Plover and Least Tern Nest Monitoring and Disturbance Comparisons between Three Coastal Sites in Texas

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Final Report
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Introduction

American Bird Conservancy and its partners are working to protect beach-nesting sites for solitary and colonial nesting birds such as Snowy Plovers, Wilson's Plovers and Least Terns with the long-term conservation goal of maintaining or increasing their nesting success. In order to determine current nesting success for these species and to establish a baseline for management practices contributing to increasing populations, ABC provided funding to an independent contractor to monitor three nesting sites near Corpus Christi, Texas.

Study Sites

There are three areas we monitored for this project: A) Mollie Beattie Habitat Community (MB), B) Mustang Island State Park (SP) and C) Nature Preserve at Charlie's Pasture in the city of Port Aransas (PA). All three areas are located on the bay side of Mustang Island, which is a barrier island between the Gulf of Mexico and Corpus Christi Bay in Texas. These sites were selected because they contain a mosaic of flats (sand, mud, algal (*Lyngbya* spp.)), tidal and non-tidal water, and scattered vegetation communities (seacoast bluestem prairie, halophytic forbs and grasses, and mangroves), all of which are known to support nesting of target species. Additionally, these three sites are under varying degrees of protection and management based on their ownership, and therefore subject to different levels and types of disturbance.

Mollie Beattie is approximately 60% blue-green algal flat, which occasionally floods, and 40% sand flat (Figures 1, 2). Its total area is roughly 1.5 km^2. Small partially vegetated mounds up to 0.5 m tall are scattered throughout the area. A 33 m wide permanent saltwater slough separates the largest part of this habitat community into three parts.

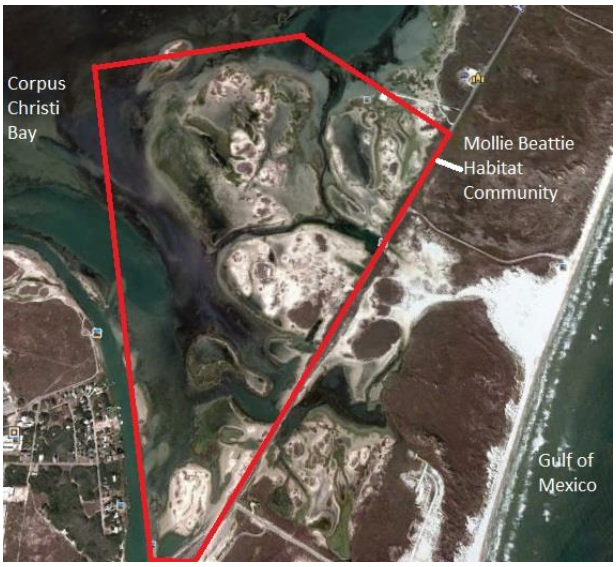

Figure 1. Mollie Beattie Habitat Community.


Figure 2. Mollie Beattie sand flat. The blue-green algal flat in this area is shown flooded in this photograph.

Mustang Island State Park is mostly composed of sand flats interspersed with low vegetated mounds (Figures 3, 4). Along the bay, there are many narrow sloughs lined with black mangrove. Further inland, the sand flats are replaced by large swaths of shoregrass and other dense vegetation (dark brown areas in Figure 3). The algal flats at this site are restricted to the very southern tip and the northern third. The surveyed area of this site was approximately 3.81 km^2.

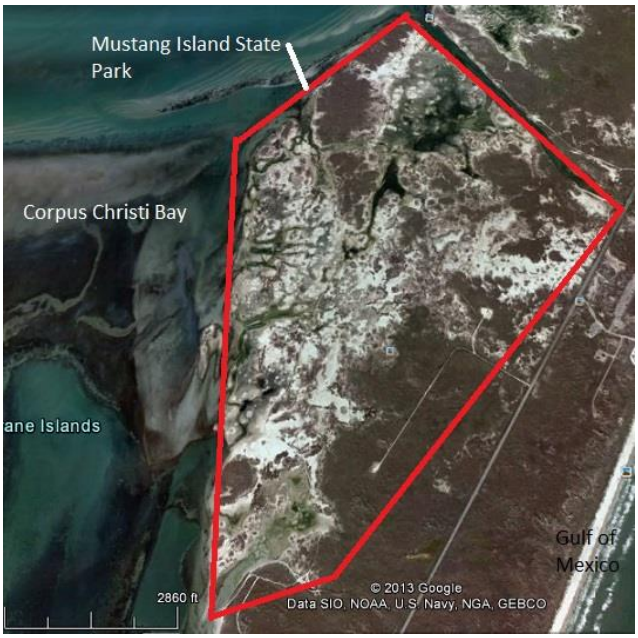

Figure 3: Mustang Island State Park, bay side, as seen from space via GoogleEarth.


Figure 4: Vegetated mounds surrounded by sand flat at Mustang Island State Park.

Nature Preserve at Charlie's Pasture in Port Aransas is largely composed of hard-packed sand, salt, and blue-green algal flats (Figures 5, 6), which occasionally flooded during high tide or after heavy rainfall. There are small pockets of vegetated mounds, but in much smaller quantities than at Mollie Beattie or Mustang Island State Park. The approximate utilized nesting area for this site was 0.44 km^2.

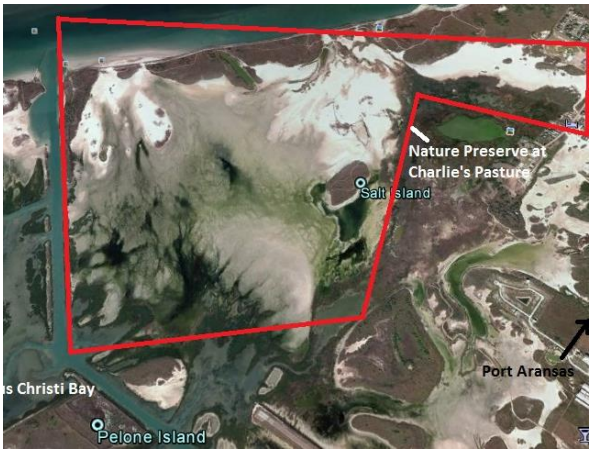

Figure 5: Nature Preserve in Port Aransas site, as seen from space via GoogleEarth. Note very large areas of sand and algal flats.


Figure 6. One of the large sand flats at Port Aransas. This is preferred habitat for Least Terns at this site. Note ATV tracks.

Methods

Nest searching

Snowy Plovers and Least Terns usually nest in open flats, while Wilson's Plovers typically place their nests among or underneath sparse vegetation. We began by walking suitable nesting habitats and looking for adult birds. While searching, we utilized the Track mode on a Garmin GPS and overlaid the data into Google Earth to determine whether the suitable nesting habitats were being thoroughly searched.

Once we located adult plovers, possible presence of a nest nearby was inferred from behavior. If adults vocalized and remained in the area, it was likely that there was a nest nearby (or chicks, if it was later in the season). We located nests either by searching appropriate habitat nearby or by distancing ourselves from the adults and waiting to see if one adult returned to a probable nest site. The first method was most useful if the adults were observed sneaking away from a nest or if they were notably agitated by the observer's presence (i.e. staying very close to the observer (<10 m) or performing Broken Wing Display). If we had not seen the adult leave the nest or could not find the nest by searching, we employed the second method.

Tern nests were found in a similar manner. Adult terns constantly incubate nests, and they most often took flight directly from the nest and landed very close to it. The most effective approach was to back away and wait for the adult terns to return to the nests.

Nests of non-target species, including Black-Necked Stilt, Common Nighthawk, Willet, Killdeer, and Horned Lark were sometimes found incidentally while searching for target species nests. We marked these nests with a GPS waypoint but did not actively monitor them.

Nest monitoring

Once we located a target species nest, we marked its location with a GPS. We took photographs of all plover nests and their surroundings. We then re-visited plover nests approximately twice per week during incubation, and more often in the week right before the hatch date.

Least Tern nests were usually checked once per week due to the large number of nests compared to the plovers. Initially, tern nests were monitored mostly by walking amongst the nests, which heavily disrupted the adults and was time-consuming. We implemented a new monitoring method in July, which was to choose a consistent viewpoint at least 20 m away and count all the nesting terns in an area. We created a simple diagram of each colony in order to track individual nests. This allowed the contractor to quickly assess any changes (i.e. hatching, failures) in the nesting area without disrupting the adults. We only entered the area if a new bird was present or a previously existing bird was missing (as determined by the diagram).

When we found a new plover or tern nest with more than one egg in it, we floated one egg per nest in a shallow plastic container of fresh water to determine projected hatch date (Figure 7). When first laid, eggs will lie horizontally on the bottom of the container, and by the end of their development they float

at a 45° angle at the top of the water. Hatch dates were estimated on a 27- day scale for plovers, and 19-day for Least Terns.

When we re-visited a known nest and found it empty with no adults or chicks nearby, we checked its approximated hatch date. If the nest was empty more than two days before its hatch date, we assumed the nest had failed and then searched the immediate area for clues concerning the cause of failure such as predator tracks (Figure 8), large egg fragments and/or yolk, or flooding. If a nest was found empty within two days of its hatch date, we assumed it had hatched. In July we also began searching presumably hatched nest cups for tiny egg fragments, which are created when chicks successfully pip out of their eggs but do not occur when the eggs are depredated (Mabee 1997). These egg fragments are 1-3 mm wide and a pale blue-green on the inside, occasionally with membrane still attached (Figure 9). The fragments fall into the nest lining material and therefore do not get carried away by adults with the larger egg pieces.

Figure 7. Wilson's Plover egg being floated in small plastic container. This egg is approximately 5 days into incubation

Figure 8. Coyote tracks next to a depredated Least Tern nest (yolk visible in lower left corner).

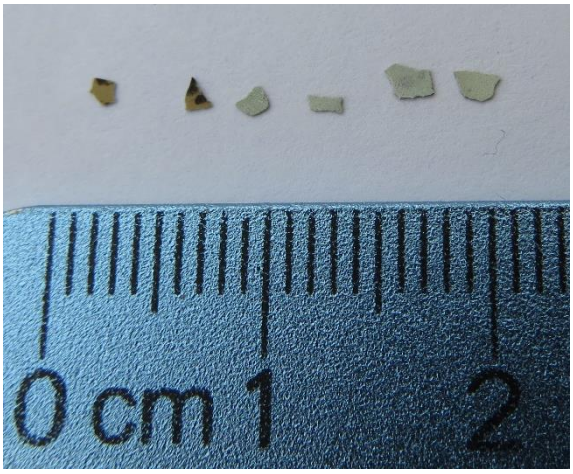

Figure 9. Eggshell fragments found in 3 successful nests. The left two show the outside camouflaged colors; the four right-most fragments show the light blue color of the insides of the shells.

Nest parameters

At the end of the season when all plover nests were empty, we returned to nests to measure habitat parameters. We recorded dominant vegetation within a 1 m radius of each former nest. Plant species were only considered dominant if they comprised more than 30% of the area. We examined nest cups to document the substrate and nest lining material. In order to determine the percent visibility of each nest, we stood directly over top of the nest and estimated the percentage of the nest cup that was visible. Using a handheld compass, we also determined each nest's relevant orientation. The orientation was measured either from the base of the nearest (usually covering) vegetation that was over 0.33 m tall, or from the center of the vegetated mound that the nest rested on. Least Tern nest parameters were not measured.

Data recording and entry

Field notes and weather measurements were recorded every day. These notes included new GPS waypoints, where adult birds were seen or new nests were found, and the status of re-visited nests. We collected multiple data points for active nests, including date found, date of each egg laid (if observed), projected hatch date, actual hatch date, and nest fate. All data were managed in Microsoft Excel.

Disturbance

All signs of disturbance were recorded and many were photographed. These disturbances included vehicle sightings or tracks, predators and most predator tracks (except coyote tracks, which were seen daily), and loose domestic dogs (Figures 6, 10, 11).

Figure 10. Road vehicle tracks at Mollie Beattie, driving directly through a sand flat and low vegetation.

Figure 11. Coyote watching contractor during nest searching activities at Mollie Beattie.

Trapping, Banding, and Geolocator Attachment

Adult Snowy and Wilson's Plovers were trapped via a box trap set up over the nest. The trap consisted of a metal cage with three enclosed sides and a roof with a small latched door, and a hinged fourth side that served as the entry to the trap (Figure 12). It was spraypainted a pale sand color to be less conspicuous. We affixed a small powerful magnet to the door to ensure that the door "locked" to the trap and prevented the bird from escaping. The box could also be deployed as a drop trap, in which the closed box was propped up over the nest using a 15 cm stick. The method depended on a nest's location. Nests underneath vegetation were set up as a "door" trap, to ensure that the bottom of the trap stayed flush against the ground. Nests in open habitat were set up as a "drop" trap.

We attached braided fishing line on a reel to the door or the stick. The trapper walked at least 35 m away, holding the reel, and hid behind vegetation or flat against the ground. Once the plover was sitting on its nest, the trapper pulled the fishing line to drop the door or the entire box over the bird. The trapper then moved as quickly as possible to remove the bird from the trap in order to minimize any risk of injury to the bird or nest, and the trap was immediately removed from the area.

Figure 12. Box trap being used in "door" mode.

Once caught, we gave each bird a uniquely numbered metal band above the right ankle. Snowy Plovers received aluminum bands and Wilson's Plovers received stainless steel bands. A single modified Darvic band was placed on both species above the left ankle as a regional identifier (red/white/red, the "white" added by affixing a thin piece of pinstriping tape to a red band). Adult birds also received uniquely colored Darvic bands below both ankles (Figure 13). Wilson's Plovers nesting on Mustang Island got a blue band below the left ankle, while Snowy Plovers on Mustang got a grey band. The lower right leg was reserved for a unique two-band color combination, which allowed us to determine each bird's identity from a distance.

The following morphological measurements were taken: Weight, using a digital scale; entire head length and bill length, using digital calipers; wing length, using a wing stop ruler; and the primary molt stage.

Due to the size of the area, total number of birds present, and limited staff, it was not possible to band all nesting birds at these sites. Typically only one bird of a pair was incubating the eggs at a time, so only one could be trapped unless we revisited the nest while the other adult was tending it. The goal was to

uniquely identify a sufficient number of birds to allow for some detection of re-nesting and/or interactions between individuals with a known nesting history.

Since all eggs of a plover nest usually hatch within a 24 hour period, and the chicks are mobile and often leave the nest area within hours of hatching, we could not effectively monitor chick growth and survival as part of this project. However, when encountered, we caught the chicks by hand, then weighed and banded them with a uniquely numbered metal band and a modified red/white/red Darvic band. Chicks were not given Darvic bands below the ankles. If they are re-captured as adults in subsequent years, they will then receive uniquely colored bands. Captured chicks were associated with a specific known nest and/or banded parent(s) when possible.

At this time very little is known of the migratory or wintering phases of Wilson's Plovers in the western Gulf of Mexico, and this information is critical for understanding population dynamics and the status of conservation throughout the birds' range. CBBEP obtained 13 geolocators, paid for by US Fish & Wildlife Service Region 2 Migratory Bird Office, to help gather data on migration and wintering movements. Geolocators record light level data for a period of at least one full year, and these data can then be used to approximate an individual plover's location. These geolocators store the data but do not transmit it, so we will search for and trap these birds in spring/summer 2014 to recover the units for download and analysis. To install these geolocators, the "backpack" harness-style geolocators were strung onto Teflon ribbon. The ribbon looped around both upper legs and behind the wings. They were knotted in place and the knots were secured with superglue and UV glue (Figure 14). Birds were monitored for a short period of time after release to ensure there were no signs of discomfort or inhibition of movement. None was detected. This is the first successful deployment of geolocators on this species.

Figure 13. Unique combination of Darvic color bands. The metal band is on the upper right leg and is difficult to see here.

Figure 14. Geolocator on the back of Wilson's Plover. The white/gold light stalk of the geolocator is visible in contrast to the bird's feathers.

Results:

Nest numbers and fates

Snowy Plover	MB	SP	PA
Hatched	0	0	4
Depredated	0	0	4
Abandoned	0	0	2
Unknown	0	1	3
Total	0	1	13

Table 1. Nest fates for Snowy Plovers at Mollie Beattie (MB), State Park (SP), and Port Aransas (PA). One nest was a failed re-nest.

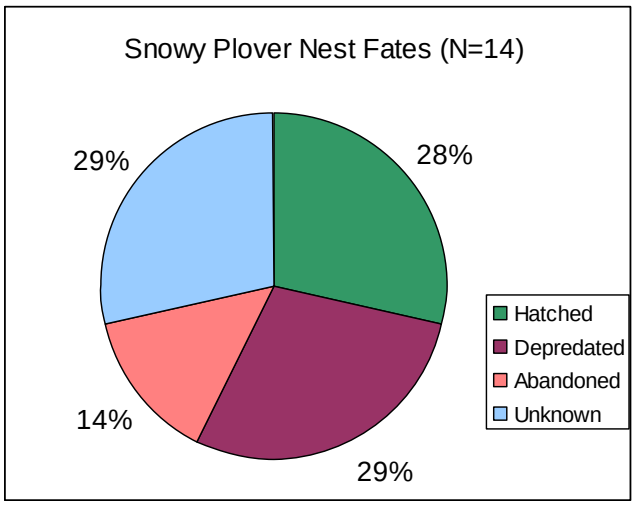

Figure 15. Nest fates of all Snowy Plover nests in all 3 locations

Wilson's Plover	MB	SP	PA
Hatched	5	6	3
Depredated	5	8	6
Flooded	0	0	1
Unknown	5	3	1
Total	15	17	11

Table 2. Nest fates for Wilson's Plovers. One successful nest at PA was a re-nest.

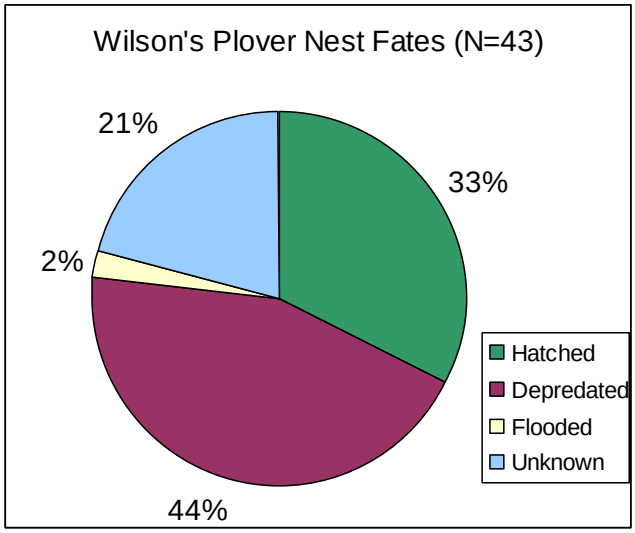

Figure 16. Breakdown of all Wilson's Plover nest fates in all 3 sites.

Least Tern	MB	SP	PA
Hatched	1	11	24
Depredated	3	5	9
Flooded	1	3	7
Abandoned	0	1	2
Unknown	0	7	74
Total	5	27	116

Table 3. Nest fates for Least Terns.

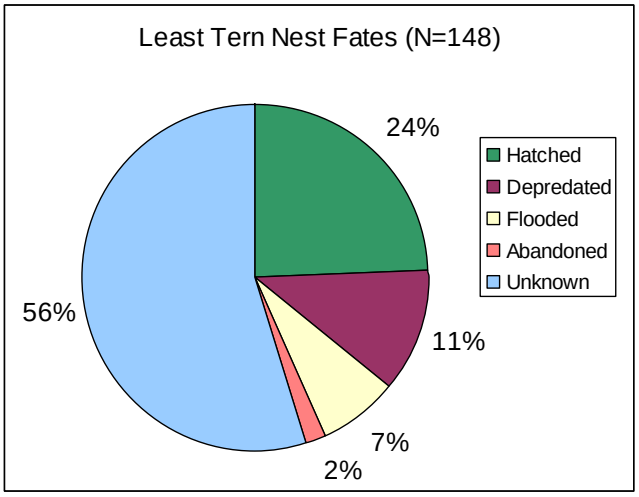

Figure 17. Breakdown of all Least Tern nest fates.

Clutch size

Wilson's Plover clutch sizes ranged from one to three eggs. Of the 39 nests that had confirmed completed clutches (i.e. the nests were not predated before clutches were completed), 31 nests had 3 eggs. Seven nests had two eggs, and one nest had only one egg. Of the ten Snowy Plover nests that had completed clutches, nine nests had 3 eggs and the remaining nest, which was later abandoned for unknown reasons, had 2 eggs.

Nest characteristics

Wilson's Plovers

Wilson's Plovers most often chose nest sites surrounded by saltwort (*Batis maritima*), glasswort (*Salicornia* spp.), Wolfberry (*Lycium carolinianum*), shoregrass (*Monanthochloe littoralis*), saltgrass (*Distichlis spicata*) and Black Mangrove (*Avicennia germinans*). Two nests were notable exceptions in that they were located in open flats and not closely associated with any vegetation. One of these nests was situated in a 1.5 m wide mound of broken glass, metal, and other human detritus (Figure 18), and the other lay next to a broken and rusted sign laying on the ground (Figure 19). Both were more than 7 m from vegetation.

Figure 18. Exposed Wilson's Plover nest in a pile of broken glass, metal, and other detritus.

Figure 19. Exposed Wilson's Plover nest next to rusted metal sign.

Figure 20. One of the 8 Wilson's Plover nests located underneath a Black Mangrove.

Eight pairs nested beneath live or dead Black Mangroves (Figure 20), two nested underneath glasswort, and three nested beneath dead Wolfberry. Nest exposure ranged from 30-100% visibility from above, with roughly equal numbers of failed and hatched nests having no vegetative cover and 100% visibility (Figures 21, 22).

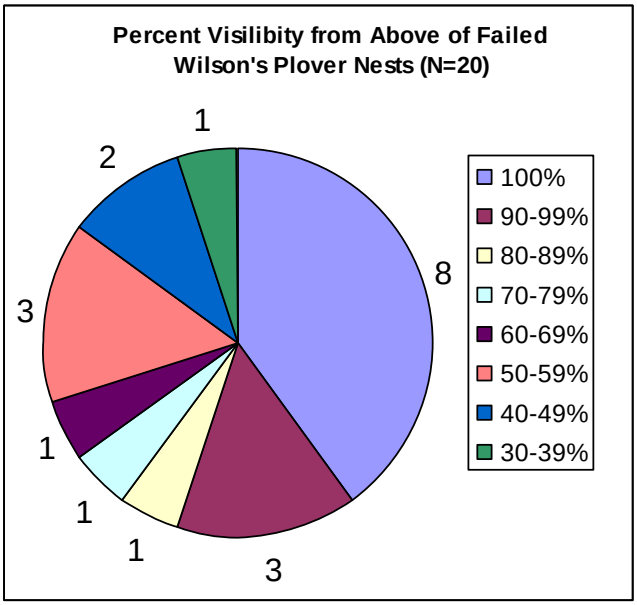

Figure 21. Number of failed Wilson's Plover nests with each range of visibility from above. No nests had less than 30% visibility.

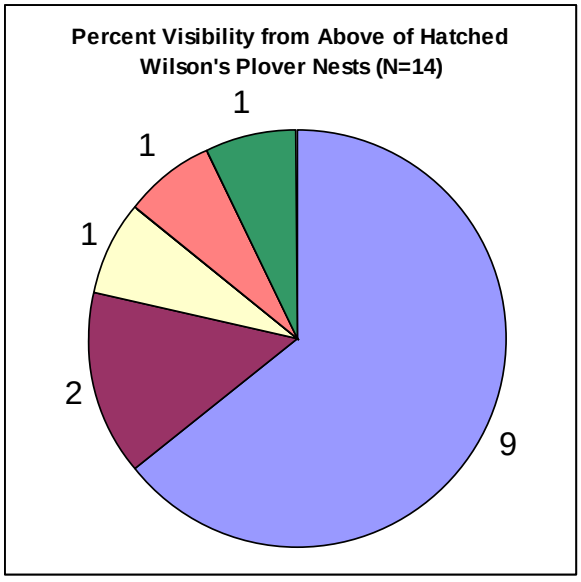

Figure 22. Number of hatched Wilson's Plover nests with each range of visibility from above. Legend and colors are the same as Figure 22. No nests had less than 30% visibility.

All Wilson's Plover nests were cup-formed. Forty-one of the 43 nests were scrapes; the remaining two were located on hard-packed muddy sand and were made from well-built raised nests, approximately 15 cm across and 2 cm high. Four nests were built on algal flats, and three of these were lined with small (<1 cm) dried flakes of blue-green algae. The remaining 39 nests were built in or on sand. Most commonly the nests were lined with 2-6 cm pieces of soft, dried vegetation, such as saltwort, shoregrass pieces, twigs, and mangrove leaves. A few also had 1 cm shells mixed in with the vegetation. Six nests had very little or no lining.

Orientation of nineteen nests relative to the base of its covering vegetation or proximate vegetated mound was recorded (Figure 23). No nests were oriented between 10-80 and 210-295 degrees. The remaining nests either did not have covering vegetation or were located in large uniform swaths of short vegetation (such as saltwort or shoregrass) with no relevant orientation.

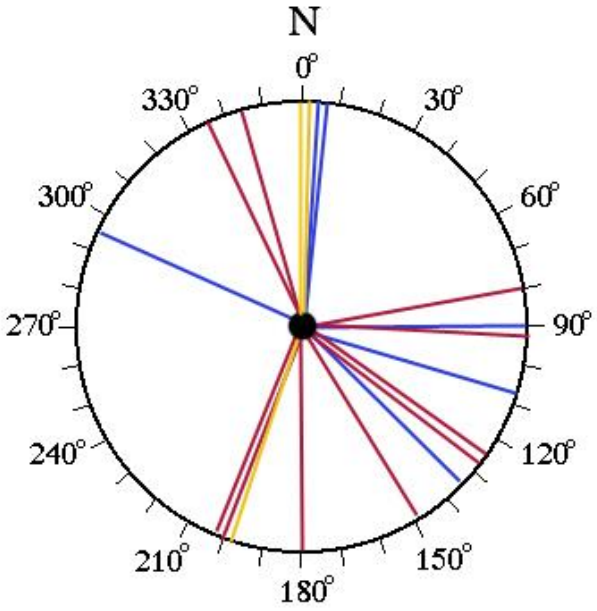

Figure 23. The orientation of Wilson's Plover nests in relation to nearby plants and/or the center of vegetated mounds. Blue indicates a successful nest, red a failure, and yellow an unknown fate.

Snowy Plovers

Nine of the 14 Snowy Plover nests were located in open sand flats with a heavy shell component, and were lined with small (0.5-1.0 cm) shells. Three nests were in the middle of algal flats and lined with 3-8 mm pieces of dried blue-green algae. The two remaining nests were at the base of plants. One was at the base of an unidentified dead 10 cm tall plant, oriented at 122 degrees from its base; the other, which had flooded before it was found, was underneath a dead plant approximately 0.33m in height.

All of the Snowy Plover nests were less than 30 meters from a patch of dense vegetation. Most were within 10-20 meters of vegetation.

Nest timing

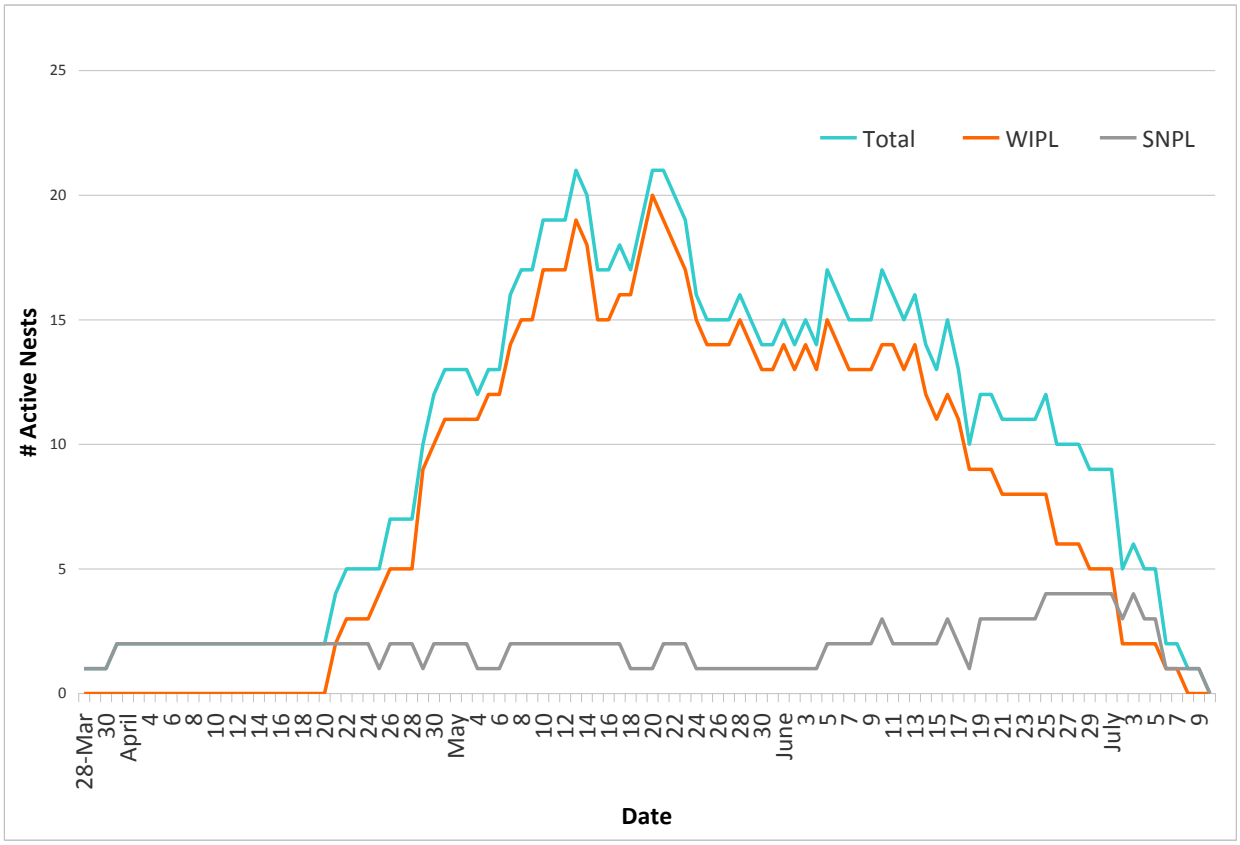

Figure 24. Number of plover nests known to be active on each date. The highest incidence was 21 active nests, which occurred on May 13, May 20, and May 21. All known nests were inactive by July 10.

Disturbance

Disturbance	MB	SP	PA	Total
Vehicle seen	1	31	0	32
Vehicle tracks	3	10	0	13
ORV tracks	0	9	6	15
ORV sighting	0	0	2	2
Bicycle tracks	1	0	3	4
Coyote seen	2	2	0	4
Loose dog seen	0	1	1	2
Feral hog tracks	0	3	10	13
Total	7	56	22	85

Table 4. Disturbances recorded by site. Coyote tracks were not recorded because they were seen nearly every day.

Banded birds and Geolocators

Snowy Plover	MB	SP	PA	Total
Females	0	0	2	2
Males	0	0	5	5
Unknown sex	0	0	1	1
Chicks	0	0	5	5
Total	0	0	13	**13**

Table 5. Number of Snowy Plovers banded at each site.

Wilson's Plover	MB	SP	PA	Total
Females	5	5	5	15
Males	4	4	3	11
Chicks	7	6	3	16
Total	16	15	11	**42**

Table 6. Number of Wilson's Plovers banded at each site.

Geolocators	MB	SP	PA	Total
Females	3	3	1	7
Males	2	1	3	6
Total	5	4	4	**13**

Table 7. Number of Geolocators placed on adult Wilson's Plovers at each site.

Physiological measurements

		Wing (mm)		Head (mm)		Bill (mm)		Weight (g)	
WIPL	**N**	**Avg**	**St Dev**	**Avg**	**St Dev**	**Avg**	**St Dev**	**Avg**	**St Dev**
All adults	**25**	119.36	2.29	49.33	1.00	20.96	0.86	60.6	4.7
Female	**14**	119.5	2.5	49.44	0.81	20.79	0.83	63.0	4
Male	**11**	119.18	2.09	49.19	1.23	21.19	0.88	57.8	3.8
Chicks	**15**	-	-	-	-	-	-	9.3	0.69
SNPL									
All adults	**8**	104	2.82	41.3	0.71	15.91	0.97	40.2	3.3
Female	**2**	103.5	3.54	41.94	0.18	16.87	1.8	42.2	2.4
Male	**5**	104	2.92	41.08	0.78	15.6	0.49	38.6	2.9
Chicks	**2**	-	-	-	-	-	-	5.7	0.71

Table 8. Averages (Avg) and standard deviations (St Dev) of physiological measurements taken in Wilson's Plover and Snowy Plover adults and chicks. An additional 4 chicks were banded, but due to equipment malfunction their weights were not taken. One Snowy Plover adult had ambiguous plumage and was counted in "all adults" measurements but was not included in either individual sex.

Discussion

Causes for Nest Failure

One of the most common confirmed reasons for nest failure in all three sites was coyote predation. Coyote predation is a natural occurrence, but it is possible that our nest searching activities may have increased the frequency of these predations. Coyote tracks were seen at all sites almost every day, and often occurred right next to older human footprints, suggesting that the coyotes may follow human tracks and/or scent. We spotted four coyotes watching observers during nest searching and monitoring activities (Table 7). In an attempt to deter additional predation due to human activities, we stayed at least 2-4 m away from the nest unless floating eggs, walked a large circle around nest sites instead of walking directly to and from the nest, and used Scent-Away on shoes and equipment. Further research should be conducted on the best method for reducing coyote impact.

Two failed plover nests at Port Aransas had raccoon tracks right next to them. These nests were 167 m apart and failed within two weeks of each other, suggesting that it may have been the same raccoon. Nine failed nests did not show any signs of predator tracks nearby. It is possible that avian predators (such as laughing gulls and/or raptors) ate the eggs and did not leave tracks, or the hard and dense substrate could not hold tracks. These nests were recorded as "Unknown depredation failure."

The only other noted causes of nest failure were flooding and abandonment. Flooding caused by high tides and/or heavy rainfall destroyed at least twelve Least Tern nests and one Wilson's Plover nest. Though the Wilson's Plover nest remained intact with the eggs present, the adults abandoned the nest. Two Snowy Plover nests were abandoned for unknown reasons. Three Least Tern nests were abandoned in July after the rest of the tern nests in their small colonies hatched. Since abandoned tern nests were not found earlier in the season, this may indicate that adults with late-laid nests abandoned their own eggs in favor of moving with the rest of the colony.

Early in this project, many failed plover nests were attributed to "unknown" causes. This number is likely inaccurate since we did not start floating plover eggs until mid-May and because the contractor was not yet adept at reading signs of failure (i.e. observer bias).

The very high number of Least Tern nests at Port Aransas, their tendency to nest in existing "cups" with no nest lining, and the somewhat inaccurate GPS made it difficult to determine the fates of most nests at this site. Seventy-four of the 116 Least Tern nests at Port Aransas had unknown fates. Accuracy of fate determination was higher once we started floating all tern nests in mid-June, but still much lower than we could get with the plover nests.

Preferred Nesting Habitat

We were surprised to find Wilson's Plovers nesting beneath Black Mangroves, as we are not aware of this type of nesting preference being previously reported in published literature. Eight nests (19% of all nests found this season) were located underneath mangroves at both the State Park and Port Aransas sites, suggesting that it may be a fairly common practice. The adaptive benefit of nesting under mangroves, if there is any, could be related to several factors including predator evasion, microclimate, olfactory effects, or partial shading from direct sunlight. There is also evidence that mangroves increase

the soil height in conjuncture with rising sea levels brought on by climate change (McIvor et al 2013), which may be a desirable attribute for nesting birds (for example, this may reduce the risk of a nest flooding). There will likely be wide-spread ecological consequences from mangrove encroachment in these habitats, and the subject merits more study.

The amount of vegetative cover did not appear to have much effect on a nest's survival chances. A roughly equal amount of successful and failed nests had no cover. Many nest cups that were barely visible from the top were clearly visible from one side at or near ground level, so this may have a greater effect on the nest's chances of survival, especially from land predators. Other variables that may affect nest survival include the type and height of surrounding vegetation, any nearby tall cover for predators to hide in (we observed this happening when a coyote hid behind 0.5 m tall mangroves), and distance to nearest thick vegetation for those nests that had no cover.

Most nests with a relevant orientation were located between 330-10 degrees (NNW to N) and 80-200 degrees (E to SSW). None were located between 10-80 (NNE – ENE)and 200-295 (SSW – NNW) degrees. We had speculations that this may be due to the sun's path and the more intense and hotter sunshine that occurs in the western sky during the afternoon. This hypothesis should be explored further, possibly by using temperature gauges in the nest cups.

Water and food sources likely factor into Wilson's Plover nest site selection, but we did not find an accurate method for measuring these parameters. Many non-tidal water sources (i.e. ponds and flats that flood after rain but are cut off from the bay) are non-perennial and dried up during the summer months. Even some sloughs that were attached to the bay in May later became cut off or dried completely as the bay's water levels dropped due to drought. Fiddler crab holes, which are a preferred food source for Wilson's Plovers, were often located within a meter of nest cups during or after active nesting, but we did not officially record this data for this season. In subsequent years it may be insightful to measure the density and distance of fiddler crab holes from nest sites.

We did not perform a dedicated study of preferred Least Tern nest sites, but there were certain general characteristics that most nests exhibited. Terns nested in a variety of locations, including algal flats, sand and salt flats, and occasionally on the edges of small sparsely-vegetated mounds. All Least Tern nests were cup nests, but the method of nest formation varied between sites. Many at Port Aransas nested in footprints (human or coyote) and natural algal flat folds; only a small number created their own scrapes, which were usually in shell mounds. Few of the footprint "scrapes" were lined with shells or vegetation. Conversely, the terns that nested at the State Park and Mollie Beattie created their own scrapes, possibly due to the scarcity of footprints. These were usually lined with a small amount of vegetation or shell matter.

Least Terns almost always nested in small colonies, with 5-15 pairs actively nesting in the same general area. They nested as close as 3 m apart from each other. Small colonies occasionally survived or failed as a group, beginning and ending incubation (or being predated) at the same time. Early in the season at the State Park, six tern pairs attempted to nest individually, isolated from all other pairs. All of these nests were predated. Later in the season, a colony of approximately 15 pairs nested in the same small area, and all but six nests hatched (two flooded, two were predated, and two were abandoned, possibly after the other adults in the area completed incubation and moved with their chicks).

Snowy Plovers and Wilson's Plovers both nested amongst these Least Tern communities, often within 3-4.5 m of active Least Tern nests. They likely benefited from the aggressive nature that Least Terns

exhibit towards predators or other intruders (i.e. mobbing). The plover nests that were among the Least Tern colonies at Port Aransas had a higher rate of survival than those that were by themselves. All four of the nests that were surrounded by Least Tern nests survived, while only 3 out of 12 nests that were isolated (>20m) from other nests survived.

Disturbance

High human disturbance seemed to discourage birds from nesting. The southwestern section of Mollie Beattie closest to Packery Channel and the area surrounding the official parking lot occasionally hosted feeding birds, but only one nest was found there and it failed prematurely (due to coyote predation). This area is frequented by fishermen, and some people walk their dogs in the area, sometimes allowing them off leash. We saw vehicle tracks in all areas of Mollie Beattie except on the island isolated by the slough. The vehicle barriers at this site are rusted and broken in many places, giving the public easy access. While no nest failures at Mollie Beattie were directly attributed to human activities or domestic dogs, the limited nesting effort in these areas may be due to the increased presence of these factors. The other 12 of the 13 nests at Mollie Beattie occurred on the north side of the slough and on the island, where humans rarely ventured.

Although Mustang Island State Park and Port Aransas also attract human visitors, the general disturbance level seemed lower. The bay side of the State Park has limited access, with only one public 4-wheel-drive road leading to the very southern tip of the park. This road is well-used by off-road vehicles and 4-wheel drive road vehicles, so it was common to see fresh tracks or vehicles. Most days we saw 2-3 vehicles on the coast as far as one mile north of the road. The State Park is much larger than Mollie Beattie, so while there were more vehicles and vehicle tracks, the disturbances were more spread out. Only one pedestrian and one loose dog were seen in the state park; most people preferred to stay in their vehicles.

Port Aransas features a gravel path and raised boardwalk that winds through the best features of the nature preserve, so people have little incentive to leave the path. However, both plover species placed nests near this boardwalk. Zero of the six nests within 30 meters of the boardwalk hatched; one was abandoned, and the other five were depredated. Each time a human would walk by on the boardwalk, the incubating adult plovers would leave the nest area. This high level of disturbance may have contributed to these nest failures. Port Aransas also has a well-kept concrete and steel vehicle barrier that effectively excludes road vehicle traffic. ATV and bicycle tracks were the most common disturbances. Twice, Parks and Recreation vehicles were seen driving on the sand flats.

Feral hog (*Sus scrofa*) tracks were recorded at Mustang Island State Park and Port Aransas. The State Park usually only had one adult walking around, while Port Aransas once had a group of approximately eight adults and piglets. No failed nests were directly attributed to feral hog activities or depredation.

Trapping

Most Snowy Plovers were very wary about entering the trap when it was set up in “door” mode. They would often attempt to go through the mesh side of the trap instead of walking around to the front of the trap. One very small adult managed to escape through the side of the trap, and we later added a layer of chicken wire mesh to the sides of the trap to ensure that adults could not escape. We managed to capture 2 of the 8 Snowy Plovers with a “door” trap, but for the remaining six we had to catch using a

"drop" trap. Wilson's Plovers were more willing to enter a "door" trap; about half were captured using a "door" trap, and the other half were caught with a "drop" trap. While we had a magnet to keep the door closed after a bird was trapped, multiple adults escaped the trap by pushing very hard against the door and disengaging the magnet. Additional magnets should be affixed to the door in subsequent years to ensure that it stays closed.

Suggestions for continuation of project

Although the State Park was the largest area, Port Aransas actually had the highest number of nests. This year we spent a roughly equal amount of time at each site, but in subsequent years it may be more effective to divide field time based on the concentration of nests.

The Least Tern nests at Port Aransas were very difficult to keep track of during the project. A more precise GPS, floating eggs from all nests found, and possibly marking nests with something small and unobtrusive may help in areas with large colonies of nesting terns. Popsicle sticks stuck in the ground 1 m away from nests has proved to be an effective method of marking Least Tern nests in Grand Isle, Louisiana.

Wilson's Plover nest placement near the base of small mangroves is of special interest, since mangroves are already encroaching into habitat used by all of these species, and is likely to continue as a result of projected sea level rise and climate change effects. Further study should be conducted on the nests that occur underneath mangroves, possibly including such things as mangrove size, soil height underneath and around the mangrove, and nest cup temperature. We can measure the nest temperature for bare-ground nesting shorebirds with tiny recording devices placed inside the nests. These could be used to provide some potentially valuable information regarding the influence of nest site choice based on exposure to temperature extremes.

Port Aransas visitors would likely benefit from informational posters or interpretive signs about nesting birds. We were approached approximately six times there by curious visitors, asking about the birds and what our project was about. The City of Port Aransas Parks & Recreation Department has communicated willingness to install such signage and this will be accomplished through the efforts of project partners. Mollie Beattie also has an existing empty informational bulletin board that could provide visitors with information about nesting birds. A project to increase educational signage at this site is being coordinated through CBBEP and the landowner/manager (Texas General Land Office). Though the signage will cover a wide range of topics, those partners have been contacted and are willing to incorporate messaging about ground-nesting shorebirds into their signage effort. Mustang Island State Park is currently considering options regarding vehicular access to that site. The regional park director has expressed interest in signage and/or additional conservation measures to protect these species, and these efforts will be subject of ongoing discussions with project partners to make sure that they are congruent with any change the Park may make with regard to access.

The high incidence of coyote depredation and possible methods of reduction are worth investigating. It is likely that our nest monitoring and trapping activities increased the disturbance and human scent in nesting areas, and these activities should be kept to a minimum as a general rule. Greater distance should be kept from the nests while monitoring; usually when a nest is approached, the incubating adult can be seen running away from the site. This is a good indicator that the nest is still there and does not need to be closely examined.

Conclusion

This season, we found 14 Snowy Plover, 43 Wilson's Plover, and 148 Least Tern nests at our three sites. We banded a total of 55 plovers and placed 13 geolocators on Wilson's Plovers, which will yield bird movement and migration data in 2014. The most common habitat disturbances were vehicles and coyotes, both of which likely play a role in nest fate and nest site selection. These sites experience lower levels of direct human disturbance than other areas along the gulf where these birds nest, which means there is limited opportunity at these sites to interact with and educate the public. However, the findings from this first year of study provide baseline data about the chances of nest survival, preferred nesting habitat, and nest densities that occur in "natural" nesting scenarios in this area of Texas. Further study in subsequent years will expand upon these data and allow for greater understanding about the status of Gulf nesting shorebirds and the conservation measures required to maintain or increase their breeding success.

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