An Assessment of the Trophodynamics of Yellow Stingrays (*Urobatis jamaicaensis*) via Electrosensory Detection

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Introduction

Yellow stingrays (*Urobatis jamaicaensis*) (Figure 1a) make up a significant part of fish biomass in coastal and near-shore ecosystems (O'Shea *et al.* 2012). Due to their high abundance, it is theorized that they play a critical role in coastal environments. As mesopredators, they link the upper and lower levels of the food chain and while regulating prey abundance, are prey themselves for sharks (Figure 1b). Since they modify the environment physically, biologically and chemically, through foraging behaviour they are considered a critical group of fish in nearshore habitats (O'Shea *et al.* 2012). Stingrays have the ability to find prey using electrosensory detection (Wueringer 2012; Bedore and Kajiura 2013) , yet few data are available on how they discriminate their prey in this way.

Figure 1a: A yellow stingray

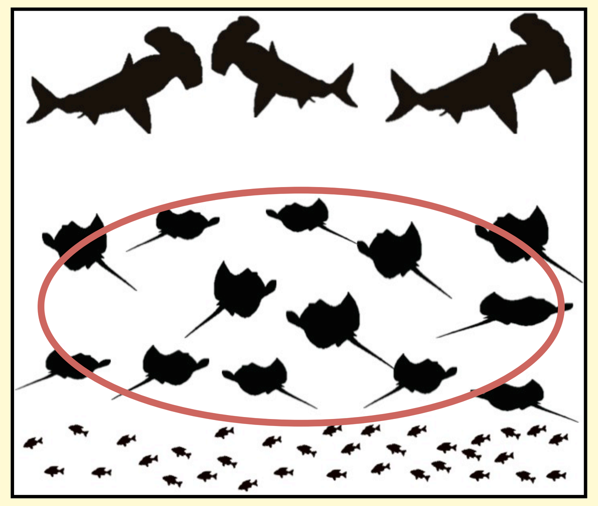

Figure 1b: A diagram demonstrating the position of rays in the food chain

Objectives

1. To determine the dietary characteristics of yellow stingrays.
2. To asses the relationship between dietary content and environmental abundance of common prey types (Figure 2).
3. To experimentally assess the extent to which electrosensory detection is used prey discrimination.

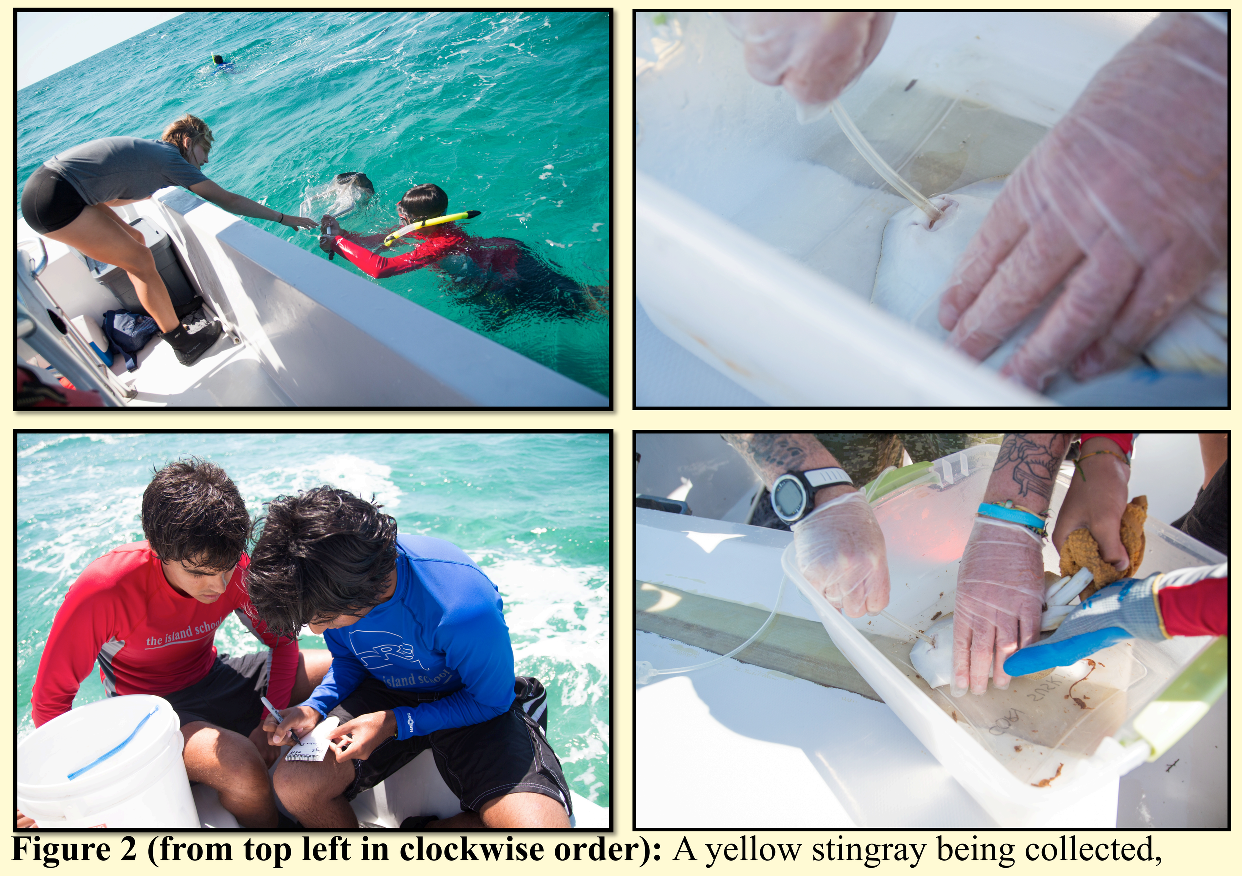

Figure 2 (from top left in clockwise order): A yellow stingray being collected, stomach content collected via regurgitation and data being recorded

Materials and Methods

- Yellow stingrays were sampled from three sites in South Eleuthera (Figure 3).
- After each stingray was caught, gastric lavage was preformed, which is a non-lethal way of extracting stomach contents via a regurgitation reflex.
- Next, sediment samples were collected to count the animals found living in the sand
- Finally, HD cameras were used to record behaviours during live prey trials, which took place in captive arenas. Live prey items were hidden in agar chambers to experimentally assess the extent to which yellow stingrays use electro-sensory detection in discriminating prey (Figure 4).

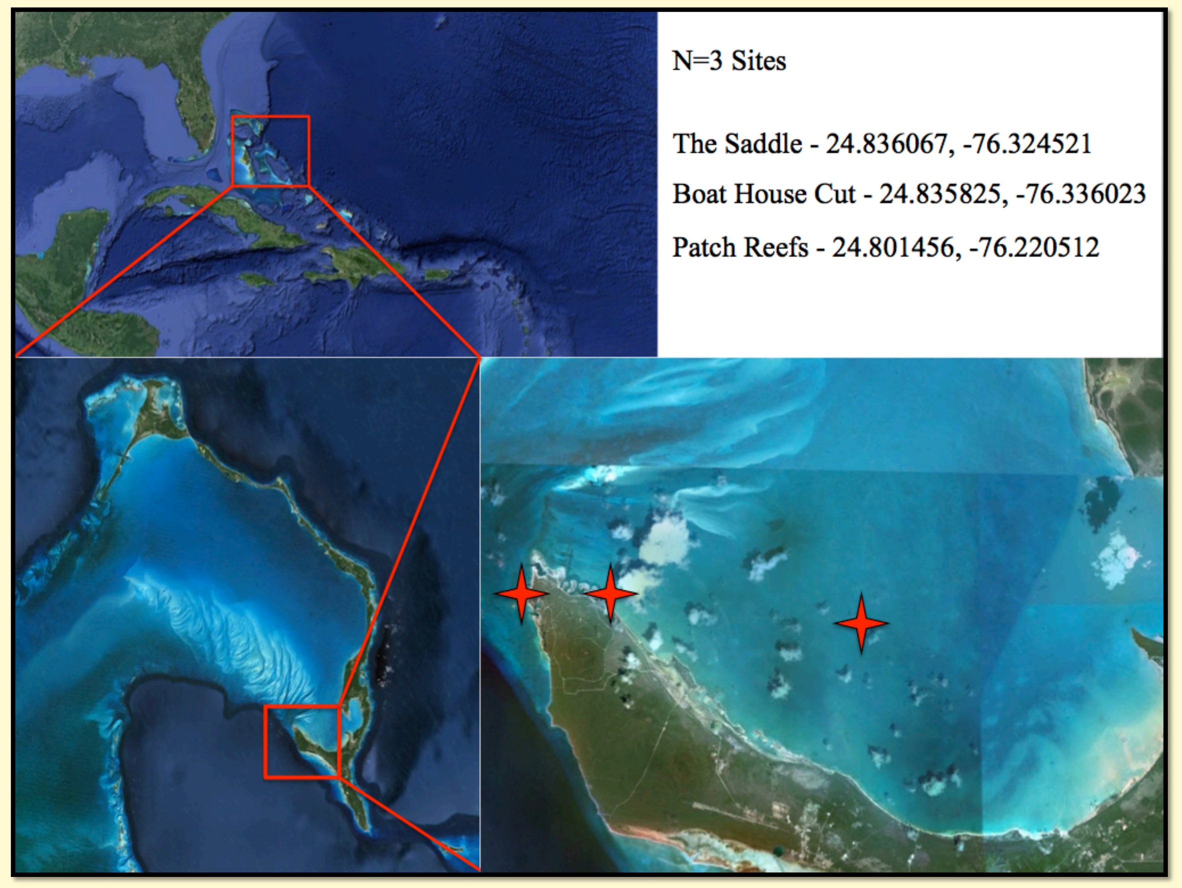

Figure 3: Site locations in South Eleuthera

Analytical Methods

In order to determine prey preference, we used a prey selectivity index (Manly-Chesson) which ranges from 0 (complete avoidance) to 1 (complete preference). Feeding strategy analysis was assessed by calculating the percentage frequency occurrence (%*Fo*) of a given prey type as well as prey selectivity index (%*Pi*) and a percentage abundance of a given prey within all prey sampled (%*n*) (Figure 5). Size measurements were also taken of each ray along with the sex recorded (Table I).

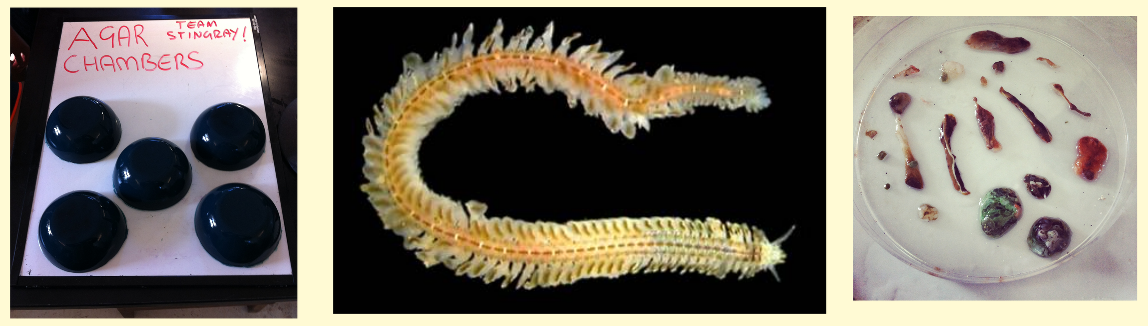

Figure 4a: Agar chambers **b)** an annelid **c)** collected stomach contents

Table 1: Ray morphometric correlating with prey abundance

		N	Mean W_D (cm) +/- SE	Mean L_T (cm) +/- SE	Annelida: Polychaeta	Annelida: Sipunculidae	Annelida: Terebellidae	Crustacea: *Panopeus herbstii*	Crustacea: Penaeidae
Saddle	**Male**	3	179.3 ± 5.8	291.3 ± 46.5	58	24	4	10	0
	Female	7	188.1 ± 5.8	342.8 ± 12.3	21	12	0	5	0
Patch Reefs	**Male**	4	181.5 ± 4.2	326.0 ± 13.0	16	1	0	0	4
	Female	6	190.6 ± 6.2	329.1 ± 7.8	30	3	5	0	7
Boat House Cut	**Male**	4	171.7 ± 6.5	306.5 ± 11.7	13	5	0	0	2
	Female	6	177.6 ± 6.1	337.0 ± 13.7	19	5	0	0	13

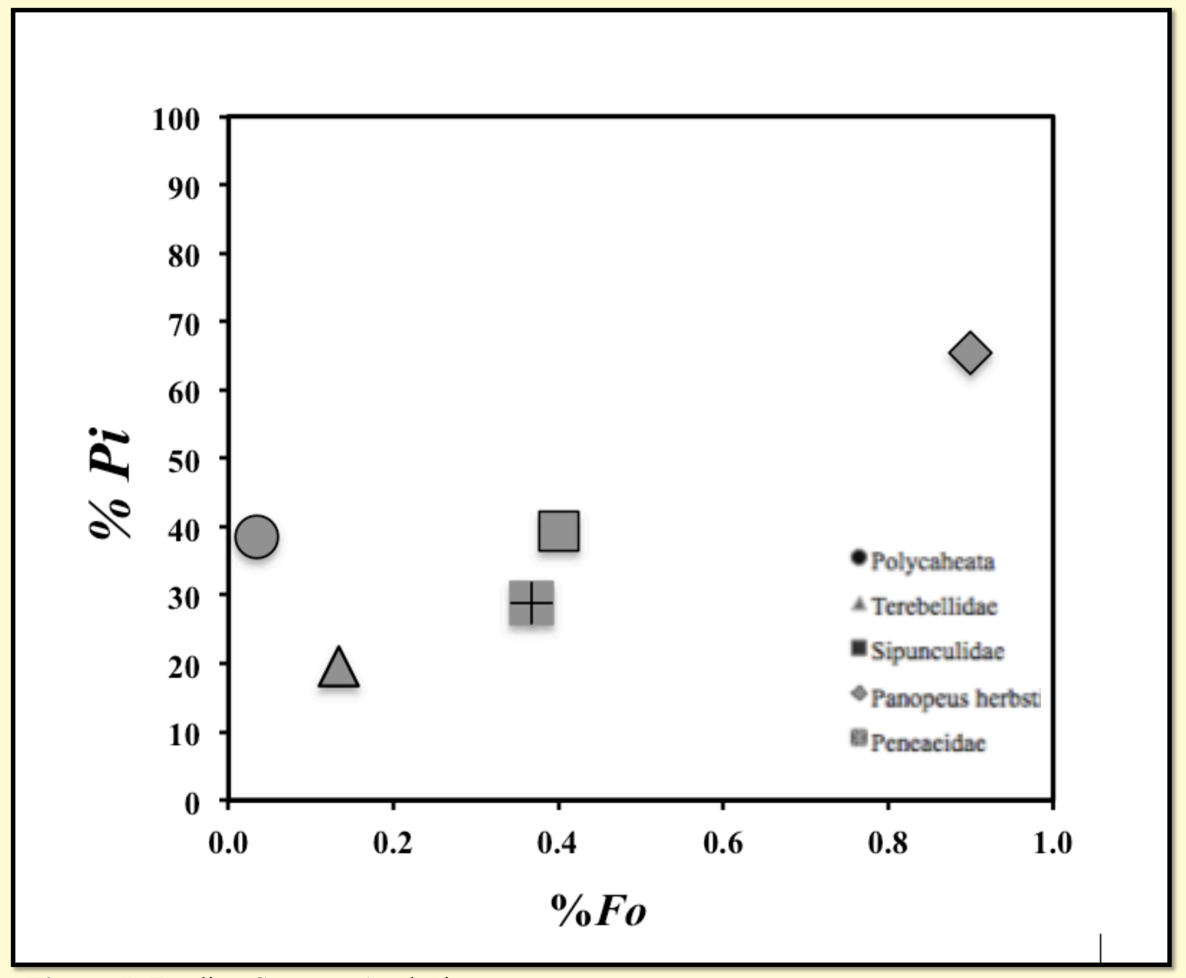

Figure 5: Feeding Strategy Analysis

Results

- Dietary composition was dominated by marine worms (Polychaeta), which conversely were found in low abundance in the environment (Figure 6). Contrastingly, bivalves molluscs were found in high abundance in the sediment compared with no bivalves found in the stomach contents collected.
- Out of six experimental trials, results were generated from two. These demonstrated that stingrays had a preference for polychaetes (88% of behaviour observed) compared to crustaceans and spent little time (<1%) in controls (Figures 7 and 8).
- Polychaetes were a preferred prey of stingrays evidenced by their high abundance in stomach samples, as well as the Manly-Chesson index (α=0.6) which uses both stomach contents and environmental abundance to determine correlations. This was further validated through dietary content and feeding strategy analysis.

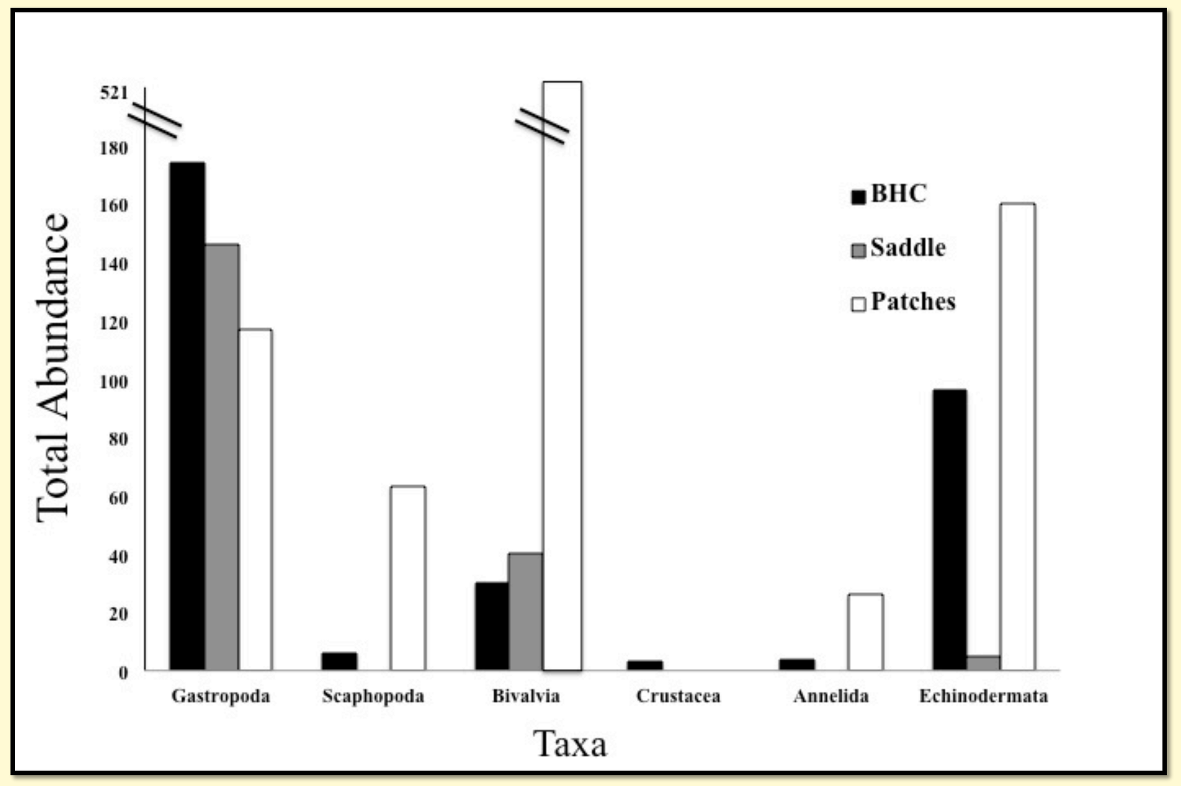

Figure 6: Animal counts recovered from sediment samples among three sampling sites

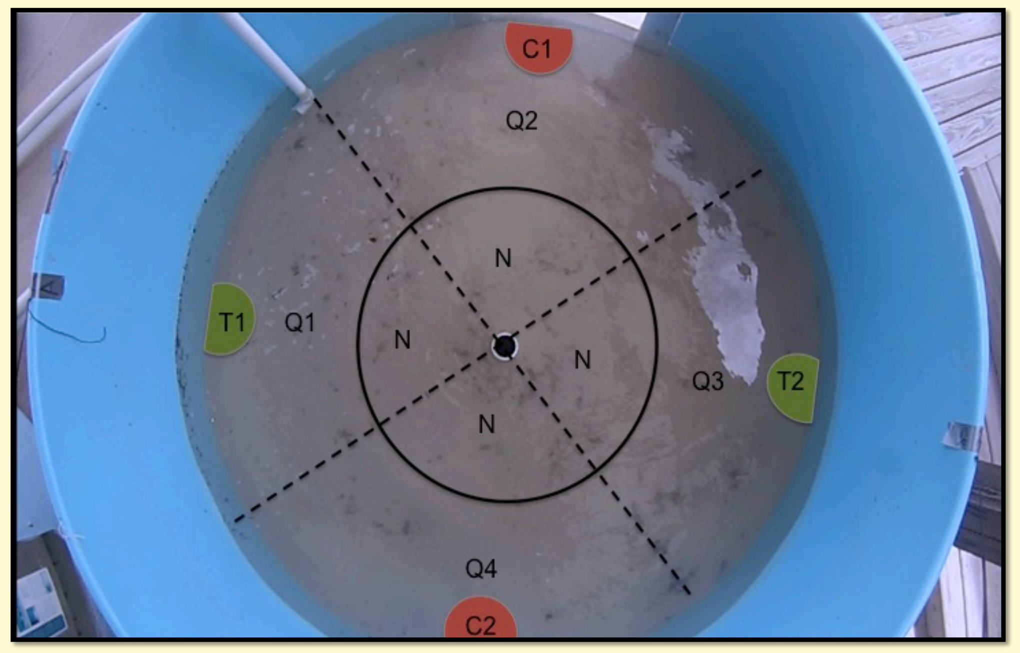

Figure 7: Experimental setup: T1 = annelid treatment; C1 = control 1; T2 = crustacean treatment; C2 = control 2; N = neutral and Q1-4 = Quadrants.

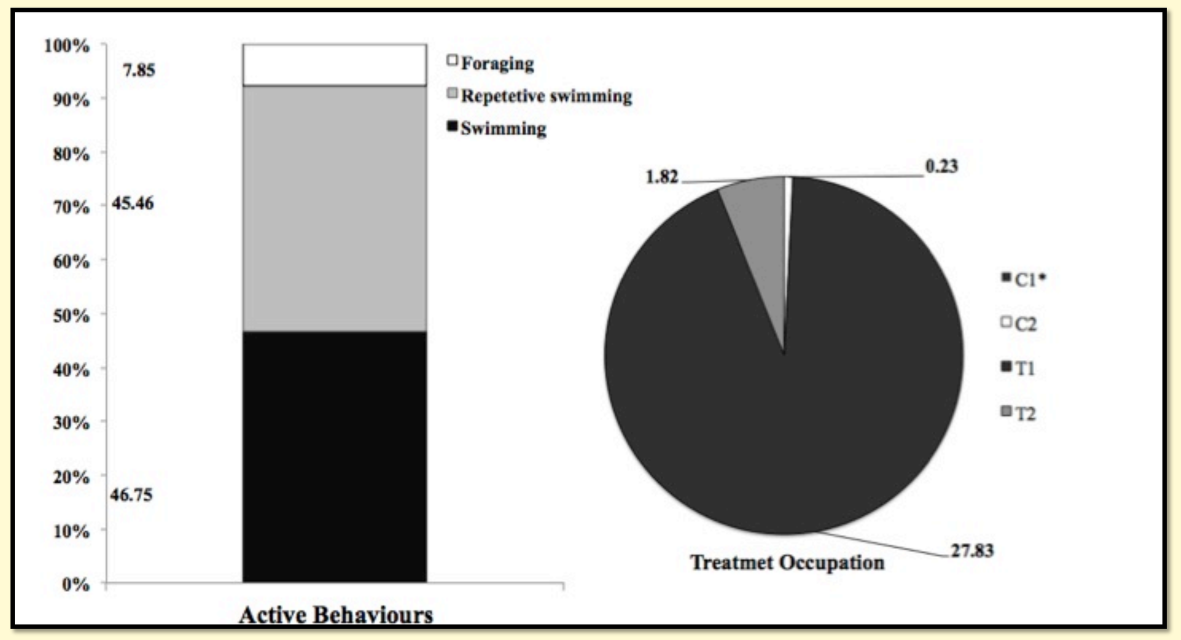

Figure 8: Duration spent exhibiting coded behaviours during experimental manipulations and time of occupation in each of the experimental zones

Discussion

- The preference for marine worms (α = 0.6) in yellow stingrays could be due to the fact that hard-bodied marine organism such as snails, crabs, shrimp and clams require a significantly greater amount of energy to digest compared to soft bodied prey such as worms.
- Our results could suggest that the sediment samples taken are not representative of the habitats in which these prey types live. A possible reason for this lack of correlation between the sediment samples and the stomach contents could be due to the fact the areas in which the sediment samples were collected are not the same locations in which rays are feeding (O'Shea *et al.* 2012).
- The preference for worms that was identified in the live prey trials could be due to the fact that stingrays have a response to different electric signal strengths of prey animals. If marine worms emit a more powerful electric signal, rays will therefore be more likely to detect and feed on them (Tillet *et al.* 2008) .

Future Directions

- Future studies should focus efforts on quantifying the energy of digestion and how it affects prey preference and prey discrimination.
- To increase the statistical robustness of the data and further aid the conclusions of the research, future studies should further enhance the area of the sediment samples collected and the increments of time that the samples are collected.
- Future efforts should test electric signals in various prey taxa of stingrays to determine if more powerful electric signals correlate to that particular taxa being in higher abundance in stomach contents.

Conclusion

Yellow stingrays are prolific predators in coastal marine environments, and it has been demonstrated that electro-sensory detection plays a significant role in foraging over small areas. Furthermore, the high abundance of yellow stingrays coupled with their predation behaviors are likely having a previously unreported impact within coastal ecosystems of The Bahamas. It is therefore essential to consider this group of fishes critical to the function and health of these habitats when determining ecosystem based approached to conservation.

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Acknowledgments

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