Shorebird Assemblages of the Cape Romain Region, South Carolina

Sarah L. Dodd
South Carolina Department of Natural Resources
Wildlife Diversity Section
Samworth WMA
420 Dirleton Rd.
Georgetown, SC 29440

present address:
222 Alabama Street
St. Simons Island, GA 31522

Mark D. Spinks
South Carolina Department of Natural Resources
Wildlife Diversity Section
Samworth WMA
420 Dirleton Rd.
Georgetown, SC 29440

Abstract

We examined abundance and distribution patterns of shorebirds (Charadriiformes: Charadrii) using natural coastal wetlands in the Cape Romain region, South Carolina. Overall, we observed 22 species and 247,574 shorebirds, most of which were Dunlin (31.7%; *Calidris alpina*) and Short-billed Dowitcher (26.5%; *Limnodromus griseus*). Maximum [38,245 (516 birds/km)] and minimum [3,629 (48 birds/km)] counts of shorebirds occurred at the end of March and June, respectively. Species composition and patterns of abundance differed significantly between outer beaches and inner estuarine habitats. *Calidris* sandpipers [Dunlin, Sanderling (*Calidris alba*), Red Knot (*Calidris canutus*), and small sandpipers (*Calidris mauri, minutilla, and pusilla*)] and plovers [(Black-bellied (*Pluvialis squatarola)*, Piping (*Charadrius melodus*), Wilson's (*Charadrius wilsonia*), and Semipalmated (*Charadrius semipalmatus*)] used mostly beaches and sand bars. By contrast, large Scolopacids predominated on oyster banks and docks [Marbled Godwit (*Limosa fedoa*), Willet (*Catoptrophorus semipalmatus*), and Short-billed Dowitcher] or high sand/mud flats [Whimbrel (*Numenius phaeopus*)]; and American Oystercatcher (*Haematopus palliatus*) used mostly oyster banks. For eight species (American Oystercatcher, Short-billed Dowitcher, Dunlin, Willet, Whimbrel, Wilson's Plover, and Semipalmated Plover), peak counts of the Cape Romain region during spring and/or fall equaled or exceeded 15% of respective species' eastern U. S. totals (based on International Shorebird Survey censuses at almost 800 sites east of the 105th Meridian from 1974-1993). Exceptionally high proportions of eastern U. S. totals resulted for spring and fall migrating American Oystercatcher ($\geq$46%) and Marbled Godwit ($\geq$20%), and spring migrating Short-billed Dowitcher (30%) and Semipalmated Plover (30%). We conclude that the Cape Romain region is a critical migration-stopover and wintering area for shorebirds using the Atlantic Coast. Moreover,

our finding that composition of shorebird assemblages varied considerably between outer beach and inner estuarine habitats suggests that the 5 - 8 km mosaic of habitats stretching from outer barrier islands to inland shallow bays contributes to the high diversity and abundance of shorebirds using the region.

Introduction

Migrant shorebirds rest and replenish fat reserves at stopover areas, predominately coastal wetland habitats with apparently high concentrations of invertebrate prey (Morrison 1984, Clark *et al.* 1993, Dinsmore *et al.* 1998, Page *et al.* 1999). Several authors (*e.g.* Senner and Howe 1984, Myers *et al.* 1987, Bildstein *et al.* 1991, Harrington 1995) have addressed the vulnerability of shorebird populations (*e.g.* North American Red Knots; Clark *et al.* 1993) that concentrate at only a few stopover sites during migration. Moreover, some authors (Howe *et al.* 1989, Clark *et al.* 1993, Morrison *et al.* 1994, Harrington 1995, Gill *et al.* 1995) have reported significant declines in Western Hemispheric populations of several species of shorebirds (*e.g.* Black-bellied Plover, Sanderling, Whimbrel, Red Knot, Short-billed Dowitcher, Semipalmated Sandpiper), not including species [Snowy Plover (*Charadrius alexandrinus*), Piping Plover, and Eskimo Curlew (*Numenius borealis*)] listed as Federally Threatened or Endangered (Harrington and Perry 1995). The creation of the Western Hemisphere Shorebird Reserve Network (WHSRN; Myers *et al.* 1987, Bildstein *et al.* 1991) in 1985 initiated a large-scale effort to conserve shorebirds by identifying wetlands that support significant concentrations of shorebirds (Harrington and Perry 1995, Page *et al.* 1999). Wetlands are designated as critical habitat reserves for a species or group of taxa based on overall annual numbers or proportions of species' flyway populations (Harrington and Perry 1995). Examples of important WHSRN reserves are Delaware Bay (Clark *et al.* 1993), Bay of Fundy (Hicklin 1987), and San Francisco Bay (Page *et al.* 1999).

Although interior regions are gaining recognition (*e.g.* Skagen and Knopf 1993, Davis and Smith 1998, Warnock *et al.* 1998), research in North America has focused on evaluating the importance of stopover sites in coastal Atlantic and Pacific flyways (Skagen and Knopf 1993). Despite this emphasis on coastal corridors, Atlantic Coast stopover sites from Florida to North Carolina remain largely undocumented, with the exception of the Outer Banks, North Carolina (Dinsmore *et al.* 1998) and Cape Romain-Santee Delta region, South Carolina (Marsh and Wilkinson 1991a, Weber and Haig 1996). All three southern Atlantic studies reported significant concentrations of several species of shorebirds. Moreover, Cape Romain National Wildlife Refuge has recently been designated an International WHSRN reserve.

Despite Cape Romain's recognition as a WHSRN reserve, abundance estimates for shorebirds using the region are conservative. Marsh and Wilkinson (1991a) surveyed little beach habitat and included no coverage of several barrier islands (Bull, Capers, and Dewees) or outer beach habitat on the region's largest barrier island (Cape Island). Consequently, Marsh and Wilkinson did not present data for small *Calidris* sandpipers, Sanderling, Piping Plover, and Wilson's Plover. They also reported that their surveys of Dunlin, Red Knot, and Black-bellied Plover were inadequate. Almost a decade later, we initiated a study of shorebirds in the Cape Romain region to obtain current baseline estimates of abundance for all species of shorebirds. In this paper, we examine patterns of migrating and wintering assemblages of shorebirds using natural coastal wetlands in the Cape Romain region with the following objectives: 1) to evaluate spatial variation in composition (overall species composition and abundance) of shorebird assemblages; 2) to assess the relative importance of the region to migrant shorebirds by comparing maximum counts from this study to those from other Atlantic Flyway sites; and 3) to discuss conservation implications, including potential threats to shorebirds using the region.

Study Area and Methods

We studied shorebirds (Charadriiformes: Charadrii) on the central coast of South Carolina in the Cape Romain region (32° 49' - 33°05' N, 79° 20' - 79° 45' W), which encompasses Cape Romain National Wildlife Refuge, Capers Island State Heritage Preserve, Dewees Island, and public salt marshes bordering the Atlantic Intracoastal Waterway (AIW) from McClellanville to Isle of Palms (Fig. 1). The Cape Romain region is characterized by several barrier islands with predominately sandy beaches that are separated from the mainland by extensive (5 - 8 km) *Spartina alterniflora* marsh, punctuated by shallow bays with expansive mudflats and oyster (*Crassostrea virginica*) beds (Marsh and Wilkinson 1991a). At high tide, shorebirds congregate on oyster banks (narrow, elongated mounds of elevated oyster shell) bordering bays, the AIW, and small estuarine islands; docks and high flats bordering the AIW; and exposed substrate on beaches and sand bars. We surveyed shorebirds using all exposed habitat on the following routes (76 km of linear shoreline with exposed substrate at high tide): 1) *Northeastern (NE)*: Horsehead Creek, Deepwater Point, and Casino Creek oyster banks; Cape and Raccoon Key barrier island beaches; Cape Island inlet and Lighthouse Island South sand bars; White Banks oyster banks, and Marsh Island sand spit; 2) *Southwestern (SW)*: oyster banks, high sand/mud flats, and docks bordering both sides of the AIW from Jeremy Creek (Marker 35) to just south of Dewees Inlet (Marker 115); and 3) *Southeastern (SE)*: southwest Bull's Bay oyster banks; Bull, Capers, and Dewees barrier island beaches; and Price Inlet sand bar. All sites are federal or state owned and uninhabited, with the exceptions of Dewees Island, which is privately owned and developed with relatively low density housing, and private docks bordering the mainland side of the AIW. All sites are accessible by boat only, with the exception of docks. We did not survey Lighthouse Island or boneyard forest habitat on Capers and Bull islands because at high tide these sites had no exposed habitat used by shorebirds (Dodd and Spinks, pers.

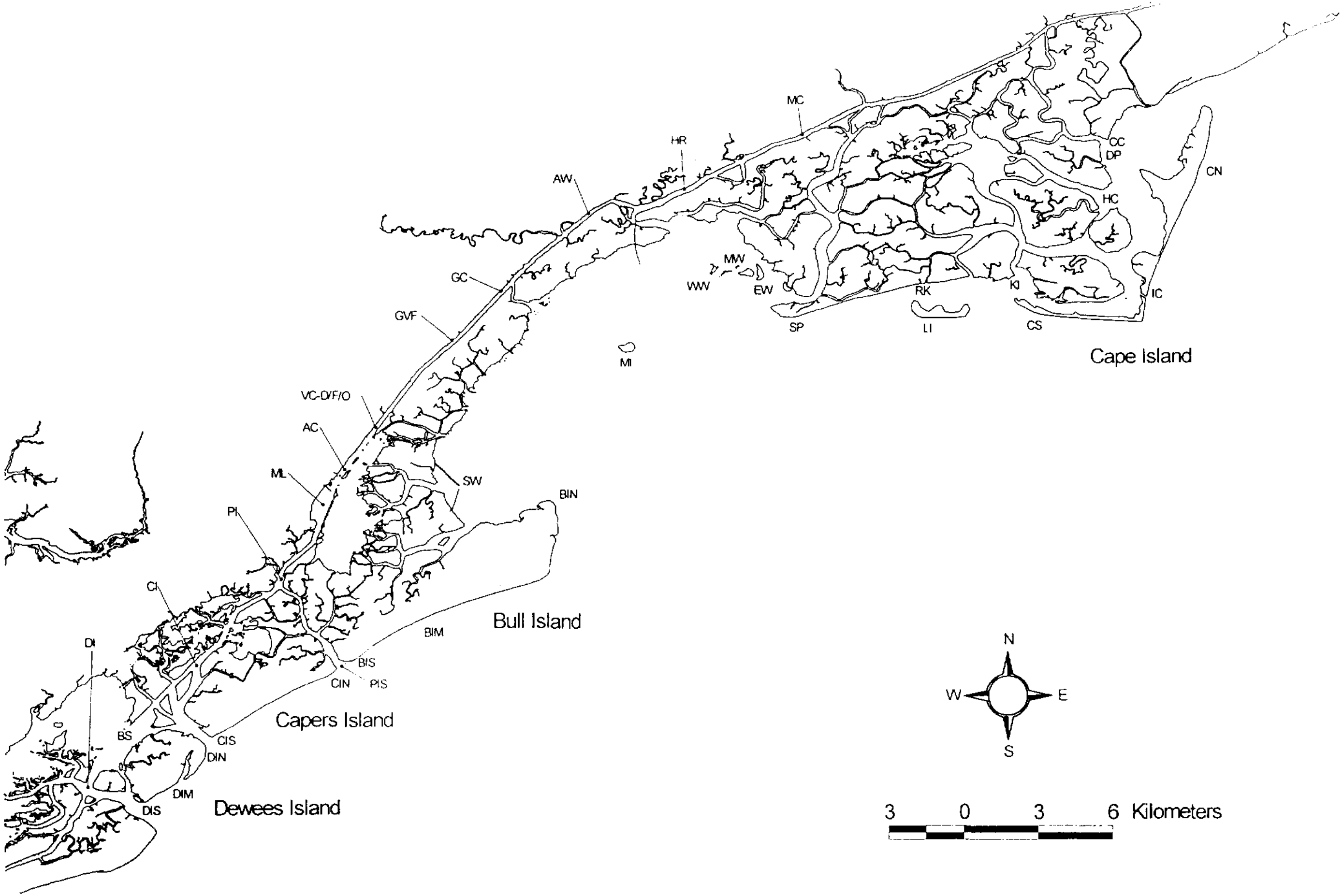

FIG. 1. Location of sites censused in the Cape Romain region on the central coast of South Carolina. See Table 2 for location codes.

observ.). We also did not survey New and Bird islands because high tides covered them during the study.

Bird Censuses.

From March - October 1997, January - May 1998, and November and December 1998, we conducted standardized censuses once each month within 2.5 hours of high ($\geq$ 1.7 m) spring tides for three consecutive days [n = 15 sets (routes 1 - 3) of censuses]. We surveyed shorebirds at high tide because birds congregated on fewer exposed sites than at lower tides, and access to the region is extremely limited at low tide. We randomly chose the day to census each route from the three days with the highest daylight tides for each month. If weather (*e.g.* high winds or heavy rainfall) prevented us from completing a route, we censused the entire route on the next day (n = 2 censuses). However, several days of extreme weather conditions prevented us from censusing the SE route in early March 1998 and from completing half the NE route (from Raccoon Key to Marsh Island) in September 1997. In addition, extremely shallow water in Bull's Bay resulting from winds pushing tides out early prevented us from surveying White Banks (n = 4) and Marsh Island (n = 6) several times. On completed censuses, however, Bull's Bay islands were used by a small proportion (8%) of shorebirds observed on the NE route.

We censused shorebirds from an outboard motor boat or all-terrain vehicle (ATV) using 8.5 X 44 mm binoculars and a 20 X spotting scope. We censused the large offshore sand bar (Lighthouse Island South) and all barrier island beaches by ATV, with the exception of Raccoon Key and the northeast point of Bull Island, where treacherous waters prevented unloading an ATV onto the beach. We unloaded the ATV from the boat onto the northwest end of each beach and maneuvered the ATV parallel to the shoreline towards the southwest end of the beach, where we reloaded the ATV and crossed the inlet to the next beach. We observed birds with the ATV motor turned off. We censused all other sites from an outboard motor boat. All sites surveyed from the boat were narrow, allowing for complete coverage. After encountering birds, the boat handler positioned the boat parallel to the shoreline approximately 20 - 40 m away, and alternated between turning off the engine and moving the boat forward until the observer had recorded data for the entire flock. We checked the marsh-side of high oyster banks for additional birds by standing on top of the oyster bank.

To minimize variation among censuses due to human factors, we used the same observer (S. Dodd) and boat operator (M. Spinks) for all censuses. After encountering shorebirds, we recorded data on species, abundance, and behavior (foraging, loafing, preening, alert, flying, or other). We estimated large flocks (>150 birds) by counting across the flock in five's for each species present. We counted large flocks at least twice and from at least two locations. We counted flying birds only when they flew prematurely from unsurveyed sites; we estimated flying birds by counting across the flock in tens for each species present.

We identified most shorebirds to species, but sometimes due to poor viewing conditions we could not distinguish among species of Least, Western, and Semipalmated sandpipers. Consequently, when necessary, we used the taxonomic group, 'small sandpipers' for observations of these species. Of the difficult to distinguish *Limnodromus* genus, we identified only Short-billed Dowitchers during the study, with the exception of one Long-billed Dowitcher (*Limnodromus scolopaceus*) identified by call during a pilot survey in February 1997. Similarly, Marsh and Wilkinson (1991a) reported Long-billed Dowitchers only on one census, but in July. Hereafter, we refer to all dowitchers observed in this study as Short-billed Dowitchers, with the caveat that we may have overlooked some Long-billed Dowitchers.

Human Disturbance.

We recorded the number of people and dogs at each site during censuses and whether or not birds flushed due to disturbance from humans or dogs. During a pilot census of the AIW in February 1997, we observed that shorebirds using oyster banks at high tide often flushed in response to boat wakes cresting over the bank. Consequently, we quantified boat traffic adjacent to oyster banks by counting the number of boats on the SW route per census period.

Data Analysis.

We combined observations of Least, Western, and Semipalmated sandpipers and unidentified small sandpipers into the 'small sandpiper' group. Hereafter, we refer to this taxonomic group as if it were a species. To represent an annual cycle, we used the most contiguous grouping of censuses from June - October 1997; November and December 1998; and January - May 1998. For the SE route, however, we used data from a census conducted in March 1997 to replace the missing (see above) March 1998 census.

For each site, we summarized abundance data by totaling the number of birds for each species from the year divided by the corresponding km of linear shoreline and number of censuses. We analyzed spatial variation in composition (overall species composition and abundance) of shorebird assemblages using Detrended Correspondence Analysis (DCA; Hill 1979), an ordination technique based on reciprocal averaging, but without the corresponding arch distortion in the axes (Gauch 1982). We used ordination because it represents community structure [a matrix of samples (sites) by species (shorebirds)] in low dimensional space by positioning samples with similar composition close together while locating samples with great differences in composition far apart (Gauch 1982). Simultaneously, species that used sites similarly are assigned similar axis scores, whereas species that inhabited different sites receive disparate axis scores. DCA axes are scaled in units of average standard deviation of species turnover so that equal distances in ordination space correspond to equal variation in species composition; a 50% change in species composition of samples occurs around one standard deviation, and a complete turnover in species composition occurs over four standard deviations (Gauch 1982). We excluded from the analysis three species (Black-necked Stilt, Lesser Yellowlegs, and Killdeer) that occurred less than five times because inclusion of rare species confounds ordination results (Gauch 1982). In addition, we removed Price Inlet sand bar from the analysis because it was exposed at high tide for only two months. *See* Colwell and Dodd (1995) and Patten and Rotenberry (1998) for additional analyses of bird communities using DCA. We evaluated variation in axes scores using Wilcoxon 2-Sample Tests with an alpha level of significance of < 0.05 (PC-SAS, Vers. 6.12, SAS 1992).

Maximum Counts.

For each species, we determined the following peak counts using all censuses: 1) a maximum daily count, using the highest count from one of three routes for spring, fall, and winter; and 2) a maximum count of the region, using the highest count from all three routes combined for each season. We evaluated the relative importance of Cape Romain as a stopover site by comparing maximum counts with those from International Shorebird Survey (ISS, Manomet Observatory for Conservation Science) censuses conducted at almost 800 sites east of the 105th Meridian, U.S. from 1974 - 1993 (Harrington and Perry 1995). By adding maximum counts from ISS sites, Harrington and Perry (1995) calculated a "national" (mostly Atlantic Flyway) spring and fall "total" for each species. Using these totals as an index of eastern U.S. populations, we calculated species' proportions by dividing maximum counts into corresponding ISS seasonal totals (with the Cape Romain count added in).

Results

Community Patterns.

During one annual cycle, we observed 22 species and 247,574 shorebirds using the Cape Romain region (Table 1). Dunlin (31.7%) and Short-billed Dowitcher (26.5%) comprised most of the birds, followed by small sandpipers (11.5%), and Red Knot (7.5%). Overall, most (66.8%) shorebirds loafed, whereas fewer birds preened (12.9%), foraged (9.8%), flew (7.6%), or exhibited alert (2.6%) behaviors at high tide. However, more Spotted Sandpipers and Black-necked Stilts foraged than loafed, and almost half the Piping Plovers foraged.

We observed shorebirds throughout the year with maximum [38,245 (516 birds/km)] and minimum [3,629 (48 birds/km)] counts occurring at the end of March and June, respectively (Fig. 2). Winter (November, December, and January) counts approached the maximum spring count when peak numbers of several species (Marbled Godwit, Short-billed Dowitcher, Dunlin, Black-bellied Plover, and American Oystercatcher) occurred.

Composition (overall species composition and abundance) of shorebird assemblages varied considerably among sites (Fig. 3). Axes one and two explained 68% and 25% of variation in data, respectively. Axis one measured

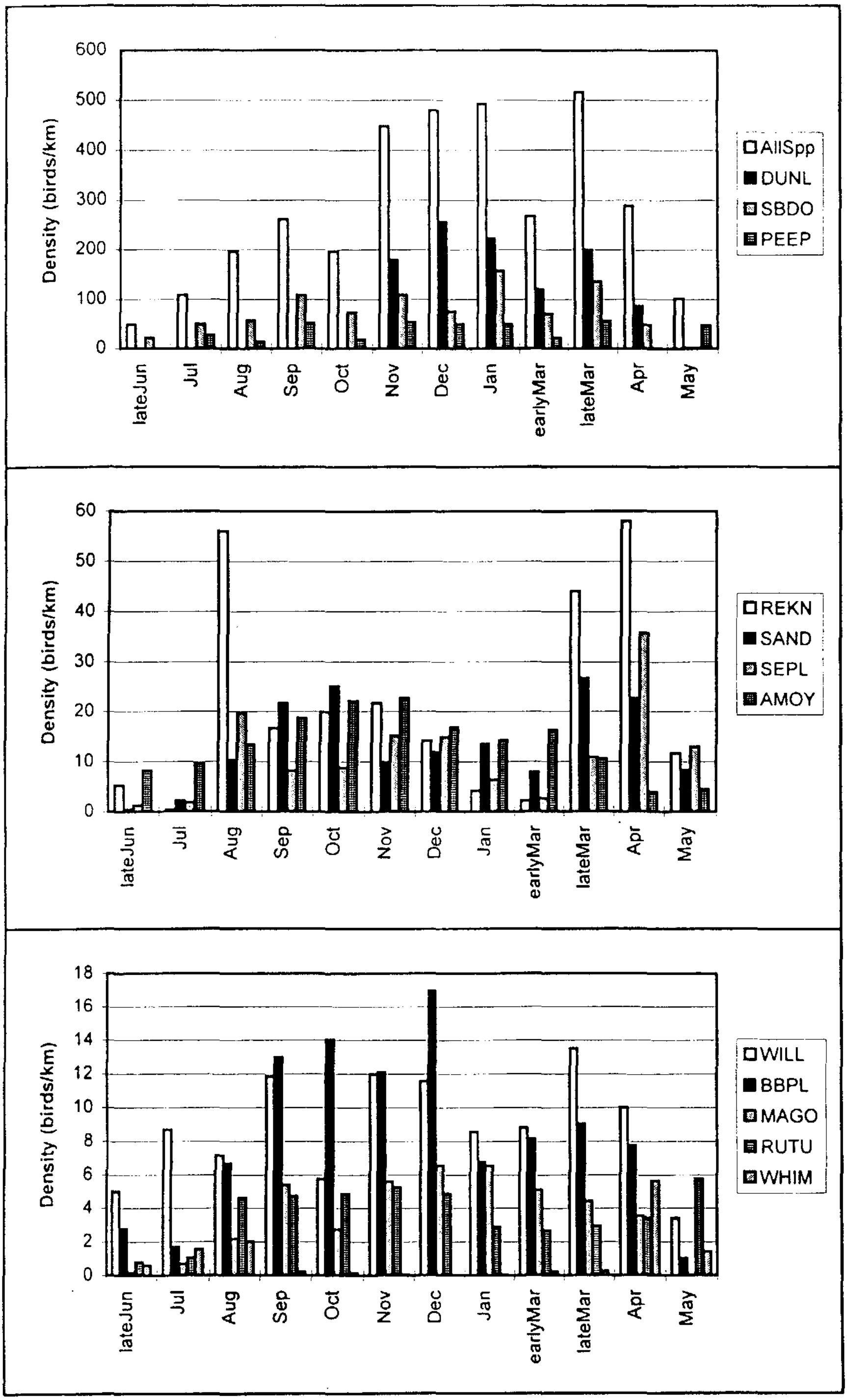

FIG. 2. Seasonal variation in abundance (birds/km) of shorebirds using the Cape Romain region, SC, from June - October 1997, November and December, 1998, and January - May 1998; data presented for the 12 most abundant species (see Table 1 for codes) and total assemblage of shorebirds (All Spp.).

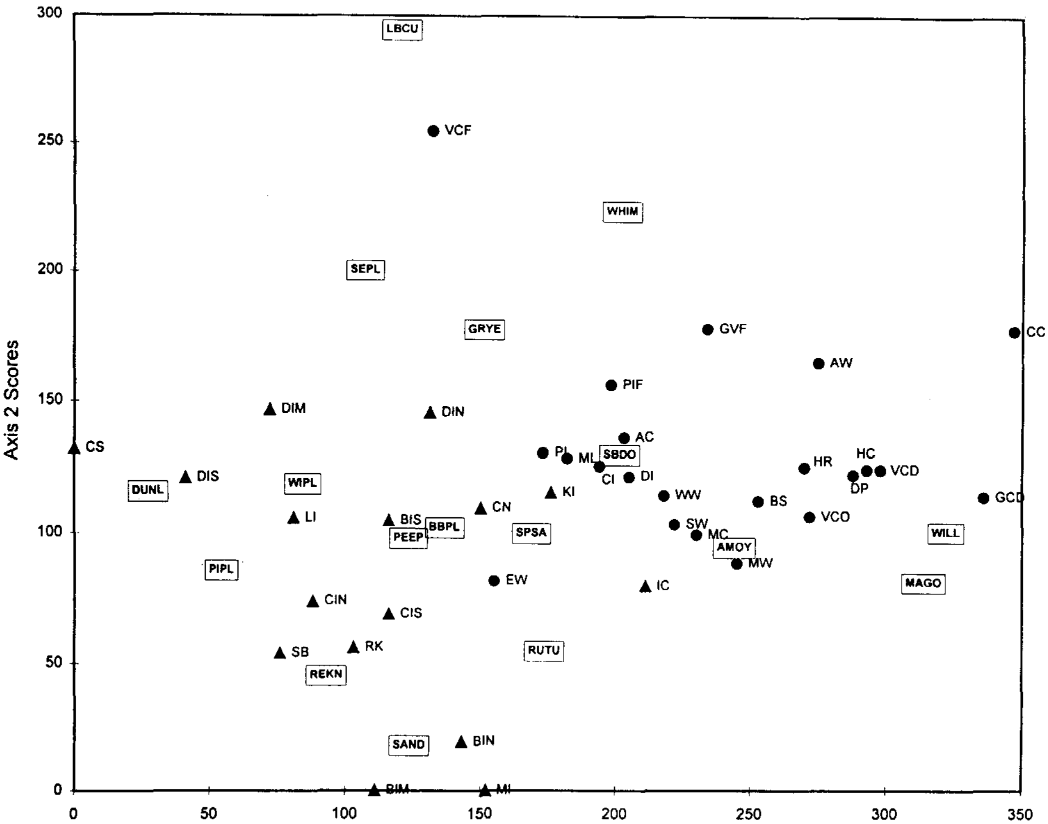

FIG. 3. Spatial variation in composition of shorebird assemblages using outer beach (triangles) and inner estuarine/AIW (circles) habitats as portrayed by Detrended Correspondence Analysis. See Tables 1 and 2 for species and site codes, respectively.

3.4 standard deviations, representing a gradient of high (> 50%) species turnover from outer beaches and sand bars to estuarine and AIW sites (*e.g.* oyster banks and docks; hereafter, referred to as inner habitats). Spanning 2.5 standard deviations, Axis two also represented a gradient exceeding a half change in species composition from outer to inner habitats. Composition differed significantly between outer (n = 16) and inner (n = 22) sites (axis 1 scores: z = - 4.8, P = 0.0001; and axis 2 scores: z = - 2.85, P = 0.004). *Calidris* sandpipers (Dunlin, Sanderling, Red Knot, and small sandpipers) and all species of plovers used mostly outer beaches and sand bars. By contrast, large Scolopacids and American Oystercatcher used mostly inner habitats: Short-billed Dowitcher, Willet, and Marbled Godwit predominated on oyster banks and docks; Whimbrel frequented high sand/mud flats and oyster banks; and American Oystercatcher used mostly oyster banks. Greater Yellowlegs, Spotted Sandpiper, and Ruddy Turnstone used many different habitats, and thus these species occupy the center of ordination space (Fig. 3; see Gauch 1982). At outer beaches and sand bars, species richness and densities (birds/km) varied from 2.9 (Dewees Is.-SW end) to 11.9 (Cape Is.-SW end) species and 29.3 (Bull Is.-middle) to 1406.3 (Dewees Is.-NE end; 3093.5 on Price Inlet sand bar when exposed) birds, respectively (Table 2). At inner habitats, species richness and densities ranged from 0.4 (Casino Creek oyster banks) to 7.9 (Price Inlet oyster banks) species and 1.2 (Matthews Creek oyster banks) to 1888.9 (Graham Creek docks) birds, respectively.

Human Disturbance.

We observed humans flushing shorebirds during few (7%, n = 3) censuses. In addition, we usually observed no people using sites on NE (median = 0, range = 0 - 32) and SW (median = 0, range = 0 - 2) routes, whereas we often observed a few people using sites on the SE route (median = 3, range = 0 - 57). We only observed dogs on the SE route (median: 0, range: 0 - 3). Boat traffic on the AIW ranged from 1.2 to 31.8 boats/h (median = 6.6 boats/h).

Relative Importance of the Cape Romain Region.

Based on maximum daily counts, nine species (American Oystercatcher, Marbled Godwit, Short-billed Dowitcher, Wilson's Plover, Dunlin, Willet, Whimbrel, Semipalmated Plover, and Red Knot) used one of three routes during fall and/or spring in numbers exceeding 5% of eastern U.S. totals (Harrington and Perry 1995) (Table 3). For these same species, peak counts from the entire region equaled or exceeded 15% of spring and/or fall eastern U.S. totals, with the exception of counts for Red Knot, which approached these proportions during fall (13%). Exceptionally high proportions of eastern U.S. totals resulted for regional peak counts of spring and fall migrating American Oystercatcher (≥ 46%) and Marbled Godwit (≥ 20%), and spring migrating Short-billed Dowitcher (30%) and Semipalmated Plover (30%).

Discussion

Based on findings from this study and Marsh and Wilkinson (1991a), we conclude that the Cape Romain region is one of the most important migration-stopover and wintering areas for shorebirds using the U.S. Atlantic Coast. The Cape Romain National Wildlife Refuge has recently been recognized as a WHSRN reserve of "international importance" for meeting the criteria of 100,000 shorebirds annually or 15% of a species' flyway population. Harrington *et al.* (1989) ranked the importance of ISS marine sites east of the 105th meridian U.S., based on each stopover's combined species' proportions of spring and fall "national totals" (also in Harrington and Perry 1995, see methods). Using this index of relative importance, the Cape Romain region (Table 3) ranked second only to Delaware Bay in spring and higher than all presented Atlantic Coast sites during fall. Harrington and Perry (1995) devised another index of relative importance that considers factors (*e.g.* overall species richness and presence of species shown in the literature to be declining significantly) additional to numbers of birds. Based on Harrington and Perry's index, Cape Romain (score = 90, using daily or regional peak counts) has a higher "critical value" than Delaware Bay (score = 65), and all potential Pacific, Atlantic, and Gulf Coast WHSRN sites (n = 34 with complete data) presented in Harrington and Perry (1995). Delaware Bay is considered one of the most important stopover areas in the Western Hemisphere (Senner and Howe 1984) and has been designated a Hemispheric WHSRN reserve for its importance to spring migrating Semipalmated Sandpiper, Ruddy Turnstone, Red Knot, and Sanderling (Clark *et al.* 1993). From our study, species' proportions for American Oystercatcher in both spring and fall and Short-billed Dowitcher and Semipalmated Plover in spring meet the criteria of 30% or more of a species' flyway population (Table 3) for designation as a hemispheric reserve. Consequently, we recommend that the Cape Romain region be redesignated as a Hemispheric WHSRN reserve and that sites exterior to but bordering the Cape Romain National Wildlife Refuge (Capers and Dewees islands; salt marshes and bays west of the AIW, and oyster banks bordering both sides of the AIW from McClellanville to Isle of Palms) be included in the reserve.

A decade ago (1988-89), Marsh and Wilkinson (1991a) showed that the Cape Romain region supported large concentrations of several species, especially American Oystercatcher and Marbled Godwit. In addition to corroborating their findings, our study documents the importance of the region to several other species, including Dunlin, Short-billed Dowitcher, Wilson's Plover, Semipalmated Plover, and Sanderling. Our study's NE and SW routes were similar to Marsh and Wilkinson's two routes, with the exception that our study covered additional habitat (the outer beach on Cape Island and Mathew's to Awendaw creeks on the AIW). None of the barrier island beaches on our SE route were censused by Marsh and Wilkinson. Despite these differences in area surveyed, some comparisons between counts are warranted. With increased survey effort from our study, peak counts for most species exceeded those from

Marsh and Wilkinson, especially for species (*e.g.* Dunlin) that inhabited predominately beach habitats. However, we obtained lower peak counts of American Oystercatcher and Marbled Godwit, even when considering regional totals from our study. Marsh and Wilkinson's peak counts of American Oystercatcher (2,482) and Marbled Godwit (735) exceeded those from our study (Table 3) by approximately 30%. Moreover, five of their six counts of oystercatchers over two winters approximated or exceeded 2,000 birds, whereas our mid-winter counts ranged from 1,035 to 1,707 oystercatchers. Spring and early fall counts of American Oystercatcher, however, are similar between studies. Marsh and Wilkinson's censuses of wintering Marbled Godwit consistently exceeded 500 birds, whereas our winter counts ranged from 369 to 480 godwits.

Differences between studies (*i.e.* methodology and/or observers) might account for lower counts. For example, Marsh and Wilkinson often censused godwits at their largest roost both before and after high tide, whereas we censused each site only once. Marsh and Wilkinson's before and after high tide counts (n = 5) suggest an increase (of up to 73%) in godwit numbers one to two hours after high tide. We typically arrived at sites used by most Marbled Godwit (Graham and Venning creeks) around one hour before high tide, which might explain our study's lower counts. It is more difficult to attribute lower counts of American Oystercatcher to variation among observers because both studies counted oystercatchers individually (C. Marsh, pers. correspondence) due to their tendency of loafing in small numbers. Of interest, other censuses (South Carolina Dept. of Natural Resources, unpubl. data) conducted in the Cape Romain region during late fall and winter in 1991 (n = 4) and 1992 (n = 3) using identical routes and boat operators (and some of the same observers) to Marsh and Wilkinson also obtained lower Marbled Godwit and American Oystercatcher counts (peak counts = MAGO: 321_{1991}, 393_{1992} ; AMOY: $1{,}773_{1991}$, $2{,}008_{1992}$) than Marsh and Wilkinson (1991a).

Limited evidence suggests that the reduced counts of American Oystercatcher since 1988/89 may be attributed to population changes. Marsh and Wilkinson (1991b) reported that numbers of American Oystercatcher using the Cape Romain region declined significantly following Hurricane Hugo (and in the subsequent winter), which came ashore at Cape Romain in 1989 with winds exceeding 100 knots. Marsh and Wilkinson suspected that approximately 400 American Oystercatchers died in the storm. Moreover, nesting effort for American Oystercatcher appears to have declined in the Cape Romain region since 1989 (based on a 50% decline in overall number of nests from 1989 to 1998; SCDNR, unpubl. data). Indeed, summarized Atlantic Coast data (Davis 1999) suggest that breeding numbers of American Oystercatcher are low or declining from Virginia south to Florida. Reduced recruitment to south Atlantic Coast populations combined with the death of several hundred adults could conceivably result in a smaller population a decade later. Alternatively, lower counts may have resulted from distributional shifts (Myers et al. 1987) to other wintering areas, perhaps initiated by detrimental changes to foraging habitat by Hurricane Hugo.

Conservation Implications.

Our finding that composition of shorebird assemblages varied significantly between beach and estuarine/AIW habitats suggests that the 5 - 8 km mosaic of habitats stretching from outer barrier islands to inland bays contributes to the high diversity and abundance of shorebirds using the Cape Romain region. Thus, we suggest that regional biologists and land managers consider potential degradation to both beach and estuarine/AIW habitats when creating future conservation plans for shorebirds. Even private docks bordering the AIW provided habitat at high tide for large congregations of shorebirds, especially Willet, Marbled Godwit, and Short-billed Dowitcher. It is noteworthy that docks provided a refuge from boat wakes (from up to 31.8 boats/h), which often crest over oyster banks at high tide (Dodd and Spinks, pers. observ.). Because shorebirds only used open (*i.e.* no railings) docks, we recommend that new dock permits adjacent to the AIW be issued with the stipulation that no railings be added.

Several species used oyster banks bordering the AIW, bays, and estuarine islands, including American Oystercatcher, which predominated on these elevated oyster shell mounds at high tide. Mining of oyster shell deposits has been an important industry in other areas (*e.g.* the Gulf Coast region) where shell is used for multiple purposes, including construction aggregate and preparation of cement (Anderson *et al.* 1979). Research is currently being conducted to evaluate the use of proteins in oyster shell for various products, including highly absorbent diapers (http://seagrant.orst.edu/plain/scripts/597.html). Consequently, there may be an increased demand for harvesting of oyster shell in the future. We urge state lawmakers to improve existing legislation to prevent the harvest of oyster shell deposits from South Carolina's estuaries. Shorebirds also used high sand/mud flats bordering the AIW, including migrating Whimbrel, which frequented flats in large numbers during spring. Runoff from increasing housing development adjacent to the mainland side of the AIW could affect the foraging quality of these flats.

Mixed species flocks of mostly *Calidris* sandpipers and plovers (including the threatened/endangered Piping Plover) inhabited beaches and sand bars. A potential threat to shorebirds using beaches and associated flats and sand bars is disturbance from humans, including increasing local ecotourism and use of personal watercraft and sea kayaks. During censuses, we regularly observed low numbers of humans using beaches, especially north of Bull Island. However, based on the projected 0.3% annual increase of people moving to the coast of South Carolina, and an additional 17,700,000 annual visitors (S.C. Department of Health and Environmental Control 1998), we anticipate that human use of the Cape Romain area will increase. We recommend that managers monitor human use of beaches and periodically adjust existing rules and the extent of law enforcement to ensure protection of shorebirds from human disturbance.

Finally, the apparent decline in wintering numbers of American Oystercatcher compared to a decade ago is worrisome considering Marsh and Wilkinson's (1991a) finding that the Cape Romain region is the major North American wintering site for American Oystercatcher. We recommend that a study be conducted investigating potential declines in local and regional populations of American Oystercatcher.

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Birds of the Carolinas
Student Research Grants Program

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TABLE 1. Relative abundance and behavior of shorebirds observed in the Cape Romain region, SC during an annual cycle (June - October 1997, November - December 1998, and January - May 1998[a]).

Species (Code)	Total Abundance	% Total Abundance	%					
			Loaf	Preen	Forage	Fly	Alert	Other
Dunlin, *Calidris alpina* (DUNL)	78,472	31.70	62.8	16.7	11.7	7.8	0.5	0.5
Short-billed Dowitcher[b]., *Limnodromus griseus* (SBDO)	65,685	26.53	74.1	09.8	1.0	10.4	4.6	0.3
Small sandpipers[c], *Calidris mauri, minutilla, and pusilla* (PEEP)	28,401	11.47	63.2	14.2	12.8	9.0	0.8	0.03
Red Knot, *Calidris canutus* (REKN)	18,537	7.49	67.7	12.2	10.5	6.1	3.5	0.0
American Oystercatcher, *Haematopus palliatus* (AMOY)	11,618	4.69	82.7	7.2	0.8	2.9	5.9	0.5
Sanderling, *Calidris alba* (SAND)	11,499	4.64	44.0	38.7	15.1	2.3	0.0	0.0
Semipalmated Plover, *Charadrius semipalmatus* (SEPL)	10,086	4.07	52.3	19.5	22.5	4.2	0.6	0.8
Willet, *Catoptrophorus semipalmatus* (WILL)	7,681	3.10	73.0	12.7	4.1	3.0	7.2	0.0
Black-bellied Plover, *Pluvialis squatarola* (BBPL)	7,193	2.91	82.8	1.9	5.7	6.1	3.4	0.04
Ruddy Turnstone, *Arenaria interpres* (RUTU)	3,178	1.28	63.2	2.7	27.9	5.0	0.7	0.5
Marbled Godwit, *Limosa fedoa* (MAGO)	3,085	1.25	76.6	7.4	0.6	0.8	14.6	0.0
Whimbrel, *Numenius phaeopus* (WHIM)	899	0.36	57.4	20.9	15.3	5.6	0.8	0.0
Wilson's Plover, *Charadrius wilsonia* (WIPL)	758	0.31	56.1	5.1	11.1	7.6	19.3	0.0
Unidentified sandpipers, *Calidris* spp.	152	0.06	1.3	0.0	55.3	42.1	0.0	1.3

TABLE 1. Continued.

Species (Code)	Total Abundance	% Total Abundance	% Loaf	Preen	Forage	Fly	Alert	Other
Spotted Sandpiper, *Actitis macularia (*SPSA)	109	0.04	10.2	0.0	49.5	38.5	1.8	0.0
Greater Yellowlegs, *Tringa melanoleuca* (GRYE)	81	0.03	80.3	0.0	17.3	1.2	1.2	0.0
Piping Plover, *Charadrius melodus* (PIPL)	79	0.03	46.8	5.1	44.3	2.5	1.3	0.0
Long-billed Curlew, *Numenius americanus* (LBCU)	26	0.01	38.5	23.1	26.9	3.8	7.7	0.0
Lesser Yellowlegs, *Tringa flavipes* (LEYE)	18	0.01	0.0	94.5	5.5	0.0	0.0	0.0
Killdeer, *Charadrius vociferus* (KILL)	14	0.01	57.1	0.0	28.6	14.3	0.0	0.0
Back-necked Stilt, *Himantopus mexicanus (*BNST)	3	0.001	33.3	0.0	66.7	0.0	0.0	0.0
Total Shorebirds	247,574		66.8	12.9	9.8	7.6	2.6	0.3

[a] March 1997 data used for SE route because several days of inclement weather prevented censusing this route in March 1998.

[b] May include some Long-billed Dowitchers (*Limnodromus scolopaceus*).

[c] Of which, 34, 11, and 0.4 % identified to Western, Semipalmated, and Least sandpipers, respectively.

TABLE 2. Description of sites censused in the Cape Romain region, SC and their use by shorebirds during an annual cycle (June to October 1997, January to May 1998, and November and December 1998).

Site (Site Code)	Site Description	Linear (km) Shoreline[a]	Mean (SD) Shorebird Abundance	Mean (SD) Shorebird Density	Mean (SD) Species Richness[b]
Beach Sites:					
Cape Island-northeast (CN)	sandy beach-barrier island	9.3	968.6 (667.8)	103.8 (71.6)	9.7 (2.2)
Cape Island-inlet (IC)	sand bar	1.0	93.3 (119.2)	96.2 (122.9)	3.4 (2.6)
Cape Island-southwest (CS)	sandy beach-barrier island	3.9	1707.7 (1763.5)	442.4 (456.9)	11.9 (1.5)
Lighthouse Island South (LI)	sand bar	1.9	1887.0 (2149.6)	977.7 (1113.8)	7.0 (2.7)
Raccoon Key-Key Inlet (KI)	sandy beach-barrier island	2.6	239.6 (281.2)	93.2 (109.4)	5.7 (4.0)
Raccoon Key-middle (RK)	sandy beach-barrier island	5.8	1006.2 (931.7)	173.8 (160.9)	8.2 (3.4)
Raccoon Key-Sandy Point Beach (SP)	oystershell beach-barrier island	2.9	591.0 (566.3)	203.8 (195.3)	6.5 (4.0)
Marsh Island (MI)	sand spit-estuarine island	0.6	235.8 (256.7)	428.8 (466.8)	4.2 (1.3)
Bull Island-northeast (BIN)	sandy beach-barrier island	1.5	630.6 (918.7)	434.9 (633.6)	5.1 (2.5)
Bull Island-middle (BIM)	sandy beach-barrier island	5.8	169.4 (140.6)	29.3 (24.3)	3.8 (2.7)
Bull Island-southwest (BIS)	sandy beach-barrier island	1.3	1071.7 (1688.7)	830.8 (1309.1)	7.7 (3.0)
Price Inlet sand bar (PIS)	ephemeral sand bar	0.9	2877.0 (1124.3)	3093.5 (1208.9)	8.0 (1.4)
Capers Island-northeast (CIN)	sandy beach-barrier island	1.3	912.7 (1152.4)	707.5 (893.4)	7.5 (1.6)
Capers Island-southwest (CIS)	sandy beach-barrier island	1.0	107.9 (197.8)	111.3 (204.0)	3.6 (3.0)
Dewees Island-northeast (DIN)	sandy beach-barrier island	2.3	3164.1 (4091.0)	1406.3 (1818.2)	8.5 (1.2)
Dewees Island-middle (DIM)	sandy beach-barrier island	1.6	530.75 (1568.5)	329.7 (974.2)	3.8 (3.0)
Dewees Island-southwest (DIS)	sandy beach-barrier island	1.1	307.0 (963.4)	271.7 (852.5)	2.9 (2.4)

Site (Site Code)	Site Description	Linear (km) Shoreline[a]	Mean (SD) Shorebird Abundance	Mean (SD) Shorebird Density	Mean (SD) Species Richness[b]
Inner Sites:					
Horsehead Creek (HC)	oyster bank	0.3	40.6 (46.4)	139.9 (160.0)	3.1 (1.7)
Deepwater Point (DP)	oyster bank	0.5	133.1 (113.3)	260.9 (222.3)	3.8 (1.9)
Casino Creek (CC)	oyster bank	0.1	1.5 (3.3)	30.0 (65.8)	0.4 (0.8)
Mathews Creek (MC)	oyster bank	1.1	1.3 (2.1)	1.2 (1.9)	0.6 (0.9)
Harbor River (HR)	oyster bank	1.6	35.1 (76.5)	22.2 (48.4)	1.3 (1.4)
White Banks-east (EW)	oyster bank-estuarine island	0.8	48.6 (93.9)	60.8 (117.4)	2.5 (1.9)
White Banks-middle (MW)	oyster bank-estuarine island	1.0	131.3 (104.2)	135.3 (107.4)	4.1 (1.7)
White Banks-west (WW)	oyster bank-estuarine island	0.3	29.3 (50.4)	91.5 (157.5)	2.0 (2.0)
Awendaw Creek (AW)	oyster bank	1.1	2.0 (3.2)	1.8 (2.9)	0.7 (1.0)
Graham Creek (GC)	docks	0.2	396.7 (442.3)	1888.9 (2106.3)	2.0 (1.9)
inbetween Graham/Venning creeks (GVF)	high elevation sand/mud flat	1.0	28.7 (88.0)	29.5 (90.7)	1.4 (2.6)
Venning Creek-flat (VCF)	high elevation sand/mud flat	0.3	75.3 (109.8)	289.7 (422.3)	2.7 (2.5)
Venning Creek-docks (VCD)	docks	0.6	346.7 (442.6)	619.0 (790.3)	2.0 (1.5)
Venning Creek-oyster bank (VCO)	oyster bank	0.5	246.0 (257.5)	546.7 (572.1)	4.5 (1.7)
Anderson Creek (AC)	oyster bank	0.7	902.2 (1413.5)	1366.9 (2141.7)	5.3 (2.5)
Moores Landing (ML)	oyster bank	2.2	1029.3 (822.1)	476.5 (380.6)	6.8 (1.6)
southwest Bull's Bay (SW)	oyster bank	2.2	167.3 (231.5)	75.4 (104.3)	4.9 (3.5)
Price Inlet (PI)	oyster bank	5.9	1690.3 (1087.4)	288.5 (185.6)	7.9 (1.7)

TABLE 2. Continued.

Site (Site Code)	Site Description	Linear (km) Shoreline[a]	Mean (SD) Shorebird Abundance	Mean (SD) Shorebird Density	Mean (SD) Species Richness[b]
Inner Sites (Continued):					
Price Inlet flats (PIF)	high elevation sand/mud flat	1.1	269.1 (720.6)	238.1 (637.7)	2.3 (3.2)
Capers Inlet (CI)	oyster bank	4.0	574.8 (534.1)	143.3 (133.2)	6.5 (2.0)
Bullyard Sound (BS)	oyster bank	3.0	489.7 (366.6)	163.8 (122.6)	4.4 (2.5)
Dewees Inlet (DI)	oyster bank	3.2	427.9 (543.9)	132.9 (168.9)	5.1 (2.3)

Shoreline with exposed substrate (i.e. marsh not included) measured at high tide with a handheld GPS unit (Garmin 58). For docks, we only included those without railings because shorebirds used almost exclusively open docks; docks measured with a measuring wheel.

Presence of small sandpipers (*Calidris mauri, minutilla*, and *pusilla*) treated as one species.

TABLE 3. Relative importance[a] of the Cape Romain region, SC, based on maximum daily counts (from one of three routes) and maximum region counts (from all three routes combined) during spring (mid-March - May 1997 and 1998), fall (July - October 1997), and winter (January - 1st week of March 1998; November - December 1998)(n = 15 sets of censuses).

	Maximum Daily Count								Maximum Region Count				
	Spring			Fall			Winter		Spring		Fall		Winter
Species[b]	Count	Route	Proportion ISS Total (%)	Count	Route	Proportion ISS Total (%)	Count	Route	Count	Proportion ISS Total (%)	Count	Proportion ISS Total (%)	Count
American Oystercatcher	568	sw	53	1033	sw	35	1340	sw	946	65	1635	46	1707
Marbled Godwit	348	sw	20	315	sw	22	480	sw	348	20	315	22	481
Short-billed Dowitcher	5013	se	17	6141	sw	9	5476	sw	10069	30	6363	9	11526
Wilson's Plover	55	ne	9	121	se	11	7	ne	104	15	241	20	7
Dunlin[c]	9245	se	12	6375	se	7	9202	se	14809	18	13551	14	18774
Willet	939	sw	14	568	sw	5	802	sw	1002	15	691	6	905
Whimbrel	307	ne	13	128	sw	5	4	sw	507	19	163	6	4
Semipalmated Plover	1922	se	15	792	se	2	711	se	4507	30	1475	4	1140
Red Knot	3260	se	3	4210	ne	13	1518	se	4203	3	4210	13	1631
Western Sandpiper	NA			1326	se	2	2002	sw	NA		1340	2	3412
Black-bellied Plover	336	ne	2	417	sw	1	904	ne	742	4	1040	2	1247
Sanderling	1600	se	2	1127	se	1	474	ne	1977	3	1861	2	988

TABLE 3. Continued.

	Maximum Daily Count								Maximum Region Count				
	Spring			Fall			Winter		Spring		Fall		Winter
Species[b]	Count	Route	Proportion ISS Total (%)	Count	Route	Proportion ISS Total (%)	Count	Route	Count	Proportion ISS Total (%)	Count	Proportion ISS Total (%)	Count
Ruddy Turnstone	185	ne	<1	250	sw	2	245	sw	427	<1	351	3	398
Piping Plover	13	ne	1	6	ne	<1	15	ne	25	3	9	<1	15
Total Index (%)			161			115				225		149	

[a] Relative importance index is calculated by dividing each species' peak count into the corresponding ISS seasonal total (plus the Cape Romain count); ISS seasonal totals presented in Harrington and Perry 1995.

[b] Data presented only for species with peak counts exceeding 1% of spring or fall ISS totals.

[c] November data used for fall because this species is a late fall migrant (Fig. 2).

NA Data not available because we did not identify most small sandpipers to species during our peak spring count (last week of March). For the maximum region count, we categorized 4,156 birds as small sandpipers, with an additional 168 identified as Western Sandpipers. Based on local abundance and migratory patterns of the three species of small sandpipers (S. Dodd, pers. observ.), most of the unidentified small sandpipers were Western Sandpipers.

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