PROTECTING WHOOPING CRANES AND COASTAL HABITATS IN TEXAS

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EARTHWATCH® INSTITUTE

Dear 2018 Team Texas Volunteers,

Conducting research in coastal wetland ecosystems can be challenging, but in looking back at your field expedition, I hope you would agree that the rewards are far reaching. During four research expeditions in 2018, we worked together in the marshes and bays along the Texas Gulf coast to collect environmental field data, conducted summertime blue crab mesocosm experiments and conducted detailed observations of whooping cranes in their winter territories. During our time together, we explored coastal ecosystems, built everlasting friendships and might have been bitten by a mosquito or two…OK maybe three! Throughout the course of your research expedition, I hope each of you gained a greater appreciation for coastal ecology, the process of collecting field data and the ever-growing need to study, understand and conserve this dynamic coastal ecosystem. My sincere thanks to all of you for your hard work in making each of our research expeditions an overwhelming success!

As you well know, our coastal marsh sites are home to the endangered whooping crane and many other wading birds of conservation interest. To successfully manage this habitat and put forth the best whooping crane conservation plan, scientists and managers must synthesize multiple factors including ecosystem assessments of habitat quality, water quality, freshwater inflows to the estuary and crane food resource availability. In addition, our summer blue crab experiments help us to understand how summertime conditions can influence blue crab behavior and survival. All in all, our research this year helped by providing data on whooping crane behavior, coastal marsh water quality and key whooping crane food resources during the wintering period.

Your hard work has contributed greatly to an ever-growing data set that has already informed other experiments in my lab and will lay the foundation for additional experiments in future Earthwatch research expeditions. On behalf of my collaborators, students and field team – thanks to each and every one of you for being such great, engaged, inquisitive, fun and hardworking researchers. Through your hard work and dedication, we have again displayed how quality research can be achieved when a group of exceptional citizen scientist come together!

All the best,

Jeffrey R. Wozniak

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Project Summary

The purpose of the “Protecting Whooping Cranes and Coastal Habitats in Texas” research program is to gain a better understanding of coastal marsh ecosystems and to determine the impacts of environmental and anthropogenic stressors on wading bird resources and habitat quality. In 2018, Earthwatch citizen scientists investigated a wide range of ecosystem-level parameters at the Aransas National Wildlife Refuge (ANWR) that drive coastal marsh habitat quality and wading bird food resource availability. Three winter teams conducted detailed behavioral observations of whooping cranes in natural and urban locations. In addition, we assessed key crane food resources (blue crabs and wolfberry fruit) and coastal habitat quality in an attempt to understand how crane behavior is linked to food resource availability. Ignite student researchers conducted habitat assessments to link summer conditions to winter food resources and completed a blue crab salinity manipulation experiment geared to determine how crab behavior differs under various environmental conditions. The overarching goal of this project is to use a holistic ecosystem approach to link these data together through time and space to not only provide yearly snapshot of the “coastal crane climate” but also provide the opportunity to compare across years, as we build a long-term data set.

Below are the three main research objectives as defined in our original research proposal. These objectives are then followed by four more detailed research focus areas that we focused on during the 2018 field season.

Original Research Proposal Objectives

Objective 1: To assess broad landscape-scale patterns that drive whooping crane (*Grus americana*) territory quality and food resource availability.

Objective 2: To determine, in a controlled mesocosm experiment, the physiological threshold of blue crabs (*Callinectes sapidus*) to highly elevated salinity, elevated temperature and decreased water depth.

Objective 3: To determine shifts in wading bird and whooping crane territory selection and feeding behavior in response to environmental shifts though field observations.

2018 Research Focus Areas

Below we present four focal research areas that guided the experiments and efforts of the 2018 fielding season:

1. **Summer & Winter Coastal Ecosystem Habitat Assessments**
2. **Summer Blue Crab Salinity & Behavior Experiments**
3. **Summer Blue Crab Hemolymph Composition**
4. **Winter Whooping Crane Observations and Habitat Assessments**

1. Summer & Winter Coastal Ecosystem Habitat Assessments:

To understand how coastal ecosystems function, volunteers collected data in the coastal saltmarshes of the Blackjack Peninsula at the ANWR and collected *in situ* environmental data. The main goal of these data was to determine the linkages between marsh hydrology, water quality, primary production (e.g., vegetation dynamics/Carolina wolfberry) and secondary consumers (e.g., blue crabs). This ecosystem-level assessment of *in situ* marsh conditions at the ANWR provides the heartbeat of our Earthwatch research. These environmental data provide the background and foundation for our subsequent exploration of other research questions (blue crabs and wading bird research areas discussed below). The long-term goal of this research is to view these data from season-to-season and year-to-year. Here we hope to improve our understanding of how both natural (e.g. drought, sea-level rise, freshwater inflows, etc.) and anthropogenic (e.g., habitat management, urban expansion, etc.) factors impact these coastal sites through time. Data collected by both the 2018 summer and winter teams are discussed below.

During the 2018 field season, both summer and winter volunteers conducted habitat quality assessments at multiple sites along the Blackjack Peninsula of the ANWR. At these sites volunteers focused on the following research question: How does changing hydrology (as impacted by water level, freshwater inflow and local precipitation) work to impact coastal marsh habitat quality? To answer this question, we collected water quality data (salinity, dissolved oxygen, pH, etc.) using a hand held YSI sonde in a wide range coastal ponds, tidal creeks and marsh locations. In addition, we surveyed Carolina wolfberry plants (# of berries, leaves, buds, flowers, etc.) in nine, $1m^2$ permanent plots and across nine, 100m long transects at our 3 long-term research sites.

For years, we have been documenting the response of wolfberry plants to the drastic drought conditions experienced in 2010-2011. Wolfberry plants have been making a slow recovery from hyper-saline conditions experienced during the drought and coastal marsh pond salinities were relatively (30-50ppt) from 2011-2016. Data collected in the summer of 2018 showed that the lower salinity levels (~15ppt) noted in 2016 and 2017 have remained in place into 2018. These lower salinities are good news for the coastal marshes of the ANWR, as mean summertime salinity (e.g., June, July and August) has a direct impact on winter peak wolfberry fruit abundance. The lower salinity values in 2018 indicate that the system continues to return to a “more normal” following the exceptional drought conditions which initiated in 2011.

2. Summer Blue Crab Salinity & Behavior Experiments

Blue crabs (*Callinectes sapidus*) are one of the whooping cranes’ most relied upon food resources during their wintertime in Texas. Crabs enter saltmarsh ponds via tidal creeks during fall high tides and can become stranded when water levels drop. During dry-down conditions, when coastal ponds are isolated from tidal creek and moreover bay water, ponds salinities can become elevated via evaporation of water. This isolation in saltwater ponds is the ecological fate that we experimentally simulated in the blue crab mesocosm experiment.

Saltwater ponds at the ANWR can experience dramatic shifts in water column salinity (~0-75ppt). Coastal saltmarsh ponds create a patchy mosaic of intermittently-connected, isolated and connected pond habitats in which blue crabs occupy throughout the year. The variability in saltmarsh pond salinity can be impacted by adjacent bay water level (i.e., hydrologic connectivity), pond location along the estuarine gradient, freshwater inflows to the estuary and local precipitation. Earthwatch students set up and conducted detailed behavior and mortality experiments to determine the effects of a salinity gradient (0, 25, 50 and 75ppt) on the blue crab. Our goal was to create a controlled mesocosm experiment that simulated water column conditions in coastal saltmarsh ponds and to record blue crab behavior, mortality and preference along a salinity gradient. The following research questions guided this research:

Q1. Is there a maximum salinity that the Texas blue crab can withstand (e.g. what is the blue crab's tolerance to extreme salinities)?

Q2. How does the blue crab's behavior and potential predator avoidance (e.g., escape-ability from a predatory whooping crane) change along a salinity gradient?

Q3. Does blue crab behavior and mortality differ between crabs collected from open bay locations and isolated coastal saltwater ponds locations?

To address these questions, Ignite student researchers constructed a large-scale mesocosm experiment (See Figure 1) that examined the following crab responses: crab orientation in mesocosm, righting response, predator jab response, mandible movement, respiration rate and mortality rate. The experiment included 4 salinity treatments (0, 25, 50, 75ppt) with 3 salinity replications per experimental run. Each mesocosm included 1 crab per mesocosm. There was a total of 12 replicates for each salinity treatment and trials ran for 3hrs (data collection every 15mins).

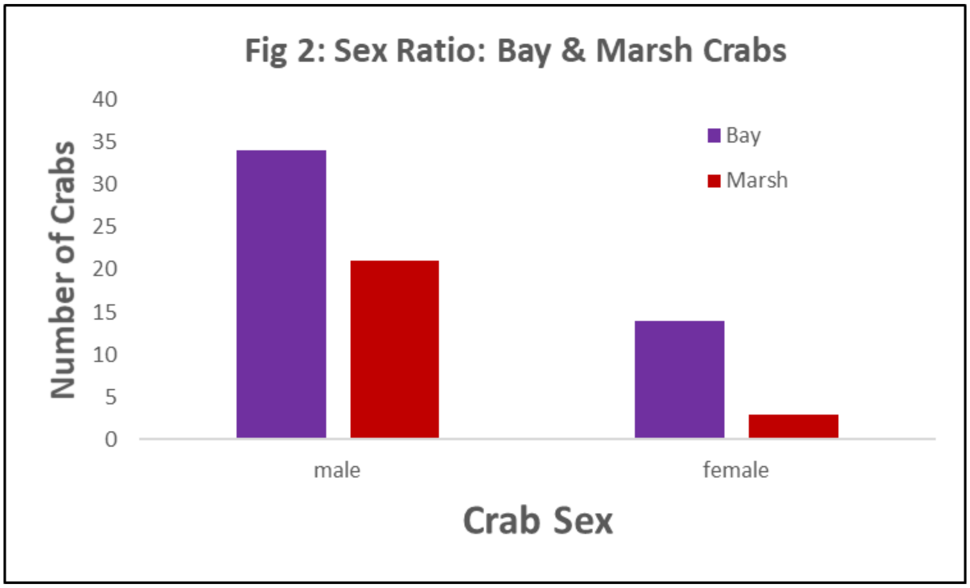
Figure 1: Photo of the blue crab mesocosm experiment designed and set up by the summer '18 Ignite student researchers.

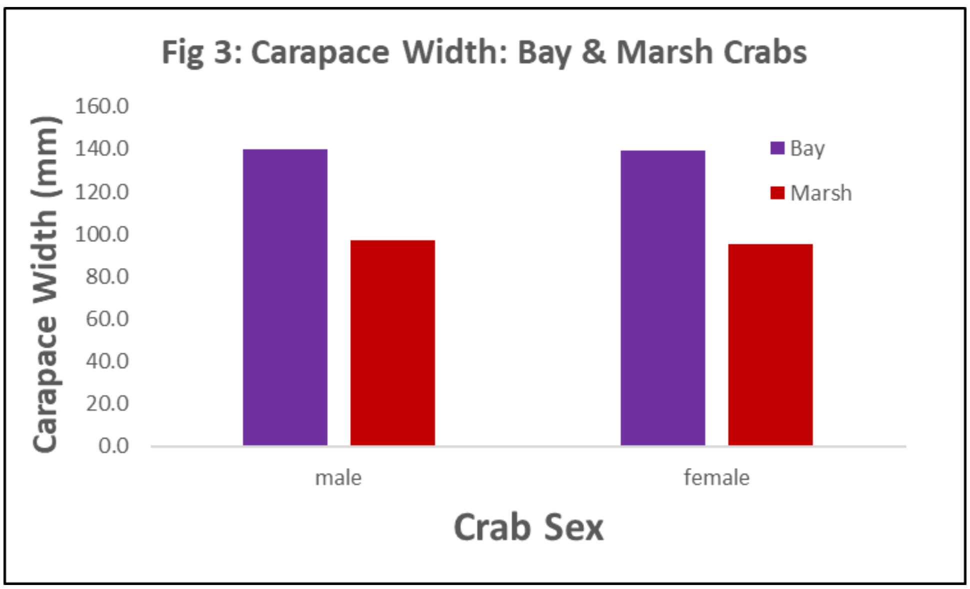
The various crab responses each had a unique method for assessment and Earthwatch Ignite students were trained in each method during pilot experiments conducted prior to actual experimental trials. Unless otherwise noted, each of these observations were made every 15mins during the 3hr experimental trials. Crab orientation was a simple assessment of crab location (facing inwards or facing outwards in the mesocosm). Righting response was determined by picking up the crab and placing it back in the water on its back. A PVC pole was then used to pin the crab down for period of 3 seconds and then the crab was released. Students then recorded the amount of time it took for the crab to flip back over, thus righting itself in the water column. This was done once every hour and not every 15mins, as we did not want to introduce un-necessary stress on the crabs. Predator jab response was determined by using a long (~1.5 meter long) piece of PVC pole. The PVC pole was thrusted into the water directly in front of the crab to simulate the attack of a wading bird on the blue crab. Crab response to this jab was recorded as high, medium, low and none. High, medium, low and none crab responses ranged from aggressive claw attacks (out of the water) combined with rapid fleeing backwards, either an aggressive claw attack or rapid reverse fleeing, a subtle claw attack or slow reverse fleeing, and no response, respectively. Mouth movements were determined by visualizing the mandible and first maxilla movement for each crab. The ranking of high, medium, low and none were based on how rapid maxillary movements were occurring – rapid and continuous was ranked as high, continuous non-rapid movement was medium, periodic movement was low and zero movement was none. Respiration rate was visualized by watching the water moving in and out of the crab. Here particulates in the water column and surface water disturbance caused by the siphoning of water by the crab were visualized. High, medium, low and none were linked the magnitude and timing of respiratory activity of each crab. In addition, "bubble blowing" was also noted by some crabs and appeared to occur in more stressful conditions, this was noted as a high response.

Additional **background/environmental parameters** (e.g., water column temperature, PAR, salinity, dissolved oxygen, pH, conductivity, water depth, etc.) were also recorded at t=0 and at the end of each experimental trial. Environmental data (water column temperature, PAR, salinity, dissolved oxygen, pH, conductivity and water depth) indicated that students were able to modify and maintain mesocosm salinities for all experimental trials. There did not appear to be any significant chamber effects during the course of the experiment.

To address Q4 (**location effects bay vs marsh crabs**), blue crabs were collected from Mustang Lake (bay site) and several saltwater ponds at the Pump Canal sites (marsh sites). Bay crabs were captured by using baited crab pots, while marsh crabs were captured in the shallow ponds via dip nets and crab tongs. All crabs were transported to the mesocosm farm in the live well of the research boat.

In the summer of 2018, there were morphological differences in crabs captured in open bay locations as compared to isolated saltmarsh pond locations. There was a higher ratio of males to females from both the bay and marsh location (Figure 2). Crabs caught in open bay sites were on average larger in size (average carapace with of bay crabs 136.9mm; average carapace width of marsh crabs 93.4mm; Figure 3). These are interesting differences and may impact whooping crane feeding behaviors if these ratios hold in place until the winter feeding period. Smaller crabs, while of a lesser total energy, do provide easier handling and decreased time/energy to capture and consumer than larger, more defensive crabs. These differences maybe an interesting research threads to further explore in the winter period when cranes occupy the coastal landscape.





The goal of the **blue crab behavior experiments** was to determine the individual responses of crabs across a salinity range (e.g., mouth movement, predator jab, righting response, respiration rate) and to determine if the likelihood of a crane being able to locate and capture a crab differs at different salinities. We have created a "blue crab health factor" that takes into consideration each of these variables in concert, creating a single value that sums all behavioral observations during experimentation. This health factor is a unit less value that is calculated for each behavioral observation. It is our goal to be able to take each response and calculate a single health factor that describes crab health through time, at each salinity treatment. In the below graphs, the blue crab health factor was calculated from all data for each salinity treatment (12 replicates {individual crabs} per salinity treatment). By using all data in this calculation, we are able to not only get the average health factor for each treatment, but also to calculate a standard deviation for each health factor and then also conduct a linear regression across all treatments. For each below graph, the percentage of each blue crab behavioral response (%) is shown on the primary y-axis and the blue crab health factor is displayed on the secondary y-axis. Blue crab health factors (black triangles) also include individual standard deviations and a linear regression trend line, including r^2 value for each graph.

Blue Crab Microcosm Pilot Study

In addition, during the 2018 summer we also designed and built a pilot blue crab microcosm experiment. This micro scale experimental set up allows for increased replication and the potential for additional experimental treatments. The microcosm array Ignite students constructed consisted of 24, 15liter microcosms. Two treatment groups were created (12 microcosms each) with each plumbed individually, each having their own water source and pump. Consistent environmental conditions (temp, pH, salinity, conductivity) were first confirmed and then a single blue crab was placed in each microcosm. Blue crab behavioral trials were conducted with the same methods employed in the mesocosm experiment. Surprisingly, we were able to keep the blue crabs alive for a period of three days. We plan to expand and build upon this successful microcosm pilot in the 2019 summer Ignite program. The potential for additional research questions that extend beyond salinity treatments(e.g., temperature, turbidity, chemical/toxins, light, density, etc.) are virtually endless.

Photos of the blue crab microcosm array designed and set up by the summer ’18 Ignite student researchers.

3. Summer Blue Crab Hemolymph Composition.

In addition to the behavioral data collected in the mesocosm/salinity experiments described above, additional blue crab chemical analyses were conducted to determine if crab stress across the salinity gradient could be captured through shifts in the chemical composition of blue crab hemolymph. The two main hypotheses that guided this research are shown below.

Q1. What are the physiological effects on blue crabs and can chemical markers in crab hemolymph be used as an indicator of crab health and behavior across a salinity gradient?

Q2. Does blue crab hemolymph chemical composition vary in crabs collected from open bay locations and isolated coastal saltwater ponds locations?

Hemolymph composition of blue crabs at the Aransas National Wildlife Refuge.

In the summer of 2018, 404 hemolymph samples were collected from 103 individual blue crabs to analyze the composition its composition under different experimental conditions. Individual crabs were sampled from each of two habitats: the coastal marshes (n = 31) and the bay (n = 72) bordering the Aransas National Wildlife Refuge (ANWR). Consistent with past seasons, individual crabs were brought back to the educational pavilion utilized by the IGNITE program on the grounds of ANWR to determine the behavioral and physiological effects of salinity variation under two testing regimens. In the first, individual crabs were placed into one of 12 outdoor mesocosms whose salinities were set at 0, 25, 50 or 75 ppt. Crabs remained in these mesocosms for up to three hours. This was design was replicated up to three times within each trial such that a total of up to 12 crabs were tested at each salinity over the course of 4 individual trials. Due to high water in the coastal marshes subsequent to a storm front moving through the region, we were only able to collect 31/48 marsh crabs that are typically used during each season. The second experimental regimen involved holding individual crabs collected from the bay indoors for up to 4 days using small holding tanks connected in series (referred to as Arrays) and a pump-filter system to recirculate the water via a large sump. For this trial run, we used two complete arrays comprised of 12 holding tanks each (total n =24) with the salinity in one of the arrays raised to 50 ppt.

Hemolymph was collected directly into a 1 mL tuberculin syringe containing an anticoagulant solution (4% sodium citrate) and immediately placed on ice afterward. The samples remained refrigerated until they were returned to Sam Houston State University for biochemical analysis. Upon arrival at SHSU samples were placed in storage in a -20° C freezer. The concentration of both glucose and total protein was then measured using commercially available reagents after dilution. Hemolymph was diluted 1:60 or 1:20 for glucose or protein concentration estimates, respectively. Any remaining hemolymph was refrozen for potential follow up analyses; for example the quantification of additional analytes and/or the osmolality of the hemolymph itself.

The Summer 2018 data marks the third season such data have been gathered from blue crab populations at ANWR. Consistent with previous seasons, we find that neither total protein nor glucose concentrations in the hemolymph of the crabs varies amongst salinities. However, there was a significant main effect of population in that both total protein and glucose levels were significantly higher in the bay crabs than those from the marshes. We also found that the level of each was significantly lower at the three hour timepoint when grouped across populations and salinities (Figure 1). These data are confounded by the high mortality rate of the crabs exposed to the 75 ppt salinity, however. In general, these data are consistent with those seen in Summer 2017; although the absolute level of both protein and glucose tended to be higher in 2018. Overall, these data once again suggest that composition of the hemolymph varies significantly among resident populations of blue crabs in ANWR, but that acute changes in salinity has little effect.

4. Winter Whooping Crane Observations and Habitat Assessments

During the winter of 2018, three Earthwatch research expeditions conducted 89 intensive surveys of whooping crane behavior in coastal habitats. In addition, a total of 59 surveys were conducted at an urban upland location (Table 1). Figure 14 shows the locations of the urban site on the Lamar Peninsula and the natural saltmarsh sites along the Blackjack Peninsula. All data were recorded on field observation data sheets (Figure 15a and 15b). The front side was for collecting bird behavior/identification information and the back side was for the collection of site/environmental data. Each crane observation lasted for 20 minutes with data collection on crane behavior occurring every 15 seconds. Whooping crane behavior was parsed into the following categories every 15 seconds: Foraging, Comfort/Maintenance, Locomotion, Interaction (noting if a territory defense), Alert and Resting (Figure 16).

Table 1: The number of individual Whooping Cranes surveyed in natural saltmarsh territories ("Natural") and at game feeders in urban upland sites ("Urban") per sampling month in 2018.

Year	Month	Natural	Urban
2018	January	27	22
	February	32	25
	March	30	12
	Total	**89**	**59**

Figure 14. (Left) A map of where crane observations occurred, with the location of the natural saltmarsh sites circled in black and the location of the urban upland sites circled in yellow. (Right) Cranes in natural saltmarsh habitat (top/black) and cranes in an urban upland habitat (bottom/yellow).

Figure 15a: Whooping crane field observation data sheet.

Whooping Crane Focal Bird Sampling Data Sheet

Date:________________ **Site:**____________________ **Observers:**____________________________

F=Foraging (Pond or Vegetation) **C=Comfort/maintenance** **L=Locomotion (note if Flying)**

I=Interaction (note if Territory Defense) **A=Alert** **R=Resting**

Bird #1						Bird #2					
Start Time:		Bands:		Observer:		Start Time:		Bands:		Observer:	
Int. #	Obs.	Comments	Int. #	Obs.	Comments	Int. #	Obs.	Comments	Int. #	Obs.	Comments
1			41			1			41		
2			42			2			42		
3			43			3			43		
4			44			4			44		
5			45			5			45		
6			46			6			46		
7			47			7			47		
8			48			8			48		
9			49			9			49		
10			50			10			50		
11			51			11			51		
12			52			12			52		
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34			74			34			74		
35			75			35			75		
36			76			36			76		
37			77			37			77		
38			78			38			78		
39			79			39			79		
40			80			40			80		

Figure 15b: Whooping crane observation site background and environmental data sheet.

Whooping Crane Site Background Data Sheet

Date:___________ Site:______________ Observers: ______________

Wind speed:________ m/sec

Direction: _________

Air Temperature:________°C

GPS Coordinates

N

W

Range (distance): ______ m

Compass direction/heading:________ °

Habitat type (circle): Saltmarsh Upland Urban

Total cranes present at time of observation:________

Other Comments:

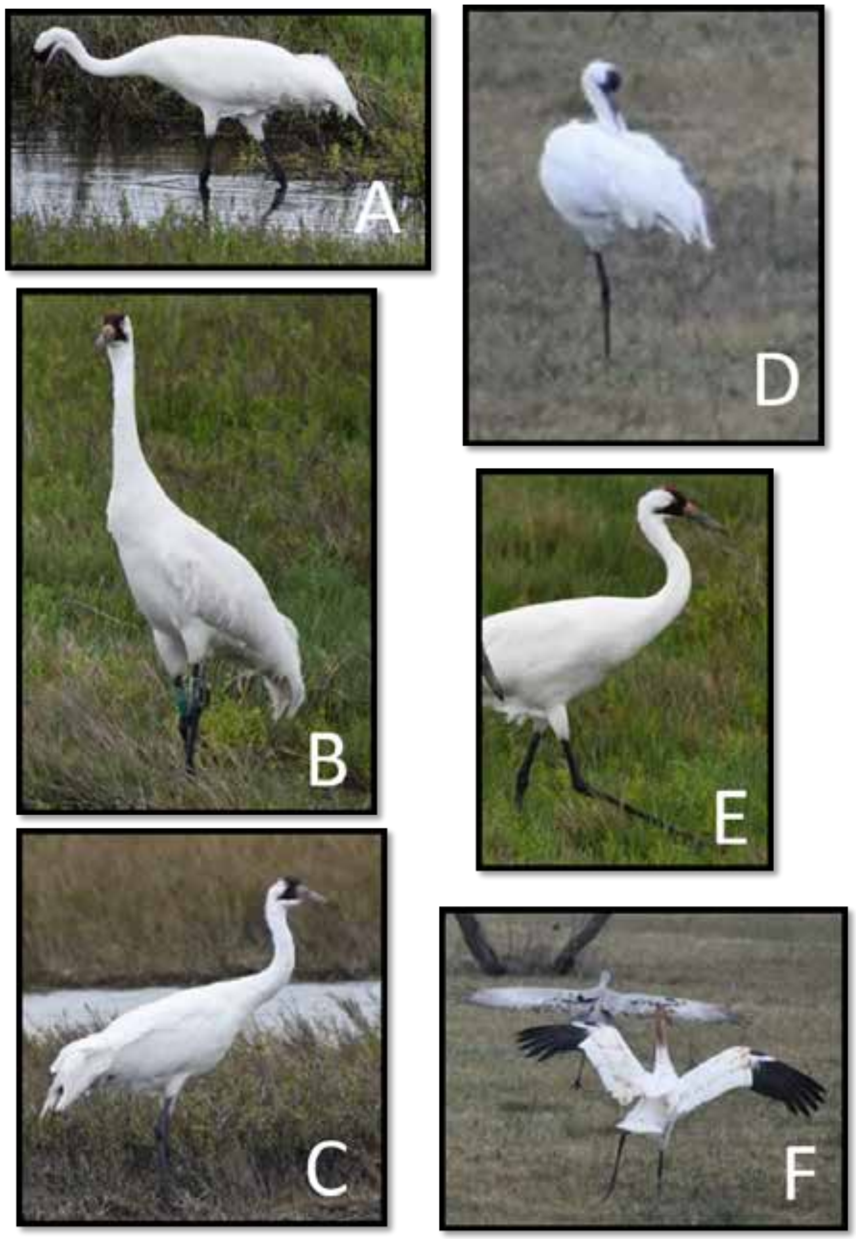

Figure 16. Images of Whooping Cranes displaying each behavioral category used during observational surveys: Foraging (A), Alert (B), Rest (C), Comfort/Maintenance (D), Locomotion (E), and Interaction (F).

Prior to whooping crane observations, all volunteers were trained for a period of ~2 days to provide them with the required background on sampling design, bird behavior identification skills and the whooping crane protection plan that was in place for the entire field expedition. This plan was a requirement of our special use permit and was complied in collaboration between SHSU and our collaborators at the International Crane Foundation. Each observation was conducted by a team of 4-6 individuals. Each team member had a different role: crane observer, data recorder, time keeper and videographer. All volunteers were given the opportunity to train on each team role and volunteers often found a particular role that they embraced for the majority of the observations. Analysis of whooping crane observations in the natural saltmarsh habitats show that cranes spent the majority of their time foraging for food across all years in natural saltmarsh and urban sites

Habitat Assessments.

During each habitat assessment **blue crab surveys** were conducted by ~3-4 volunteers, each either serving as crab surveyors, data recorder and or transect distance measurers. At each site, ≥300m of pond or creek edge habitat (water edge extending to ~3m into the water) per site was be surveyed. The survey method called for one person to walk in the water ~ 1m from the water from the edge while another surveyor is 1m out from the pond edge. Surveyors walk side by side at the same pace while conducting the survey and worked together to both "kick-up" crabs and to visually located crabs. Total crabs number per transect was recorded and crabs were also classified by carapace width as small, medium or large (small: <6cm; medium: 6-10cm; large: >10cm). The recorder/measurer walks behind surveyors to help measure out 100m of pond edge for the survey of that given pond. In the case of small ponds (<100m), the whole pond is surveyed and measured. In addition, at each location of a crab survey water quality data, as previously described, was collected.

During each habitat assessment **wolfberry surveys** were conducted by ~4-5 volunteers, each serving as a wolfberry surveyor (3 volunteers), data recorder and a transect GPS marker. The three wolfberry recorders each carried $1m^2$ transect made from PVC. The transect GPS marker kept track of where each sample was taken and worked to guide the team in a logical direction across the marsh landscape. For each sample point, there are 3, $1m^2$ plots recorded, each plot is located 10m apart from each other. Wolfberry recorders counted the number of red and green Carolina wolfberries within their 1 m^2 quadrat, with data reported to the recorder in order A, B, C. After these three plot are recorded, the group then advanced 15m into the marsh and each recorder places their quadrant for the next sample. A minimum of 15 quadrants/plots wad determined to be the minimum number collected at each site (i.e., 5 repetitions).

As a note, the wolfberry survey was conducted simultaneously with the blue crab survey at each habitat assessment site. Both of these surveys were able to be completed in <1hr and provided a wealth of data on food resources, including spatial distribution, at each site in a very limited amount of time. Here the sample design directly benefited from a large group of volunteers, thus minimizing our total time at each marsh assessment site.

Project Impacts

Report contributions in the categories below for the past fielding year.

1. Increasing Scientific Knowledge

a) Total citizen science research hours

We departed for the field site at 7:00am and often worked till sunset or ~5:30pm. Additional time was often spent in the evening entering data. So I would say an average day easily ~ 10-11hrs of project time/volunteer.

b) Peer-reviewed publications

In order to be effective in ecosystem ecology, long-term data is critical to assess how ecological systems respond to grand environmental drivers (e.g., seal level rise, freshwater inflows, anthropogenic influences, etc.). For this reason, ecosystem studies tend to be long-term (≥ 1 year in length), resulting in fewer, but more comprehensive datasets. With the help of Earthwatch, we have been able to support this long-term research philosophy and have conducted extensive field research to maintain several long-term data sets. We are currently at the point in time when our efforts will begin to pay off in the form of higher impact, broader scope and more scientifically relevant manuscripts.

Following this model, below I have listed five manuscripts that are "Long-term Data Sets in Preparation for Publication." These data sets focus on several key aspects of coastal saltmarsh ecology at the ANWR: primary producers (wolfberry plants), primary consumers (blue crabs) and higher trophic level consumers (Whooping cranes).

The first three manuscripts focus on the endangered Whooping crane, and are the culmination of the ongoing research of my graduate student, Lindsey Tiegs. These manuscripts focus on understanding how the long-term shifts in estuarine conditions (e.g., freshwater inflows, precipitation regimes and hydrological connectivity) influence Whooping crane behavior and habitat quality. Below is more information on each of these research projects.

Manuscript #1: The first manuscript focuses on a multi-year (2016-2018) analysis of Whooping crane behavior. In this project, we are conducting our third and final year of behavioral observations of cranes during the winter season (when Whooping cranes over-winter in Texas). A two-year analysis of crane behavior offers little statistical power when attempting to differentiate the variability between crane foraging, resting, interaction, locomotion and comfort behaviors. Simply stated, by "adding a third dot to the graph," we are confident that the addition of this third year of data will result in a much stronger analysis of the data and a more accurate assessment of Whooping crane behavior across time and space. We anticipate submitting this manuscript to *PLOS One* for publication.

Manuscript #2: The second Whooping crane manuscript focuses on conducting environmental assessment of coastal saltmarsh habitats and then linking that habitat quality to water resources (e.g., freshwater inflows and hydrologic connectivity) within the greater estuary. Here a long-term model is required to be able to tease out the differences in sea level, freshwater inflow amounts, local precipitation and season storm events across multiple years and the related impacts those factors have on key Whooping crane food resources (e.g., blue crabs and wolfberry fruit). We anticipate submitting this manuscript to *Animal Behavior* for publication.

Manuscript #3: The third manuscript explores the use of urban habitats by Whooping cranes. This research project has documented a dramatic increase in urban habitat usage across years. In January '18 we observed ~20 Whopping cranes in urban habitats – this total for one week was more than we had observed in the previous 2 years combined and speaks to the rapid increase in urban habitat usages by the cranes. This rapid escalation in usage over the past 3 years has not been documented elsewhere and will be a focal point of this manuscript. In addition, we have observed significantly different crane behavior in urban settings where the birds are able to consume corn from residential game feeders. In these urban settings, the cranes are far less active than in their natural saltmarsh habitats. As Whooping cranes will only become more intertwined in urban landscapes as their population continues to increase, these findings prove to be significant in the field of Whooping crane ecology. We anticipate submitting this manuscript to the *International Journal of Waterbird Biology* for publication.

Lindsey graduated in fall '17 and has completed a detailed statistical analysis and discussion of the first two years of Whooping crane data for each of these three manuscripts. See the above link to her full thesis and the complete analysis of the first 2 years of data on this project. We anticipate submitting each of these manuscripts this spring, following our last 2018 Earthwatch Expedition, scheduled for March 11-17, 2018. These three manuscripts were 100% supported by Earthwatch.

The fourth and fifth manuscripts in preparation focus on long-term blue crab and wolfberry datasets (data collection for ~4yrs and ~6ys, respectively). Both data sets focus on understanding how long-term shifts in estuarine conditions (e.g. freshwater inflows, salinity, water levels and drought) work to influence blue crab behavior/mortality and wolfberry phenology, respectively. To accurately assess these responses, multiple years are required to capture how these variables differ in the greater estuary. In the summer of 2018, I will collect a 5th year of data on the blue crab for this project. Over the past four years, we have been able to qualify and quantify crab responses to estuarine conditions that range from low freshwater inflows and high salinity, to high freshwater inflows and low salinity in the estuary.

The wolfberry project was initiated following the exceptional drought of '11 in Texas. We have been collecting data on the response and recovery of the wolfberry plants since that drastic event. Our data show that wolfberry phenology was completely overhauled/decoupled and that it has taken ~5 years for the plants to start to return to their historical growth patterns. In addition, with both the blue crab and wolfberry datasets, we will now have the opportunity to collect an additional year of data that will capture responses to Hurricane Harvey, which directly influenced my study sites in 2017. If it was not for this long-term approach, we would not be able to effectively show how blue crab and wolfberry plants respond to a unique event like Hurricane Harvey. This is the strength of long-term ecosystem based studies and is the hallmark of research in my lab. The blue crab behavior manuscript is 100% supported by Earthwatch and the wolfberry phenology paper is partially supported by Earthwatch.

c) Non-peer reviewed publications:

None

d) Books and book chapters

None

e) Presentations:

2018. Lindsey A. Tiegs, Elizabeth H. Smith, **Jeffrey R. Wozniak**. Time Activity Budgets of Wintering Whooping Cranes in Texas. Animal Behavior Society Meeting. Milwaukee Wisconsin. *Oral Presentation.*

2018 Elizabeth Smith, Nicole A. Davis, Lindsey A. Tiegs and **Jeffrey R. Wozniak**. Using Behavioral Responses by

Whooping Cranes to Evaluate Conservation Needs on Protected and Private Lands. Animal Behavior Society Meeting. Milwaukee Wisconsin. *Oral Presentation.*

2018 Lindsey A. Tiegs and **Jeffrey R. Wozniak.** A citizen scientist project: determining drivers of crane resources across the coastal landscape. In: Special Symposia: Waterbird habitat modeling and conservation: spatial dynamics, management, and citizen science. US Regional Association of International Association for Landscape Ecology. *Oral Presentation.*

2. Mentoring

a) Graduate students

Student Name	Graduate Degree	Project Title	Anticipated Year of Completion
Amanda Lofthus	**In Progress (masters)**	Effects of freshwater management on the estuarine nursery dynamics of a coastal predator	**Fall 2019**
Mallika Beach-Mehrotra	**In Progress (masters)**	Effects of urbanization and habitat complexity on predator habitat use	**Fall 2019**

Note: At this time the research projects of the graduate students Lofthus and Beach-Mehrotra are not directly supported by Earthwatch. However, their research projects are directly related to the coastal research we are conducting with Earthwatch. I list each of their projects here to reference that overlap. Mallika and Amanda are currently assisting with the winter adult teams as Field Team Leaders.

b) Community outreach

Name of school, organization, or group	Education level	Participants local or non-local	Details on contributions/ activities
International Crane Foundation	**Various**	**both**	**A portion of our collaboration including the research findings and methods from this project filters into the outreach information of the ICF, especially their Texas Program.**
Texas Master Naturalists	**Various**	**local**	**A portion of our collaboration**

			including research findings and methods from this project filters into the outreach information of the Texas Master Naturalists.

3. Partnerships

Partner	Support Type(s)[1]	Years of Association (e.g. 2006-present)
International Crane Foundation	**ICF provides expertise in crane biology, volunteer training and supports this research project through a continued collaboration with the USFWS**	**2009-present**
Texas Master Naturalists	**The Master Naturalists support this project by aiding us in the training of our volunteers in whooping crane biology.**	**2014-present**

1. Support type options: funding, data, logistics, permits, technical support, collaboration, academic support, cultural support, other (define)

4. Contributions to management plans or policies

None

Plan/Policy Name	Type[2]	Level of Impact[3]	New or Existing?	Primary goal of plan/policy[4]	Stage of plan/policy[5]	Description of Contribution

2. Type options: agenda, convention, development plan, management plan, policy, or other (define)
3. Level of impact options: local, regional, national, international
4. Primary goal options: cultural conservation, land conservation, species conservation, natural resource conservation, other
5. Stage of plan/policy options: proposed, in progress, adopted, other (define)

5. Conserving natural and sociocultural capital

a) Conservation of taxa

i. List any focal study species that you did not list in your most recent proposal

Species	Common name	IUCN Red List category	Local/regional conservation status	Local/regional conservation status source
Grus americana	**Whooping Crane**	**endangered**	**endangered**	**Wide impact of research on coastal marshes, resource availability and human impacts**

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ii. In the past year, has your project helped conserve or restore populations of species of conservation significance? If so, please describe below.

Species	IUCN Red List category	Local/regional conservation status	Local/regional conservation status source	Description of contribution	Resulting effect[6]

6. Resulting effect options: decreased competition, improved habitat for species, range increased, population increase, improved population structure, increased breeding success, maintained/enhanced genetic diversity, other

b) Conservation of ecosystems

In the past year, has your project helped conserve or restore habitats? If so, please describe below.

Habitat type	Habitat significance[7]	Description of contribution	Resulting effect[8]
Coastal Marshes	**Refuge, winter range**	**Research uplift**	**Better understanding of system**

7. Habitat significance options: nursery, breeding ground, feeding site, corridor, migration path, refuge, winter range, summer range, spring range, fall range or other (define)

8. Resulting effect options: extent maintained, condition achieved, restored, expanded, improved connectivity or resilience

c) Ecosystem services

Indicate which ecosystem service categories you are **directly studying** in your Earthwatch research and provide further details in the box below.

☒Food and water

☐Flood and disease control

☒Spiritual, recreational, and cultural benefits

☒Nutrient cycling

Details:

I would say that we cover all of these except flood and disease control. Coastal wetlands are an integral system that has far reaching impacts for humans and wildlife.

d) Conservation of cultural heritage

Provide details on intangible or tangible cultural heritage components that your project has conserved or restored in the past year.

Cultural heritage component[9]	Description of contribution	Resulting effect

9. Cultural heritage component options: traditional agriculture, artifacts, building(s), hunting ground or kill site, traditional ecological knowledge and practices, monument(s), oral traditions and history, spiritual site, traditional subsistence living

RESEARCH PLAN UPDATES

Report any changes in your research since your last proposal/annual report. For any 'yes' answers, provide details on the change in the 'Details' box. This section will not be published online.

1) Have you added a new research site or has your research site location changed? ☐ **Yes** ☐ **No**
2) Has the protected area status of your research site changed? ☐ **Yes** ☐ **No**
3) Has the conservation status of a species you study changed? ☐ **Yes** ☐ **No**
4) Have there been any changes in project scientists or field crew? ☐ **Yes** ☐ **No**

Details – provide more information for any 'yes' answers

There were no changes to the research team or overall research themes in 2017

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