FINAL REPORT

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Project 53: Effects of Human Disturbance on Threatened Wintering Shorebirds

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Project Title: Effects of Human Disturbance on Threatened Wintering Shorebirds

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Objective:

Evaluate the effects of human disturbance on piping and snowy plovers at three sites along the Texas coast with varying levels of human disturbance.

PREFACE

The attached draft manuscript entitled "Effects of Human Disturbance on Threatened Wintering Songbirds" by Lee F. Elliot and Tamara Teas resulted directly from this project and is submitted in fulfillment of the Final Report requirement.

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EFFECTS OF HUMAN DISTURBANCE ON THREATENED WINTERING SHOREBIRDS

By Lee F. Elliott and Tamara Teas

Introduction

The two species under study are the piping plover (*Charadrius melodus*) and the snowy plover (*Charadrius alexandrinus*). The piping plovers that winter along the Texas coast are listed as threatened under the Endangered Species Act and by the state of Texas. More than half the world population of the species winters on the Texas coast and individuals typically begin arriving in mid-July and have usually departed for the breeding grounds by mid-May. They can be found on mud, sand, or algal flats, as well as on beaches, all along the coast.

The western snowy plover (*C. alexandrinus nivosus*) nests and winters along the Texas coast and had previously been a candidate (C2) for Federal listing. The southeastern snowy plover (*C. alexandrinus tenuirostris*) winters along the Texas coast. Populations of the western snowy plover that nest along the Pacific coast have recently been listed as threatened by the U. S. Fish and Wildlife Service.

One of the factors that has been identified in the Recovery Plan as having a negative influence on the piping plover is human disturbance. Studies addressing the problem have focused on nesting birds, where negative impacts are more clearly linked to decreases in reproductive success for the species. On the wintering and migratory grounds, birds may be on a marginal energy budget, attempting to build up or maintain fat reserves for longer range migration or maintain adequate body temperature under cooler winter conditions. Additional stresses associated with avoidance of human disturbance may induce population losses associated with predation, starvation, or disease. Birds may be forced to use areas of marginal habitat because of their inability to forage effectively in optimal habitats. Reproductive success of breeding snowy plovers may be directly impacted by human disturbance, however this impact will not be evaluated in this study.

Methods

Study Sites: Plover time budget and census data have been collected at three sites. These sites were chosen to provide data on plovers experiencing varying degrees of human disturbance.

1) Matagorda. Matagorda Island National Wildlife Refuge represents the area with the least amount of human disturbance. This site, located in Calhoun County, has vehicular access limited to Refuge personnel and pedestrian access is limited. An eight-kilometer stretch of beach is monitored from Cedar Bayou at the southern tip of the island, northward.
2) Malaquite. Malaquite Beach represents the area with restricted vehicular traffic but open access to pedestrians. This site is located within Padre Island National Seashore in Kleberg County. The study focused on the southern 1.9 kilometers of this limited access beach, from the Malaquite Visitor Center northward.
3) Surfer. Nueces County Beach, on Mustang Island constitutes the area with

vehicular and pedestrian access. This stretch of beach is locally referred to as Surfer Beach because of the frequent use of the area for surfing. Parking stickers are required for use of this beach, but vehicular use is relatively heavy. A 3.7 kilometer stretch of beach between Zahn Road and Mustang Island State Park barrier was monitored.

Time Budget: This study will provide a comparison of time spent in active non-foraging movement, foraging, and resting relative to disturbance for the piping and snowy plovers. Focal animals were identified and followed for ten minutes, recording time spent within the various activity categories. Behavioral categories included foraging (including pecking and short movements in pursuit of prey), running (defined as movements greater than 5 m to distinguish them from movements associated with foraging), flying, roosting (including sitting and standing), and aggression (inter- and intraspecific). Individuals were observed from the base of the dunes (upland vegetation line) using binoculars and a 20x spotting scope, from between forty and one hundred (mean = 75) meters away. In most cases, individuals were easily observed for ten minutes and displayed no visible signs of disturbance from the observer (observations where the observer created a disturbance were terminated). Occasionally, individuals moved out of sight of the observer before completion of the observation, this however was relatively rare. Roosting birds may spend long periods with little activity, therefore, birds first located as roosting birds were observed for 30 minutes.

Periods of data collection at each site were chosen in order to sample during varying weather, tide, and human activity conditions. For the case of Matagorda Island, boat access to the island is available between about 09:00 in the morning and about 15:00 in the afternoon. Observations at this location are limited to these hours. Any type of disturbance that the focal animal encountered was recorded along with the time budget. Distance between focal animal and disturbing entity, speed of moving disturbances and whether or not the disturbance was moving directly toward or tangential to the focal animal was also recorded. In beach habitats, piping plovers typically distribute themselves along the beach and appear to maintain foraging territories. This distribution of focal animals allowed observers to be fairly confident that birds were not repeatedly sampled during the same day of observation. Because birds were not individually marked and individuals could use the same area of beach on multiple occasions, the frequency of re-sampling of individuals on separate sampling days is unknown. To provide additional information on habitat use, distance from tide line to the focal animal was estimated and recorded.

Foraging Efficiency: To evaluate foraging efficiency for the observed birds, foraging attempts were counted and timed for the foraging birds either simultaneous with the time budget observation, or directly following an observation. For these observations a 40x spotting scope was used. Fifty foraging attempts were counted and timed and successful attempts were also recorded. Evaluation of success of foraging attempts is often difficult. We plan to use this information as a relative measure, not an absolute estimate of efficiency. In some cases, birds quit foraging or were not foraging. No foraging efficiency data was collected for these birds. Occasionally prey items can be identified. A long, thin, red polychaete is occasionally captured as are arthropods (likely to be amphipods). Otherwise, identification of prey items is infeasible. Additionally, foraging effort was measured by counting the number of strides the focal animal made between foraging attempts. Number of strides were counted for ten attempts to provide an average foraging effort.

Indirect Measures: Although the focus of the study was on direct measures of the effects of human disturbance on shorebird behavior, indirect data will also be collected. Number of pedestrians and/or vehicles was recorded for each beach along with the number of piping and snowy plovers. This will provide data comparable to similar data collected by other researchers in the area.

Weather, Season, Tide and Associated Species: Tidal conditions will be evaluated for their effect on bird numbers and behavior. Tide level data, gathered by the Conrad Blucher Institute, are from tide gauges at Bob Hall Pier between the Malaquite and Surfer Beaches, Packery Channel on the bayside of Surfer Beach, and Bird Island on the bayside of Malaquite Beach. Tidal condition was categorized into high (peak) tide, low (trough) tide, early ebb (falling and less than half way between high and low tides for the cycle), late ebb (falling and more than half way between high and low tides), early flood (rising and less than half way between low and high tides) and late flood (rising and more than half way between low and high tides). Wind speed and direction, air temperature, and cloud cover are recorded during each observation period. For focal animal samples, shorebird species within 100 meters of the focal animal were identified and counted. Seasons were defined for the purposes of analysis as winter (between November 1 and February 20) and migratory (otherwise).

Results

<u>Descriptive Results</u>

No analysis was attempted for the associated shorebird species recorded within 100 m of focal animals, however results of those surveys are presented in Table 1.

Table 1. Numbers of shorebirds recorded within 100 meters of focal animals.

Species	Mean	Standard Deviation
Sanderling (*Calidris alba*)	8.78	11.53
Willet (*Catoptrophorus semipalmatus*)	2.27	1.84
Western Sandpiper (*Calidris mauri*)	1.95	6.37
Red Knot (*Calidris canutus*)	1.33	5.55
Piping Plover (*Charadrius melodus*)	1.32	0.86
Ruddy Turnstone (*Arenaria interpres*)	1.00	1.60
Black-bellied Plover (*Pluvialis squatarola*)	0.77	1.11
Peep (unidentified *Calidris* sp.)	0.70	2.76
Snowy Plover (*Charadrius alexandrinus*)	0.57	1.54
American Oystercatcher (*Haematopus palliatus*)	0.20	0.86
Long-billed Curlew (*Numenius americanus*)	0.13	0.36
Wilson's Plover (*Charadrius wilsonia*)	0.00	0.07
Greater Yellowlegs (*Tringa melanoleuca*)	0.00	0.07

Aggressive interactions were recorded for focal animals. Of 80 interactions recorded for piping plover focal animal samples, 53 involved another piping plover, 13 involved a sanderling, 11 involved a snowy plover, 2 involved a western sandpiper and 1 involved a black-bellied plover. Of 13 interactions recorded for snowy plovers, 2 involved other snowy plovers, 6 involved a piping plover, and 5 involved a sanderling. On the beaches, piping plovers appear to be territorial of foraging habitat, as evidenced by the large number of intraspecific interactions recorded for this species. Piping plovers tend to space themselves evenly along the beach and will run or fly towards another piping plover that approaches and proceed to strut and display with the intruder, until one or the other of the birds retreats. Birds may, however, roost in areas near beach foraging habitat in close proximity to one another without displaying aggressive behavior. Spacing of foraging individuals along the beach front simplified observation of separate individuals.

Distance to water was also recorded for foraging focal animals. Piping plovers tended to forage in the swash zone or close to the water line (mean distance of 3 m from the water), while snowy plovers frequently foraged in wrack on the beach, often further from the water line (mean distance of 27 m from the water).

ANOVA was used to determine whether or not bayside tidal conditions had a significant effect on beach piping and snowy plover densities. Densities from Surfer and Malaquite Beaches were used in this analysis because bayside tidal condition was available for these two sites. No significant difference was detected among bayside tidal conditions with respect to piping plover density on the beach. However, there was a significant difference ($F=2.95$, $df = 5$, $P = 0.015$) among tidal conditions with respect to density of snowy plovers on the beach, with the highest mean density of 1.5 birds/km at high bayside tide and the lowest mean density of 0.3 birds/km at low bayside tide.

Comparisons of Plover Numbers and Sources of Disturbance

Plover densities on each of the three beach sites and human disturbance factors are summarized in Table 2.

Table 2. Plover densities and densities of human disturbance factors (pedestrians and vehicles) on each of the three study sites. Average densities (followed by maximum densities in parentheses) are expressed as individuals per kilometer.

Sites	Piping Plovers	Snowy Plovers	Vehicles	Pedestrians
Surfer	3.13(37.6)	0.59(5.9)	3.08(37.8)	2.23(30.0)
Malaquite	4.51(15.3)	1.84(7.4)	0.07(1.0)	2.59(26.3)
Matagorda	1.11(5.6)	0.46(2.1)	0.0(0.1)	0.0(0.0)

Product-moment correlations (Sokal and Rohlf, 1981) were used to analyze the relationship between the number of plovers occurring on a site and the level of disturbance on the site. For Surfer Beach, number of vehicles was significantly negatively correlated with number of piping plovers ($r = -0.2346$, $P < 0.05$). No significant correlations were detected between numbers of pedestrians and numbers of piping plovers or snowy plovers at either Surfer or Malaquite Beaches. Nor was number of vehicles correlated with number of snowy plovers on Surfer Beach. In order to address the possibility that the correlation with vehicular density was a spurious correlation caused by an effect of season or bayside tidal condition, I analyzed the effects of these variables using factorial ANOVA (Sokal and Rohlf, 1981). Neither effect nor their interaction had a significant effect on vehicle density ($F = 0.931$, $p = 0.431$).

Time Budget Analyses

A total of more than 80 hours of focal animal observations (10 minute foraging observations and 30 minute roosting observations) was collected between September 1993 and June 1996. A total of 84 site visits was made to Surfer Beach, 52 to Malaquite Beach, and because of more difficult access, 18 site visits were made to Matagorda Beach.

Results from the various sites may be confounded by differences due to variance in quality of foraging habitat in addition to differences due to variance in amount and type of human disturbance. To approximate differences among sites relative to foraging habitat quality, measures of foraging success and foraging effort were compared among sites for those records for piping plovers (for which more data was available) without disturbance. Foraging success was measured as the number of successful foraging attempts made per second. Foraging effort was measured using the number of foraging attempts made per second and the number of strides per attempt. Comparisons among sites using these three measures were made using Analysis of Variance. Results of the analysis indicate no significant difference among the three sites for any of the three variables. A comparison is provided in Table 3. These results are based on 163 observations (51 observations for locomotion comparisons) over all three sites but suggest little difference among sites relative to foraging success or effort.

Table 3. Comparison of foraging success and effort among sites for piping plovers without human disturbance. Foraging success is expressed as mean number of successful attempts per second, foraging effort is expressed as mean number of attempts/second and mean number of strides per foraging attempt.

	Success	Effort	
Sites	Foraging Success (successes/sec.)	Attempts (attempts/sec.)	Locomotion (strides/attempt)
Surfer	0.086	0.322	8.0
Malaquite	0.105	0.329	7.2
Matagorda	0.096	0.338	6.7

Kruskal-Wallis ANOVA (Siegel, 1956) was used to analyze differences among the three sites with respect to activity budgets. For the purposes of this analysis, only records without disturbance were compared so that the comparison could be comparable across sites. Activities were categorized into active (running or flying), resting (sitting, standing, or preening), aggression (aggressive interaction which may include running, flying or displaying), or foraging. No significant differences were detected among sites and a summary representing the average behavioral profiles at each site is provided in Table 4.

Table 4. Comparison among sites for observations of piping plovers without disturbance. Profiles are presented as means of percentages in each activity. Comparisons were analyzed using the nonparametric Kruskal-Wallis ANOVA with 2 degrees of freedom and the chi-square statistic and probabilities are reported.

	Mean Percentages of Sample in Activity			
Sites	Foraging	Resting	Active	Aggression
Surfer	89.5	1.3	3.6	5.5
Malaquite	86.7	6.8	3.3	2.1
Matagorda	96.2	1.8	1.5	0.4
X^2	5.47	0.68	4.08	3.14
P	0.06	0.71	0.13	0.21

T-tests (Sokal and Rohlf, 1981) were used to compare the foraging efficiency (successful attempts/second), foraging effort (attempts/second), and locomotory foraging effort (strides/attempt) between piping plover records with pedestrian encounters and records without pedestrian encounters. Likewise, a t-test was used to compare these variables between records with vehicular encounters and records without vehicular encounters. Pedestrian comparisons were made using data from Surfer and Malaquite Beaches. No significant effect of presence of pedestrians was detected for foraging efficiency ($t = 0.46$, $df = 263$, $p = 0.648$), foraging effort ($t = 0.20$, $df = 277$, $p = 0.845$), or locomotory effort ($t = 0.30$, $df = 104$, $p = 0.763$). Vehicular comparisons were restricted to Surfer Beach (the only beach with significant vehicular traffic). No significant effect of presence of vehicles was detected for foraging efficiency ($t = 1.58$, $df = 137$, $p = 0.116$), foraging effort ($t = 1.69$, $df = 147$, $p = 0.094$), or locomotory effort ($t = -1.96$, $df = 49$, $p = 0.055$). ANOVA analysis also revealed no significant effect of beach tidal condition on any of the three variables.

The nonparametric Mann-Whitney U (Siegel, 1956) test was used to compare behavioral profiles between records with pedestrian encounters to those without pedestrian encounters. Activities were categorized into foraging, resting and active to evaluate the effects on important aspects of the birds' energy budget. Significant differences were detected between percentages of time spent foraging (see Table 5) with and without pedestrian encounters and between percentages of time active (see Table 5) with and without pedestrian encounters. While there is a seasonal effect on piping plover time budgets as presented in Table 6, analysis of pedestrian effects within seasons does not change the significance nor direction of the results of the analysis.

Table 5. Comparison between observations of piping plovers encountering pedestrians with those not encountering pedestrians. Analyses of Surfer and Malaquite Beaches are made separately. Profiles are presented as means of percentages of time spent in each activity. Comparisons were analyzed using the nonparametric Mann-Whitney U and the U statistic and probabilities are reported.

	Mean Percentages of Sample in Activity			Number of Records
	Foraging	Resting	Active	
Surfer				
with pedestrian	83.5	2.6	9.2	32
no pedestrian	90.7	7.2	6.6	111
U	1208.5	1556.5	1166.5	
P	0.006	0.2118	0.0030	
Malaquite				
with pedestrian	83.3	6.8	9.9	43
no pedestrian	87.8	7.1	5.1	78
U	1080.0	1504.5	984.5	
P	0.001	0.260	0.002	

Table 6. Seasonal comparison of observations of piping plovers without disturbance across all three sites. Profiles are presented as means of percentages of time spent in each activity. Comparisons were analyzed using the nonparametric Mann-Whitney U and the U statistic and probabilities are reported.

	Mean Percentages of Sample in Activity			Number of Records
Season	Foraging	Resting	Active	
Migratory	88.0	4.8	7.1	97
Winter	93.8	2.4	3.8	44
U	1535.5	1983.5	1564.5	
P	0.007	0.399	0.010	

Mann-Whitney U analysis for differences between piping plover records on Surfer Beach with and without vehicular encounters was also accomplished. These analyses revealed no significant differences for percentages of time spent foraging, resting, or active between records with and without vehicular encounters.

While fewer records were available for snowy plovers, similar results were discovered. Results for pedestrian and vehicular comparisons are provided in Table 7.

Table 7. Comparison between observations of snowy plovers encountering pedestrians with those not encountering pedestrians on Surfer and Malaquite Beaches. Comparisons between observations of snowy plovers on Surfer Beach with vehicular encounters to those without encounters is also provided. Profiles are presented as means of percentages of time spent in each activity. Comparisons were analyzed using the nonparametric Mann-Whitney U and the U statistic and probabilities are reported.

	Mean Percentages of Sample in Activity			Number of Records
	Foraging	Resting	Active	
with pedestrian	66.7	22.2	11.1	11
no pedestrian	81.0	14.1	5.0	23
U	66.0	81.0	68.0	
P	0.025	0.080	0.030	
with vehicles	78.5	11.0	10.5	6
no vehicles	77.3	17.2	5.6	9
U	16.0	20.0	24.5	
P	0.224	0.456	0.776	

Insufficient data is available to allow for reliable analysis of roosting bird behavior, however a behavioral profile for roosting snowy and piping plovers is provided in Table 8. This profile is based on 30-minute focal animal samples made on individuals first located in as roosting (not foraging) condition.

Table 8. Behavioral profiles of 16 piping plovers and 14 snowy plovers based on thirty 30-minute focal animal samples. Mean percentages of observation period are provided.

Activity	Piping Plover	Snowy Plover
Foraging	16.1	12.4
Running	2.3	3.9
Flying	0.3	0.3
Sitting	53.2	36.2
Standing	16.1	34.4
Preening	11.9	12.3
Aggression	0.04	0.10

Discussion

Two significant factors were revealed from analyses of time/activity budgets for piping and snowy plovers and from analyses of correlations between bird number and density of disturbance factors. First, there was a significant difference between birds (both piping and snowy plovers) encountering pedestrians and those not encountering pedestrians with encounter-free birds spending proportionately more time foraging and proportionately less time in active nonforaging behavior. This suggests that interactions with pedestrians on beaches cause birds to shift their activities from calorie acquisition to calorie expenditure.

Interestingly, interactions with vehicles using the beach did not have a similar effect. This may be due to the difference in interactions relative to foraging plovers. Of 134 vehicle encounters recorded, only 3 of these approached the focal animal directly (the rest had a tangential trajectory relative to the focal animal) and the average closest estimated distance between the bird and the vehicle was 47 meters. In contrast, of 124 pedestrian encounters with similar data recorded, 42 approached the focal animal directly and the average closest estimated distance to the focal animal was 33 meters. Because pedestrians (beachcombers, fishermen, swimmers, etc.) tend to use the swash zone, they also tend to interact more directly with shorebirds foraging in that same area. Because vehicles tend to avoid the swash zone, their interactions with foraging plovers is more distant, less direct, and more fleeting (as vehicles tend to move at about 15 miles/hr along the beach). Pfister and Harrington (1992) noted an effect on various shorebird species of human disturbance using indirect measures.

The other significant result, the negative correlation between vehicle number and piping plover number on Surfer Beach, seems puzzling given the previous analysis. If vehicles do not appear to have a direct effect on plover time budgets, why is there a significant negative correlation? There is a significant correlation between pedestrians on the beach and number of vehicles on the beach ($R = 0.89$, $P < 0.001$). While this did not result in a significant negative correlation between pedestrians and piping or snowy plovers, it could have the overall effect of decreasing the time available to plovers to forage. Given this circumstance, plovers may decide to move to other habitats or areas of the beach less available to pedestrians.

Results from this study contrast to some degree with those of Staine and Burger (1994). Their results indicate a more marked effect of disturbance on foraging birds (36% decrease in time devoted to foraging). Their results also showed a 27% decrease in peck rate as a result of human activity and no such reduction in foraging effort was detected in this study. Their study differed in being on the breeding ground and focusing on nocturnally foraging birds.

The effects of human disturbance on the time and energy budgets of foraging plovers and shorebirds during the winter is unknown. Reductions in time spent foraging may be sufficient to cause birds to move to habitats where time budgets are unaffected by human disturbance. This may entail moving to bayside habitats or beaches occupied by fewer pedestrians. Nocturnal foraging may become an important option to avoid human disturbance and take advantage of nocturnal prey organisms (Dugan, 1981; Burger and Gochfeld, 1991).

Observations by Dr. Allan Chaney and Mr. Gene Blacklock and others suggest that piping plovers (and presumably other species) become habituated to interactions with humans with flight distances becoming greater in areas where plovers do not as frequently encounter humans. This effect was not investigated in the current study.

Additionally, effects of vehicular traffic on prey species upon which these bird species depend has not been thoroughly investigated. Vehicles driving on the beach may cause compaction of the substrate thereby causing a shift in benthos community structure. In addition, beach maintenance, including the scraping of the beach and removal of detrital material has an unknown effect on the benthos upon which beach foraging piping and snowy plovers depend.

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