Effects of Long Piers on Birds in Tidal Wetlands

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ABSTRACT As human development continues in coastal areas, shoreline properties adjacent to expansive tidal marsh habitat are increasingly used for access to coastal waterways via long piers (>30 m) over marsh habitat. These tidal wetlands provide breeding and foraging habitat for many marsh birds, which may be affected by the human disturbance associated with long piers. Our objectives were to determine the effect of long piers over vegetated tidal marshes on the relative abundance and species richness of marsh birds. We completed combined passive and callback surveys in tidal marsh habitat at 22 sites with long piers and 24 sites without long piers, May–July 2005–2006 in Worcester County, Maryland, USA. Pier sites had lower relative abundance and species richness of obligate marsh birds than nonpier sites. Pier sites had a greater relative abundance of gulls, terns, herons, and egrets than nonpier sites. Pier sites had fewer species of herons and egrets than at nonpier sites. The presence of long piers had no affect on facultative marsh birds. Long pier density was negatively related to obligate marsh bird relative abundance and species richness, and facultative marsh bird species richness, whereas it was positively related to the relative abundance and species richness of gulls and terns. Herons and egrets relative abundance and species richness were not related to long pier density. Obligate marsh birds were negatively affected by long piers, whereas herons, egrets, gulls, and terns appeared to benefit from perching opportunities. Based on the negative effects of long piers on obligate marsh birds, management should focus on reducing the presence and density of long piers in tidal marshes by requiring the removal of existing long piers, or reducing or eliminating permits for construction of new long piers. (JOURNAL OF WILDLIFE MANAGEMENT 73(8):1362–1367; 2009)

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The strong desire for waterfront property as vacation or permanent residence has led to a dramatic increase in the demand for private pier permits (Resler 2001, Kelty and Bliven 2003). Increasingly, properties are developed in coastal areas that have expansive marsh between the shoreline and open water, which require long piers ($\geq$30 m) for open water access. These piers and the related human activity may have biological and aesthetic consequences. Although no data exist for the effects of long piers, concerns regarding piers have included vegetation loss, decreased shoreline stability and water quality, and the effects of chemicals leaching from construction materials (Kelty and Bliven 2003, Ayella 2004). These concerns address changes and disturbances to the marsh that may affect birds that depend on marsh habitat for breeding and foraging.

Management actions that alter resources in the marsh (e.g., water levels, mudflats, invertebrate communities, and plant cover) may affect habitat quality for marsh birds (Conway 1995, 2005). For example, marsh area has been positively related to marsh bird occurrence (Naugle et al. 1999), species richness (Findlay and Houlahan 1997, Shriver et al. 2004), and relative abundance (Benoit and Askins 2002). Birds may become accustomed to some common activities (e.g., walking and fishing), but more disruptive intrusions (e.g., motorized boat traffic) will influence waterbirds by disturbing foraging and resting behavior (Weller 1999). Bratton (1990) demonstrated that passing boats flushed wading birds from foraging on shorelines and in marshes. Although some studies have shown that marsh birds are affected by human disturbances, no study has determined the effect of long piers on birds in tidal marshes.

The challenge for resource managers is to ensure the integrity of coastal habitats but still allow for recreational use. Kelty and Bliven (2003) reported that as coastal development and pier permit requests increased, coastal managers were in need of science-based information to guide the regulatory process. Because of their sensitivities to habitat and landscape characteristics and by occupying a higher trophic level, birds can be used as bioindicators for assessing ecological integrity (DeLuca et al. 2004, Conway 2005). Although concerns regarding the influence of long piers on the avian community have been suggested (Ayella 2004), no study has tested the effects of long piers on the avian community. Understanding these effects will allow managers to design effective long pier regulations. Our objectives were to determine the effect of long pier presence and density over tidal marshes on the relative abundance and species richness of marsh birds in a tidal marsh.

STUDY AREA

We conducted our research in Worcester County, Maryland, USA, within the Inland Coastal Bays Watershed. Maryland's Coastal Bays Watershed stretched over 600 km^2 (Wazniak et al. 2005) and included approximately 6,742 ha of salt marsh (U.S. Army Corps of Engineers 1998, Bleil et al. 2005). Between 1990 and 1995, the population of Worcester County grew by approximately 15%, 3 times the growth rate of the state of Maryland (Polhemus and Greeley 2001). In 2000, 44,000 residents lived in Worcester County and 5–10 million people visited annually (Polhemus and Greeley 2001). Human activity and development within the county were concentrated on the coast, with 70% of

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residents living within the Coastal Bays Watershed (Polhemus and Greeley 2001). Wind, tide, and salinity exposure throughout the study area varied, but all sites were tidal salt to brackish marshes dominated by emergent vegetation. Salinity across sites was generally mesohaline (5–18 parts per thousand [ppt]) or polyhaline (18–35 ppt; Wazniak et al. 2005). Common plant species in these tidal marshes were black needlerush (*Juncus roemerianus*), groundsel tree (*Baccharis halimifolia*), marsh elder (*Iva frutescens*), phragmites (*Phragmites australis*), saltgrass (*Distichlis spicata*), saltmarsh cordgrass (*Spartina alterniflora*), saltmeadow hay (*Spartina patens*), and sea lavender (*Limonium carolinianum*; Banning 2007). Worcester County, Maryland was a humid, temperate region. The average monthly minimum and maximum temperatures during 2005–2006 were similar to the 30-year range (May: 9.4° C, 21.2° C; June: 16.2° C, 26.2° C; and July: 19.5° C, 30.7° C; National Oceanic and Atmospheric Administration [NOAA] 2007). Average monthly rainfall during 2005–2006 was 6.6 cm, 13.9 cm, and 7.9 cm for May, June, and July, respectively (NOAA 2007), and was similar to the 30-year average, excluding a large rain event during June 2006.

METHODS

We selected survey sites by examining 1997 aerial photographs (10-cm resolution) of Worcester County for long piers (≥30 m) and undeveloped marsh habitat. We identified long piers over marsh, and we visited each location to confirm pier length and extent of marsh. Because development was clustered in the northern part of Worcester County, the pier distribution followed a similar trend, as did the distribution of our sample points. We discovered recently built piers during our site assessments, and we added these piers to the sample population. A long pier was at the center of each pier survey site and we spaced survey sites at least 500 m apart to ensure independence (Conway 2005). Our sample included the maximum number of piers that we could gain access to from the piers that we knew to exist, which fit our independence criteria. To select nonpier sites, we identified similar marsh habitat without piers of any length within 200 m. In these areas, we selected survey sites that were at least 500 m apart. We matched the number of nonpier sites and pier sites within bays or river inlets for consistency in landscape context and salinity. We selected 18 pier locations and 14 nonpier locations for sampling in 2005. We removed as survey sites 2 nonpier sites and 2 pier sites that subsequently became inaccessible. We obtained 2004 aerial photographs before the 2006 surveys and increased the sample size to 20 pier and 20 nonpier sites. The length of long piers ranged 30–210 m and averaged 78 m. Pier width and height ranged 0.89–1.98 m and 0.64–1.47 m, and averaged 1.39 m and 1.10 m, respectively. Most study sites were privately owned (pier sites: 95%, nonpier sites: 79%). Nonpier sites averaged 0.4 (SE = 0.13, range = 0–2) long piers within a 500-m radius, whereas pier sites averaged 5.6 (SE = 0.64, range = 1–12) long piers within a 500-m radius. We considered pier age and human activity around the piers, but could not quantify these variables because of access limitations.

We used the Standardized North American Marsh Bird Monitoring Protocols (Conway 2005) to guide our sampling procedures. We combined passive and callback techniques to detect birds within a 50-m radius of the sampling point. During the survey, we recorded all birds detected (i.e., auditory, visual, flyovers, foraging, and perching). We based seasonal timing for surveys on local marsh bird migration and breeding chronology (Conway 2005, Banning 2007). Surveys began the first week of June in 2005 and mid-May in 2006 and continued until late July in both years. We scheduled survey replicates in 6-day windows spaced by 5-day breaks. Each year, we completed 4 replicates of the bird survey at each survey location (2 mornings and 2 afternoons, 2005–2006). We began morning surveys at sunrise, continuing until 0900 hours, and began afternoon surveys 3 hours before sunset, continuing until sunset. We surveyed only during midtide, and we did not survey the one hour before or after high or low tide (Conway 2005). We postponed surveys due to steady rain, fog that obstructed visibility to <50 m, or winds >15 km/hour (Conway 2005). We rated the noise level for each site, postponing the survey if conditions prevented detecting birds within 50 m.

Pier sampling locations were at the base of the pier at the upland–marsh interface. We established a sampling point at nonpier sites at the upland–marsh interface suitable for pier construction. This approach allowed easy access for surveying, did not trample marsh vegetation, and provided elevation to improve bird detection (Conway 2005). Upon arriving at a survey location, we waited 2–3 minutes as a settling period for birds to resume normal activity and vocalizations. We began with a 5-minute passive visual and an auditory scan of the site, followed by a 10-minute callback survey. We completed callback surveys with a broadcast system (Johnny Stewart Power Pro Convert-A-Caller; Hunter's Specialties, Cedar Rapids, IA) and a custom compact disc (Cornell University Lab of Ornithology, Ithaca, NY) that included the primary advertising calls for 10 species (black rail [*Laterallus jamaicensis*], least bittern [*Ixobrychus exilis*], sora [*Porzana carolina*], Virginia rail [*Rallus limicola*], king rail [*R. elegans*], clapper rail [*R. longirostris*], American bittern [*Botaurus lentiginosus*], common moorhen [*Gallinula chloropus*], American coot [*Fulica americana*], and pied-billed grebe [*Podilymbus podiceps*]). The 1-minute track for each species, played in order of least to most vocal, consisted of 30 seconds of primary advertising calls followed by 30 seconds of silence (Conway 2005). We measured sound level and adjusted the compact disc player sound pressure to 80 decibels with a digital sound level meter (407730; Extech Instruments Corporation, Waltham, MA; Conway 2005).

We separated detected species into guilds based on breeding, nesting, and foraging behaviors (Bradford et al. 1998, Canterbury et al. 2000, Bryce et al. 2002). We chose 22 focal species from those detected over both seasons, and assigned them to 4 guilds for data analysis: herons and egrets, obligate marsh birds, facultative marsh birds, and

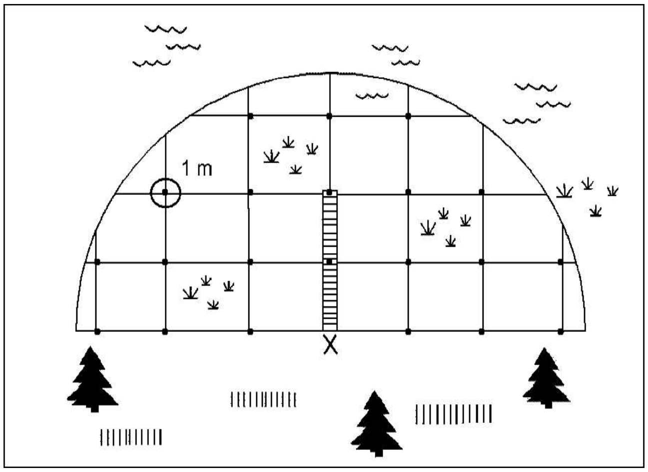

Figure 1. Microhabitat sampling design for determining the effects of long piers on the marsh bird community, Worcester County, Maryland, USA, 2005–2006. We sampled microhabitat within a 1-m radius of each grid interaction. The X denotes the location of the bird sampling point.

gulls and terns. The herons and egrets group included black-crowned night-heron (*Nycticorax nycticorax*), great blue heron (*Ardea herodias*), great egret (*A. alba*), green heron (*Butorides virescens*), little blue heron (*Egretta caerulea*), snowy egret (*E. thula*), and tricolored heron (*E. tricolor*). Obligate marsh birds included American bittern, clapper rail, seaside sparrow (*Ammodramus maritimus*), swamp sparrow (*Melospiza georgiana*), Virginia rail, and willet (*Catoptrophorus semipalmatus*). The facultative marsh birds guild consisted of boat-tailed grackle (*Quiscalus major*), fish crow (*Corvus ossifragus*), and red-winged blackbird (*Agelaius phoeniceus*). The gulls and terns guild included common tern (*Sterna hirundo*), Forster's tern (*S. forsteri*), great black-backed gull (*Larus marinus*), herring gull (*L. argentatus*), laughing gull (*L. atricilla*), and least tern (*S. antillarum*).

We quantified marsh microhabitat composition at each survey location during midtide once during May–July. We used a half-circle sampling plot (50-m radius) broken into a 15-m grid centered on the established sampling point (e.g., the base of the pier) and oriented toward the marsh (Fig. 1). At each of the 21 grid points, we measured the microhabitats (i.e., exposed mudflat, open water, upland habitat, and wetland plants) within a 1-m radius of the grid point. We visually estimated the proportion of each microhabitat and wetland plant $\geq$10% cover and averaged the 21 proportions for each microhabitat and plant species for that survey site.

We characterized site microhabitats with the mean proportions of the 7 most common plant species, open water, mudflats, and upland habitat. We compared microhabitat variables between pier and nonpier sites with a *t*-test (Sokal and Rohlf 1995). We also compared amount of high marsh (i.e., black needlerush, groundsel tree, marsh elder, phragmites, salt grass, and saltmeadow hay) between treatments with a *t*-test.

We calculated the proportion of the 4 survey replicates in which a species occurred to estimate detection probabilities individually for the 22 focal species. We excluded surveys with zero detections for all 4 replicates because we assumed the species was not present at that survey site. We compared detection probability values between treatments (pier and nonpier) only if that species occurred in $\geq$25% (18/72) of the surveys. We compared detection probabilities for the focal species between pier and nonpier sites with an analysis of variance blocking on year (Sokal and Rohlf 1995).

We compared total species richness (i.e., all species detected) between treatments (pier and nonpier) with a *t*-test. We used the maximum value from the 4 survey replicates for analyses involving bird abundance. We used the percentage of smooth cordgrass at each site as a covariate in all bird guild analyses because it was the only microhabitat variable that differed between treatments. We determined if relative abundance or species richness differed between treatments by bird guild with an analysis of covariance (ANCOVA) blocking on year. We tested if relative abundance for individual species detected in $\geq$25% (18/72) of the surveys differed between treatments with an ANCOVA blocking on year. We determined if a relationship existed between bird guild, relative abundance, or species richness and long pier density within a 500-m buffer of each site with multiple linear regression (Sokal and Rohlf 1995), with long pier density and percent saltmarsh cordgrass as independent variables. We conducted all analyses with SAS (version 9.1; SAS Institute, Cary, NC) and an alpha level of 0.10.

RESULTS

Microhabitat generally was similar between nonpier and pier sites, although nonpier sites contained 16% more saltmarsh cordgrass than pier sites ($\bar{x}_{\text{pier}} = 24.6$, $\bar{x}_{\text{nonpier}} = 41.0$; $t_{1,41} = 3.04$, $P = 0.004$). We detected 93 bird species at pier sites (21 of the 22 focal species) and 101 species at nonpier sites (all 22 focal species). Detection probabilities did not differ between pier and nonpier sites for most focal species. Detection probabilities for laughing gulls ($\bar{x}_{\text{pier}} = 0.7$, $\bar{x}_{\text{nonpier}} = 0.5$; $F_{1,62} = 5.60$, $P = 0.021$) and fish crows ($\bar{x}_{\text{pier}} = 0.4$, $\bar{x}_{\text{nonpier}} = 0.3$; $F_{1,43} = 3.63$, $P = 0.063$) were greater at pier sites than nonpier sites, whereas red-winged blackbirds had a greater detection probability at nonpier sites ($\bar{x}_{\text{pier}} = 0.6$, $\bar{x}_{\text{nonpier}} = 0.8$; $F_{1,60} = 8.69$, $P = 0.005$).

Overall bird species richness did not differ by treatment ($\bar{x}_{\text{pier}} = 22.4$, $\bar{x}_{\text{nonpier}} = 21.1$; $F_{1,68} = 1.79$, $P = 0.185$), but the effect on relative abundance and species richness of the bird guilds varied by guild (Table 1). Pier sites had 1.4 fewer individual obligate marsh birds than nonpier sites, whereas pier sites had 1.8 more individual herons and egrets than nonpier sites (Table 1). Pier sites also had 2.5 more individual gulls and terns than nonpier sites (Table 1). The presence of a long pier did not affect the relative abundance of facultative marsh birds (Table 1). Species richness of obligate marsh birds was 0.7 species greater at nonpier sites than pier sites, whereas herons and egrets had 0.5 fewer species at nonpier sites (Table 1). No effect was detected for the species richness of the other bird guilds (Table 1).

Table 1. Relative abundance and species richness of bird guilds for long pier sites (n = 38) and nonpier sites (n = 34) in Worcester County, Maryland, USA, May–July, 2005–2006.

Bird guild	Pier sites		Nonpier sites			
	$\bar{x}$	SE	$\bar{x}$	SE	$F_{1,68}$	P
Relative abundance						
Obligate marsh birds	1.5	0.33	2.9	0.36	3.55	0.064
Facultative marsh birds	9.9	1.23	11.0	1.86	1.58	0.213
Herons and egrets	3.7	0.64	1.9	0.26	6.29	0.015
Gulls and terns	7.4	1.22	4.9	0.59	3.34	0.072
Species richness						
Obligate marsh birds	0.9	0.15	1.6	0.19	4.50	0.038
Facultative marsh birds	2.3	0.13	2.4	0.10	0.22	0.641
Herons and egrets	2.1	0.23	1.6	0.20	4.69	0.034
Gulls and terns	2.7	0.18	2.6	0.20	1.22	0.273

The relative abundance of individual species did not differ between treatments for most species (Table 2). We observed 0.6 more individual red-winged blackbirds at nonpier sites than pier sites, whereas we observed twice as many great blue herons and laughing gulls at pier sites compared to nonpier sites (Table 2).

The relative abundance of obligate marsh birds was negatively related to pier density and accounted for >22% of the variation in relative abundance (Table 3), whereas the relative abundance of gulls and terns was positively related to long pier density and accounted for 12% of the variation in relative abundance (Table 3). Relative abundances of herons and egrets and facultative marsh birds were not related to long pier density (Table 3). Obligate and facultative marsh bird species richness was negatively related to long pier density and accounted for 15% and 8% of the variation in species richness, respectively. Species richness for gulls and terns was positively related to long pier density and accounted for 10% of the variation in richness, whereas the species richness of herons and egrets was not related to the density of long piers (Table 3).

DISCUSSION

Pier presence and density negatively influenced obligate marsh bird relative abundance and species richness, but the influence on the other bird guilds varied. Obligate marsh birds use tidal marshes exclusively during the breeding season. These secretive species may be affected by human activity related to piers (e.g., noise, boats, or walking), pier lighting, or increased predation (Burger 1991). Long piers also may create barriers that prevent movement throughout the marsh and reduce essential behaviors (e.g., foraging, escaping predators, nesting, or rearing young; Bliven 2005). Long piers may represent a novel, unfamiliar object in marsh habitat that is avoided even in an otherwise suitable habitat (Greenberg 1989). Marsh area can affect marsh bird occurrence (Naugle et al. 1999), richness (Findlay and Houlahan 1997, Shriver et al. 2004), and relative abundance

Table 2. Relative abundance of marsh birds at pier (n = 38) and nonpier sites (n = 34) in Worcester County, Maryland, USA, May–July, 2005–2006. We compared only species that occurred at ≥25% of survey locations (n = 18).

Bird guild and species	Pier sites			Nonpier sites				
	n[a]	$\bar{x}$	SE	n[a]	$\bar{x}$	SE	$F_{1,68}$	P
Obligate marsh birds								
American bittern	0	0.0	0.00	1	<0.1	0.03		
Clapper rail	11	0.4	0.12	16	0.6	0.13	0.02	0.900
Seaside sparrow	2	0.1	0.04	8	0.3	0.10		
Swamp sparrow	4	0.1	0.05	7	0.3	0.11		
Virginia rail	2	0.1	0.08	2	0.1	0.06		
Willet	16	0.8	0.20	21	1.6	0.30	2.07	0.155
Facultative marsh birds								
Boat-tailed grackle	34	6.5	1.08	29	7.1	1.80	1.28	0.261
Fish crow	26	1.4	0.27	20	1.1	0.30	0.88	0.352
Red-winged blackbird	29	2.1	0.35	33	2.7	0.23	3.45	0.068
Herons and egrets								
Black-crowned night heron	7	0.4	0.19	2	0.1	0.04		
Great blue heron	18	0.6	0.12	8	0.3	0.10	5.85	0.018
Great egret	27	1.7	0.42	23	0.9	0.15	1.54	0.218
Green heron	6	0.2	0.12	3	0.1	0.05		
Little blue heron	6	0.2	0.07	2	0.1	0.04		
Snowy egret	13	0.6	0.15	11	0.4	0.10	1.95	0.167
Tricolored heron	3	0.1	0.04	5	0.1	0.06		
Gulls and terns								
Common tern	15	0.7	0.21	12	0.7	0.25	0.07	0.792
Forster's tern	8	0.3	0.11	9	0.3	0.10		
Great black-backed gull	4	0.2	0.08	4	0.1	0.07		
Herring gull	30	1.8	0.34	19	1.2	0.26	0.80	0.374
Laughing gull	34	4.0	0.92	31	2.1	0.23	3.09	0.083
Least tern	12	0.5	0.14	12	0.4	0.09	0.88	0.351

[a] The no. of surveys in which a species was detected.

Table 3. Relationships between long pier density and proportion of saltmarsh cordgrass to marsh bird relative abundance and richness in Worcester County, Maryland, USA, May–July, 2005–2006.

Bird guild	Piers (*n*)		Saltmarsh cordgrass (%)			
	Estimate	SE	Estimate	SE	R^2	*P*
Relative abundance						
Obligate marsh birds	−0.06	0.028	0.02	0.006	0.216	<0.001
Facultative marsh birds	−0.02	0.022	<−0.01	0.005	0.010	0.696
Herons and egrets	<0.01	0.043	0.01	0.009	0.011	0.690
Gulls and terns	0.09	0.034	0.01	0.007	0.117	0.014
Species richness						
Obligate marsh birds	−0.10	0.063	0.03	0.013	0.149	0.004
Facultative marsh birds	−0.43	0.281	−0.13	0.057	0.081	0.054
Herons and egrets	0.01	0.101	−0.01	−0.021	0.002	0.937
Gulls and terns	0.51	0.181	0.01	0.037	0.106	0.021

(Benoit and Askins 2002). Increasing pier density may fragment the marsh, affecting marsh specialists with area requirements (Bliven 2005).

Facultative marsh birds were the most abundant of all the focal species and we detected them in most surveys. These species forage in agricultural fields or on human refuse, and they may be less responsive to nonnatural structures. Relative abundance of this guild was not related to pier density; however, species richness was related negatively. Red-winged blackbirds were less abundant at pier sites; shrub and reed removal from the shoreline may reduce nesting and socializing habitat of this species.

Piers may attract gulls and terns by increasing perching and socializing sites. Larids perch on docks and pylons along developed shoreline in lieu of natural perches (Traut and Hostetler 2004). Greater relative abundance of these species likely was due to birds congregating and not a true increase in the abundance of gulls and terns as a result of long piers. Although only laughing gulls differed significantly between treatment types, herring gulls and great black-backed gulls also were more abundant at pier sites, and mean relative abundance for each tern species was nearly equal. Behavioral differences (e.g., flocking, aggression, or foraging patterns) between gulls and terns may explain the different reactions to long piers.

Long piers may attract herons and egrets, which perch and fish from the pier. Some waterbird species used docks and pylons for perching along developed shorelines in place of natural perches (Traut and Hostetler 2004). Waterbirds commonly use docks for foraging because fish concentrate in the shade (Ciuzio and Murphy 2007). Perching on piers over shallow water may provide protection from passing boats. Herons and egrets are less likely to be flushed by a passing boat when perched in a tree or on a dock than in the water, on a bank, or in smooth cordgrass (Bratton 1990). Although piers offered some benefits for herons and egrets, these benefits could be provided in less obstructive and disturbing ways via pilings or natural perches.

We documented that pier presence and density had varying impacts on tidal marsh birds. Although we used smooth cordgrass cover as a covariate to account for any influence of smooth cordgrass on marsh birds, we suggest additional research on the importance of smooth cordgrass on tidal marsh birds in association with long piers. The age of piers and human activity associated with piers are 2 other variables that require additional research. Reducing or eliminating long piers would reduce human disturbance and contribute to less fragmented, more expansive marsh habitat. In fact, requiring pier users to limit activity during the breeding season might reduce or eliminate the effect we documented on tidal marsh birds. Another limitation of our study was our sample framework. We only sampled out to 50 m, so any pier that was longer could have had unmeasured impacts, such as missing roosting birds at the end of the pier. We believe that the differences we noted would only be strengthened because Larids, herons, and egrets were the most commonly sighted birds roosting on piers. Additionally, future research should investigate how far the impact of a pier extends away from the pier. We suggest future research focus on an approach to pier construction that would minimize the long term impacts of piers on tidal marsh birds because the elimination of piers seems unlikely.

MANAGEMENT IMPLICATIONS

The avian community in tidal marshes was affected by long piers. Management strategies to improve or maintain marsh bird populations should consider the particular sensitivities of specific marsh bird groups. Effects on obligate marsh birds were the most consistent for management purposes. Given their reliance on marshes and their sensitivities to habitat characteristics and disturbance by humans, obligate marsh birds are a valuable tool for ecological assessment. As such, their relative abundance and species richness indicated that future management should focus on reducing or eliminating the presence and density of long piers. We observed that in most areas piers were clustered in developed areas. If more residential housing developments offered a community pier in lieu of individual, private piers, local pier densities would be greatly reduced. We suggest that as old piers require replacement or new piers are proposed, their placement should be limited to community piers.

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