A Survey of Wintering Piping Plovers on the Upper Texas Coast; Their distribution and Aspects of their Ecology

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Grant Manager: Cecilia M. Riley
Executive Director
Gulf Coast Bird Observatory
103 W. Hwy 332
Lake Jackson TX 77566
Office: 979-480-0999
criley@gcbo.org

Principle Investigator: John C. Arvin
Gulf Coast Bird Observatory, 103 W. Hwy 332
Lake Jackson, TX 77566
Telephone (979) 480-0999
jarvin@gcbo.org

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This report consists of two parts, a narrative summary of the entire project (this document) and a GIS component in which the results are displayed graphically. Due to its size the GIS data was mailed separately.

Abstract

We surveyed the upper Texas coastline from the mouth of the Sabine River to the mouth of the Colorado River, a straight-line distance of about 200 km. between January 2008 and January 2009. We recorded 1131encounters with Piping Plovers at 748 locations marked by GPS coordinates. We observed any interactions between Piping and Snowy and Wilson's Plovers which share the same coastline and recorded color marked Piping Plovers so we could observe the movements of uniquely marked birds. We compared our GIS data with published Designated Critical Habitat areas for the species. We attempted to measure human disturbance as a factor in Piping Plover wintering distribution by comparing our survey results between a moderately heavily used beach with an adjacent beach with little or no human disturbance. Our study was seriously interrupted by landfall of Hurricane Ike at approximately the mid-point of our study area in mid September. The storm affected the distribution of Piping and other small "sand plovers" and we attempted to document the movements of plovers in response to the severe habitat alteration caused by it. Finally, based on a year of observation of Piping Plover distribution we attempted to assess any imminent threats to the areas where relatively high numbers of Piping Plovers were consistently encountered.

Introduction

The Piping Plover, *Charadrius melodus,* has three disjunct breeding populations in North America, the northeast Atlantic coast from North Carolina to the Canadian Maritime Provinces, the area around the Great Lakes, and the prairie states and provinces from Nebraska to Saskatchewan (Elliott-Smith and Haig, 2004). The eastern and western breeding populations are ranked as Threatened and the Great Lakes population is ranked Endangered by the U.S. Fish & Wildlife Service (50 CFR 17.11). All three populations winter on the Atlantic and Gulf of Mexico coastlines from North Carolina through Texas and eastern Mexico sparingly as far south as Yucatan, and locally scattered through the Greater Antilles (Elliott-Smith and Haig, 2004; Nicholls and Baldassarre, 1990b). All Piping Plovers are rated Threatened on the wintering grounds as different populations cannot be distinguished in the field unless uniquely marked birds are involved. The coast of Texas is known to be one of the major wintering areas for the species (White and Elliott, 1999; Drake, et al. 2001). However, most previous studies of the wintering distribution and ecology of Piping Plovers on the Texas coast have been carried out along the lower and middle Texas coast (Mabee, et al., 2001; White and Elliott, 1999); Zdravkovic, 2004). Few data are available from the upper coast and these are from one day counts of selected coastal units known to host relatively high numbers of wintering plovers (Elliott-Smith, *et al*., 2009) and some prey base work at one area (Zonick, 2000). This project was aimed at providing more detailed information about Piping Plovers on the upper Texas coast throughout the annual cycle.

We also collected population size data for two other species of "small sand plovers", Snowy Plover *Charadrius alexandrinus,* and Wilson's Plover, *Charadrius wilsonia,* and attempted to assess their interactions, if any, with migrating and wintering Piping Plovers. Snowy Plover is considered "Threatened" by the USFWS (50 CFR, *ibid*) for details, and Wilson's Plover has a world population estimated to be only 5000 pairs,

although no significant decline in population size has been noted (Corbat and Bergstrom, 2000). Both species use the same heavily populated Gulf coast as does Piping Plover.

Our survey of Piping Plovers on the upper Texas coast throughout a calendar year was seriously disrupted by Hurricane Ike, which made landfall at approximately the midpoint of the study area on September 13, 2008 (Figure 1). The ensuing damage made access to parts of the study area impossible for weeks and seriously altered habitat that previous visits had identified as moderate to high use, causing plovers to disperse to other parts of the coast. Thus the survey is necessarily divided into two, non-comparable datasets. However, the storm did provide a unique opportunity to focus on the adaptability of the species to periodic major perturbations in the environment.

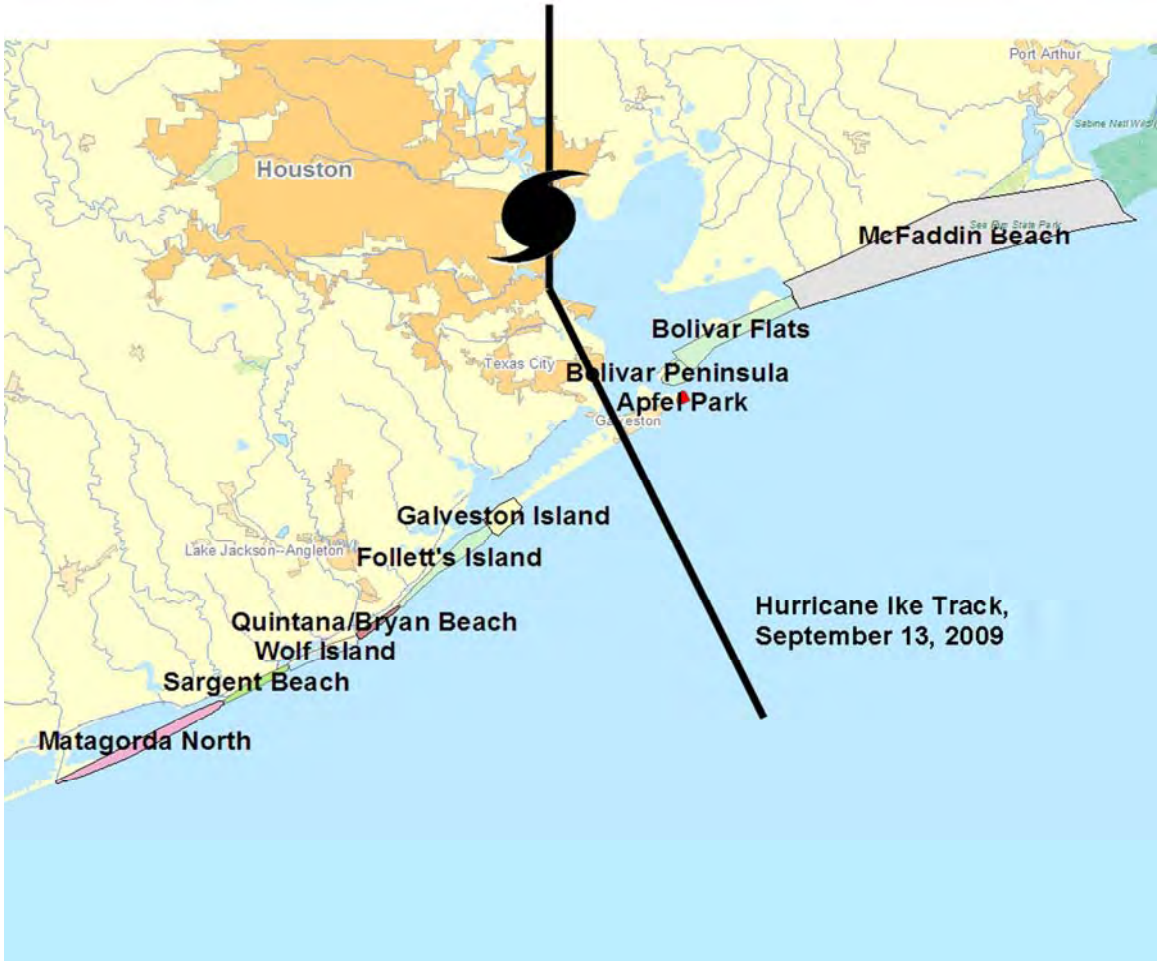


Figure 1: Hurricane Ike landfall in relation to plover survey units.

Objective

To quantify the population of Piping Plover (*Charadrius melodus*), an endangered shorebird that winters on the Texas coast and is present from approximately August through early May, on the upper coast of Texas throughout the 2007-2008 season to determine population size of wintering plovers and factors which influence their differential use of habitat.

Methods and Materials

Benjamin Wardwell was the primary field investigator with occasional help by the Principle Investigator and several volunteers. We surveyed "sand plovers" the upper Texas coast, defined as the coastlines of Jefferson, Galveston, Brazoria, and part of Matagorda Counties. The latter terminated on its southern end at the mouth of the Colorado River. We designated these areas as follows: Jefferson County was designated "McFaddin Beach" because the McFadden NWR extended almost the entire length of that coastline. Galveston County was separated into "Bolivar Peninsula", and "Bolivar Flats", a small, very rich shorebird location just north of the entrance to Galveston Bay and the Houston/Galveston ship channel, "Apfel Park" on the northern tip of Galveston Island (a portion of "Big Reef"), and "West Galveston Island", limited to the beaches and tidal inlet at and near San Luis Pass, the southern outlet of Galveston Bay. Brazoria County was separated into "Follett's Island", that stretch of coastline from San Luis Pass southwestward to Surfside, at the entrance to the Port of Freeport (site of the former Brazos River mouth), "Quintana/Bryan Beach" south of the entrance to the port of Freeport and terminating at the present Brazos River mouth, and "Wolf Island" south of the mouth of the Brazos to near the Matagorda County line. The opening of the San Bernard River mouth in June 2008 limited our ability to survey past that point after the river mouth was opened. In Matagorda County, "Sargent Beach" is the segment from the community of Sargent northeastward to an extensive shallow lagoon system with dangerous beach driving conditions, and "Matagorda North" from the mouth of the Colorado River north to "Brown Cedar Cut", a manmade channel into the marsh-lined shallow lagoon lying behind the beach.

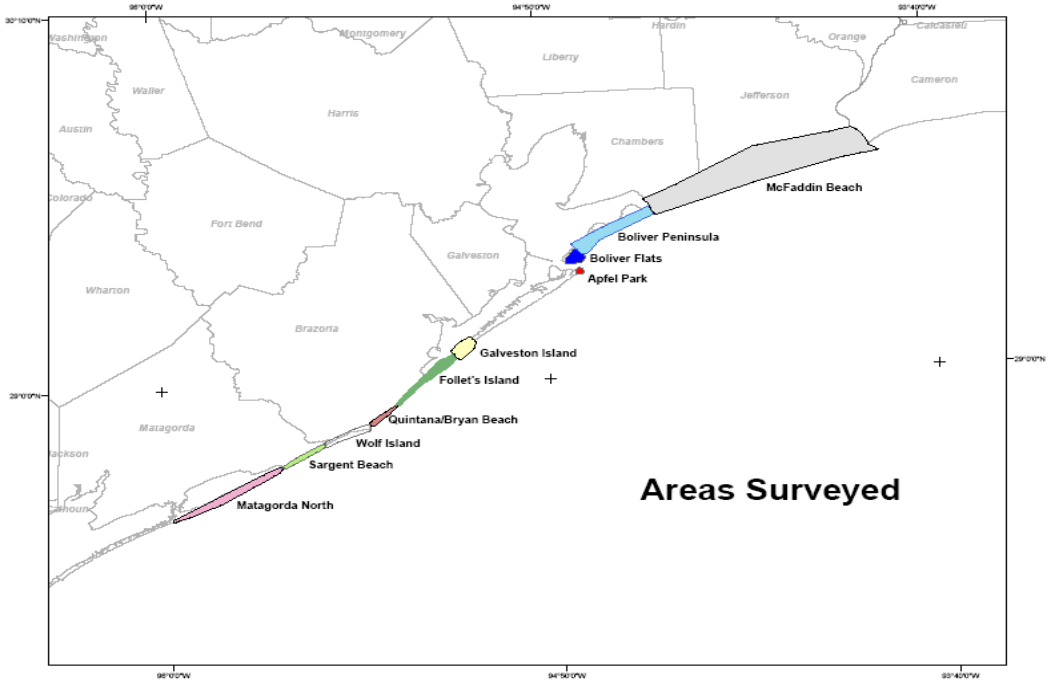


Figure 2. Coastal Units Surveyed During 2008.

Our goal was to survey the Gulf beaches and tidal inlets twice each month during 2008. We conducted surveys using automobiles with four wheel drive, all-terrain vehicle (ATV), bicycle, and on foot, depending on circumstances. All Piping Plovers encountered were counted and their locations were marked by GPS coordinates. The coordinates represent the closest location to the plovers being observed that they would tolerate the observer without flushing, or the closest point that the physical situation would permit. Thus a point may represent multiple birds. Plovers were examined by telescope (Swarovski ST-80 with 20 X 60 zoom eyepiece) in an effort to determine gender and age, and to ascertain the color combinations of bands and flags on marked birds.

Additionally we recorded the numbers of Snowy and Wilson's Plovers and their observed interactions, if any, with Piping Plovers. We did not mark locations of these species by GPS coordinates, but we did record total numbers of each for each survey of a coastal segment. For each coastal transect unit we recorded the date, starting and ending times, sky condition, wind speed and direction, air temperature, and relative tide level. We also recorded observed plover activity (foraging, resting/roosting) and in what microhabitat each activity was taking place (intertidal foreshore, backshore, rear dune pools and lagoons, exposed tidal flats, etc.).

To attempt to assess the effects of human disturbance on the distribution of plovers in the study area we chose to examine two adjacent beach segments. Quintana/Bryan Beach on the north bank of the Brazos River is relatively heavily used by humans. On the south bank of the Brazos, just .5 km. away, Wolf Island is accessible only by boat and is rarely visited by humans. Piping Plovers used both these beaches. It should be noted that as a condition of providing permission to operate a non-street legal vehicles (ATV) on the beaches, we were required to refrain from surveys on weekends and holidays. This biased our human disturbance observations by limiting surveys to those periods of relatively low human beach use.

Results and Discussion:
Before Hurricane Ike

The GPS coordinates of each Piping Plover located were mapped using ArcGIS 9.1. Various attributes of the points may be displayed graphically. These data are included in the GIS portion of this report and some important maps were made as figures for this document. We recorded 1131 Piping Plover encounters at 748 GPS locations during the study. Of these we recorded 691 before landfall of Hurricane Ike and 440 afterward. The GIS data includes Piping Plover locations by coastal unit as well as absolute location, number of individuals per by date and season, whether marked, and population changes throughout the annual cycle, and changes in numbers and location of Piping Plovers after the Hurricane. During the same period, we recorded 401 Snowy Plover encounters and 291 encounters of Wilson's Plovers. These were counted by coastal unit surveyed but were not mapped.

Interactions Among and Between Piping and Other Plover Species

Our observations indicate that there is intra- and interspecific competition among most small shorebirds. Piping, Snowy, and Wilson's Plovers show both types of competition, but the strongest aggression is seen during conspecific encounters. This seems to be due to food resource competition between individuals. This hypothesis is further supported by noted incidents when food was abundant, as with exceptionally low tides exposing prey items rarely available, personal space was suspended and individuals tolerated close conspecific competitors. This suggests that Piping Plovers maintain individual feeding territories that are variable in size depending on the abundance of the resources. Plovers are gregarious in resting/roosting situations and these groups may contain all three species with no observed interaction other than association.

Wilson's Plover

No interspecific competition was noted between Piping and Wilson's Plovers when the two occurred syntopically on the upper Texas coast. The phenology of the two species in the region is essentially reversed, with only a limited period of overlap in the spring and again in late summer (Figure 3).

Wilson's Plovers were observed to utilize larger prey, primarily insects and crustaceans such as ghost crabs and fiddler crabs. This prey-base segregation is predicted by the much heavier and longer beaks of Wilson's Plover. These prey items were obtained landward of the intertidal zone where Piping Plovers forage. Wilson's Plovers carry on most of their activities in areas behind the narrow dune line after the young hatch, where adults and unfledged juveniles spend two to three weeks feeding primarily on crabs (Zdravkovic 2004). After the juveniles fledge and become independent, both adults and juveniles appear on the Gulf beaches for a short period prior to a relatively early departure from the breeding grounds. Post-breeding withdrawal is near complete, although a few birds do occasionally winter at rich foraging sites (e.g. Bolivar Flats). We recorded only a single Wilson's Plover after Hurricane Ike, but this is partially due to the necessary suspension of surveys for several weeks in late September and early October due to access and travel problems (Figure 3).

Some areas, such as Bryan Beach in Brazoria County, have shallow lagoon areas behind the dune line that offer habitat to many shorebirds when water levels are appropriate including Piping, Snowy, and Wilson's Plovers. These areas are ephemeral in nature and exhibited high levels of evaporation during the abnormally dry summer months of 2008. Most shorebirds were forced to disperse to other areas. Only a small percentage of the migrant and/or wintering population of Piping Plovers was present during the earlier part of that season, but migrants began arriving in numbers in August. Due to the dry conditions these birds were forced to use the Gulf beaches.

Snowy Plover

We observed the ecological overlap between Snowy and Piping Plovers to be less sharply demarcated. In terms of temporal occurrence, the phenology of the two species is similar (Figure 3.). Although Snowy Plovers nest in moderate numbers on the lower Texas coast, only two pair exhibited breeding behavior in our study area, one pair on McFaddin Beach and the other near Bolivar Flats at the southern end of Bolivar Peninsula. Both Snowy and Piping Plovers were observed feeding in the intertidal zones at times (Zonick, 2000). However, Snowy Plovers fed more often on flies, midges, and coleopterans on the higher backshore and on dry to wet (but exposed) sand and algal flats well behind the dune line (Page et al., 2005). These latter habitats are quite limited and ephemeral in the study area, however. We observed no instances of aggressive interactions between Piping and Snowy Plovers

All three species formed mixed flocks, sometimes with Sanderlings *Calidris alba*, and used the backshore for resting and roosting. This was especially prevalent when tides were high, covering the foreshore areas. Birds rested in small hollows in the sand or behind driftwood and other beach debris to shelter from windblown sand.

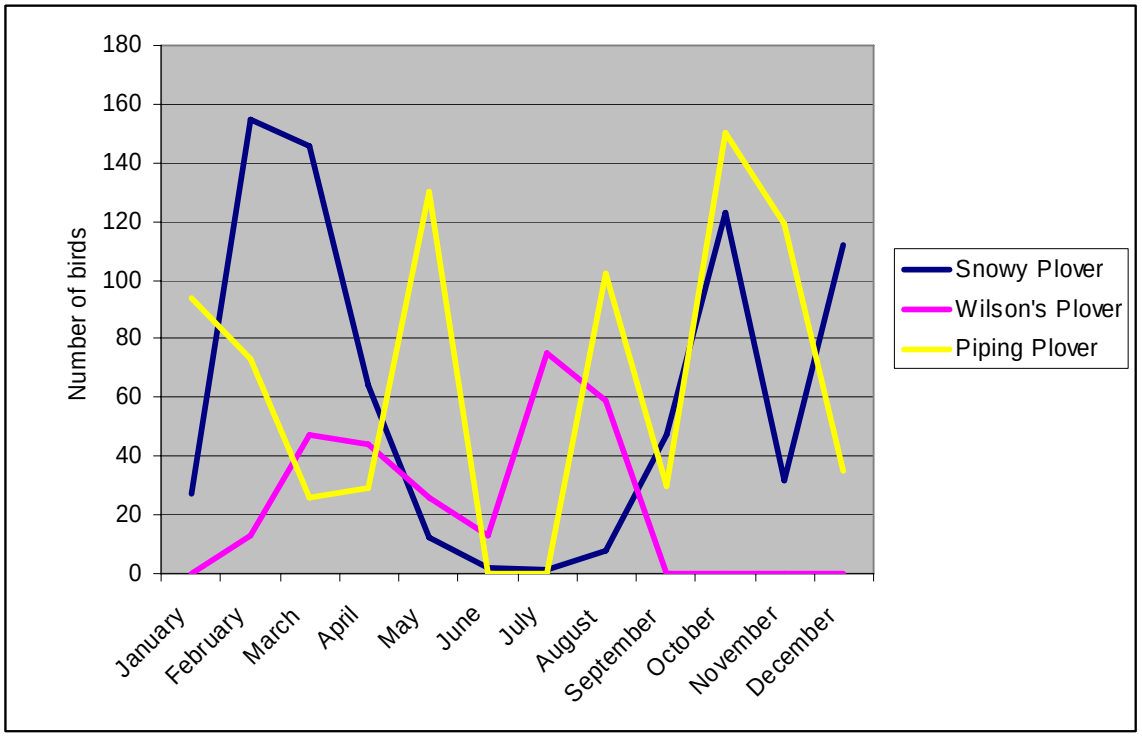


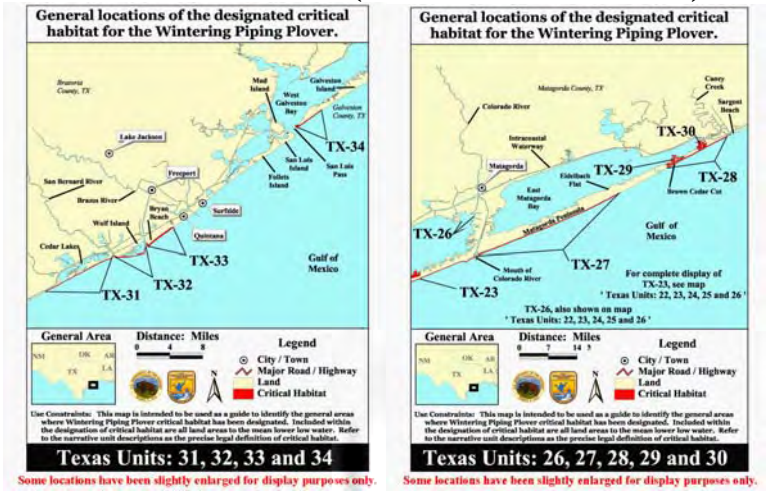
Figure 3. Comparative abundance through the year of three species of plovers on the upper Texas coast.

Piping Plover Heavy Use Areas in 2008 vs. Designated Critical Habitat

Most of the areas we identified as heavy use by Piping Plovers corresponded with USFWS Critical Winter Habitat as published. (USFWS, 2009). Significant deviations in

our results from designated areas include Wolf Island (Unit TX 32) which had light plover presence before Hurricane Ike. Plover usage did greatly increase after the hurricane leading us to speculate that birds displaced from coastal areas that were severely impacted might be forced to utilize marginal habitats on less affected parts of the coast. We made no Piping Plover detections at Apfel Park (Unit TX 35, "Big Reef", in part, in Designated Critical Habitat maps) before the storm. Use increased after the storm but the sample size was still very small. Conversely we consistently recorded high numbers of plovers on Follett's Island, not designated Critical Habitat except for the Brazoria County side of San Luis Pass (Unit TX 34 in part). Moderately high numbers used Sargent Beach, likewise not Designated Critical Habitat, especially during migration periods (Figures 5a. and 5b.)

Comparing the results from our GIS data with the currently designated Critical Habitat, one (50 CSR part 17, 2001) can see that the latter areas need to be expanded to include heavily used habitat identified in this study (Figures 5a and 5b.). GIS display of our results indicates that major areas of Piping Plover concentration are the mouths of rivers, particularly the Brazos River mouth at Bryan beach and the Colorado River mouth at Matagorda Bay Nature Park, or passes, natural or manmade, into major bay systems. These habitats exist at Bolivar Flats at the northern entrance to Galveston Bay, and San Luis pass at the southern entrance (Nicholls and Baldarassare, 1990). We found that plovers were not equally distributed on both sides of tidal inlets but tended to cluster on the north sides. This trend is likely due to the nature of the sedimentation flowing out from these areas with the currents and tides which tends to deposit silt rich in organic material on the north sides (Britton and Morton, 1989).



Figures 4a. and 4b. Designated Critical Habitat Maps from USFWS website.

Figure 5a: Heavy use of Follett's Island by PIPL; compare with 4a. above.

Figure 5b. Moderate use of Sargent Beach by PIPL; compare with Fig. 4b. above.

Figure 6. Piping Plovers tended to cluster at tidal inlets and river mouths, especially on the north sides.

Many of the beaches along the entire survey transect are bordered on their landward sides by salt and brackish marshes dominated by *Spartina patens* and *S. alterniflora*, which offer little or no habitat used by Piping Plovers. Tidal inlets were characterized by sand substrates around their entrances extending suitable habitat for plovers a short distance into the marsh-lined embayments behind the Gulf beaches. The broad exposed algal flats heavily used by wintering Piping Plovers on the lower Texas coast (Mabee *et al*., 2001) are almost entirely absent on the upper coast. Beach washover areas, also a heavily used habitat on parts of the Texas coast, primarily for roosting (Elliot and Zonick, 1998; Zonick, 2000), were also virtually lacking from most of the study area northeast of Matagorda Peninsula before Hurricane Ike. Apparently these do not form in the absence of a lagoon system behind a beach as in a barrier island situation. Washovers became numerous after the hurricane but were almost uniformly scoured of sand and most contained water through the remainder of the study. They may become suitable for Piping Plovers as they revert to unvegetated sandy washes over time.

Human Disturbance

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We compared two adjacent coastline segments - Quintana/Bryan Beach in Brazoria County, with relatively high human traffic seasonally, but low levels of development on or just behind the beach, with an area of entirely undeveloped beach of approximately the same length, Wolf Island, with almost no human activity. Wolf Island is between the

mouths of the Brazos and San Bernard Rivers, separated from the mainland by the Intracoastal Waterway, and is accessible only by boat. Piping Plovers were considerably more numerous on the Quintana/Bryan Beach side (the north side of the river mouth and the area more heavily used by humans), than on the inaccessible Wolf Island side of the river mouth The northeastern side of the mouth of the Brazos River had 103 Piping Plover detections compared with only 18 detections on the southwestern, Wolf Island side, before landfall of Hurricane Ike.

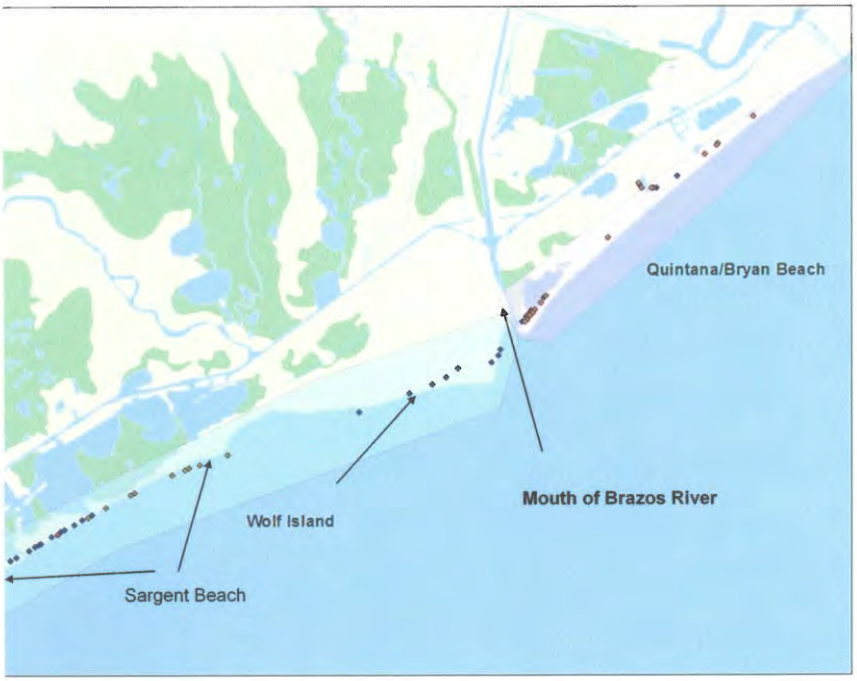

Figure 7. Comparative Piping Plover use of Wolf Island, an isolated, seldom-visited coastline segment with Quintana/Bryan Beach, a moderately heavily used recreational beach.

These results are counter to expectations (cf. Amos, 2005). In this specific instance, our comparison between a relatively heavily used beach with that of an adjacent, isolated and essentially unused adjacent beach may be invalid. Human disturbance may be less significant as an influence on plover use than is the suitability of the habitats on the adjacent beaches to support the food base for plovers. Effluent from the Brazos River is picked up by longshore currents which flow southwestward, parallel to the Wolf Island beach (Britton and Morton, 1989).This current deposits copious amounts of debris, especially driftwood and sediment, on the Wolf Island side. The constant accumulation of sediments on this section of beach may tend to limit the intertidal fauna that forms the food base for Piping Plovers. Amos (2005) surveyed adjacent beaches that are separated by a man-made ship channel with little fresh water inflow from streams carrying sediment.

Although Burger (1994) found that Piping Plovers spent significantly less time foraging when people were present and more time being alert, we did not find general human

presence on beaches with high plover use to be a major factor in Piping Plover distribution or behavior on the upper Texas coast (*contra* Elliot 1966). The differences are possibly due to the fact that Burger's work was done in a breeding context rather than a wintering situation. Moderate recreational use of the beach does not seem to provide any significant deterrent to plovers using the beach on the upper Texas coast during winter. Most of the recreational use of beaches during the period when Piping Plovers are present in the study area in significant numbers is by fishermen, which Burger *et al.* (2007) found to have the least negative impact on foraging plovers among various categories of beach users. It should also be noted that we were constrained from conducting surveys on weekends and holidays when recreational use is highest as a condition for allowing us to use a non street-legal vehicle (All Terrain Vehicle) on the beaches of the entire study area. Thus, all of our detections were during periods of relatively light human use of the coastlines. Also, Piping Plover are present in significant numbers on the upper Texas coast during months when human beach use is low overall.

Foraging Piping Plovers tended to ignore automobile traffic unless it actually threatened them. Most automobile traffic was well above the swash zone where Piping Plovers foraged. Resting/roosting congregations were more subject to traffic disturbance than were foraging birds because they occurred on the upper beach where automobile traffic was heavier. Pedestrian traffic causes minor disruption to foraging birds. Piping Plovers may relocate short distances to avoid pedestrian traffic, but they generally return as soon as pedestrians are past. Pedestrians with dogs that chase plovers and other shorebirds, however, do cause plovers to depart the area (Burger, et al. 2007; pers. ob.).

Housing or retail developments that front directly on the beach and back dune areas did negatively affect beach use by Piping Plovers. In all sections surveyed, detections were low in areas with significant beach development (e.g., areas of intensive residential development bordering the beaches on Galveston Island and sections of the Bolivar peninsula) (Ledee, 2005). Since the housing/business development doesn't actually occupy space normally used by Piping Plovers during the winter the reasons why it seems to impact negatively on their use of adjacent areas remain unclear. Narrowing of the beach corridor and the increased year-round presence of pedestrians, dogs and free ranging cats may have a discouraging effect on plovers.

II. Plover Response to Hurricane Ike

Due to personal safety and access issues, and the disruption of the normal functioning of the Observatory for a period of several weeks, we were unable to observe the direct effects of the storm on those plovers which had already arrived in their fall migration at the time of landfall, so we have no data on mortality that may have occurred. It should be

noted, however, that shorelines in the study area had been flooded by higher than average tides dating from the landfall of Hurricane Gustav approximately 200 km. east of the study area on September 1, 2008. Tides remained unusually high until water levels rose still more ahead of Hurricane Ike. The shorelines used by plovers became deeply inundated by high tides for several days prior to actual landfall of Hurricane Ike,

beginning September 10. Many of the plovers that had arrived were probably forced to relocate before the most violent weather arrived in the study area. For tide data between September 1 and 13 see (http://co-ops.nos.noaa.gov/data_menu.shtml?bdate=20080901&edate=20080913&unit=0&shift=d&mins=60&datum=6&stn=8771510+Galveston+Pleasure+Pier%2C+TX&type=Tide+Predictions&format=View+Data. 28 Sept. 2009). Exactly where Piping Plovers and other shorebirds relocate to avoid the widespread coastal flooding and violent weather associated with tropical storms is not known.

Some of the Piping Plover response to the indirect effects primarily due to severe habitat alteration can be seen in the results of surveys conducted from October 2008 through January 2009 in the GIS data that accompanies this document. Figure 5a., 5b., and 5c. show the relative distribution of Piping Plover encounters before and after the storm. The spike in birds per hour from West Galveston Island and adjacent coastal segments would imply that birds moved from heavily impacted coastal areas at and east of landfall, but did not move farther than necessary. Wolf Island and Apfel Park show dramatic spikes in plover numbers after the storm which may imply that displaced birds were forced to use lower quality habitat that had not been used at all, or used very lightly, before the storm. However the sample size is low, especially for Apfel Park.

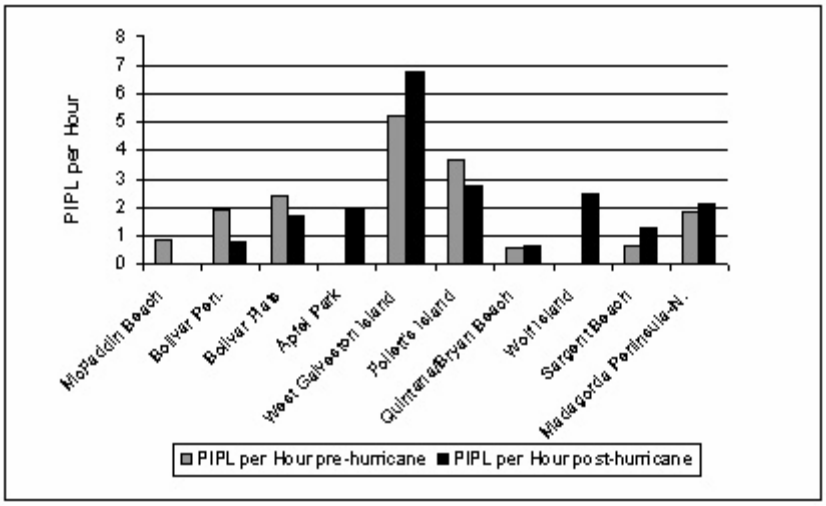

Figure 8. Piping Plover encounters per survey hour before and after passage of the Hurricane

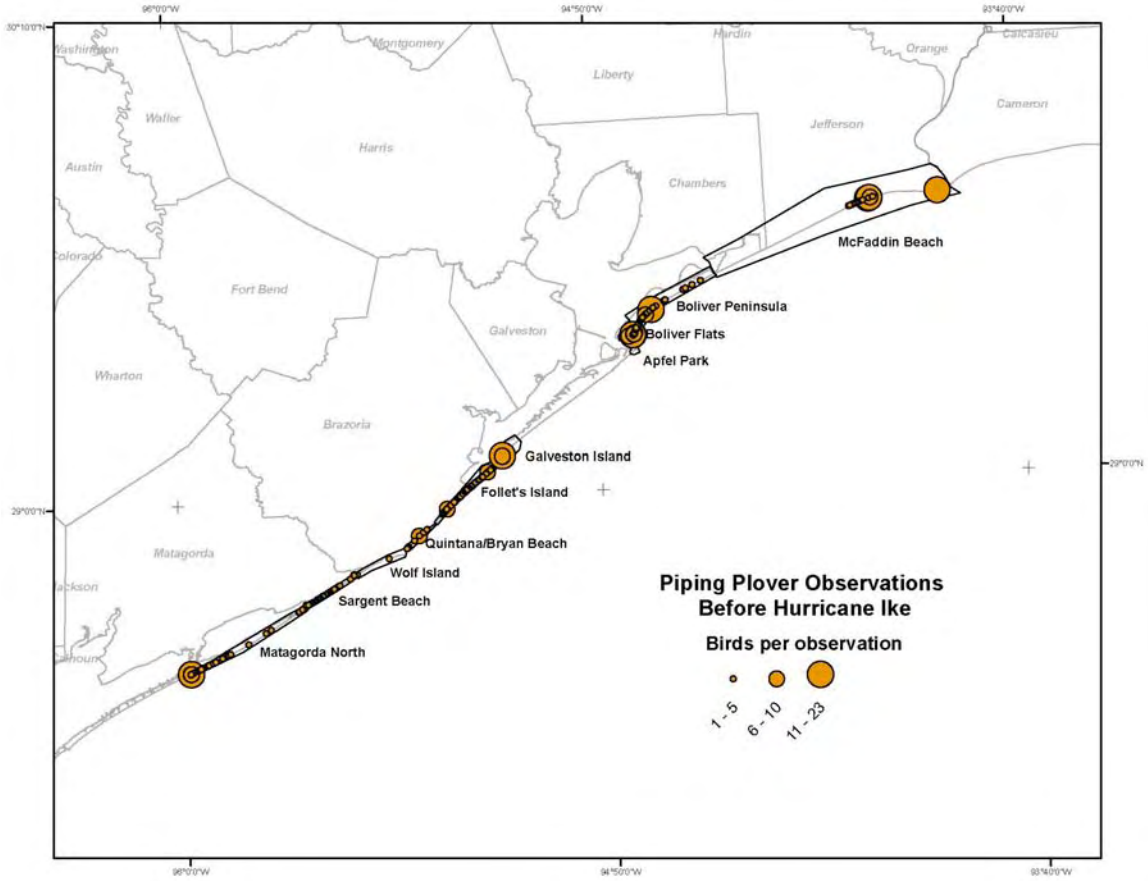

Figure 9a. Distribuition of Piping Plover encounters in 2008 before Hurricane Ike. Notice that plovers tend to concentrate at specific sites. Most of these sites are at the mouths of tidal inlets.

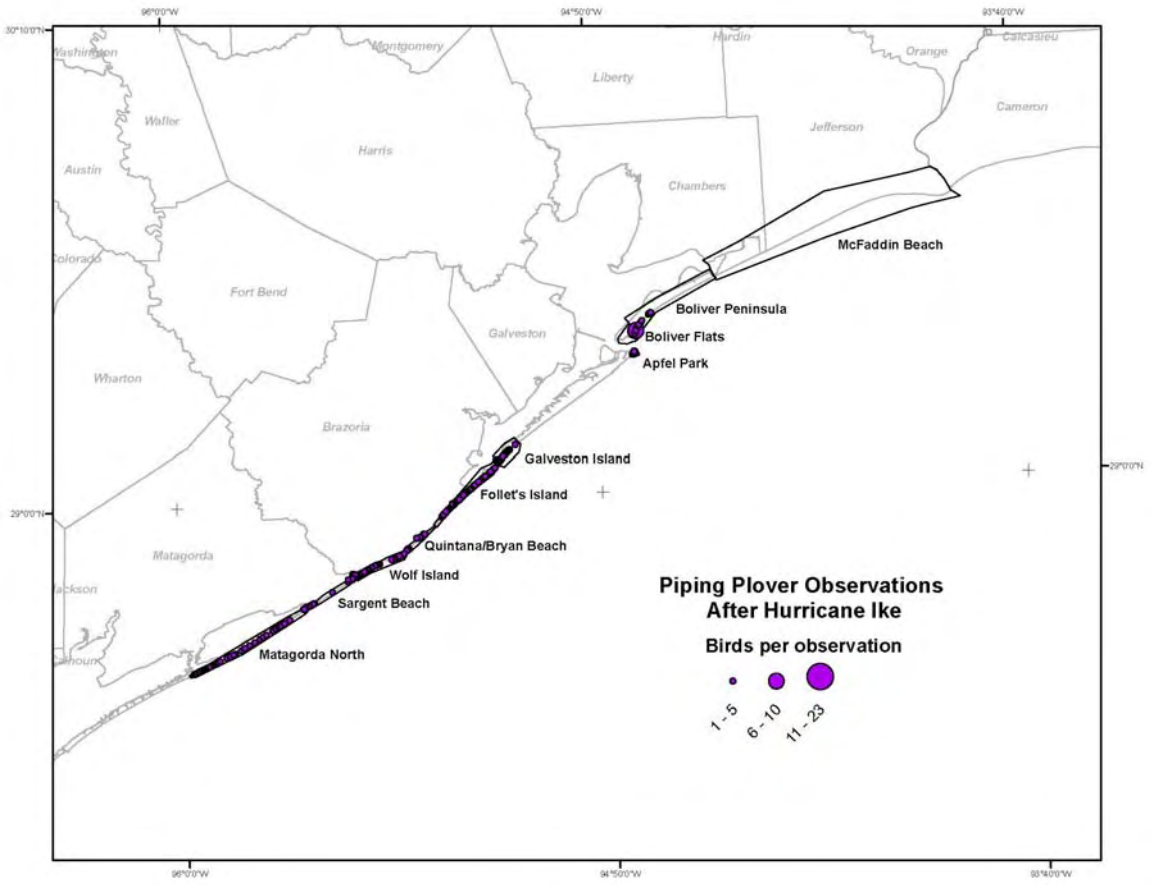

Figure 9b. Distribution of Piping Plovers in 2008 After Hurricane Ike. Notice that plovers disappeared completely from Bolivar Peninsula northward and that plovers that formerly congregated at specific sites are much more widely dispersed.

Color-marked Piping Plovers

During this year-long project we sighted 61 color-marked Piping Plovers well enough to be reasonably confident of our correct interpretation of the marking patterns. See Appendix A for full information on the uniquely color-marked plovers encountered during the survey.

During the winter/migration season of Piping Plover prior to hurricane passage almost all uniquely marked birds that were resighted were very sedentary and were relocated at or very near the site of the original sighting, often multiple times. Of the plovers that were resighted at later dates, seven were relocated after Hurricane Ike, two of these twice. Of the seven relocated birds, five had been initially recorded during the winter and early spring and only two in fall and early winter of the following wintering season. Not only had the five birds survived the migration to and from the breeding grounds, but had also survived Hurricane Ike and it's after effects. However, all but one had relocated to a coastline segment southwest of their location where initially sighted the preceding season indicating adaptability to negative habitat changes.

Short Term Risk Assessment of Piping Plover Habitat on the Upper Texas Coast

During the months between January and September, 2008, we learned of no specific new projects or other activities that would, in the next five or so years, pose a new major threat to the various segments of the upper Texas coastline that we surveyed. Our sources of information were direct observation and regular attention to the both the local print and electronic media as well as word-of-mouth communication with colleagues in the conservation community. There remain several inactive projects that have been proposed in the past, but which have not yet been approved that would affect certain areas in major ways if enacted (e.g. a causeway bridge to connect Galveston Island to Bolivar Peninsula). At the moment such projects lie dormant, but have not been abandoned as future possibilities.

There is on-going gradual man-created Piping Plover habitat degradation in virtually every segment surveyed, with the exception of Wolf Island, although it is not entirely secure from future development schemes. The mouth of the San Bernard River silted in and ceased to function as an active outlet during the 1990s. In June 2008 the mouth was dredged open by the US Army Corps of Engineers. There had been several plans to establish development projects on Wolf Island that were abandoned during the period that the river mouth was closed. Now that it is again open some of these may be revived. Elsewhere housing and recreational pressure increases constantly along the coast and this, plus the incremental occupation of small sites by human activity continually erode the quality of the upper Texas coastline as Piping Plover wintering habitat.

Hurricane Impacts

For the short term, natural forces in the form of Hurricane Ike impacted the entire study area, the northern half of it severely. The most severely damaged areas were from the point of landfall northeastward to the Sabine River and beyond (Figure 1). This is in addition to the erosion and subsidence that have been experienced by most of that shoreline for decades. Ike caused massive beach erosion from Bolivar Peninsula northward to the mouth of the Sabine River and literally removed the entire sand layer exposing the stiff clay subsoil in these areas and locally in other areas. The geologic origin of the latter is old coastal marsh bottom sediment that formerly lay a kilometer or more inland of the Gulf beach. The shoreline has now been eroded completely away (Figure 9).

Figure 10. Beach stripped of sand, upper Bolivar Peninsula.

It is not suitable for Piping or other species of plovers and none were recorded from northern Bolivar Peninsula to the Sabine River after Hurricane Ike. Most man-made structures from the southern terminus of Bolivar Peninsula northward were destroyed. This not only impacted the shoreline but also our ability to survey it. Access was difficult to impossible and support infrastructure was eliminated causing surveys of this area after Hurricane Ike to be limited to two. Massive cleanup efforts on Bolivar Peninsula that began in January 2009 further impacted what shorebird habitat remained.

Coastal segments less affected included West Galveston Island southwestward through the northern Matagorda Peninsula. Beach erosion was moderate to locally heavy on Follett's Island and Quintana/Bryan Beach. Wolf Island southwestward to the mouth of the Colorado River suffered minimal erosion and other negative impacts.

Acknowledgements

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Ray Jordan, and Jim Renfro helped survey certain coastal segments, and Joseph Kennedy kindly provided his photographic record of marked Piping Plovers. Karen Barrett, Cecilia Riley, and Susan Heath kindly reviewed earlier versions of this document and made many valuable improvements. Cullen Hanks previewed the GIS data and made constructive comments that resulted in its improvement. He also constructed some of the figures used in this document. Melissa Schlothan helped prepare certain maps. To all these persons we extend our thanks for their contributions.

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Significant Deviations

An attempt was made to visit each of these coastline segments a minimum of twice each month between January 2008 and February 2009. This goal was attained for some of the coastal segments named above and not for others. Some segments were inaccessible for varying periods of time following landfall of Hurricane Ike on 13 September, 2008, and others were not surveyed for various reasons at certain other times (e.g. a boat was not acquired until April so Wolf Island could not be surveyed until that month).

Sections of the City of Galveston were excluded from the survey because of lack of vehicular access and high levels of pedestrian traffic year round. The area unsurveyed extends from approximately two miles northeast of San Luis Pass to Apfel Park on the northern end of the island. That portion of the beach essentially consists of the City of Galveston behind the seawall and a smaller area of intensive development west of the western terminus of the seawall. Preliminary visits to the area indicated that the beach is too narrow and heavily developed in this area to support plovers in any significant numbers (cf. Ledee, 2005).

Also, the language of the "Location" section of the proposal is unclear on one point. It states that "the upper Texas coast is defined for the purposes of this study as extending from the mouth of the Sabine River in Jefferson County to the *tip of the Matagorda Peninsula in Matagorda County"*. It should read "to the base of Matagorda Peninsula in Matagorda County". The Matagorda Peninsula actually consists of upper and lower peninsulas. The base of the Upper Peninsula is at the mouth of the Colorado River. South of the Colorado River the lower peninsula is extremely remote. There is no practical access to this part of the coastline with the resources that are available to us.