. The reasons for the inability of ARUs to detect calling rails are unknown.

Results

Delmarva Peninsula Surveys

We surveyed 234 of the 242 points on the Delmarva Peninsula two times during 2008. The remaining 8 points were only visited once that year. All Black Rail detections were from the bayside of the Peninsula (Table 1). There were no Black Rails detected on

Table 1. Survey effort and results for Black Rail detections.

General Location	Number of points surveyed	Number of occupied points	Proportion Detected	Number of birds detected	
				1st visit	2nd visit
Delmarva Peninsula					
Bayside					
Pocomoke River/ Bullbegger Creek	10	1	0.10	0	1
Saxis	20	4	0.05	6	2
Michael Marsh	13	1	0.08	1	0
Byrds Marsh	17	0	0.00	0	0
Island Field Creek to Guilford Creek	17	2	0.12	3	0
Guilford Creek to Hunting Creek	19	3 (same bird at 3 pts)	0.16	3 (1 bird re-counted at 3 points)	1
Willis Gut (Doe Creek) to Deep Creek	2	1	0.50	0	1
Big Marsh	9	0	0.00	0	0
Parkers Marsh	9	0	0.00	0	0
Onancock Creek to Pungoteauge	7	0	0.00	0	0
Hack's Neck to Nandua Creek (Hyslop Marsh)	7	0	0.00	0	0
Seaside					
Chincoteague Bay / Chincoteague Inlet	32	0	0.00	0	0
Wallops Island to Metompkin Island	24	0	0.00	0	0
Parramore Island & Lagoon	13	0	0.00	0	0
Hog Island	5	0	0.00	0	0
Cobb Island	4	0	0.00	0	0
Mainland - seaside	20	0	0.00	0	0
Mockhorn Island	6	0	0.00	0	0
Smith Island	5	0	0.00	0	0
Western Shore					
Milford Haven to Bethel Beach	11	0	0.00	0	0
New Point Comfort	5	0	0.00	0	0
Mobjack Bay / Guinea	14	0	0.00	0	0

Table 1 continued

General Location	Number of points surveyed	Number of occupied points	Proportion Detected	Number of birds detected	
				1st visit	2nd visit
Western Shore					
Godwin Island / Seaford	7	0	0.00	0	0
Ragged Island	8	0	0.00	0	0
Nansemond River	7	0	0.00	0	0
Cattlett Island	3	0	0.00	0	0
Plumtree Island	5	0	0.00	0	0
Mulbery Island / Fort Eustis	8	0	0.00	0	0
Purtan Island	3	0	0.00	0	0
Back Bay	15	0	0.00	0	0

the seaside (N = 110 points). We detected a total of 19 Black Rails at 12 points (Appendix II) over 2 survey visits with an average of 1.3 $\pm$ 0.49 (SD) per occupied point. The same individual bird was detected at 3 survey points so an adjusted total of unique detections would yield 16 Black Rails at 10 pts over the two survey visits. However, the maximum number detected per point over both visits was 15 Black Rails. This number provides a conservative estimate of the actual number of rails in the marshes we surveyed. Black Rail detections were made at 4 points visited by boat and 8 points visited by land. The greatest concentration of birds was on the Saxis Wildlife Management Area where a maximum total of 6 Black Rails were detected. These birds were detected at only 4 of the 20 survey points distributed in this managed area.

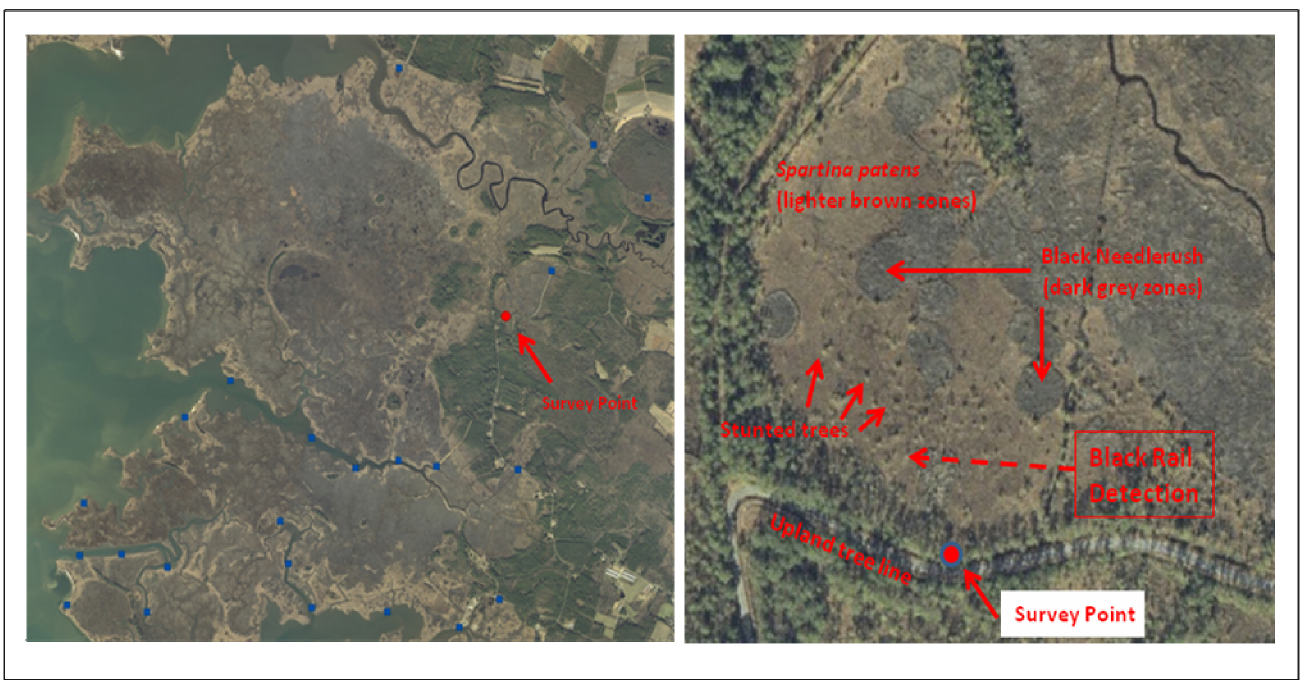
The estimated occupancy rates produced by the two occupancy models were relatively indistinguishable as was their likelihood for best candidate model (constant detection AIC = 163.63, visit-specific detection AIC = 163.72, ΔAIC = 0.09). Both models provided a higher estimate for occupation rate compared to the survey results (Table 2). This result suggests that an additional 2 % (4.68 points) of the survey points included the model could be occupied by Black Rails even though they were not detected there.

Detection probability over the entire study period was low and dropped between the first and second visit (Table 2). We detected 13 Black Rails during the first visit to each point and 6 rails during the second visit. Black Rails were detected during the first visit at 10 points and only detected for the first time during the second visit at two points. The overall decline in detection rate was evident by the individual patterns for detection history. Detections before May 20 (n=10 birds) were typically made during the initial silent period and did not require playback to incite calling. During the latter half of the season, the period of first detection occurred after the Black Rail playback sequence began broadcasting (n=8 birds). Finally, one Black Rail detected late in the season only began calling during the very last silent listening period.

Table 2. Parameter estimation of Black Rail site occupancy models on the Delmarva Peninsula for 1) constant detection probability through entire season and 2) visit specific detection probability (N=2 visits).

Site Occupancy Model	**Actual Proportion of Points Detected (N = 234)**	**Estimated Proportion of Points Occupied (*p*)**	**Detection Probability (*Ψ*)**	**Probability of not detecting a bird that is present (*F*)**
Constant Detection	0.047	0.069	0.428	0.327
Visit-specific Detection	0.047	0.064	(1st visit) 0.630 (2nd visit) 0.333	0.137 0.445

Figure 3. Photographic example of Black Rail habitat at two spatial scales. Photograph depicts the same survey point where a Black Rail was detected near Shiloh Church, part of Michael Marsh.



Detection distance of Black Rails varied with a total of 4 detections within 100 meters of the observer, 7 from 100-200 meters of the observer, and 8 detected > 200 m away from the observer.

The mapped position of all Black Rail detections shared 4 primary spatial characteristics; 1) being within the high marsh zone, 2) near the upland edge, 3) within a zone of scattered red cedars or pines, and 4) adjacent to upland forest composed of pine (e.g., Figure 3-preceeding page).

Black Rails were detected within salt marshes at 11 of 12 points and within an oligohaline marsh at 1 point. High salt marshes were composed of salt-meadow hay, salt-grass, and black needlerush. The one oligohaline marsh was located on the Pokomoke River and dominated by tall cordgrass (*Spartina* cynosuroides). The lone rail in this marsh was detected from within a small patch (~0.7 ha) of *Phragmites austrailis* in the high marsh zone.

Surveys of the Western Shore of the Chesapeake Bay and Back Bay

All survey points on the western shore and Back Bay were visited two times during 2008. No Black Rails were detected within this region.

Discussion

The current status of the Black Rail population in Virginia is that this species breeds in very low numbers and is entirely restricted to the bayside marshes of the Delmarva Peninsula in Accomack County. Black Rails were detected in only a very small fraction of the available high marsh habitat surveyed.

Black Rails also appear to have declined on the Delmarva Peninsula, both in the number of locations known to be occupied and the number of birds within occupied sites. Historically, Black Rails were distributed in appropriate habitat throughout both the bayside and seaside of the Delmarva Peninsula. Harold H. Bailey (1927) mentions his father, Harold B. Bailey, collected a nest with eggs on Cobb Island and six to seven nests on Hog Island in 1917. Charles Handley reported a nest on Gull Marsh (Northampton Co., west of Cobb Island) in 1938 (Clapp 1997). An individual was detected on the mainland of the seaside near Locustville in the early 1990s (Bob Cross, unpublished record). We surveyed 110 points on the seaside, including places on Cobb and Hog islands and no Black Rails were detected.

Traditional strongholds such as the Saxis Wildlife Management Area have held more than 20 Black Rails in the past (Rottenborn and Brinkley, 2005). We recorded a high count of 6 Black Rails at Saxis suggesting that this population has substantially declined. Steve Rottenborn (personal comm..) and Rottenborn and 0'connell detected Black Rails along the bayside without using broadcasted playback on two separate survey nights in 1991. We detected birds at the 3 of these 4 locations in 2007 that Rottenborn did in 1991 although we re-surveyed all the marshes he included. The only place we did not detect a Black Rail as Rottenborn had was on the north facing shore of

Saxis in Pokomoke Sound (i.e. Pig Point). We surveyed two other points in the same vicinities as Rottenborn's 1991 effort and received the same result of no Black Rail detections as he did. Black Rails have been detected during previous years in Hyslop Marsh (N. Brinkley, personal comm.) but were not detected there during our survey effort.

The fact that we did not detect Black Rails on the western shore of the Chesapeake Bay or Back Bay is not surprising given the lack of any substantial records from these regions in recent decades. However, the longer-term historical status of Black Rails in the tidal portions on the western shore is unclear. One bird was observed in Seaford (York County) on August 21, 1949 (Scott 1950). An observation on this date could plausibly be a breeding bird but it is impossible to rule out that the bird dispersed from another site. Other plausible records include a Black Rail flushed at Grandview Beach on May 11, 1968, 15 Black Rails flushed during marsh disking on the Back Bay National Wildlife Refuge (NWR) on May 18, 1966, and one bird calling at Back Bay NWR on May 27, 1968 (Buckley and Buckley 1968). A Black Rail was also reported from Back Bay NWR during the Virginia Breeding Bird Atlas Project 1985-1989 (Trollinger and Reay 2001). We surveyed all of these locations because of the presence of potential Black Rail habitat. The western shore has expansive cover high marsh habitat. Most notable are the Ragged Island Wildlife Management Area, the Plumtree Island NWR, and the Guinea marshes in Matthews County. Watts (2004) reported a breeding record for Saltmarsh Sparrows (*Ammodramus caudacautus*) in Four Points Marsh (Matthews County) indicating the potential of the area to support the high marsh suite of bird species.

Although Black Rail populations have been declining along the Atlantic coast for over for over a century, reductions over the last 10-15 years appear to be more rapid and devastating. Dramatic population changes over this period appear to be pervasive throughout the Mid-Atlantic region and probably extend along the entire Atlantic coast. For instance, the bayside marshes of the Delmarva Peninsula, from Dorchester County, Maryland through Accomac County, Virginia have long been considered the most important region in the Mid-Atlantic for the suite of high-marsh nesting birds including Black Rails. Brinker et al. (2005, and unpublished data) conducted surveys for Black Rails on the bayside and seaside of the Maryland's Delmarva Peninsula in 1992 and replicated these counts in 2007 to find an 85 % decline in the number of locations where they were found. As a specific example, Elliot Island marsh (Dorchester Co., MD) was once heralded for supporting a large population of birds but that now appears to be vanishing (unpublished data).

The number of reports for Black Rails in the Piedmont to mountain areas has declined as well. However, this phenomenon appears to be a long-term decline dating back to the early 1900s rather than the rapid decline that is now observed along the coast. Whether or not populations outside the coastal plain were remnants of a long-standing population or a flush of birds that increased their range from tidal areas following a wave of land clearing in the late 19th century is unknown. Breeding records of western North Carolina date back to the early late 19th century and early 20th century (Lee 1999). These records are non-native plant communities such as wet hayfields so it is not known if natural habitats supported birds. Lee (1999) suggests that changes in land use practices, including the draining of wet grassy fields could have reduced habitat opportunities for Black Rails in the western region of North Carolina and have been partly responsible for the declines witnessed there. Black Rail records in the Piedmont and mountains of Virginia have mostly consisted of scattered accounts of individual birds that are typically observed at a location for only one year. There are very few locations outside of the coastal plain with persistent breeding season records. Handley (1941) observed such an exception in Virginia with a report of an "number" of Black Rails in two Montgomery County wetlands over a period of 4 years but continued to comment that in the last year of this period that the numbers were reduced to only one site that may have only supported one bird. Most records outside the coastal plain are from a period of the 1930s through the 1950s (e.g., Murray 1931, Handley 1939, Stevenson 1947). Rottenborn and Brinkley (2005) summarize some of these older unpublished records as well as more recent unpublished records that document observations of single birds at the Dulles Greenways Wetlands (Loudon County) in 2001 (also see Cross 1999) and North Fork Wetlands (Prince William County) in 2002. Allen Bryan (personal comm.) detected one calling bird in late May, 2008 in Fluvanna County. The breeding status of Black Rails detected in the Piedmont and mountains of Virginia has never been determined but certainly there is the possibility of these birds nesting based on the number of occurrences. There have been 8 confirmed nesting records in western North Carolina between 1887 and 1961 (Lee 1999).

Black Rails in our study were typically detected in the highest topographical portions of marshes that are directly adjacent to the upland edge. This habitat is composed of a complex of emergent marsh vegetation, shrubs, and upland trees that border the marsh. Emergent marsh vegetation was typically a mixture of salt-meadow hay, saltgrass, and black needlerush. Typical shrubs species include saltbush, and wax myrtle (*Myrica cerifera*), and the upland border was typically composed of stands of mature loblolly pine and red cedar. Stunted pines and cedars were also scattered throughout the marsh zone where rails were detected. Black Rails were not detected in the larger, more open, expanses of salt-meadow hay or saltgrass that were positioned away from the upland edge. It is unclear why Black Rails select these specific places in the landscape. One suggestion is that Black Rails are using areas that contain a specific combination of resources and these are only found in certain places in the high marsh. For example, Black Rails may require the areas of dense salt-meadow hay for nesting but rely on wetter areas of black needlerush or low forms of smooth cordgrass for foraging purposes. We are unsure if upland habitats or scattered trees within the high marsh complement marsh resources for Black Rails or if the presence of small trees is simply a product of where the combinations of other marsh resources align in the landscape. We did not conduct a habitat analysis to determine if there were any statistical differences in the habitat composition between used and unused locations. However, a cursory examination of aerial photographs seems to indicate considerable overlap in vegetation conditions of used and unused marshes. It is unclear why certain marshes support Black Rails where many other marshes of similar vegetation composition do not.

Because Black Rails have a relatively low probability of detection it is possible that we missed detection of birds in some marshes. However, when occupancy analysis adjusted for detection probability there was only a small increase (possibly 5 points) in the number of locations where Black Rails may be estimated to occur but were not detected. Based on the detection probability of Black Rails in our study, we estimate that it would take up to 5 visits to the same point to produce a 95 % confidence level in the true status at that location (using $N_{minimum}$ = log (0.05)(log[1-*p*]). Certainly, future surveys for Black Rails would benefit from a greater number of visits.

The Delmarva Peninsula is also a critical region for supporting populations other bird species that rely on the high marsh. Species such as the Virginia Rail (*Rallus limicola*), the Atlantic Coast subspecies of Henslow's Sparrow (*Ammodramus henslowii henslowii*) and Saltmarsh Sparrow occur in small or declining populations within this area. The small population of Henslow's Sparrows once known to breed at Saxis has not been detected since the late 1990s (D. Schwab, personal comm.) and appears to have vanished. There is only one location remaining in Virginia where Henslow's Sparrows are still believed to breed in saltmarshes (CCB unpublished data). Similarly, Henslow's Sparrows have not been observed on the coastal plain of Maryland since the early 1990s. These trends, when taken together with the notion of Black Rail declines, indicate a common problem across the entire high marsh nesting suite of birds.

The Black Rail appears to be on the verge of extirpation from Virginia. Reasons for this imperilment are unknown but may be due the loss and degradation of breeding habitat. High marshes are highly susceptible to loss from human development and use, drowning by sea level rise, invasion by Phragmites, and nest predation by ground predators.

The Atlantic Coasts have lost nearly 9 % of its estuarine marsh cover since the 1950s (Dahl 2006). Nearly 27 % of these losses are attributable to the conversion of marsh to agriculture or coastal development, such as urbanization, suburbanization, and road/bridge construction (Tiner 1987). Black Rails rely on the highest portions of marshes that are rarely inundated by tidal waters. Because of the drier hydrology, the high marsh has typically been the most favored wetland zone for filling and development. Coastal development can also lead to a host of negative impacts on Black Rails beyond direct habitat loss. Many salt marshes positioned near development have been ditched for mosquito control, submerged by water control structures, and used as grazing areas for livestock. Development of upland areas are known to reduce the bird diversity and abundance of marshes they interface (DeLuca et al. 2004, Shriver et al. 2004). Black Rail territories are typically located directly adjacent to upland habitats so are particularly vulnerable to conversion of adjoining forest land to human uses. Coastal counties now support some of the largest urban concentrations in the United States. The demand for new development by an ever burgeoning human population within coastal zones will bring another era of impacts on Black Rail habitats unless appropriate management is undertaken.

The Chesapeake Bay region is experiencing sea-level rise rates that are twice the global average (Douglas 1991, Zervas 2001). Sea-level rise of this region is projected to rise 0.3 m to 2 m before the end of the 21st century. Rising waters have already been responsible for up to 50 % of the total estuarine wetland losses since the 1950s (Tiner 1987). Because of their low position within the landscape, salt marshes will be one of the first habitats consumed by rising seas. Moreover, because the high marsh requires longer periods of time than low marsh to accumulate sediments to maintain elevation they can be quickly lost after submergence. One possibility for salt marshes to continue existence with sea-level rise is to migrate upslope where topography is favorable. However, barriers to salt marsh transgression such as naturally steep topography, sea-walls, and the impermeable surfaces of developed land will eventually squeeze marshes out of existence. The high marsh zone that Black Rails rely on for breeding are particularly susceptible to be converted to low marsh where barriers to landward migration are present. Simulations of the impact of sea-level in this region indicate that 51 % of Black Rail habitats will become submerged or converted to low marsh and vanish by the year 2100 under current rates of sea-level rise (Wilson and Watts unpublished data). Sea-level rise is predicted to accelerate leading to a possible increase of 1-2 m by 2100. Under these possible sea-level rise scenarios, we project that 90-99 % of Black Rail breeding areas will disappear (Wilson and Watts, unpublished data). It is unlikely that Black Rails will exist in this region under those limitations. Improved regulation and spatial planning of development and barriers to marsh transgression are needed to proactively reduce the impacts of sea-level rise on Black Rails and their habitats.

Nest predators may be the most direct and current threat to Black Rails. Although the impacts of nest predators on Black Rails in this region has not been studied, evidence from other marsh nesting birds indicate that the probability of nest predation is related to water level and the surrounding habitats in the landscape. Marsh birds have a higher probability of nest predation when water levels are low and where marshes are surrounded by development (Jobin and Picman 1997). Black Rails may be particularly vulnerable to nest predators because they rely exclusively on high marsh zones for breeding. The high marsh zone is infrequently flooded by tidal waters providing mammalian predators such as raccoons (*Procyon lotor*) and Red Fox (*Vulpes vulpes*) greater access. Additionally, high marsh zones are positioned directly adjacent to upland habitats that are the source of mammalian nest predators. Feral cats (*Felis catus*) were observed at most of the locations that supported Black Rails in this study. Nest predation is believed to be the most significant limiting factor and cause of decline for populations for some species of ground and beach nesting colonial waterbirds on the Delmarva Peninsula. Populations of these colonial waterbirds began a sudden decline in the late 1980s that is believed to be associated with increasing nest predator populations (Erwin et al. 2001). This timing is significant because it also coincides with rapid decline of Black Rails suggesting that population reduction could also be related to nest predation.

The status of the Black Rail as a breeder in Virginia appears to be in jeopardy. Studies designed to investigate the reasons for population decline are needed. This study provides the first systematic benchmark of Black Rail distribution that can also serve as the survey framework for future population comparisons.

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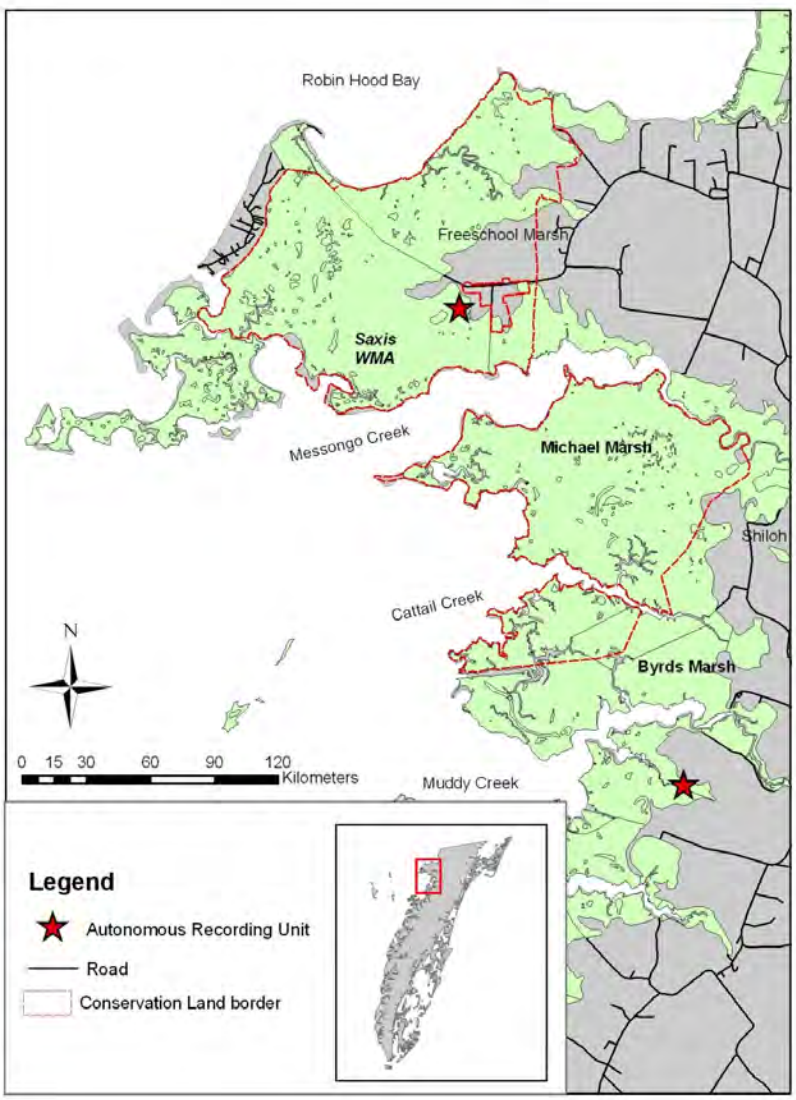
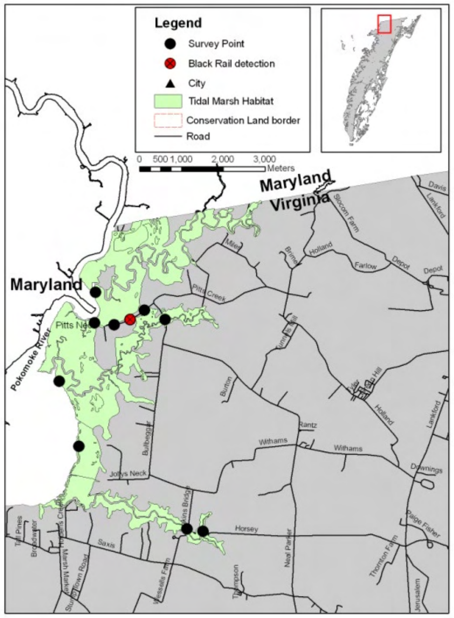
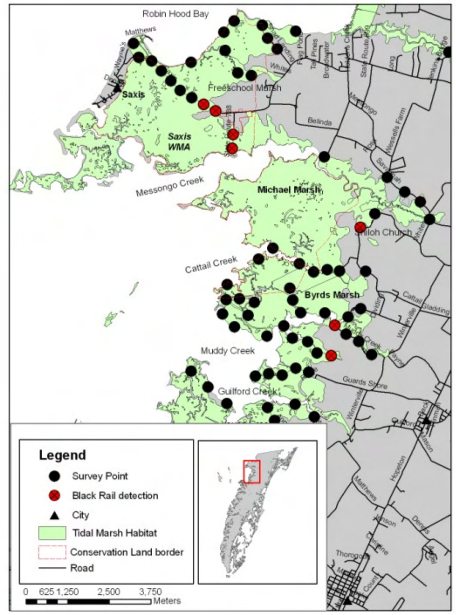
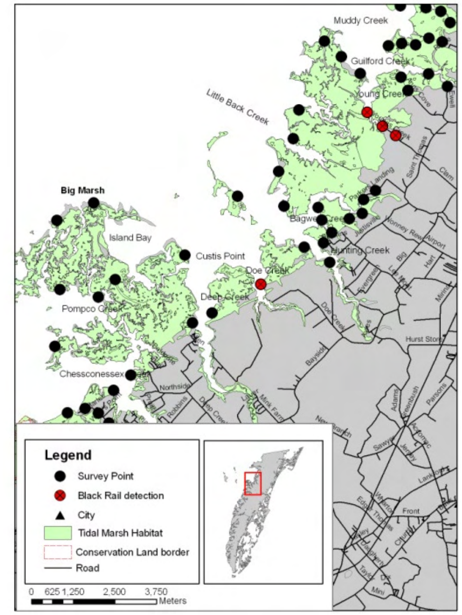
Appendix I. Location of Autonomous Recording Units (ARUs) used during the 2007 breeding season.

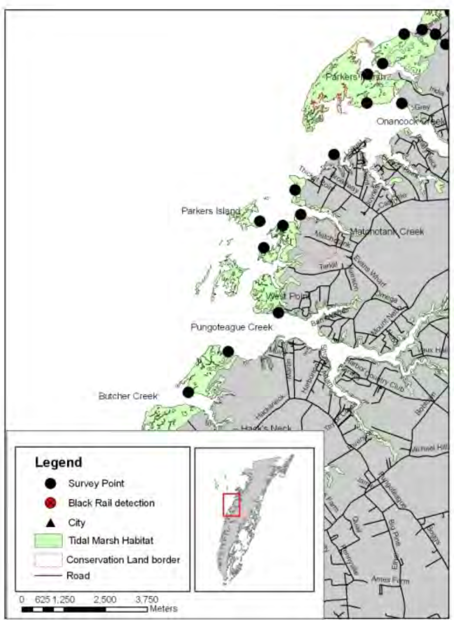


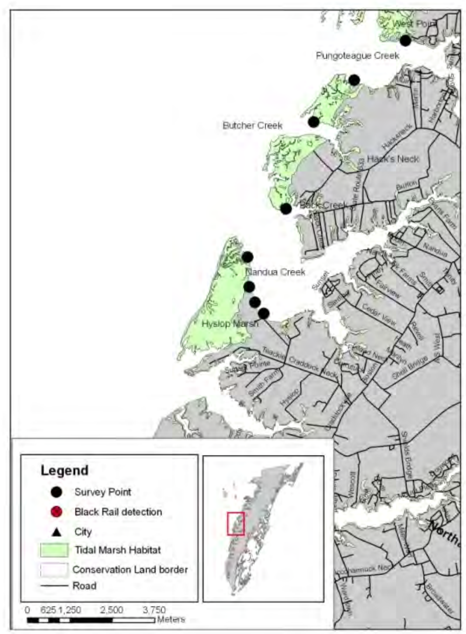
Appendix II. Map location of survey points in 2007 and 2008.

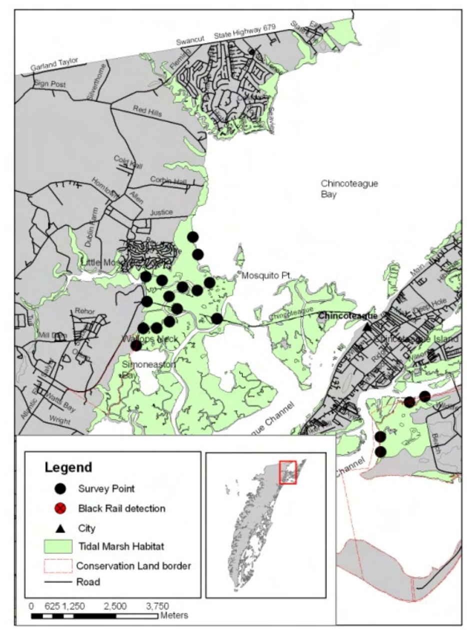


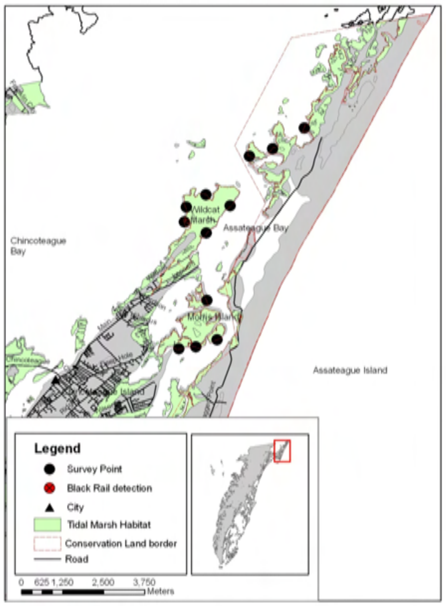











Chincoteague Bay
Wildcat Marsh
Assateague Bay
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Legend
Survey Point
Black Rail detection
City
Tidal Marsh Habitat
Conservation Land border
Road
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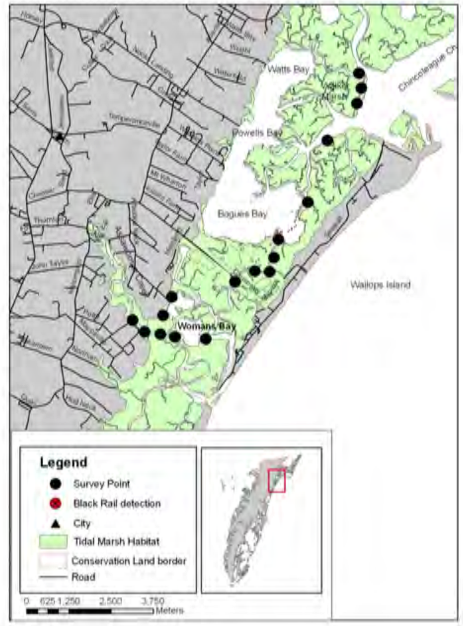
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Powells Bay
Bogues Bay
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City
Tidal Marsh Habitat
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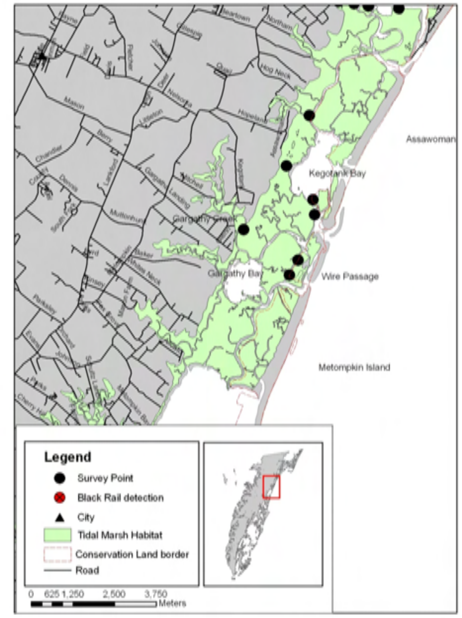
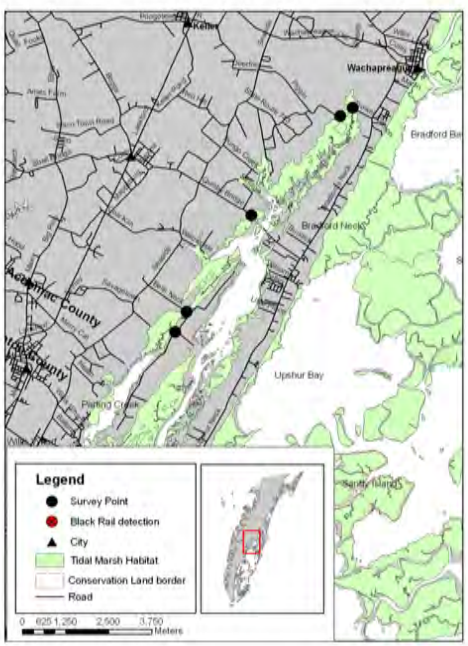
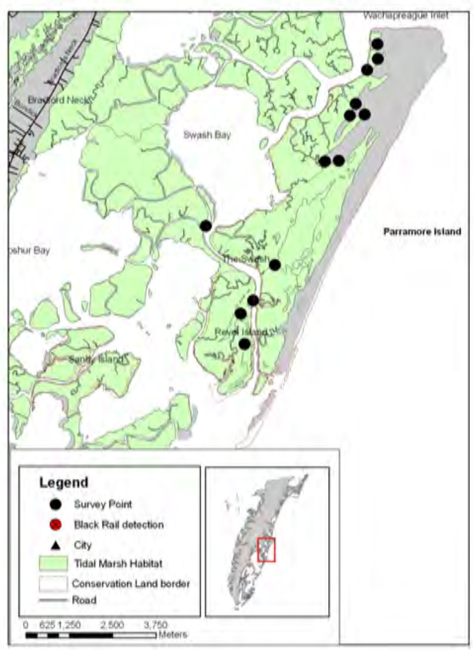

Assawoman
Kegotank Bay
Gargathy Bay
Wire Passage
Metompkin Island
Legend
Survey Point
Black Rail detection
City
Tidal Marsh Habitat
Conservation Land border
Road
0 625 1,250 2,500 3,750 Meters


Wachapreague
Bradford Neck
Accomac County
Upshur Bay
Legend
Survey Point
Black Rail detection
City
Tidal Marsh Habitat
Conservation Land border
Road
0 625 1,250 2,500 3,750 Meters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Bradford Neck
Swash Bay
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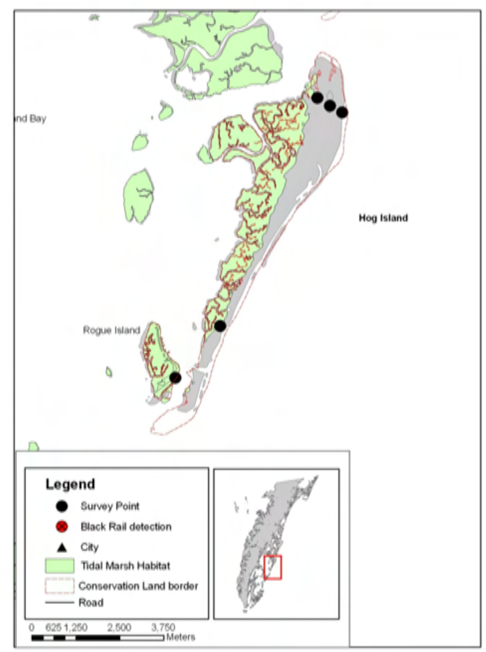
Survey Point
Black Rail detection
City
Tidal Marsh Habitat
Conservation Land border
Road
0 625 1,250 2,500 3,750 Meters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Rogue Island
Legend
Survey Point
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City
Tidal Marsh Habitat
Conservation Land border
Road
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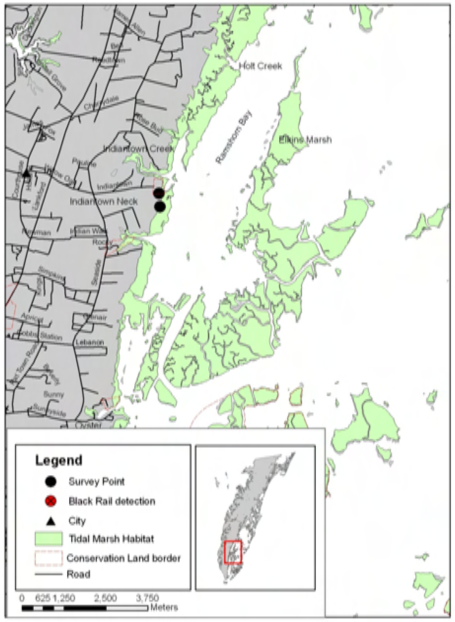
Holt Creek
Ramshorn Bay
Elkins Marsh
Indiantown Creek
Indiantown Neck
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City
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Conservation Land border
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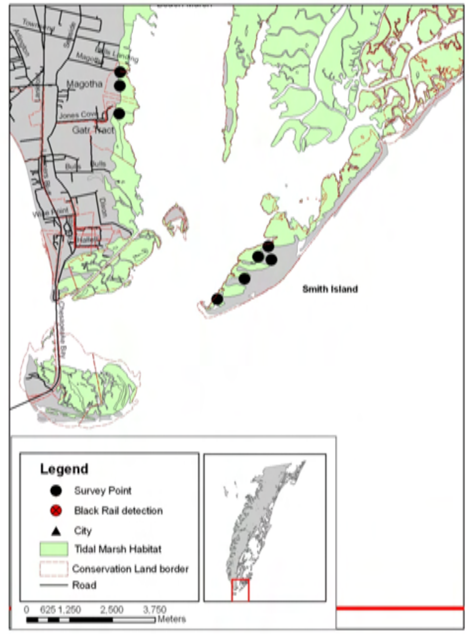
Meters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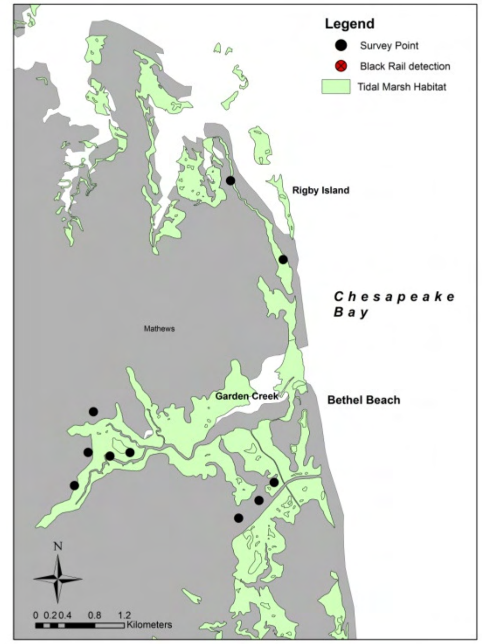
Meters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Survey Point
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Mathews
Garden Creek
Bethel Beach
N
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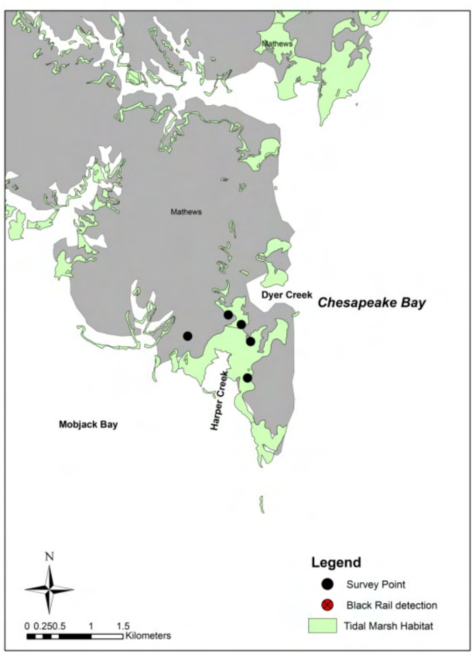
Kilometers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Dyer Creek
Chesapeake Bay
Harper Creek
Mobjack Bay
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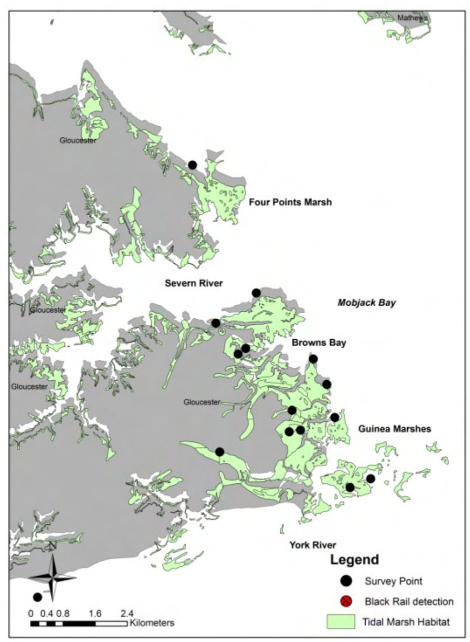
Kilometers
Legend
Survey Point
Black Rail detection
Tidal Marsh Habitat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Four Points Marsh
Severn River
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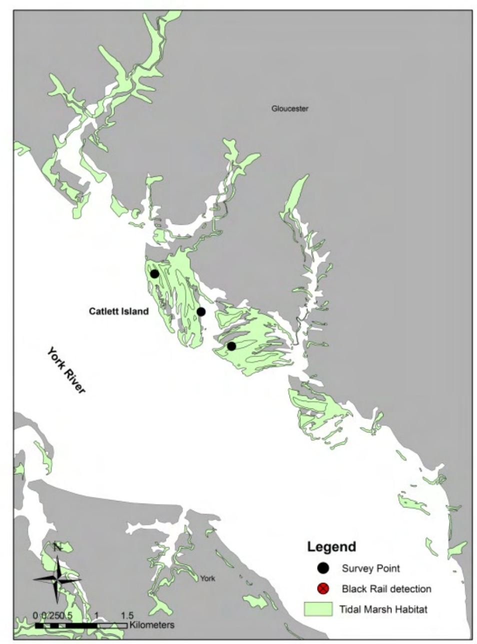
Kilometers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York River
York
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N
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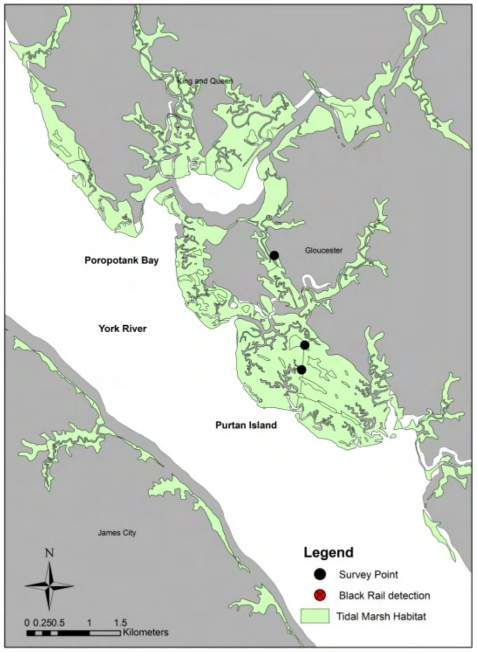
Kilometers


King and Queen
Poropotank Bay
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Black Rail detection
Tidal Marsh Habitat
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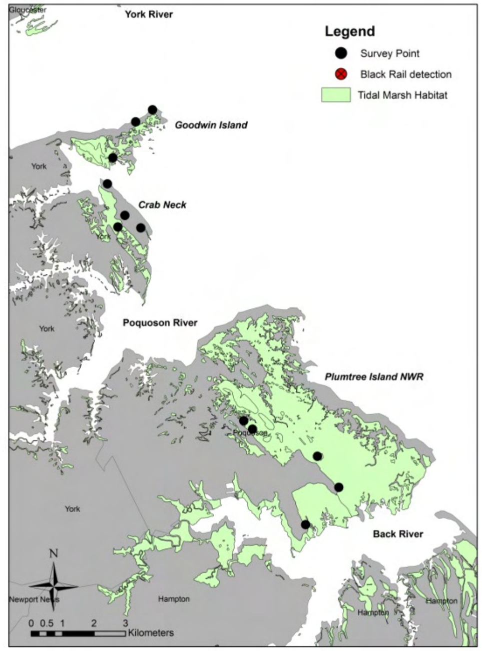
Kilometers


York River
Legend
Survey Point
Black Rail detection
Tidal Marsh Habitat
Goodwin Island
York
Crab Neck
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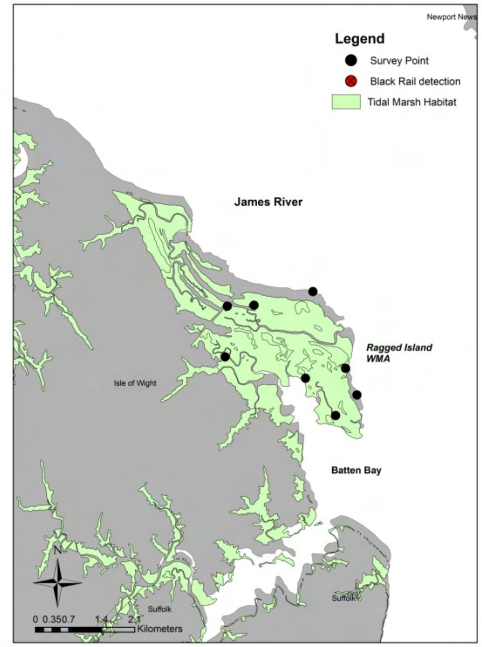
N
Newport News
Hampton
Hampton
Hampton
0 0.5 1 2 3
Kilometers


Newport News
Legend
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N
Suffolk
Suffolk
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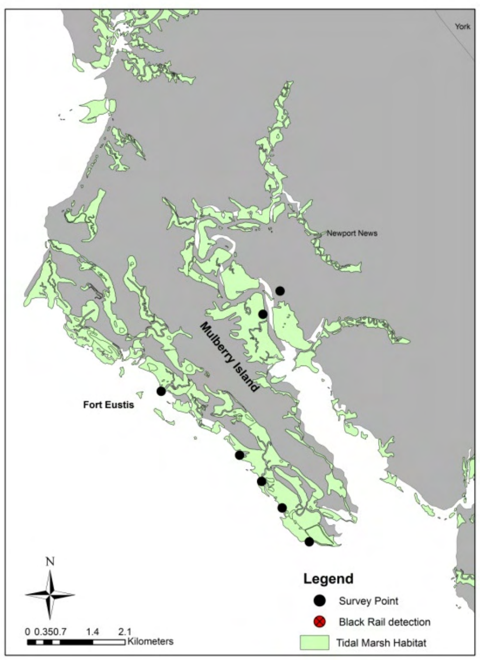
Kilometers


York
Newport News
Mulberry Island
Fort Eustis
N
Legend
Survey Point
Black Rail detection
Tidal Marsh Habitat
0 0.350.7 1.4 2.1
Kilometers


Atlantic Ocean
Back Bay NWR
Impoundments
Virginia Beach
N
Legend
Survey Point
Black Rail detection
Tidal Marsh Habitat
0.6 0.9
Kilometers