

WINTER DISTRIBUTION OF PIPING PLOVERS ALONG THE ATLANTIC AND GULF COASTS OF THE UNITED STATES

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ABSTRACT.—We conducted winter surveys of Piping Plovers (*Charadrius melodus*) along the Atlantic Coast (December 1986–March 1987) and Gulf Coast (December 1987–March 1988) of the United States to identify specific wintering sites. A total of 222 Piping Plovers was observed on the Atlantic Coast (about 14% of the entire Atlantic Coast breeding population) and 1508 on the Gulf Coast (about 56% of the entire Great Lakes/Northern Great Plains breeding population). Highest Atlantic Coast estimates occurred in Georgia (N = 105; 47.5%), whereas the most plovers on the Gulf Coast occurred in Texas (N = 834; 55.3%). The survey included 1422 km of barrier beach on the Atlantic Coast (69% of the coast) and 1283 km on the Gulf Coast (50% of the coast). The greatest potential for locating more plovers in the United States is in South Carolina and Louisiana. However, a large percentage of the North American breeding population (particularly on the Atlantic Coast) probably winters outside the United States, thus future surveys should explore the Caribbean and Mexico. *Received 28 April 1989, accepted 21 Nov. 1989.*

The Piping Plover (*Charadrius melodus*) is a migratory shorebird endemic to North America, which was designated as threatened/endangered in 1986 (Federal Register 1985). Piping Plovers breed along the Atlantic Coast from Maritime Canada to North Carolina, along the Great Lakes, and in the northern Great Plains of Canada and the United States (Johnsgard 1981, Haig and Oring 1985). The primary winter range is along the Atlantic and Gulf Coasts from North Carolina to Mexico (Haig and Oring 1985).

Knowledge of the winter distribution of migratory shorebirds is important because substantial mortality can occur during this portion of their annual cycle (Baker and Baker 1973, Evans 1976, Myers 1980). Such data are especially important for Piping Plovers because they can spend 7–8 months per year away from breeding areas (Haig and Oring 1985). Research on breeding areas has contributed knowledge of demographics (Wilcox 1959, Haig and Oring 1988a, b), behavior (Cairns 1982), and reproductive activity (Gaines and Ryan 1988, Haig and Oring 1988a). However, studies of wintering plovers are few (Haig and Oring 1985, Johnson and Baldassarre 1988).

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Haig and Oring (1985) conducted winter distribution surveys in 1983 along the Texas coastline and in 1984 along 1228 km of Gulf Coast beaches from Mexico to Florida. Although these surveys were the first on-site assessments of winter populations, they tallied only 25% of the total breeding population. Further, the Atlantic Coast portion of the winter range was not surveyed.

A comprehensive conservation plan for the Piping Plover must incorporate strategies addressing winter habitat. However, such strategies cannot be developed until winter distribution is delineated. Indeed, the Atlantic and Great Lakes/Northern Great Plains Recovery Plans for Piping Plovers include the determination of winter status and distribution as high priorities relative to population recovery efforts for this species (Dyer et al. 1987, Haig et al. 1988). The primary objective of our study was to provide a more accurate estimate of the distribution of Piping Plovers wintering in the United States.

METHODS

We determined winter distribution of Piping Plovers by surveying suitable habitat along the Atlantic Coast from Virginia to Key West, Florida (15 December 1986–15 March 1987), and along the Gulf Coast from Everglades National Park, Florida, to Brownsville, Texas (4 December 1987–23 March 1988). Survey sites were selected based on previous sighting records such as Christmas Bird Counts (CBC), historical accounts and recommendations from reliable sources (e.g., state biologists, Natural Heritage Program personnel, bird club members). We also distributed a flyer (Nicholls 1989) to various clubs, universities, and museums to publicize the survey and to request additional sighting information. Coastal ecological inventory maps (1:250,000; U.S. Fish and Wildlife Service 1982), topographic maps (1:24,000), and aerial and Landsat photographs also were analyzed to locate additional potential habitat. Thus, to increase the probability of locating major wintering sites, the survey deliberately focused on areas most likely to contain wintering Piping Plovers. Nicholls (1989) provides a detailed listing and associated maps of survey sites along both coasts.

Sites were surveyed by walking or driving a vehicle or 3-wheel all-terrain vehicle along the beach. Several islands and mudflats along intracoastal waterways were surveyed by boat. Aerial surveys of the Georgia coastline and the Ten Thousand Island and Big Bend regions of Florida were conducted to assess habitat potential in these less accessible areas. Less suitable areas of Piping Plover habitat (e.g., highly eroded and/or developed beaches) were checked by walking/driving 1-km sections of habitat every 1.6 km for sites 3–16 km long, every 4 km for sites 16–32 km long, and every 8 km for sites greater than 32 km. Thus, two coverage estimates were calculated: (1) the total km included in the survey (i.e., the total sampled area along the coastline), and (2) the total number of km actually walked or driven. Length of coastline (i.e., mainland and oceanside of islands) was determined from NOAA reports (National Oceanic and Atmospheric Administration 1979).

We counted Piping Plovers, using binoculars and a spotting scope. Double counting was not considered a problem because Piping Plovers generally occurred in small and/or discrete groups. Separate coastal estimates were made to represent the respective breeding populations because Haig and Oring (1988b) have demonstrated that Piping Plovers breeding on

the northern Great Plains and Great Lakes winter primarily along the Gulf Coast, whereas birds breeding along the Atlantic Coast winter farther south on the Atlantic.

We then quantified potential disturbance factors (e.g., human and off-road vehicle traffic, water and shoreline stabilization structures) and noted land ownership at each site. Finally, we rated each site (1 = highest) in importance to Piping Plovers based on the number of birds seen at the site and assessment of three habitat related criteria: (1) suitability of habitat (a subjective, comparative assessment of the quality and quantity of foraging and roosting area at the site), (2) CBC evidence of historical use, and (3) disturbance level, which was measured as either high or low/none, with a high level indicating potential threats to use of an area by plovers and/or imminent loss of habitat.

RESULTS

Atlantic Coast survey.—The Atlantic Coast survey covered 1422 km of coastline (659 km mainland and 763 km island) from the eastern shore of Virginia to the Florida Keys and examined 134 sites comprising 69% of the total coast; 41% of the coast actually was walked or driven. Survey coverage in each state ranged from 64–86%, and was highest in North Carolina (72%) and Georgia (86%) (Table 1). Sites with potential habitat but not included in the survey were Wreck, Ship Shoal, and Smith Islands in Virginia; Corncake Inlet on Bald Head Island, Brown and Bear Inlets at Camp LeJeune Marine Corps Base, and Tubbs Inlet at Waites Island in North Carolina; Cedar, Murphy, Dewee's, Capers, Morris, and Baypoint Islands in South Carolina; Little Tybee and Little Cumberland Islands in Georgia; and Cape Canaveral National Seashore and the Marquesas Keys in Florida.

We counted 222 Piping Plovers along the Atlantic Coast from North Carolina through Florida (Table 2). This represented about 5% of the total North American breeding population and 14% of the entire Atlantic Coast breeding population (Dyer et al. 1987), although a few Piping Plovers breeding on the northern Great Plains winter along the Atlantic Coast (Haig and Oring 1988b). Piping Plovers were found most frequently in Georgia (69.2% of the sites had birds) and least frequently in Florida (12.5% of the sites had birds) (Table 2). Georgia also had the highest density of plovers per km surveyed (0.77), followed by South Carolina (0.22). Individual sites with the highest numbers of Piping Plovers were Little St. Simon's Island (N = 32), Cumberland Island National Seashore (N = 20), and Pelican Spit (N = 19) in Georgia; Rachel Carson's Estuary (N = 16) in North Carolina; Huntington Beach State Park (N = 12) and North Island (N = 12) in South Carolina; and Shackleford Banks (N = 9) in North Carolina (Table 3). The remaining 30 sites with plovers had groups of <9 birds; mean group size was 6.

Sites with the highest plover numbers ranked a 1 or 2 and were considered the most important plover areas (Table 3). Importantly, 10 of these 12

TABLE 1
SURVEY COVERAGE OF THE ATLANTIC AND GULF COASTS, DECEMBER 1986–MARCH 1987

Coast State	Coverage				Percent of islands surveyed
	Percent of coast surveyed ^a	No. of sites surveyed	Mainland km ^b	Island km ^c	
Atlantic					
Virginia	66.1	12	29.6	88.8	69.4
North Carolina	72.2	31	46.4	301.6	82.9
South Carolina	63.6	22	85.6	105.4	58.2
Georgia	85.5	13	0.0	136.8	85.5
Florida	67.8	56	497.3	130.4 ^d	72.2
Gulf					
Florida	43.8	94	212.5	326.8	73.7
Alabama	55.6	5	32.0	15.2	52.8
Mississippi	83.0	14	18.4	40.0	62.5
Louisiana	18.1	17	64.8	50.4	26.9
Texas	89.0	46	216.5	306.4 ^d	80.6

^a Percent of mainland and island barrier beach (NOAA 1979).

^b Includes mainland barrier beach and coastal bay sites.

^c Includes island barrier beach; estimates from Heritage Conservation and Recreation Service 1979.

^d Does not include the Keys or barrier islands separated from the mainland by the intracoastal waterway.

TABLE 2
RESULTS OF THE PIPING PLOVER SURVEY ON THE ATLANTIC AND GULF COASTS, DECEMBER 1986–MARCH 1988

Coast State	Actual survey			Number per km		Sites with birds		
	Number of plovers	Percent survey total	Percent total population	Actual survey	Coast estimate	Number	Total sites visited	%
Atlantic								
Virginia	0	0	0	0	0	0	12	0
North Carolina	50	22.6	1.2	0.14	0.10	13	31	41.9
South Carolina	43	19.0	1.0	0.22	0.14	8	22	36.4
Georgia	105	47.5	2.5	0.77	0.66	9	13	69.2
Florida	24	10.9	0.6	0.04	0.03	7	56	12.5
Gulf								
Florida	351	23.3	8.4	0.66	0.28	32	94	34.0
Alabama	52	3.4	1.2	1.20	0.61	3	5	60.0
Mississippi	37	2.5	0.9	0.63	0.52	9	14	57.1
Louisiana	234	15.5	5.6	2.00	0.39	9	17	52.9
Texas	834	55.3	19.9	1.60	1.40	22	46	52.4

TABLE 3
 IMPORTANT WINTERING SITES OF PIPING PLOVERS ALONG THE ATLANTIC COAST, DECEMBER
 1986–MARCH 1987

State Site	Plovers surveyed		Importance rank ^{a,b}	Ownership
	Number per site	Percent of survey total		
North Carolina				
Shackleford Banks	9	4.1	2	Federal
Rachel Carson's Estuary	16	7.2	1	Federal
South Carolina				
Huntington Beach State Park	12	5.4	2	State
North Island	12	5.4	2	State
Hunting Island State Park	8	3.6	2	State
Georgia				
Williamson Island	8	3.6	2	State
Blackbeard NWR	8	3.6	2	Federal
Little St. Simon's Island	32	14.5	1	Private
Pelican Spit	19	8.6	2	State
Cumberland Island				
National Seashore	20	9.0	1	Federal
Florida				
Anastasia State Recreation Area	6	2.7	2	State
Ohio Key ^c	4	1.8	2	Private

^a Ranking is based on the following formula: 1 = ≥ 20 birds, or 15–19 birds and all three criteria met; 2 = 6–14 birds and two–three criteria met, or 15–19 birds and two criteria met.

^b Criteria were: (1) habitat quality, i.e., excellent, with expansive mudflats adjacent to sandy beach; (2) historical data, i.e., presence on Christmas Bird Count at least once in previous five years; and (3) disturbance level, i.e., moderate to no disturbance at site (e.g., ≤ 1.4 people and/or 0.2 off-road vehicles observed per km).

^c Ohio Key is an exception to the ranking system because it was the only location in the Florida Keys with consistent CBC data documenting Piping Plover use.

sites are under state/federal ownership. Sites that ranked a 3 or 4 were considered supporting sites, whereas sites ranked 5 probably are not quality sites and may represent incidental sightings (Nicholls 1989).

We recorded evidence of disturbance at 56% of the sites with no plovers, in contrast to 38% at sites with wintering plovers. We tallied an average of 3.5 people and 0.7 off-road vehicles per km at non-plover sites and 1.4 people and 0.2 off-road vehicles per km at plover sites. Plovers generally were seen foraging on sandflats near inlets, at tidal creeks, near dune ponds, and along the foreshore. Most roosting birds were found on the upper beach.

Gulf Coast survey.—The Gulf Coast survey covered 1283 km (739 km mainland and 739 km island) from the Everglades National Park, Florida,

to Brownsville, Texas. This included 176 sites comprising 50% of the total Gulf Coast; 39% actually were walked or driven (Table 1). Sites with potential habitat but not included in the survey were portions of the Big Bend Region and St. Joseph's Bay in Florida; Cat and Deer Islands in Mississippi; Breton National Wildlife Refuge (i.e., lower half of the Chandeleur Islands) and East and Central Isles Dernieres in Louisiana; and sections of the Laguna Madre in Texas and Mexico.

We counted 1508 Piping Plovers along the Gulf Coast from Florida to Texas (Table 2), which represented 35% of the total breeding population and 56% of the Great Lakes/Northern Great Plains population (Haig et al. 1988). Haig and Oring (1988b) reported only one Piping Plover breeding on the Atlantic Coast that was confirmed wintering along the Gulf Coast. Piping Plovers were observed most frequently in Alabama, Mississippi, Texas, and Louisiana (52–60% of the sites had birds) and least often in Florida (34% of the sites had birds) (Table 2). Louisiana (2.0/km) and Texas (1.6/km) had the highest Piping Plover density. Sites with the highest plover numbers were San Jose Island (N = 146) and Corpus Christi Pass (N = 108) in Texas, Chandeleur Islands (N = 80) in Louisiana, Bolivar Flats (N = 66) and Laguna Madre (N = 63) in Texas, Rockefeller Refuge (N = 52) in Louisiana, Honeymoon Island State Park (N = 53) in Florida, Little Dauphin Island (N = 50) in Alabama, Matagorda Peninsula (N = 50), Brazos Island State Park (N = 48), private land (i.e., between the Brazos and San Bernard Rivers in Brazoria County) (N = 48), Matagorda Island (N = 46) and San Bernard National Wildlife Refuge (N = 42) in Texas, and Mullet Key (N = 42) in Florida (Table 4). The other 61 sites had <40 birds per site; mean group size was 20.

On the Gulf Coast survey, we noted potential disturbances at 43% of the non-plover sites and 41% of the plover sites. Recreational activity also was higher at non-plover sites (6.5 people and 0.4 off-road vehicles per km) compared to plover sites (0.7 people and 0.2 off-road vehicles per km).

Piping plovers were found foraging on sandflats adjacent to passes and inlets, on mudflats near sandy beaches, on overwash sandy mudflats, and on the foreshore of open beaches (Nicholls 1989). Sites were ranked on the Gulf Coast using the same criteria described for the Atlantic Coast, excepting adjustments for the higher plover numbers, with 21 of the 27 most important sites under state/federal ownership (Table 4).

DISCUSSION

Atlantic Coast survey.—Georgia and South Carolina had the highest density of plovers per km surveyed and per km coastline, perhaps because both states contain numerous islands that create a diverse array of mi-

TABLE 4
 IMPORTANT PIPING PLOVER WINTERING SITES ALONG THE GULF COAST, DECEMBER 1986–
 MARCH 1987

State Site	Plovers surveyed		Importance rank ^{a,b}	Ownership
	Number per site	Percent of survey total		
Florida				
Marco Island	18	1.2	2	Private
Estero Island	14	0.9	2	Private
Mullet Key	42	2.8	1	State
Honeymoon Island State Park	53	3.5	1	State
Sandbar Island ^b	17	1.1	2	State
Phipp's Reserve	25	1.7	2	Private
Cape San Blas	16	1.1	2	State
St. Joseph Peninsula	18	1.2	2	State
Crooked Island East	17	1.1	2	Federal
Shell Island	19	1.3	2	Federal
Alabama				
Little Dauphin Island	50	3.3	1	Federal
Mississippi				
Buccaneer State Park	10	0.7	2	State
Louisiana				
Chandeleur Islands	80	5.3	1	Federal
Isle Dernieres East	34	2.3	1	Private
Rockefeller Refuge	52	3.4	1	State
Texas				
Bolivar Flats	66	4.4	1	State
San Luis Pass	39	2.6	2	State
Private land ^c	48	3.2	1	Private
San Bernard NWR	42	2.8	1	Federal
Matagorda Peninsula	50	3.3	1	State
Matagorda Island	46	3.1	1	Federal
Corpus Christi Pass	108	7.2	1	State
San Jose Island	146	9.7	1	Private
Laguna Madre North	63	4.2	1	State
Laguna Madre South	29	1.9	2	State
South Padre Island	39	2.6	2	State
Brazos Island State Park	48	3.2	1	State

^a Ranking based on the following formula and the same set of criteria used on the Atlantic Coast (see Table 3); 1 = >40 birds; 2 = 20–40 birds and 2–3 criteria met or 10–19 birds and three criteria met.

^b Accreting sandbar between Honeymoon Island State Park and Anclote Keys NWR in Pinellas County.

^c Land between the Brazos and San Bernard rivers in Brazoria County.

crohabitats (tidal inlets and creeks, barrier spits, tidal pools, and dune ponds) which may provide more plover habitat due to the heterogeneity of the coastline. Zivojnovich and Baldassarre (1987) speculated that habitat heterogeneity was an important factor influencing wintering Piping Plovers in Alabama, because multiple feeding and roosting sites occurred in close proximity. In contrast, long barrier islands and uniform stretches of beach characterize the North Carolina and Florida coasts. Therefore, reduced habitat diversity along these higher energy systems may explain lower plover numbers.

The CBC data from 1969–1984 were used to identify wintering sites of Piping Plovers (unpubl. data, C. Raithel, Rhode Island Dept. Environmental Management), and results of our survey generally were comparable. For example, CBC's for Virginia suggest that the species is a rare winter resident (e.g., only 52 Piping Plovers recorded from 1975–1985). Thus, the absence of Piping Plovers in Virginia during our survey indicates that North Carolina is the northern edge of the winter range on the Atlantic Coast. Similarly, Piping Plover sightings on CBC's along the Atlantic Coast of Florida are low. The CBC areas recognized by Raithel (unpublished data) as having a high frequency of Piping Plover occurrence (i.e., >10.0 plovers/100 person-h) also correlated with survey estimates. However, we identified the specific sites within CBC areas where Piping Plovers are actually found (see Nicholls 1989). For example, Piping Plovers tallied during the Morehead City CBC in North Carolina occur in the Rachel Carson's Estuary. Similarly, Piping Plovers reported on the Glynn County CBC in Georgia actually occur on Jekyll Island and Pelican Spit. Only a few CBC's such as Sapelo Island, Georgia, and Miami/Dade County, Florida, reported more birds than our survey, but local movements of birds, yearly fluctuations in habitat, or decline of the Atlantic Coast breeding population could explain survey differences at these sites.

Our survey also identified wintering areas never covered by CBC's, and thus unknown as concentration sites for wintering Piping Plovers. These sites include Portsmouth Island and Shackleford Banks in North Carolina; North and Little Capers Islands in South Carolina; Williamson, Ossabaw, Blackbeard National Wildlife Refuge, and Little St. Simon's Islands in Georgia; and Fort Mantanzas National Monument and Carl Ross Key in Florida.

Winter habitat loss is difficult to document, but historical data indicate that some degradation has occurred along portions of the Atlantic Coast (Dyer et al. 1987). For example, Piping Plovers were considered "abundant" from July to March in Florida (Stevenson 1960). Numerous man-made structures (e.g., seawalls, groins, and jetties) are present in Florida, and beaches typically are steep and narrow, reflecting severe erosion (U.S.

Department of Interior 1985). These factors may have reduced wintering plover habitat by eliminating feeding and roosting areas. Piping Plovers also spend a high percentage of time foraging during the winter period (Johnson and Baldassarre 1988), an activity that may be disrupted by frequent recreational activity. However, although our data suggest that human disturbance impacts wintering Piping Plovers on both coasts, because disturbance was less on sites with plovers versus sites without plovers, further research is needed to determine the exact mechanisms and degree of disturbance necessary to preclude use of an area by wintering Piping Plovers.

The Atlantic Coast survey located only 14% of the entire estimated Atlantic Coast population of Piping Plovers, yet we considered our survey coverage extensive (except in South Carolina) because it included 69% of the mainland and 58–85% of the offshore island barrier beach (Table 1). Clearly a large percentage of the population either is wintering in areas not surveyed or winters outside the United States.

A few anecdotal accounts indicate that Piping Plovers winter sporadically in the Bahamas and the Greater Antilles (Wetmore and Swales 1931, Bond 1947, Maurice 1953, Raffaele 1983), and Haig and Oring (1985) also reported sightings of wintering Piping Plovers in the Caribbean. From 1985–1988, two wintering Piping Plovers were sighted in the Greater Antilles, five in the Bahamas, one in Bermuda, one in Puerto Rico, one in the Virgin Islands, and one in Yucatan (Nicholls 1989). Group sizes of these sightings averaged 3.4, with the largest group ($N = 15$) reported from Eleuthera Island in the Bahamas in 1986. However, few coastal CBC's are conducted in the Caribbean, and birders rarely visit some islands, which may contribute to the paucity of sighting records. Thus, given that our survey coverage along the Atlantic Coast was extensive (69% of the total coastline) and that the average group size was only 6.0 plovers per site, there exists a strong possibility that wintering Piping Plovers are spread widely throughout the Caribbean islands. This dispersion may be beneficial, however, since small, scattered groups of plovers may be less vulnerable to climatic or man-made disasters than would be larger concentrations.

Gulf Coast survey.—On the Gulf Coast, Texas and Louisiana had the highest number of Piping Plovers per km surveyed. The barrier islands in these states are characterized by low-lying dunes and gently sloping beaches, which may offer more intertidal area for foraging shorebirds. The higher total plover count in Texas probably can be attributed to a longer barrier beach coastline, whereas Louisiana predominantly is fringed with coastal marsh. The Gulf side of Florida also contained a large percentage of the survey total, but the numbers per km surveyed and per km

of coastline were low. Perhaps the expansive sections of saltmarsh and mangrove reduce suitable habitat to more isolated patches. In contrast, the high density of Piping Plovers in Alabama may occur due to the diversity of habitats within the Mobile Bay barrier island system (Zi-vojnovich and Baldassarre 1987).

Raithel (1985, unpubl. data, Rhode Island Dept. of Environmental Management) identified historical concentration areas on the Gulf Coast, such as Port St. Joe in Florida, Dauphin Island in Alabama, and Bolivar Flats in Texas, which was supported by the 1984 survey of Haig and Oring (1985). Our survey results also corroborate these records (Nicholls 1989). However, increased coverage in Louisiana and Florida yielded additional wintering sites, such as the Chandeleur Islands, Fourchon Pass, Elmers Island, Isle Dernieres, Marsh Island, and Rockefeller Refuge in Louisiana, and Marco Island, Estero Island, Cayo Costa State Park, North Captiva Island, Anclote Keys, Hagen's Cove, Carabelle Beach, and Davis Point in Florida (these sites also are not included in CBC). Thus, given the previous surveys and that our survey accounted for approximately 56% of the entire Great Lakes/Northern Great Plains breeding population, the winter distribution of Piping Plovers on the Gulf Coast is becoming better known.

Deterioration of habitat used by wintering Piping Plovers has been suggested in portions of Alabama (Baldassarre 1986), Florida, and Texas (Haig et al. 1988). Hurricane Elena in 1985 was responsible for destroying intertidal flats used by plovers on the west end of Dauphin Island (Johnson 1987), however, increased development along the Alabama coastline also may have contributed to habitat loss. Future habitat loss may be imminent in Mississippi (beach restoration projects on mainland beaches), Louisiana (continuing coastal erosion), and Texas (new coastal development projects).

Total Gulf Coast coverage (50%) appears low because shoreline estimates include large sections of unsuitable habitat (e.g., saltmarsh) that were not surveyed. However, survey coverage of potential habitat (e.g., barrier beach) was more thorough. For example, coverage of the barrier beach coastline on the Gulf side of Florida was 78%, whereas total coastline coverage was only 44%. On the Gulf Coast, the highest potential for locating more plovers is in Louisiana, because only 27% of the barrier islands were covered. The lower Laguna Madre (below the Port Mansfield Ship Channel) in Texas also may yield more birds because of the expansive and relatively inaccessible sandflats and spoil islands throughout this system. Potential habitat also exists in the Laguna Madre de Tamaulipas (Tamaulipas), Altamira (Tamaulipas), and Rio Lagartos (Yucatan) (Haig and Oring 1985). Haig and Oring (1985) sighted few birds along the

Mexican Gulf Coast; however, only 25% of the coastline from Tamaulipas to the Yucatan peninsula was covered. Indeed, fluctuations of Piping Plover numbers during spring and fall migration along the Texas coast suggest that some birds may overwinter in Mexico (Blacklock and Rappole 1985).

CONCLUSIONS AND CONSERVATION RECOMMENDATIONS

Knowledge of winter distribution is of considerable importance in shorebird conservation (Myers 1983, Senner and Howe 1984, Morrison 1984) because such wide-ranging migrants often depend on several sites during their annual cycle (Morrison and Harrington 1979). Accordingly, the Western Hemispheric Shorebird Reserve Network has identified important staging and wintering areas for many shorebird species, and efforts have been made to protect these sites (Myers et al. 1987).

Conservation efforts for the Piping Plover also must include identification and protection of important wintering areas. Our survey documented exact locations of known Piping Plover wintering sites, and it also located previously unknown sites (see Nicholls 1989 for location maps). That 31 of the 39 sites we ranked as most important to Piping Plovers are under state/federal ownership indicates that protection efforts should focus on key winter habitats in private hands. We found that Piping Plovers usually occurred in small groups and were distributed unevenly along the two coasts. Sites with the largest concentrations of plovers generally consisted of expansive sandflats, or sandy mudflats, and sandy beach in close proximity. These diverse coastal systems, such as the barrier island complex of Mobile Bay or the Laguna Madre system in Texas, may concentrate wintering Piping Plovers because of the juxtaposition of roosting and feeding areas. Research efforts should determine the influence of habitat heterogeneity on the wintering ecology/distribution of the species.

Finally, coordinated regular censuses of major wintering sites could be effective in monitoring population status. An Atlantic Coast volunteer network was created to survey specific sites during 1987–1988 (Nicholls 1989). Results generally supported survey estimates and thus, if continued, may provide insight into yearly fluctuations and long-term site importance.

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