

Distribution of Non-Breeding Great Lakes Piping Plovers Along Atlantic and Gulf of Mexico Coastlines: 10 Years of Band Resightings

Jennifer H. Stucker^{1,*}, Francesca J. Cuthbert^{1,2}

¹ Department of Fisheries, Wildlife and Conservation Biology, University of Minnesota, St. Paul, MN

* Current address: Northern Prairie Wildlife Research Center, USGS/BRD, Jamestown, ND 58401
jstucker@usgs.gov

² Conservation Biology Graduate Program, University of Minnesota, St. Paul, MN

1 February 2006

A Report to US Fish and Wildlife Service:

East Lansing Field Office
2651 Coolidge Road
East Lansing, MI 48823

Panama City Field Office
1601 Balboa Ave.
Panama City, FL 32405



© Arthur Morris, Birds As Art

A Great Lakes Piping Plover observed at Fort DeSoto, FL in August 2005

Introduction

Shorebirds are highly mobile species characterized by semi-annual hemispheric migrations between breeding and non-breeding habitats. Among shorebirds (suborder Charadrii), Piping Plovers (*Charadrius melodus*) exhibit comparatively restricted seasonal local distributions within the northern Western Hemisphere (Haig and Elliott-Smith 2004). The three discrete Piping Plover breeding populations have protected status (Threatened or Endangered) throughout the U.S. and Canada. The smallest population occupies the Great Lakes region; in 2005 its size was estimated at ≥ 58 breeding pairs. During winter, all three populations have Federal threatened status throughout the winter range within the U.S.; Critical Habitat was designated by US Fish and Wildlife Service (USFWS) under the Endangered Species Act (ESA) in 2001 for the winter range (66 FR 36038). All three populations have been well studied during the breeding season (Haig and Elliott-Smith 2004). However, despite spending approximately 75% of their annual life-cycle undergoing migration or on the wintering grounds, information on many aspects of winter ecology and distribution is very limited for this species, particularly as it relates to the individual breeding populations. Studies of unmarked birds indicate that wintering Piping Plovers appear to prefer coastal habitat types that include mud flats and mud-sand flats (Johnson and Baldassarre 1988, Nicholls and Baldassarre 1990). Additionally, Drake et al. (2001) evaluated winter Piping Plover habitat use in Texas and determined they have relatively small home-ranges and high survivorship from arrival in fall through spring departure. Winter records obtained during the 1991 International Piping Plover Census first hinted at a potentially broad non-breeding distribution of Great Lakes Piping Plovers (Haig and Plissner 1992) based on observations of banded individuals in South Carolina, Gulf coast of Florida, and central Texas.

In 1993 a population-wide banding and color marking effort was initiated in the Great Lakes region to estimate demographic parameters for this critically small population. In 1995 we began to receive and compile sighting reports of banded Great Lakes individuals on the wintering grounds and during migration. This effort has continued until present. The purpose of this report is to summarize color band resighting records obtained from January 1995 - May 2005, to describe non-breeding coastal distribution, habitat use during migration, winter site fidelity and use of designated Critical Habitat. We also report distribution of family units and timing of arrival from and departure to breeding grounds. Finally, we use these records to

estimate non-breeding season adult survival. This information is needed for development of a winter recovery strategy (plan) for Piping Plovers and for identification of important wintering sites for protection.

Methods

Piping Plovers in the Great Lakes were banded in two phases. Adult Piping Plovers were captured in the Great Lakes on their nests during the middle two weeks of incubation using modified Potter or fall traps. Adults were marked using a metal USFWS band and unique combinations of three ultraviolet-resistant color bands (A.C. Hughes). Chicks were captured by hand after 3 days of age, generally after 7 days, and marked with a metal (incoloy or aluminum) USFWS band and one ultraviolet-resistant color band as a brood marker. As fledglings returned in subsequent years, they were retrapped, and additional color bands added to obtain a new color band combination. See Wemmer (2000) and Wemmer and Cuthbert (1999) for additional details.

Resightings of banded individuals on the wintering grounds, or during migration, were obtained opportunistically from birders and researchers who submitted observations via e-mail, fax, phone and/or digital photographs to the University of Minnesota and the U.S. Army Corps of Engineers (USACE) Piping Plover Winter databases. We also received records of Great Lakes birds from observers who participated in International Piping Plover Census efforts (1996 and 2001). Whenever possible, we contacted observers to evaluate quality of observations and clarify color-band combinations. Because concurrent banding efforts using similar band combinations began in the Canadian Prairies in 1999 no records were included in this analysis if identity of the bird was uncertain. Additionally, birds with a single brood marker band were eliminated from analyses, unless the band confirmed the individual was clearly a Great Lakes bird (i.e., unique color or band number reported). We separated sighting records into three categories based on date of observation: fall migration (July – October), winter (November – February) and spring migration (March – May). Seasonal cutoffs were assigned based on observer reports of migratory behavior, known departure/arrival dates in Great Lakes population, and observed breaks in submitted data. Each sighting was assigned a date, physical location and geographic coordinates based on observer description or GPS report. We did not correct for observer effort.

Annual estimates of adult (>1 year) survival were based on the proportion of visual recaptures of uniquely marked adults in subsequent breeding seasons in the Great Lakes. Individuals are observed in the Great Lakes and presence documented, usually daily, through the breeding season. Survival estimates were corrected over time to account for individuals not observed in consecutive breeding seasons but observed subsequently. We believe our survival estimates are conservative.

To determine distribution of family members during the winter, we used 1995-2005 records from the Great Lakes population breeding database, maintained at the University of Minnesota, to match winter band combinations to family member identities. Using estimates developed by Drake et al. (2001) we evaluated winter site fidelity by recording if birds were relocated within 3.5 km of initial and subsequent sightings within and between seasons. To estimate distance between members of a pair we measured straight-line distances between known wintering sites of mates using ArcView 3.2 (ESRI). Members of a pair were assessed post breeding season and subsequent pairings. Distance estimates between parents and offspring were calculated using the same method. Distance between offspring and male and female parents was compared with a paired t-test. Because difference was not significant, distances between offspring and both parents were pooled.

Results

Between 1995 and fall 2005 we obtained 578 probable sighting records of plovers from the Great Lakes population. We were highly confident of individual identity reported in 434 records; from these observations, 154 individuals were confirmed, including 51 pairs and 45 parent-offspring combinations. The records were categorized into the 3 seasons as follows: fall (152), winter (219) and spring (63).

Non-Breeding Season Coastal Distribution

The Great Lakes Piping Plover population exhibits a broad non-breeding coastal distribution along the Atlantic and Gulf of Mexico coastlines, with sightings documented from New Jersey to the southern Texas-Mexico border on the Laguna Madre, and Andros Island,

Bahamas (Figure 1). Density of wintering Great Lakes individuals across all years was highest between St. Catherine's Island, GA, and Jacksonville, FL, and the Gulf of Mexico coast of Florida, particularly in the Tampa – St. Petersburg region. (Figure 2). Annual density distribution is similar, but with fewer individuals in a given year. Great Lakes Piping Plovers are often reported in association with banded conspecifics from Atlantic Canada and Canadian Prairies, but do not appear to occur at any location in significantly greater frequency than birds from the other two populations. Over the course of this study, no individuals banded from the Great Lakes population, adults or offspring, were observed breeding outside the Great Lakes region.

Distribution during Migration

Thirteen individuals were observed at one or more sites in one or more years during the spring and fall migration seasons. Great Lakes Piping Plovers have been reported as far north as New Jersey during southward migration to their winter locations. Several plovers have been observed on North Carolina's Outer Banks in fall and later observed farther south during winter. Seven migrants were recorded in the Little St. Simon's/Altamaha River, Georgia area during fall, with known winter locations in the Bahamas, south-eastern Florida and Florida's Gulf coast. Although some stopovers were reported to last several days, one bird remained for a month before continuing south to the location where it spent most of the winter. Observations during spring migration are more limited, but follow a similar pattern. Northward observations of known "southern" wintering birds have been reported from Georgia/northern Florida, North Carolina, and Assateague Island. Too few records were obtained to detect trends in fidelity to migration stopover sites but one migrant was reported at Edwin B. Forsythe National Wildlife Refuge, near Brigantine, New Jersey, in two consecutive years on approximately the same calendar date in fall.

Fidelity to Winter Site

Among the reported sighting, 33 individuals were identified as site faithful (within 3.5 km) to a specific location within a winter season (October – February). Among those, 30 individuals were also identified as site faithful (within 3.5 km) in subsequent 2-7 winter seasons (October – February) following their initial observation date. Most individuals were reported

multiple times within the fall-winter- spring seasons at the same location. Among individuals identified as site faithful, 30% (10 of 33) arrived at their winter location in July; half had arrived by August. Additionally, >30% were observed until March or April.

Use of Critical Habitat

On July 10, 2001, the USFWS published a final rule designating 137 areas along the coasts of North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas as critical habitat for wintering Piping Plovers (USFWS 2001 66 FR 36037). Thirty- three percent of declared winter Critical Habitat units are known to be used by Great Lakes Piping Plovers, with 40 (29%) documented as winter sites (Table 1). An additional six critical habitat units were used during spring and/or fall migration: AL-3, GA-2, FL-7, FL-9, FL-12 and SC-2. Although 95% of reported observations occurred in or on land adjoining designated winter Critical Habitat, five additional winter sites used within the U.S. by Great Lakes Piping Plovers were not designated as Critical Habitat: Crandon Beach, Key Biscayne (FL), Dog Island (FL), Fort Pickens (FL), Onslow Beach, Camp LeJeune (NC), and Smith Island (VA). Fourteen individuals used more than one Critical Habitat unit over the course of the winter during one or more years. Use of multiple units included situations where units were in close proximity to each other and could not be described as geographically isolated. Movements of individuals across inlets and sounds to adjoining habitats were particularly noteworthy. Units characterized by plover movement between and among them include: NC-3/4/5 (Cape Hatteras), NC-7/8 (Cape Lookout), GA-12/13 (Altamaha River mouth and Little St. Simon's Island), FL-15/16/17 (Honeymoon Island, Three Rooker Bar and Anclote Key). Movements between units occurred within day and season.

Winter distribution of family groups

Following the breeding season, male and female individuals representing 51 Great Lakes Piping Plover pairs wintered at locations 0 – 1,920 km apart (mean = 557 km ± 609 km SD); only four pairs were observed using approximately the same location during winter (Figure 3). After excluding one spatially distant Texas male and his mates, estimated distance between pairs, ranged from 0 – 1,170 km (n=43, mean = 321 km ± 270 km SD). Distances to previous and subsequent mates were not significantly different (non-parametric t-test: $p=0.58$).

Parents and offspring winter at sites distant from each other. Of 45 offspring identified, average distance between offspring and parents was 481 ± 489 km SD (0 – 2,277 km) (Figure 3). Seven of 28 (25%) offspring wintered 0-10 km from the male, while 0 of 17 offspring wintered closer than 80 km from female parent. Overall distance from offspring to male parent (n=28, 448 ± 568 km SD) was shorter than distance to the female parent (n=17, 536 ± 320 km SD), although not statistically significant (non-parametric t-test, $p=0.61$). If the spatially distant Texas male is again removed from analysis, distance from offspring (n=24) to male parent is 247 ± 240 km SD; this distance is still not significantly different from the distance between offspring and female parent (paired t-test $p=0.799$).

Phenology

Band resightings have provided important insights into the timing of migration by the Great Lakes population. Females initiate the post-breeding (fall) migration; individuals typically depart the breeding area by the second week of July. In at least two documented cases, females left their brood and mate and arrived on the wintering grounds prior to the date their brood fledged. Earliest arrival dates at wintering sites by females include: 7 July (New Drum Inlet, NC), 13 July (Little St. Simon's Island, GA), and 22 July (Crooked Island/East Pass, FL). Males from the Great Lakes population typically begin arriving at winter sites by early August. Individuals arriving at winter sites in July and/or remaining until March/April were disproportionately (>90%) identified as females (as determined on the breeding grounds). Last to migrate are young of the year; some individuals continue to move south through November.

Pre-breeding (spring) migration usually commences in March; some individuals move north within the population winter range. Males are first to arrive on the breeding grounds in the Great Lakes. They predictably arrive in late-April; the first females typically arrive later within the week. Some females were reported at their "winter" location until late in the migration period: 16 April (Crooked Island/East Pass, FL), 19 April (Pea Island NWR, NC), 22 April (Marco Island, FL), 24 April (Little St. Simon's Island, GA), 6 May (Cape San Blas, FL). One year-old birds rarely appear in breeding grounds before the third week of May. The shortest known northward and southward migrations (n=5), estimated from observations of color-banded individuals, ranged from 7-10 days for hypothetical >2,300 km straight-line migrations.

Survival

Annual adult survival for Great Lakes Piping Plovers averages 0.73 (0.57-0.82) using cumulative and annual mark-recapture estimates (1997-2005). Verification of survival was based on intensive breeding season observations. We estimate typical breeding season losses due to injury or predation at 2-4% of the breeding population. Annually, we receive reports of individuals at their winter site that disappear mid-season and do not return to breed. As a percentage of the previous season's marked adult breeding population, winter population loss has varied from 0-7% (mean 3.6%) of the breeding population lost per winter for the time period 1998-2003. Estimates of mortality based wholly on a subset of known winter site faithful individuals over the course of two recent winters 2003/2004 and 2004/2005 was 12.7% and 22.7% of the known "winter" marked population respectively. These disappearances occurred during the winter season after individuals were confirmed at the wintering site. Suspected severe losses indicated by reports of missing birds during the 2004/2005 winter were substantiated when annual adult survival (from spring 2004 to spring 2005), as measured by birds returning to breed, was estimated at 0.57 (19 of 44 marked adults from 2004 missing in 2005). Although this survival estimate may be low, the magnitude of change from previous annual and cumulative estimates suggests adult mortality during winter 2004-2005 and spring migration 2005 was higher than normal.

Discussion:

Non-breeding coastal distribution

Great Lakes Piping Plovers exhibit a broad low density distribution throughout the known species winter range, with a few exceptions. Of particular conservation interest are coastal island and inlet sites off the Georgia coast, and secondarily, North Carolina, South Carolina, and Alabama. Although observer effort likely increased reported sightings for this region, regular sightings of many individuals have been documented for >8 years, suggesting this region is of significant conservation value for the Great Lakes population. The Coastal Tampa Bay, FL, region also appears important; it is characterized by a complex of habitats and protected areas in a highly urbanized setting. Lack of confirmed sightings in Mississippi, Louisiana and Texas may be a consequence of fewer observers than on the Atlantic and Florida's Gulf of Mexico coasts. Additionally, extensive coastline (ocean, bay and wind tidal flats), and limited

access to offshore and remote areas may also limit the number of reports. Because > 50% of over winter survivors are not reported during the winter season, we believe Great Lakes individuals are likely wintering throughout the Gulf of Mexico, but we predict they do not occur in densities exceeding those observed locally in Georgia and Florida.

Habitat use during migration

Coastal habitats, barrier beaches, bay and inter-tidal flats appear to be used regularly by migrating Great Lakes Piping Plovers observed along Atlantic and Gulf of Mexico Coasts. Use of these habitats coincides with the primary constituent elements defined in the winter Critical Habitat designation (USFWS 2001), but coastal migration stopover sites also extend as far north as New Jersey, into Atlantic Coast breeding habitat. Stopover length cannot be quantified in this study using observer sightings. However, we believe it is variable in length based on anecdotal reports. Although observers report relatively high plover numbers at some coastal areas during migration (e.g. Altamaha River mouth, GA) no location stands out as a probable staging area. Northward and southward migrations are equally variable in length, with northward movements occurring much more quickly. More frequent and comprehensive surveys during spring and fall migration would aid understanding of migration periods in the Piping Plover's annual cycle.

Winter site fidelity and phenology

Winter site fidelity has been documented in shorebirds (Dierschke 1998, Hui et al. 2001, Fernández et al 2001, Sanzenbacher and Haig 2002a/2000b) and appears quite strong in individuals from the Great Lakes Piping Plover population. Repeated sighting of individuals at the same location throughout a winter season, and in subsequent years, indicates predictable winter and fall season use can be expected. Additionally, movement of some individuals indicates a relatively direct and brief migration from the breeding to winter location, as early as July. Identifying an annual window for dates when Great Lakes Piping Plovers are expected at coastal sites will facilitate coastal monitoring and protection efforts by agencies. Efforts to protect important sites from disturbance, including humans and pets, are likely to benefit all populations of Piping Plovers. Priority sites for protection include areas and complexes of habitats that maintain the highest number of habitat elements, or primary constituent elements (PCEs) described in the designation of winter critical habitat (USFWS 2001) throughout the tidal

and seasonal cycle. Necessary habitat components include those “essential for the primary biological needs of foraging, sheltering, and roosting ... coastal areas that support intertidal beaches and flats (between annual low tide and annual high tide) and associated dune systems and flats above annual high tide” (USFWS 2001). Barrier beaches with overwashes, inlets, and bayside, and intertidal mudflats, are habitats used by Piping Plovers and indicate dynamic coastal processes are occurring. Of additional importance are those areas that maintain PCEs throughout the annual cycle, including migration. North Carolina’s Outer Banks, Georgia’s coastline and NE Florida and Florida’s Gulf coastline emerge as priorities for conservation for Great Lakes Piping Plovers during the non-breeding season, including migration.

Because preferred Piping Plover habitats are dynamic, high energy environments, habitat quality and use by Piping Plovers is expected to change over time and within a season. Periodic monitoring may be necessary to identify newly created habitats. For example, no habitat for Piping Plovers was identified in Pensacola harbor prior to the hurricanes in winter 2004-2005. After the hurricane season, new habitat accreted off Fort Pickens and was occupied by a Great Lakes Piping Plover for the remainder of winter prior to migration (pers com. NPS biologist). Because Fort Pickens is located between two currently used Critical Habitat sites (FL-1 and FL-2) this record suggests Piping Plovers will explore and locate newly created habitat. Conversely, one Great Lakes bird temporarily stopped using a Marco Island, FL, site after habitat became less suitable following a hurricane. However, this bird, and other banded individuals, returned within several years when habitat was again suitable (pers. comm. Ted Below). Similar changes in habitat use were observed in North Carolina after hurricane Isabel in 2003 (pers observ. Sidney Maddock).

Use of Critical Habitat

Great Lakes Piping Plovers predominately, though not exclusively, use locations identified under the Critical Habitat designation (USFWS 2001). Because opportunistic observer data used for these analyses were often vague as to location within a specific area, frequently we were unable to identify precise areas within units occupied by individual birds. We are also unable to estimate the proportion of time that individuals spent in specific units. But it is also important to note that absence from units not identified here (text above or Table 1) does not

document lack of occupation by individuals from the Great Lakes or the other two populations. Lack of records may be due to no observers, infrequent visits to these sites, or absence of reliable reporting. A very important result from our study is documentation of individual bird use of 46 Critical Habitat Units for extended periods, up to 9 months of the year (e.g. July–April). Thus non-breeding Piping Plovers are using “winter” habitats, including designated Critical Habitat for 75% of the annual cycle.

On a landscape scale, winter sighting reports demonstrate Piping Plovers frequently use one or more designated Critical Habitat Units in an area. These units are frequently, but not always, close together. During winter and migration, Piping Plover habitats (foraging and roosting) need to be available throughout all tidal stages, including refugia from spring tides and storm surge events. Therefore, protection for more than one site in a given area may be critical for plover survival during the non-breeding season. Additional research on habitat use and time allocation, particularly on the Atlantic Coast, is needed to determine scale (spatial and temporal) of actual habitat use and needs under a variety of conditions. If additional areas of Critical Habitat are designated, priority should go to those spatially distant from currently designated units (e.g. Key Biscayne) and those whose juxtaposition to existing units will complement landscape movements of plovers.

Winter distribution of family units

Because pairs and their offspring are not intact as family units during winter, and Great Lakes birds do not exhibit exclusive inter-annual mate fidelity (Wemmer 2000), local threats will likely have no or minimal impact on stability of breeding pairs prior to return to the breeding grounds. This observation also supports the hypothesis that Piping Plovers do not form or maintain pair bonds during the wintering; rather, evidence strongly suggests individuals separate to distinct populations prior to pairing. Although, indirect fitness costs may be incurred if one individual of a pair dies during winter or migration, the returning individual needs to seek a new mate and/or new nest territory, and this may be costly in delaying breeding by one or more weeks. Because offspring winter at locations without the benefit of parental care, quality of suitable winter and migration sites must remain high to favor overwinter survival of subadult plovers. Survival of Great Lakes Piping Plovers from fledging to year 2 is roughly half that of adult survival

(Wemmer 2000). Declines in winter habitat quality and quantity may reduce survival of this important and potentially vulnerable component of the future breeding population.

Survival -

Conservation efforts for recovery of the Great Lakes population of Piping Plovers have centered on managing reproductive success on the breeding grounds. As this population has increased, knowledge of movements of individuals within the Great Lakes population has heightened concerns over the need for habitat protection to help maintain survival during winter and migration periods has heightened. Because >50% of the population, predominately breeding females, reside 8-9 months annually on “winter” grounds, survival until they return to breed is an important concern. Although Drake et al. (2001) reported 100% overwinter survival, band resightings suggest stochastic high losses (e.g. 43% from 2004 to 2005) of Great Lakes individuals during the non-breeding season, with over half of losses suspected during the winter. These losses may be indicative of overall habitat condition (e.g. forage and roosting habitats) and/or effects of disturbance (weather and/or human), on the ability of Piping Plovers to maintain body condition and/or to avoid death through winter. Although a breeding population decline was not noted in 2004 or 2005, we expected a population increase of 5-10 pairs based on good fledging success in preceding two breeding seasons; 2005 season monitors reported many “extra” males and much competition for paired females. If survival on the winter grounds is disproportionately lower than on the breeding grounds, and females spend more time on the wintering grounds, we may expect reduced survival of breeding females over time. Any alteration in sex ratio of the Great Lakes population is likely to reduce ability of this impaired population to recover. Ability of researchers and agencies to partition survival estimates by season (breeding, migration and winter), will assist agencies in identifying the need for additional monitoring or protection during and across annual movements. Although migration is inherently risky, known stopover habitats, particularly coastal, can be given extra protection, often with little additional effort because these locations, in many cases, already have habitat protection efforts in place for other coastal species. These sensitive areas may benefit from year-round protected status. For example, breeding Atlantic Coast populations of Piping Plovers receive protection beginning mid-March to early April through to end of breeding. Because southward migration begins in July, retaining protected areas available through August and

September protects local offspring in addition to migrants. Other species that would benefit from more comprehensive protection of sensitive coastal beach and inlet habitats include Wilson's Plovers (*Charadrius wilsonia*), colonial nesting waterbirds, other resident and migrant shorebirds and nesting sea turtles.

Summary of Important Conservation Implications:

1. The most important conservation implication of this study is that we have diverse evidence for the importance of winter/migration habitat for recovery of the Great Lakes population. Evidence includes: adult and subadult overwinter survival estimates; fidelity to winter sites; use of Critical Habitat Units; use of multiple habitat units; and high densities of color-banded Piping Plovers at specific locations within particular areas
2. Some areas of winter habitat for the Great Lakes population are under-surveyed (e.g. central Gulf from Mobile Bay to Galveston); information on the use of this broad region is needed for winter conservation planning efforts.
3. Critical Habitat Units are used heavily during migration as well as by wintering birds; this extends the value of these units to a longer annual time period. This information demonstrates that the process of Critical Habitat designation for Piping Plovers appears to have effectively identified most of the important non-breeding habitat for the Great Lakes population.
4. If additional areas of Critical Habitat are designated, priority should go to those spatially distant from currently designated units (e.g. Key Biscayne) and those whose juxtaposition to existing units will complement landscape movements of plovers.
5. Observers report relatively high plover numbers at some coastal areas during migration (e.g. Altamaha River mouth, GA) although no location stands out as a probable staging area. This may represent uneven reporting/access to migration stopover sites but Pompei (2005) found inland plover stopover sites were simultaneously visited by only one or several individuals.
6. Unlike breeding plovers, migrant and wintering plovers use a variety of habitat types; availability to these sites are influenced by predictable (tides) and stochastic (hurricanes, tropical storms) events than alter habitat temporarily or permanently.

7. Priority sites for protection include areas and complexes of habitats that maintain the highest number of habitat elements, or primary constituent elements (PCEs) described in the designation of winter critical habitat (USFWS 2001) throughout the tidal and seasonal cycle. Key sites identified in this study include: North Carolina's Outer Banks, Georgia's coastline and NE Florida and Florida's Gulf coastline.
8. Because of the dynamic nature of winter and migration sites, monitoring for detection of new sites is needed, particularly after major storm events.
9. Many other threats, in addition to storms, can influence plover survival and quality of habitat and these include: development, dredging, mosquito control, vehicles driving on beaches, pets, boats, natural predators (e.g. falcons), oil spills, high density human presence, and various methods of shoreline restoration. A comprehensive non-breeding season conservation plan for Piping Plovers will need to incorporate strategies for monitoring and evaluating these threats in isolation and in combination.
10. Because sub-adult plovers do not migrate or winter with their parents, we believe birds in this age class are particularly vulnerable during their first winter because they do not have the benefit of experience to know where to winter, find food, locate refugia, and avoid predators and other threats. This assumption is supported by survival estimates and provides strong evidence for the importance of protection of Piping Plover wintering sites. Protection of wintering sites may help increase 1st year and adult survival rates, factors critical for population recovery.
11. In contrast to results reported by Drake et al. (2001) we documented adult mortality during the winter that is considerably higher than estimates from the breeding grounds. We do not have estimates for migration. These estimates are additional evidence that conservation and protection of birds during the non-breeding season is critical for the recovery of this population.

Acknowledgements:

Preparation of this manuscript came through grants from U.S. Fish and Wildlife Service's Panama City and East Lansing Field Offices through the USGS Cooperative Fish and Wildlife Research Unit of University of Minnesota. Assistance of years in interpretation of sighting

records came from: Elizabeth Price, Catherine Haffner, Olivia LeDee, Vanessa Pompei, and Erin Roche. We acknowledge Rosemary VanderLee, USACE Omaha District for maintaining the Piping Plover winter sighting database. Lastly, without the hours of observations thoughtful submissions, this manuscript would have been impossible. We acknowledge the following observers for their assistance: Andie Nel, Bob & Kathy Sanger, Cameron Kepler, David Allen, Dennis Forsythe, Irene Hernandez, Jamie King, Jeff Lewis, John O'Brien, Katherine Miehl, Kiel Drake, Keith Watson, Lex Glover, Lucy Duncan, Marcia Lyons, Jane Pinkston, Mark Spinks, Mike Hannisian, Neil Lamb, Sue Cameron, Doris Leary, Patty Kelly, Paul Blair, Paul Sykes, Robin Diaz, Shane Cammuck, Steve Calver, Sudie Daves, Ted Below, Wilfred Yusek, and Brian Harrington. Additional contributing authors for proposed Waterbird journal publication include: Brad Winn, Brandon Noel, Sidney B. Maddock, Patrick R. Leary, Jeff Cordes, Lauren C. Wemmer, and Alexander C. Smith

Literature Cited

- Dierschke, V. 1998. Site fidelity and survival of purple sandpipers *Calidris maritima* at Helgoland (SE North Sea). *Ringing and Migration*, 19:41-48
- Drake, K.R., J. E. Thompson, K. L. Drake, C. Zonick. 2001. Movements, habitat use and survival of non-breeding Piping Plovers. *Condor* 103:259-267
- Fernández, G., H. De La Cueva, and N. Warnock. 2001. Phenology and length of stay of transient and wintering western sandpipers at estero Punta Banda, Mexico. *J. of Field Ornithology* 72:509-520
- Haig, S. M. and J.H. Plissner. 1992. 1991 International Piping Plover Census. USFWS technical Report 18pp.
- Haig, Susan M., and E. Elliott-Smith. 2004. Piping Plover. *The Birds of North America Online*. (A. Poole, Ed.) Ithaca: Cornell Laboratory of Ornithology; Retrieved from *The Birds of North American Online* database: http://bna.birds.cornell.edu/BNA/account/Piping_Plover/.
- Hui, C. A., J. Y. Takekawa, and S.E. Warnock. 2001. Contaminant profiles of two species of shorebirds foraging together at two neighboring sites in south San Francisco Bay, California. *Environmental Monitoring and Assessment* 71: 107-121.
- Johnson, C. M. and G.A. Baldassarre. 1988. Aspects of the wintering ecology of Piping plovers in coastal Alabama. *Wilson Bulletin* 100:214-223
- Nicholls, J. L. and G.A. Baldasarre 1990. Habitat association of Piping Plovers wintering in the United States. *Wilson Bulletin* 102:581-590
- Pompei, V. 2004. Great Lakes Piping Plover Migration. MS thesis, University of Minnesota, Twin Cities 120 p.
- Sanzenbacher, P. M. and S M. Haig. 2002a. Regional fidelity and movement patterns of wintering killdeer in an agricultural landscape. *Waterbirds* 25(1): 16-25
- Sanzenbacher, P. M. and S M. Haig. 2002b. Residency and movement patterns of wintering dunlin in the Willamette Valley of Oregon. *Condor* 104:271-280
- U.S.Fish and Wildlife Service. 2001 Final determination of critical habitat for wintering Piping Plover. *Federal Register* 66(132):36037-36086
- Wemmer, L. C. and F. J. Cuthbert. 1999. Banding Piping Plovers in the great Lakes: an evaluation and new insights. *in* *Proceeding Piping Plovers and Least Terns of the Great Plains and Nearby*. Eds., K. F. Higgines, M. R. Brashier, and C. D. Kruse.
- Wemmer, L.C. 2000. Conservation of the piping plover (*Charadrius melodus*) in the Great Lakes Region : a landscape-ecosystem approach Ph.D. dissertation. University of Minnesota, Twin Cities Campus p. 155

Figure 1. Coastal distribution of Great Lakes Piping Plover sightings of, July – April, 1995-2005.

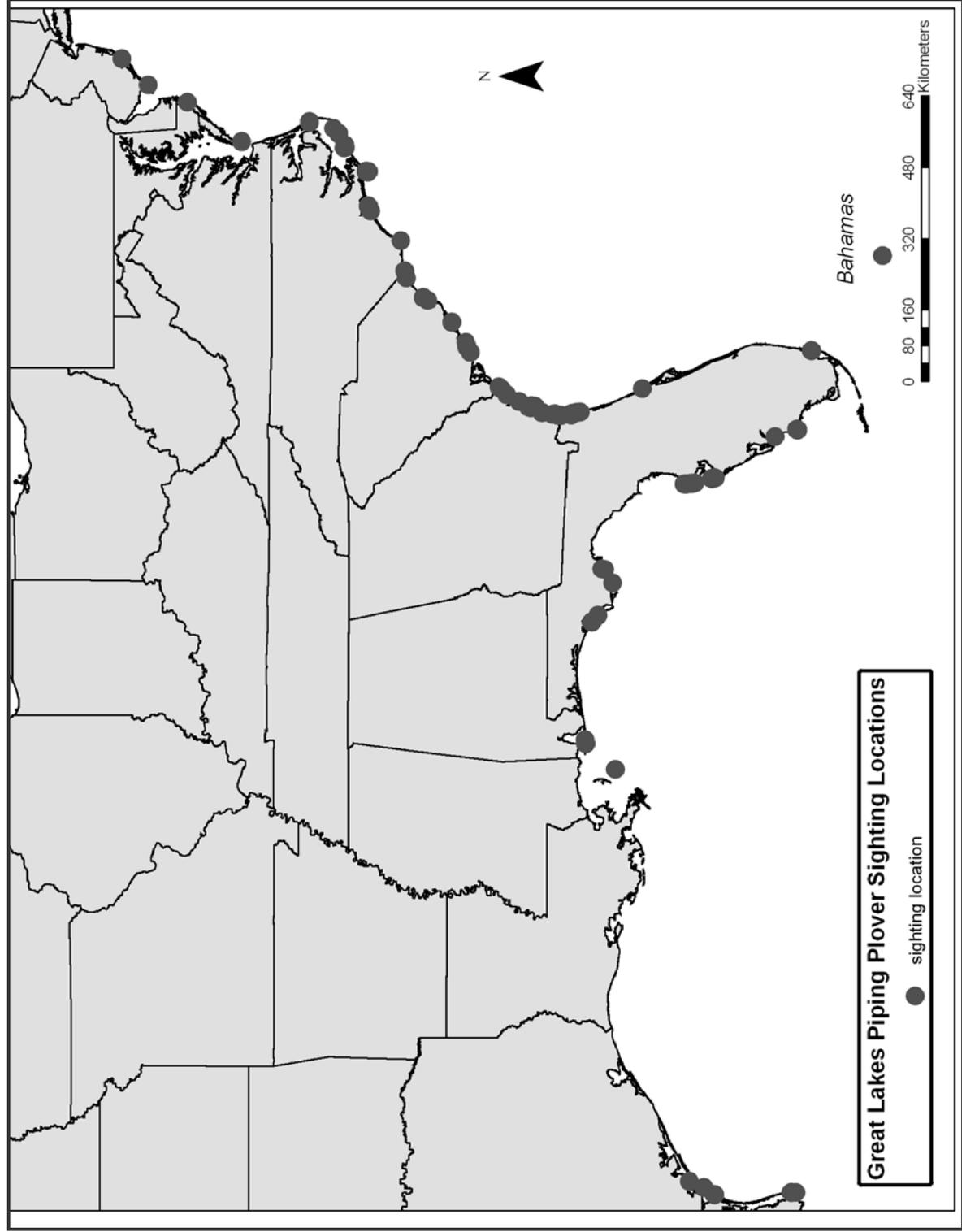


Figure 2. Cumulative counts of unique Great Lakes Piping Plover individuals wintering at coastal locations between November - February, 1995-2005.

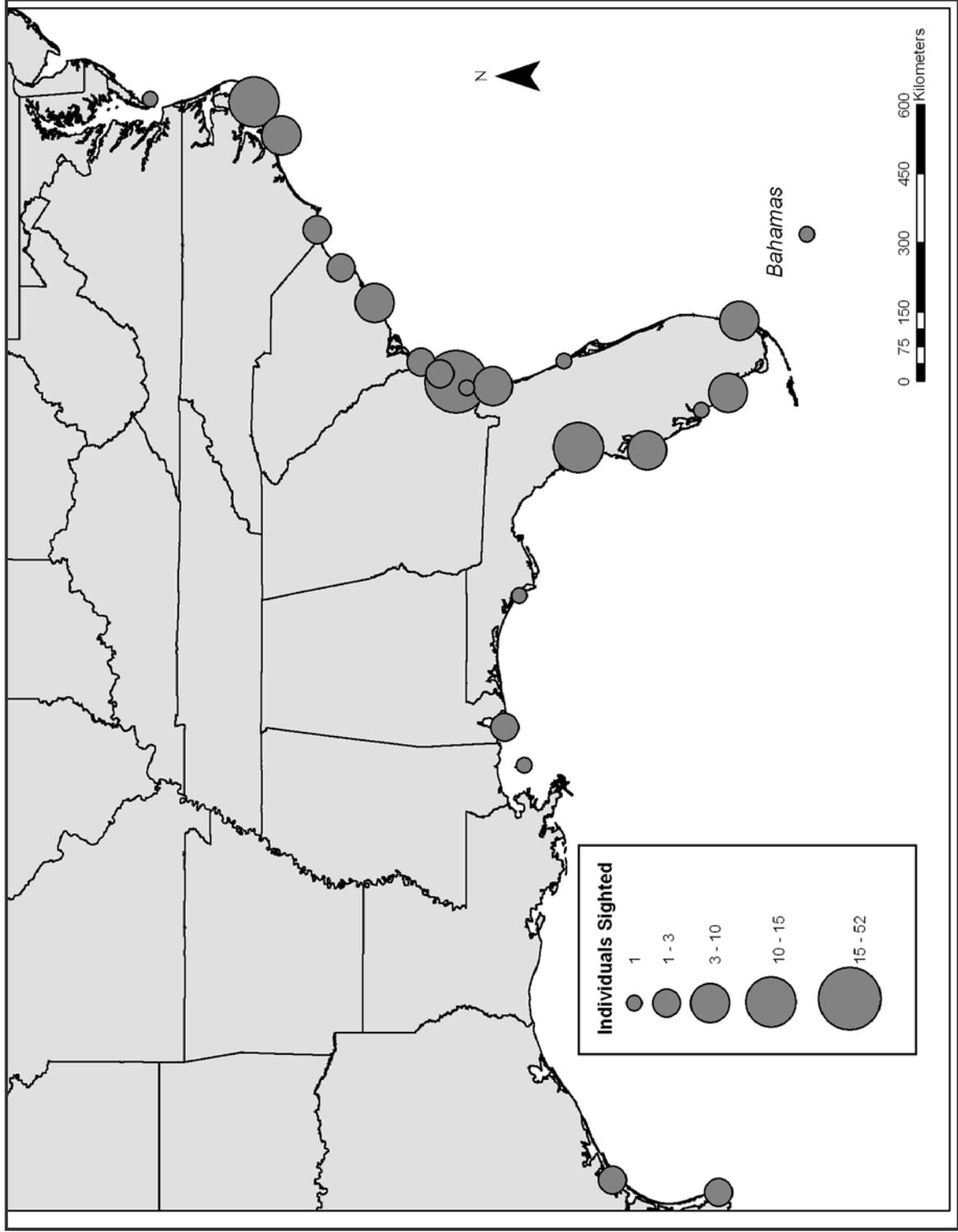


Figure 3. Distance between parents and offspring and between adult male and female during winter.

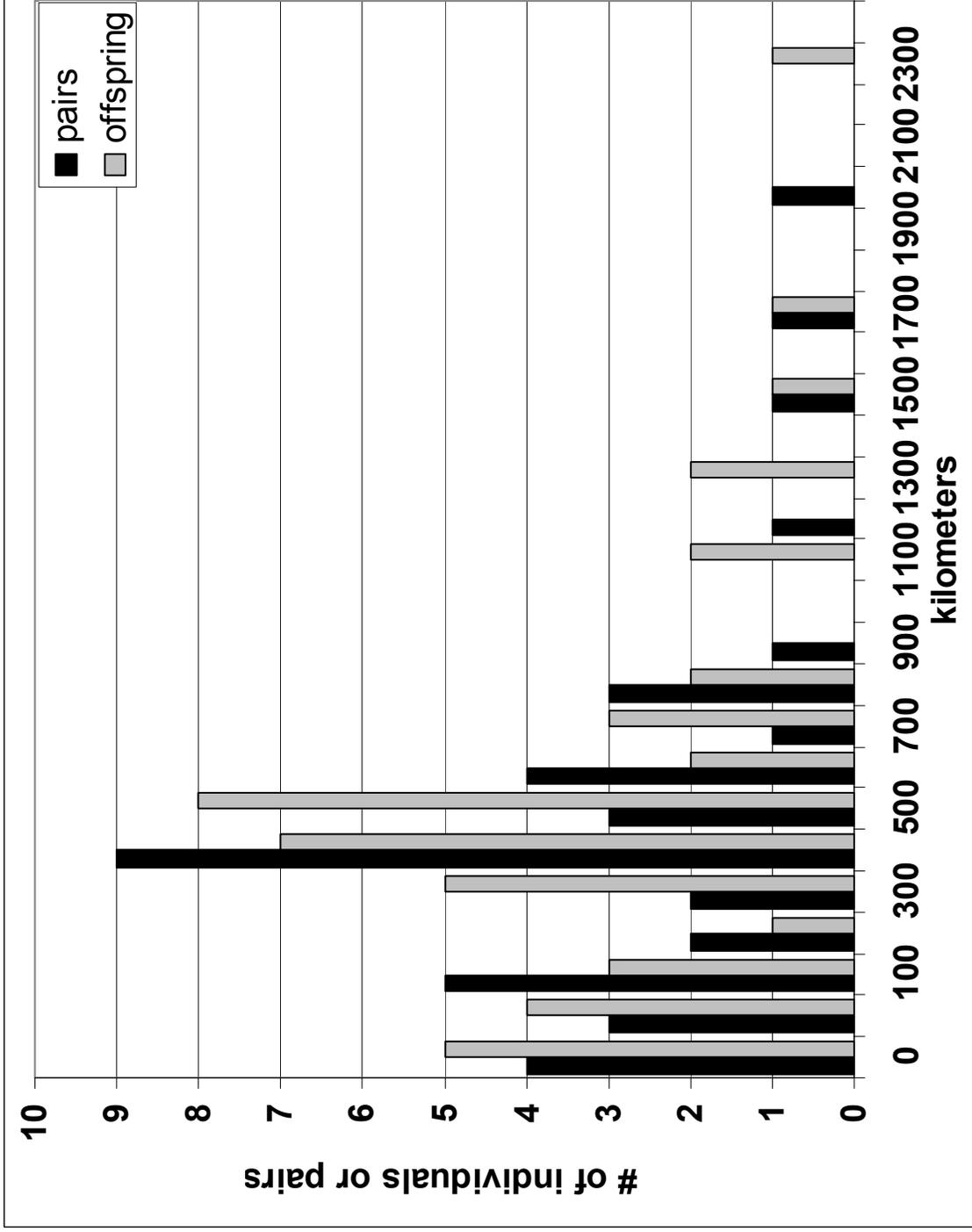


Table 1. Occurrence of individual Great Lakes Piping Plovers observed one or more times in winter Critical Habitat units between November–February in 1995-2005.

state	County	Critical Habitat Unit	Location	count of individuals in unit
North Carolina	Dare	NC-1 *	Oregon Inlet (CAHA) and Pea Island NWR	1
		NC-3	Bird & Clam Shoals	2
		NC-4 *	Hatteras Inlet CAHA	7
	Hyde	NC-5 *	North Core Banks and Ocracoke Inlet CALO	4
		NC-7	South Core Banks, CALO	2
		NC-8	Shackleford Banks, CALO	6
	Carteret/Onslow	NC-10	Bogue Banks/Inlet	2
	New Hanover	NC-15	Ft. Fisher State Recreation Area	1
Brunswick	NC-18	Sunset Beach	1	
South Carolina	Georgetown	SC-3	Huntington Beach State Park, Murrells Inlet	2
		SC-4	North Island, Litchfield	1
	Charleston	SC-8	Bull Island & Cape Romain NWR	2
		SC-9	Bird Key - Stono Heritage Preserve	1
		SC-10	Kiawah Island, east, part of Seabrook unit	1
		SC-11	Deveaux Bank	1
Georgia	Chatham	GA-3	Wassaw Island NWR	1
		GA-5	Ossabaw Island	2
	Liberty McIntosh	GA-8	St. Catherine's Island	2
		GA-11	Wolf Island NWR	2
		GA-12	Altamaha Bar and Egg Island	12
	Glynn	GA-13	Little St. Simon's Island	38
		GA-15	Jekyll Island	1
Camden	GA-16	Cumberland Island	1	
Florida	Bay	FL-5	Shell / Crooked Island	1
		FL-15	Anclote Keys	5
	Pinellas	FL-16	Three Rooker Island	7
		FL-17	North Honeymoon Island	3
		FL-19	Caladesi Island	1
		FL-20	Shell & Mullet keys, Ft de Soto Cnty Park	9
	Lee	FL-26	Estero Island, Bonita Shores	1
	Collier	FL-27	Marco Island, Tigertail Beach	8
	Volusia	FL-34	Ponce de Leon Inlet	1
	Duval	FL-35	Huguenot	8
	Nassau	FL-36	Tiger Islands	1
Alabama	Mobile	AL-2	Dauphin , Little Dauphin & Pelican/Sand Islands	3
Louisiana	St. Bernard	LA-7	Breton Islands and Chandeleur Island Chain	1
Texas	Cameron	TX-2/3	Queen Isabella Causeway & Padre Isld	2
	Aransas	TX-19/21	Aransas NWR – Mustang Island	2

* Critical habitat units vacated by 1 Nov. 2004 court order and remanded to USFWS for reconsideration. (Cape Hatteras Access Preservation Alliance v. U.S. Dept of the Interior).