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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.

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Executive Summary

Tidal marshes are one of the most characteristic habitats of estuaries in the Chesapeake Bay and Mid-Atlantic Region. A number of bird species that are entirely dependent on high marsh zones of tidal marshes for nesting are of conservation concern because of recent population declines. The Black Rail is the most imperiled bird species among this group. Recent evidence suggests that Black Rails may be heading towards extirpation in the Mid-Atlantic region. High marsh nesting bird species are particularly vulnerable to changes in sea level and nest predation. Determining the relative contribution of the leading factors believed to be influencing population declines requires special investigation to aid management efforts.

This study was designed to investigate the nesting potential of marsh birds using high marsh habitats in Virginia. Birds that nest in the high marsh may be highly susceptible to nest depredation because of low water levels that make for easy accessibility by mammalian and other nest predators. We determined the nest fate of natural bird nests and by using an artificial nest experiment.

The number of natural bird nests discovered during the study was low and lacked the sample size for adequate statistical summary. However, the fate of artificial nests monitored over 11 experimental plots showed relatively high nest predation rates. Daily nest survival of artificial nests was 0.88 and an overall probability of nest success of 0.07 across 99 nests. The average number of exposure days before an artificial nest was depredated was less than half the period required for successful incubation by most marsh nesting species including the Clapper Rail, Virginia Rail, and Black Rail. Daily survival rates and nest success of artificial nests were somewhat lower compared to natural nests from other studies of marsh nesting birds. Although some caution must be made when comparing artificial and natural nest outcomes, the results suggest that birds nesting in high marsh are vulnerable to high rates of nest depredation.

Introduction

Tidal salt marshes are one of the most characteristic habitats within the mid-Atlantic region and are important to the regional avifauna. The endemic salt marsh bird community is comprised of two functional groups of species that are separated by their use of the high marsh versus low marsh zones. Species that are restricted to the high marsh zone include the American Black Duck, Willet, Black Rail, Sedge wren, Saltmarsh Sparrow, and Henslow's Sparrow. The other group of species includes the Clapper Rail, Virginia Rail, and Seaside Sparrow that utilize both marsh zones but reach their highest densities in the low marsh. Although there is concern for the population status of both groups, the suite of species that use high marsh habitats are among the most imperiled. A survey conducted through State Wildlife Grant Funding in 2007-08 indicated that Black Rails populations have declined substantially in Virginia and currently found at only a small fraction of their historical locations (Wilson et al, 2009). Without management intervention, it is believed that Black Rails will be extirpated in Virginia as well as other regions in the Mid-Atlantic. Black Rails are Virginia's most imperiled bird species and are in need of studies to help explain population declines so management actions may be taken.

The high vulnerability of the high marsh bird species suite is likely a combination of factors such as sea-level rise, Phragmites invasion, and nest predation. Nest predation is likely the leading factor responsible for population declines of Black Rails and possibly other high marsh nesting species but it is difficult to separate the relative contribution of all possible factors without more detailed investigations. High marsh bird species are considered particularly susceptible to mammalian nest predators because their habitats are easily accessed during low water levels and the close proximity of the high marsh to an upland source of predators.

This project is designed to follow a line of investigation on the nesting potential of high marsh nesting birds. It is part of a larger series of investigations that also investigates the role of habitat change and other factors that may contribute to population declines. Specifically, the objective of this study is to determine the fate of nesting marsh birds in high marsh habitats in Virginia. In addition to natural nests of marsh birds we also implemented a simple artificial next experiment to help explain patterns of nest success and failure.

Methods

Nest Study Plots

We selected 6 marsh complexes in Accomac County, Virginia for study (Figure 1). Each marsh complex was divided into 2 separate parcels (study plots) for a total of 12 individual plots. All study plots were located entirely within the high marsh zone of these complexes. The high marsh is flooded infrequently by high spring tides and storms that create a boundary between the terrestrial shoreline and the low marsh zone. Vegetation of these marshes are dominated by Salt

Meadow Hay (*Spartina patens*), Olney's Three-square (*Scirpus americanus*) and Salt Grass, or Glasswort, (*Distichlis spicata*) often interspersed with shrub species such as Marsh Elder (*Iva frutescens*) or Saltbush (*Baccharis halmifolia*). Each study plot was bounded by approximately 10ha to help focus nest searching to a standardized area between plots. The length and width of each nest searching area varied between marshes to accommodate large marsh patches and narrow marsh patches. We used a variety of cues to find natural nests including observation of adult birds building nests, moving to nests for incubation or feeding, and short rope drags to flush birds.

Artificial nests were alternately placed in one of two study plots of each marsh complex. We used two rounds of artificial nest deployment identified as early (22 April to 26 April) and late (27 May to 6 June) so only one study grid of a marsh complex received either an early or late artificial nest deployment. Only one artificial next experiment was conducted on the Wallops Island Flight Facility due to timing of access. Both study plots of a marsh complex were searched for natural nests continuously while also visiting artificial nests over both the early and late phases of artificial nest experiments.

Each artificial nest study plot received 9 artificial nests containing 2 japanese quail (*Coturnix japonica*) eggs. Artificial nests were arranged in a 3x3 grid with 3 nests positioned parallel to the upland edge and 3 rows of nests running perpendicular to the upland edge and moving towards the shoreline at intervals of 50m (Figure 2). Artificial nests are composed of dead marsh grasses and designed to best mimic Clapper Rail nests by adding a slight dome to their construction. All nests were placed on the ground and within dense vegetation in a similar fashion that a Clapper Rail may nest. Latex gloves were used to handle all eggs and artificial nest material in attempt to reduce transfer of scent from field technicians.

All study plots were visited in a 7 or 8 day rotation so that each were visited 4 times in both early and late phase of the season.

Data Summary and Analysis

Nest outcome (predated or successful), total exposure days, and number of exposure days before depredation were calculated for all nests. Because study plots were visited in 7 or 8 day intervals, nests that were depredated between visits were considered to have failed on the midpoint day between visits (i.e, 3.5 days or 4 days since last visit depending on interval). Mayfield nest success was calculated for artificial nests (Mayfield 1971, 1975) so descriptive comparisons could be made to other studies. Nesting season is a primary parameter for Mayfield nest success estimation. We used a nesting season of 20 days for artificial nests to overlap the incubation period of Clapper Rail. The number of days of exposure before depredation was compared between study plots, early and late seasons, and distance from upland using appropriate parametric or nonparametric statistics where needed.

Figure 1. Location of marshes used for study (in red) and identified by name and landowner.

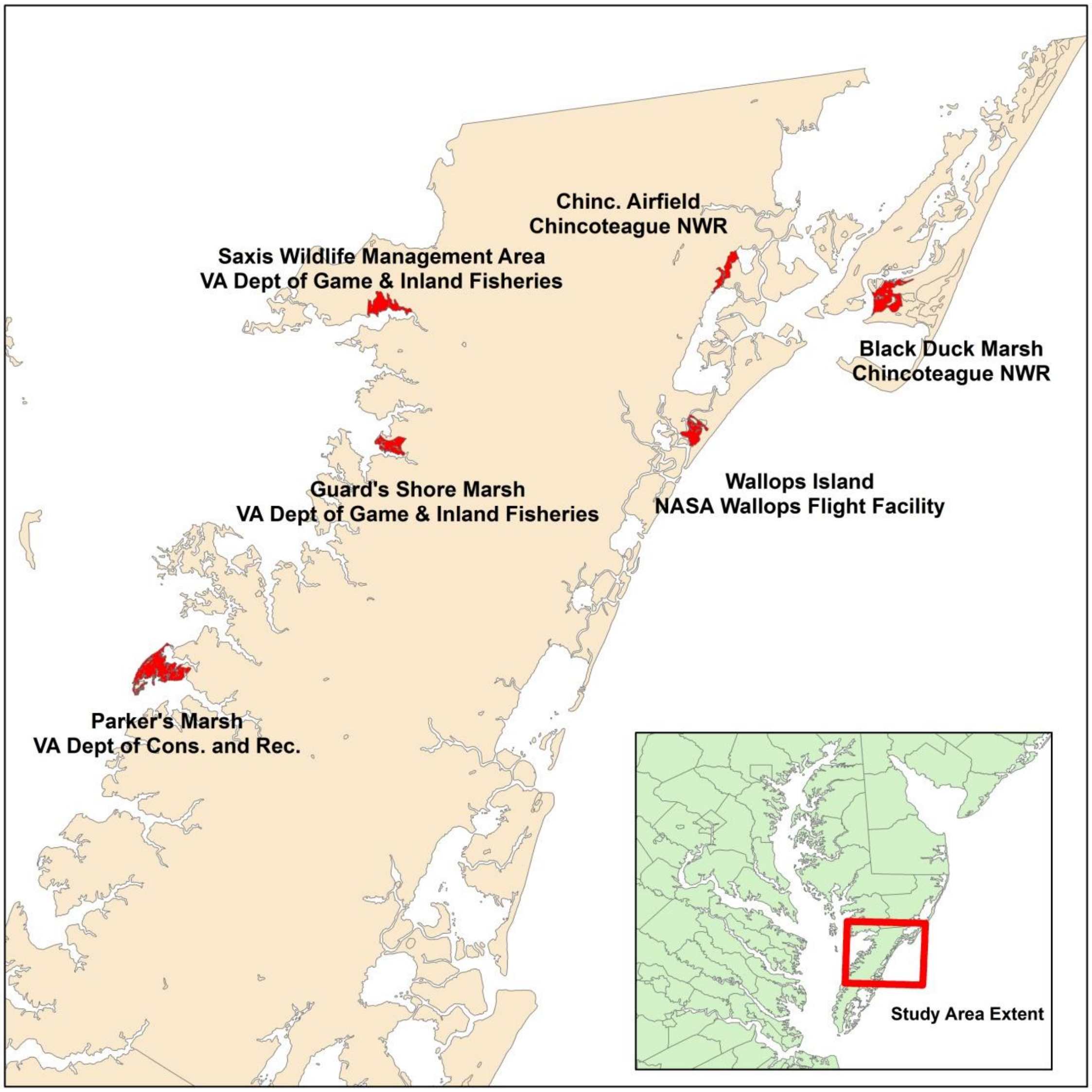
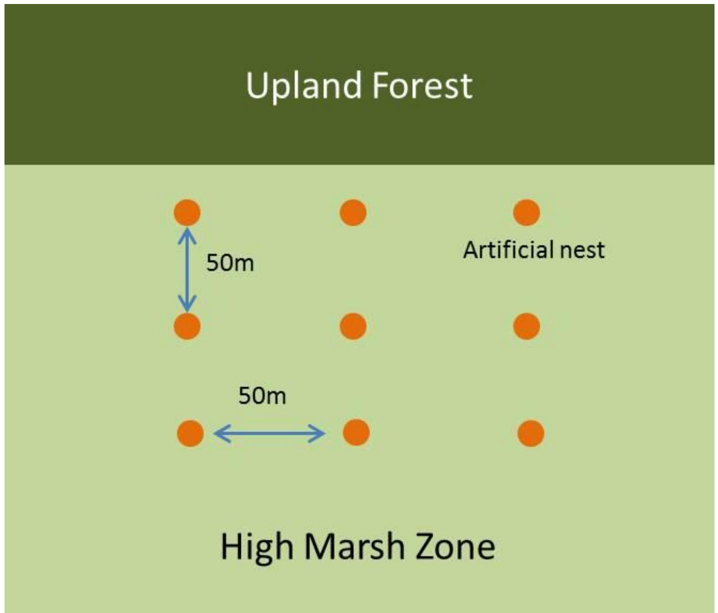


Figure 2. Generalized depiction of the artificial nest grid embedded within study plots.



Results

Artificial Nests

Predation rates on artificial nests were very high with 88 % of nests being depredated with less than 20 days exposure (Figure 3). Nearly 64 % of nests were lost to depredation within 7 days of exposure. The Mayfield Daily Survival Rate for artificial nests was 0.881. Using this rate, the survival probability for artificial nests in the study, given a 20 day incubation period, was 0.08.

The average number of exposure days before depredation was spatially variable between marsh patches (Kruskal Wallis ANOVA H=25.03, $P < 0.01$). Parkers Marsh and Saxis WMA had significantly longer periods of exposure before nests were depredated compared to other marshes used in the study (Figure 4). All artificial nests at Chincoteague Airfield and Wallops South were depredated upon the first visit after placement. The distance between the nest location and the terrestrial upland edge did not have a significant effect on exposure time before depredation (ANOVA, DF = 2, 96, F = 2.26, $P > 0.10$) (Figure 5).

The time of season had a significant influence on the average number of days of exposure before depredation (T-Test, T= 4.7, $P < 0.01$). The number of days before predation for nests placed before 26 April was two times greater than nests placed after 25 May (mean = 5.1 ± 4.9 SD, and 10.3 ±

Figure 3. Number of artificial nest depredated over exposure time. Total N = 99 nests.

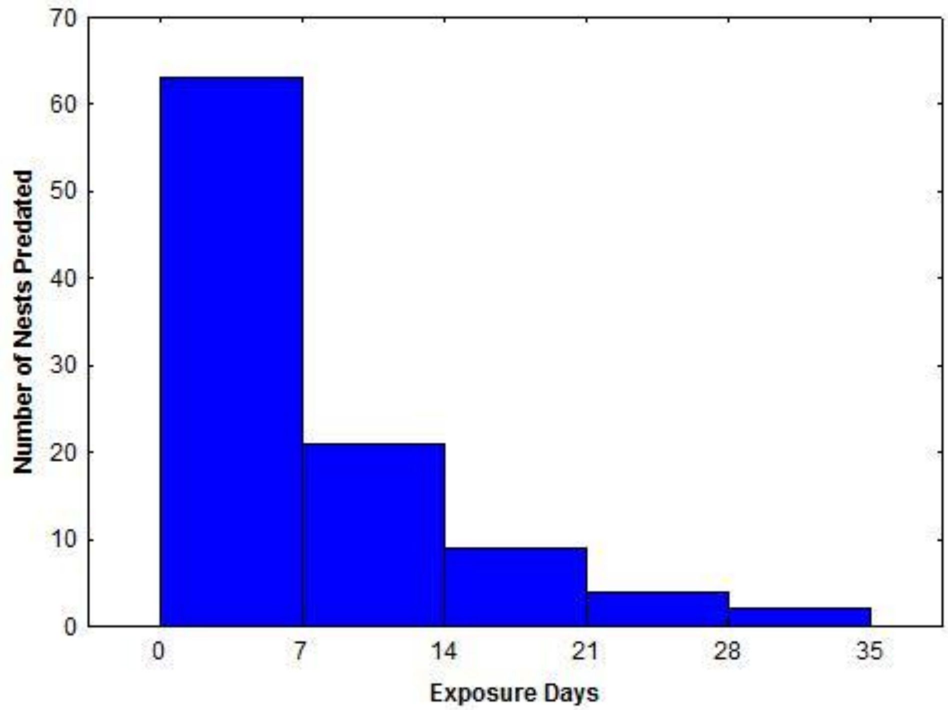


Figure 4. Average number of exposure days for nests before depredation across marshes used in the study.

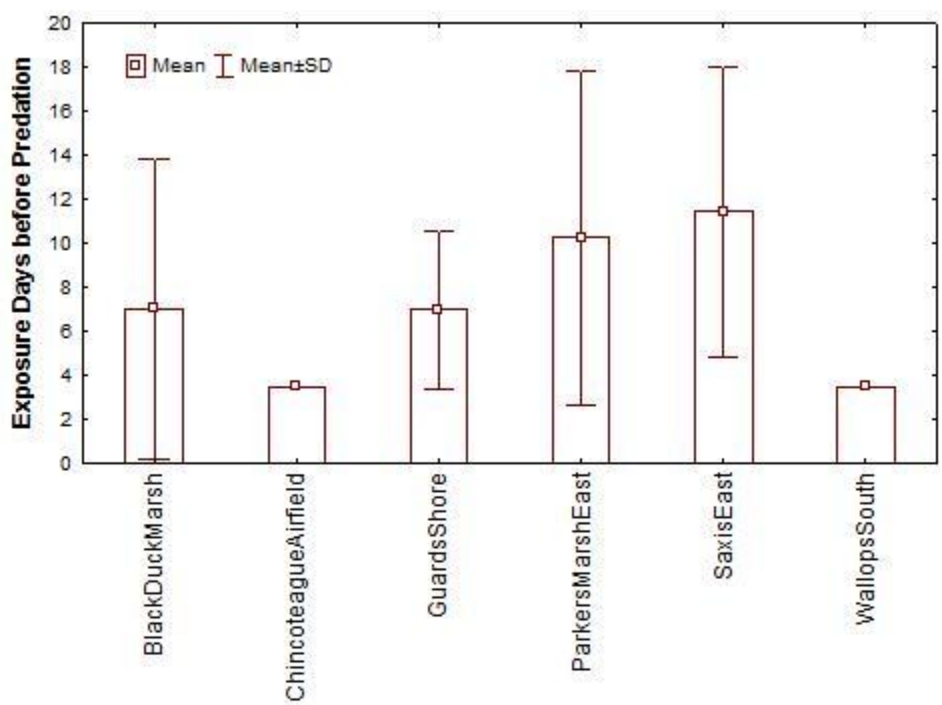
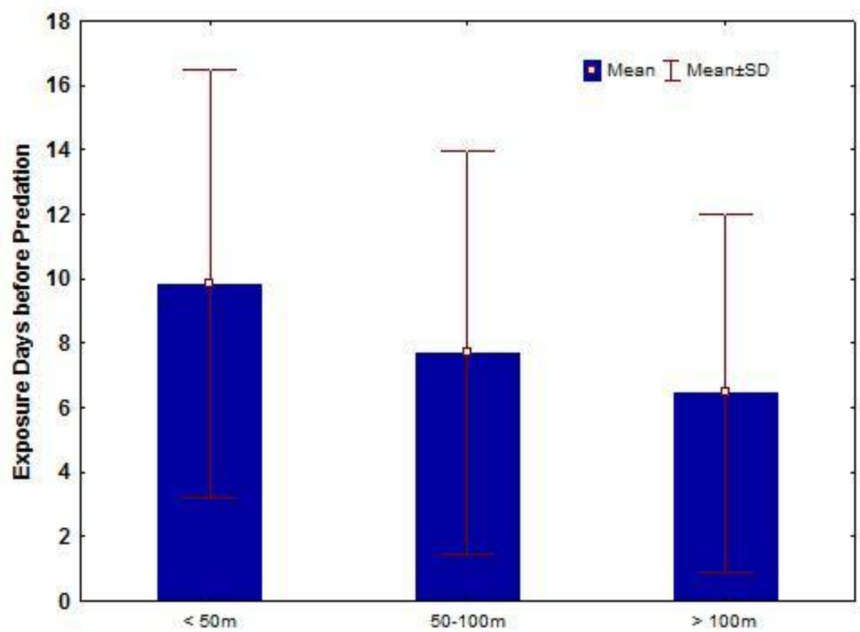


Figure 5. Average exposure days for nests before depredation as a function of distance from the upland edge.



6.8 SD, respectively). However a significant interaction term between season and marsh patch(Two-way ANOVA, F = 8.45, P < 0.01) indicated a seasonal result was not consistent among all study sites.

Marshbird Nest Monitoring

A total of 43 nests of 11 species were discovered and monitored during the study (Table 1). Sample sizes for each species are considerably low and not very beholden to analysis. There were also a large percentage of nests with an unknown fate. These are nests that were monitored for several visits but the final outcome was not certain. In some cases, nests were tracked to nestling stage and upon return the nest was empty, appeared to be undisturbed, but no fledglings were located in the vicinity following intensive searches. Fourteen of the nests categorized as having an unknown fate were brooding nestlings but nonetheless making a final determination of their final success without seeing fledglings can introduce bias not worth summarizing. Moreover, species such as the Willet are precocial so the young move from the nest soon after hatching.

The only species that deserves further discussion is the Seaside Sparrow. The majority of Seaside Sparrow nests had unknown outcomes. However the remaining 41% were tracked to final result with 2 known to be successful and 5 depredated. Placing a range for nest success from a low if all nests of unknown fate nests were not successful to a high if all unknown fate nests were successful suggests that Seaside Sparrows would have a probability of nest success ranging from 0.11 to 0.70.

Table 1. Number of marsh bird nests and final status during monitoring.

Species	**Number of nests discovered**	**Number of Successful Nests**	**Number of Nest Predated**	**Unknown Fate**
Canada Goose	2	1	1	-
Black Duck	1	-	1	-
Clapper Rail	1	0	0	1
Willet	5	1	1	3
Unknown Rail	2	-	-	2
Mourning Dove	1	-	-	1
Marsh Wren	1	-	-	1
Saltmarsh Sparrow	2	-	-	2
Seaside Sparrow	17	2	5	10
Eastern Meadowlark	1	-	-	1
Red-winged Blackbird	9	0	2	7
Unknown Species	1	-	-	1
Total	**43**	**4**	**10**	**29**

Discussion

Nest loss from predation is the principal factor contributing to reproductive failure in marsh nesting birds. Within tidal marshes, predation of nests has been recognized to have a greater influence on lowering nest success than flooding or other factors. Nest depredation rates for marsh birds have been reported to range from 30 to 90% of natural nests monitored during other studies (Conway et al. 1994, Schwarzbarch et al. 1998, Greenburg et al. 2006). Although we were not successful in accruing enough samples of natural nests of marshbirds for analysis, the artificial nest experiment designed for this study suggests that nest located in tidal high marshes on the Eastern Shore of Virginia may experience very high levels of predation.

Daily survival rates and overall nest success of artificial nests in this study (0.88 DSR and .07 nest success rate, respectively) suggest that the nesting potential of study marshes were substantially lower compared to other studies of naturally nesting marsh birds. Gjerdum et al. (2005) indicated that Seaside

Sparrows in Delaware Bay marshes experienced daily survival rates near 0.97 and overall success rates nearing 0.50. Similarly, Rush et al. (2010) reported daily survival rates of 0.98 and overall nest success of 0.53 for Clapper Rails in the Gulf of Mexico. Greenburg et al (2006) reviewed a number of studies and reported relatively high rates of nest success, ranging from 0.3 to 0.75 in the face of nest predation.

Rates of nest predation for artificial nests in this study provides a relative index of what may be expected for natural nests but direct comparisons between the two are difficult. In general, depredation rates on artificial nests appear to be greater than those experienced by natural nests when compared directly in experimental studies (Ortega et al. 1988, Wilson et al. 1998). Rates of nest depredation may be 30 to 50 % higher in some instances. There are many factors that can contribute to discrepancies between rates of predation and artificial nests including those induced by human construction and placement of nests. We used special care in the construction and placement of nests to both mimic natural Clapper Rail nests and reduce human exposure (e.g., scent) but there will likely always be some unknown affect that could bias results in a positive or negative direction.

Daily survival rates of artificial nests in this study and the average number of days of exposure before depredation indicate that bird species with long incubation periods may be at high risk of nest loss. The average number of days before depredation (mean = 7.4 ± 6.04) was less than half the length of time required by Clapper Rail, Virginia Rails, and Black Rails for full incubation (i.e. 17-20 days). It is possible that these species could be experiencing nest success rates of less than 20% across the study area if nest failure rates are even two times greater than artificial nests.

The relatively high rate of predation on artificial nests is not surprising given the ease of access for predators in high marsh habitats. Aside from episodic flooding events, the high marsh remains relatively dry during the nesting season. Picman et al. (1993) indicated that nest success of birds in marshes was inversely related to water levels. Bird nesting in deeper water habitats had higher nesting success than birds in dryer portions of the marsh. Picman further explained that this result was due to higher levels of mammalian nest predation on habitats with lower water levels. Mammalian predators could easily traverse the high marshes that we used in our study. Although we were not able to record what species were responsible for depredating artificial nests, the circumstantial evidence we witnessed that most nests were heavily disturbed in the process may indicate the result of mammalian predators. Other species may be likely as bird species such as American Crows, Fish Crows, Common Grackles, and Marsh Wrens are often recognized as nest predators in marsh environments (Jobin and Picman 1997).

Although nest predation is often suggested to be the most important limiting factor to nest success of marsh birds, the relative contribution of tidal flooding should not be ignored. The Chesapeake Bay is currently undergoing sea-level rise rates that are two times greater than other coastlines in the world (Douglas 1991). Birds in tidal marshes are experiencing greater levels of flooding in terms of duration and height than in previous decades. Tidal flooding does have the potential to contribute substantially to nest failures in the Chesapeake Bay region and deserves more attention. Marsh flooding was shown to be of greater importance to nest failures of Clapper Rails nesting in low marshes in the Gulf of Mexico (Rush et al. 2010) and from a few studies on Saltmarsh Sparrows in the Delaware Bay (Greenburg et al. 2006). The increase in tidal flooding has been suggested to be a reason for site abandonment of Laughing Gulls in the Virginia Barrier-Island lagoon system (Watts unpublished data). Most high marsh sites in this study experienced at least one extreme flooding event. However there was no indication that flooding negatively affected artificial nests.

The low number of natural nests discovered severely limits any direct inferences on the relative contribution of predation on nesting potential. In future studies, more emphasis could be placed on finding natural nests by increasing the number of field technicians or decreasing the number of sites each person is responsible for searching for nesting activity.

Acknowledgements

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