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Short-term Demographic Responses of a Coastal Waterbird Community after Two Major Hurricanes

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Abstract.—Response of breeding waterbird communities to the effects of hurricanes remains poorly understood. The impact of two 2008 hurricanes on the breeding waterbird community was investigated at the Isles Dernieres Barrier Island Refuge in southern Louisiana using pre- and post-hurricane survey data. After the 2008 hurricanes, the breeding community was reduced from 44,042 breeding pairs in 2008 to 27,977 pairs in 2009 and to 23,544 pairs in 2010. Populations of the five most abundant species, Brown Pelican (*Pelecanus occidentalis*), Laughing Gull (*Leucophaeus atricilla*), Royal Tern (*Thalasseus maximus*), Sandwich Tern (*Thalasseus sandvicensis*), and Black Skimmer (*Rynchops niger*), decreased from 2008 to 2010. In contrast, populations of Roseate Spoonbill (*Platalea ajaja*), Sooty Tern (*Onychoprion fuscatus*), and Gull-billed Tern (*Gelochelidon nitotica*) increased from 2008 to 2009 but declined in 2010. The dramatic decline of total breeding pairs in the year following hurricanes demonstrates the vulnerability of this community to tropical storms and habitat degradation. Further investigations of this community are necessary to understand how major disturbances affect resilience and long-term viability of colonial waterbird communities on barrier islands. Received 21 June 2012, accepted 4 October 2012.

Key words.—Gulf of Mexico, hurricane disturbance, species of concern, waterbirds.

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Disturbances are ecosystem processes that regularly function across various ecological scales and exert powerful selective pressure on communities (Levin and Paine 1974; Wootton 1998). As the frequency and intensity of hurricanes is predicted to increase (Webster *et al.* 2005), understanding the ways in which communities respond to disturbance may provide some indication of their susceptibility to stochastic events (Spendelov *et al.* 2002; Leberg *et al.* 2007). However, few studies have used baseline information collected prior to local storm events to examine short-term responses of waterbird communities to hurricanes.

Hurricanes are broad-scale disturbances experienced most frequently by populations along the Gulf coast of the United States (Gornitz 1995). Although most major storms occur after the colonial waterbird breeding season, hurricanes have the potential to alter habitats and thereby influence demographics in the following breeding season (Shepherd *et al.* 1991; Leberg *et al.* 2007; Nisbet *et al.* 2010).

Two major hurricanes impacted the coast of the northern Gulf of Mexico during Sep-

tember 2008. On 1 September 2008, Hurricane Gustav moved north directly between Trinity and Wine Islands of the Isles Dernieres Barrier Islands Refuge (IDBIR; Fig. 1), before making landfall at Cocodrie, Louisiana. Hurricane Gustav made landfall as a Category 2 storm (Saffir-Simpson index) with winds of 175 km/h (Rego and Li 2009).

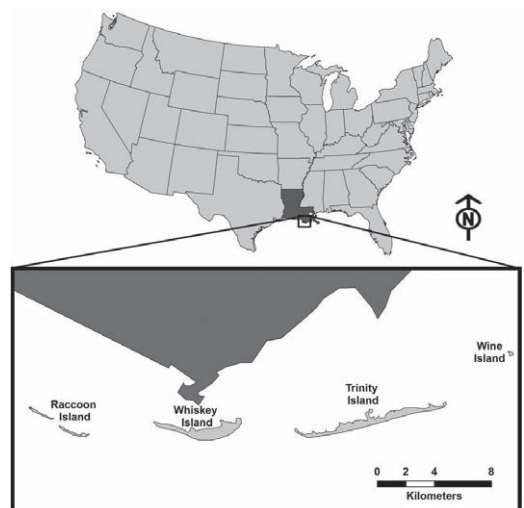


Figure 1. The Isles Dernieres Barrier Island Refuge, Terrebonne parish, Louisiana, USA.

Gustav resulted in severe damage to woody vegetation along the coast of Louisiana and extensive removal of sandy beaches (Doran *et al.* 2009; M. Carlos, pers. commun.). At the largest waterbird rookery on the refuge, Raccoon Island, Curole and Babin (2010) found that the storm expanded the breach separating Raccoon Island and its western spit from approximately 46 to 457 m (Fig. 2). Additionally, the western spit experienced a reduction in mean elevation (-0.15 m), width (-7.62 m), and area (-4.04 ha). Less than 2 weeks after Gustav's landfall, Hurricane Ike entered Galveston Bay, Texas, on 13 September 2008 as a Category 2 storm. Ike's storm surge encompassed 644 km of the northern Gulf of Mexico coast (Kraus and Lin 2009) and over-washed the IDBIR (E. Raynor and A. Pierce, pers. obs.).

Given the contribution of Louisiana's barrier island populations to the continental population of several waterbird species (Spendelov and Patton 1988), widespread collapse of historically important colonies (e.g., the Isles Dernieres and Chandeleur Islands' colonies) could have implications extending beyond the immediate coast of Louisiana. Moreover, several species of regional

conservation concern including Brown Pelican (scientific names are in Table 1) and Reddish Egret use barrier islands as nesting habitat and the degree to which these species are affected by hurricane impacts remains unclear.

Our objective was to examine changes in the nesting waterbird community at the IDBIR following hurricanes Gustav and Ike. We use baseline surveys conducted along the IDBIR during the 2008 breeding season (May-June) and repeated surveys in the 2009 and 2010 breeding seasons to evaluate effects of the hurricanes on waterbird communities.

METHODS

Study Area

The study was conducted in the Gulf Coast Prairies and Marshes Ecoregion of the Terrebonne Basin, on IDBIR in south-central Louisiana (29° 03' N, 90° 57' W to 29° 05' N, 90° 36' W; Fig. 1). The IDBIR is managed by the Louisiana Department of Wildlife and Fisheries and includes Raccoon, Whiskey, Trinity, and Wine Islands, encompassing approximately 32 km of barrier islands located 13 km south of Cocodrie, Louisiana. Raccoon Island was bisected by hurricane Andrew in 1992; therefore, we refer to East Raccoon Island, which is protected by 16 breakwater structures, and West Raccoon Island, unprotected by rock structures, separately (Fig. 2).

Data Collection

In May of 2008, 2009, 2010, breeding waterbird colonies were identified by visual surveys on each island of the IDBIR to determine the presence or absence of colonies. Ground surveys were then conducted at each colony to determine species composition and abundance. In all years, ground-nesting waterbird populations were surveyed between 21 May and 2 June, while wading bird and Brown Pelican populations were surveyed between 22 June and 24 June. The May-June period has been established in Louisiana as the optimum period for observing most nesting species while minimizing biases associated with juveniles (Michot *et al.* 2003). Only adult birds standing on nesting substrate were counted at each colony and each individual was assumed to represent a breeding pair (Michot *et al.* 2003). Surveys were always conducted by two persons using 8-10x binoculars, from observation points located 15-30 m from colonies, with breeding pairs being estimated every 100 m along the colony periphery. Boat surveys were conducted when colonies were not accessible or viewable from the island. For boat surveys, breeding pairs were estimated by a single observer counting from the bow of the vessel cruising near idle speed along the bay-side of the islands. All waterbirds were censused either by the

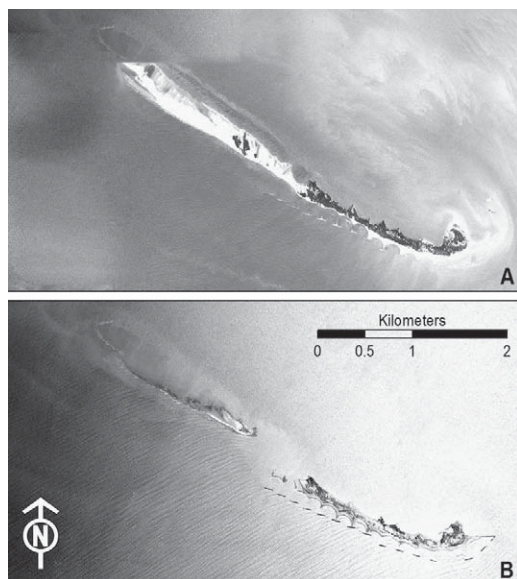


Figure 2. Digital ortho imagery (U.S. Department of Agriculture 2007, 2009) of the Raccoon Island study area before (A) and after (B) the 2008 hurricane season.

Table 1. Breeding pairs of waterbirds detected and percent annual change on each island of the Isles Dernieres Barrier Islands Refuge, Louisiana from 2008-2009.

Species	Raccoon			Wine			Whiskey			Trinity			Total		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
Brown Pelican ¹	7,600	7,125	2,260	1,100	425	40	0	0	0	0	0	0	8,700	7,550	2,300
Great Egret	150	150	120	10	0	0	0	0	0	0	0	0	160	150	120
Snowy Egret	80	20	30	0	0	0	0	0	0	0	0	0	80	20	30
Tri-colored Heron	400	95	17	30	2	0	0	0	0	0	0	0	430	97	17
Reddish Egret ¹	20	5	5	0	0	0	0	0	0	0	0	0	20	5	5
Green Heron	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
Black-crowned Night-heron	120	30	15	10	0	0	0	0	0	0	0	0	130	30	15
White Ibis	70	5	0	0	0	0	0	0	0	0	0	0	70	5	0
Roseate Spoonbill ¹	30	70	26	0	0	0	0	0	0	0	0	0	30	70	26
Clapper Rail	0	0	0	0	0	0	10	6	0	10	0	0	20	6	0
Wilson's Plover ¹	0	0	0	0	0	0	40	20	1	30	10	0	70	30	1
American Oystercatcher ¹	2	5	5	1	0	0	10	6	0	5	5	0	18	15	1
Black-necked Stilt	0	0	0	0	0	0	3	0	0	0	0	0	3	0	0
Willet	0	0	0	0	0	0	20	15	0	10	6	0	30	21	0
Laughing Gull	8,000	4,540	2,740	2,300	625	20	0	0	0	0	0	0	10,300	5,165	2,760
Sooty Tern ¹	0	2	0	0	1	0	0	0	0	0	0	0	0	3	0
Least Tern	0	0	0	0	0	0	70	90	0	50	100	35	120	190	35
Gull-billed Tern ¹	15	5	1	0	0	0	10	65	3	1	0	0	26	70	4
Royal Tern	9,980	4,680	6,595	3,140	2,830	3,175	0	0	0	0	0	0	13,120	7,510	9,770
Sandwich Tern	4,640	2,870	5,070	4,310	2,870	2,650	0	0	0	0	0	0	8,950	5,740	7,720
Black Skimmer	1,100	480	250	40	35	50	540	780	450	80	5	0	1,760	1,300	750
Total	32,207	20,082	17,130	10,941	6,788	5,935	703	982	454	191	126	35	44,042	27,977	23,554
(% change)		(-38)	(-15)		(-38)	(-13)		(+40)	(-54)		(-34)	(-72)		(-36)	(-16)

¹Indicates species of Louisiana conservation concern.

ground or boat surveys described with the exception of Royal and Sandwich terns. Breeding pairs of Royal and Sandwich terns were surveyed by counting the number of nests inside 5×5 m quadrats established in a grid system throughout the colony.

RESULTS

Breeding waterbird colonies were detected on all four islands of the IDBIR during the 3 years of this study. The species composition of the IDBIR included 20 species in 2008, 18 species in 2009, and 15 species in 2010 (Table 1). Little variation was observed in the breeding waterbird species composition on each island; however, the number of breeding pairs on each island varied greatly between 2008 and 2010 (Table 1). Nesting Green Heron and Black-necked Stilt were only detected in 2008. Two Sooty Tern pairs, the only new nesting species detected in 2009, nested on East Raccoon Island and one pair on Wine Island in 2009.

The mean annual breeding community of the IDBIR from 2008 to 2010 was $31,857 \pm 6,224$ (mean \pm SE) breeding pairs (bp). The year-to-year variation of the breeding community from 2008 (44,042 bp) to 2009 (27,977 bp) and from 2009 to 2010 (23,544 bp) was -36% and -16%, respectively (Table 1). Breeding waterbird communities on Raccoon Island (East and West) and Wine Island comprised 98% to 96%, respectively, of the total waterbird community at the IDBIR from 2008 to 2010. All island waterbird communities had continual declines from 2008 to 2010 except on Whiskey Island, where the breeding waterbird community increased 40% from 2008 to 2009 (Table 1).

Populations of the five most abundant species, Brown Pelican, Laughing Gull, Royal and Sandwich terns, and Black Skimmer, decreased from 2008 to 2010 (Table 1). During this study, the IDBIR hosted substantial numbers of breeding pairs of Royal Tern ($10,133 \pm 1,629$ bp) and Sandwich Tern ($7,470 \pm 935$ bp; Table 1). In the post-hurricane nesting seasons, the number of crested tern breeding pairs decreased at all study areas. The decline was most evident from 2008

to 2009, especially on Raccoon Island (-48%; Table 1).

Seven waterbird species, Brown Pelican, Reddish Egret, Roseate Spoonbill, Wilson's Plover, American Oystercatcher, Sooty and Gull-billed terns, that were listed as state species of conservation concern by the Louisiana Department of Wildlife and Fisheries bred on the IDBIR during our study. Abundance of breeding species of concern was 8,864 bp, 7,743 bp, and 2,337 bp in 2008, 2009, and 2010, respectively. Raccoon and Wine Islands hosted 99% of the populations of species of concern during our study (Table 1). Populations of Brown Pelican, Reddish Egret, Wilson's Plover, and American Oystercatcher declined from 2008 to 2010. Meanwhile, populations of Roseate Spoonbill, and Sooty and Gull-billed terns increased from 2008 to 2009 but declined in 2010.

DISCUSSION

The most dramatic and biologically significant effect seen on the IDBIR was the reduction in the total breeding population size (-36%) during the post-hurricane nesting season. Although the analysis was not statistically rigorous due to a lack of replication, the results indicate that populations of many species declined considerably after the hurricanes. For example, the three most abundant species, Laughing Gull and Royal and Sandwich terns, decreased -50%, -43%, and -36%, respectively, from 2008 to 2009. Declines in ground-nesting waterbirds were most likely due to hurricane-induced degradation of preferred nesting habitat, as observed in similar studies (Marsh and Wilkinson 1991; Visser and Peterson 1994).

Tropical storms are known to have sufficient intensity to affect coastal habitats and the species that depend on them (Leberg *et al.* 2007; Doran *et al.* 2009). Our results demonstrate this effect through the apparent loss of nesting habitat at Raccoon Island (Fig. 2) and concurrent decrease in waterbird abundance. Wine Island also lost 51% of its total vegetation cover, including 99% of its woody

vegetation, following the 2008 hurricanes (Walter 2012). However, long-term data is necessary to accurately distinguish between the effects of random fluctuations and hurricanes on the breeding waterbird populations (Hsieh *et al.* 2005).

Waterbird communities on the IDBIR have experienced reductions in the nesting season following other local hurricanes. There was a 27% reduction from 54,780 bp in 1985 to 39,455 bp in 1986 on Wine and Raccoon Islands after five local hurricanes in the post-breeding season of 1985 (J. M. Visser, pers. commun.; Visser and Peterson 1994). The breeding waterbird community on Wine and Raccoon Islands from 1985 to 1993 had a mean annual size of 30,096 \pm 4,586 bp (Visser and Peterson 1994). Our results are within the range of these historical community estimates reported by Visser and Peterson (1994), which suggests long-term stability of the IDBIR breeding waterbird community but that short-term demographics can reflect stochastic events.

Direct mortality due to passage of a hurricane through a breeding area or near a migratory route may be another potential explanation for the dramatic declines detected in our study. Hurricanes are known to cause mass mortality of waterbird species when birds are nesting (Morris and Charline 1995) or migrating near a storm's path (Spendelow *et al.* 2002). However, carcass surveys on the IDBIR immediately after the 2008 hurricanes found only 10 Brown Pelican carcasses (M. Carloss, pers. commun.). Results of this damage assessment and evidence that most of the waterbird community had fledged at least a month prior to the hurricanes (Owen 2010; Raynor *et al.* 2012) suggest that mass mortality did not occur as a result of the hurricanes.

In contrast to the population reductions seen on Raccoon, Wine and Trinity Islands, Whiskey Island experienced an influx of nesting Black Skimmers in 2009, which we presume was initiated by the expansion of sand flats, caused by extensive removal of vegetation by the 2008 hurricanes (E. Raynor, pers. obs.). Instances of hurricane-induced changes creating suitable habitat

has been documented for nesting Least Tern (Leumas 2010) and wintering Black-bellied Plover (*Pluvialis squatarola*; Marsh and Wilkinson 1991).

Louisiana's barrier islands continue to host thousands of nesting and wintering colonial waterbirds each year although persistence of this habitat is questionable. For example, 120 km east of our study area lies the Chandeleur barrier island chain, a historically important waterbird rookery (Michot *et al.* 2003), which has not received substantial restoration efforts (Bohannon *et al.* 2008). The Chandeleur's have experienced rapid degradation primarily due to hurricane impacts (Fearnley *et al.* 2009), and a decrease in waterbird colonies has been observed as nesting habitat undergoes submergence (Bohannon *et al.* 2008). Moreover, waterbird colony collapse following a major hurricane season has also occurred on the Timbalier Islands, which lie approximately 5 km east of our study area. Visser and Peterson (1994) state that loss of suitable nesting habitat due to hurricane impacts on East Timbalier Island corresponded with a reduction in the nesting waterbird population. The devastation of the Louisiana barrier islands and the waterbird population they host is a clear indication of the importance of barrier island restoration to waterbird conservation in disturbance-prone areas.

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