PIPING PLOVER POPULATION ABUNDANCE, TREND AND SURVIVAL AT BOCA CHICA 2018-2021

Report by Coastal Bend Bays & Estuaries Program – D. Newstead and B. Hill

22 October 2021

INTRODUCTION

Piping Plovers are known to be highly faithful to wintering sites. Habitat used in winter consists mainly of Gulf beaches, and tidal flats ("mud flats," "algal flats," "sand flats" are commonly used descriptors). The species' preference for one habitat or another is largely a function of habitat availability. High water levels that inundate the tidal flats reduce potential habitat there, at which time they are often found on the Gulf beach. While daily lunar-driven tides are relatively minor in the western Gulf of Mexico, seasonal tides are a more influential driver of habitat availability. Overall, tides tend to be highest in spring and fall periods, and lowest in summer and winter periods. Weather can have a strong overriding influence on this (e.g. storm surge from tropical systems, strong cold fronts), so plover habitat usage is not strictly a function of season.

The Boca Chica area is unique in that the inundation/exposure regimes of the flats north and south of the highway often alternate (Fig. 1). The north side becomes inundated when tides or strong northerly winds drive water through the pass into South Bay off the Brownsville Ship Channel. When this happens, water can be driven off the flats on the south side of the highway, "dewatering" those flats via a mangrove-lined connection to the Rio Grande near the rivermouth. When winds reverse, the opposite occurs. Flats that have recently become exposed after inundation provide preferred habitat for Piping Plovers and many other shorebirds, as prey items are still close to the surface. Blue-green algal mats are also an important foraging strata, where they forage on dipteran larvae that grow in cracks and crevices of the desiccated surface algal layer (Zonick 2000). Plovers are often found in groups when on the flats, and sometimes in groups exceeding 100 individuals. This would constitute an exceptionally large concentration in most parts of the species' winter range, but in the past it has not been uncommon at Boca Chica to encounter groups of 200 or more (Zonick 2000, Maddock 2010). When flats are not available, they are more frequently found on the Gulf beach, where they are often quite territorial to a given linear stretch of beach. This mosaic of multiple habitat options – at least one of which is virtually always available to them – in a relatively confined area makes this site of unique importance for the species.

Piping Plovers depart their breeding grounds and arrive on the Texas coast as early as mid-July, and generally stay until at least March or April before returning north to breed. Based on previous radiotelemetry projects (Drake et al 2001, unpubl. data), most Piping Plovers are very territorial while on the beach and have small home range sizes throughout the full nonbreeding season. However, several birds captured in late September to mid-October (our study) on Padre Island National Seashore wintered further south in the Lower Laguna Madre including one that wintered in the flats at Boca Chica/South Bay.

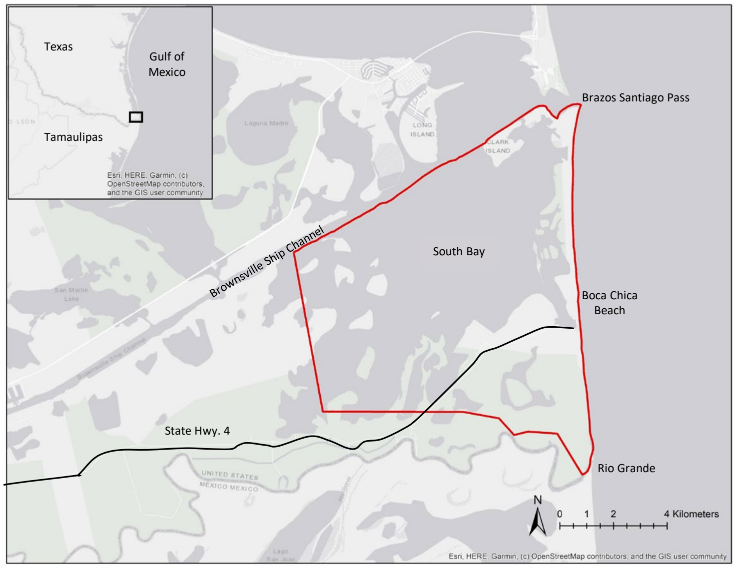

Figure 1. Study area including Piping Plover Critical Habitat Unit TX-1 outline in red.

Over the past 30 years there have been multiple banding programs on the species' breeding grounds. Most plovers that migrate to and winter in south Texas are from the Northern Great Plains (including Prairie Canada) and Great Lakes populations (Gratto-Trevor et al 2011). Birds captured for those projects were uniquely marked with a combination of color bands/flags and/or a leg flag with a unique alphanumeric code. Incorporating encounter histories of these birds – including the original marking and subsequent resightings – as well as proportions of marked and unmarked individuals into population models allows for estimation of important population parameters, including abundance and survival.

The objective of this analysis was to estimate population abundance, trend, and survival of Piping Plovers in the Boca Chica/South Bay area.

METHODS

From late summer 2018 through fall 2021, we conducted surveys of Piping Plovers in the Boca Chica/South Bay area. The site is designated Critical Habitat Unit TX-1 for Piping Plover. Surveys were conducted along the Gulf beach, and in the tidal flats north and south of State Highway 4 (Fig.1).

Beach surveys were conducted as a linear transect covering the Gulf beach from the south jetty of Brazos Santiago Pass on the north end to the Rio Grande/Bravo rivermouth (international border) to the south. A skilled observer drove the beach slowly in order to detect Piping Plovers before they might be flushed. A GPS point was recorded for each individual observed. Each encountered plover was observed using binoculars and/or a spotting scope to determine if it was uniquely marked. If marked, the full band color/leg flag combination was recorded. If the observer was unable to read the full combination, it was recorded as "marked but unread."

On the flats, a skilled observer familiar with habitats and behaviors of Piping Plovers used binoculars or a spotting scope to locate individuals or flocks from the highway or other access point, and then approached on foot. A GPS point was recorded in approximately the center of the flock. The whole flock was counted, and then the entire flock (or a sample in the case of a few very large flocks) were closely observed to determine how many marked and unmarked individuals were present. Once the ratio had been recorded, the observer recorded the band combination of all uniquely marked plovers. In some cases, not all marks could be read.

In addition to records of individuals uniquely-marked on breeding grounds, we captured and marked four additional plovers at Boca Chica during the study (one in fall 2018, three in fall 2019) and these encounter histories were included in the analysis.

We used a Mark-Resight model in Program MARK to estimate abundance and other demographic parameters. Specifically, we used the Zero-Inflated Unidentified Marks Poisson Mark Resight Robust Design across Primaries model type (a type of zero-inflated Poisson log-normal estimator, hereafter, ZPNE). The ZPNE model allows for the estimation of the total population size by incorporating data describing temporal patterns in the number of both marked and unmarked individuals within a study system. This model assumes geographic closure within a single survey period (hereafter, primary period), but allows individuals to leave the population via mortality or permanent emigration (i.e., apparent survival; φ) between primary periods.

Encounter histories were compiled for each individual for each of the primary periods of the time range. A primary period consisted of all surveys conducted within a nonbreeding period ("year"). The year began with surveys following the arrival of birds from breeding grounds (earliest survey date July 24) and continued until as late as February 20. Each survey is considered a secondary occasion, and were grouped into 4 primary periods, with a varying number of secondaries in each: 2018/19 (16); 2019/20 (12); fall 2020 (9); and fall 2021 (8). The numbers of "marked unidentified" and "unmarked" for each primary period were also incorporated into the data structure to allow for an unbiased estimate of the total overwinter population size. As the number of marked birds within the system on the initial time step was considered known, we constrained the presence parameters (*w* and *g*) to 1.0 (McClintock 2021). Likewise, as zero banded birds were observed beyond the confines of the study system during the overwinter period, we fixed the temporary emigration parameters (γ\`, $\gamma$\`\`) to zero to allow for the apparent survival (φ) and resight parameters to fully estimate. Models allowing the other parameters (σ^2 – individual heterogeneity across primaries; φ – apparent survival between primary occasions) to vary among years or remain constant were tested to determine the most parsimonious fit.

To assess the potential for immigration or emigration of individuals to or from the study area between occasions, we searched other datasets of similar surveys in the Mustang and North Padre Island areas (near Corpus Christi) and South Padre Island (just north of Boca Chica) for records of the individuals encountered at Boca Chica. The Boca Chica area was considered the terminal wintering site.

RESULTS

A total of 379 observations of 85 uniquely marked Piping Plovers were recorded in the surveys. With the exception of the four individuals captured at Boca Chica, all others were originally marked on breeding grounds in the Northern Great Plains.

The model allowing α, σ^2, U, and φ to vary with time (with w and g fixed to 1.0 and γ\` and $\gamma$\`\` fixed to 0.0) was the only model that properly estimated all real and derived parameters.

The point estimates ($\hat{N}$) indicate the wintering Piping Plover population at the site declined from approximately 308 to 142 over the course of three years, a 54% decline (Table 1, Fig. 1) since 2018 (= the 2018/19 nonbreeding season). The decline between the first and second years was over 38%, and the trend continued downward in the following years. None of the confidence intervals in the last three years of the study overlap with the initial year. The fit of a linear trend through the point estimates over time was 0.82.

Apparent annual survival (φ_a) measured in this study ranged between 0.57-0.62 (Table 1). Since all marked birds in this study were breeding-age adults prior to entering the study area (or for those banded on site – were breeding-age adults at capture), these estimates reflect adult apparent annual survival.

Table 1: Population size ($\hat{N}$), encounter probability ($\hat{p}^*$) and annual survival estimates (φ_a) with lower/upper 95% confidence intervals for Piping Plovers at Boca Chica. “Year” is the calendar year of the beginning of the nonbreeding period (i.e. “2018” is fall and winter beginning 2018, ending 2019).

Year	**$\hat{N}$**	**LCI (95%)**	**UCI (95%)**	**$\hat{p}^*$**	**LCI (95%)**	**UCI (95%)**	**φ_a**	**LCI (95%)**	**UCI (95%)**
2018	308.0	260.7	363.8	0.91	0.83	0.95	-	-	-
2019	189.0	146.1	244.4	0.83	0.72	0.91	0.57	0.43	0.69
2020	147.8	118.2	184.9	0.93	0.84	0.97	0.62	0.44	0.78
2021	141.8	86.6	232.3	0.81	0.49	0.95	0.61	0.30	0.85

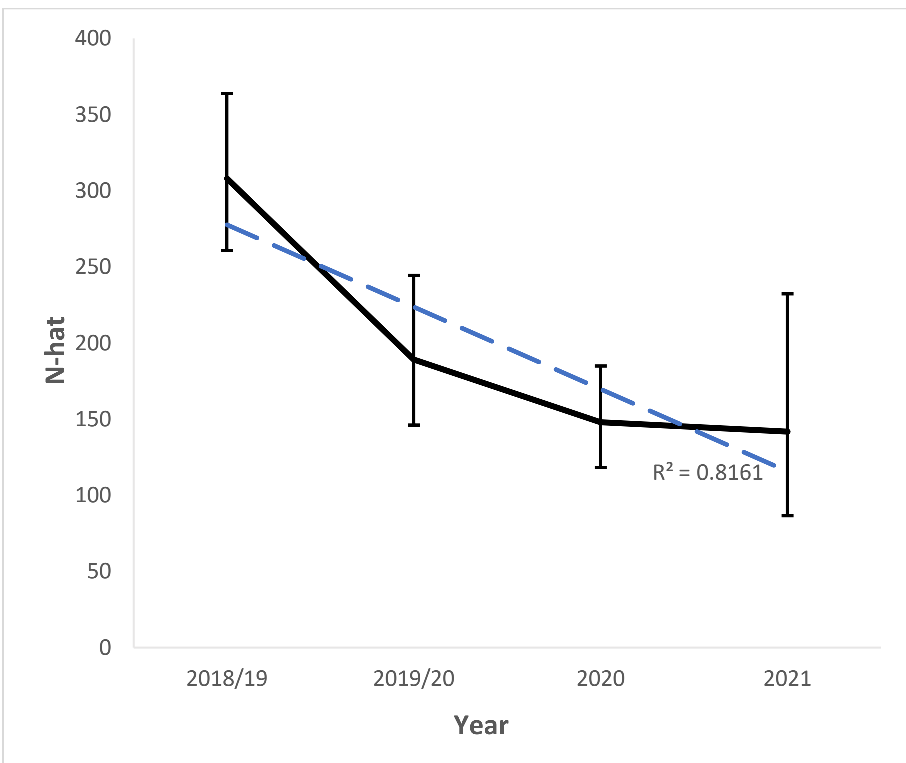

Fig. 1. Population estimate (including 95% confidence intervals) and trend of Piping Plovers at Boca Chica, 2018-2021.

DISCUSSION

The overwhelming provenance of marked individuals from the Northern Great Plains (NGP) breeding population suggests plovers wintering at Boca Chica are almost entirely associated with that population (the two other breeding populations – the Great Lakes population of *C. m. circumcinctus* and the coastal Atlantic *C. m. melodus* population – had even more extensive banding programs during this timeframe but were not detected at the site during the study period), consistent with results of a range-wide connectivity analysis (Gratto-Trevor et al 2011). While birds from the far smaller Endangered Great Lakes population have been documented at the site in the past, none were detected at the site during this study.

The NGP breeding population is estimated at 4,700 individuals (Andres et al 2012). The population point estimate at Boca Chica in the first year of the study (~308) represents approximately 6.5% of that population while the point estimate in 2021 (~142 individuals) represents 3.0%. With no evidence that birds have changed wintering areas, this would suggest the NGP population experienced a ~3.5% decline over the period solely based on the trend at this specific site. Alternate hypotheses are that the entire NGP population has undergone a >50% decline in only four years, or that the population is in fact stable but greater numbers of unmarked individuals are now occupying other sites. The former hypothesis has no support, as such a catastrophic decline would not escape notice of many field-based projects on the species both in breeding and other wintering areas. While the latter hypothesis is plausible (it would require similar analysis of concurrent years at many other sites across the wintering range to test), wintering site fidelity is known to be very high with this species. If this hypothesis were correct, we would likely have detected at least some of these individuals at other wintering sites (none were).

Based on this model and data structure, the survival estimates represent the probability of an adult bird surviving from one nonbreeding season to the next. Since the nonbreeding season for Piping Plovers at the site is fairly long (~8 months), it cannot be definitively determined what part of the annual cycle is responsible for the highest component of the mortality (the inverse of survival). This model estimates "apparent" survival, assumed to be equal or lower than "true" survival which is the sum of apparent survival plus emigration from the site (a bird that survived but is no longer "available" to be seen at the site). However, none of the birds in this study were detected in other surveys in the most adjacent suitable habitat (Laguna Madre shoreline of South Padre Island), suggesting emigration is unlikely to have been a significant component of the inverse of apparent survival (i.e. the decline more likely reflects true mortality). The propensity for individuals to remain faithful to a wintering site despite high disturbance and/or degraded habitat quality can lead to lower site-level survival (Gibson et al 2018) as seen in this study.

Breeding-ground-based studies have yielded adult apparent annual survival estimates between 0.69-0.81 (Larson et al 2000; Roche et al 2010). Using a Barker model which approximates true survival (accounting for movement in/out of a site), Cohen and Gratto-Trevor (2011) estimated annual survival at 0.80 for adults for the studied Prairie Canada component of the NGP population. Similarly, a study incorporating both breeding and nonbreeding areas estimated apparent annual survival of the Texas population at 0.80 (Ellis et al, *in press*). Given the geographic scope of that study and very limited evidence of emigration, the authors suggest the apparent survival estimates closely approximate true survival.

Estimates from nonbreeding-ground-centric studies are more variable. Gibson et al (2018) estimated true survival at a range of sites across the southeast US Atlantic coast between 0.50-0.92, linking lower survival rates with sites experiencing higher levels of anthropogenic disturbance (a composite metric incorporating recreational beach usage and shoreline modification). The only sites in that study with lower survival estimates (0.50 and 0.55) than in our study were geographically proximate, not truly independent, and one was undergoing a significant natural loss of suitable habitat during the studied interval while the other had high levels of anthropogenic disturbance. Estimates of site fidelity in the Gibson et al (2017) study ranged from 0.73-0.91. While we did not explicitly measure site fidelity in this study, the fact that none of the uniquely-marked individuals detected in the study were ever detected in nearby sites in the winter suggests fidelity was very high. This would mean our apparent survival estimates are likely a close approximation to true survival.

A simulation study on the US NGP population of Piping Plovers (i.e., this study population, in part) demonstrated that variations in adult survival have the strongest potential to affect population trends compared to other demographic rates (McGowan and Ryan 2009). This means relatively minor decreases in adult survival across the population would likely accelerate population declines. A drastic decrease in survival at a key site such as this could have similar consequences.

The results of this study indicate a rapid and substantial loss of the population of Piping Plovers at the site (and to the NGP population), and that it may be functioning as a population sink.

LITERATURE CITED

Andres, B.A., P.A. Smith, R.I.G. Morrison, C.L. Gratto-Trevor, S.C. Brown and C.A. Friis. 2012. Population estimates of North American Shorebirds, 2012. Wader Study Group Bulletin 119(3):178-194.

Cohen, J.B. and C. Gratto-Trevor. 2011. Survival, site fidelity, and the population dynamics of Piping Plovers in Saskatchewan. Journal of Field Ornithology 82(4):379-394.

Drake, K.R., J.E. Thompson, K.L. Drake and C. Zonick. 2001. Movements, habitat use, and survival of nonbreeding Piping Plovers. Condor 103:259-267.

Ellis, K.S., M.J. Anteau, F.J. Cuthbert, C.L. Gratto-Trevor, J.G. Jorgensen, D.J. Newstead, L.A. Powell, M.M. Ring, M.H. Sherfy, R.J. Swift, D.L. Toy and D.N. Koons. *In press*. Impacts of extreme environmental disturbances on survival of Piping Plovers are partially moderated by migratory connectivity. Biological Conservation.

Gibson, D., D.H. Catlin, K.L. Hunt, J.D. Fraser, S.M. Karpanty, M.J. Friedrich, M.K. Bimbi, J.B. Cohen and S.B. Maddock. 2017. Evaluating the impact of man-made disasters on imperiled species: Piping plovers and the Deepwater Horizon oil spill. Biological Conservation 212:48-62.

Gibson, D., M.K. Chaplin, K.L. Hunt, M.J. Friedrich, C.E. Weithman, L.M. Addison, V. Cavalieri, S. Coleman, F.J. Cuthbert, J.D. Fraser, W. Golder, D. Hoffman, S.M. Karpanty, A. Van Zoeren and D.H. Catlin. 2018. Impacts of anthropogenic disturbance on body condition, survival, and site fidelity of nonbreeding Piping Plovers. Condor 120:566-580.

Gratto-Trevor, C., Amirault-Langlais, D., D. Catlin, F. Cuthbert, J. Fraser, S. Maddock, E. Roche and F. Shaffer. 2011. Connectivity in Piping Plovers: Do breeding populations have distinct winter distributions? Journal of Wildlife Management 76(2):348-355.

Larson, M.A., M.R. Ryan and B.G. Root. 2000. Piping Plover survival in the Great Plains: an updated analysis. Journal of Field Ornithology 71: 721–729.

McClintock, B.T., G.C. White and M.A. Pryde. 2019. Improved methods for estimating abundance and related demographic parameters from mark-resight data. Biometrics 75(3):799-809.

McClintock, B. [online]. 2021. Mark-resight models. Chapter 18 *in* Cooch, E.G. and G.C. White. 2019. Program Mark: a gentle introduction, 19th ed. <http://www.phidot.org/software/mark/docs/book/> (5 September 2021).

McGowan, C.P. and M.R. Ryan. 2009. A quantitative framework to evaluate incidental take and endangered species population viability. Biological Conservation 142:3128-3136.

McGowan, C.P., M.R. Ryan, M.C. Runge, J.J. Millspaugh and J.F. Cochrane. 2010. The role of demographic compensation theory in incidental take assessments for endangered species. Biological Conservation 144:730-737.

Roche, E.A., J.B. Cohen, D.H. Catlin, D.L. Amirault-Langlais, F.J. Cuthbert, C.L. Gratto-Trevor, J. Felio and J.D. Fraser. 2010. Range-wide Piping Plover survival: correlated patterns and temporal declines. Journal of Wildlife Management 74(8):1784-1791.

Zonick, C.A. 2000. The winter ecology of Piping Plovers (*Charadrius melodus*) along the Texas Gulf Coast. PhD Dissertation. University of Missouri-Columbia. 180 pp.