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Created Versus Natural Coastal Islands: Atlantic Waterbird Populations, Habitat Choices, and Management Implications

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ABSTRACT: Nesting colonial waterbirds along the Atlantic Coast of the United States face a number of landscape-level threats including human disturbance, mammalian predator expansion, and habitat alteration. There have been changes from 1977 to the mid-1990s in use of nesting habitats and populations of a number of seabird species of concern in the region, including black skimmers *Rynchops niger* Linnaeaus, common terns *Sterna hirundo* Linnaeaus, gull-billed terns *Sterna nilotica* Linnaeaus, least terns *Sterna antillarum* Lesson, royal terns *Sterna maxima* Boddaert, and sandwich terns *Sterna sandvicensis* Cabot. These species form colonies primarily on the following habitat types: large, sandy barrier or shoal islands, natural estuarine or bay islands (mostly marsh), man-made islands of dredged deposition materials (from navigation channels), and the mainland. Significant changes in the use of the dredged material islands have occurred for these species in New Jersey and North Carolina, but not in Virginia. Population declines and changes in bird habitat use appear to be at least partially associated with the conditions and management of the existing dredged material islands, coastal policy changes associated with creating new dredged material islands, and competing demands for sand for beach augmentation by coastal communities. As these and other coastal habitats become less suitable for colonial waterbirds, other man-made sites, such as bridges and buildings have become increasingly more important. In regions with intense recreational demands, coastal wildlife managers need to take a more aggressive role in managing natural and man-made habitats areas and as stakeholders in the decision-making process involving dredged materials and beach sand allocation.

Introduction

Global concern for the population status of many species of colonially nesting waterbirds has often centered on habitat degradation and its many causes (Croxall et al. 1984; Nettleship et al. 1994; Tucker and Evans 1997). This group of birds includes a number of diverse seabirds such as albatrosses, petrels, boobies, cormorants, gulls, and terns that typically nest on islands on the ground in colonies (Palmer 1962; Nelson 1979). Along the Atlantic Coast of the United States, ground-nesting waterbirds face an increasing number of threats associated with the growth of human populations and the associated disturbances (Erwin 1979, 1980; Buckley and Buckley 1980; Culliton et al. 1990). Except for double crested cormorants *Phalacrocorax auritus* and the large gull species that continue to increase in many states, concerns by state resource managers have been expressed since the early 1980s for many ground-nesting species including black skimmers *Rynchops niger,* common terns *Sterna hirundo,* gull-billed terns *Sterna nilotica,* least terns *Sterna antillarum,* royal terns *Sterna maxima,* and sandwich terns *Sterna sandvicensis.* As many of the larger barrier islands have been developed, disturbed by recreationists and their pets, or invaded by mammalian predators or competing gulls, optimal habitats have declined for these species as have their populations (Buckley and Buckley 1980; Erwin 1980; Burger and Gochfeld 1990, 1991; Erwin et al. 2001). As new habitats have been created, for example by depositing dredged material from navigation channels, many of these species shifted from barrier island sites to these small dredged material islands along the intracoastal waterways from New York south to Florida and west to Texas (Soots and Landin 1978; Parnell and Soots 1979). Since the early to mid 1980s, maintenance of these dredged islands has been substantially reduced in all states (Allen and Jenkins personal observations; Truitt personal communication).

We focus on the differential use of these major habitat types, especially examining the role of dredged material islands for 1977 and 1993–1995. We examine changes in nesting populations and numbers of colonies during this 16–18-yr period.

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Because of the changing demands for dredged sand for beach communities and the limited resources for state management agencies to effectively maintain wildlife habitat on these dredged material islands, concerns have been voiced about the long-term population viability of many of these colonial waterbirds (Parnell and Shields 1990; Burger and Gochfeld 1991; Erwin 1996). The primary null hypothesis is that there has been no change in the use of these nesting habitat types relative to their availability over time by terns and black skimmers.

Materials and Methods

Study Sites

We examined the nesting populations of waterbirds along the coasts of New Jersey, Virginia, and North Carolina of the eastern U.S. The vast majority of these species' populations in the Mid-Atlantic region nest in this coastal region (Erwin 1979).

Data Collection

Data on the 6 species listed above were compared with 1977 breeding colony surveys supported by the United States Fish and Wildlife Service (Erwin 1979; Erwin and Korschgen 1979) for New Jersey and Virginia; in North Carolina, similar colony surveys were conducted at the same time (Parnell and Soots 1979). In all areas, fixed wing aerial surveys were conducted at 100–200 m altitude covering all beach segments, with one observer recording data using tape recorders and topographic maps. Aerial surveys were conducted in May to locate colony sites and take photographs of habitats. Following these surveys, boat and walking surveys were conducted in late May and June to estimate numbers of birds by species. Except for very small colonies (<50 nests) where all nests could be recorded, estimates were made by counting incubating adults as pairs using binoculars at distances of 50–150 m from the colony perimeter. In some cases where visibility was difficult, birds were flushed from nests and estimates of total numbers of adults (those in the air and those remaining on the ground) were recorded on field forms. Species correction factors were then used to convert the number of adults estimated to numbers of pairs (see below, Erwin 1979). Where there were two or more estimates made at a single colony, we used the maximum estimate made during June, considered to be the peak of nesting in this region.

For the 1990s data, the most comparable (i.e., similar time period, aerial and ground methods used, and level of effort) data sets we could obtain for all three states were in 1993 in Virginia (Watts 1994), and 1995 for New Jersey (Jenkins unpublished reports) and North Carolina (Allen unpublished reports). The recent survey data in Virginia and North Carolina were reported as numbers of nesting pairs, but in New Jersey, data were reported as breeding adults. We converted the New Jersey data, i.e., number of adults to nesting pairs, using the same correction factors as were used in the 1977 (Erwin 1979); for common and gull-billed terns, $\times$ 0.66, for black skimmers, $\times$ 0.5, and for least terns, $\times$ 1.0. Every two black skimmers counted in the air represents an average of one nesting pair found on the ground, whereas for least terns, every tern counted in the air averages one nest found on ground surveys.

Nesting habitats were divided into 4 primary types: barrier islands and shoals in or adjacent to inlets, natural estuarine islands in the bays behind the barrier islands (mostly salt marsh), dredged material (man-made) island, and mainland. Actual nesting substrates within a habitat type may vary considerably, but we focus on the general macrohabitat distribution.

We conducted $n \times 2$ χ^2 contingency table analyses to compare the changes in habitat associations (range from two to four habitat types) between the 1977 and mid-1990 periods. These were performed separately in each state where species data were sufficient. States were analyzed separately because of the different geographic, land management, and disturbance histories among the three (e.g., Erwin 1980).

Results

With respect to habitat distribution shifts, both New Jersey and North Carolina revealed rather marked changes (Fig. 1, Tables 1–3). Both the total abundance of breeding birds and their relative abundance on dredged material islands declined in both states. The number increased in barrier island use in New Jersey (Table 1) and natural estuarine island use in North Carolina (especially gull-billed and royal terns, Table 3). In New Jersey, use of mainland habitats and natural estuarine islands declined, mostly due to declines in common terns (Table 1). In Virginia, where the vast majority of the barrier islands are undeveloped and not accessible to the public, nesting remained predominantly on the barrier islands. Regional shifts away from the ocean coast have taken place since the 1980s.

Chi-squared contingency table analyses for each species resulted in significant ($p < 0.01$) values for New Jersey (χ^2 value range 757–1,749, df = 2; all species except gull-billed tern tested), Virginia (black skimmer, 110.3; common tern, 10.1, df = 2), and North Carolina (range 135–2,569, df = 2 for all species except least tern where df = 3; sand-

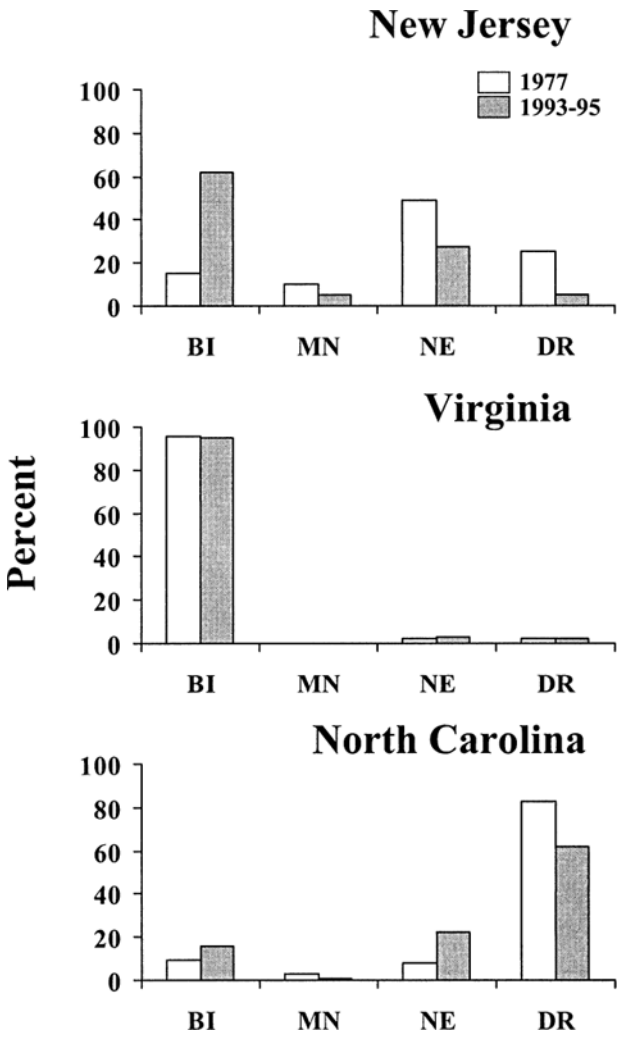

Fig. 1. The distribution of nesting terns and black skimmers among barrier islands (BI), mainland (MN), natural estuarine islands (NE), and dredged material islands (DR), in New Jersey, Virginia, and North Carolina, 1977 and 1993–1995.

wich tern not tested) resulted in p values < 0.01 (usually $p < 0.0001$).

Populations of these waterbirds declined in all three states between 1977 and the 1993–1995 period, with New Jersey experiencing a total 14% decline, Virginia, a 37% decline, and North Carolina, a 24% decrease (Tables 1–3). In Virginia, the large-scale decline of some species such as common and royal terns along the ocean barrier beaches is compensated by large increases in the Chesapeake Bay portion of the state (Table 4). In coastal Virginia and North Carolina, 5 species declined and one increased, whereas in New Jersey, two increased and two declined. Some species consistently declined across states, such as common, royal, and gull-billed terns, while others such as least terns and black skimmers increased in New Jersey, but decreased in the other two states. Sandwich terns increased quite considerably in North Carolina. Change in the number of colonies was not a good indicator of population status, as colony number appeared to increase in states where populations were strongly declining (e.g., common terns in New Jersey and Virginia; Tables 1 and 2). Only in North Carolina did changes in colony number appear to parallel those in population numbers. Number of colonies appeared to increase most dramatically for black skimmers and common terns in New Jersey and Virginia, and least terns and gull-billed terns in Virginia. In North Carolina, none of the species of interest here showed an increase in number of colonies from 1977 to 1995.

Discussion

The concern for coastal wildlife populations in the face of increasing human pressures along the Atlantic Coast has been widely recognized (Erwin 1980; Myers et al. 1987; Burger and Gochfeld 1990, 1991; Clark 1991) and solutions often center on habitat management. Our results suggest that between 1977 and the mid-1990s in Mid-Atlantic

TABLE 1. Nesting distribution (pairs of birds, with number of colonies in parentheses, percent of total birds in brackets) of terns and black skimmers by habitat type comparing 1977 with 1995 in coastal New Jersey. Data for 1977 from Erwin and Korschgen (1979); data for 1995 from field records (Jenkins unpublished).

Species	Year	Habitat Type				Total
		Barrier	Mainland	Natural Estuarine	Dredged Material	
Black Skimmer	1977	335 (2) [35]	0	64 (8) [7]	550 (3) [58]	949 (13)
	1995	1,131 (4) [84]	0	133 (7) [10]	82 (9) [6]	1,346 (27)
Common Tern	1977	295 (2) [7]	420 (4) [9]	3,445 (29) [77]	302 (9) [7]	4,462 (44)
	1995	876 (6) [33]	0	1,564 (37) [58]	236 (10) [9]	2,676 (53)
Gull-billed Tern	1977	0	0	19 (4)	0	19 (4)
	1995	0	0	6 (1)	0	6 (1)
Least Tern	1977	489 (6) [27]	325 (3) [18]	0	972 (9) [54]	1,786 (18)
	1995	1,860 (16) [84]	342 (2) [16]	0	0	2,202 (18)
Total	1977	1,119 [15]	745 [10]	3,528 [50]	1,824 [25]	7,216
	1995	3,867 [62]	342 [6]	1,703 [27]	318 [5]	6,230

TABLE 2. Nesting distribution (pairs of birds, with number of colonies in parentheses, percent of total birds in brackets) of terns and black skimmers by habitat type comparing 1977 with 1993 on the Eastern Shore of Virginia. Data for 1977 from Erwin and Korschgen (1979), Williams et al. (1990), and the Virginia Coast Reserve—The Nature Conservancy (Truitt unpublished records); data for 1993 from Watts (1994).

Species	Year	Habitat Type				Total
		Barrier	Mainland	Natural Estuarine	Dredged Material	
Black Skimmer	1977	2,595 (14+)[a] [98]	0	59 (2) [2]	0	2,654 (16+)
	1993	1,893 (19) [93]	0	61 (4) [3]	82 (2) [4]	2,036 (25)
Common Tern	1977	3,074 (14+)[a] [88]	0	198 (3) [6]	198 (3) [6]	3,470 (19+)
	1993	1,182 (27) [90]	0	79 (9) [6]	52 (3) [4]	1,313 (39)
Gull-billed Tern	1977	720 (9+)[a]	0	—[b]	—[b]	720 (9+)
	1993	503 (17)	0	61 (6)	42 (3)	606 (26)
Least Tern	1977	1,013 (7+)	0	0	0	1,013 (7+)
	1993	625 (27)	0	0	0	625 (27)
Royal Tern	1977	4,600 (1)	0	0	0	4,600 (1)
	1993	3,300 (2)	0	0	0	3,300 (2)
Sandwich Tern	1977	5 (1)	0	0	0	5 (1)
	1993	30 (2)	0	0	0	30 (2)
Total	1977	12,007 [96]	0	257 [2]	198 [2]	12,462
	1993	7,533 [95]	0	201 [3]	176 [2]	7,910

[a] Colony boundaries on barrier islands were designated differently by different observers in 1977 and 1993, so colonies were often lumped in 1977, resulting in fewer being listed.

[b] Indicates that surveys for the species in these habitats were not comprehensive, and may have missed some active colonies.

coastal estuaries, changes have occurred that resulted in reduced suitability of dredged material islands, and barrier islands in some areas, for beach-nesting species. Our experience in these areas suggests that several factors conspire against the welfare of this guild of waterbirds.

Dredging policy of the U.S. Army Corps of Engineers has changed as a result of consultation among local officials, and state and federal natural resource agencies. In the 1970s, many dredged material islands were created by adding unconfined material to bay bottoms adjacent to intracoastal waterway channels (Soots and Landin 1978). The result was a series of sandy, gradually sloped small (most < 10 ha) islands with open sand and shell. These were especially attractive to nesting terns and black skimmers. After the early 1980s, concerns with loss of fish spawning habitat resulted in a policy shift in which permits to build new islands were much more difficult to obtain in most states. New sites often required diking and become known as Confined Disposal Facilities, or CDFs. These CDFs often created high steep sides, were invaded by *Phragmites australis,* and were not attractive to ground-nesting birds (Soots and Landin 1978).

Islands that were used by these species in the 1970s became less attractive through time as vegetation succession resulted in establishment of dense grasses and woody vegetation (Parnell and

TABLE 3. Nesting distribution (pairs of birds, with number of colonies in parentheses, percent of total birds in brackets) of terns and black skimmers by habitat type comparing 1977 with 1995 in coastal North Carolina. Data for 1977 from Parnell and Soots (1979); data for 1995 from field records (Allen unpublished).

Species	Year	Habitat Type				Total
		Barrier	Mainland	Natural Estuarine	Dredged Material	
Black Skimmer	1977	664 (7) [34]	0	29 (3) [2]	1,232 (16) [64]	1,925 (26)
	1995	517 (13) [68]	0	70 (3) [9]	174 (2) [23]	761 (18)
Common Tern	1977	1,008 (8) [20]	0	618 (16) [13]	3,270 (27) [67]	4,896 (51)
	1995	1,025 (12) [60]	0	213 (10) [13]	461 (2) [27]	1,699 (24)
Gull-billed Tern	1977	96 (4) [15]	0	1 (1) [<1]	524 (16) [84]	621 (21)
	1995	88 (5) [35]	0	33 (2) [14]	128 (3) [51]	249 (10)
Least Tern	1977	896 (11) [38]	79 (3) [4]	22 (1) [1]	1,349 (30) [57]	2,366 (45)
	1995	1,549 (22) [89]	77 (4) [4]	0	107 (5) [7]	1,733 (31)
Royal Tern	1977	0	0	1,392 (2) [8]	15,316 (9) [92]	16,708 (11)
	1995	0	0	4,334 (2) [31]	9,816 (5) [69]	14,150 (7)
Sandwich Tern	1977	0	0	94 (1) [5]	1,847 (5) [95]	1,941 (6)
	1995	0	0	247 (1) [10]	2,658 (5) [90]	2,905 (6)
Total	1977	2,664 [9]	79 [<1]	2,156 [8]	23,538 [83]	28,437
	1995	3,179 [15]	77 [<1]	4,897 [23]	13,344 [62]	21,497

TABLE 4. Shift in nesting distribution of common and royal terns from ocean coastal islands to Chesapeake Bay islands in Virginia, 1977–1993. Numbers of pairs and percentages in parentheses.

Species	Year	Ocean Coast	Chesapeake Bay	Total
Common Tern	1977	3,470 (98)	86 (2)	3,556
	1993	1,313 (45)	1,605 (55)	2,918
Royal Tern	1977	4,600 (100)	0	4,600
	1993	3,300 (52)	3,046 (48)	6,346

Soots 1979; Soots and Landin 1979). Other species such as gulls, brown pelicans *Pelecanus occidentalis,* and wading birds then invaded these habitats. Gulls in particular have expanded and usurped many colony sites that might still be suitable for nesting terns and skimmers (Erwin 1979; Buckley and Buckley 1980; Croxall et al. 1984; Burger and Gochfeld 1990, 1991). Limited resources in most coastal states including North Carolina and New Jersey precluded any major habitat management to encourage continued use by terns and skimmers (Allen and Jenkins personal observations).

Independent of the issues concerning dredged material islands, the increase in mammalian predators on barrier islands appears to be a growing concern among wildlife biologists and managers in many states along the Atlantic Coast. In Virginia, red fox *Vulpes vulpes* and raccoon *Procyon lotor* expansion along the barrier islands in the past 20 years has reduced the attractiveness of many barrier islands for waterbirds (Erwin et al. 2001). Even though the relative distribution of waterbirds among habitats in Virginia has changed little (Fig. 1), the overall populations have declined markedly for most terns and skimmers. Norway rats *Rattus norvegicus,* have also caused serious problems for nesting waterbirds in New Jersey, North Carolina, and elsewhere. One result has been a recent (1995–2001) increase in rooftop nesting by least terns in New Jersey and North Carolina (Jenkins and Allen unpublished data). A second consequence appears to be the fractionation of large colonies into more numerous smaller ones, as indicated by several terns and skimmer species in New Jersey and Virginia (Tables 1 and 2). Such an effect was also noted by Butler and Vennesland (2000) in heron colonies in western Canada. While there may be some reduction in risk by having more colonies, an undesirable conservation outcome might be a reduction in fecundity with smaller colonies (Nelson 1979). A third consequence may have been a large-scale shift from the outer coast to the Chesapeake Bay in Virginia (Table 4). The largest common tern colony in Virginia during the past decade now occupies an artificial island: the man-made Hampton Roads Bridge Tunnel. From 1998 to 2001, more than 3,000 pairs occupied the former parking lot at the facility, with smaller numbers of black skimmers and gull-billed terns (Erwin et al. 2001). Only 6 dredged material islands exist along the eastern shore of Virginia, with only 5 of these being potentially suitable for terns; it appears that good alternative nesting habitat may be limiting.

One must exercise caution in interpreting population results based on only two time periods, as these populations may vary considerably (Erwin 1979; Williams et al. 1990). The population declines we report during the mid 1990s do represent a trend that continues to the present (Truitt unpublished data). Estimates for common, least, and gull-billed terns and black skimmers continue to be at or below the 1993 estimates in Virginia (Truitt unpublished data) and the 1995 estimates in North Carolina (Allen unpublished data). In New Jersey, estimates for these species seem to be similar to those reported in 1995 (Jenkins unpublished data).

Management Implications

Conflict appears to occur among wildlife needs and those of coastal resort communities in some areas (Erwin 1996). Demands by coastal communities for dredged sands for outer beach nourishment or augmentation increased since the 1980s in New Jersey and North Carolina. Because most of the islands are owned either by The Nature Conservancy or federal agencies along the eastern shore of Virginia, no such beach demands exist in that region. A recent North Carolina Coastal Management statute (15A NCAC 7M.1101) dictates that inlet sands that are dredged must remain within the active, nearshore, beach, or inlet shoal system. This usually means that it is delivered to adjacent beachfronts, precluding augmentation of dredged material islands. Colony abandonment has occurred on some of these dredged material islands as they have either eroded or become heavily vegetated (Parnell and Shields 1990). Although there may have been some competition in the past in New Jersey between dredged island maintenance and beach community needs, the current practices involve pumping sand onto beaches from offshore bars (Jenkins unpublished material). With only modest funding and effort, small amounts of sand from inlet and intracoastal waterway maintenance dredging could be added to existing dredged islands that might greatly enhance their nesting habitat potential. If this does not prove feasible, the alternative is a manpower-intensive habitat management program aimed at reducing vegetation annually. Manual cutting and herbiciding are usually

necessary to keep succession at early stages (Soots and Landin 1978).

A caveat to consider here is the relative quality of the habitat being managed. Few contemporary data are available to compare relative reproductive success of these species by habitat (but see Erwin and Smith 1985). A relative shift of these species to barrier islands by common terns in New Jersey may not result in higher success if disturbance and predators render these habitats as population sinks instead of serving as sources of recruits.

While more research information will always improve habitat management decisions, it can still be argued that previous success of these species on dredged material islands (Soots and Landin 1978) should favor additions to, or management of, selected dredge islands. Concurrent improvement of conditions on barrier islands as well, by removing invasive plants or predators, or by reducing disturbance is also recommended (Erwin et al. 2001). Providing more options for waterbird nesting in areas with increasing human pressures can only be beneficial (Erwin et al. 1998). Coastal wildlife managers need to become more active in protecting and managing natural beach habitats. In areas where man-made habitats have proven to be significant resources for waterbirds, managers need to become more active stakeholders in the arenas where dredging and other coastal engineering policy decisions are made.

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