SPATIOTEMPORAL DISTRIBUTION AND ABUNDANCE OF ATLANTIC STINGRAYS (DASYATIS SABINA) AND COWNOSE RAYS (RHINOPTERA BONASUS) IN GALVESTON BAY, TX

An Undergraduate Research Scholars Thesis

by

JENNA BROGDON and MADISON GRAVES

Submitted to the Undergraduate Research Scholars program at
Texas A&M University
in partial fulfillment of the requirements for the designation as an

UNDERGRADUATE RESEARCH SCHOLAR

Approved by Research Advisor: Dr. R. J. David Wells

May 2020

Major: Marine Biology

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ABSTRACT

Spatiotemporal Distribution and Abundance of Atlantic Stingrays *(Dasyatis sabina)* and Cownose Rays *(Rhinoptera bonasus)* in Galveston Bay, TX

Jenna Brogdon and Madison Graves
Department of Marine Biology
Texas A&M University

Research Advisor: Dr. R. J. David Wells
Department of Marine Biology
Texas A&M University

As mesopredators, stingrays play a crucial role in coastal and estuarine food webs by feeding on benthic prey and being consumed by pelagic apex predators. This effectively links the lower and higher trophic levels together, which is critical for the functioning of the entire ecosystem. In order to successfully connect these levels, stingray species must specialize their movements in order to avoid overlap thereby inhibiting the chance of prey shortage and trophic cascade. While these organisms tend to be a popular subject of study, little information is currently available on stingray spatiotemporal distribution patterns in Texas estuaries, where multiple species of stingrays co-occur and potentially compete for resources. To better understand interspecific seasonal interactions of stingray mesopredators and how two similar stingray species are able to coexist in a shared environment, we conducted catch per unit effort (CPUE) analysis across seasons on the Atlantic Stingray (*Dasyatis sabina*) and the Cownose Stingray (*Rhinoptera bonasus*) in Galveston Bay, Texas. In order to calculate seasonal CPUE for both species, historical data obtained by Texas Parks and Wildlife Division (TPWD) from 1986 to 2018 was analyzed and evaluated. This data was acquired via gillnet, where the specimens

were caught, recorded, and released swiftly, making this a non-lethal study. This insight into the spatiotemporal movement patterns of two sympatric species could aid in determining how these species may move through Galveston Bay during specific time intervals in order to thrive in a shared environment.

ACKNOWLEDGEMENTS

We would first and foremost like to thank our research advisor, Dr. David Wells, for giving us the opportunity to conduct this study and providing us with the resources to do so. We would also like to thank Mariah Livernois for guiding us through this process and never missing a chance to provide help, opinions, and knowledge. Additionally, we would like to thank the Texas Parks and Wildlife Department for allowing the use of their data. This study would not have been possible without them.

Thanks also goes to the LAUNCH program, the UGR program and Dr. Lene Petersen for keeping our progress on track and guiding us through all uncertainties. We would also like to extend our gratitude to our university, Texas A&M at Galveston and all faculty and staff that made our research facilities what they are today. Finally, we would like to thank the ACES committee for believing in our research and providing the funds to make it possible.

NOMENCLATURE

CPUE	Catch Per Unit Effort
TPWD	Texas Parks and Wildlife Department
ArcGIS	Aeronautical Reconnaissance Coverage Geographic Information System

CHAPTER I

INTRODUCTION

Stingrays can be found in tropical and subtropical environments around the world. More specifically, stingrays thrive in coastal, estuarine environments where they play a key role in the food web as mesopredators (Dale et al., 2011; Struhsaker, 1969; Snelson Jr, 1988). Mesopredators prey on animals at lower trophic levels and are consumed by animals at higher trophic levels, thereby effectively linking trophic levels. In order to successfully manage this species and the species they interact with, understanding abundance and distribution is crucial. Galveston Bay is a prime example of a coastal, estuarine environment which exhibits both spatial and temporal stingray movement patterns.

As an estuary, Galveston Bay hosts a diverse array of life that can tolerate constant water quality fluctuation. The Galveston Bay Foundation generates average values of Galveston Bay air temperature, water temperature, salinity, water transparency, dissolved oxygen, Enterococci bacteria, and Ph range which can be seen in Table 1. With cooler air comes cooler water which has a higher capacity of dissolved oxygen (Galveston bay foundation, 2020). This change in environmental parameters ultimately leads to the movement of stingrays in and out of Galveston Bay.

Table 1. The averages of Galveston Bay parameters by the Galveston Bay Foundation (2020).

Environmental Parameter	Average in 2018
Air Temperature (°C)	22.3
Water Temperature (°C)	21.8
Salinity (ppt)	13.8
Dissolved Oxygen (mg/L)	6.5
Enterococci Bacteria (MPN)	14.1
Water Transparency (meters)	0.45
pH Range	6-10

Note: The 2018 air and water temperature were lower than previous years and the Enterococci Bacteria was higher than previous years. Dissolved oxygen was in good condition and the water transparency, pH, and salinity were all like previous years.

As mesopredators, stingrays in Galveston Bay have the same ecological function, stabilizing the ecosystem by linking the upper and lower trophic levels. Alternatively, interspecific migration patterns differ. While broad scale movement patterns of the cownose ray have been previously studied, with movements out of Galveston Bay as winter sets in, fine scale movement patterns are unknown (Smith and Merriner 1987; Schwartz 1965; Smith and Merriner 1985). The Lesser electric ray has exhibited a tighter spatial range of migration than the

Cownose ray, showing movements into deeper water but not different coastlines (Vianna & Vooren 2009). These sympatric species are able to coexist by way of resource partitioning, negating energy expenditure on competitive behaviors. This enables the two species to thrive in a shared habitat (O'Shea et al., 2012; Thrush, 1999).

The Atlantic stingray and the Cownose ray overlap spatially with respect to season. The Atlantic stingray ranges from Chesapeake Bay to Mexico and the Cownose ray ranges from New England to south Florida. The spatial overlap lies in Galveston Bay with coexistence of the sympatric species occurring primarily in the fall. This is made possible by Galveston Bay exhibiting a wide range of salinities which can be attributed to it being an estuarine system. This system enables the euryhaline species, the Atlantic stingray and Cownose ray, to utilize both the bay, where salinities are low, and offshore waters, where salinities are higher, as seasonal habitats (Neer et al., 2007). These two species have been previously classified as eurythermal by Neer et al. which could also contribute to these large-scale seasonal movements.

The Atlantic and Cownose ray are key species in the Galveston Bay trophic system. The linkage between the benthic and pelagic species allows for an exchange of nutrients that would not be possible without the presence of these mesopredators. Additionally, these elasmobranch species have the capability to effectively change their diet in order to contain a trophic cascade event. Understanding the abundance and spatiotemporal movement patterns of the sympatric Atlantic stingray and Cownose ray is essential to understanding the functions of mesopredators in an estuarine system.

CHAPTER II

METHODS

The Texas Parks and Wildlife Department conducts gillnet sampling in the Galveston Bay system. The Galveston Bay system is defined by the Texas Parks and Wildlife Department as, “All waters, including all saltwater bayous, bounded by a line behind the Surfline from the bridge over the ICWW at High Island to the southwestern shoreline of Drum Bay and the north edge of Trinity Bay where the Trinity River enters the bay. On 21 November 1982, the area between the State Highway 146 bridge over the Houston Ship Channel and the junction of the San Jacinto River and the Houston Ship Channel was added to the Galveston Bay System.” The data used for this paper was gathered between 1986 and 2018.

Seasonal sampling for the spring begins the second week of April and extends for the next ten weeks, and sampling for the fall begins the second week of September and extends for the next ten weeks. Between three and five nets are set per week, with no more than three set per night. A total of 45 nets are set per season (90 per year). Sampling begins one hour before sunset, with the net set by sunset, and ends at sunrise, with the net pulled no later than four hours after sunrise.

The Coastal Fisheries gill nets measure 182.9m long with four 47.7m sections. In most cases, the net will cover the water column, reaching the bottom. In other cases, the net can move as much as 1.2m up from the bottom. Mesh monofilament webbing sizes are 152mm, 127mm, 102mm and 76mm.

At the field station, random shoreline is selected for sampling via a grid system. Each grid measures one-degree longitude by one-degree latitude. Each grid is divided into 144 gridlets which measure 5 seconds by 5 seconds. Gridlets on the shoreline are chosen at random to sample. Upon arriving at the field location, shoreline distance is estimated and divided by 2 to find 15.2m of shoreline to sample. Gillnets are set perpendicular to the shoreline with the smallest mesh near shore by way of boat. Five buoys are distributed evenly along the net with one at each end. Buoys are brightly colored and labeled with TPWD. Nets should be one kilometer apart at least. GPS coordinates, depth, temperature, salinity, dissolved oxygen, turbidity, water sample, and other hydrological data should be collected at the buoy farthest from shore.

Upon the catch of an organism, it is removed from the net, taxonomically identified, sexually identified, measured and released as quickly as possible. Total length measurements are done by taking the total wingspan of the stingray.

Catch per unit effort was calculated in order to standardize the data and allow for comparisons to similar studies globally. CPUE was then compared across seasons per species. CPUE was then compared across years sampled (1986-2018) per species.

CHAPTER III

RESULTS

Data showed strong evidence for temporal and spatial distributions for both species. While both species CPUE indicate seasonal-temporal distribution, the season at which high CPUE values are shown is highly variable. CPUE calculated across seasons for *Dasyatis sabina* showed increased catch during the spring and decreased catch during the fall (Figure 1). Conversely, *Rhinoptera bonasus* exhibited increased catch in the fall and decreased catch in the spring (Figure 1). When examining CPUE per year, 1996, 2009, and 2016 show notably higher catch rates for *Rhinoptera bonasus* than other years in the survey period (Figure 2). Although *Dasyatis sabina* catch rates were notably higher in 2011, the value is still lower than all three high CPUE values for *Rhinoptera bonasus* (Figure 2 and 3).

Using ArcGIS, maps were generated using CPUE data in order to visualize exact catch points and variation with season. *Dasyatis sabina* exhibited a lower presence in the bay in the fall compared to the spring (Figure 4 and 5). Catch was higher near the mouth of Galveston Bay in the fall. Although that trend continued throughout the year, more inland catches were made in the spring (Figure 4 and 5). *Rhinoptera bonasus* exhibited slightly higher CPUE in fall than spring (Figure 6 and 7). More catches were made in East Galveston Bay in the fall and West Galveston Bay in the Spring (Figure 6 and 7). The year around dispersal of *Rhinoptera bonasus* in the bay is contrary to the dispersal of *Dasyatis sabina* near the edge of the bay.

CHAPTER IV

CONCLUSION

The results of this study indicate these two species of rays have different spatiotemporal distribution patterns. *Rhinoptera bonasus* are more evenly dispersed around the bay with a higher abundance in the fall. *Rhinoptera bonasus* were caught less during the spring, which could be attributed to the known northern migration event which occurs in the spring (Schwartz 1965). *Dasyatis sabina* resides around the mouth of the bay annually with a higher abundance in the spring. New findings of this study include the movement patterns of *Dasyatis sabina* species in Galveston Bay. These species exhibited a higher CPUE in the spring which has strong implications for a migration event in the fall. While environmental parameters were measured at each site (Figure 8 and 9), there were no statistical analyses conducted to determine the significance of environmental parameters on CPUE. Including this analysis in a future study could give rise to important ecological trends that have not previously been studied in Galveston Bay.

In 1965, Schwartz conducted a study similar to this one which uncovered *Rhinoptera bonasus* movement patterns. Schwartz reported a clockwise migration pattern of rays in the Gulf of Mexico (GOM) with the rays seeking warmer waters in the Southern GOM in the fall. It is largely thought that temperature fluctuations drive the movement of *Rhinoptera bonasus* (Goodman et al., 2011). Conversely, this study found a higher CPUE value in the fall than the spring which was not expected, as it is thought the rays are in the Southern GOM in the fall. The presence of *Rhinoptera bonasus* in the spring could indicate the use of Galveston Bay as a parturition site and/or nursery habitat. Also reported was the average depth at which the rays travel in the GOM, 15 meters. Due to the depth limitations of Galveston Bay, *Rhinoptera bonasus* are less likely to travel through the area. This data can be used to support our findings of low abundance of the species in Galveston Bay as a whole.

Contrary to *Rhinoptera bonasus,* the migration routes of *Dasyatis sabina* are unknown. While studies have reported a clear migration, others have reported no yearly movement patterns (Schwartz & Dahlberg, 1978; Schwartz 2000). Studies conducted on the Texas coast have described a high abundance of *Dasyatis sabina* year around which suggests no large-scale movement patterns of the species (Sage et al., 1972). As a hardy species which can tolerate a wide range of water quality parameters, there is no need to expend metabolic energy traveling to a new location entirely (Schwartz, 2000). While no large-scale movement patterns were observed, there were slight variations in CPUE across seasons which could be associated with prey abundance, predator avoidance, parturition behaviors etc. (Goodman et al., 2011).

It should be noted this study was not without error or limitations. This study included CPUE rates which were limited by using only passive capturing gear as well as sampling bias. Due to logistical constraints, specimens were caught using only gillnets which were deployed around the edge of the bay, never in the middle. This type of sampling could lead to inconsistencies in the population dynamics of these species. The study's geographical barriers prevented sampling outside of Galveston Bay which could also lead to discrepancies in population dynamics when examining immigration and emigration patterns, such as in this study. Additionally, this study did not include a statistical analysis on environmental parameters due to time constraint. This information could provide insight on attributing factors to large and fine scale movement patterns of stingrays in Galveston Bay and should be included in a future study.

Overall, the seasonal variation of movement patterns of two sympatric species proves their ability to thrive in a shared environment. This data provides an insight to the process of avoiding overlap in order to prevent prey shortage and thereby avoiding a trophic cascade. This process being, specialized movement patterns. Specifically, timing immigration in, and emigration out of Galveston Bay also prevents crowding of parturition and nursery sites thereby increasing the fitness of both species. These spatiotemporal movements provide a way for an array of species, both on upper and lower trophic levels, to coexist in a shared environment. Mesopredator movement patterns play a critical role in community structure and are crucial for the upkeep of estuarine ecosystems globally.

REFERENCES

Dale, J. J., Wallsgrove, N. J., Popp, B. N., & Holland, K. N. (2011). Nursery habitat use and foraging ecology of the brown stingray dasyatis lata determined from stomach contents, bulk and amino acid stable isotopes. *Marine Ecology Progress Series, 433*, 221-236.

Galveston bay foundation. (2020). Retrieved from http://waterdata.galvbay.org/download_data

Goodman, M. A., Conn, P. B., & Fitzpatrick, E. (2011). Seasonal occurrence of cownose rays (rhinoptera bonasus) in north carolina's estuarine and coastal waters. *Estuaries and Coasts, 34*(3), 640-652. Retrieved from http://www.jstor.org/stable/41333003

Neer, J. A., Rose, K. A., & Cortés, E. (2007). Simulating the effects of temperature on individual and population growth of rhinoptera bonasus: A coupled bioenergetics and matrix modeling approach. *Marine Ecology Progress Series, 329*, 211-223.

O'Shea, O. R., Thums, M., van Keulen, M., & Meekan, M. (2012). Bioturbation by stingrays at ningaloo reef, western australia. *Marine and Freshwater Research, 63*(3), 189-197.

Sage, M., RG, J., WL, K., & VL, D. (1972). Growth and seasonal distribution of the elasmobranch dasyatis sabina.

Schwartz, F. J. (1965). Inter-american migrations and systematics of the western atlantic cownose ray, rhinoptera bonasus. Paper presented at the *Association of Island Marine Laboratories of the Caribbean, Sixth Meeting,* 1.

Schwartz, F. J. (2000). Elasmobranchs of the cape fear river, north carolina. *Journal of the Elisha Mitchell Scientific Society,* 206-224.

Schwartz, F. J., & Dahlberg, M. D. (1978). Biology and ecology of the atlantic stingray, dasyatis sabina (pisces: Dasyatidae) in north carolina and georgia. *Gulf of Mexico Science, 2*(1), 1.

Smith, J. W., & Merriner, J. V. (1985). Food habits and feeding behavior of the cownose ray, rhinoptera bonasus, in lower chesapeake bay. *Estuaries, 8*(3), 305-310.

Smith, J. W., & Merriner, J. V. (1987). Age and growth, movements and distribution of the cownose ray, rhinoptera bonasus, in chesapeake bay. *Estuaries, 10*(2), 153-164.

Snelson Jr, F. F., Williams-Hooper, S. E., & Schmid, T. H. (1988). Reproduction and ecology of the atlantic stingray, dasyatis sabina, in florida coastal lagoons. *Copeia,* 729-739.

Struhsaker, P. (1969). Observations on the biology and distribution of the thorny stingray, dasyatis centroura (pisces: Dasyatidae). *Bulletin of Marine Science, 19*(2), 456-481.

Thrush, S. F. (1999). Complex role of predators in structuring soft-sediment macrobenthic communities: Implications of changes in spatial scale for experimental studies. *Australian Journal of Ecology, 24*(4), 344-354.

Vianna, Gabriel Maciel de Souza, & Vooren, C. M. (2009). Distribution and abundance of the lesser electric ray narcine brasiliensis (olfers, 1831) (elasmobranchii: Narcinidae) in southern brazil in relation to environmental factors. *Brazilian Journal of Oceanography, 57*(2), 105-112.

APPENDIX

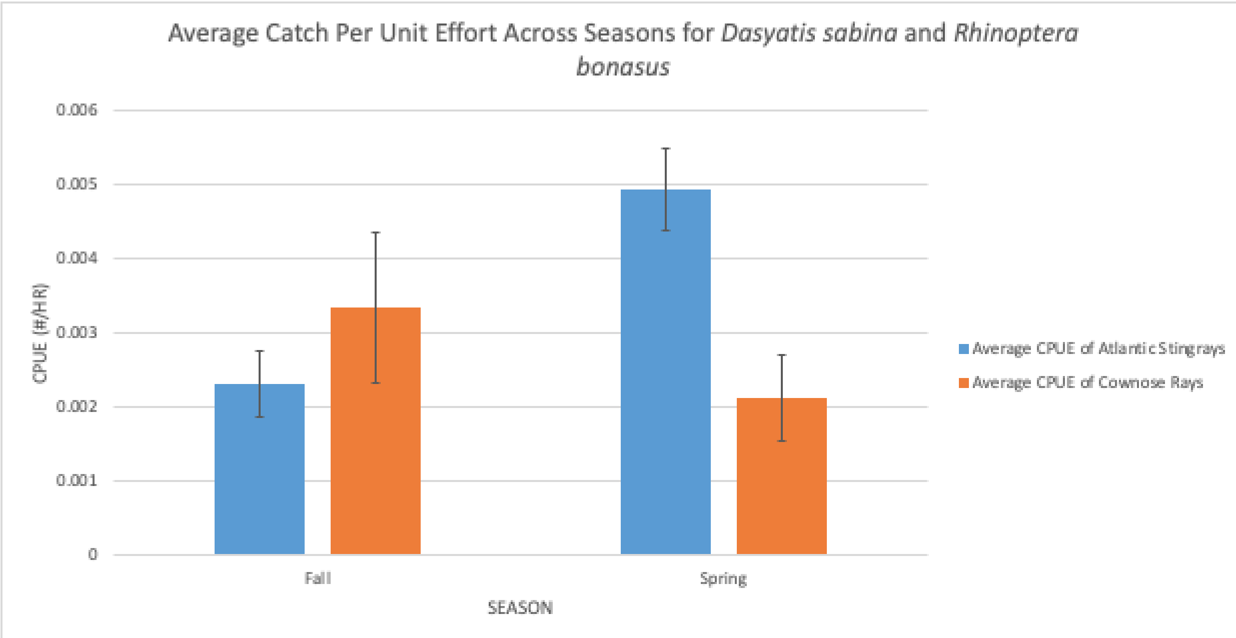

Figure 1**.** CPUE of *Dasyatis sabina* and *Rhinoptera bonasus* in Galveston Bay over 32 years seasonally.

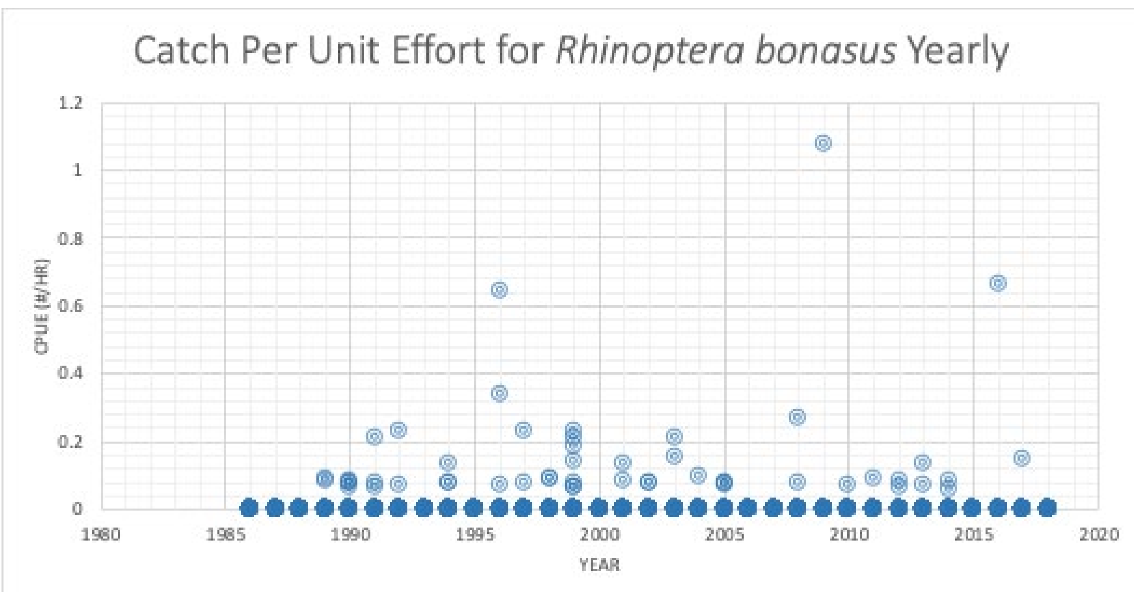

Figure 2. CPUE for *Rhinoptera bonasus* between the years 1986 and 2018.

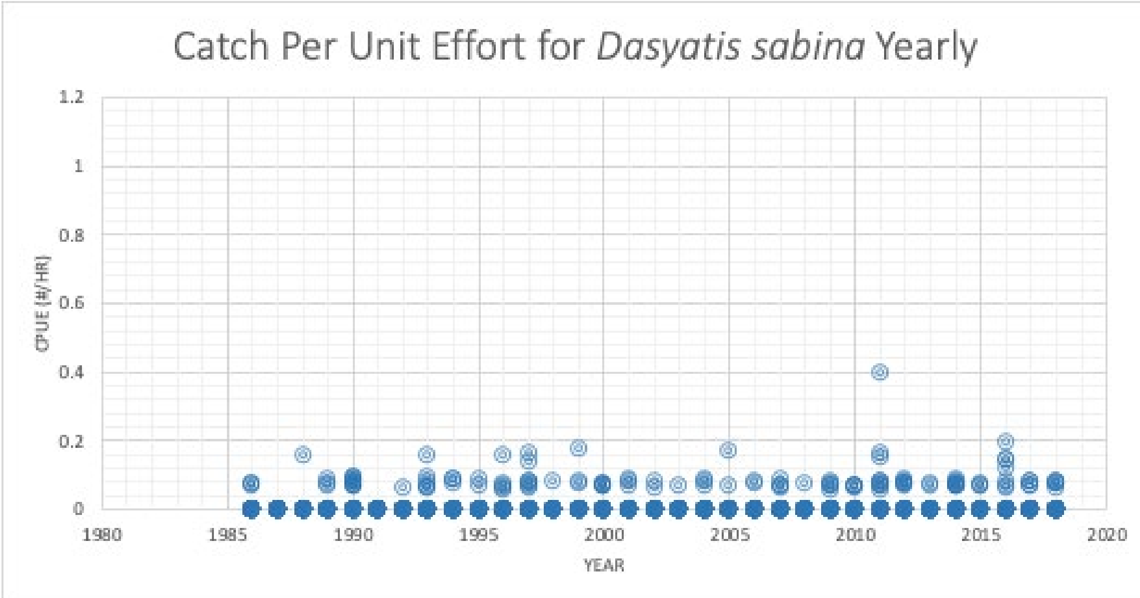

Figure 3. CPUE for *Dasyatis sabina* between the years 1986 and 2018.

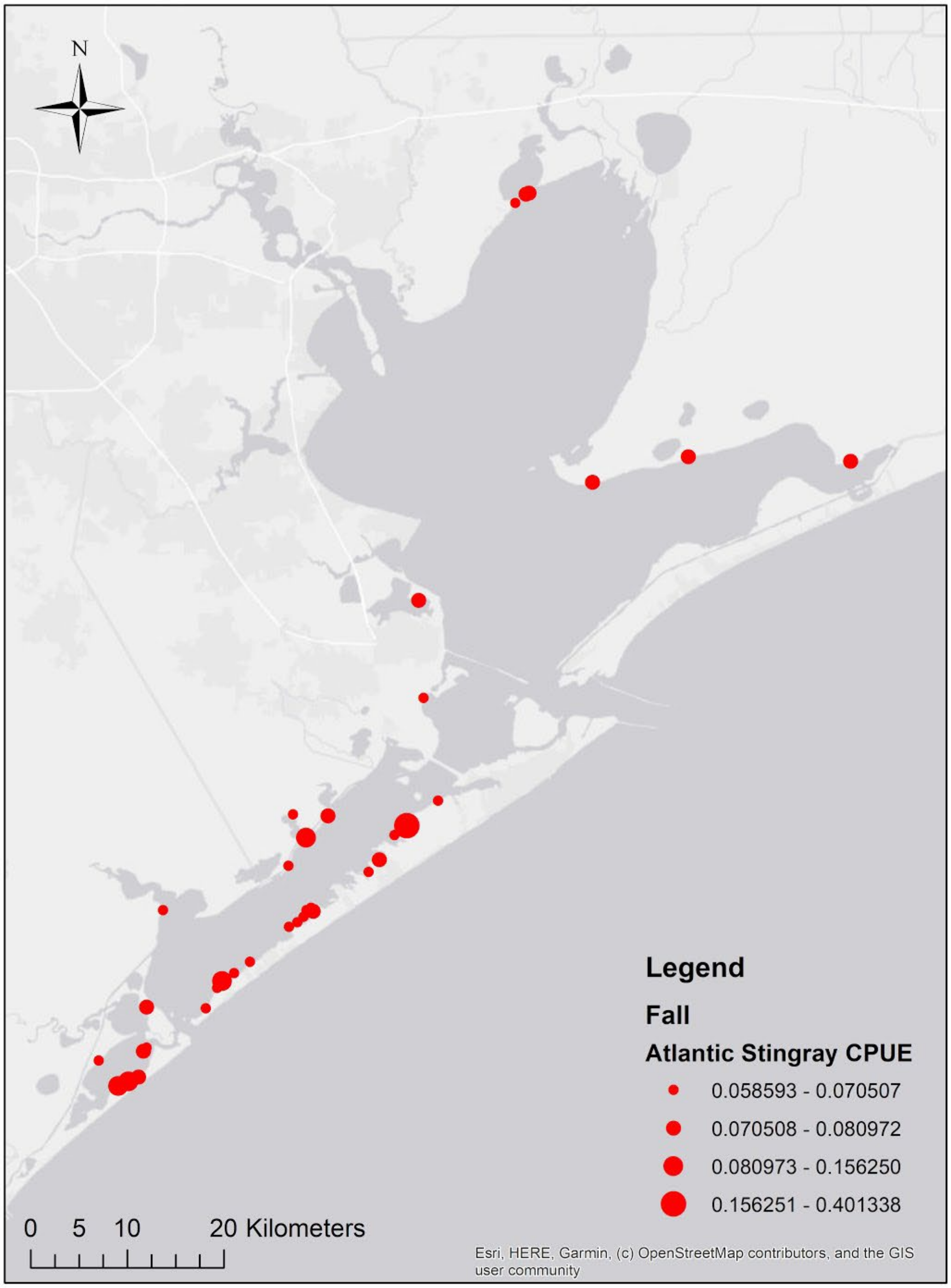

Figure 4. Spatial distribution of *Dasyatis sabina* in Galveston Bay. Data points represent specimens caught in the fall seasons of 1986 to 2018.

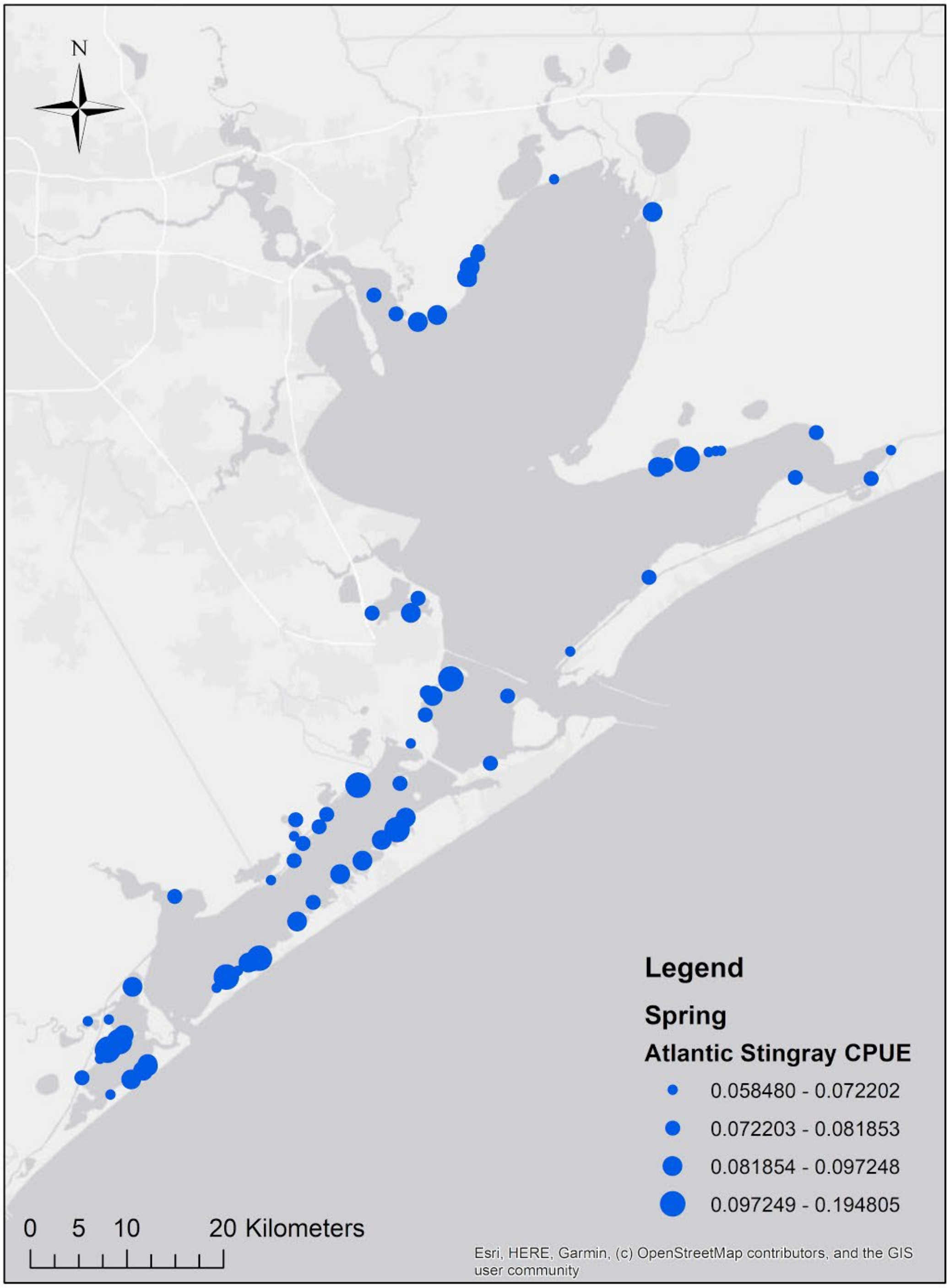

Figure 5. Spatial distribution of *Dasyatis sabina* in Galveston Bay. Data points represent specimens caught in the spring seasons of 1986 to 2018.

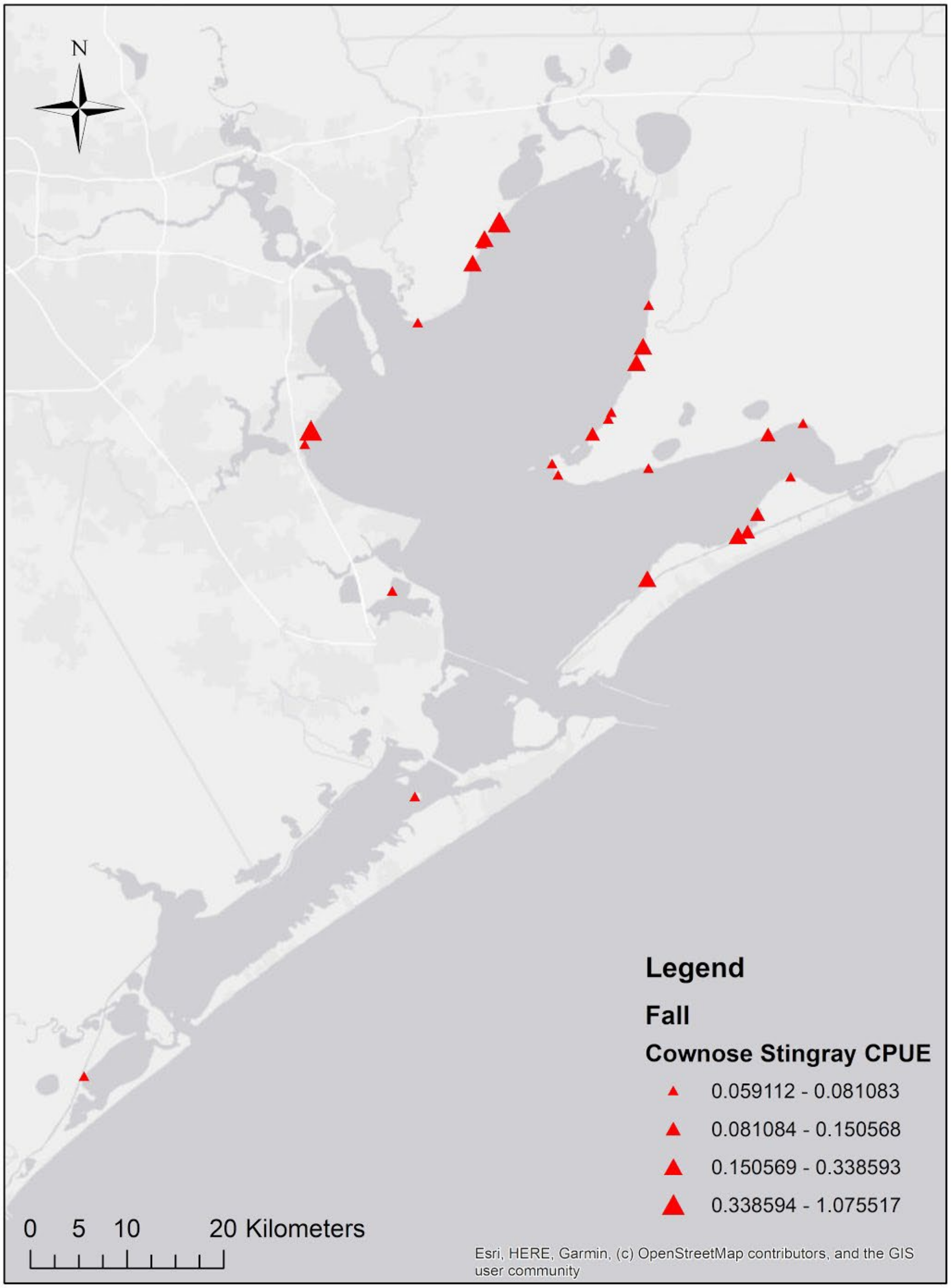

Figure 6. Spatial distribution of *Rhinoptera bonasus* in Galveston Bay. Data points represent specimens caught in the fall seasons of 1986 to 2018.

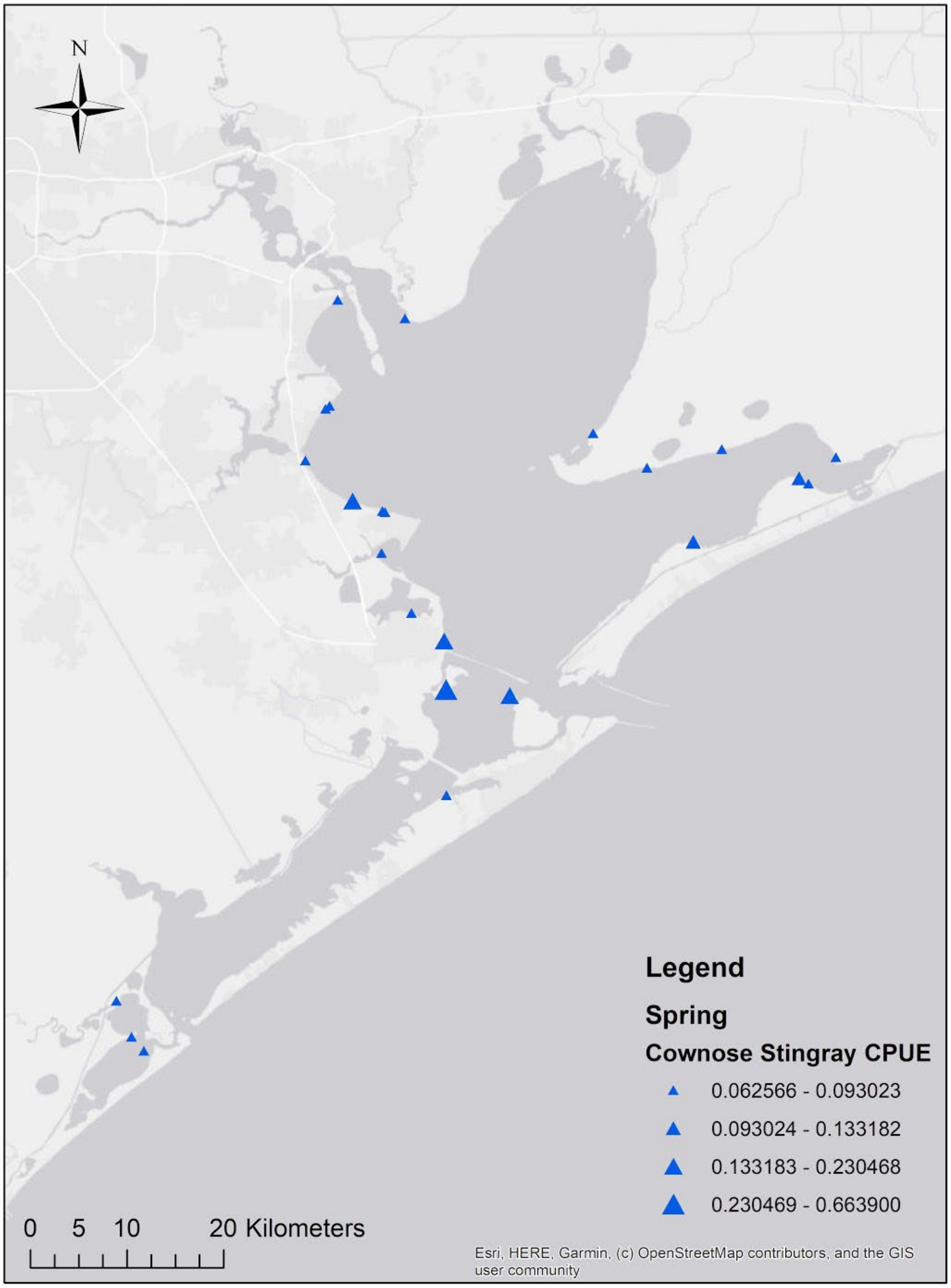

Figure 7. Spatial distribution of *Rhinoptera bonasus* in Galveston Bay. Data points represent specimens caught in the spring seasons of 1986 to 2018.

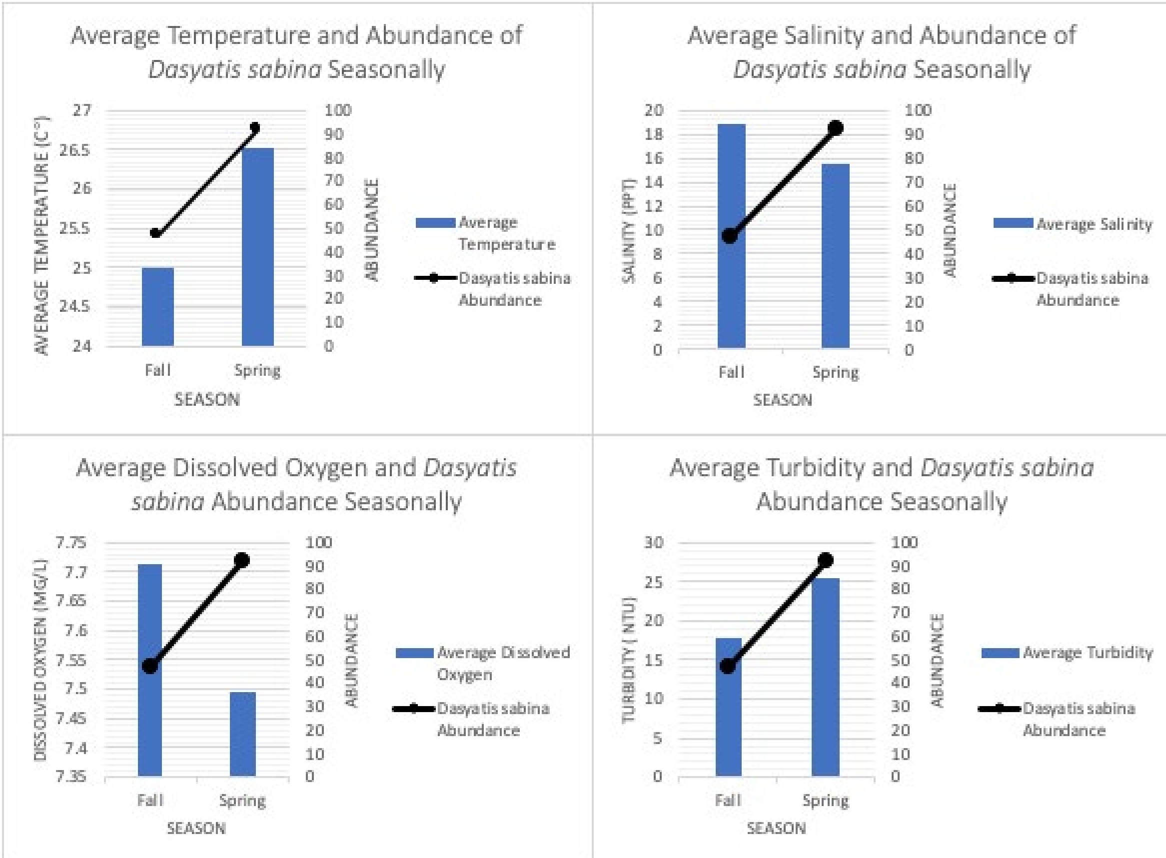

Figure 8. Average environmental parameters of Galveston Bay against abundance of *Dasyatis sabina* in Galveston Bay (top left is temperature, top right is salinity, bottom left is dissolved oxygen, and bottom right is turbidity). The graphs are suggesting that there could be possible connections between the different parameters and the abundance of Atlantic stingrays (*Dasyatis sabina*).

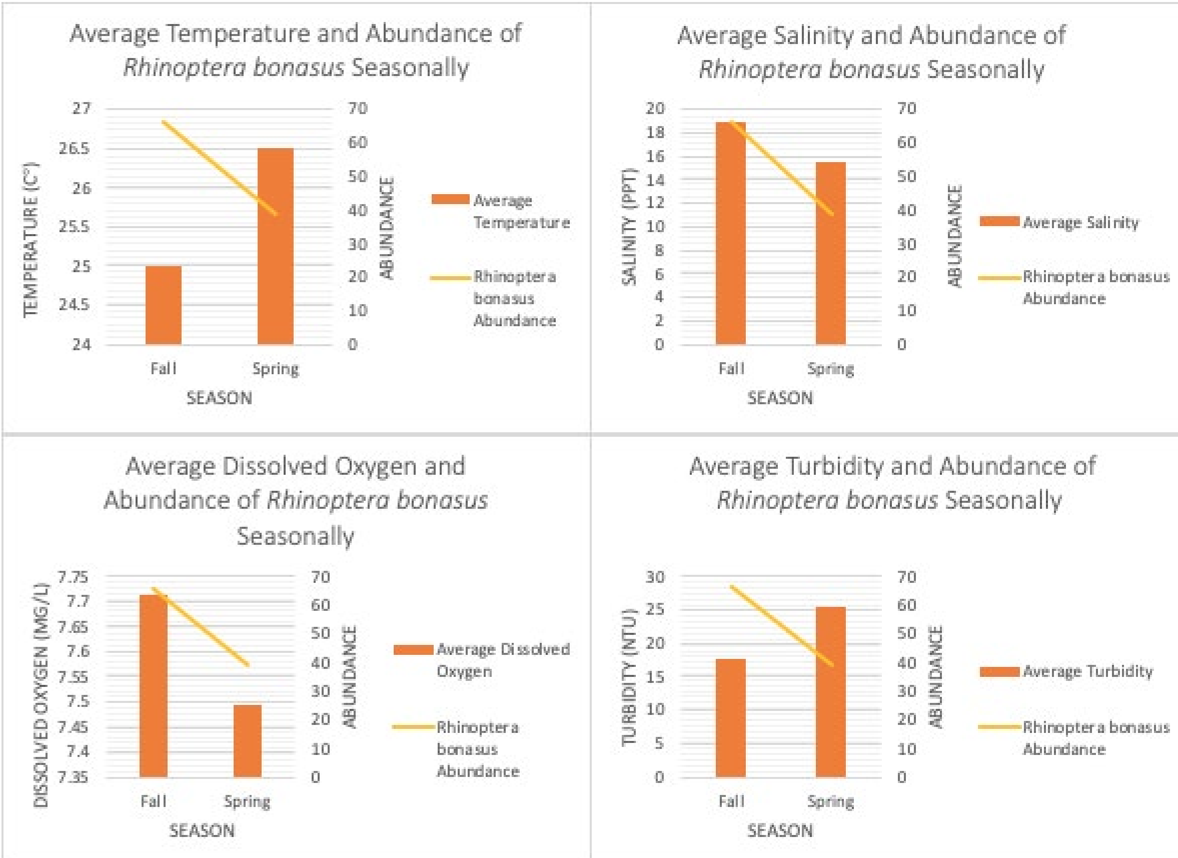

Figure 9. Average environmental parameters of Galveston Bay against abundance of *Rhinoptera bonasus* in Galveston Bay (top left is temperature, top right is salinity, bottom left is dissolved oxygen, and bottom right is turbidity). The graphs are suggesting that there could be possible connections between the different parameters and the abundance of Cownose rays (*Rhinoptera bonasus*).