Graduate Research Plan Statement

The Texas coastline consists of seven major estuaries and bay systems separated from the Gulf of Mexico by chains of barrier islands. In southern Texas, Aransas Bay, Redfish Bay, and Corpus Christi Bay provide essential fish habitats and nurseries for several elasmobranch species, including bonnethead sharks (*Sphyrna tiburo*), spinner sharks (*Carcharhinus brevipinna*), and cownose rays (*Rhinoptera bonasus*)[3, 4]. *S. tiburo* and *R. bonasus* have been observed in these bays across all life history stages, whereas *C. brevipinna* mainly use estuaries as a pupping ground and nursery, with mature individuals occupying more coastal and oceanic environments.[4] While it is known that these species occupy this area during periods of their life histories, it is unknown how they utilize the three bays. It is also unclear on how each species exhibits niche partitioning, or the varying patterns of resource utilization (i.e., niches) caused by competition between species. Niche partitioning can take form in spatial or temporal partitioning, where individuals utilize different physical locations or utilize resources at different times, respectively. It can also have an impact on the timing of migrations between coastal and oceanic environments.

For this study, *S. tiburo*, *C. brevipinna*, and *R. bonasus* will be captured using gillnets and bottom-set longlines in Aransas Bay, Redfish Bay, and Corpus Christi Bay. Twenty individuals of each species will have a V13 acoustic transmitter (Innovasea Systems) surgically implanted into the body cavity. Each transmitter emits a uniquely-coded 'pulse-train' and has a battery life of 911 days. A spatial array of 27 underwater acoustic monitoring receivers will be positioned around the Aransas Pass inlet, the major tidal inlet connecting the three bays to the Gulf of Mexico (**Fig. 1**). Given the compatibility of this technology, existing acoustic monitoring receivers along the Texas coast and Gulf of Mexico (Integrated Tracking of Aquatic Animals in the Gulf of Mexico) will enable tracking movements across broad geographic areas outside of the focal bays and inlet. The acoustic receiver array, that simultaneously records in situ water temperature data, is positioned near established weather stations to determine environmental drivers of movement and habitat use. This research will describe whether niche partitioning is present across the focal species within an estuarine nursery habitat (Aim 1). This research will also categorize whether individuals immigrate and emigrate between inlet systems along the western Gulf of Mexico (Aim 2). Lastly, we will use the meteorological and hydrological data collected from the weather stations to compare movement data with weather patterns (Aim 3).

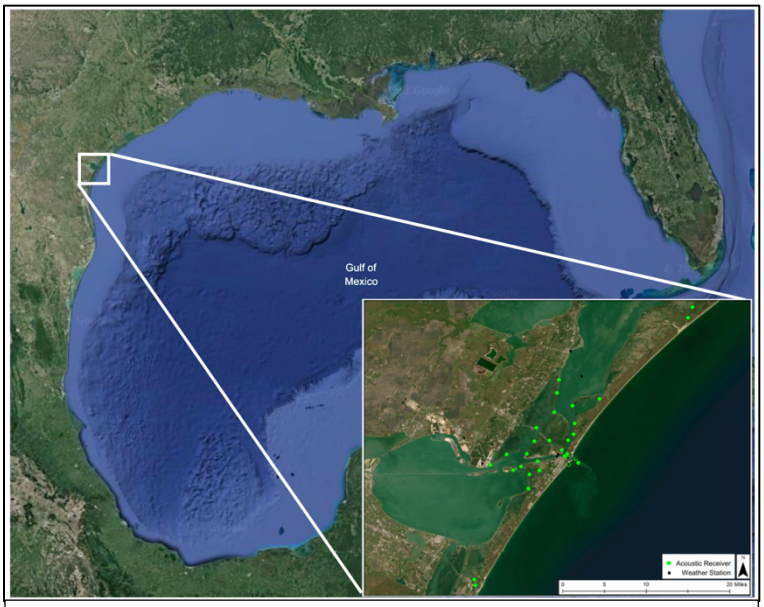

Figure 1. Map of acoustic monitoring receiver locations (yellow circles) and National Data Buoy Center weather stations (black squares), which record meteorological and hydrological environmental parameters.

Aim 1: The wide array of acoustic receivers will provide data on whether *S. tiburo*, *C. brevipinna*, and *R. bonasus* exhibit niche partitioning. Movements will determine whether there is spatial or temporal partitioning by determining what locations each species mainly occupy as well as determining if movement patterns change based on the time of day (e.g., diel or tidal patterns). **This study will address the fundamental ecological question of how these species share this nursery environment in a way that promotes successful growth into adult life stages.**

Aim 2: The long battery life of the acoustic transmitters will allow us to study the long-term movements of the three species. We will use the data collected by the Aransas Pass inlet receiver array, as well as the arrays located at other inlet systems, to examine potential emigration and immigration from the bays. **This**

study will provide a clear insight on the connectivity of inlet systems along the western Gulf of Mexico and how niche partitioning extends beyond the Aransas Pass inlet system.

Aim 3: The weather stations located in the bays where the acoustic receivers will be installed will provide accurate meteorological data of the study sites during the duration of the study. **This data, along with temperature data recorded by the receivers, will be used to determine how the weather patterns in the southern Texas coast impact the habitat use and migration patterns of the target species, which can be then used to predict movement patterns during future weather events.**

Intellectual Merit

Currently, it is unknown how *S. tiburo*, *C. brevipinna*, and *R. bonasus* utilize this vital shared environment. Previous work has been done using acoustic telemetry with coastal elasmobranch species in the eastern Gulf of Mexico (e.g., Alabama and Florida[1, 2]), however, there have been no studies using acoustic telemetry of *S. tiburo*, *C. brevipinna*, and *R. bonasus* along the Texas coast or western Gulf of Mexico. More specifically, it is unknown how these species interact and how they exhibit niche partitioning, either spatially or temporally. The goal of this study is to determine how the three species exhibit niche partitioning within a shared nursery habitat, and whether they exhibit temporal or spatial partitioning. The movements and habitat use will provide insight on potential resident and migration patterns among the bays, which will demonstrate important foraging and refuge areas. Long-term tracking, including the data collected from weather stations, can provide insight on how seasonality shapes movement behaviors and if important areas shift with season and weather. It can also tell us if movements are different during specific times during the day (e.g., sunset vs sunrise) which will describe niche partitioning. This research will be a starting point for further research on other elasmobranch species within the area, which can be applied to other coastal regions along the western Gulf of Mexico to determine niche partitioning in other important habitats. Finally, we will disseminate our findings with the public by publishing and presenting the results through open-access peer-reviewed publications, K-12 presentations, and community lectures. By sharing our findings, we will set a precedent for similar studies and promote the conservation of these species, which are listed as vulnerable or endangered (*S. tiburo*) by the IUCN Red List.

Broader Impacts

The southern Texas coast, specifically Redfish Bay and Corpus Christi Bay, have high human activity in the form of aquaculture, shipping, tourism, oil and gas production, and industrial development. The area surrounding our study site is economically important, as this location attracts many sport fishermen from around the country. Recreational catch-and-release shark fishing has grown in popularity over the past few decades, creating a large local economic driver for coastal communities in Texas. Besides tourism, the Port of Corpus Christi, located within Corpus Christi Bay, is a site of economic importance, as the port is a large driver for shipping and industrial growth in the area. Since *S. tiburo*, *C. brevipinna*, and *R. bonasus* are strong k-selected species and local populations are primarily composed of juvenile individuals, sustainable management of these populations are important for species health and longevity. There is a balancing act between conserving the local populations and promoting economic growth. These species are vital for the overall health of the ecosystem by balancing consumer species populations. By understanding their habitat use and the factors that impact them, we can create management plans to conserve populations and promote overall population sustainability. Lastly, by researching their habitat use and sharing the data we gather, we will help destigmatize species that are misunderstood by the public due to the media and popular culture.

References

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[2]Matich, P, & Heithaus, MR. (2014). Multi-tissue stable isotope analysis and acoustic telemetry reveal seasonal variability in the trophic interactions of juvenile bull sharks in a coastal estuary. *Journal of Animal Ecology*, *83*(1), 199–213.

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Personal, Background, and Future Goals Statement

I grew up in the northern Chicago suburbs. Since an early age, I stood out from my peers due to my passion for marine biology and sharks. Because I lived in Illinois, I lacked the ability to regularly go to the ocean. The closest that I could get to experience marine life was to go to the Shedd Aquarium. The Shedd was also my only source of marine education. Even though I was near the shore of Lake Michigan, my science classes never spoke about lake biology. Throughout high school I participated in Club Shedd, which was a program created by the Shedd Aquarium for students interested in marine sciences to foster and grow innovative ideas on how to better care for the animals in their care. The experiences I had at the Shedd helped me to become aware of the many possible careers available in the study of marine life. I realized that in order to pursue a degree in marine biology, I would need to attend a school that had both an active research program and was near an ocean. The University of Rhode Island fit both criteria and has provided so many learning opportunities.

Right from the start, I reached out to different professors to see if I would be able to work in their labs. I contacted Dr. Bradley Wetherbee, Assistant Professor of Biology, at the beginning of my first semester on campus. He offered me a research position in his lab working on various small projects ranging from the effects of sunscreen on southern stingrays to the bycatch distribution in Delaware Bay. I have worked in his lab continuously since that first semester. During my second semester, I reached out to Dr. Jacqueline Webb, Professor of Biology and Coordinator of URI Marine Biology Program. I have worked closely with her PhD candidate on a project involving fish husbandry and the study of lateral line morphology in the silverjaw minnow since my sophomore year.

In the summer between my sophomore and junior year at URI, I worked with Dr. Wetherbee as his Coastal and Environmental Fellow. The URI Coastal and Environmental Fellowship provides students the opportunity to work directly with a professor on a project and present a poster at the URI Undergraduate Research Symposium. My project examined the three-dimensional habitat use of shortfin mako sharks using data collected from satellite transmitters called SPLASH tags. Each SPLASH tag recorded up to two months' worth of depth and locational data. Depth is recorded in two and a half minute intervals, creating a fine-scale data set. These tags provided me with over 70,000 observations. I used the depth and locational data to determine trends based on the sharks' behavioral states. This project was my first-time analyzing satellite data to determine shark behavior and really strengthened my interests in behavioral ecology. After my fellowship, I asked to continue my project as a Senior honors thesis. My thesis was a comparison study of the SPLASH data with a data set from a different type of satellite tag called pop-up tags. These tags collect depth and temperature data in fifteen-minute intervals and can record many months' worth of data. I compared the trends in depth between both types of tags to see if my original hypotheses that shortfin mako sharks are deeper in the water column while traveling and are shallower when searching for prey were still supported. Through my project, I found that both tag types demonstrate similar behavior and that the behavioral states of individuals were correlated with their depth behaviors.

In addition to my research project, Dr. Wetherbee gave me the opportunity to mentor high school students from the surrounding area on their own projects. These students used the same data set as I did, which helped me with my own analysis. This mentorship gave me the ability to act in a leadership role early on in my academic and research career. I also learned how to be an effective mentor for these students and organize a collaborative research project.

More recently, the summer before my senior year, I worked as a Naval STEM Intern for the Naval History and Heritage Command Underwater Archaeology Branch (UAB). With UAB, I analyzed ROV footage of three US WWII Pacific Arena shipwrecks- USS *Helena* CL-50, USS *Juneau* CL-52, and USS *Lexington* CV-2. Being the only person in the office with a background in marine biology, I was tasked with identifying the organisms inhabiting the wreck sites with the direct purpose of identifying potential biological effects. While my research with UAB veered from my interest in shark behavioral ecology, my internship gave me invaluable experience writing scientific articles. For each shipwreck, I wrote environmental reports highlighting the species that I had identified along with the environmental conditions surrounding the wreckage, such as sediment composition, salinity, and bathymetry. I also had the opportunity to identify a rare species of sea cucumber.

All the opportunities that I have been fortunate to have throughout my undergraduate experience has strengthened my desire to pursue graduate work by studying shark behavioral ecology. My goal is to earn my doctoral degree and ultimately continue to add to the research on shark behavior as well as share that information with others through a teaching career at a research institution. I am actively working towards my goal, as I just started my master's degree working under the supervision of Dr. Daniel Coffey at Texas A&M University- Corpus Christi. My project is focusing on the juvenile habitat use of bonnethead sharks (*Sphyrna tiburo*), spinner sharks (*Carcharhinus brevipinna*), and cownose rays (*Rhinoptera bonasus*) in coastal southern Texas.

Intellectual Merit

Given my interest in sharks, I focused my education and lab work on marine biology at URI. I maintained a GPA of 3.87 while actively working in two different labs each semester. Dr. Wetherbee's labs have focused on field research while Dr. Webb's lab has focused on research within a controlled laboratory setting. Through both experiences I learned to better understand ecological impacts and the various types of research opportunities that exist. I spent one summer as a URI Coastal and Environmental Fellow, presenting my research on the three-dimensional habitat use of shortfin mako sharks at the University of Rhode Island Undergraduate Research Symposium in 2021. I presented in front of hundreds of students, faculty, and broader community members. I have also given a presentation on my 2022 internship with Navy's UAB to fellow undergraduate students. My senior Honors project and thesis were designed to further my Coastal and Environmental Fellowship research. I presented the findings of my Honors project as a twelve-minute talk this past summer at the Joint Meeting of Ichthyology and Herpetology during the American Elasmobranch Society seminar on behavior in Norfolk, VA. In addition to a major in marine biology at URI, I earned a second major in the Spanish language, as I believe that in a global world, communication is a vital skill. I am currently applying the knowledge I gained through my undergraduate research experiences towards completing a M.S. in marine biology.

Broader Impacts

I have always been actively involved with community service. In high school that involved work with the Shedd Aquarium in Chicago as well as with a local charity, Feed My Starving Children, which is a non-profit organization that packs meal kits for malnourished children in developing countries.

At the University of Rhode Island, I was heavily involved with the URI Scuba Club. The URI Scuba Club creates a community for divers in the university community while also educating students on learning how to dive and diving safety. The club also serves as a way for students in marine related degree programs to have an extracurricular exposure to the ocean. I was elected president of the club beginning the 2020-21 academic year and have continued to lead until I graduated. My duties as president included organizing meetings and dives, as well as promoting the club to the student body. My biggest accomplishment through Scuba Club was keeping the community alive throughout the COVID-19 pandemic. Even though the club was not able to meet regularly in person during the 2020-21 school year, I held weekly meetings over zoom. That year I was also able to organize a few dives, with our group being one of the few student organizations being permitted to hold activities by the university. The 2020-21 year had also brought us many new members, many of whom had just recently gotten certified.

One of the accomplishments of the URI Scuba Club is that it makes scuba diving accessible to university community members. The club reimburses a considerable portion of dive equipment rental fees, so that students are not required to pay excessive amounts. Before I became president, the university's budget had decreased yearly. My first year in charge, I fought for an increased budget so that we would be able to cover the expenses of more club members. Since then, I raised the club's budget yearly, so that more people were able to dive without the financial burden.

Along with my work with the URI Scuba Club, I was also the contact person within the marine biology department for questions and emails from prospective students. I responded to emails with additional information about our program as well as offered students encouragement to pursue studies within the field of marine biology. This position gave me the opportunity to share my passion for marine biology and teach others about the great opportunities that URI provides to its students.

My research as a Naval STEM has been used to better manage our nation's shipwrecks. The information I gathered on the occupying species helps identify potential biological threats to the integrity of each wreck site, as each ship is considered to have live ordinance and other ecologically harmful substances aboard. The understanding of what is living on each wreck helps predict whether there is a potential for a leak and what can be done to stop any ecological damage.

During my senior year of my undergraduate degree, I mentored local high school students under the supervision of Dr. Wetherbee. These students participated in the URI Shark Camp and attended the MET School in Providence, RI, and Newport, RI, an experience-based high school serving underrepresented students throughout Rhode Island. I taught them how to analyze and manage large datasets. I also encouraged them to create their own questions based off the data, so that they could design their own projects.

I hope to continue working with students at TAMU-CC (a Hispanic and Minority Serving Institution where 50% of recent graduates are first generation, 46% are Hispanic, and 51% are minority students) utilizing my Spanish skills to serve broader and underrepresented communities. As I progress through my master's degree, I will include undergraduate students in my project. I want to give opportunities for students to pursue research at an undergraduate level, just like how I was fortunate enough to have undergraduate research experiences at URI. I also plan to use Spanish to share information about the conservation and management of shark populations with community members. Future outreach events will include speaking to school-aged children about the importance shark research through K-12 and local aquarium programs and teaching the broader community about various conservation efforts.

Collectively, these experiences have reinforced my desire to continue my education and research within the field of marine biology. If I were to be awarded this grant, I will work to further the broad dissemination of my research findings by publishing and presenting my work to local communities. I will also work to further the inclusion of underrepresented voices in marine science.