Evaluation of Bird Nesting Use of Restored Beach Habitat: 2016 Season Report
October 4, 2016

Least Tern loafing on the Caminada Headlands shoreline.

A Report of the:

Barataria-Terrebonne National Estuary Program

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Prepared for the:

The Coastal Protection and Restoration Authority

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Contents

Introduction

Background Information

Louisiana's barrier shoreline serves an important societal function through the protection of coastal communities and infrastructure by absorbing storm energy. It also provides necessary habitat for numerous species of wildlife. Millions of birds utilize these habitats each year either as a stopping grounds to refuel on long migratory journeys, or to breed and raise their young. In particular, the Caminada Headland in southeast Louisiana was identified by the Louisiana Coastal Area Ecosystem Restoration Study as essential habitat due to its role in the preservation and protection of gulf shoreline, inland wetlands and bays, as well as a significant and unique foraging and nesting area for threatened and endangered species (USACE 2004). Surveys conducted by the Barataria Terrebonne National Estuary Program (BTNEP) since 2005 have documented extensive breeding use along the Caminada Headland by Least Tern (*Sternula antillarum*) and Wilson's Plover (*Charadrius wilsonia*). Both species are listed on the U.S. Fish and Wildlife Service (USFWS) Birds of Conservation Concern (2008), making it a vital area to focus coastal conservation efforts.

Over the last several decades, the Caminada Headland has experienced significant shoreline erosion and land loss due to anthropogenic impacts, storm over-wash, saltwater intrusion, wind and wave induced erosion, sea level rise, and subsidence (CEC 2012). These factors, in conjunction with extensive development along the Gulf Coast, have drastically reduced the availability of prime foraging and nesting habitat for shorebirds (Johnson, 2016). To combat the issue of rapid land loss, Louisiana and the federal government have developed funding streams meant to help restore these important habitats. One such endeavor, The Caminada Headland Beach and Dune Restoration Project (BA-45), was designed to protect and preserve the structural integrity of the barrier shoreline and to restore hydrologic conditions, ecosystem processes, and habitats (CPRA 2015). Managed by the Coastal Protection and Restoration Authority of Louisiana (CPRA), construction of the project began in August of 2013 and was completed in January of 2015. One of the main goals of the project was to create approximately 303 acres of beach and dune habitat along the Caminada Headland through dredging and pumping sand from an offshore location at Ship Shoal (CPRA 2015). However, beach nourishments projects such as this one can degrade beach habitat for many species of wildlife, and monitoring studies are essential to determine the ecological impacts (Peterson and Bishop 2005). BTNEP, in collaboration with CPRA, are in the process of evaluating the impacts of the restoration from the construction phase, to the long-term effects of the completed project on the foraging and breeding ecology of shorebirds.

Focal Species

The Least Tern is the smallest tern species in North America. It is a widely distributed colonial nesting seabird that breeds both along major interior rivers and coastal beaches and islands, including those found in southeast Louisiana. The Least Tern spends its winters on the marine coastlines of Central and South America (Thompson et al. 1997). Its preferred nesting sites are relatively open beaches or islands with little vegetation. Unfortunately, these habitats are the same areas utilized by humans for recreation, residential development, and alteration by water diversion, which has led to a serious lack in suitable nesting habitat for the species and widespread population decline (Thompson et al. 1997). According to the North American Breeding Bird Survey, Least Tern populations have declined by about 88% between 1966 and 2015 (USGS 2015). The North American Waterbird Conservation Plan estimates a continental population of 60,000-100,000 breeding birds, and lists it as a Species of High Concern (Kushlan et al. 2002). Many historical breeding areas have been altered to the point that terns can no longer nest on them, or are subject to high rates of human disturbance and predation. The Least Tern is listed as a Species of Greatest Conservation Need in the Louisiana Wildlife Action Plan (Holcomb et al. 2015).

Much of the habitat loss and disturbance of traditional nesting areas was concurrent with a rise in buildings constructed with gravel-covered rooftops. Least Terns, along with several other species of beach nesting birds, began nesting on rooftops as early as the late 1950's with some success, and have been consistently documented utilizing them since that time (Butcher et al. 2007). The proportion of Least Terns nesting on beaches in the southeastern United States has decreased as the numbers of birds nesting on artificial habitats has increased. For example, in South Carolina between 1989 and 1995, the frequency of roof colonies as a proportion of all colonies increased from 14 to 61% (Krogh and Schweitzer 1999). Recently however, changes to building codes mean that gravel rooftops are being phased out and replaced by newly developed, energy efficient materials not suitable for nesting (Forys and Borboen-Adams 2006). This means that terns will again have to adapt to find new suitable nesting habitats.

The Wilson's Plover is a mid-sized ringed plover that is most easily distinguished by its thick, black bill and pinkish legs. It breeds on the American seacoasts from Virginia south to Brazil and the Caribbean, and on the Pacific from Baja California south to Peru (Bergstrom 1988). They are migratory in northern parts of their breeding range and spend winters from southern Mexico to northern South America, but remain resident in their more southern locations (Corbat and Bergstrom 2000). In Louisiana, Wilson's Plovers breed in coastal marine habitats across the southernmost portions of the state. Louisiana hosts a small, year-round resident population as well as a small, migrating population. The range-wide total population estimate for Wilson's Plover is 26,550-31,650 breeding adults, with the Gulf Coast population estimated at 3,000-3,200 breeding pairs (Zdravkovic 2005). Wilson's Plovers typically nest on beaches and near-shore islands, but the nest sites themselves can be highly variable. Studies have documented nesting on bare soil to pavement, on interdune areas to sand flats, and variable microhabitat characteristics with regards to amounts of shell, rock, vegetation and even nest decoration (Corbat and Bergstrom 2000; Bergstrom 1988; DeRose-Wilson et al. 2013). Like other beach nesting species, the Wilson's Plover is subject to ever increasing pressure from loss of habitat and disturbance. Due to these pressures, the species has been designated as a Species of High Concern in the U.S. Shorebird Conservation Plan (Brown et al. 2001). The Louisiana Department of Wildlife and Fisheries (LDWF) has listed Wilson's Plovers as imperiled under their Louisiana Wildlife Action Plan due to many threats including habitat destruction, conversion, fragmentation and human disturbance (Holcomb et al. 2015).

Research Justification and Plan

Least Terns as well as Wilson's Plovers, have taken to nesting on dredge-spoil islands due changes in natural habitats. Navigable waterways and channels are maintained in the U.S. to the proper depths through dredging, which removes the excess material and redeposits it elsewhere. This material is used to form or restore islands, creating the early successional habitat preferred by many beach nesting birds. Studies in the 1970's realized just how important the use of dredge material sites are to nesting waterbirds, documenting 50-90% of key nesting sites in the Atlantic and Gulf Coast states were on dredged material (Golder et al. 2008). Since that time, these man-made habitats have become even more important, especially in Louisiana where land loss is so rapid and widespread. Creation and restoration of dune, beach, and back barrier marsh through use of dredge materials to restore or augment Louisiana's offshore barrier islands and headlands is commonly used (CPRA, 2016). Studies (Golder et al. 2008, Krogh and Schweitzer 1999, Leberg et al. 1995, Mallach and Leberg 1999, and Owen and Pierce 2013) have examined hatching success and nests site characteristics of dredge material islands. They have found that the success of these sites for nesting varies depending on the type of material utilized, leading to different rates of habitat suitability contingent on species-specific characteristics. Dredged material is often fine sand or silt, which is not ideal for Least Terns who prefer to nest on shell-rich substrates (Mallach and Leberg 1999) or coarse sand/loose gravel (Gochfeld 1983). While Wilson's Plovers have a wider range of suitable nesting habitats, information is still lacking on habitat characteristics of successful nest sites (DeRose-Wilson et al. 2013), nor is much known about how they respond to restored beach habitat. Most of the current research has been conducted on dredge spoil islands and not large-scale beach nourishment projects like the Caminada Headland Beach and Dune Restoration Project. While Mallach and Leberg in their 1999 Louisiana based study on Black Skimmers supplemented dredge material by creating 64, $1m^2$ plots with 2.5cm deep with shell, no studies are known that examine the effects of supplementation of dredge material on waterbird nesting at larger scale. Specifically, the large-scale addition of limestone and sandstone has not been tested.

BTNEP will conduct an experiment to evaluate nest site selection among substrate types and hatching success of Least Tern and Wilson's Plover along the Caminada Headland. In addition to examining how birds utilize the new habitat created by restoration, we will supplement the restored beach with the placement of #57 grade limestone and #57 grade sandstone. These materials were selected because they are both readily available in construction and economically feasible. Nine experimental plots of approximately 45,000 sq. ft. each have been delineated along the beach. Three plots will be left as the control, three will have a layer of approximately 2in of limestone, and three will have a layer of approximately 2in of sandstone. The project will last for a duration of three years beginning in April, 2016 and continuing through August, 2018. Year one will consist of a pre-treatment evaluation through monitoring breeding activity within all the study plots as controls, followed by placement of the substrate treatments in the fall of 2016. During years two and three, we will conduct the experiment using the supplemental material.

Nest predation by mammals, ghost crabs, and other birds can have devastating impacts on the success of ground nesting shorebirds. Predation is the primary cause of nest failure for most birds (Ricklefs 1969 and Martin 1992 in Smith et al. 2007). The study will also record habitat use of nest predators through identifying their tracks and use of motion sensor cameras to log their daily activity. The hope is that one of the substrates placed on the study area may make it more difficult for predators to find the nests, leading to greater hatching success. The data collected will help define nest fate associated with each substrate type through use of a nest survivorship model. Statistical analysis of the data would also determine whether there are any significant differences in the selection of nesting substrate and any significant differences in nest fate by substrate type. The goal of this study is to utilize the results to guide best management practices of future beach restoration projects to include the application of supplemental material if it would benefit nesting birds on the Louisiana coast.

Methods

Research Area

The area of focus is the section of beach restored by the Caminada Headland Beach and Dune Restoration Project BA-45 (Figure 1). Specifically, the nine study plots are located on “East Beach” otherwise known as “Fourchon Beach”, which lies East of the end of highway 3090 in Port Fourchon. The plots lie along the shore of the Caminada Headlands and stretch from approximately 29° 6'46.27"N, 90°10'29.05"W to 29° 7'10.45"N, 90° 9'49.65"W (Figure 2; Appendix A). The habitat consists of the dredge material pumped in from the offshore location on Ship Shoal. During 2014, native vegetative plantings occurred as part of the restoration plan. Plants were left to proceed through natural succession, and during the 2016 field season the majority of plants found within the plots were Sea Oats (*Uniola paniculata*) and Bitter Panicum (*Panicum amarum*), in addition to smaller numbers of Greg’s Amaranth (*Amaranthus Greggii*), Sea Rocket (*Cakile maritima*) and Gulf Croton (*Croton punctatus)*. The vegetation found within the plots was left as is. Plots were consecutively labeled A-I from West to East and are delineated by four posts, one in each corner of the plot which are rectangular in shape to correspond with the shape of the beach. All plots are located south of the sand fencing, on the gulf-side beach.

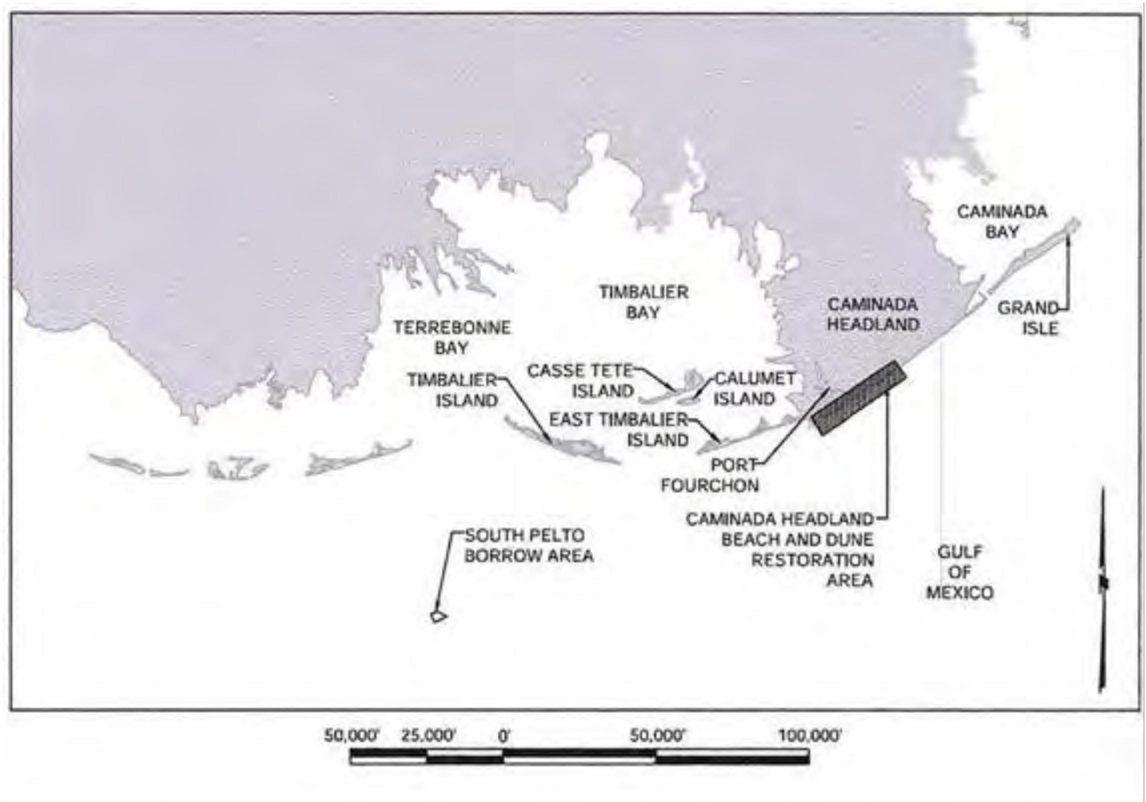

Figure 1. Location of the section of beach to be restored by the Caminada Headland Beach and Dune Restoration Project BA-45 is highlighted.

Figure 2. Location of the research study plots (A – I) on East Beach, Port Fourchon.

Field Techniques

Surveys of each study plot are conducted every 1-3 days during the entirety of the nesting season. This begins after the arrival of birds from spring migration and signs of courtship behavior begin (displays, vocalizations, scraping, territoriality), which generally occurs in early to the middle of April for Wilson's Plover, and middle to late April for Least Terns. Surveys cease after all nests are hatched and no new nests occur for 10 consecutive survey days, which occurs in late July or early August. During each visit to the study area, the date, time of day (arrival and departure), weather conditions, human disturbance, and other wildlife present besides the focal species are recorded.

Plots are monitored in rotating order to avoid searching at the same time of day in each plot. Surveys take place between 5:30 am and 10:00 am to avoid heat stress to the birds. Time spent in each plot is recorded and is limited to a maximum of 25 minutes to ensure that birds are not being kept off nests for prolonged periods. Additionally, surveys are not conducted during inclement weather which includes rain or wet conditions, as well as wind speeds greater than 20mph or when sand is blowing on the surface, which could potentially damage eggs. Scent masking spray is applied frequently during the survey in order to help reduce predator attraction. The number of adults and their behavior, the number of scrapes, and evidence of predator activity (tracks, scat, missing nests) is noted. A systematic grid-search pattern is used to nest search (Figure 3). To perform this method, one to two observers forms a straight line on the edge of the boundary of the plot, perpendicular with the water. Researchers are evenly spaced and the distance between them (or consecutive turns if only one observer) does not exceed 3m apart to ensure visibility to the area 1.5m to the right and left of them. Researchers carefully, but swiftly, walk each plot looking for signs of nesting.

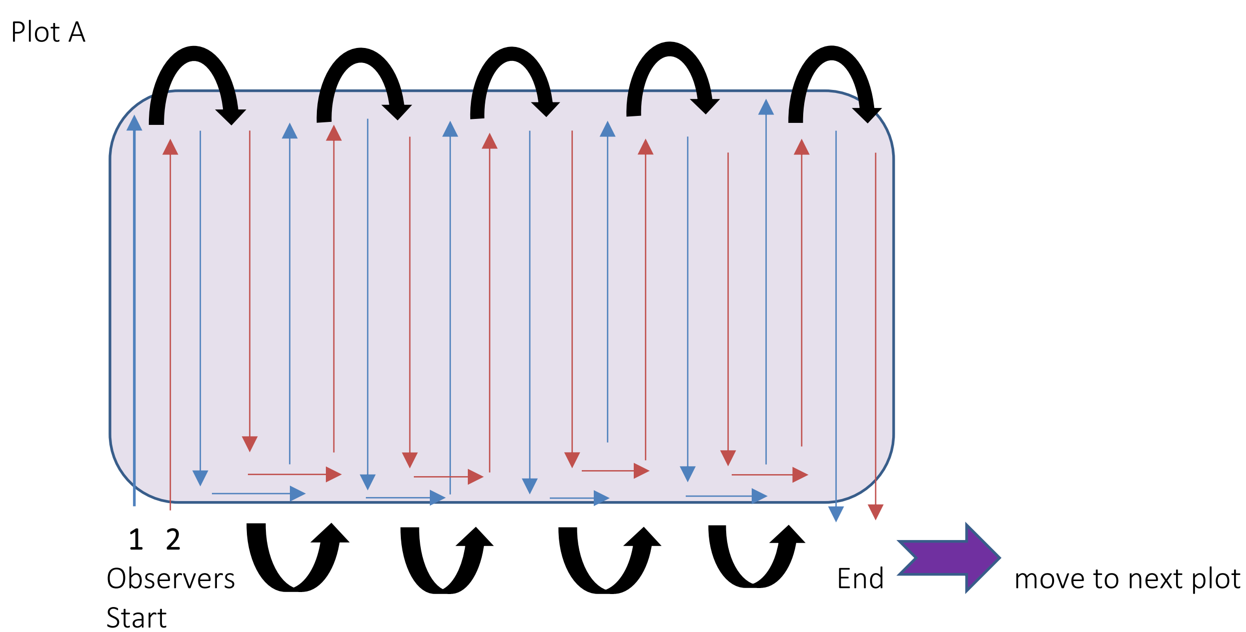

Figure 3. Systematic grid-search pattern used to locate nests within the study plots.

When a new nest is observed researchers: 1) document the presence of adults tending the nest, 2) record the number of eggs, 3) collect a GPS location of the nest (GARMIN GPSMAP 78), 4) float eggs if the initiation date is unknown, 5) mark nests with unique code, and 6) take a photograph of the nest centered in a $1m^2$ quadrant to later determine microhabitat characteristics (Canon Rebel XS with 50mm lens). The nest markers (tongue depressors) are pre-labeled by listing the plot name (A-I) and the next sequential number. For example, the third nest found in Plot C would be labeled C3. The PVC quadrant is placed with the nest in the center. The nest marker is first used as the unique identifier for the nest picture by placing it flat on the surface in the bottom right corner of the quadrant. A picture of the nest is taken with a digital camera approximately 1.5m above the surface, with the quadrant encompassing the entirety of the view finder, and the image taken facing south towards the water (Figure 4). Use of pre-labeled markers and digital photographs allow for the documentation the physical characteristics of the nest while minimizing time spent with the adults off the nest. The nest marker is then placed into the sand 1m from the top right corner of the quadrant and at a 45˚ angle to allow researchers to locate and identify nests on subsequent visits. If the initiation date is unknown, eggs are floated on the first visit following the methods of Hays and LeCroy (1971) for Least Terns and Hood (2006) for Wilson's Plover to determine the developmental stage. Eggs are handled using latex gloves.

Figure 4. Placement of PVC grid and nest marker used to document the unique nest code and physical nest habitat characteristics.

Nests are monitored until nest fate (hatching success) can be determined. A nest is defined as successful if at least one egg hatches, and is considered failed if the nest is abandoned, depredated, or damaged prior to any eggs hatching. A nest is considered abandoned if the eggs appear to be unattended (cold, covered in sand, out of the original nest bowl, or no adults present) for 3 consecutive nest checks. Nest fate is deemed undetermined if the eggs are missing on or around the hatch date, but no chicks are found, nor any signs of predator activity. Nests are examined for evidence of predation which includes tracks, broken eggshells, missing eggs, or yolk found in the nest bowl. The type of predator is determined if possible based on the evidence, but will be listed as unknown if there is not sufficient evidence. The number of hatched chicks will be recorded and broods will be followed as long as possible. An estimate of the number of successfully fledged chicks will be made based on the date chicks are last observed alive or if fledglings are observed flying from the natal area.

Nine camera traps (one for each plot) are utilized to help document predator activity (Stealth Cam-G30). The cameras are strategically placed either to view nests themselves, or in areas of high predator activity. They are attached to the plot posts or sand fencing and checked every 1-2 weeks. A data logging rain gauge (Davis Instruments Rain Collector model # 7857M) was set up in approximately the middle of the survey area (Plot E) to record the rainfall within the study region. Temperature data is recorded by the KXPY weather station located at the Port Fourchon Terminal (29° 7' 23" N, 90° 12' 7" W) and downloaded periodically to obtain daily high and low temperatures for the region.

Analysis

Data collected for the entirety of the season are summarized to make inferences on each variable that may impact nest survival. After the 3 field seasons are complete, we will use data from nest monitoring to estimate nest survival using the nest survival utility in Program MARK. Based on the methodology used by Brown et al. 2015, we will construct encounter histories by summarizing the day each nest was found (k), the last day the nest was found active (l), the last day the nest was checked for activity (m), and the fate of the nest (f). We will determine both apparent daily survival probability and apparent seasonal survival probability dependent on the substrate type. Apparent seasonal survival is the probability a nest will survive the 21 day (for Least Tern) or the 25 day (for Wilson's Plover) incubation period. It is estimated by extending the daily survival probability to the appropriate number of incubation days.

Results & Discussion

Logistics & Weather

The 2016 survey season began on April 19th and finished on July 27th after 10 consecutive surveys in which no new nests had been observed and there were no active nests within the study plots. This comprised 47 survey days with an effort of approximately 200 hours in the field. The average temperature for the month of April (26-30th) was 77.1˚F, 77.5˚F for May, 83.1˚F for June, and 85.6˚F for July (1-27th). The monthly low temperatures for the same periods during April-July were 69.8˚F, 66.2˚F, 71.6˚F, and 75.2˚F respectively. The monthly high temperatures from April-July were 80.6˚F, 86.0˚F, 89.6˚F, and 91.4˚F. There were no significant tropical storms during this period that caused high-water events. Rainfall varied throughout the season; the maximum rainfall in one day was 46.4mm on 5/20/16 (Figure 5).

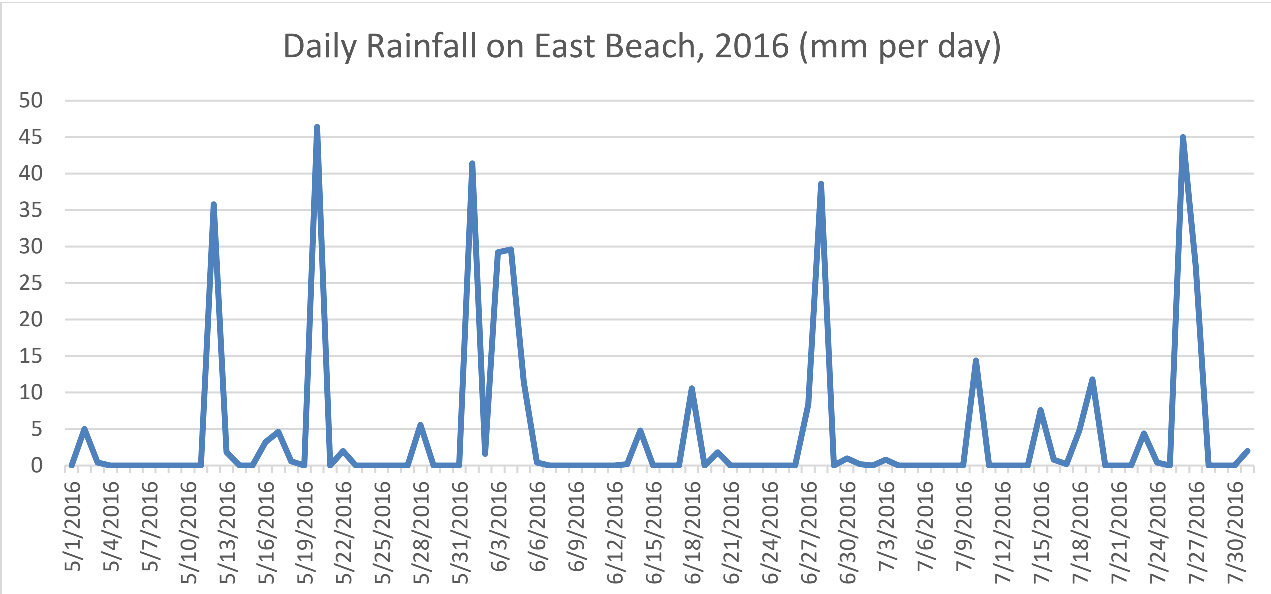

Figure 5. Daily rainfall on Each Beach for the months of May through July, 2016 (measured in mm per day.)

Nesting Activity of Wilson's Plovers

The first Wilson's Plover nest was found on April 19th in Plot C (Appendix B). This was the only nest observed by Wilson's Plover within the study region. It was a 3 egg clutch that hatched 3 chicks based on the evidence at the site including small plover tracks and small egg-shell fragments (Mabee et al. 2006). However, the chicks were never found, and therefore their fate (productivity) could not be determined. The habitat in its current form does not appear to be favored by Wilson's Plovers for nesting. This could be due in part to the lack of vegetation in many areas, which does not provide adequate cover. Also, the plots are located on the other side of the sand fencing away from mud flats, which are favored habitats to bring young chicks to forage. Other pairs located on concurrent breeding bird surveys were observed mainly defending territories along the vegetation adjacent to bay, not on the open beach.

Nesting Activity of Least Terns

There were no Least Tern nests observed during the month of April. The first nest was laid on approximately May 5th based on egg flotation (first observed on May 7th). Activity increased steadily during May with 29 nests observed, peaked in June with 46 nests observed, and rapidly declined in July with only 8 nests observed during the beginning of the month (Figure 6). A total of 83 nesting attempts were made by Least Terns, with the last nest laid on July 11th. The nests were distributed across the 9 plots, with the most nests laid in plots G and H (Figure 7; Appendix C). Nests that fell within 5m outside of the plot boundaries were also monitored and included in the study as it is suspected that some were re-nests from pairs that had previously nested inside the plots.

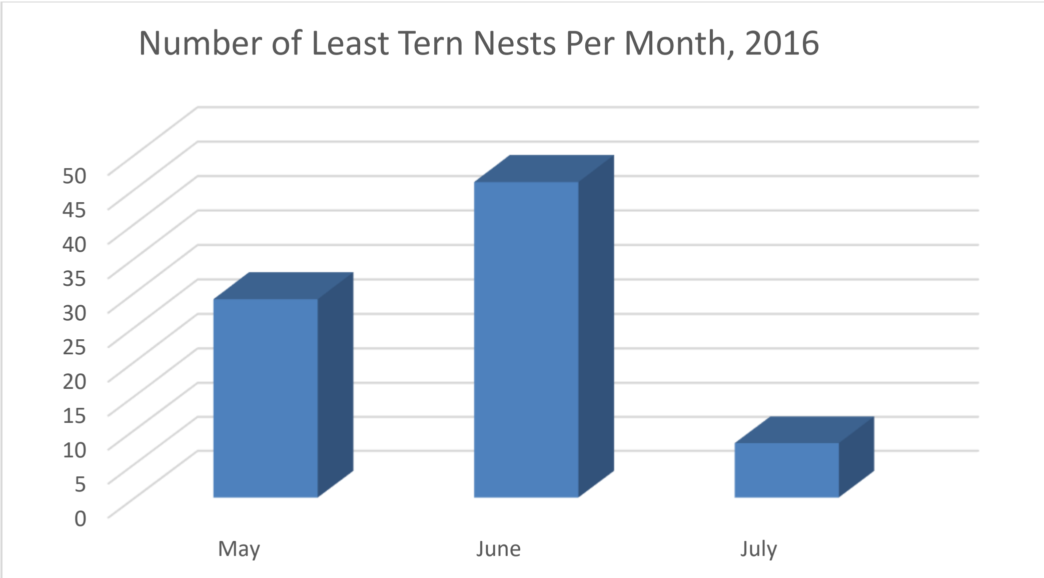

Figure 6. Nesting chronology of Least Terns within the study region by total number of nests laid per month.

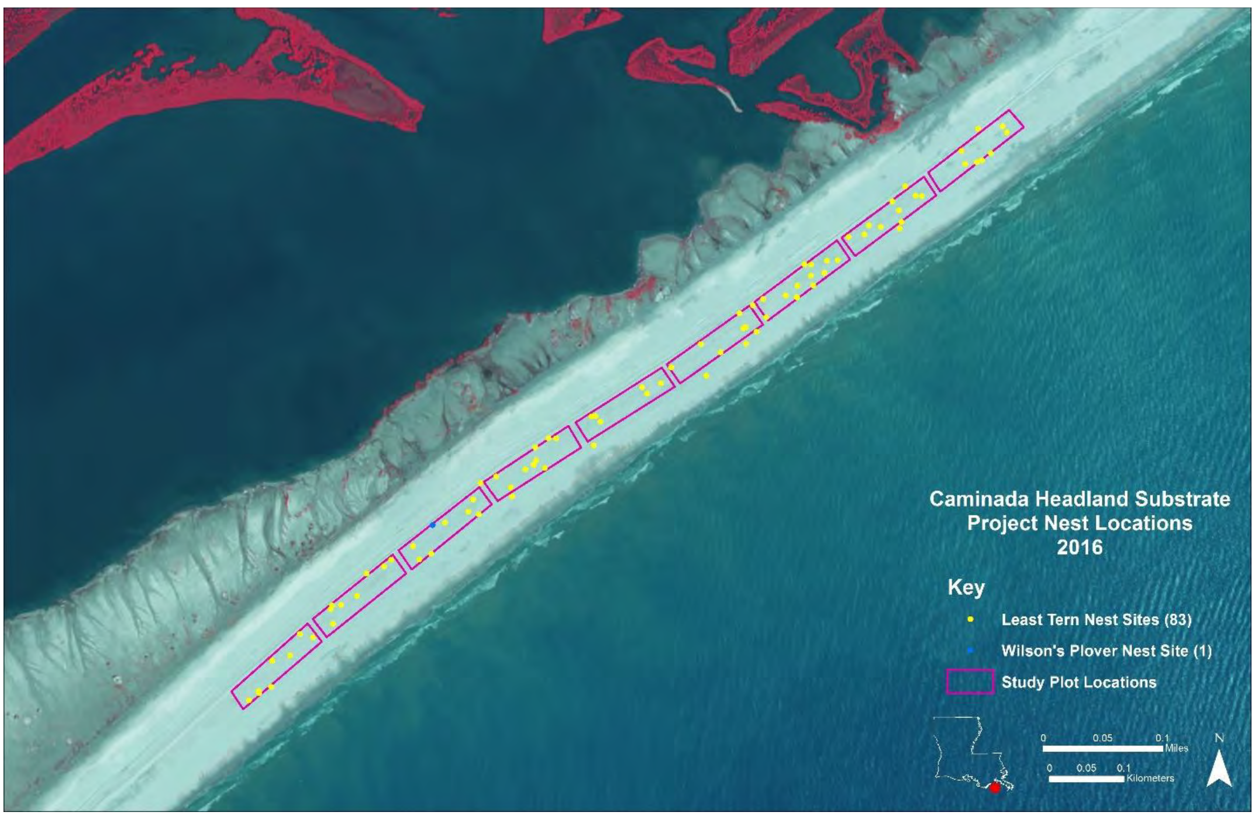

Figure 7. Distribution of Least Tern Nests (83) within the study region, 2016.

Hatching Success of Least Terns

The hatching success of Least Terns was very poor, with only 2 nests out of the 83 observed confirmed hatched. The fate of 6 nests could not be determined, while 75 nests were confirmed to have failed prior to their expected hatch dates (Table 1). This represents a hatching success rate of only 3%, an undetermined rate of 7%, and a failure rate of 90% (Figure 8) for the study region. Of the 2 nests that hatched, both only hatched 1 chick even though they had clutches of 2 and 3 eggs respectively. The chicks were not seen on subsequent visits, and are presumed to have been depredated. This yields a 0% productivity rate (chicks fledged per pair) for the study region.

Table 1. Hatching success of Least Tern nests within the East Beach study plots and the entire study region, 2016.

Plot	A	B	C	D	E	F	G	H	I	(N)	$\bar{x}$	SD
Successful	0	0	0	0	0	0	0	0	2	2	0.22	0.67
Failed	8	8	8	9	7	8	13	9	5	75	8.33	2.12
Undetermined	0	0	0	1	0	1	1	2	1	6	0.67	0.71
TOTAL	8	8	8	10	7	9	14	11	8	83		

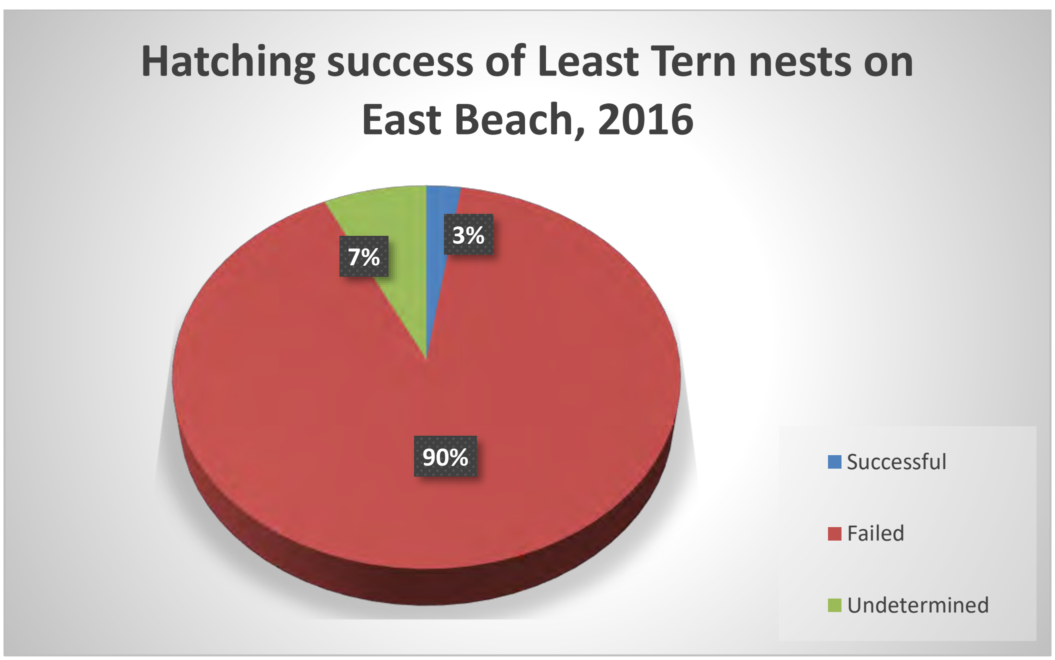

Figure 8. Hatching success of Least Terns within the East Beach Study Region, 2016.

Causes of Nest Failure for Least Terns

The causes of nest failure were either abandonment by the adults or depredation. There were no extreme weather events that caused flooding of the nests this season. This could be due in part to the increased elevation of the beach created during the restoration. Of the 75 nests that failed, 8 were abandoned, 16 were depredated by Ghost Crab (*Ocypode quadrata*), 24 were depredated by Coyote (*Canis latrans*), and the exact predator was unknown for 27 nests, although depredation was confirmed (Table 2). The unknown predator category accounted for 36% of failed nests, Coyote depredation accounted for 32%, Ghost Crab depredation accounted for 21%, and abandonment accounted for 11% of the failed nests (Figure 9). Of the 8 nests that were abandoned, the reason for the abandonment was unknown in five of nests. Predator activity is one possibility; another is human disturbance from nest searching or people crossing through plots (see human disturbance below). The three remaining nests that were abandoned were done so after one mate from each pair was killed (see predator activity below). It is assumed that the death of one adult in the pair caused the abandonment of these nests, as a single adult would have a very difficult time both feeding itself and incubating a nest until it hatches. However, other species of terns have been documented raising chicks as single parents and in at least one case, a female Roseate Tern successfully incubated and fledged a chick after the death of her mate (Spendelow and Zingo, 1997). However, this outcome is unlikely. In the 3 cases observed this season, the remaining mates did not continue to incubate as single parents, and none of those nests hatched.

Table 2. The causes of Least Tern nest failure by plot during 2016.

Plot	A	B	C	D	E	F	G	H	I	(N)	$\bar{x}$	SD
Abandoned	0	0	0	3	2	2	1	0	0	**8**	**0.89**	**1.17**
Ghost Crab	4	4	2	2	2	1	0	1	0	**16**	**1.78**	**1.48**
Coyote	3	2	1	1	2	1	6	5	3	**24**	**2.55**	**1.67**
Unknown	1	2	5	3	1	4	6	3	2	**27**	**3.00**	**1.73**

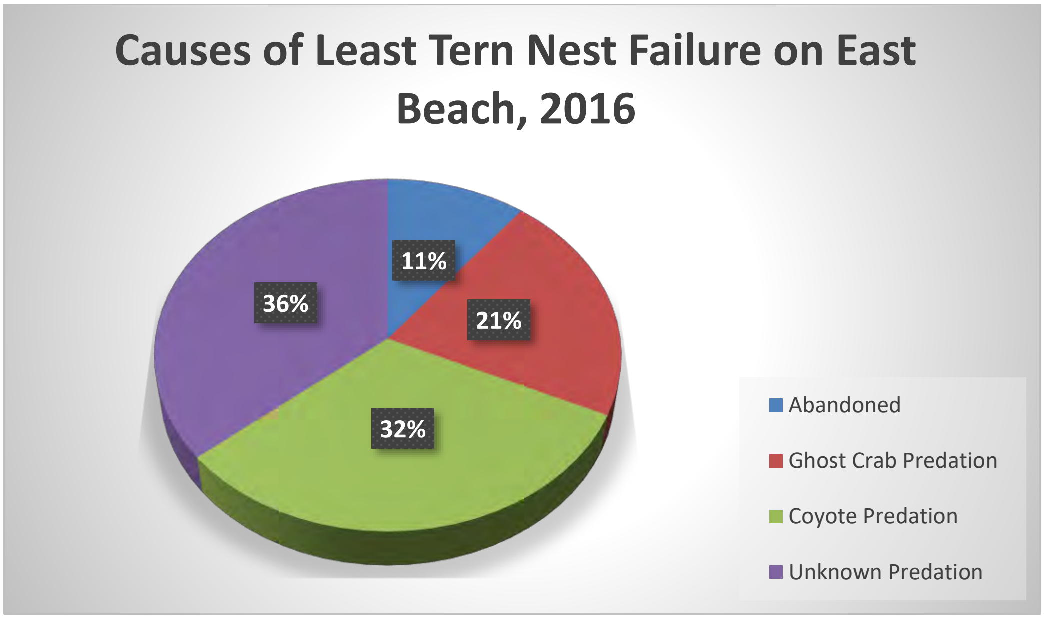

Figure 9. Causes of Least Tern Nest Failure within the East Beach Study Region, 2016.

Predator Activity

Ghost Crabs

Ghost Crabs were vigorous predators for Least Tern eggs this season. While an exact count of the number of Ghost Crab burrows was not conducted on each survey, burrows and adults were observed on every visit within the study region. Ghost Crabs regularly depredated eggs directly from the nest bowl, either eating them on-site or rolling them to nearby burrows (Figure 10). They often seemed to move their burrows closer to the active nests. On a few instances, Ghost Crabs burrowed from underneath the sand directly where the Least Tern nest was located. The eggs were missing and in its place was a Ghost Crab burrow; it was assumed that the eggs were consumed by the Ghost Crabs. Adult Least Terns were observed defending nests from Ghost Crabs by stretching out their wings presumably to look larger, and trying to “push” the crab away from the nest. This behavior was observed in single adults as well as group defense displays in which a few other individuals came to the aid of other Least Terns. It was not documented how successful the terns were at dispelling the crabs.

Figure 10. Ghost Crab burrow with a depredated Least Tern egg.

Coyote

Coyotes were the most frequently observed and detrimental predator of Least Tern nests within the study region. Activity was documented on each visit by noting their tracks in each plot (it was possible to distinguish fresh versus old tracks), as well as through the use of motion activated cameras (taking both still images and video), which is summarized in Table 3. Coyote presence was consistently observed within all study plots, and peak activity levels coincided with months of peak nesting activity (Figure 11). While these numbers represent a picture of the Coyote activity, they should be considered on the low end as surveys were not conducted on a daily basis, and the cameras did not always get triggered (as with a fast moving gate). As shown in Table 2, Coyotes were confirmed to have depredated 24 nests, and were suspected of numerous others. Of greatest concern was that 3 adult Least Terns were also killed within the study plots while at their nests. The predator cannot be determined for certain, however Coyote are suspected due to evidence found at the kill sites that was not typical of a bird of prey. Coyote depredation represents a serious threat to the Least Tern population on East Beach.

Table 3. The number of survey days per month (in parentheses), and the number of days per month coyote activity was detected within each plot either by tracks or photos from game cameras, 2016.

Plot	A	B	C	D	E	F	G	H	I
April (5) *	1	0	0	0	0	2	1	1	1
May (15)	10	7	9	9	9	11	7	10	6
June (15)	7	6	9	10	9	5	6	10	11
July (12) *	6	5	6	6	5	6	6	6	9

* The months of April and July were not surveyed in totality, so only represent a portion of the month's activity.

Figure 11. Coyote captured on a game camera searching for Least Tern nests within study plot F.

Avian

While avian predators including herons, gulls, raptors, or falcons can be a serious threat to nesting Least Tern colonies, that did not seem to be the case this season. No tracks were observed and only one, a Great-Blue Heron (*Ardea herodias*), was documented within the study plots during nesting season on the video camera. This individual did not stay long and appeared to just be walking towards the water's edge. There were no signs of avian predation at any of the nests, but it cannot be ruled out for those whose predator was unknown.

Human Disturbance

East Beach is closed to the general public and is supposed to only be accessible to the land owners and those with permission to access it. Despite these restrictions, people still managed to illegally gain access to the property, and some that had permission to be there did not follow best management practices to avoid disturbance to beach nesting birds. The Wisner Property owners employ a site manager to keep an eye on the area, and to deter people from accessing the property. However, alot of these events occurred very early in the morning or at night; periods when the property manager isn't there. We worked together to document disturbance events, and some signs and symbolic fencing were strategically placed to try to inform people about the nesting birds. Of greatest risk to the birds was the illegal driving of vehicles up on the sand and across the nesting habitat. Driving on the beach was permitted to some access holders, but only at the water's edge where the birds do not nest. Violators included pipeline and construction workers, as well as the police force. Five instances were documented in which the beach was traversed by vehicle (trucks or ATV's) either through direct observation, or by the cameras in the study plots. These events were very disruptive to the birds' nesting activities, and potentially crushed eggs and chicks. While a survey was undertaken to look for casualties within the study plots and none were found, that area represents only a small portion of the beach that was driven on (Figure 12). It is very likely that eggs were crushed on other sections of the beach. Additionally, there were 7 instances documented (by direct observation or caught on the cameras) in which people on foot crossed through the study plots, narrowly avoiding nests. These people were usually coming from the bayside to fish in the gulf, and seemed totally unaware that they were walking through a colony of bird nests. Human activity and disturbance pose a threat that needs to be better managed.

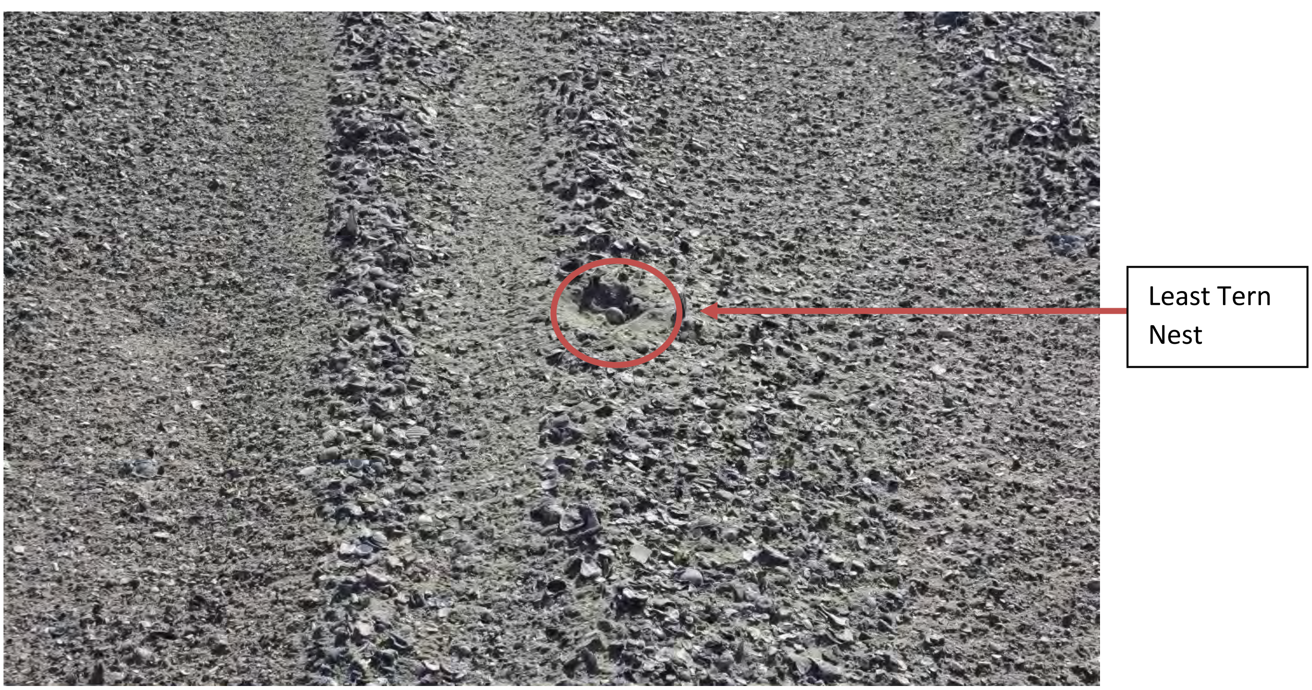

Figure 12. Least Tern nest narrowly missed by an ATV track.

Future Recommendations

The 2016 nesting season was very poor for Least Terns. It is very alarming to have such low rates of hatching success and no chicks fledged within the study site. Although some chicks, and later fledglings and hatch-year birds were observed in other areas, the numbers were very low in comparison to the estimated number of birds nesting along the entire stretch of beach. If this trend continues, the Least Tern population here is at risk. More effort needs to be taken to alert those with beach access about how to avoid disturbance to beach nesting birds. Informative signage should be placed to deter those without access permission. A professional biologist that is able to point out nesting areas and keep disturbance to a minimum should accompany anyone approved to work in the area. A predator management plan should be researched to see if there are ways to target Coyotes that have adapted to find Least Tern nests and implemented as needed. Further research is required into Ghost Crab behavior and predator activity. Little is known about their abilities to target bird nests, and what management actions could be taken to deter them. We hope to test whether the addition of hard substrate will deter Ghost Crabs from having burrows within the Least Tern colony in subsequent field seasons.

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Appendix A. Study Plot Locations

Study Plot Locations

Post ID	Latitude	Longitude
A1	29.11276496	-90.17472404
A2	29.112987	-90.17488003
A3	29.11378998	-90.17380203
A4	29.11356602	-90.17361302
B1	29.11361698	-90.17354102
B2	29.11384304	-90.17373104
B3	29.11460001	-90.17259898
B4	29.11436699	-90.17242304
C1	29.11441603	-90.17234601
C2	29.11464997	-90.17251901
C3	29.11539302	-90.17138301
C4	29.11518297	-90.17121202
D1	29.11522304	-90.17112996
D2	29.11545698	-90.17131898
D3	29.11611202	-90.17012699
D4	29.11584699	-90.16995801
E1	29.11591798	-90.16986396
E2	29.116152	-90.17002598
E3	29.11679196	-90.16881304
E4	29.11655702	-90.16863903
F1	29.11659499	-90.16856602
F2	29.11683203	-90.16874397

F3	29.11752203	-90.16757797
F4	29.11728499	-90.16739801
G1	29.11733201	-90.16733204
G2	29.11756502	-90.16750496
G3	29.11828604	-90.16634499
G4	29.11805	-90.16617098
H1	29.118093	-90.16609998
H2	29.11831998	-90.16628204
H3	29.11903404	-90.16512098
H4	29.11880404	-90.16495703
I1	29.11884704	-90.16490003
I2	29.11908299	-90.16506004
I3	29.11982202	-90.16392203
I4	29.11961004	-90.16372204

Appendix B. 2016 Wilson's Plover Nest Location

Wilson's Plover Nest Location, 2016

Nest ID	Latitude	Longitude
WC1	29.11494803	-90.17203697

Appendix C. 2016 Least Tern Nest Locations

Least Tern Nest Locations, 2016

Nest ID	Latitude	Longitude
LA1	29.11361799	-90.17373296
LA2	29.113347	-90.17430503
LA3	29.11298297	-90.17450301
LA4	29.113031	-90.17432699
LA5	29.11340601	-90.174055
LA6	29.11295598	-90.17449597
LA7	29.11287401	-90.17463796
LA8	29.11366702	-90.17391401
LB1	29.11400104	-90.17345502
LB2	29.11400598	-90.17333197
LB3	29.11395997	-90.17347598
LB4	29.11411	-90.17310801

LB5	29.11446196	-90.17272504
LB6	29.11437898	-90.17296803
LB7	29.11454	-90.17262203
LB8	29.11377699	-90.173451
LC1	29.11469699	-90.17231701
LC2	29.115246	-90.17146901
LC3	29.11497401	-90.17186497
LC4	29.11460202	-90.17206698
LC5	29.11544499	-90.17136097
LC6	29.11509898	-90.17154101
LC7	29.11506504	-90.17139299
LC8	29.11453497	-90.17223302
LD1	29.115648	-90.170619
LD10	29.115274	-90.17092503
LD2	29.115518	-90.17114304
LD3	29.11570399	-90.17058204
LD4	29.11538498	-90.17094397
LD5	29.11596802	-90.17040099
LD6	29.11559704	-90.17073501
LD7	29.115965	-90.17030099
LD8	29.115863	-90.17059
LD9	29.11561003	-90.17046402
LE1	29.11587096	-90.16978299
LE2	29.11648401	-90.16902401
LE3	29.11615603	-90.16968098
LE4	29.11656104	-90.16909098
LE5	29.11622099	-90.16980403
LE6	29.116224	-90.16974997
LE7	29.11660496	-90.16882896
LF1	29.11706898	-90.16826604
LF2	29.11696102	-90.16799203
LF3	29.11726101	-90.16763496
LF4	29.11720301	-90.16748903
LF5	29.11667797	-90.16819898
LF6	29.11679397	-90.16868404
LF7	29.117431	-90.16771803
LF8	29.11724903	-90.16767
LF9	29.117057	-90.16763798
LG1	29.117374	-90.16735299
LG10	29.11752404	-90.16753002
LG11	29.11763401	-90.16707203

LG12	29.11804698	-90.16634197
LG13	29.11759696	-90.16738602
LG15	29.11760501	-90.16691303
LG2	29.11789603	-90.16653098
LG3	29.11800499	-90.16680197
LG4	29.11800197	-90.16671002
LG5	29.11786602	-90.16671999
LG6	29.117747	-90.16668797
LG7	29.11775001	-90.166908
LG8	29.11804296	-90.16648999
LG9	29.11761196	-90.16692501
LH1	29.118438	-90.16573696
LH10	29.11841202	-90.16547402
LH11	29.11849399	-90.16544402
LH2	29.11846097	-90.16589899
LH3	29.11863204	-90.16547704
LH4	29.11874302	-90.16556497
LH5	29.118798	-90.16515501
LH6	29.11892398	-90.16538199
LH7	29.11832702	-90.16618598
LH8	29.118352	-90.16596504
LH9	29.11880597	-90.16524101
LI1	29.11955003	-90.16395397
LI2	29.11919497	-90.16438404
LI3	29.11930201	-90.16418396
LI4	29.11921903	-90.16430902
LI5	29.11933696	-90.16458998
LI6	29.11962303	-90.16401297
LI7	29.11917603	-90.16454204
LI8	29.11959998	-90.16435403