The Significance of the Central Coast of South Carolina as Critical Shorebird Habitat

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There has been increasing interest in monitoring populations of North American shorebirds (Charadrii) because several species appear to be experiencing significant population declines (Howe et al. 1989). Early in this century flocks of shorebirds were decimated by indiscriminate market hunting (Bent 1927, 1929), but present-day declines probably result from loss of critical habitat (Howe et al. 1989).

A major difficulty in detecting long term changes in shorebird numbers is obtaining accurate estimates of population sizes (Howe et al. 1989). Christmas Bird Counts provide data on winter distributions of shorebirds and their relative abundances in different parts of the country (Root 1988), but are of limited value in monitoring abundances on a local scale. Individual counts often differ dramatically from year to year because of differences in both weather and the quality of observer effort, masking all but the most dramatic population trends.

The central coast of South Carolina has long been recognized for its abundance of birdlife (Sprunt and Chamberlain 1970). Anecdotal accounts suggest that this region historically has been a major wintering site for several species of shorebirds. Most of this region, which is hereafter referred to as the Cape Romain-Santee Delta region, is protected as wildlife management areas or refuges. Root's (1988) summary of Christmas Bird Count data indicate that the region has exceptionally high concentrations of American Oystercatcher (*Haematopus pallidus*), Semipalmated Plover (*Charadrius semipalmatus*), and Black-bellied Plover (*Pluvialis squatarola*) compared to the rest of coastal North America. The purpose of this study was to make estimates of the numbers of migratory shorebirds using this region during the nonbreeding season (July-May). Such censuses had not been attempted earlier, and therefore provide important baseline data that can be used to follow future trends of local shorebird populations.

DESCRIPTION OF THE REGION

The Cape Romain-Santee Delta region (extending for approximately 75 km from North Inlet (near Georgetown) south to Caper's Inlet north of Isle of Palms) has received international recognition because of its expansive and diverse coastal habitats, and is now one of three units of the Carolinian-South Atlantic Biome Reserve, a part of UNESCO's Man and Biosphere Programme (Hopkins-Murphy 1989).

A series of uninhabited barrier islands along the outer coast are separated from the mainland by expansive salt marshes. The larger, older islands (North, South, Murphy, Bull, and Caper's I.) have stands of oaks (primarily *Quercus nigra*), loblolly pine (*Pinus taeda*), and cabbage palmetto (*Sabal palmetto*) along the remnant dune systems. A series of retreating, sparsely vegetated islands (Cape Island, Lighthouse Island, Raccoon Key, White Banks, and Marsh Island and formerly Bird Island prior to Hurricane Hugo) stretch south from the Santee Delta into Bulls Bay, and are included in the Cape Romain National Wildlife Refuge. The sand islands are separated from the mainland by

approximately 5–8 km of saltmarsh and shallow bays, and are major nesting sites for large colonies of Brown Pelicans (*Pelecanus occidentalis*), Black Skimmers (*Rynchops niger*), Laughing Gulls (*Larus atricilla*), oystercatchers and Royal (*Sterna maxima*), Sandwich (*Sterna sandvicensis*), Least (*Sterna antillarum*), and Gull-billed (*Sterna nilotica*) Terns.

The wetlands of the region represent an interesting mosaic of pristine salt marshes and altered wetlands that were originally diked for cultivation of rice during the eighteenth and nineteenth centuries. The unaltered outer coastal wetlands consist of expanses of the saltmarsh cordgrass *Spartina alterniflora*, dissected by networks of tidal creeks and muddy bays. Brackish marshes characterized by needlerush (*Juncus roemerianus*) and tall cordgrass (*Spartina cynocuroides*) border Winyah Bay and extend up the Santee Delta for approximately 15 km. Most freshwater forests (primarily cypress *Taxodium distichum*) and moderately brackish (<15 ppt) wetlands in the region were converted to rice fields during the eighteenth and nineteenth centuries (Thompkins 1986) by diking, clearing trees, and using water-control structures to manipulate water level and salinity in the diked-in cultivated marsh. This created large expanses of wetlands with controlled water levels.

Approximately 4,300 hectares of former rice fields in the Cape Romain-Santee Delta Reserve are managed for waterfowl and other wildlife (Hopkins-Murphy 1989). Management practices (e.g. flooding schedules) differ depending on salinity and substrate, and types of vegetation and wildlife desired (Thompkins 1986).

The Cape Romain area and the Tom Yawkey Wildlife Center, were selected as sites for shorebird censuses because (1) both sites, historically, have been described as having large concentrations of shorebirds (Sprunt and Chamberlain 1970), and (2) they represent the two general types of wetland habitats regularly used by shorebirds: undisturbed tidal mudflats and managed, diked wetlands that are periodically drawn down to a shallow depth., respectively. In addition, the Yawkey center has restricted public access and therefore minimal human disturbance.

The Cape Romain census area which extends from Cape Island south to Dewee's Inlet (Fig. 1, see pp. 88–89), was selected because it represented a single, continuous system consisting of pristine *Spartina alterniflora* salt marsh interspersed with expansive shallow muddy bays with oyster (*Crassostrea virginica*) beds. The Santee Delta borders the area to the north, and the Charleston Harbor borders the area to the south. The census area includes the Cape Romain NWR (13,857 hectares), the Capers Island State Management Area (441 hectares), and the public salt marshes adjacent to Capers Island, Dewees Island, and the Isle of Palms (Sewee Bay, Mark Bay, Copahee, Bullyard, Hamlin, and Gray Sounds; approximately 9,000 hectares).

The Tom Yawkey Wildlife Center, including South Island, has approximately 8,000 hectares of marshes that are managed primarily for waterfowl.

At the Yawkey Center, the objective of the management scheme is to create large areas of open water that are colonized by ephemeral aquatic plants (e.g., widgeon grass *Ruppia maritima* and saltmarsh bullrush *Scirpus robustus*) that are preferred food of waterfowl, and to prevent the establishment of tall perennial marsh grasses (such as *Spartina alterniflora*). Typically, most managed marshes at the Yawkey Center are gradually flooded during the summer,

and water is regularly flushed through the marsh to expose mosquito larvae to fish. Maintaining water circulation through the managed marsh also reduces the likelihood that algal blooms will occur. The water level is gradually drawn down during the winter months while waterfowl are present until it has been lowered to a depth of 5–25 cm. Water is flushed through the marsh at this shallow depth (hereafter referred to as sheet flow) during the spring, creating expansive areas of shallow water and mudflats suitable for shorebirds. In the early summer the managed marshes are subsequently drained for several weeks to ensure the bed of the marsh has a firm substrate for the preferred aquatic plants. Subsequently, the marshes are slowly reflooded, and the cycle is repeated.

CENSUS METHODS

The goal of this study was to estimate actual population sizes of target species. Therefore we attempted to census all areas within each study area rather than checking only selected sections. Initially designed to count larger species of shorebirds during winter 1988 (i.e., American Oystercatcher, Marbled Godwit, and Willet), the census methods were used to count all species of shorebirds using high tide roosts during the 1988-89 field season.

The most successful method for estimating numbers of most species of shorebirds in the Cape Romain region proved to be visiting all high tide roosts in the area by boat during a high spring tide. This protocol is similar to that used in the British surveys (Prater 1981, p. 119), with all counts being made within the four-hour period that the tide was the highest. At this time most of the marsh grass was submerged, and therefore shorebirds concentrated on the unvegetated islands and the oyster mounds, or rakes, bordering the Intracoastal Waterway. High tide roosts were located initially by aerial survey on 7 November 1987. The northern and southern sections of the Cape Romain region were censused within the same four-hour period by using two parties of observers. Route 1 censused a series of high tide roosts along the Intracoastal Waterway in the southwestern section of the study area, and hereafter is referred to as "the southwestern section" of Cape Romain. Route 2 surveyed the roost sites located on the northern barrier islands and those in Bulls Bay. Hereafter this is referred to as "the northeastern section" of Cape Romain (see Fig. 1). This included checking the beaches of Lighthouse Island and Raccoon Key for oystercatchers roosting on the beach by running the boat parallel to the shoreline just outside of the breakers.

During the first year of the study only the southwestern section was censused on 23 January 1988 and 16 and 17 April 1988. The December 1988 census differed from the other census dates in that the two routes were done on consecutive days rather than simultaneously. The northeastern section was done during excellent weather conditions on 22 December 1988, but the southwestern section was censused in dense fog the next day. On two dates (19 March 1988 and 7 April 1989) censuses were conducted, but ocean conditions were too rough for checking the ocean side of Raccoon Key, the longest barrier island in the study area.

A few areas in the Cape Romain region that were exposed during spring high tides were not censused regularly. The outer beaches of the forested islands (Bull, Capers and Dewees Islands) were not included because aerial sur-

veys indicated that flocks of shorebirds did not roost in these areas during high tide. The outer beach of Cape Island, the northernmost barrier island in the study area, was checked infrequently because of the treacherous waters at the Cape, and because previous surveys indicated that no significant concentrations of shorebirds occurred here.

Birds within a flock were initially estimated by fives to obtain quickly an estimate of flock size in case the birds flushed prematurely. Next, birds were counted individually as a second estimate of flock size. Results from the two methods usually differed by less than five percent, confirming the accuracy of the first method. Large flocks were counted at least twice, and whenever possible, from at least two angles to help minimize underestimating the number of individuals in the interior of these flocks. We discovered that shorebirds on the back side of oyster bars often would move to the top where they could be counted if we approached the flock slowly, making the entire flock visible to the observer.

Census techniques used to monitor shorebird abundance at the Yawkey Wildlife Center differed from those used at the Cape Romain study area. Monthly counts were standardized by driving a regular route along the dikes bordering the marshes, and stopping at regular observation sites. Twelve of the 15 managed marshes were included in the census route. Three ponds were excluded because they had large areas of emergent plants with potholes and did not have large open areas suitable for shorebird habitat in them. Counts were conducted monthly from May 1988 through July 1989 except in December 1988 when the ferry to the Center was not working. All the marshes at the Yawkey Center were checked on each census date.

Censuses done at the Yawkey Center were conducted at a time when the tide was high in the tidal areas, thereby reducing the influence of tidal height on shorebird activity in managed marshes as was observed by Epstein and Joyner (1986). Managed marshes should experience the heaviest use by shorebirds during high tide because mudflats in the adjacent tidal marshes are submerged.

Several potential problems are associated with attempts to estimate total populations of shorebirds in the field. Inaccurate counts can result from errors in the observer's ability to estimate the number observed, as well as from an inability to find all the birds in the area (Prater 1981, p. 123). To minimize variability, our surveys were always run along the same route, and with few exceptions, had the same individuals making the counts.

When weather permitted, we attempted to replicate counts during the winter months to provide an estimate of variation in the count method. Replicate counts were possible during February 1988, March 1988, and January 1989. Variation between replicate censuses was expressed as a coefficient of variation corrected for bias due to small sample size (Sokal and Rohlf 1981, p. 59).

RESULTS AND DISCUSSION

SPECIES ACCOUNTS

American Oystercatcher (*Haematopus pallidus*)

The number and distribution of American Oystercatchers in the region fluctuated seasonally (Fig. 2). In 1988-89 the numbers of oystercatchers increased

dramatically after the breeding season from 796 on 6 August 1988 to 1,949 on 13 October 1988. Accurate counts were not obtained during November and December because of inclement weather, but sometime during this period the numbers of oystercatchers in the study area increased to over 2,300. The numbers of oystercatchers declined during the late winter and spring to 653 birds on 8 May 1989. A shorebird survey was not conducted in June 1989, but a total of 171 oystercatcher nests were located in the area during Summer 1989 as part of the annual survey conducted by the S.C. Wildlife and Marine Resources Department. The shorebird survey conducted in late July 1989 found a total of 534 individuals, 9.5% of which were young of the year.

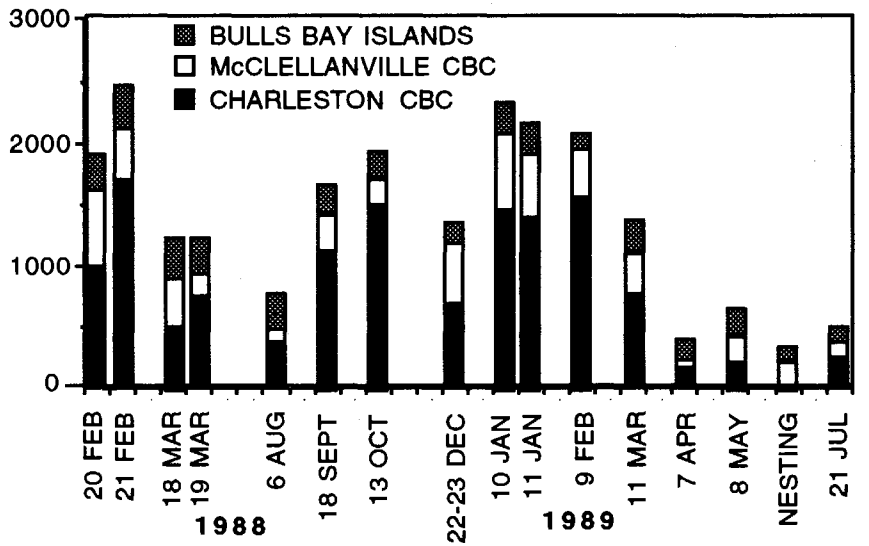


Fig. 2. Seasonal abundance of the American Oystercatcher in the Cape Romain region. The southwestern area includes all suitable oystercatcher habitat in the Charleston Christmas Bird Count circle; the northeastern area includes both the McClellanville Christmas Bird Count circle and the islands in Bulls Bay.

The numbers of oystercatchers in mid-winter in the Cape Romain area appeared to be similar in 1988 and 1989. The highest counts for the two years were 2,401 and 2,347, respectively; whereas the average of the winter counts for the two years were 2,190 (C.V.=15.3%) and 2,258 (C.V.=6.2%), respectively. The higher variation in 1988 was due to a low count (1,979) during a census made during marginal weather conditions when visibility was impaired.

Approximately three-fourths of the oystercatchers present at Cape Romain in winter used high tide roosts in the southwestern section of the area (Fig. 2). The largest high tide roosts were adjacent to Sewee Bay, Bullyard Sound, and Copahee Sound (see Fig. 1). In contrast, most nesting activity was on the northern barrier islands (= the McClellanville CBC area of Fig. 2), and, to a lesser extent, on the islands in Bulls Bay.

Our censuses confirmed the importance of the Cape Romain region as the major wintering site of American Oystercatchers in North America. Root's

(1988) analysis of Christmas Bird Counts indicated that Cape Romain NWR had the highest number of American Oystercatchers in North America during the winter.

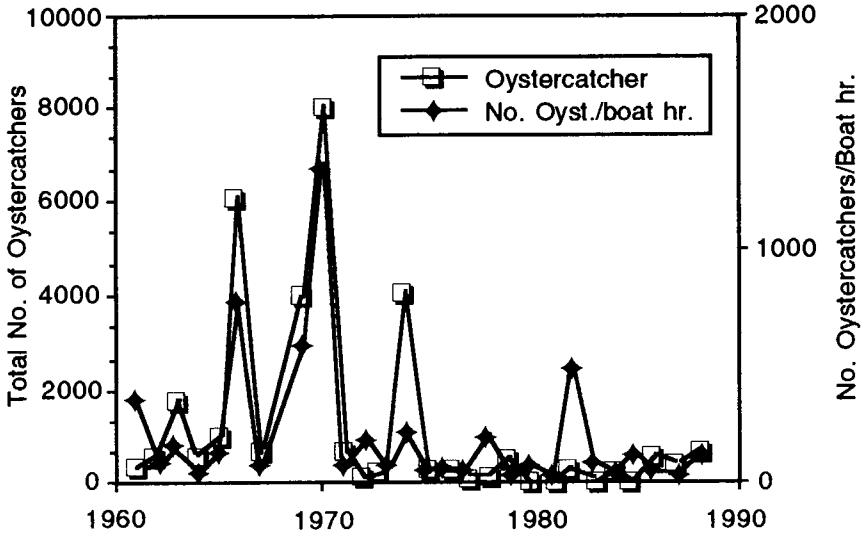


Fig. 3. Numbers of American Oystercatchers from 1960 to 1988 as determined by Charleston Christmas Bird Counts. The open squares denote total numbers of oystercatchers seen on the count, and the closed diamonds denote the number of oystercatchers seen per hour of boat time.

The actual size of the winter population of American Oystercatchers in the region prior to these surveys is enigmatic because the number of oystercatchers observed on past Charleston Christmas bird counts has varied drastically. During the period 1960 to 1988 oystercatcher counts ranged from 35 (1981) to 8,121 (1970) (Fig. 3). The possibility that oystercatchers were dramatically more common during 1966 to 1974 can not be ruled out since all the exceptionally high counts occurred during this nine-year period (6,069 in 1966, 4,057 in 1969, 8,121 in 1970, and 4,063 in 1974). These exceptionally high counts also were not correlated with observer effort. To examine this possible source of variation oystercatcher counts were standardized by dividing total number of oystercatchers seen on a count by observer effort (the number of hours observations were made by boat). These results showed the same general pattern except the period of peak oystercatcher numbers appeared to be from 1966 to 1970 only. Observer bias in estimating numbers of shorebirds was examined indirectly by comparing numbers of oystercatchers and dowitchers, the other most common shorebird present in this habitat, for each count (Fig. 4). In general, the numbers of oystercatchers and dowitchers appeared to be correlated except in 1970 when the highest number of oystercatchers were observed, but the number of dowitchers was lower than usual.

One of the difficulties in censusing oystercatchers in the Charleston Count

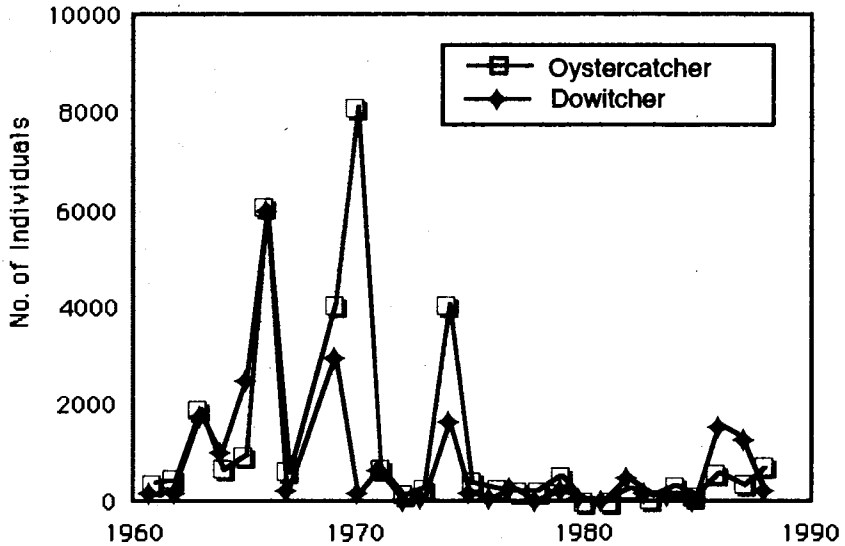
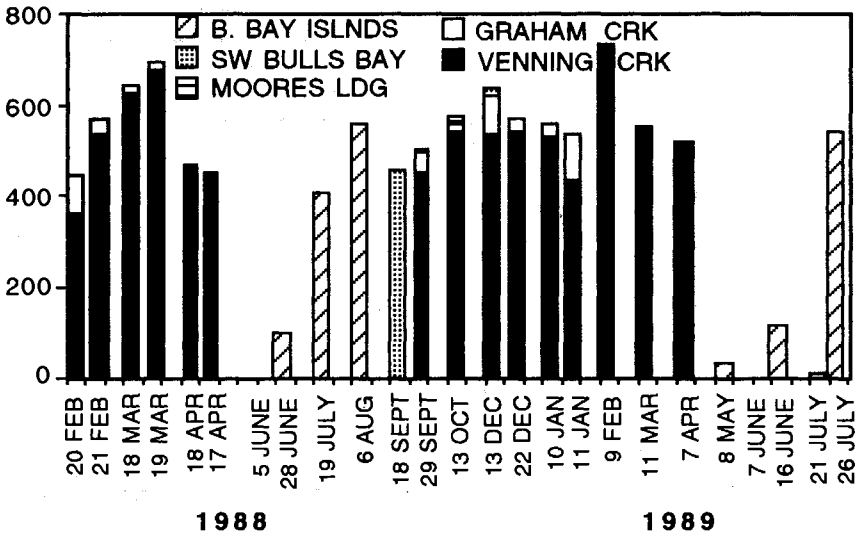


Fig. 4. A comparison of numbers of oystercatchers and dowitchers seen on the Charleston Christmas Bird Counts during 1960–1988.

Circle is that they are highly clumped during high tide, and all the major roost sites and feeding areas must be visited by boat. Consequently, during this study Christmas Bird Count totals were significantly less than the totals observed during the shorebird censuses. On 27 December 1987, 388 American Oystercatchers were observed on the Charleston Christmas Bird Count, whereas 1,004 and 1,701, respectively, were observed in February 1988 on our shorebird censuses. Similarly, 685 oystercatchers were observed on the December 1988 Charleston Christmas Bird Count, whereas 1,515 oystercatchers were present on 13 October 1988, and winter counts in this section were 1,457, 1,392, and 1,562 during January and February 1989. The similarity of the winter shorebird censuses suggests that the local winter population of oystercatchers was relatively stable, and that use of Christmas Bird Count data is not appropriate to monitor population trends in this area because of the area's inaccessibility.

Marbled Godwit (*Limosa fedoa*)

Although Marbled Godwits were common in the Cape Romain region, they were highly gregarious and localized during high tide. Godwits were only observed at seven high tide roosts during this study compared with American Oystercatchers being found at 23 high tide roost sites. Often all of the godwits in the region were found together in a single large flock during high tide (11 of 21 censuses with godwits). Only small flocks (<10 godwits) were observed on the outer islands during the winter, and no godwits were observed south of Price's Inlet in the vicinity of Bullyard or Copahee Sounds, suggesting that the latter area lacked suitable prey or feeding conditions required by Marbled Godwits.



Fig, 5, Numbers of Marbled Godwits at high tide roosts in the Cape Romain region. Note the seasonal shift from the Bulls Bay islands in late summer to the Venning Creek and Graham Creek roost sites in the winter and spring. Location of geographic names is depicted in Fig. 1.

The winter population of Marbled Godwits at Cape Romain was consistently over 500 individuals during 1988 and 1989, with the largest flocks being 670 individuals on 19 March 1988 (Venning Creek) and 735 individuals on 9 February 1989 (Venning Creek) (Fig. 5). These counts are much higher than the previous record high count of 200 godwits observed on the 1971 Charleston Christmas Bird Count (Post and Gauthreaux 1989).

Table 1. Counts of Marbled Godwits at Venning Creek

	Before High Tide[a]	After High Tide
21 Feb 1988	142	536
19 March 1988	485	670
16 April 1988	345	458
17 April 1988	369	453
13 Dec. 1988	365	518
11 March 1989	547	547

[a] Before-high-tide counts of Marbled Godwits were made 1 to 2 hours before high tide and after-high-tide counts were made 1 to 2 hours after high tide.

The location of the main flock during high tide shifted seasonally (Fig. 5). During the summers 1988 and 1989 godwits were only observed on the islands in Bulls Bay, but during the winter months all godwits roosted west of Bulls Bay, usually at the junction of Venning Creek and the Intracoastal Waterway. Godwits apparently congregated at this site because the adjacent tidal flat was one of the first feeding areas exposed by the receding tide. That the number of godwits at this high tide roost increased as the tide cycle progressed supports this hypothesis (Table 1).

Seventeen to 20 Marbled Godwits were present at the Yawkey Center during monthly censuses between January and April 1989. The low variation among these counts suggests that a flock of approximately 18 birds resided continuously at the Yawkey Center during this period.

American Avocet (*Recurvirostra americana*)

Avocet distribution was very localized. Individuals were observed only in managed marshes on South Island at the Yawkey Wildlife Center, where large numbers (>100) were seen on two of the managed marshes (Sand Creek Basin and Wheeler Basin) we censused (Fig. 6). It is not readily apparent why avocets prefer these two marshes; but these are the only two ponds at the Yawkey Center that have supported the aquatic muskgrass (*Chara hornemannii*) in the past, suggesting that there may also be invertebrate fauna that have a similar restricted distribution.

The highest counts of Avocets present at the Yawkey Center were 694 and 736 which occurred 24 January 1989 and 23 February 1989, respectively. The numbers of avocets present subsequently declined to 467 in March and 418 in April, and by mid-May only three birds were present. A lone individual was present on 16 June 1989. Nesting activity was not observed during summer 1989.

The status of the American Avocet in South Carolina has changed dramatically during the past century. This species nests in the western United States along alkaline lakes and typically winters along the coasts of Louisiana, Texas, and California (Johnsgard 1981). Prior to the mid-1900s sightings of the Avocet in South Carolina were unusual, but in the 1950s observations of Avocets became increasingly common, especially at South Island (Sprunt and Chamberlain 1970). The numbers of Avocets at South Island have increased from 50 individuals on 26 February 1952 to 600-1000 in February 1969 (Sprunt and Chamberlain 1970). Large flocks of avocets have been present at South Island from 1966 to the present (P. Wilkinson and R. Joyner, personal communication). Our censuses represent the first recent attempt to estimate the numbers of avocets present.

Willet (*Catoptrophorus semipalmatus*)

The peak numbers of Willets found in the region were 540 on 9 February 1989 and 569 on 11 March 1989 (Table 2). Although Willets are found throughout the region during the breeding season, most of the individuals observed on the shorebird counts during 1987-89 were in a single flock at the junction of Graham Creek and the Intracoastal Waterway (west of Bulls Bay).

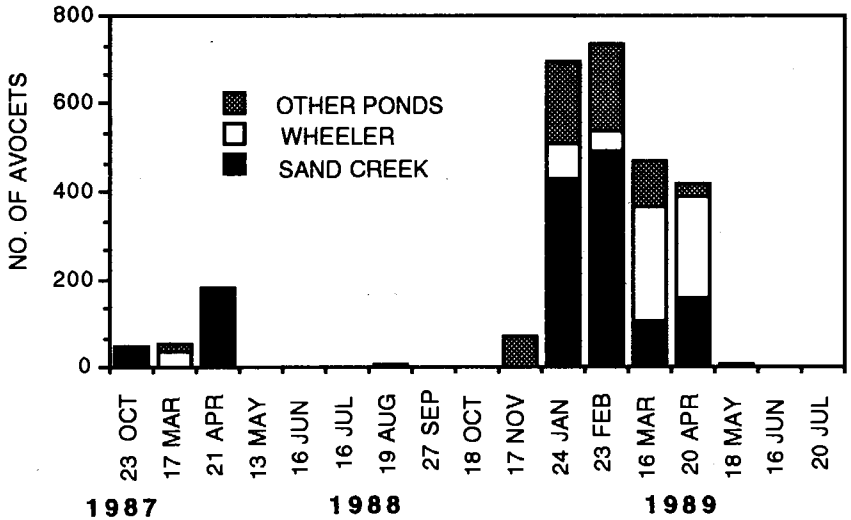


Fig. 6. Seasonal abundance of American Avocets at the Tom Yawkey Wildlife Center during the study period. Note that most avocets were observed in only two of the twelve managed marshes. Location of geographic names is depicted in Figure 1.

This roost site was used from September through March, with most counts ranging between 170 and 400 individuals. Other large concentrations of Willets were often associated with the large Marbled Godwit flock, e.g. 347 Willets were with the Marbled Godwit flock at Marsh Island on 6 August 1988. Unlike Marbled Godwits, however, small flocks of Willets did occur in the southern section of the study area in Bullyard Sound and at Dewee's Inlet.

Small numbers of Willets were regularly seen on South Island at the Yawkey Center. Most of the Willets seen were on Lower Reserve, a 128 ha pond that borders the North Santee, with the highest count being 66 individuals on 17 November 1988. Interestingly, few Willets were seen on ponds, such as Sand Creek Basin, that were used extensively by Avocets during the 1988-89 season.

Willets at the Graham Creek roost (Cape Romain) were only slightly smaller than the Marbled Godwits with which they associated, indicating that these individuals were of the larger western race (*C. semipalmatus inornatus*) which nests in the Great Basin region of the western United States (Hayman et al. 1986). Sprunt and Chamberlain (1970) also suggested that most Willets wintering along the South Carolina coast are *C. semipalmatus inornatus*.

Short-billed (*Limnodromus griseus*) and Long-billed Dowitcher (*L. scolopaceus*)

The Short-billed Dowitcher was one of the most abundant shorebirds in the Cape Romain region, with high winter counts of 2,370 on 11 January 1989 and 2,750 on 9 February 1989 (Table 2). We may have undercounted this species because flocks of dowitchers can be easily overlooked due to their cryptic col-

Table 2. Species totals for the Southwestern Section of the Cape Romain Region

	1988					1989						
	6 Aug	18 Sep	13 Oct	13 Dec	23 Dec	10 Jan	11 Jan	9 Feb	11 Mar	7 Apr	8 May	21 July
Willet	150	182	330	127	392	90	295	540	502	146	53	127
All Dowitchers	350	1635	1860	3635	2815	1410	1835	1745	1955	4350	2252	1109
Dunlin	0	0	0	600	475	120	40	625	685	N.C.	615	0
Black-bellied Plover	8	200	95	48	27	53	68	45	134	120	304	13
Semipalmated Plover	1	0	1	0	0	0	0	0	32	N.C.	1784	1
Ruddy Turnstone	15	50	0	1	14	0	6	5	48	20	60	0
Whimbrel	239	14	14	1	4	0	1	0	25	98	343	83

N.C. = no count

oration and their ability to roost on floating mats (wrack) of *Spartina* in the marsh.

Long-billed Dowitchers were only observed in the Cape Romain region on 21 July 1989 when approximately 30% of a flock of 330 dowitchers at Dewee's Inlet were identified by their heavily streaked breeding plumage and the characteristic staccato "keek" call given when they flew. Visual identifications of Long-billed Dowitchers in basic plumage were based on the presence of heavy barring along the entire length of the flanks that created a distinct vest-like pattern on the venter. Many dowitchers could not be identified to species because they were silent or too far away, and therefore conclusions about seasonal patterns of Long-bills is still preliminary. On all other Cape Romain surveys only the rapid, mellow three noted call of Short-billed Dowitchers were heard.

The distribution of dowitchers in the Cape Romain region was similar to oystercatchers and, like oystercatchers, the largest concentration during the winter occurred at Dewees Inlet. Other important roosting sites included Venning Creek (with the Marbled Godwits), Moore's Landing, Price Inlet, and, during migration, Marsh Island. The highest number of dowitchers was 4,350 individuals observed along the Intracoastal Waterway on 7 April 1989.

Both species were seen at Yawkey. Short-billed Dowitchers were abundant at Yawkey during the spring draw-down with peak counts occurring on 20 April and 18 May 1989 (3,265 and 3,241, respectively).

Apparently, Long-billed Dowitchers occurred at Yawkey primarily during the fall and winter. Sightings included 27 Sept.1988(16), 18 Oct. 1988 (21), 17 Nov. 1988 (1), 24 Jan 1989 (appr. 90), 23 Feb. 1989 (1 by call), and 18 May 1989 (1 by call).

Long-billed Dowitchers were most often observed in nontidal managed marshes at Yawkey, whereas Short-billed Dowitchers were regularly observed in both managed and unmanaged areas, an observation consistent with the conclusions of others (Hayman et al 1986, Johnsgard 1981).

Whimbrel (*Numenius phaeopus*) and Long-billed Curlew (*N. americanus*)

The Whimbrel was a common migrant in the salt marshes of the Cape Romain area, and a small number of individuals remained through the winter. Unlike other large species of sandpipers, Whimbrels often hid in clumps of grass during high tide, and therefore many individuals were probably overlooked. Thus, a high count of 483 Whimbrels on 17 April 1988 is probably a fraction of the total birds in the area (Table 2).

Whimbrels were present in the salt marshes at Yawkey, but seldom used the managed wetlands as feeding habitat during this study. On 18 and 25 May 1989 flocks of Whimbrels (13 and 38, respectively) were observed roosting in a pond adjacent to North Santee, but only one Whimbrel was ever observed feeding in a pond at the Yawkey Center (18 May 1989: Sand Creek Basin).

Approximately three to eight Long-billed Curlews were present at Cape Romain NWR during this study. Individuals were seen on 18 March 1988 (3), 15 September 1988 (8), 18 September 1988 (1), 29 September 1988 (2), 13 October 1988 (7), 22 December 1988 (4), and 9 February 1989 (8). This species is now considered a regular winter visitor at Cape Romain from late July through March (Potter et al. 1980).

Long-billed Curlews and Whimbrels had substantially different distributions at Cape Romain. Whimbrels were most common in the southwestern area, but occurred throughout the Cape Romain region during migration. Long-billed Curlews were only observed on the northern barrier islands (Cape Island, Lighthouse Island, Raccoon Key), and on Marsh Island in Bulls Bay. These islands were the only areas in the region with expansive sandy mudflats adjacent to inlets.

Greater Yellowlegs (*Tringa melanoleuca*) and Lesser Yellowlegs (*T. flavipes*)

Both species of yellowlegs were common on the managed ponds at Yawkey. Peak numbers of Lesser Yellowlegs were 854 and 796 individuals, respectively, on 20 April and 20 July 1989. Peak number of Greater Yellowlegs was 159 individuals on 20 July 1989. Our counts are substantially higher than previously reported sightings in the area (Table 3).

The number of Greater Yellowlegs present at the Yawkey Center was relatively constant (20-33 individuals) except in late fall when ponds were completely flooded and numbers dropped to 1-17 individuals. An exceptionally high count occurred on 20 April 1989 when 87 individuals were present (Fig 7). In contrast, the numbers of Lesser Yellowlegs increased slowly from 3 on 27 Sept. 1988 to 162 on 16 March 1989, and then jumped to 854 on 20 April 1989. In late summer the largest concentrations of yellowlegs were observed in Lower Reserve and Cooperfield Ponds. These two ponds differ from most of the other ponds at the Yawkey Center in that they are managed primarily for sea purslane (*Sesuvium maritimum*) rather than widgeongrass (*Ruppia maritima*) or saltmarsh bullrush (*Scirpus robustus*).

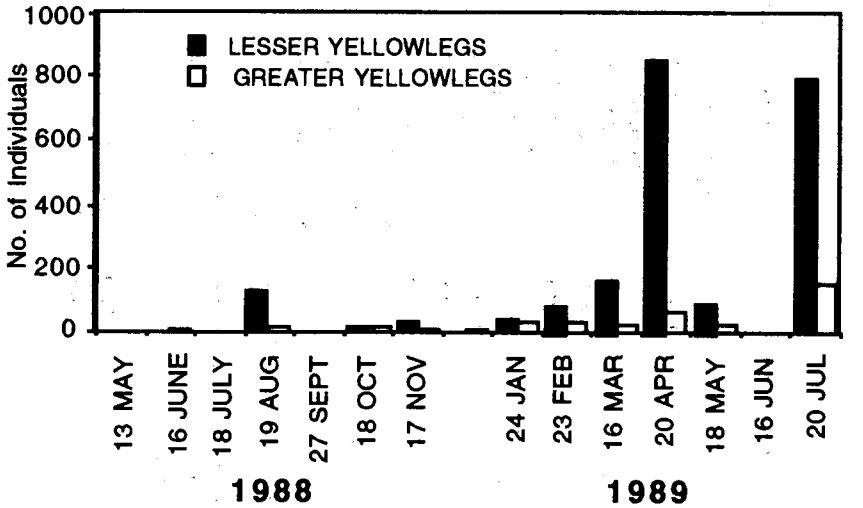


Figure 7. Numbers of Greater Yellowlegs and Lesser Yellowlegs seen at Tom Yawkey Wildlife Center during the study period.

Greater Yellowlegs were occasionally seen feeding in the Cape Romain

Table 3. Highest counts of each species observed during 1988-1989. Exceptionally high counts are bold-faced.

SPECIES	CAPE ROMAIN		YAWKEY CENTER		PREVIOUS HIGH	
	Count	Date	Count	Date	COUNT IN S.C.[a]	
American Avocet		not observed	**736**	23 Feb 1989	600–1000	Yawkey Ctr.[b]
Am. Oystercatcher	2,482	21 Feb 1988	2	20 Apr 1989	8,121	Charleston CBC
	2,347	11 Jan 1989				
Black-bellied Plover	**304**	SW: 8 May 1989	73	18 May 1989	319	Litchfield CBC
Semipalmated Plover	**1,784**	SW: 8 May 1989	**1,719**	18 May 1989	1,300	Yawkey Ctr.
Ruddy Turnstone	60	SW: 8 May 1989	6	24 Jan 1989	1,000	Charleston Co.
Marbled Godwit	**670**	19 Mar 1988	19	24 Jan 1989	200	Awendaw
	735	9 Feb 1989	20	20 Apr 1989		
Whimbrel	483	SW:17 Apr 1988	38	25 May 1989	1,155	Awendaw
	351	SW: 8 May 1989				
Long-billed Curlew	**8**	NE:15 Sep 1988		not observed	recent-5	Cape Isl.
		9 Feb 1989				
Willet	**569**	SW:11 Mar 1989	66	17 Nov 1988	509	Awendaw
Short-billed Dowitcher	**3,635**	SW:13 Dec 1988	**3,265**	20 Apr 1989		no information
	4,350	SW: 7 Apr 1989	**3,241**	18 May 1989		
Long-billed Dowitcher	**110**	SW:21 Jul 1989	90	24 Jan 1989	100	SW Jasper Co.
Greater Yellowlegs	not observed in roosts		**159**	20 Jul 1989	41	McClell. CBC
Lesser Yellowlegs		not observed	**854**	20 Apr 1989	60	Clemson
			796	20 Jul 1989		
Red Knot	**3,200**[d]	NE:18 Sep 1988		not observed	2,030	Awendaw
	1,043	NE:12 May 1989				

Table 3. (cont.) Highest counts of each species observed during 1988-1989. Exceptionally high counts are bold-faced.

SPECIES	CAPE ROMAIN		YAWKEY CENTER		PREVIOUS HIGH COUNT IN S.C.[a]	
	Count	Date	Count	Date		
Dunlin	1,500[d]	NE:11 Jan 1989	**2,291**	18 May 1989	2,040	Litchfield CBC
Semipalmated Sandpiper	c		**35,100**[d]	18 May 1989	5,000	Yawkey Center
Western Sandpiper	c		651	16 Mar 1989	6,051	Awendaw
Least Sandpiper	c		44	20 Apr 1989	65	Yawkey Center
Pectoral Sandpiper		not observed	122	20 Jul 1989	55	Thomasville
Stilt Sandpiper		not observed	40	18 May 1989	40	Yawkey Center
			20	20 Jul 1989		
White-rumped Sandpiper		not observed	7	18 May 1989	35	Jasper Co.
Wilson's Phalarope		not observed	**10**	18 Jul 1988	3	Clemson
			9	20 Apr 1989		

a from Post and Gauthreaux (1989)
b from Sprunt and Chamberlain (1970)
c species was present, but was not counted (see text)
d numbers estimated by counting part of flock and extrapolating for rest of group

SW = Route 1; Southwestern Area
NE = Route 2; Northeastern Area

salt marshes but they were not observed in the high tide roosts during the Aug 1988-July 1989 surveys. We have seen Greater Yellowlegs roosting on floating *Spartina* wrack, and therefore counts at high tide roosts are probably an inappropriate method for censusing this species. Lesser Yellowlegs were only observed along the Santee Delta in areas of brackish shallow water, but were not seen in the Cape Romain salt marshes.

Red Knot (*Calidris canutus*)

Large flocks of Red Knots were observed on several occasions on the outer islands at Cape Romain during migration, but only a few individuals were seen along the Intracoastal Waterway. On 16 August 1988, 580 knots were counted on New Island (in Bulls Bay), and a dense flock estimated to be 3,100 individuals was discovered roosting on Marsh Island in Bulls Bay on 15 and 18 September 1988. On 12 May 1989, 1,043 Red Knots were counted as they fed on an exposed peat bed on the beach at Raccoon Key (Table 3).

Large flocks of knots have been observed in the region previously (Post and Gauthreaux 1989) suggesting that Cape Romain is an important staging area, or "refueling site," for this species (see Myers et al. 1987). Cape Romain may be a critical staging area for this species. Delaware Bay is the only other staging area on the eastern U.S. coast that has been described for this species. We do not know if the Red Knots that stage in the area belong to the population that winters in the southeastern U.S. (primarily Florida) or in eastern South America.

Semipalmated Sandpiper (*Calidris pusillus*) Western Sandpiper (*C. mauri*) Pectoral Sandpiper (*C. melanotos*) and Stilt Sandpiper (*C. himantopus*)

On 28 May 1989 an estimated 35,100 Semipalmated Sandpipers were observed on the managed ponds at Yawkey. Semipalmated Sandpipers were common on all eight of the twelve marshes that had extensive areas of wet mud, but approximately 70% of these birds were feeding in Wheeler Basin. Seven days later (on 25 May) only 85 Semipalmated Sandpipers were present at Yawkey. This decline was probably due, in part, to drier mud conditions and the timing of this species' migration.

Small species of *Calidris* sandpipers or "peep" were present on the ponds at Yawkey most of the year, except in fall when water levels were high. All peep closely observed on the January and February censuses were Western Sandpipers, and therefore we assigned all small gray peep seen on these censuses (225 and 320, respectively) to that species.

Stilt Sandpipers were regular spring and late summer migrants at Yawkey, with sightings on 19 August 1988 (1), 20 April 1989 (1), 18 May 1989 (40), and 20 July 1989 (20). The regularity of these sightings indicate that Stilt Sandpipers may be more common in the region than previous records suggest. A large flock of Stilt Sandpipers (up to 249) was also observed elsewhere directly north of the census area at a spoil area at Hobcaw Barony on the north side of Winyah Bay from 18 May to 24 May 1989 (W. Allen, S. Gauthreaux, and C. Marsh, pers. obs.)

Pectoral Sandpipers were most common during migration in the ponds

managed for sea purslane, a vascular plant (10-15 cm in height) which requires a summer drawdown type of water level management. The highest count consisted of 122 birds (in flocks of 10-30) in Lower Reserve on 20 July 1989 when large expanses of sea purslane were slowly being reflooded after the summer drawdown.

Black-bellied Plover (*Pluvialis squatarola*) and Semipalmated Plover (*Charadrius semipalmatus*)

Plovers were censused on the southern route of Cape Romain because they could be seen easily on the oyster banks bordering the Intra-coastal Waterway, but were not counted on the northern route at Cape Romain because they often roosted on the upper beach or among the dunes of the outer islands away from the high tide roosts of other species. Individual birds in these habitats could not be censused reliably by observers in a boat bouncing in the surf. Consequently, counts of plover abundances at Cape Romain are underestimates. Piping Plovers, which only occur at sandy inlets, were not censused during this study.

Black-bellied Plovers were present at Cape Romain on all censuses (Table 2). This species is normally solitary, and most individuals roosted in small groups (5-15 birds). The winter counts (13 Dec. 1988 to 9 Feb. 1989) of the southwestern route ranged from 45 to 68 individuals except on the 23 Dec. 1988 when dense fog was present (Table 2). In contrast, the 1988 Charleston Christmas Bird Count recorded 12 Black-bellied Plovers. Black-bellied Plovers were most abundant on 8 May 1989 when 304 individuals were counted in high tide roosts along the Intracoastal Waterway.

Root's (1988) analysis of past Christmas Bird Counts indicated that Cape Romain had the highest concentrations of this species on the Atlantic Coast. Charleston Christmas Bird Count totals for Black-bellied Plovers during the years 1961-1988 ranged from eight (1972) to 821 (1965). Most of the exceptionally high counts of Black-bellied Plovers occurred during the 1960's and early 1970's (711 in 1964, 256 in 1961, 223 in 1970, 185 in 1975, and 179 in 1967), suggesting that numbers of Black-bellied Plovers in the area may presently be lower.

Semipalmated Plovers were not observed roosting on the oyster bars adjacent to the Intracoastal Waterway during the winter censuses, but three large flocks (498, 480, and 312) were observed on the 8 May 1989 census. Semipalmated Plovers were also abundant at Yawkey on 18 May 1989 (1,719 individuals). Totals for both areas were significantly higher than the previous highest count in South Carolina, an estimated 1,300 individuals at South Island (Yawkey) on 13 May 1984 (Post and Gauthreaux 1989) (Table 2).

The low number of Semipalmated Plovers at Cape Romain during the winter is contradictory to the conclusions of Root (1988). She determined this region to be one of the areas of high Semipalmated Plover density in the eastern United States. This discrepancy could be due to this species not using the high tide roosts, or its absence from the Cape Romain area during the winter of 1988-89 being atypical.

Wilson's Phalarope (*Phalaropus tricolor*)

The Wilson's Phalarope is a rare migrant along the South Carolina coast (eight previous sightings), but was observed on four occasions at Yawkey: seven individuals on 18 July 1988 (S. Gauthreaux and P. Wilkinson, pers. obs.), nine individuals on 20 April 1989, two individuals on 18 May 1989, and three individuals were observed by C. Marsh and L. Glover on 20 July 1989. These observations suggest that Wilson's Phalarope is a regular, but rare, migrant at Yawkey.

THE EFFECTIVENESS OF THE SHOREBIRD CENSUSES

The effectiveness of counts depended on the location, and habitat type. Counts conducted at Yawkey were more accurate than those at Cape Romain, because all sections of the former region were readily accessible by vehicle, and because all counts at the site were made with a spotting scope. In contrast, many of the counts at Cape Romain were made with binoculars from a moving boat.

At Cape Romain the most accurate counts probably were made of American Oystercatcher, Marbled Godwit, Willet, Short-billed Dowitcher, and Black-bellied Plover because these species were most visible and usually roosted in flocks on unvegetated, exposed bars. Counts were probably lower overall for species which did not congregate at high tide roosts, but roosted in stands of vegetation or on floating mats of dead Spartina grass (Whimbrels, Greater Yellowlegs, Dunlin, and Semipalmated Plover). Dunlin, Western and Semipalmated Sandpipers were probably the most often overlooked because of their small size and their reluctance to flush unless approached closely.

Most high-tide roosts at Cape Romain typically were associated with one of two habitats: (a) shallow, mud bays with expansive oyster beds and mudflats where shorebirds congregated on oyster rakes (elevated mounds of oyster shells), and (b) outer barrier islands where shorebirds congregated on sandy beaches or sand bars near an inlet. (A notable exception was the Graham Creek high tide roost where large numbers of Willets and Marbled Godwits roosted on a dock bordering the Intracoastal Waterway.) Flocks of shorebirds roosting on oyster rakes were usually easier to locate and count than those on barrier islands. Most oyster rakes are relatively small and localized, border deeper water (i.e., navigable creeks), and are surrounded by tidal marsh that is submerged during spring high tides. Consequently, during high tide these oyster rakes provide the only suitable high roost sites for shorebirds in Cape Romain's many expansive muddy bays, and therefore flocks of species (primarily American Oystercatchers, Marbled Godwits, and Short-billed Dowitchers) could be accurately censused.

In contrast, flocks of cryptically colored shorebirds roosting on barrier islands were often hard to find and count from a boat. Beaches and sand flats of the barrier islands often could not be approached closely due to either shallow water or breaking waves. In addition, the roosting sites were not as localized, and flocks often did not use the same location during subsequent counts. Species most commonly associated with outer barrier islands included Dunlin, Western Sandpipers, Sanderlings, Red Knot and Black-bellied, Semipalmated,

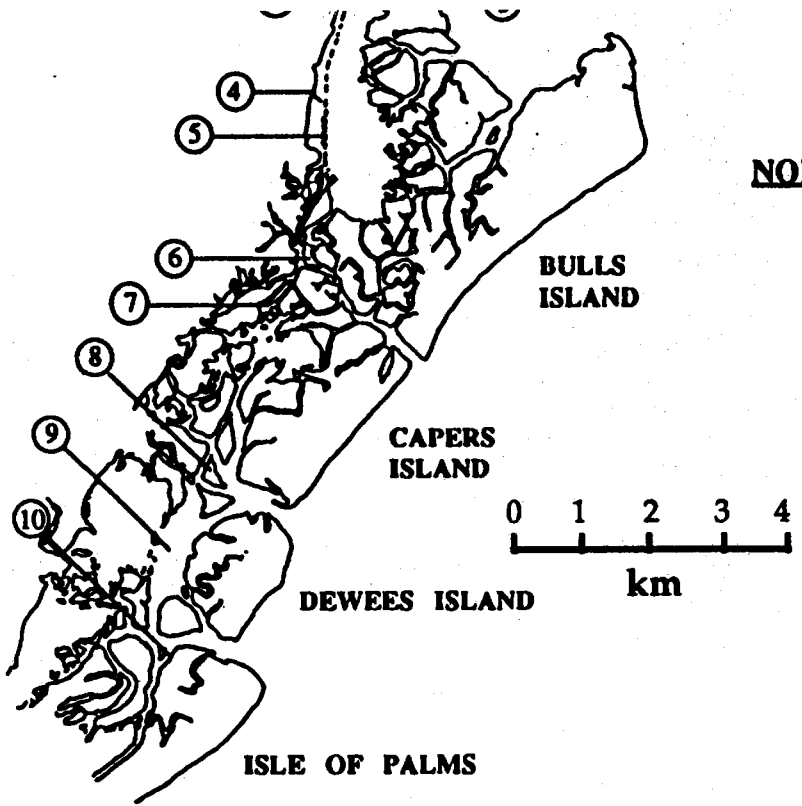
and Piping Plovers. The high variability of counts from the outer barrier islands suggests that coverage of these species was probably inadequate and that, to obtain more accurate censuses, this habitat should be censused by observers on foot or with bicycles rather than by boat.

SIGNIFICANCE OF THE CAPE ROMAIN-SANTEE DELTA AS SHOREBIRD HABITAT

Our study confirms the importance of the Cape Romain region and the Santee Delta as important habitat for migratory shorebirds and provides the first estimates of shorebird population sizes based on standardized census methods. These data indicate that the Cape Romain-Santee Delta Biosphere Reserve ranks as an important area for shorebirds on the eastern North American coast. We recommend that the area become part of the Western Hemisphere Shorebird Reserve Network (WHSRN). WHSRN is sponsored by the International Association of Fish and Wildlife Agencies and was established to encourage protection and management of areas that serve as critical "refueling sites" for migratory species of shorebirds (Myers et al. 1987). Reserves in this network are identified as being hemispheric or regional sites. Hemispheric sites are used by more than 250,000 birds or at least 30% of the flyway population of a species, whereas regional sites are used by more than 20,000 birds or at least 5% of the flyway population (Myers et al. 1987).

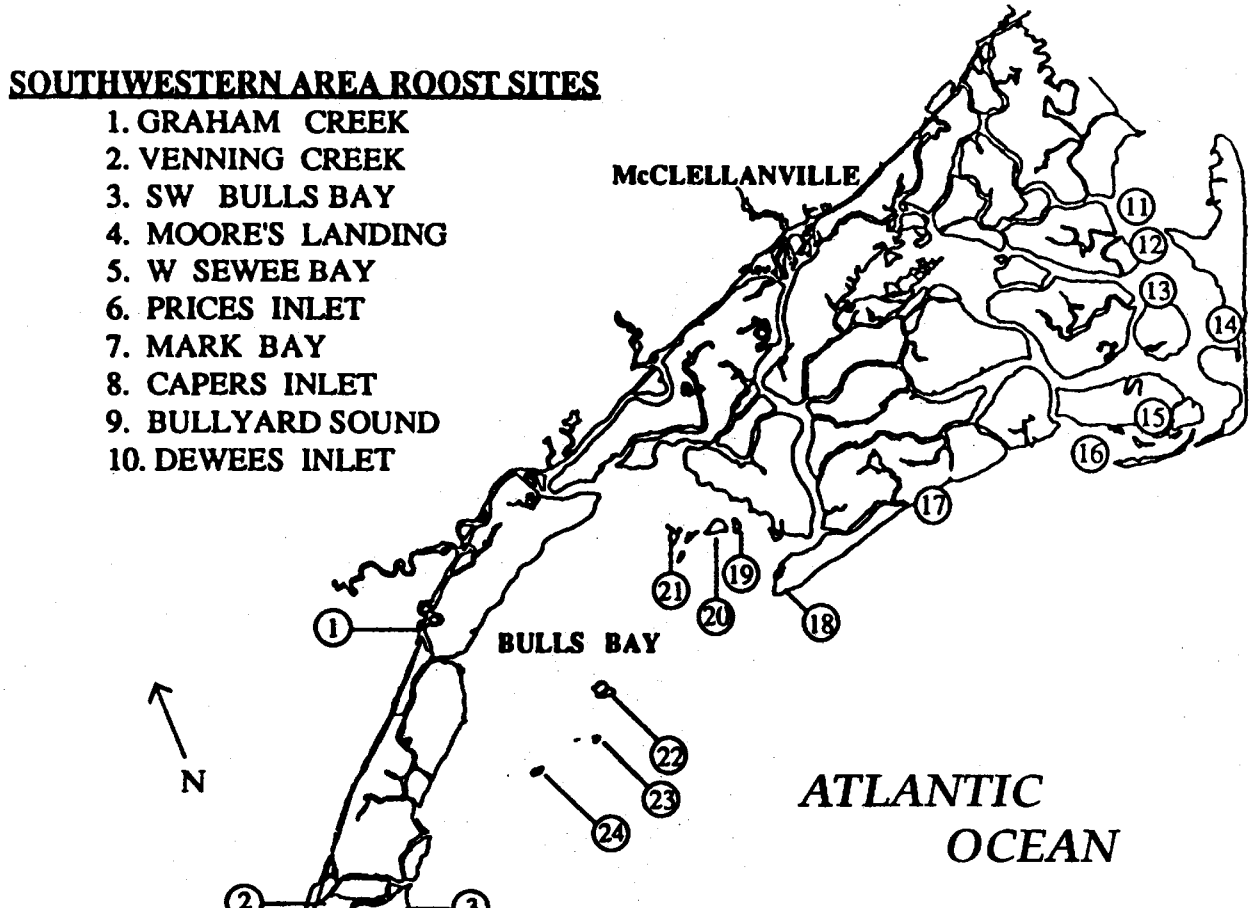
Table 4. Site-importance of Cape Romain and Yawkey Center during 1988-89

	Cape Romain		Yawkey Center
	Spring	Autumn	Spring
Am. Oystercatcher	73%	44%	0
Marbled Godwit	34%	34%	0
Whimbrel	19%	10%	0
Willet	9%	3%	0
Red Knot	1%	10%	0
Am. Avocet	0	0	5%
S.B. Dowitcher	14%	3%	10%
Semipalmated Plover	13%	0.04%	12%
Black-bellied Plover	2%	0.4%	0.4%
Semipalmated Sandpiper	0	0	8%
Dunlin	1%	0	3%
Lesser Yellowlegs	0	0	1%
Ranking Index	166	104	39



NORTHEASTERN AREA ROOST SITES

11. CASINO CREEK
12. DEEPWATER POINT
13. HORSEHEAD CREEK
14. CAPE ISLAND - WEST SIDE
15. LIGHTHOUSE ISLAND
16. KEY INLET
17. RACCOON KEY
18. SANDY POINT
19. EAST WHITE BANKS
20. MIDDLE WHITE BANKS
21. WEST WHITE BANKS
22. MARSH ISLAND
23. NEW ISLAND
24. BIRD ISLAND


SOUTHWESTERN AREA ROOST SITES
1. GRAHAM CREEK
2. VENNING CREEK
3. SW BULLS BAY
4. MOORE'S LANDING
5. W SEWEE BAY
6. PRICES INLET
7. MARK BAY
8. CAPERS INLET
9. BULLYARD SOUND
10. DEWEES INLET
McCLELLANVILLE
BULLS BAY
N
ATLANTIC
OCEAN

Harrington et al. (1989) calculated a "national season total" (autumn and spring) for each species by summing the highest counts made at each of 650 sites in the eastern United States during that season. The Cape Romain and Santee Delta totals were compared to the data provided by Harrington et al. 1989 by adding these two totals to the appropriate seasonal national totals, and then expressing each site's results as a proportion of the adjusted national total (Table 4). Using this criterion Cape Romain has over 30% of the flyway's American Oystercatchers and Marbled Godwits during Spring and Autumn, and therefore qualifies as a hemispheric reserve. In addition, it meets the criterion of over 5% for regional reserve status for five additional species (Whimbrel, Short-billed Dowitcher, Semipalmated Plover, Red Knot, Willet). The Yawkey Center qualifies as a regional reserve for four species: Semipalmated Plover, Short-billed Dowitcher, Semipalmated Sandpiper, and American Avocet.

The Cape Romain and Yawkey Center totals were added to the appropriate (autumn or spring) national totals as calculated by Harrington et al. 1989, and then expressed as a proportion of the adjusted national total.Harrington et al. 1989 ranked the importance of marine sites along the Atlantic Coast (U.S.A. only) that were included in the International Shorebird Survey. Ranking was based on the total of the scores (proportion of national total) for each species at the site. Using this criterion, the Cape Romain region spring index (166) was second only to Delaware Bay (307 in spring), and higher than that of Chincoteague, Virginia (157 in spring) and Monomoy NWR (140 in fall). Based on this method of site evaluation, the Cape Romain region is one of the most important shorebird refuges in the eastern United States.

Most of the Cape Romain region is protected as part of the Cape Romain NWR or the Capers Island State Wildlife Area. However, the western section of the area, which includes Dewee's Inlet and Copahee, Bullyard, Hamlin, and Gray Sounds, presently has status only as state waters and, therefore, is not guaranteed the same degree of environmental protection as the remainder of this region. This estuary system has the highest concentrations of American Oystercatchers and Short-billed Dowitchers during winter and spring, and inferential evidence suggests that flocks of shorebirds regularly move into this southwestern section from the remainder of the Cape Romain region during winter storms with strong northeastern winds. To better protect this area as shorebird habitat, we recommend that this western section (the 9,000 hectares of tidally flooded marsh between Hamlin Creek and Anderson Creek) be included as part of a Cape Romain-Santee Delta Western Hemisphere Shorebird Reserve.

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REQUEST FOR INFORMATION

I am writing a review about the hour of egg-laying of passerines. As published data on this topic are scarce, I would appreciate hearing from persons who have unpublished records on laying times that they would allow me to use with appropriate acknowledgements. The records should include species name, locality, date, estimate of hour of laying, and type of time used (e.g. Eastern Standard Time or Eastern Daylight Time in North America, or British Summer Time, etc.). Information on whether the observation was of the first, second, or third egg, etc., of the clutch would also be useful. Please write to David M. Scott, Professor emeritus, Department of Zoology, University of Western Ontario, London, Ontario, Canada, N6A 5B7.

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