Flooding and Sea Level Rise at Waterbird Colonies in Virginia

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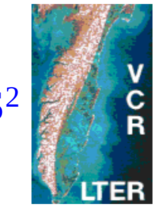

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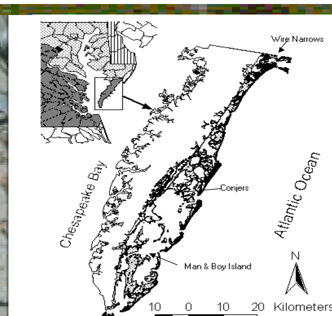


Figure 1. Map of the eastern shore of Virginia with locations of study shellpiles

Abstract

Rising sea levels in the mid-Atlantic region pose a long-term threat to marshes and their avian inhabitants. Gull-billed Terns (*Sterna nilotica*), Common Terns (*S. hirundo*), Black Skimmers (*Rynchops niger*), and American Oystercatchers (*Haematopus palliatus*) nest on low, shell edges of salt marsh islands in coastal Virginia. Marsh shellpiles are free of mammalian predators, but subject to frequent floods that reduce reproductive success. Previous studies of these species suggested that elevation was an important nest-site determinant (Lauro and Burger 1989). To test this, we created twenty-eight 4m^2 elevated shell plots, with matched controls, at 5 shellpile sites to examine habitat selection. We monitored nest-site choice and fate of each species from May 1 to August 1, 2002. Forty-seven percent of early season nests were destroyed during a flood on June 7. Only 4% of late season nests were lost to floods. Only 5% of pairs of all species nested in elevated plots, although the plots were immune from flooding. Common Tern nests were significantly lower in elevation than random points at 3 shellpiles and were often on low-lying areas exposed to open water. Common Terns had higher hatching success at higher elevations, and in the late season. Gull-billed Terns, Black Skimmers, and American Oystercatchers primarily chose sites at higher elevations in areas protected from flooding; however 56% of Gull-billed Tern nests were flooded at one site. Flooding has a significant impact on waterbird breeding success on low-lying shellpiles and is likely to increase with rising sea levels; however, our experiment met with limited success in improving breeding success. We suspect previous experience at sites may bias nest-site choices.

Introduction

Because of growing mammalian predator populations on barrier islands, and frequent flooding events in salt marshes, safe nesting sites for waterbirds are limited in coastal Virginia (Erwin et al. 2001). Shellpiles on salt marsh islands provide a haven from mammalian predators, and are slightly higher than surrounding marsh, but flooding during the breeding season may be frequent and cause breeding failure (Eyler et al. 1999). Gull-billed Terns, Common Terns, Black Skimmers, and American Oystercatchers are all species of concern in Virginia and other Atlantic states. Habitat enhancement by manipulation of nesting sites may provide one simple way to reduce the frequency of flooding, and to refine methods to develop and/or protect colony sites during times of higher sea levels. The objectives of this project are to determine: (1) how four species of waterbirds differ in their nest-site choices, (2) whether manipulation of habitat elevation influences nest-site choice, and (3) whether manipulation of habitat elevation can improve reproductive success.

Methods

We conducted the study at 5 marsh shellpiles from Chincoteague to Oyster, Virginia (Figure 1) from March to August 2002. In early spring, we created twenty-eight 4m^2 elevated plots, with matched controls, using in situ oystershells. Elevated plots (ranged 9 to 32 cm above control) were created adjacent to control plots, so that elevation was the only differing variable. Twenty-five random points were also established at each shellpile. I monitored the shellpiles twice a week for nesting activity from May 1, 2002 to August 1, 2002. All nests were individually marked and I recorded the species, content of the nest, substrate, level of exposure to open water, and presence of nearby vegetation during each visit. Empty nests were examined for evidence of flooding or predation. The elevation of all plots, random points, and nests were measured using a total station GPS. Statistical analyses included t-tests, chi-square, Fisher's Exact test, and a multiple logistic regression to evaluate the relative importance of elevation, date of nest-initiation, clutch size, and nearest-neighbor distance to hatching success.

Results

Experimental Plots

Use of experimental plots for nesting was low at all shellpiles, ranging from 2% to 19% of nests (Table 1). However, 28% of Gull-billed Tern nests at one shellpile were found on experimental plots. At all five shellpiles, nesting birds did not select experimental plots as nest sites at different frequencies than expected based on area alone (Table 1).

Experimentally elevated plot

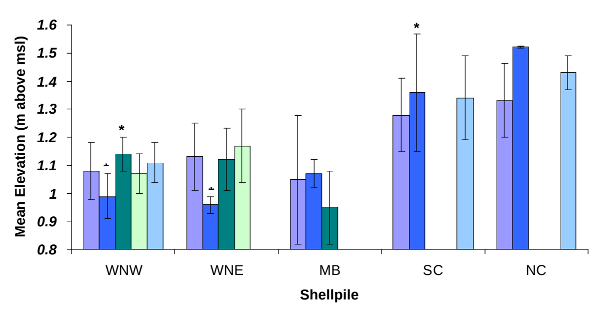


Figure 2. Nest elevation (mean ± 1 SD) vs. random point (RP) elevation at 5 shellpiles for Common Terns (COTE), Gull-billed Terns (GBTE), Black Skimmers (BLSK), and American Oystercatchers (AMOY). Shellpile codes: WNW = Wire Narrows West, WNE = Wire Narrows East, MB = Man & Boy, SC = South Conjers, NC = North Conjers.
*Indicates significant difference(P<.01) from random point elevations.

Table 1. Number of nests in experimental plots for 4 waterbird species and area of habitat flooded at 5 shellpile sites.

Site	Total no. of nests	% of total nests	No. of early nests	No. of late nests	% nests in plot*	% random points in plots	Area flooded (m^2)	% used habitat flooded
Wire Narrows West	19	6	9	10	6	4	142	42
Wire Narrows East	4	2	0	4	2	8	66	38
Man & Boy	5	3	2	3	3	4	66	22
South Conjers	8	8	4	4	8	12	30	29
North Conjers	2	7	2	0	7	4	16	32

*There were no differences in frequencies of random points or nests in plots at any site based on chi-square analysis

Nest Elevation

Common Tern nests were only significantly higher than random points at 2 sites (Figure 2), which accounted for only 20% of all Common Tern nests. Eighty percent of Common Tern nests, therefore, were either of similar elevation to random points or lower. At 3 shellpiles late Common Tern nests were significantly higher than early nests (Figure 3). Gull-billed Tern nests were significantly higher than random points at one colony, and lower at another colony, though not significantly. Black Skimmer nests were not different in elevation than random points. American Oystercatcher nests were, on average, higher than random points at all sites, although not significantly (Figure 2). Elevation had a significant positive effect on hatching success for Common Terns at all shellpiles except North Conjers (Table 2). At 3 shellpiles, however, hatching success was improved only in early nests. Hatching success of Black Skimmers and Gull-billed Terns was not significantly affected by nest elevation.

Flooding and Hatching Success

One major episode of flooding occurred between June 7 and June 14. During this time 47% of all the nests on all shellpiles were flooded. This flood had major effects for all species (Figure 4) and on all 5 sites. Wire Narrows West suffered the largest amount of colony habitat flooded, while Man & Boy had the smallest area flooded (Table 1). Because the major flood occurred early in the season, hatching success was much higher in the late season (Figure 5). For all sites and species, regression results revealed that elevation was the most important variable explaining hatching success. Season was also important for Common Terns at all sites, while clutch size and nearest-neighbor distance were significant at 2 sites each. Clutch size was also a significant variable explaining Gull-billed Tern hatching success.

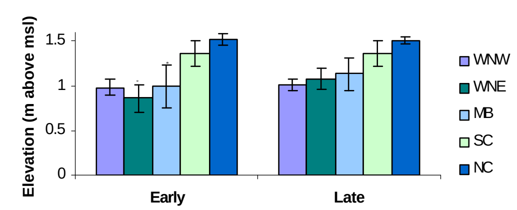


Figure 3. Common Tern nest elevation (mean ± 1 SD) at 5 shellpiles (see Fig. 2 for sites codes) : early vs. late nests. * Significant difference between early nest elevation and late nest elevation. Early nests are significantly lower than late nests. WNW: T=-2.93,P=.004, n=187 nests; WNE: Wilcoxon Z=7.73, P<.001, n=139 nests; MB: Wilcoxon Z=-3.82, P<.001, n=153 nests.

Discussion

• Experimentally elevated plots were not preferentially selected for at any of the shellpiles or by any species, despite the extra protection from floods elevated plots provided to nesting birds. A number of other factors involved in nest-site selection could explain this including substrate, vegetation and previous experience at specific nesting sites.

North Conjers Shellpile

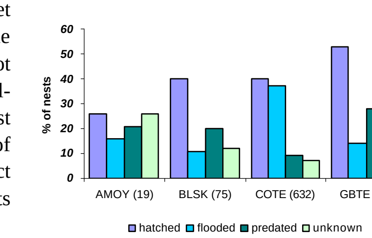
• Because Common Terns did not select nest sites based on higher elevations, elevated plots were not selected preferentially. Common Terns selected nest sites on wrack and near vegetation in low-lying areas of the shellpile, which may have contributed to the small number of Common Tern nests on elevated plots. Paradoxically, the most important predictor of Common Tern hatching success was nest elevation, even though elevation did not appear to be the most important factor in nest-site selection.

• Gull-billed Terns may have been primarily selecting sites based on previous nesting experience at these shellpiles. For example, at one site Gull-billed Terns established nests in the same area that was occupied in 2001.

• Black Skimmer nest-site selection was probably primarily influenced by the location of already-established tern nests (Erwin 1977, Pius and Leberg 1997). Black Skimmers primarily nested in the higher shell areas that were used by both Gull-billed Terns and Common Terns.

• Overall, providing small elevated plots for nests met with limited success. The elevated plots did not provide the habitat preferred by Common Terns, and may not have been located in areas previously used by Gull-billed Terns. The elevation of a nest had the most influence on its success. Despite this, the majority of nesting pairs of all four species did not select experimentally elevated plots for nest sites. Late nests had higher hatching success than early nests at most shellpiles, primarily because the major flooding occurred in early June. Also, Common Terns showed a tendency to renest in higher sites later in the season.

Figure 4. Nest Outcomes combined for all shellpiles. (n)



Management

Because elevation is important to nesting waterbirds in low salt marsh habitats, especially with rising sea levels in many regions, we maintain that habitat enhancement may still be effective in increasing nesting success if a combination of wrack and shell material is used over larger, previously used areas.

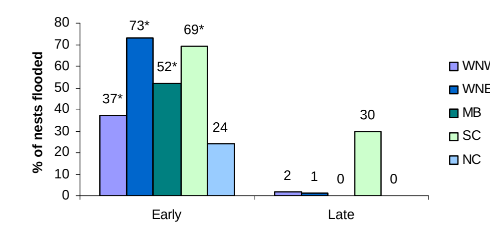


Figure 5. Flooding in early and late nesting seasons at 5 sites. *Results from chi-square analysis on contingency table. WNW ?2=52.15, P<.001, n=309; WNE ?2=89.77, P<.001, n=177; MB ?2=52.96, P<.001, n=178; SC ?2=14.96, P<.001, n=99. There was no significant difference for NC.

Table 2. The effect of elevation on hatching success on 3 species of waterbirds.

Site	Species	Mean Elevation (m ± 1 S.D.) (n) Hatched	Mean Elevation (m ± 1 S.D.) (n) Failed	
Wire Narrows West				
	COTE	1.02 ± .07 (83)	0.97 ± .08 (90)	**
	GBTE	1.13 ± .06 (39)	1.18 ± .07 (8)	*
	BLSK	1.07 ± .07 (26)	1.06 ± .06 (28)	ns
Wire Narrows East				
	COTE	1.08 ± .11 (57)	0.9 ± .16 (52)	**
Man & Boy				
	COTE	1.14 ± .18 (72)	0.97 ± .25 (69)	**
South Conjers				
	COTE	1.41 ± .12 (34)	1.32 ± .15 (54)	**
North Conjers				
	COTE	1.52 ± .07 (9)	1.5 ± .05 (12)	ns

Analyzed with a logisitc regression looking at the effects of elevation on hatching success.
* WNW-GBTE ?2=4.7, P=.03. Decreased hatching success with increasing nest elevation.
** WNW-COTE: ?2=19.1, P<.001; WNE-COTE ?2=27.1, P<.001; MB-COTE ?2=15.8, P<.001; SC-COTE ?2=7.19, P<.001. All show increased hatching success with increasing nest elevation.

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Acknowledgements

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