AVIAN SPECIES COMPOSITION AND MOVEMENT RATES IN TWO COASTAL HABITATS NEAR CHARLESTON, SOUTH CAROLINA

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ABSTRACT

Avian activity in two South Carolina coastal habitats was monitored on a weekly basis over a three year period in Charleston County, South Carolina. The Isle of Palms study site was saltmarsh habitat while the Breach Inlet area was a front-beach site adjacent to Isle of Palms. Individual species or ecological groups of species (e.g., gulls, shorebirds) were recorded as they crossed transect lines. Over 100 species were observed, including 6 species of concern: Wilson's Plover (*Charadrius wilsonia*), Least Tern (*Sterna antillarum*), Glossy Ibis (*Plegadis falcinellus*), Wood Stork (*Mycteria americana*), Peregrine Falcon (*Falco peregrinus*), and Bald Eagle (*Haliaeetus leucocephalus*). Most ecological groups exhibited significant daily/weekly temporal and site variation in occurrence and movement rates. This study illustrates the tremendous avian species richness at coastal sites, yet demonstrates the variability of site use over the annual cycle. Future plans to conserve biodiversity will need to consider these factors.

INTRODUCTION

Some of the largest remaining tracts of pristine wetlands on the Atlantic coast are located in South Carolina (Hopkins-Murphy 1989, Bildstein et al. 1991, Marsh and Wilkinson 1991). Consequently, the state enjoys a rich diversity of avian species (Bildstein et al. 1991, Marsh and Wilkinson 1991). However, increasing human land-use pressures and subsequent habitat loss make it necessary to document species composition among various coastal habitats and travel corridors (Morrison and Harrington 1979, Beatley 1991), particularly those which have high commercial value (e.g., ocean front beaches and marshes that contain deep waterway systems). Because some wetland corridors may serve as local and/or migratory travel routes for threatened or endangered species (Post and Gauthreaux 1989), measuring use of these areas will increase our awareness of their ecological importance and may provide additional incentive for their protection.

Our study compared species composition and movement rates between two heterogeneous coastal wetland travel corridors: an inland saltmarsh and an ocean-facing beach. We also examined intra- and interspecific temporal variation in species composition and movement rate at both sites over a three year period.

STUDY AREA AND METHODS

Study Area and Sampling Regime

The study was conducted from 15 September 1991 to 30 May 1994 in

Charleston County, South Carolina (Figure 1). We observed birds crossing 3,927 m of a 115-kV electrical transmission line extending from Mt. Pleasant to Isle of Palms (hereafter referred to as the Isle of Palms transect). Area beneath the powerline consisted of 70% (2,751 m) cordgrass(*Spartina* spp.) and *Juncus roemerianus* saltmarsh, 24% (928 m) tidal creeks and navigable waterways, 4% (160 m) upland habitat, and 2% (88 m) dredged spoil.

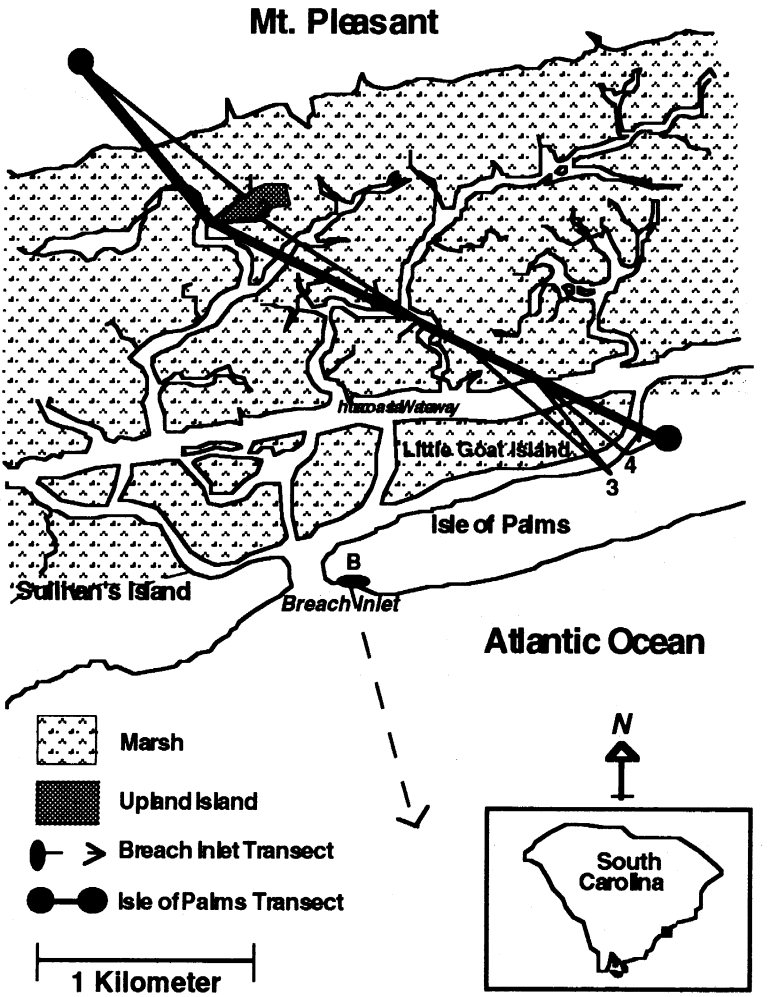

Figure 1. Breach Inlet (observation post B) and Isle of Palms (observation posts 1–4) transects, Charleston County, South Carolina.

We also monitored avian activity on the front beach of Isle of Palms near

Breach Inlet (hereafter referred to as Breach Inlet transect; Figure 1). Birds crossing an imaginary line that extended from a specified point on the beach (approximately 100 m east of Breach Inlet above the mean high tide mark) to a shipping channel buoy approximately 1,500 m offshore were recorded. This site encompassed sandy beach, and intertidal and subtidal marine zones. Once a week, observations were conducted concurrently at both sites. All non-passerine species that flew, walked, or swam across the transects were recorded from first light (10 lux) until three hours after sunrise and from three hours before sunset until dark (10 lux). Observations were made with 10 x and 20 x binoculars and 20 x spotting scopes. Because the entire Isle of Palms transect could not be monitored by a single observer from one vantage point, four observation posts were established along its length to insure complete coverage (Figure 1). The Breach Inlet transect required only one post and one observer (Figure 1). All posts were monitored simultaneously during the morning and evening sampling periods. Observers were rotated systematically among sites, posts, and time periods to reduce observer bias.

Bird movements were recorded in 15-minute blocks unless weather or light conditions terminated observations early. We used a combination of focal group and sequence sampling (Altmann 1974) to collect the following information on each flock (one or more birds) that entered the transects: species or ecological group (e.g., tern, gull, shorebird), number of individuals, age (adult or juvenile), and direction of flight (north or south). Multi-species flocks were recorded as subflocks according to species (or group). Birds that could not be identified to species or group were categorized as "unknown".

Statistical Analysis

Because we lacked sufficient data to permit analysis of some individual species, we placed all species into categories of ecological groups (Appendix 1). General linear models for unbalanced ANOVA's were used to examine habitat (site) and temporal effects on movement rate for all birds combined (including "unknown" birds) and among individual ecological groups. Because of insufficient data, movement rates of grebes, swans, rails, owls, and goatsuckers were not analyzed further. Independent terms included main effects of site, month, and time of day (morning and evening sampling periods) as well as interaction effects between site and month, site and time of day, and month and time of day. Preliminary analyses indicated no significant annual variation in hourly movement rate, therefore year was not included in the model. The dependent variable, mean movement rate (birds per hour), was calculated by summing the number of birds that crossed within a time block, dividing the total by the number of minutes within the time block (not all time blocks encompassed 15 minutes), and multiplying the quotient by 60. A separate ANOVA was conducted for each ecological group analyzed. All model terms were considered significant if probability levels were less than 0.05. Analyses were performed using Statistical Analysis System (SAS Institute, Inc. 1990).

RESULTS

Species Richness and Composition

During 644 hours (121 days) of observation, we recorded 94,496 birds in 46,169 flocks at Isle of Palms and 277,394 birds in 41,238 flocks at Breach Inlet. We observed 102 species (67 at Isle of Palms transect and 56 at Breach Inlet transect), which were later placed in 24 ecological groups along with birds previously identified to group during field observations (Appendix 1). Less than 9% of the birds were classified as "unknown" at both sites (Isle of Palms transect: n = 2,849; Breach Inlet transect: n = 23,984).

More species were consistently observed during each month at Isle of Palms (Figure 2). At Isle of Palms species richness peaked in April (n=53 species) and November (n=57). At Breach Inlet diversity peaked in March (n=37) and September (n=37). Lowest diversity occurred in August at both Isle of Palms (n=35) and Breach Inlet (n=22). The greatest difference in richness between sites occurred in November (n=29), and the smallest in May (n=6).

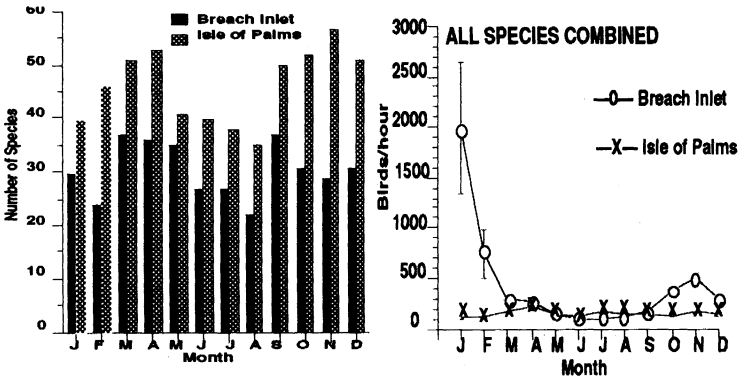

Figure 2. Seasonal species richness and monthly mean movement rates (birds/hr ± SE) at Isle of Palms and Breach Inlet transects, Charleston County, SC, September 1991 - May 1994.

Study areas were used by six species of concern (Appendix 1). We observed state threatened Wilson's Plovers and Least Terns at both sites. State threatened Glossy Ibises, state and federally endangered Wood Storks and Peregrine Falcons, and state endangered and federally threatened Bald Eagles traveled exclusively through Isle of Palms transect.

Movement Rate

Hourly movement rates for all birds (Figure 2) were significantly different between sites and among months, but not for time of day (morning or evening sampling periods; Table 1). Movement rates also varied significantly by site x month and by month x time of day.

When examined individually, most ecological groups, even those with

monthly means below 5 birds/hr (Figure 3), exhibited significant site and temporal variation (Table 1). Movement rates for all groups except loons, geese, shorebirds, and gulls differed significantly between sites. Herons, storks, ibises, vultures, raptors, doves, kingfishers, and woodpeckers traveled almost exclusively through the Isle of Palms transect, whereas pelicans, gannets, ducks, and terns traveled more often, or exclusively through the beach transect.

Movement rates of all ecological groups varied significantly among months (Table 1). Cormorants, doves, ducks, gulls, herons, ibises, pelicans, terns, shorebirds, and raptors were present year-round. In January, ducks exhibited the most dramatic increase in movement rates of all groups (Figure 3b). This was preceded by a small, but substantial increase in November. Other ecological groups that exhibited maximum peaks only in fall and/or winter included gannets, cormorants, vultures, raptors, kingfishers, and woodpeckers. Movement rates of loons, geese, and shorebirds were highest in spring, whereas movements of pelicans and doves peaked in summer. The following ecological groups exhibited more than one peak in movement rate: ibises (March and August); herons (spring and late summer); storks (July and September); gulls (late summer and fall); and terns (fall and spring - mid-summer).

Interaction between site and month was significant for all groups except geese and shorebirds, which exhibited similar seasonal peaks at both sites (Table 1 and Figure 3). Obvious seasonal shifts between transects, defined by an increase in movement rate at one site and a corresponding decrease at the other site, occurred only among gulls.

DISCUSSION

Species Richness

Conservation of biodiversity is, by definition, conservation of life (Beatley 1991). Coastal systems, which include upland areas adjacent to shorelines, marshes, estuaries, beaches, and inshore marine zones, harbor a tremendous diversity of life-forms throughout the world (Beatley 1991, Bildstein et al. 1991). In temperate environments, coastal wetland complexes support a greater diversity of organisms than most inland habitats (Beatley 1991). Dependence on these complexes by migrant organisms shows that coastal complexes are not separate biological systems, but rather vital links within a network of systems that, as a whole, supports the world's biota.

The Santee Delta-Cape Romain coastal unit, located just north of our study area, received national recognition for its rich biodiversity when it was included in the Carolinian-South Atlantic Biome Reserve, a part of the U.S. Man and the Biosphere program (Hopkins-Murphy 1989). Recent efforts have been made to document the importance of this complex to nonbreeding shorebirds (Marsh and Wilkinson 1991; Boettcher et al. 1995; Weber and Haig 1996). We measured avian species richness on a broader scale in two heterogeneous habitats that are currently receiving minimal protection. Our study demonstrates that species richness was high in both transects throughout the annual cycle (Figure 2; Appendix 1).

Table 1. Habitat (site) and temporal factors affecting hourly movement rates of non-passerine avian species observed at Isle of Palms marsh transect and Breach Inlet beach transect in Charleston County, SC, September 1991 - May 1994.

Ecological Group	R^2	F value / P					
		Site	Month	Time of day	Site x month	Site x time of day	Month x time of day
All combined	0.04	23.26***	5.23***	0.01	7.47***	0.01	3.68***
Loons	0.05	0.02	10.45***	19.09***	2.20*	0.05	9.32***
Pelicans	0.29	867.95***	38.17***	141.31***	45.16***	108.86***	6.54***
Gannets	0.09	110.66***	14.56***	0.44	15.02***	1.06	5.97***
Cormorants	0.04	6.41*	9.20***	18.57***	3.50***	6.65**	7.08***
Herons	0.35	2133.60***	28.81***	31.56***	25.49***	24.96***	4.14***
Storks	0.05	51.27***	9.35***	6.98*	9.05***	6.79*	1.45
Ibises	0.04	108.55***	3.41***	2.35	3.28**	1.61	1.63
Geese	0.02	1.18	2.38*	6.07*	0.96	1.37	2.46*
Ducks	0.04	14.10***	5.43***	0.78	6.79***	0.75	3.07**
Shorebirds	0.08	2.92	35.65***	0.00	0.97	26.45***	1.12
Gulls	0.06	0.09	15.96***	15.76***	13.25***	0.19	2.61*
Terns	0.08	190.89***	6.85***	5.24*	11.54***	6.08*	2.79*
Vultures	0.03	21.19***	3.72***	0.11	4.41***	0.02	3.50***
Raptors	0.20	685.91***	17.75***	13.16**	19.19***	13.31**	3.62***
Doves	0.06	128.54***	7.23***	25.95***	6.88***	31.30***	2.12*
Kingfishers	0.17	437.81***	22.12***	5.47*	23.14***	6.09*	1.99*
Woodpeckers	0.03	38.45***	3.44***	3.81	3.58***	5.81*	1.39

* $P \leq 0.05$ ** $P \leq 0.01$ *** $P \leq 0.001$

Heterogeneity among macrohabitats increases species richness within a wetland complex (Craig and Beal 1992). Therefore, microhabitat heterogeneity within a macrohabitat should have a similar effect. The Isle of Palms transect offered a mosaic of terrestrial and aquatic microhabitats which included mudflats (during low tide), spoil sites characterized by dense shrub, *Spartina* spp. and *Juncus roemerianus* saltmarsh, tidal creeks, occasional ancient remnants of sand dunes now characterized by palmetto (*Sabal palmetto*)/pine (*Pinus* spp.)/oak (*Quercus* spp.) communities, and adjacent upland habitat. Breach Inlet transect, on the other hand, offered only sand dunes, ocean beach, and intertidal and subtidal ocean. These differences in habitat diversity may explain why total and monthly species richness at Isle of Palms was greater than at Breach Inlet.

Peaks in monthly species richness are likely attributable to peaks in spring and fall migration. By the same token, the decline in avian richness at both sites from May through August may be because migratory movements are at a minimum during this period, which limits the number of species to local breeders and nonbreeding summer residents. Spring species richness was greatest at both sites in March and April, corresponding with shorebird movements (Figure 3a). However, peaks in species richness during fall were not as closely synchronized between sites. Breach Inlet species richness peaked in September and declined in October and November, correlating with peak shorebird movements (Figure 3a). Species richness at Isle of Palms increased in September and October and peaked in November. This period corresponded with peak raptor movements (Figure 3b) and migration (Laurie et al. 1981).

Movement Rate

Movement rate peaks for seasonal ecological groups largely corresponded with migratory activity and/or winter residency. This was most evident in the 18-fold increase in ducks at the beach transect in January. For resident ecological groups, with the exception of ibises, peaks in movement rates may be largely attributed to breeding activity and the formation of post-breeding aggregations (Figure 3). Two peaks in White Ibis movement rate may have corresponded with adult pre-nesting/incubation weight-gain and post-breeding recruitment of young into the population (Bildstein 1993). The decline in movement rates during the breeding season may be explained by the low-salt dietary tolerance of ibis nestlings. Adult ibis regularly leave the area and travel inland to procure freshwater invertebrates for nestlings (Bildstein 1993).

Although most ecological groups occurred predominantly in one transect rather than the other, we did observe seasonal shifts between transects among gulls and terns (Figure 3). Peaks in gull movement rate at one site were usually accompanied by declines of comparable magnitude at the other, except during fall migration when movements increased at both sites. This phenomenon may be indicative of either an intraspecific seasonal change in habitat use or an interseasonal shift in gull species with differing habitat needs. The peak in gull movements during the summer months at the marsh transect was largely attributable to Laughing Gulls. The winter peak can be explained

by the large numbers of Ring-billed Gulls that occurred along the beach transect.

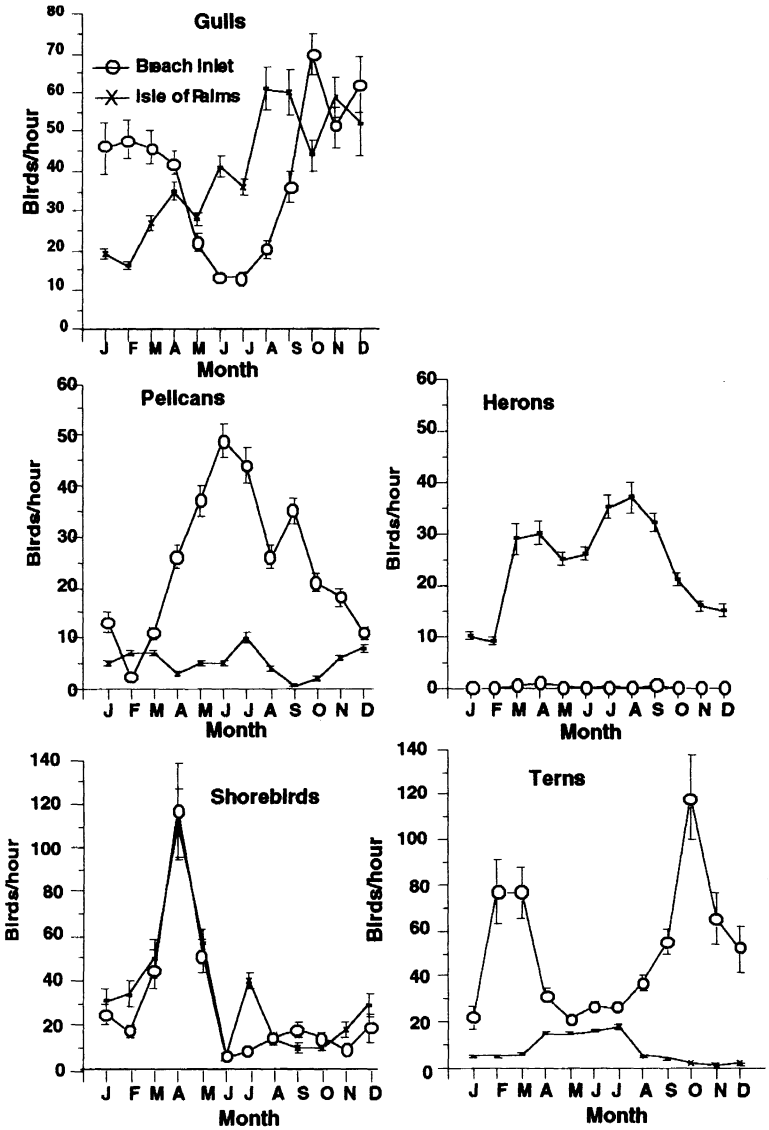

Fig. 3a. Monthly mean movement rates (bird/hr. ± SE) at Isle of Palms and Breach Inlet transects among ecological groups that exhibited significant site and/or temporal variation in movement rates.

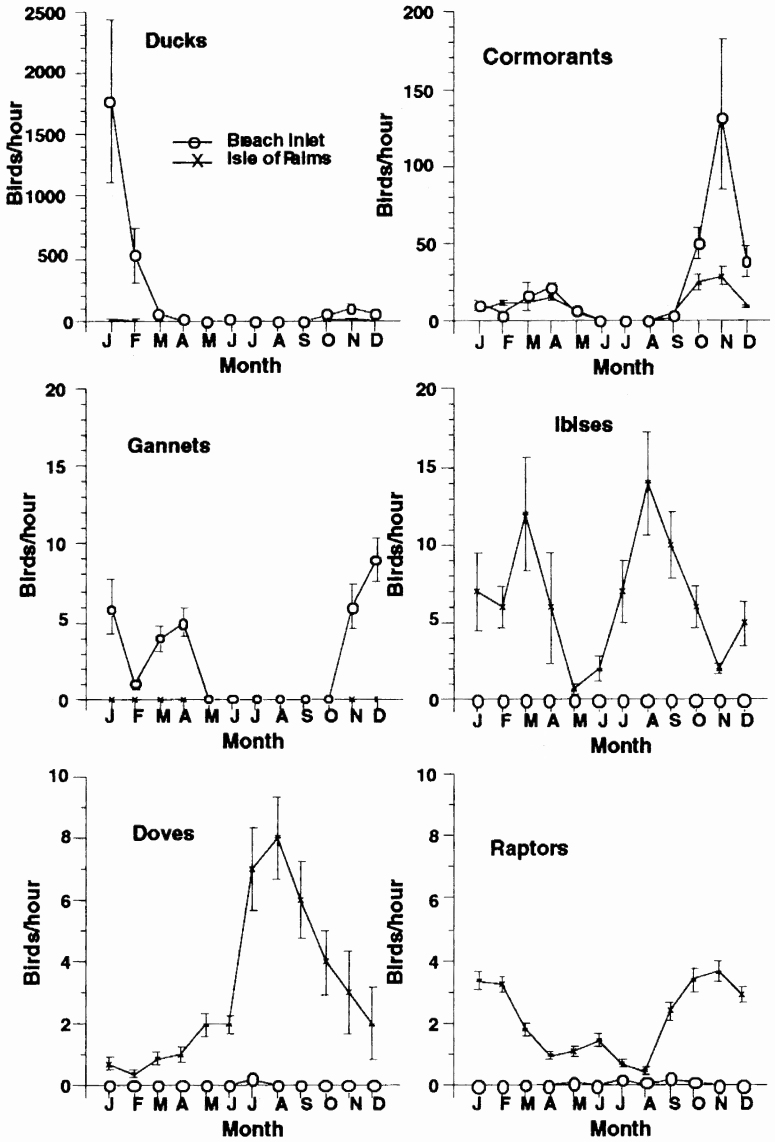

Fig. 3b. Monthly mean movement rates (bird/hr. ± SE) at Isle of Palms and Breach Inlet transects among ecological groups that exhibited significant site and/or temporal variation in movement rates.

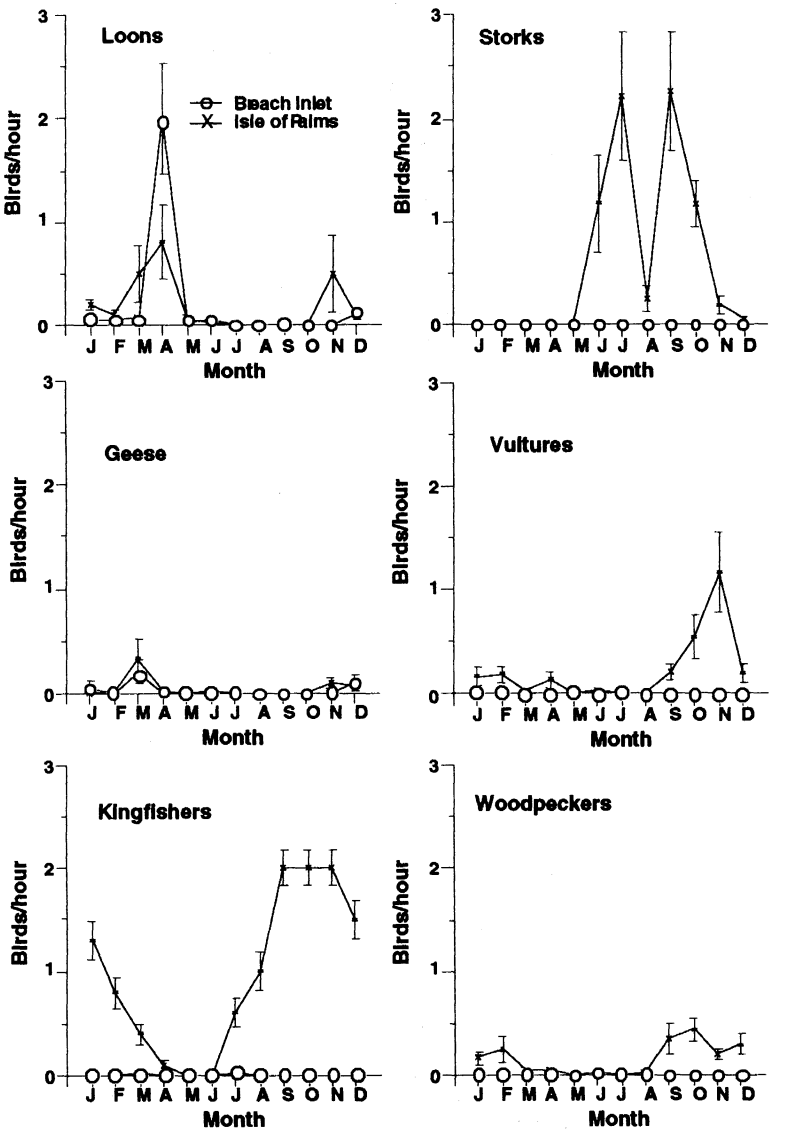

Fig. 3c. Monthly mean movement rates (bird/hr. ± SE) at Isle of Palms and Breach Inlet transects among ecological groups that exhibited significant site and/or temporal variation in movement rates.

At Isle of Palms, tern activity peaked during the summer. Least Terns bred locally at two rooftop colonies, each located within 1 km of the Isle of Palms transect (T. Murphy and M. Dodd, South Carolina Dept. of Natural Resources, pers. comm.). Feeding activity of nesting adult Least Terns may account for the increase in tern movement rates during this period. At Breach Inlet tern activity peaked in February - March and again in October. Peaks may be explained, in part, by the fact that Forster's and Caspian Terns are common winter visitors (Post and Gauthreaux 1989) and were frequently observed during our study (Appendix 1). Furthermore, large flocks of Black Skimmers were often observed loafing and foraging near the beach observation post during fall and winter, and thus contributed substantially to tern movement rates during these periods.

CONCLUSIONS

Conservation and management efforts have focused primarily on threats to biodiversity in terrestrial environments such as rain forests of Amazonia or old-growth forests of the U.S. northwest. Less attention has been paid to loss of biodiversity in coastal environments (Beatley 1991). Avifauna rank high in the food chain as primary and/or secondary consumers in most coastal wetland systems. As a result, fluctuations in abundance, distribution, and richness of birds over time serve as important indicators of how environmental changes (natural and human-induced) impact a coastal system. For this reason alone, wildlife conservation and management agencies should be encouraged to keep abreast of changes in avian population dynamics. Our study demonstrated that the coastal wetland complex of central South Carolina supports a high richness of avian species throughout the annual cycle and therefore warrants the close attention of wildlife managers and researchers alike. This study can be used as a benchmark for an ongoing monitoring program of avian richness, distribution, and abundance in this area. Data can be used in the preparation of environmental impact statements, to evaluate permits for wetland alteration, and for management and protection of wetlands. Census efforts will also allow researchers and managers to accurately follow future local trends in avian populations. Such information can also be used in conjunction with similar data from other geographic regions to monitor world-wide population trends.

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Appendix 1. Species composition and abundances at Isle of Palms and Breach Inlet transects, Charleston County, South Carolina, September 1991 - May 1994.

		Isle of Palms		Breach Inlet	
Species	*Scientific Name*	*Ind.*	*Sp.*	*Ind.*	*Sp*
LOONS		*134a*	*1*	*126*	*2*
Common Loon	*Gavia immer*	128		72	
Red-throated Loon	*G. stellata*	0		1	
GREBES		3	1	2	1
Horned Grebe	*Podiceps auritus*	0		2	
Pied-billed Grebe	*Podilymbus podiceps*	3		0	
PELICANS		3288	1	15671	1
Brown Pelican	*Pelecanus occidentalis*	3288		15671	
GANNETS		0	0	1851	1
Northern Gannet	*Morus bassanus*	0		1851	
CORMORANTS		7836	1	18102	2
D-c. Cormorant	*Phalacrocorax auritus*	4951		4450	
Great Cormorant	*P. carbo*	0		2	
HERONS		14866	9	165	6
B-c. Night Heron	*Nycticorax nycticorax*	367		0	
Y-c. Night Heron	*Nyctanassa violacea*	176		2	
Gr.-backed Heron	*Butorides striatus*	1183		6	
Tricolored Heron	*Egretta tricolor*	2999		26	
Little Blue Heron	*E. caerulea*	1118		17	
Snowy Egret	*E. thula*	2031		0	
Cattle Egret	*Bubulcus ibis*	28		0	
Great Egret	*Casmerodius albus*	2500		7	
Great Blue Heron	*Ardea herodias*	745		14	
STORKS		420	1	0	0
Wood Stork[FE, SE]	*Mycteria americana*	420		0	
IBISES		4060	2	1	1
Glossy Ibis[ST]	*Plegadis falcinellus*	223		0	
White Ibis	*Eudocimus albus*	3562		1	
SWANS		1	1	0	0
Black Swan	*Cygnus atratus*	1		0	
GEESE		31	2	16	0
Canada Goose	*Branta canadensis*	21		0	
Snow Goose	*Chen caerulescens*	2		0	
DUCKS		3224	12	137128	14
Mallard	*Anas platyrhynchos*	27		2	
Green-winged Teal	*A. crecca*	21		0	
American Wigeon	*A. americana*	0		25	
Northern Pintail	*A. acuta*	1		1	
Blue-winged Teal	*A. discors*	2		0	
Ruddy Duck	*Oxyura jamaicensis*	0		2	
Wood Duck	*Aix sponsa*	47		0	
Canvasback	*Aythya valisineria*	0		410	
Redhead	*A. americana*	7		0	
Ring-necked Duck	*A. collaris*	0		1	
Lesser Scaup	*A. affinis*	8		12	
Black Scoter	*Melanitta nigra*	0		1343	

Surf Scoter	*M. perspicillata*	0		120	
Oldsquaw	*Clangula hyemalis*	0		2	
Com. Goldeneye	*Bucephala clangula*	1		0	
Bufflehead	*B. albeola*	64		6	
Com. Merganser	*Mergus merganser*	10		13	
Red-br. Merganser	*M. serrator*	182		259	
Hooded Merganser	*Lophodytes cucullatus*	702		2	
RAILS		8	1	0	0
Clapper Rail	*Rallus longirostris*	4		0	
SHOREBIRDS		22067	17	18985	21
Am. Oystercatcher	*Haematopus palliatus*	46		37	
Black-necked Stilt	*Himantopus mexicanus*	81		6	
Wilson's Plover[ST]	*Charadrius wilsonia*	1		166	
Semipal. Plover	*C. semipalmatus*	78		168	
Killdeer	*C. vociferus*	28		5	
Black-bel. Plover	*Pluvialis squatarola*	106		156	
Lr. Golden Plover	*P. dominica*	0		10	
Marbled Godwit	*Limosa fedoa*	2		1	
Whimbrel	*Numenius phaeopus*	1585		74	
Long-b.Curlew	*N. americanus*	0		4	
Willet	*Catoptrophorus semipalmatus*	1428		665	
Gr. Yellowlegs	*Tringa melanoleuca*	187		0	
Lr. Yellowlegs	*T. flavipes*	71		4	
Spotted Sandpiper	*Actitis macularia*	44		25	
Sh.-b. Dowitcher	*Limnodromus griseus*	78		0	
L-b. Dowitcher	*L. scolopaceus*	25		0	
Ruddy Turnstone	*Arenaria interpres*	0		254	
Red Knot	*Calidris canutus*	40		4312	
Dunlin	*C. alpina*	35		954	
Sanderling	*C. alba*	0		5055	
Semi. Sandpiper	*C. pusilla*	0		56	
Western Sandpiper	*C. mauri*	0		353	
Least Sandpiper	*C. minutilla*	61		130	
Wh-r. Sandpiper	*C. fuscicollis*	0		23	
GULLS		26287	6	26455	5
Laughing Gull	*Larus atricilla*	13402		5472	
Bonaparte's Gull	*L. philadelphia*	64		433	
Ring-billed Gull	*L. delawarensis*	1503		5321	
Herring Gull	*L. argentatus*	193		989	
Glaucous Gull	*L. hyperboreus*	1		0	
Gr. Bl.-back Gull	*L. marinus*	3		26	
TERNS		4990	9	34807	9
Common Tern	*Sterna hirundo*	2		154	
Forster's Tern	*S. forsteri*	704		6098	
Gull-billed Tern	*S. nilotica*	150		51	
Least Tern[ST]	*S. antillarum*	1382		1836	
Sandwich Tern	*S. sandvicensis*	24		158	
Royal Tern	*S. maxima*	784		5724	
Caspian Tern	*S. caspia*	78		459	
Black Tern	*Chlidonias niger*	73		29	
Black Skimmer	*Rynchops niger*	747		15370	
VULTURES		174	2	0	0

Black Vulture	*Coragyps atratus*	1		0	
Turkey Vulture	*Cathartes. aura*	172		0	
RAPTORS		1481	9	38	2
Bald Eagle[FT, SE]	*Haliaeetus leucocephalus*	29		0	
Northern Harrier	*Circus cyaneus*	472		1	
Sh-shin. Hawk	*Accipiter striatus*	11		0	
Cooper's Hawk	*A cooperii*	7		0	
Red-tailed Hawk	*Buteo jamaicensis*	232		0	
Osprey	*Pandion haliaetus*	284		34	
American Kestrel	*Falco sparverius*	77		0	
Merlin	*F. columbarius*	6		0	
Peregrine F.[FE, SE]	*F. peregrinus*	20		0	
DOVES		1867	2	16	2
Rock Dove	*Columba livia*	171		11	
Mourning Dove	*Zenaida macroura*	1680		5	
OWLS		18	1	0	0
Great Horned Owl	*Bubo virginianus*	15		0	
GOATSUCKERS		11	1	2	1
Com. Nighthawk	*Chordeiles minor*	9		2	
KINGFISHERS		641	1	2	1
Belted Kingfisher	*Ceryle alcyon*	641		2	
WOODPECKERS		113	2	0	0
R.-b. Woodpecker	*Melanerpes carolinus*	2	0		
Northern Flicker	*Colaptes auratus*	91	0		
TOTAL		91520	82	253367	69

* Includes birds identified to species as well as those only identified to ecological group.

[ST] threatened species - state listed

[FE] endangered species - federally listed

[SE] endangered species - state listed