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Spatial Distribution of Cownose Rays (*Rhinoptera bonasus*) Within St. Joseph Sound, Florida

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ABSTRACT

Pinellas County is known for its multitude of highly diverse barrier islands, one of which is Honeymoon Island State Park. On the eastern side of the island is Saint Joseph Sound, an intracoastal waterway containing important seagrass habitat that supports high biodiversity. Cownose rays (*Rhinoptera bonasus*) are pelagic intermediate predators that migrate seasonally into Saint Joseph Sound. The species' spatial distribution within the waterway was analyzed in relation to shark landings (potential predators) from years 2013–2019. Multiple spatial maps were produced using geoprocessing tools from ESRI ArcGIS. Statistical analysis indicated that the Catch Per Unit Effort (CPUE) was not significant, but sharks and *R. bonasus* were inversely associated with each other within the sample sites. Boggy Bayou, a seagrass flat, located outside the state park boundary contained 405 *R. bonasus* individuals caught within the sampling period, while 23 individuals were caught inside the state park boundary. The spatial maps and statistical tests indicated that *R. bonasus* are not associated with state park boundaries in the intracoastal waterway. Data configured in the GIS project map aided in locating aggregation sites of *R. bonasus* and identified their preferred local habitat as a protected seagrass bed with an adjacent sandy bottom. Further analysis, along with habitat restoration in the intracoastal waterway would help to ensure the abundance of *R. bonasus* within the local area.

1 INTRODUCTION

Cownose ray (*Rhinoptera bonasus*) ecology is not well understood along the west central coast of Florida. *R. bonasus* is a pelagic ray that migrates seasonally into nearshore estuarine ecosystems and is an intermediate predator within the food chain (Graig et al., 2010). Interactions between intermediate and apex predators (such as sharks) provides insight into estuarine functions and dynamics and can identify areas of high predation within the ecosystem.

There is evidence that the population of *R. bonasus* in the Gulf of Mexico is different from the population in the Atlantic Ocean, because both have different migration patterns and adapt to different environmental factors (Collins et al., 2007). Further, the migration route in the Gulf of Mexico is not well understood, but the species is abundant nearshore during late spring and summer months (Vaudo & Heithaus, 2011). A portion of the population in the Gulf of Mexico could also be residential and have different life history strategies based on their local habitat (Collins et al., 2008). Foraging locations of *R. bonasus* are around barrier islands and riverine inputs into estuarine ecosystems, and recent studies found that they can be specialists or opportunists depending on prey availability (Ajemian & Powers, 2012). They mostly eat sessile invertebrates, but with apex predators declining the trophic effects can be seen down to the local bay scallop (*Argopecten irradians*) populations based on their specialist foraging behavior (Ajemian et al., 2012). These rays are able to swim long distances in a short amount time, which allows them to partition food along microhabitats in these coastal ecosystems (Vaudo & Heithaus, 2011). The foraging effects may be site/habitat specific or driven by predator avoidance (Ajemian & Powers, 2013; Collins et al., 2007). Determining the spatial distribution of *R. bonasus* will help understand their use of inshore habitats and how they interact with apex predators (Collins et al., 2007).

This study aims at analyzing the spatial distribution of *R. bonasus* within St. Joseph Sound, an estuarine intracoastal waterway in Pinellas Country, Florida. Pinellas County is home to many barrier islands and a multitude of aquatic ecosystems. The estuary supports one of the largest seagrass habitats along the central and southwest coast of Florida (Pinellas County DEI , 2011). The main area of study is Honeymoon Island State Park and a small bay named Boggy Bayou. Honeymoon Island's morphology can change often as a result of both natural and anthropogenic changes (Davis & Elko, 2003), but the island contains important seagrass beds within its boundary and houses a "no internal combustion engine zone" on its eastern side. Boggy Bayou is a bay with freshwater input from Wall Springs Park. The park contains a natural spring that discharges on average 4.2 million gallons (15.9 million liters) of freshwater per day into St. Joseph Sound, which creates a unique estuarine system based on the tidal sequence in the area (Pinellas County DEI , 2011).

The data was collected through The Coastal Marine Education and Research Academy's (C.M.E.R.A.) research on elasmobranch species near Clearwater, Florida in St. Joseph Sound. The research is in conjunction with a population study of elasmobranch species during the years of 2013–2019. C.M.E.R.A's research took place from the areas of Clearwater Beach up to Anclote Key during the months of May through August. Student researchers collected different species of elasmobranchs by using tangle nets.

Several statistical methods were utilized in this study in an effort to explain recorded spatial distribution of *R. bonasus* among the sample sites based on environmental factors. Catch per Unit Effort (CPUE), species richness, and spatial distribution of *R. bonasus* were statistically analyzed within the same sample areas to determine areas of greatest abundance and correlations with environmental factors. We hope to provide information related to the ecology and spatial distribution of R. bonasus within this intracoastal waterway and determine if the distribution is related to environmental and/or predator avoidance.

2 METHODS

Field Methods

C.M.E.R.A has 51 elasmobranch capture sites spread along the Florida west coast in Pinellas County that were utilized between 2013–2019. These sites were differentiated based on geographic location, depth, substrate, and species richness; each is given a numerical designation. Different sites known for elasmobranch congregation in St. Joseph Sound were randomly chosen each sampling day based on tide stage, water temperature, and time of day for sampling locations. Tangle nets were used in the catch process. The tangle nets used to capture the elasmobranch species were nylon with floating headline, a leaded bottom line and were 61 m long, 2 m high, and had a 10 cm stretch mesh. The nets were each placed in the water for a maximum of 30 minutes to ensure little to no mortality happened due to suffocation. Once the shark or ray swam into the net, it would be caught and wrapped up allowing researchers to bring the animal onto the boat to collect data and then released. In total, there would be on average, eight nets set per day in about a 6-hour time period. Each elasmobranch caught was identified with a tag, sexed, measured, and the location of capture noted. Dart tags were used for shark species and T-bar tags were used for ray species for identification if recaptured.

Spatial Analysis

All spatial data collected was imported into ESRI ArcGIS 10.6 for spatial analysis. The site polygons were constructed from a preexisting image of the sampling area using Georeferencing. A spatial join was also used to count the number of individual points within the sample sites, this made it possible to identify how many sharks and *R. bonasus* were caught at each of the four sites from years 2013–2019.

Sample Sites

Between 2013–2019, *R. bonasus* was only caught in four of the C.M.E.R.A. sampling sites located in St. Joseph Sound (Figure 1). Sites 27 and 31 are seagrass beds located on the eastern side of Honeymoon Island State Park, directly adjacent to the "no internal combustion engine zone". Site 30, Boggy Bayou, is a seagrass flat between Garden Island and Indian Bluff Island and near Wall Springs Park, surrounded by mangroves. Site 38 is located near Homeport Marina north of the Dunedin Causeway.

Statistical Analysis

A Welch's ANOVA was used to analyze the CPUE of *R. bonasus* between the sample sites to determine the areas where the species were most abundant. CPUE was used to analyze catch per net between the sample sites, because one net setout is equal to one unit of effort. CPUE was calculated by taking the total number of individuals caught in a site divided by the total number of nets set in a site for a particular year. The data was not normally distributed based on the CPUE values. The variances were also not equal (Bartlett K-squared $(3) = 16.13$, $p < 0.001$), and therefore a nonparametric test was used for this analysis. Welch's ANOVA is a non-parametric test used for heteroscedastic datasets and was used to determine if there was a statistical difference between the CPUE means. To investigate if trophic interactions play a role in CPUE, a chi-squared analysis was used.

3 RESULTS

The highest abundance of *R. bonasus* was in Site 30; 405 individuals were caught from 2013–2019 in that sample site, and 225 of those individuals were caught in 2015 (Figure 2). Honeymoon Island State Park had the highest abundance of sharks, with low abundance of *R. bonasus*. Twenty-three R. bonasus were caught within the state park boundary and 151 sharks were caught within those same sites (Figure 2). Shark species richness also varied depending on the sample site. Sites 27 and 31 located inside Honeymoon Island had a species richness of 9 shark species (Figure 3), while only 5 shark species were tagged at Site 30 (Figure 4). Since no shark species were tagged at Site 38, a species richness map was not constructed. The Welch's ANOVA indicated that there was not a statistical difference between CPUE of the sample sites (Welch's F $(3, 8.46) = 3.55$, $p = 0.06$). Despite the Welch's ANOVA result, several components using CPUE were still explored to see if anything could help explain unevenness of the data (Table 1).

Table 1 indicates that there were differences in the means and standard deviations between the sample sites, with Site 30 having the largest mean catch per net (0.6102 ± 0.0216) and Site 27 with the lowest mean catch per net (0.0033 ± 0.0033). A chi-squared analysis reflected that sharks and *R. bonasus* are not independent of each other within the sample sites ($\chi^2(3,\ N = 596) = 231.41$, $p < 0.001$). The expected values for CPUE were different than the observed values and indicated that *R. bonasus* is related to shark abundance within the sample sites, but in an inverse relationship (Figure 2).

The habitat across all sample sites includes either continuous or discontinuous seagrass habitat, with a variety of salinity ranges (Figure 5). Site 30 had the largest salinity range (32–36‰), Sites 27 and 31 had a narrower salinity range (35–37‰), and no data was recorded for Site 38.

Fig. 1. Four sample sites in which R. bonasus were caught in St. Joseph Sound (2013-2019).

Sample Site	n	Mean	SD	SE
27	6	0.0033	0.0080	0.0033
30	6	0.6102	0.4939	0.2016
31	6	0.0308	0.0522	0.0213
38	6	0.2167	0.4021	0.1641
Total	24	0.2152	0.3874	0.0800

Table 1. The means, standard deviations and standard errors of CPUE between the four sample sites where *R. bonasus* were caught.

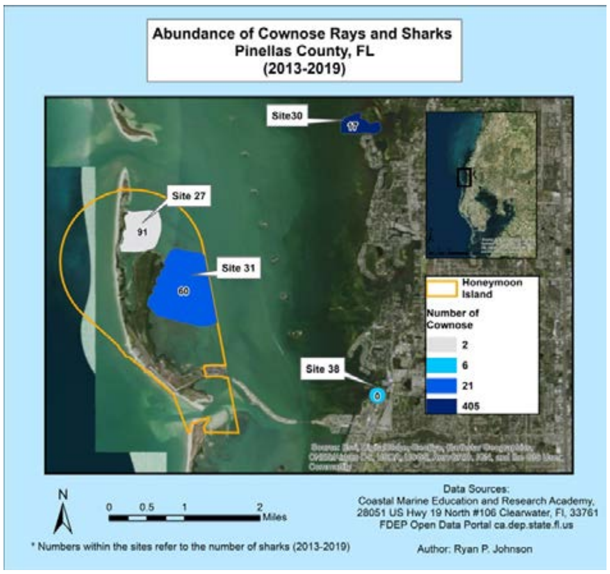

Fig. 2. Abundance of R. bonasus and shark species within the four sample sites (2013-2019). The numbers within the site polygon refer to the abundance of sharks, whereas the colors associated with the legend refers to the abundance of *R. bonasus* within each site.

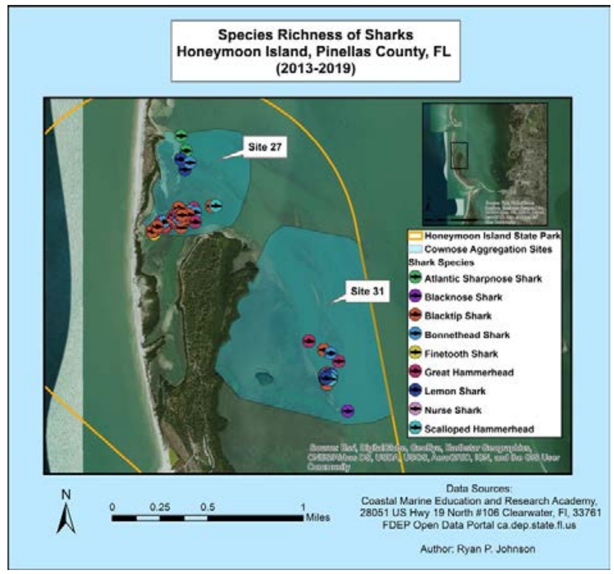

Fig. 3. Species richness of sharks within Honeymoon Island where R. bonasus has been tagged. There have been 9 shark species tagged in the sample sites inside Honeymoon Island.

4 DISCUSSION

This preliminary research resulted in finding areas of habitat partitioning with *R. bonasus* in St. Joseph Sound sampling sites. There was not a significant difference between the CPUE of the sample sites, but Site 30 was a major outlier. This site saw 405 *R. bonasus* landings, and also had the highest abundance of sharks, and the largest salinity range (32–36‰). The CPUE is skewed because out of the 405 R. bonasus that were caught, 225 of those individuals were caught in 2015. This could have been due to multiple large aggregations swimming through the area. However, even if you subtract those 225; site 30 still had the most landings by a degree of magnitude. An interesting observation is that they were not caught in any other site that year.

Higher shark presence seems related to lower *R. bonasus* presence. Areas with high abundance and high species richness of sharks contain low numbers of *R. bonasus* (Figure 2). Due to the high species richness located inside the state park, this could be causing competition displacement of *R. bonasus*. This is a due to interspecific competition and is when a species is relocated because of an interaction with another species (Reitz & Trumble, 2002). There have been observations of a higher abundance of *R. bonasus* in years prior to this study by state park rangers. C.M.E.R.A (personal communication) has recorded an increase of shark abundance inside the state park since 2013. R. bonasus was an established species within the state park but competing for space and resources has forced the species out of that local area. Just being in the high density of sharks would cause the stingray to go into fight or flight mode. These species also have chemoreceptors, which allows them to smell and taste if a shark is nearby. All of these factors could contribute to the displacement of *R. bonasus* out of the state park boundary.

Site-specific parameters could also be contributors to this uneven spatial distribution of *R. bonasus*. Site 30 contains a natural spring which flows directly into this bay, and it was hypothesized that the input of freshwater into this estuarine system would decrease the

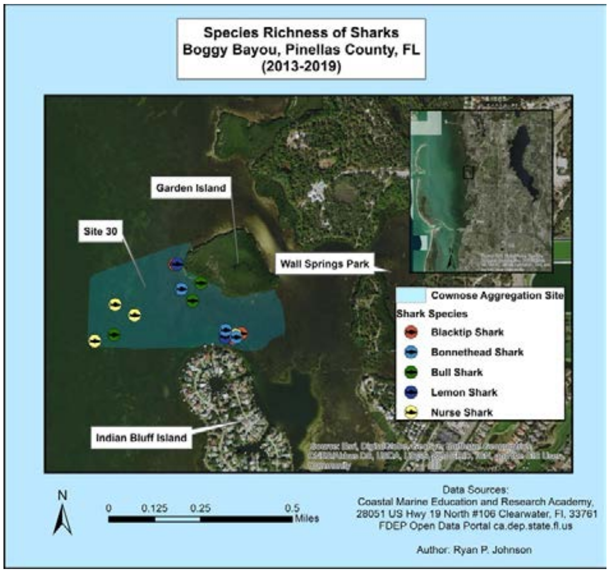

Fig. 4. Species richness of sharks within Site 30 (Boggy Bayou) where R. bonasus has been tagged. There have been 5 shark species tagged at Boggy Bayou, including the bull shark. There were no sharks that were tagged at site 38.

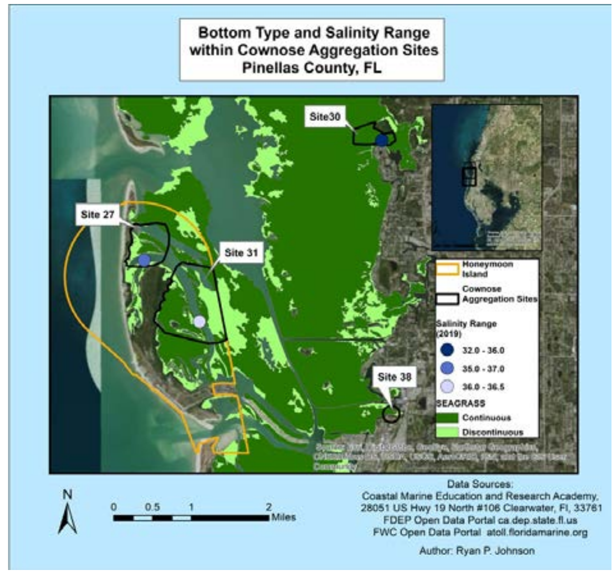

Fig. 5. The bottom type within St. Joseph Sound (Seagrass bed) and salinity ranges of the sample sites. Salinity samples were taken in months May and June in 2019. Site 30 (Boggy Bayou) had the highest salinity range. No salinity samples were taken in site 38, because the research vessel was not able to maneuver in the site.

salinity during low tides. Analyzing the species richness and salinity range in site 30 aided in answering that question. There have been bull sharks caught in Site 30, but in a low abundance. Bull sharks can reside in high or very low saline waters. The difference in shark species richness provided evidence that salinity ranges were different between the sample sites. Salinity samples were taken in 2019, and the salinity ranges within the state park sites were different than Site 30.

St. Joseph Sound has a diurnal tidal cycle, which produces two high and two low tides within a 24-hour period. Observationally, the best time to catch *R. bonasus* in Site 30 was just after high tide or during a low tidal sequence. This could have been because the salinity in that area (Site 30) was lower, and *R. bonasus* like to forage in low saline waters. Foraging in low saline waters could also be a way to avoid predators such as sharks. It could also be posited that enhanced prevalence or accessibility to the prey species of *R. bonasus* exists at site 30.

It is possible that oyster abundance is higher in Site 30, because it is located between a mangrove island and a residential area with a high abundance of dock pilings, but no quantitative data was collected between the sites located inside the state park (sites 31 and 27, Figure 1) and at site 30, bay scallops (*Argopecten irradians*) have been observed, but there has been no recent data recorded about their abundance in the local area. Adding these oyster prevalence components to this study was not possible due to resource and time constraints but could be a future area of interest. The habitat type is also the same between the sample sites (Figure 5). With *R. bonasus* having a wide range in diet preferences, it is likely that competition and/or environmental factors have contributed to its spatial distribution within the intracoastal waterway.

Future research would include a robust assessment of *R. bonasus* preferred diet species (like bay scallops and other bivalve species), prevalence/distribution of prey species, and a more in depth look at temperature and salinity profiles to determine potential environmental forcing. We would also like to analyze spatial distribution of shark species outside the *R. bonasus* sites. All of this data aided in locating aggregation sites of *R. bonasus* and identified their preferred local habitat. This habitat consists of lower saline waters, a low abundance of predators, and a wide variety of foraging options.

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