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Red Drum *(Sciaenops ocellatus)* Trophic Web Reconstruction Using Stable Isotopes in Two Systems in the Northwestern Gulf of Mexico

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RED DRUM (*SCIAENOPS OCELLATUS*) TROPHIC WEB RECONSTRUCTION USING STABLE ISOTOPES IN TWO SYSTEMS IN THE NORTHWESTERN GULF OF MEXICO

A Thesis

by

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ABSTRACT

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Estuaries act as nurseries for many important fishes, including predators like Red Drum (*Sciaenops ocellatus*). Using gut content and stable isotope analyses to better understand juvenile *S. ocellatus'* diet and role within the trophic web, a full year of data was collected on a quarterly basis to illustrate a change in diet based on resource availability at two study sites and for two non-overlapping *S. ocellatus* sizes. Panopeidae and Penaeidae were the most abundant prey items found in *S. ocellatus* stomachs for both sizes, sites, and four quarters representing over 50% of the diet. Stable isotope analyses from 80 fish show that *S. ocellatus* are feeding in very similar trophic levels but nonetheless there are significant differences for all quarters in $\delta^{15}N$ between sites and $\delta^{13}C$ between sizes, sites, and quarters. Differences may be linked to changing resources throughout the year, site composition differences, and seasonal changes in productivity.

DEDICATION

This thesis is dedicated to everyone I have crossed paths with that has opened my eyes to the world of education and the love for science. Thank you to my wonderful parents for allowing me to pursue my passions, keeping me inspired, and instilling the love for our marine world at such an early age. My brother, Josh, and dear friend, Chelsea, thank you for showing me how to push myself as a graduate student and how fun coastal ecology can be. This is for all of you.

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CHAPTER I

INTRODUCTION

Estuaries: Nursery Role

Estuaries play an important role within the coastal environment, acting as a nursery and protective habitat for a diverse set of marine organisms (Connolly 1994; Heck, Nadeau and Thomas 1997; Minello 1999; Pawluk, Fujiwara and Martinez-Andrade 2021; Whitfield 2017). Mangroves, seagrasses, oyster reefs, mud tidal flats, and salt marshes are different type of habitats that are found within estuaries (Beck et al. 2001; Rozas and Minello 1998; Whitfield 2017) that provide a high amount of primary and secondary production (Beck et al. 2001; Minello 1999). Within these nursery systems that many species live and feed in, interactions are high which creates a complex system (Whitfield 2017).

Vegetated areas within the estuary are shown to be associated with higher abundances of marine organisms compared to non-vegetated sandy or muddy bottoms (Connolly 1994; Heck, Hays and Orth 2003; Rozas and Minello 1998; Summerson and Peterson 1984; Whitfield 2017). Seagrass meadows allow for predatory fishes to use estuaries as both nurseries and areas to forage due to the high diversity and biomass of invertebrates and fish species that occur in the area, especially within the northern hemisphere (Heck et al. 1995; Heck, Hays and Orth 2003; Larkum, Orth and Duarte 2006). Invertebrates that are a large part of fish diets, such as shrimps and crabs, are largely found within seagrasses and salt marsh habitats (Heck et al. 1995; Rozas and Minello 1998), the former being represented in both herewith study sites.

Seagrass meadows are very prevalent within the Gulf of Mexico (Onuf 1996) and become increasingly important along the southern coast of Texas. The Laguna Madre (LM) is the most southern bay extending along the Texas coast from Corpus Christi to the Rio Grande, expanding up to 12 km in width and 3 m deep (Onuf 1996). In the United States (U.S.) the LM is split into the Upper and Lower portions with slight differences in vegetation and substrate. The Upper Laguna Madre mostly consist of *Halodule wrightii* whereas the Lower Laguna Madre (LLM) had more of a mixed assemblage of seagrass including *H. wrightii*, *Thalassia testudinum*, *Syringodium filiforme* Kützing, 1860, and *Halophila engelmannii* Ascherson, 1875 (Onuf 1996).

Increasing Threats

Changing climate conditions can have a range of impacts on the estuary habitat that can alter fish and invertebrate communities, such as fluctuations in salinity, temperature, and tides (Breaux et al. 2019; Fujiwara et al. 2019; Kowalski et al. 2018; Pawluk, Fujiwara and Martinez-Andrade 2021). Due to storm events bringing in heavy rainfall, salinity can decrease temporarily acting as a stressor to fishes, invertebrates, and vegetation (Breaux et al. 2019; Kowalski et al. 2018; Van Diggelen and Montagna 2016) living in more hypersaline environments. Some storms, like hurricane Dolly occurring August 2008, can have temporary effects that only last 2 weeks but other, like hurricane Alex occurring June 2010, can take several weeks for effects to clear up (i.e., salinity levels to recover) (Kowalski et al. 2018; Preen, Long and Coles 1995). Seagrass meadows can also see a shift in species composition, or just complete loss in some areas, due to storm surges causing changes in salinity, turbidity, uprooting, and erosion (Oprandi et al. 2020; Patriquin 1975; Preen, Long and Coles 1995).

A decrease in seagrasses is also a result to storm events and decreases in salinity, Kowalski et al. (2018) noted a 58-74% decrease within the LLM after the two above mentioned major hurricanes with a decrease in *T. testudinum* and *S. filiforme* in areas of hyposalinity after a storm. Pawluk, Fujiwara and Martinez-Andrade (2021) also found a shift in fish diversity within the estuaries off the coast of Texas due to fluctuating salinity trends. They found that salinity patterns with seasons had a positive relationship with fish diversity and higher salinities cause an increase in abundance of marine species. There has also been a shift in habitats within estuaries, with migration of mangroves in areas that were more seagrass dominant or salt marsh species encroaching on mangrove-dominant areas (Pawluk, Fujiwara and Martinez-Andrade 2021).

Furthermore, a trend has also been shown with increasing temperatures. Fish diversity increased as it allowed for more tropical species to use the space (Fujiwara et al. 2019; Pawluk, Fujiwara and Martinez-Andrade 2021). This pattern also explains vegetation changes. Mangroves have also been seen to migrate north due to warming temperatures and higher sea levels, creating more habitat for a diverse set of fishes and invertebrates (Pawluk, Fujiwara and Martinez-Andrade 2021). A continuation of changing and more intense climatic events can cause for permanent changes in habitats and fish species assemblages, which can be seen within Texas bays (species range expansion for tropical species due to shifts in habitats and increases in temperature, increase in diversity, alter in species interactions, and resource partitioning (Fujiwara et al. 2019; Pawluk, Fujiwara and Martinez-Andrade 2021)).

Plant material, such as the seagrass beds and mangroves in South Texas, within the nursery systems have a heavy influence on the productivity and success of many species. These environments tend to have a detritus-based habitat that provides high nutrient availability and energy transfer (Llansó et al. 1998). Important fishery species, such as Red Drum (*Sciaenops* *ocellatus*) (Linnaeus, 1766), benefit from this type of trophic web and influences their diet of mainly benthic organisms (Llansó et al. 1998; Overstreet and Heard 1978).

Texas bays and estuaries have been affected greatly by changing climate conditions and anthropogenic effects that have caused a decrease or shift in natural resources (Llansó et al. 1998). Since 1975, there has been a large decrease in wetlands and vegetation due to dredging, erosion, and upland conversion (Porch, Fisher and McEachron 2002). These crucial environments house many important and charismatic species, especially during their first few years of life. Changing environmental conditions can lead to the displacement or loss of species.

Red Drum (*Sciaenops ocellatus*)

Sciaenops ocellatus are important recreational fish that can be seen throughout the Gulf of Mexico and off the eastern coast U.S. from Key West, Florida to Massachusetts and New York (Facendola and Scharf 2012; Overstreet 1983; Peters and McMichael 1987). For the Gulf of Mexico, about 16 million individual *S. ocellatus* were caught recreationally from 2010 to 2019 with an average of ~ 6.9 million kg harvested between the years 2015 to 2019 (National Marine Fisheries Service (NMFS) 2021). Most of these fish caught for harvesting are located inland or up to 4.8 km offshore with Texas harvesting 4,025,000 fish in the years 2018 and 2019 (NMFS 2021).

Estuary systems are the major nursery grounds for this species, as they do not typically settle in offshore areas (Facendola and Scharf 2012; Pattillo et al. 1997). After spawning near the mouths of estuaries and bays in the mid-summer to late fall near shore, the larvae move into the shallower water for their juvenile stage (Malinowski et al. 2019; Peters and McMichael 1987; Scharf and Schlight 2000). Unlike the larval stage where they tend to be found in the middle open water of that bays, juvenile *S. ocellatus* prefer backwaters in bays and lagoons (Peters and McMichael 1987) or areas close to shorelines in which there is an abundance of seagrass meadows and shallow water. Moulton et al. (2017) found a greater presence of *S. ocellatus* in habitats that were dominated by seagrass or oyster reefs compared to bare substrate associated with areas that are boundary or edge dominated. Sexual maturity comes around the 4th year, all individuals matured fully at age 5 or 6, and that is when the fish will begin to move out of the estuary (Wilson and Nieland 1994). With a growing pressure for conservation and restoration of many coastal ecosystems, it is crucial to understand the movements of top predators that use many of these estuaries and bays as nursery grounds.

Juvenile *S. ocellatus*, also commonly known as Rat Reds (Overstreet 1983), are estimated to range from about 250-700 mm in total length (TL) after completing squamation at around 200-230 mm in standard length (SL) (Facendola and Scharf 2012; Havel, Fuiman and Ojanguren 2015; Malinowski et al. 2019; Overstreet 1983; Scharf and Schlight 2000). Young *S. ocellatus* have been noted to grow very quickly at the beginning of their life cycle throughout their juvenile years (Porch 2000), on average growing about 18.8 mm within the 1st year reaching around 300 mm SL (Overstreet 1983; Peters and McMichael 1987). Though many factors such as salinity, temperature, and predation can have an effect on the growth rates of larval and juvenile *S. ocellatus*, prey availability may also be a driving factor (Rooker and Holt 1997).

Facendola and Scharf (2012) reported the 0-1 age class to have a TL range of 300-400 mm while the age class of 1-2 reached 600-700 mm. Scharf and Schlight (2000) captured *S. ocellatus* for the ages 1-4 that reached sizes of 291-763 mm TL in the fall, and 345-751 mm TL in the spring. Malinowski et al. (2019) reported a mean size of 541 mm TL with an age range of 1-8 yrs. Following the prior information and the knowledge that sexual maturity is achieved during the 3rd and 4th year of the *S. ocellatus*'s life (Facendola and Scharf 2012), the target age (size) classes for this study focused on juveniles ranging between the years of 0-3 measuring around 300-700 mm TL.

Diet

It is known that there are ontogenetic changes in *S. ocellatus* diet from larval stages to juveniles (Soto et al. 1998), but there is less known about any changes in diets between different sizes of juveniles prior to adulthood. The feeding of *S. ocellatus* can vary but there is a preference for feeding at the bottom (Overstreet and Heard 1978), though flexibility in diet has been noted given prey availability and changing conditions (Llansó et al. 1998). Overstreet (1983) noted that growth is very rapid but inconsistent for juvenile *S. ocellatus*, especially within their 1st two years of life, which can be heavily influenced by their diets. Changes in prey abundances or availability within the bay systems that they live and forage in can either hinder or increase their growth and cause for intraspecific competition between other *S. ocellatus* or different age classes. Prey availability can also cause *S. ocellatus* to move and inhabit other areas that may lead to higher success in foraging (Overstreet 1983).

Following the pattern of bottom feeding, the main food source within *S. ocellatus* juveniles consist of - not surprisingly - bottom-dwelling organisms, mainly crustaceans followed by fishes (Overstreet and Heard 1978). Most of the crustaceans consumed are also of high commercial importance such as Penaeid shrimp (80.6 million kg in Gulf of Mexico's region landings) and Blue Crabs (*Callinectes sapidus*) (21.1 million kg for Gulf of Mexico's region landings) (NMFS 2021). Overstreet and Heard (1978) noted most of the taxa found within the stomachs of *S. ocellatus* off the coast of Mississippi consisted of crustaceans with only one fish out of the 104 total with full stomachs lacking a crustacean in it. Although there is a preference, many e.g., Facendola and Scharf (2012); Kroetz, Drymon and Powers (2017); Llansó et al. (1998); Pattillo et al. (1997); Scharf and Schlight (2000) have considered *S. ocellatus* to be more opportunistic or generalist feeders due to finding more than one taxon of prey in their stomachs at a time.

Seasonal variations in *S. ocellatus* diet have been reported too. For example, Scharf and Schlight (2000) showed such diet changes which can be linked to prey availability in the Galveston Bay area, Texas. Most prey items found in the stomachs of *S. ocellatus* in the fall were decapod crustaceans while most prey items found in their stomachs in the spring were fishes. This can be attributed to higher numbers of shrimps usually present within these areas during the fall (Overstreet and Heard 1978). Juvenile *S. ocellatus* greater than 20 cm in TL off the coast of Florida showed a preference for shrimps over crabs in the fall of 1990 (Llansó et al. 1998). As summarized by Facendola and Scharf (2012), juvenile *S. ocellatus* have a diet consisting of mostly fishes and macrocrustaceans but a shift in diet will occur throughout the seasons with consumption of shrimp and planktonic copepods in the summer to macrocrustaceans in the fall. Pattillo et al. (1997), also reported a trend in a dominance of fishes within the diet of *S. ocellatus* during the winter and spring months while crustaceans increased in importance in the late spring and summer months. Malinowski et al. (2019) highlighted seasonal variations in diet of *S. ocellatus* as well, with a decrease in Pink Shrimp (*Penaeus duorarum* Burkenroad, 1939) and fishes with an increase in Snapping Shrimp (*Alpheus heterochaelis*) in the spring. “Rare” food items such as bryozoans, annelids, and stomatopods were also reported to only show up based on certain seasons (Overstreet and Heard 1978), an example of how seasons can also have an effect on the lesser prey items that are consumed when main items such as crustaceans are not abundant or present. Showing that shifts in prey availability depending on the season will ultimately determine the diet of *S. ocellatus* (Facendola and Scharf 2012). Herzka and Holt (2000) concluded that feeding likely depends on the local trophic web structure which can be seen to change seasonally with *S. ocellatus* feeding on a variety of organisms such as shrimp, copepods, and invertebrate eggs depending on a given time of the year.

Along with seasonality, diet shifts have also been studied regarding *S. ocellatus* size or age class. For the age class of 0-1, Penaeid shrimp were the most dominant prey item while the 1-2 age class prey was dominated by *C. sapidus* and fishes (Facendola and Scharf 2012) showing diversity in diet between the two age classes. Overstreet and Heard (1978) also found that larger fish, usually associated with being older, had a larger presence of *C. sapidus* and fishes within their stomachs compared to smaller-sized fish had more shrimps and polychaetes. On the other hand, Scharf and Schlight (2000) did not find a strong selectivity of prey based on size with a range of 300-800 mm of *S. ocellatus* sampled in both the fall and spring. There was a consistent size of prey items with an increase in *S. ocellatus* size with selectivity only being based on seasonal availability rather than size. Pattillo et al. (1997) found that there is little variety in food habits for fish ranging from SL of 250-924 mm with a consumption of shrimp, crabs, and fishes for all sizes, noting that the variety comes from smaller fish generally eating smaller sized prey items.

Within the winter months, there is a possibility of freezing temperatures even in the southmost parts of the Texas coast. Changing weather patterns, especially those that happen quickly and are prolonged, can also have a great impact on the availability of prey. Freezes, such as those reported by McEachron et al. (1994) and the one experienced during this study in February 13-17, 2021 (Winter Storm Uri, reaching temperatures below freezing for two days (National Weather Service 2022)), can cause for large numbers of species such as fishes and invertebrates to die off, as was the case for Winter Storm Uri causing for 3.5 million fish to die in the LLM (National Weather Service 2022). Fishes and invertebrates mainly of prey importance to predator fish, like *S. ocellatus*, massively disappearing in an area creating a lack of food and cause for movement or changes in diet.

Location may also take part in shaping the diet of juvenile *S. ocellatus* due to changing environmental conditions or prey availability, but that is less studied. Overstreet and Heard (1978) noted a wide variety of habitats that *S. ocellatus* may prey upon including both muddy and sandy bottoms, as well as feeding from shallow waters to more deeper areas within the bay systems. They also noted slight changes in diets based on geographical location of *S. ocellatus*, such as some found off the coast of Georgia consuming crustaceans, fishes, and echinoderms compared to those found off the coast of Mississippi also consuming polychaetes. There was also little diet overlap for juvenile *S. ocellatus* found in different areas within the Alafia River in Florida (Peters and McMichael 1987), but this was only a pattern for their larger size class (75-105 mm SL) with juveniles (<75 mm SL) showing greater than 60% diet overlap and individuals >105 mm SL showing 90% in diet overlap. Though location and habitat may impact juvenile *S. ocellatus* diet, other factors such as the fish' size can influence these changes.

Fisheries and Management

Recreational fisheries are a large supporter of the U.S. economy, especially for coastal states. In 2019, recreational fishing had about $89.3 billion USD in sales impacts and supported 553,499 jobs across the nation (U.S. Department of Commerce 2022). In Texas alone, 3,996 jobs were supported and $508 million was accrued in sales in 2019 (U.S. Department of Commerce 2022).

Sciaenops ocellatus are a very important sport fish on the coast of Texas (Llansó et al. 1998). A fish that is heavily monitored alongside Spotted Seatrout (*Cynoscion nebulosus* (Cuvier, 1830)) by Texas Parks and Wildlife Department (TPWD) since 1975 by use of gill net surveys (Porch, Fisher and McEachron 2002). Gillnets were also banned for commercial use in Texas water in 1981 following the decline of important fish species such as *S. ocellatus*.

Beginning in 1981, the state of Texas no longer allowed for *S. ocellatus* to be sold commercially following a large decrease in their population (Porch 2000). Alongside the prohibition of commercial sales, the size limit for recreational fishing became narrower: maximum TL of 762 mm and minimum of 406 mm from 356 mm (Porch, Fisher and McEachron 2002). Seven years later, the regulations changed again with a limit of three fish per day allowed with a new maximum TL of 711 mm and minimum of 508 mm (Porch, Fisher and McEachron 2002). According to these authors, the regulations were created with the intentions to increase the survivability of smaller juveniles usually around the age of 1 and 2. Within Texas, there is also an effort to restock juvenile *S. ocellatus*, *C. nebulosus*, and Southern Flounder (*Paralichthys lethostigma* Jordan & Gilbert, 1884) in the hopes of keeping their populations stable. In 2019, a total of 1,222,340 *S. ocellatus* fingerlings were stocked within Texas bays (TPWD 2022a).

Trophic Web Reconstruction

The structure of the trophic web gives an understanding of the interactions among different trophic levels, and how the presence and abundance of certain species plays a role in biotic communities (Kroetz, Drymon and Powers 2017). The flow of energy from basal resources to top predators can be illustrated by trophic webs, and the exchange of matter among organisms can also be depicted (Middelburg 2014). The stomach content of a target predator species allows for an assessment of what prey items are regularly consumed (Kroetz, Drymon and Powers 2017), while the use of stable isotopes allows for the analysis of smaller amounts of material and the tracing of smaller individuals with a habitat-specific approach (Selleslagh et al. 2015). The combination of identifying prey items within stomach content [representing short term diet] with stable isotope analyses [representing long term diet] can lead to a more detailed and less biased reconstruction of the trophic web (Kroetz, Drymon and Powers 2017). A link between the impacts on the lower levels of the trophic web and climatic change and how nutrient cycling are impacted by top predators is created by the combination of these methods (Middelburg 2014). Using these techniques together in two systems (a bay and a lagoon), as it is proposed in this study, can lead to more knowledge on feeding habits depending on resource availability and as Kroetz, Drymon and Powers (2017) indicated, give insights of possible change in competition and resource partitioning. A full reconstruction of the trophic web will allow for a better understanding of the trophic levels and how the energy flow between levels in two coastal systems that provide a vast amount of ecosystem services (e.g., carbon sequestration, nutrient uptake, sediment stabilization, tourism, storm protection, fisheries (Barbier et al. 2011; Costanza et al. 1997)).

The use of stable isotope analyses allows for a deeper understanding of habitat-specific diets on an individual basis and allows for trophic webs to be constructed from end-to-end (Breaux et al. 2019; Middelburg 2014; Selleslagh et al. 2015). This method has been established and used by scientists for more than 50 years within estuarine systems due to the ability of tracing the origin and transformation of biological elements (Bouillon, Connolly and Gillikin 2011). When looking at complex systems, such as estuaries, stable isotopes allow for the incorporation of many factors that stomach-content analysis cannot provide. These factors include the ability to incorporate difficult organisms to work with (i.e., soft-bodied, microscopic), tracking of signals through tropic levels, shifts in niche, migration patterns, and resource or habitat use (Bouillon, Connolly and Gillikin 2011; Middelburg 2014).

Using stable isotopes, such as ^{15}N and ^{13}C, in combination with gut content allows for proteins in food sources to be reflected (Perkins et al. 2014), alongside the identification of the prey type being consumed (Malinowski et al. 2019). The difference in isotopic composition of the inorganic carbon substrate causes for a variance in stage carbon isotope ratios between C_3 and C_4 plants; these carbon isotope ratios are then found in the tissues of consumers (Middelburg 2014). To determine the trophic level of an individual, ^{15}N is used while ^{13}C represents the connections in the trophic web from predator to prey (Perkins et al. 2014). Stable isotope ratios for carbon and nitrogen ($\delta^{13}C$ and $\delta^{15}N$) are used to estimate food chain length (Perkins et al. 2014) and expressed as parts per thousand (‰) in the delta (δ) notation, uses the Pee Dee Belemnite standard for carbon and atmospheric N_2 for nitrogen and are calculated by the formula:

$$\delta X \text{ (‰)} = [(R_{\text{sample}}/R_{\text{standard}}) - 1] \times 1000$$

where X is the stable isotope for carbon or nitrogen (^{13}C or ^{15}N), *R* is the stable isotope ratio of carbon or nitrogen ($^{13}C/^{12}C$ or $^{15}N/^{14}N$), and δ represents the measure of heavy to light isotopes in the sample (Selleslagh et al. 2015).

There is a typical finding of enrichment in $\delta^{15}N$ of 2-4 parts per thousand (‰) from diet to consumer at each trophic level with a smaller enrichment (0-1‰) for $\delta^{13}C$ from diet to consumer (Middelburg 2014; Perkins et al. 2014). Combining both stable isotopes for analysis allows for a complete understanding of energy flow through the trophic webs given the location's resources and gives the idea that after correction for isotopic discriminations, the isotope ratio provided by the subject will reflect its diet (Middelburg 2014).

Due to seasonal changes, prey isotope signatures may change based on diet and available resources. Malinowski et al. (2019) found a higher degree of correlation to area with diet being strong with more enriched ^{13}C signatures in areas that were heavily populated with seagrass compared to those with mangroves and other levels of vegetation that resulted in more depleted ^{13}C signatures. Hence, it is expected to find a difference in ^{15}N and ^{13}C among seasons and both study sites as also found by Selleslagh et al. (2015).

Understanding trophic webs in coastal areas where major predator fishes spawn and feed as juveniles is important for many commercial and recreational fisheries, and for conservation and restoration efforts in these areas (Malinowski et al. 2019; Moulton et al. 2017). If the trophic web assemblages are altered in any way due to a change in available resources and prey items, higher trophic levels will be affected greatly (Llansó et al. 1998). This is especially important for organisms that have a specified diet only selectively eating in a certain area or trophic level, such as those that only feed on benthic organisms (Llansó et al. 1998).

Thus, the objectives for this study are to 1) determine the diet composition based on stomach contents of *S. ocellatus* in two sites within the LLM, 2) reconstruct the *S. ocellatus* trophic web using stable isotopes (^{13}C and ^{15}N) in both sites within the LLM, and 3) compare if there are any differences in the diet and trophic web between the two sites, two size classes, and among quarters (seasons). It is hypothesized that 1) diets will be different between size classes (small and medium, detailed below), 2) diet composition will differ between the two sites, and 3) diet will change throughout the year (quarters) given prey availability and abundance, which will be reflected in the isotope signatures.

CHAPTER II

MATERIALS & METHODS

Site Description

The study sites for this project took place in two areas that are in Cameron County, Texas and where ecological and environmental data are limited. Both are located on the southern part of the LLM which is a bar-built shallow body of water that is one of the six largest hypersaline estuarine systems in the world (Delgado, Cintra-Buenrostro and Fierro-Cabo 2017; Kowalski et al. 2018), and somehow a neglected study-wise area within the U.S. Gulf of Mexico. The LLM climate is classified as semiarid and subtropical (Texas Water Development Board 2022). Though has minimal freshwater input (Breaux et al. 2019), the LLM is connected to three different freshwater sources including the Arroyo Colorado, the Brownsville watershed, and the Rio Grande/Rio Bravo (Kowalski et al. 2018). The Arroyo Colorado is the largest source for freshwater out of the three points with the North Floodway emptying into it (Kowalski et al. 2018). The Brownsville Ship Channel (BSC), which was constructed in the 1930s, resides at the southern point of the LLM, connecting the estuaries to the Gulf of Mexico (Marquez, Fierro-Cabo and Cintra-Buenrostro 2017) and is the point in which the Brownsville watershed empties into (Kowalski et al. 2018).

The first site (a representative area within the lagoon system) Holly Beach (HB) [26°07'30.5"N 97°17'48.4"W] (Fig. 1) is a shallow body of water (average of 1 m depth) located north of the BSC residing between the Laguna Atascosa National Wildlife Refuge (LANWR) and the LLM with the Laguna Vista Cove on the south end (Murphy, Cintra-Buenrostro and Fierro-Cabo 2021). Holly Beach is part of the LLM water system, thus for this study the area sampled was ~ 41.2 km^2 (Figure 1), estimated using Google Earth (2022). The land is now part of the LANWR and contains a variety of flora and fauna. Holly Beach is a popular site for recreational fishing and the observation of birds and butterflies (Murphy, Cintra-Buenrostro and Fierro-Cabo 2021). The climate is characterized as semiarid and there is a presence of seagrass beds near the shore.

The second site (a bay system, by name but actually an enclosed lagoon) South Bay (SB) [26°01'20.6"N 97°11'03.8"W] (Figure 1) is another shallow body of water (average of 0.85 m depth) with an area of about 17.0 km^2 estimated using Google Earth (2022) that connects to the BSC and the LLM through a narrow channel that is about 185 m in width at the north end, and the Rio Grande River on the south end (though only connected in rare large flooding events). This site is popular for recreational fishing, provides a variety of ecosystem services, hosts productive marine life, and has extensive seagrass beds making it a common reference system for many restoration studies (Marquez, Fierro-Cabo and Cintra-Buenrostro 2017). *Sciaenops ocellatus* is one of the most sought fish resources by recreational anglers in SB. Although bound to the Rio Grande River, SB experiences a low amount of freshwater inflow; due to high temperatures and the region’s subtropical climate, the bay experiences high evaporation rates and low average rainfall (Marquez, Fierro-Cabo and Cintra-Buenrostro 2017).

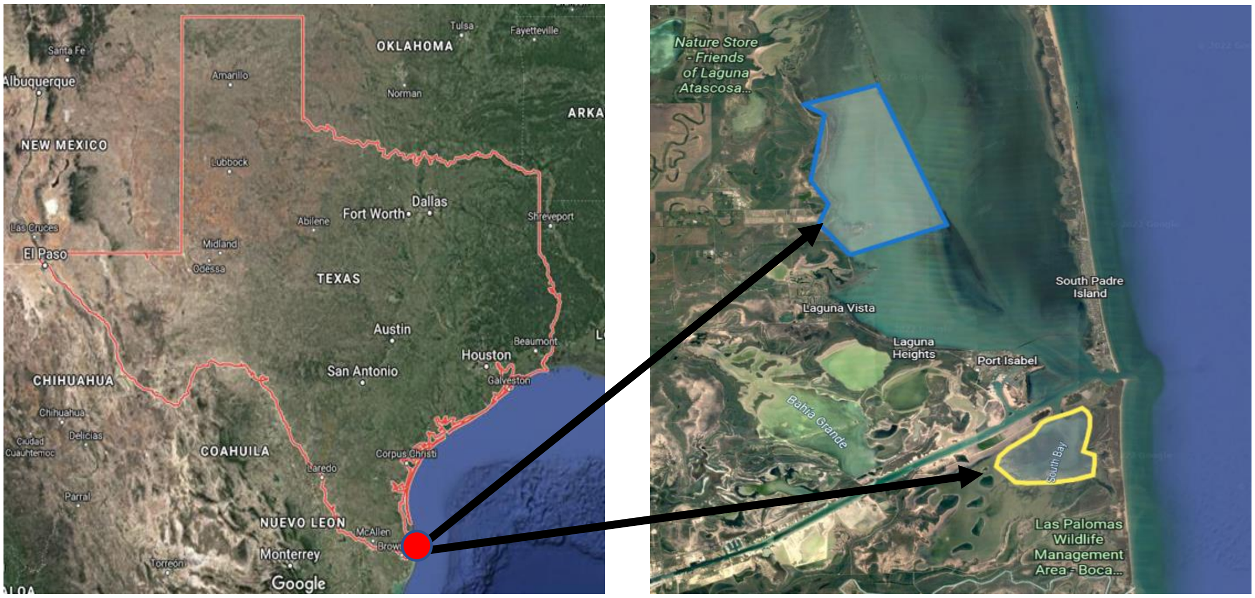

Figure 1. Study sites Holly Beach [26°07'30.5"N 97°17'48.4"W] (blue outline) and South Bay [26°01'20.6"N 97°11'03.8"W] (yellow outline) within Cameron County, Texas, U.S. Outlines represent where net deployments occurred within each site. Modified from Google Earth (2022).

Sampling

To facilitate comparison with ongoing sampling efforts by the TPWD in the region, the same fishing gear was used in this study, such data will be presented elsewhere. The netting used for the capture of the target fish species consisted of bag seines and gill nets. From the gear description provided by TPWD, the dimensions of the gillnets are 182.9 m long, 1.2 m deep, with 45.7 m sections of 76, 102, 127, and 152 mm stretched monofilament mesh. The bag seine is 18.3 m long, 1.8 m deep, with 19 mm stretched nylon #5 multifilament mesh in wings, and 13 mm stretched nylon #5 multifilament mesh in bag. The rope for the bag seine is 12.2 m long and hung between two pull poles. Gill nets were allowed to be used in this study by TPWD (Permit number: SPR-0808-314).

Beginning in October 2020, two gill nets were randomly deployed at sunset and left until sunrise at a single site per outing. Distance between nets was at the very least 500 m. There were four full gill net deployments per site per quarter (Q) throughout the year, unless maximum number of *S. ocellatus* were captured given Institutional Animal Care and Use Committee (IACUC) permits, the later Animal Use Permit (AUP-19-40) allowed a maximum of 300 fish/Q as a part of a related study that focuses on growth of the species in the same two sites. October 2021 marked the end of the full year of sampling (Q1: October – December, Q2: January – March, Q3: April – June, Q4: July – September). Each sampling event resulted in numerous *S. ocellatus*. For stable isotope analyses, there was a minimum collection goal of 15 and a maximum of 30 individuals per Q to equal a total of 120 maximum number of individuals to limit analyses costs (details below). For gut content analyses, individuals that fit within the size classes (detailed below) were used. Following the TPWD fishing protocol, the gill nets were positioned parallel to the shoreline at both sites every Q as *S. ocellatus* were reported to not utilize the open portions of the bays (Llansó et al. 1998; Porch, Fisher and McEachron 2002); while the bag seines were used in concordance with the gill nets to capture more of the target species (including smaller sizes) and some of their potential prey (Llansó et al. 1998; Scharf and Schlight 2000).

Once specimens were caught, the measurements for biometrics including weight (± 0.01 kg), SL and TL (± 1 mm) were taken in the field. After measurements, fish were decapitated as per AUP-19-40 and both clearly labelled body parts were placed on ice in a cooler to be transported to the laboratory (lab hereafter). Measurements for biometrics were taken once again in the lab with the addition of eviscerated weight (± 0.01 kg). Stomach content and tissue collection followed, and samples were stored in the freezer until analyses.

Alongside specimen collections, aquatic vegetation and sediment samples were collected for stable isotope analyses in guidance of potential sources of C and N to be used and mobilized by *S. ocellatus*. Seagrass and macroalgae samples consisting of leaves and blades, as well as roots for seagrass, were obtained from three randomized areas within each site and placed in Ziploc bags on ice in a cooler and transported to the lab. Sediment samples were taken randomly from five different areas within each site consisting of three core samples (6 x 15 cm)/area. To limit stable isotopes analyses cost, samples from aquatic vegetation and sediments were composites with either material from each collection area forming one composite sample for these sources.

Gut Content

Stomach samples were stored in a freezer for preservation. Upon thawing in the lab, a sieve (2,500 µ) was used to rinse the stomach samples for the retrieval of prey, which was achieved using forceps. Each prey item that was retrieved, identified to the lowest taxonomic level possible under a dissecting microscope. A blotted wet weight of each retrieved prey item was also taken to the nearest 0.01 g (Malinowski et al. 2019). From these prey items, the three more abundant were used for the stable isotopes approach (as the use of ^{13}C and ^{15}N isotopes can represent the contribution of three diet resources (Middelburg 2014) (described below), and live individuals of the same species were monitored and collected on a quarterly basis to provide any potential stable isotope signature change within the year.

The classified prey items were tallied and categorized into taxonomic groups to compare the presence of each species with the stomach of the *S. ocellatus* (Kroetz, Drymon and Powers 2017). Each prey item was separated by site to compare prey importance relative to location and population. Three metrics were used to analyze the contributions of the stomach content and to calculate the percent index of relative importance (% IRI): IRI = F% (N% + W%). A frequency of occurrence percentage (F% = the number of stomachs containing food of a specific category/total number of stomachs containing food x 100), a percentage number (N% = number of prey in a specific category/total number of prey x 100), and a weight percentage (W% = weight of prey in a specific category/total weight of prey x 100) (Kroetz, Drymon and Powers 2017; Scharf and Schlight 2000; Soto et al. 1998).

Stable Isotopes

For the stable isotope analyses, white muscle tissue as recommended by Kroetz, Drymon and Powers (2017), Malinowski et al. (2019), and Selleslagh et al. (2015) was taken from a total of 80 *S. ocellatus* (five fish from each nonoverlapping size class (small: 200-400 mm TL, medium: 500-700 mm TL) to avoid confounding factors, and site (total of ten) used per Q) and any available prey items. A restriction of *S. ocellatus* size(s), alongside the average trophic discrimination factors, were used to limit stable isotope analyses costs and create a distinction for $\delta^{13}C$ source signatures to represent different energy pathways (Perkins et al. 2014; Selleslagh et al. 2015).

For all fish species, white muscle tissue was taken from the dorsal fin; for any other prey items, the extraction came from any area of availability such as stomachs (if large enough), claws (crabs), or mid-sections (shrimp) (Kroetz, Drymon and Powers 2017). Fishes tissue samples needed to be de-oiled with a 2:1 Chloroform:Methanol mixture by soaking. Samples were soaked for 50 min, removed from the mixture, and set in a fume hood to dry (Perkins et al. 2014). All tissue samples, including plant samples, were rinsed with DI water thrice and dried. Once the tissue samples were completely dried for a period of 24 h, they were ground up to a fine powder using a Marathon Motors 40LM75 mill. After pulverizing to powder, 0.5 mg of the sample was placed into tin capsules (Selleslagh et al. 2015). The Environmental Isotope Laboratory at the University of Arizona analyzed tissue samples for stable isotope with a continuous-flow gas ratio mass spectrometer (Finnigan Delta Plus XL). There is a set precision of ± 0.2 for $\delta^{15}N$ and ± 0.1 for $\delta^{13}C$ (1 standard deviation, "σ") with acetanilide IAEA-N-1 and IAEA-N-2 routinely used as a standard for elemental concentration for $\delta^{15}N$, and NBS-22 and USGS-24 for $\delta^{13}C$. The tropic discrimination factors ($\Delta\delta^{13}C$ and $\Delta\delta^{15}N$) are calculated by subtracting the stable isotopic ratio of the consumer by the diet (Perkins et al. 2014).

All ten sediment samples were also dried completely for a period of 24 h at 60°C and ground to a fine powder using a mortar and pestle. Ten extra samples from the same sites were also dried and then acidified using HCl to remove any carbonates. All ground sediment samples were sent to the University of Arkansas Stable Isotope Laboratory for analyses using an elemental analyzer (NC 2500 FINN with a Finnigan MAT ConFlo II with a Delta Plus Mass Spectrometer), using USGS 41a with a precision of ± 0.11 for $\delta^{15}N$ and ± 0.03 for $\delta^{13}C$ (1σ), USGS 8573 with a precision of ± 0.11 for $\delta^{15}N$ and ± 0.02 for $\delta^{13}C$ (1σ), and silty soil with a precision of ± 0.13 for $\delta^{15}N$ and ± 0.1 for $\delta^{13}C$ (1σ) as standards.

Statistical Analyses

All three metrics (N, W, F) and the IRI were calculated in Excel. All means and standard deviations (SD) of fish measurements and statistical analyses were performed in IBM SPSS Version 27. Stable isotope biplots were created for data visualization using R (RStudio Version 1.4.1106).

Gut Content

A t-test was performed between either size class or site to test for the presence of potential prey in a given category, for Qs a one-way Analysis of variance (ANOVA) was used to assess any differences in mean N%, W%, F%, and IRI% for each prey type in each Q. This was performed because some prey items were missing in either size, site or Q, and this would have affected the outcome of a three-way ANOVA, that might be deem as the appropriate test for the three variables (i.e., size, site and Q). A Tukey test was performed when significant differences were indicated by the ANOVA in order to identify the Q(s) causing the difference. Outcomes that violated Kolmogorov-Smirnov and Levene's tests for normality and homoscedasticity, respectively (Sokal and Rohlf 2011), were arcsine transformed but the non-transformed data were used as the transformations either did not change the outcome or made them worse and the ANOVA was deemed robust enough to part from the assumptions of normality and homoscedasticity (Underwood 1997).

Stable Isotopes

Kolmogorov-Smirnov and Levene's tests were used to test for normality and homoscedasticity (Sokal and Rohlf 2011) for all stable isotope signatures. A t-test was performed with Q1 data to compare the stable isotope ratios of the partially digested prey (i.e., items in stomachs) and the collected alive preys because it is known that proteins in food sources can be detected by the stable isotope signatures (Perkins et al. 2014), which might be affected during digestion. Results are presented only for those prey items that showed a significant difference. A t-test was also performed to compare the stable isotope signatures of the acidified sediment samples and those not acidified.

Because both assumptions were violated for *S. ocellatus* stable isotope signatures, the data were $\log_{10}(1 + Y – MIN(Y))$ transformed, with minimum value used instead of maximum or mean values to avoid large shifting effects given negative ^{13}C values. To analyze stable isotope variance between both sites (HB and SB), both fish sizes (small and medium) and the four Q's (approximately fall, winter, spring, and summer) a three-way ANOVA was performed using the non-transformed data as the ANOVA is deemed robust enough (Underwood 1997). For any significant outcomes among Qs, a Tukey post-hoc test was used to determine which Qs were responsible, such test was nor necessary for sites neither fish sizes as the smaller or larger values could be used when significant differences were indicated by the ANOVA.

CHAPTER III

RESULTS

A total of 336 *S. ocellatus* were collected, measured, and dissected for gut content analyses. For stable isotope analyses, a total of 80 individuals were used (5 per size class per site per Q). The average ± SD TL for small-size *S. ocellatus* was 353.8 ± 28.6 mm and 570.8 ± 50.5 mm for the medium-size fish (Table 1). The average ± SD TL for fish collected in SB was 453.3 ± 115.6 mm while HB was 479.7 ± 115.7 mm (Table 1). The *S. ocellatus* collected in Q1 were the largest on average (477.4 ± 117.7 mm TL), followed by each consecutive quarter (Q2: 477.0 ± 123.9 mm, Q3: 465.2 ± 110.7 mm, Q4: 444.5 ± 111.8 mm TL) (Table 1). The average weight ± SD for the small-size *S. ocellatus* was 0.44 ± 0.12 kg while the medium-size *S. ocellatus* averaged 1.18 ± 0.56 kg (Table 1). On average, the *S. ocellatus* collected from SB (1.05 ± 0.79 kg) were lighter than those collected in HB (1.28 ± 0.78 kg) (Table 1). The weights for all Qs were similar with Q4 fish weighing the least on average (0.99 ± 0.80 kg) (Table 1).

Table 1. Mean ± standard deviations (SD) standard lengths (SL) and total lengths (TL) in mm, weights (W, kg) of *Sciaenops ocellatus* collected throughout one year by size class, sample site, and quarter. Quarter (Q) 1 = October – December 2020, Q2 = January – March 2021, Q3 = April – June 2021, Q4 = July – September 2021. Small = 200 – 400 mm, Medium = 500 – 700 mm TL.

	Mean SL ± SD	**Mean TL ± SD**	**Mean W ± SD**
Small	294.1 ± 28.2	353.8 ± 28.6	0.44 ± 0.12
Medium	479.0 ± 47.1	570.8 ± 50.5	1.18 ± 0.56
South Bay	378.9 ± 101.1	453.3 ± 115.6	1.05 ± 0.79
Holly Beach	401.5 ± 98.2	479.7 ± 115.7	1.28 ± 0.78
Q1	412.4 ± 99.9	477.4 ± 117.7	1.21 ± 0.77
Q2	397.5 ± 108.4	477.0 ± 123.9	1.26 ± 0.83
Q3	386.8 ± 93.6	465.2 ± 110.7	1.16 ± 0.76
Q4	367.5 ± 96.1	444.5 ± 111.8	0.99 ± 0.80

Gut Content

Out of the 401 *S. ocellatus* stomachs retrieved, 65 were empty (~ 16.2%) (Table 2)), therefore 336 were used to characterize their diets. Overall, crabs and shrimps were the most important prey items as per IRI% found in both sizes (small: 30.75% and 19.70%; medium: 37.57% and 13.32%), both sites (SB 32.17% and 13.83%; HB: 36.13% and 17.56%), and all four Qs (Q1: 20.76% and 36.55%; Q2: 85.23% and 5.83%; Q3: 25.53% and 24.50%; Q4: 11.28% and 10.44%) (Tables 3-5). Out of the three identified crab species or taxa, mud crabs (Panopeidae) were the most abundant, accounted for the most weight, and occurred most frequently. For shrimps, the Penaeidae family was the most abundant, contributed to the most weight, and occurred most frequently.

Table 2. Total number (No.) of *Sciaenops ocellatus* stomachs used for gut content analyses throughout one year by size class, sample site, and quarter and those stomachs found empty. South Bay = SB, Holly Beach = HB, size class and Q as in Table 1.

	Small	Medium	SB	HB	Q1	Q2	Q3	Q4
Total No. Stomachs	165	171	197	139	57	90	88	101
No. Empty Stomachs	38	27	40	25	11	14	14	26
Overall	**203**	**198**	**237**	**164**	**68**	**104**	**102**	**127**

Table 3. Index of relative importance (IRI%) and associated metrics (number (N), number percentage (N%), weight percentage (W%), frequency of occurrence percentage (F%)) for *Sciaenops ocellatus* prey items found by size class (small = S1 and medium = S2). Size classes as in Table 1. Bold font represents total for major categories (i.e., prey type groups), regular font is the contribution by the lowest taxonomic identified taxa in a given major category.

Prey Type	N	N%	W%	F%	IRI%	Prey Type	N	N%	W%	F%	IRI%
S1						**S2**					
Crabs	**183**	**37.81**	**39.40**	**46.06**	**30.75**	**Crabs**	**387**	**45.85**	**32.92**	**64.33**	**37.57**
Panopeidae	175	36.16	38.11	41.21	30.61	Panopeidae	341	40.40	29.96	52.05	36.62
Callinectes sapidus Rathbun, 1896	8	1.65	1.29	4.85	0.14	*Callinectes sapidus*	45	5.33	2.73	11.70	0.94
Pisinae	0	0	0	0	0	Pisinae	1	0.12	0.24	0.58	0.00
Shrimps	**157**	**32.44**	**13.71**	**49.09**	**19.70**	**Shrimps**	**212**	**25.83**	**8.39**	**46.20**	**13.32**
Penaeidae	148	30.58	11.95	46.06	19.59	Penaeidae	201	24.53	7.83	40.94	13.24
Alpheus heterochaelis Say, 1818	9	1.86	1.76	3.03	0.11	*Alpheus heterochaelis*	10	1.18	0.48	4.68	0.08
Squillidae	0	0	0	0	0	Squillidae	1	0.12	0.08	0.58	0.00
Snails	**35**	**7.23**	**1.30**	**18.79**	**1.33**	**Snails**	**57**	**6.75**	**0.83**	**30.41**	**1.41**
Cerithiidae	32	6.61	1.15	16.97	1.32	Cerithiidae	44	5.21	0.49	23.39	1.33
Neritidae	3	0.62	0.16	1.82	0.01	Neritidae	9	1.07	0.23	5.26	0.07
Olividae	0	0	0	0		Olividae	4	0.47	0.11	1.75	0.01
Fishes	**71**	**14.67**	**43.22**	**13.94**	**1.21**	**Fishes**	**95**	**11.26**	**55.00**	**31.58**	**4.93**
Lagodon rhomboides (Linnaeus, 1776)	7	1.45	18.29	1.82	0.36	*Lagodon rhomboides*	39	4.62	27.87	7.60	2.47
Opsanus beta (Goode & Bean, 1880)	2	0.41	14.66	1.21	0.18	*Opsanus beta*	11	1.30	19.08	4.09	0.83
Unidentified Fish	8	1.65	4.61	3.64	0.23	Unidentified Fish	32	3.79	7.36	14.04	1.57
Bollmannia communis Ginsburg, 1942	40	8.26	4.07	2.42	0.30	*Bollmannia communis*	2	0.24	0.05	1.17	0.00
Hippocampus erectus Perry, 1810	2	0.41	0.06	0.61	0.00	*Hippocampus erectus*	0	0	0	0	0

Table 3, cont.

Syngnathus louisianae Günther, 1870	1	0.21	0.13	0.61	0.00	*Syngnathus louisianae*	1	0.12	0.00	0.58	0.00
Ophichthidae	11	2.27	1.40	3.64	0.13	Ophichthidae	9	1.07	0.40	3.51	0.05
Eucinostomus gula (Quoy & Gaimard, 1824)	0	0	0	0		*Eucinostomus gula*	1	0.12	0.24	0.58	0.00
Plants/Algae	**32**	**6.61**	**1.75**	**19.39**	**0.71**	**Plants**	**81**	**9.60**	**1.85**	**47.37**	**2.05**
Rhodomelaceae	3	0.62	0.06	1.82	0.01	Rhodomelaceae	18	2.13	0.22	10.53	0.25
Halodule wrightii (Ascherson, 1868)	17	3.51	1.06	10.30	0.47	*Halodule wrightii*	23	2.73	0.51	13.45	0.44
Thalassia testudinum K.D. Koenig, 1805	12	2.48	0.63	7.27	0.23	*Thalassia testudinum*	40	4.74	1.12	23.39	1.37
Other	**6**	**1.24**	**0.62**	**1.82**	**0.02**	**Other**	**6**	**0.71**	**1.01**	**2.92**	**0.02**
Foreign Object	1	0.21	0.53	0.61	0.00	Foreign Object	1	0.12	0.98	0.58	0.01
Nereididae	5	1.03	0.09	1.21	0.01	Nereididae	5	0.59	0.03	2.34	0.01

Table 4. Index of relative importance (IRI%) and associated metrics (number (N), number percentage (N%), weight percentage (W%), frequency of occurrence percentage (F%)) for *Sciaenops ocellatus* prey items found by sample site (South Bay = SB; Holly Beach = HB). Bold and regular font used as in Table 3.

Prey Type	N	N%	W%	F%	IRI%	Prey Type	N	N%	W%	F%	IRI%
SB						**HB**					
Crabs	**289**	**39.43**	**38.11**	**48.22**	**32.17**	**Crabs**	**281**	**47.23**	**30.78**	**65.47**	**36.13**
Panopeidae	279	38.06	35.19	43.65	31.98	Panopeidae	237	39.83	28.42	51.08	34.86
Callinectes sapidus	10	1.36	2.92	4.57	0.20	*Callinectes sapidus*	43	7.23	2.00	13.67	1.26
Pisinae	0	0	0	0	0.00	Pisinae	1	0.17	0.36	0.72	0.00
Shrimps	**198**	**27.01**	**8.40**	**45.18**	**13.83**	**Shrimps**	**177**	**29.75**	**10.44**	**51.08**	**17.56**
Penaeidae	187	25.51	7.51	41.62	13.75	Penaeidae	168	28.24	9.71	46.04	17.47
Alpheus heterochaelis	11	1.50	0.89	3.55	0.08	*Alpheus heterochaelis*	8	1.34	0.61	4.32	0.08
Squillidae	0	0	0	0		Squillidae	1	0.17	0.12	0.72	0.00
Snails	**56**	**7.64**	**1.24**	**21.32**	**1.12**	**Snails**	**36**	**6.05**	**0.64**	**22.30**	**1.20**
Cerithiidae	44	6.00	0.75	15.23	1.03	Cerithiidae	32	5.38	0.51	20.14	1.19
Neritidae	10	1.36	0.38	5.08	0.09	Neritidae	2	0.34	0.07	1.44	0.01
Olividae	2	0.27	0.12	1.02	0.00	Olividae	2	0.34	0.06	0.72	0.00
Fishes	**109**	**14.87**	**49.71**	**23.86**	**2.79**	**Fishes**	**57**	**9.58**	**55.18**	**18.71**	**2.56**
Lagodon rhomboides	18	2.46	21.61	3.05	0.73	*Lagodon rhomboides*	28	4.71	29.78	4.32	1.49
Opsanus beta	9	1.23	17.40	3.05	0.57	*Opsanus beta*	4	0.67	18.88	2.16	0.42
Unidentified Fish	26	3.55	8.06	10.15	1.18	Unidentified Fish	14	2.35	5.67	7.19	0.58
Bollmannia communis	42	5.73	1.83	3.05	0.23	*Bollmannia communis*	0	0	0	0	0
Syngnathus louisianae	1	0.14	0.06	0.51	0.00	*Syngnathus louisianae*	1	0.17	0.01	0.72	0.00
Ophichthidae	11	1.50	0.73	3.55	0.08	Ophichthidae	9	1.51	0.48	3.60	0.07
Hippocampus erectus	2	0.27	0.03	0.51	0.00	*Hippocampus erectus*	0	0	0	0	0
Eucinostomus gula	0	0	0	0	0	*Eucinostomus gula*	1	0.17	0.36	0.72	0.00
Plants/Algae	**72**	**9.82**	**2.25**	**36.55**	**1.70**	**Plants/Algae**	**41**	**6.89**	**1.45**	**29.50**	**1.31**
Rhodomelaceae	13	1.77	0.16	6.60	0.13	Rhodomelaceae	8	1.34	0.21	5.76	0.09
Halodule wrightii	35	4.77	1.27	17.77	1.07	*Halodule wrightii*	5	0.84	0.05	3.60	0.03

Table 4, cont.

Thalassia testudinum	24	3.27	0.83	12.18	0.50	*Thalassia testudinum*	28	4.71	1.20	20.14	1.19
Other	**9**	**1.23**	**0.29**	**3.05**	**0.03**	**Other**	**3**	**0.50**	**1.51**	**1.44**	**0.01**
Foreign Object	1	0.14	0.23	0.51	0.00	Foreign Object	1	0.17	1.48	0.72	0.01
Nereididae	8	1.09	0.06	2.54	0.03	Nereididae	2	0.34	0.02	0.72	0.00

Table 5. Index of relative importance (IRI%) and associated metrics (number (N), number percentage (N%), weight percentage (W%), frequency of occurrence percentage (F%)) for *Sciaenops ocellatus* prey items found by quarter (Quarter 1 = Q1; Quarter 2 = Q2; Quarter 3 = Q3; Quarter 4 = Q4). Quarters as defined in Table 1, bold and regular font used as in Table 3.

Prey Type	N	N%	W%	F%	IRI%
Q1					
Crabs	**66**	**30.14**	**17.31**	**52.63**	**20.76**
Panopeidae	62	28.31	16.86	45.61	20.60
Callinectes sapidus	4	1.83	0.44	7.02	0.16
Shrimps	**93**	**42.47**	**23.31**	**57.89**	**36.55**
Penaeidae	92	42.01	23.07	56.14	36.54
Alpheus heterochaelis	1	0.46	0.24	1.75	0.01
Snails	**13**	**5.94**	**0.81**	**19.30**	**0.80**
Cerithiidae	10	4.57	0.48	14.04	0.71
Neritidae	3	1.37	0.33	5.26	0.09
Fishes	**24**	**10.96**	**56.51**	**21.05**	**5.52**
Lagodon rhomboides	16	7.31	50.45	8.77	5.07
Unidentified Fish	4	1.83	3.71	5.26	0.29
Ophichthidae	3	1.37	1.18	5.26	0.13
Eucinostomus gula	1	0.46	1.17	1.75	0.03
Plants/Algae	**18**	**8.22**	**1.95**	**31.58**	**1.33**
Rhodomelaceae	2	0.91	0.04	3.51	0.03
Halodule wrightii	8	3.65	1.40	14.04	0.71
Thalassia testudinum	8	3.65	0.50	14.04	0.58
Other	**5**	**2.28**	**0.12**	**3.51**	**0.08**
Nereididae	5	2.28	0.12	3.51	0.08
Q2					
Crabs	**285**	**64.33**	**66.52**	**68.89**	**85.23**
Panopeidae	282	63.66	66.31	65.56	85.20
Callinectes sapidus	3	0.68	0.21	3.33	0.03
Shrimps	**57**	**12.87**	**4.29**	**41.11**	**5.83**
Penaeidae	52	11.74	4.00	36.67	5.77
Alpheus heterochaelis	5	1.13	0.30	4.44	0.06
Snails	**37**	**8.35**	**1.01**	**28.89**	**2.19**
Cerithiidae	34	7.67	0.76	25.56	2.16
Neritidae	3	0.68	0.25	3.33	0.03
Fishes	**27**	**6.09**	**27.07**	**17.78**	**1.60**
Lagodon rhomboides	6	1.35	8.74	2.22	0.22
Opsanus beta	5	1.13	14.55	4.44	0.70
Unidentified Fish	14	3.16	3.54	10.00	0.67
Ophichthidae	2	0.45	0.24	1.11	0.01
Plants/Algae	**36**	**8.13**	**1.10**	**40.00**	**1.48**
Rhodomelaceae	10	2.26	0.11	11.11	0.26
Halodule wrightii	7	1.58	0.13	7.78	0.13

Table 5, cont.

Thalassia testudinum	19	4.29	0.86	21.11	1.09
Other	**1**	**0.23**	**0.00**	**1.11**	**0.00**
Nereididae	1	0.23	0.00	1.11	0.00
Q3					
Crabs	**150**	**40.43**	**29.92**	**63.64**	**25.53**
Panopeidae	105	28.30	24.17	40.91	21.46
Callinectes sapidus	45	12.13	5.76	22.73	4.07
Shrimps	**148**	**40.16**	**12.86**	**59.09**	**24.50**
Penaeidae	139	37.47	10.87	50.00	24.17
Alpheus heterochaelis	9	2.43	1.70	7.95	0.33
Squillidae	1	0.27	0.29	1.14	0.01
Snails	**16**	**4.31**	**0.92**	**17.05**	**0.61**
Cerithiidae	13	3.50	0.71	13.64	0.58
Neritidae	3	0.81	0.20	3.41	0.03
Fishes	**24**	**6.47**	**49.68**	**17.05**	**2.13**
Opsanus beta	3	0.81	37.64	2.27	0.87
Unidentified Fish	9	2.43	11.34	7.95	1.10
Bollmannia communis	1	0.27	0.08	1.14	0.00
Ophichthidae	10	2.70	0.60	4.55	0.15
Syngnathus louisianae	1	0.27	0.02	1.14	0.00
Plants/Algae	**28**	**7.55**	**2.60**	**31.82**	**1.33**
Rhodomelaceae	5	1.35	0.18	5.68	0.09
Halodule wrightii	8	2.16	0.74	9.09	0.26
Thalassia testudinum	15	4.04	1.68	17.05	0.98
Other	**4**	**1.08**	**4.02**	**3.41**	**0.11**
Foreign Object	2	0.54	3.96	2.27	0.10
Nereididae	2	0.54	0.06	1.14	0.01
Q4					
Crabs	**69**	**23.39**	**12.80**	**37.62**	**11.28**
Panopeidae	67	22.71	8.81	35.64	11.23
Callinectes sapidus	1	0.34	3.36	0.99	0.04
Pisinae	1	0.34	0.64	0.99	0.01
Shrimps	**76**	**25.76**	**4.79**	**37.62**	**10.44**
Penaeidae	72	24.41	4.02	36.63	10.41
Alpheus heterochaelis	4	1.36	0.77	0.99	0.02
Snails	**26**	**8.81**	**0.90**	**20.79**	**1.11**
Cerithiidae	19	6.44	0.49	14.85	1.03
Neritidae	3	1.02	0.12	2.97	0.03
Olividae	4	1.36	0.29	2.97	0.05
Fishes	**91**	**30.85**	**79.52**	**33.66**	**8.09**
Lagodon rhomboides	24	8.14	50.02	8.91	5.18
Opsanus beta	5	1.69	17.34	2.97	0.57

Table 5, cont.

Unidentified Fish	13	4.41	8.52	10.89	1.41
Bollmannia communis	41	13.90	2.85	4.95	0.83
Ophichthidae	5	1.69	0.66	3.96	0.09
Syngnathus louisianae	1	0.34	0.09	0.99	0.00
Hippocampus erectus	2	0.68	0.04	0.99	0.01
Plants/Algae	**31**	**10.51**	**1.96**	**30.69**	**1.58**
Rhodomelaceae	4	1.36	0.34	3.96	0.07
Halodule wrightii	17	5.76	0.63	16.83	1.08
Thalassia testudinum	10	3.39	0.99	9.90	0.43
Other	**2**	**0.68**	**0.03**	**1.98**	**0.01**
Nereididae	2	0.68	0.03	1.98	0.01

Size and Diet

Panopeidae were the most commonly abundant prey item found for both size classes (small: 36.16% and medium: 40.40%, Table 3, Figures 2 and 3) occurring in 41.21% of small-size *S. ocellatus*' stomachs and 52.05% in those medium-sized. Penaeidae were the second most abundant prey item (small: 30.58% and medium: 24.53%, Table 3, Figures 2 and 3) occurring in 46.06% of small-sized fish stomachs and 40.94% in those medium-sized. Panopeidae and Penaeidae were the most important prey items (Table 3). For the small-sized *S. ocellatus*, fishes were the third most abundant prey type (14.67%, Table 3, Figure 4) dominated by *Bollmannia communis* (8.26%, Table 3, Figure 2) which occurred in 2.42% of the small-size stomachs containing food and accounted for 4.07% of the weight (Table 3). Fishes made up the third most important prey type (4.93%, Table 3, Figure 5) in IRI% for the medium-sized *S. ocellatus*, with Pinfish (*Lagodon rhomboides*) as the most abundant (4.62%), most frequently occurring (7.60%) after unidentified fish (14.04%) and contributing to most of the weight (27.87%) (Table 3). Fishes, overall, significantly occurred more frequently in the stomachs of medium-sized *S. ocellatus* ($t_{(14)} = 2.57$, $p = 0.022$). Plant material was also significantly different between sizes. Medium-sized *S. ocellatus*' stomachs contained more plant material (N%: $t_{(14)} = 2.23$, $p = 0.042$; F%: $t_{(14)} = 5.51$, $p = 0.000$; IRI%: $t_{(14)} = 2.77$, $p = 0.015$), more specifically containing significant amounts of *T. testudinum* (F%: $t_{(14)} = 0.24$, $p = 0.007$; IRI%: $t_{(14)} = 2.23$, $p = 0.039$) and red algae (Rhodomelaceae) (N%: $t_{(14)} = 1.61$, $p = 0.007$; F%: $t_{(14)} = 3.18$, $p = 0.003$; IRI%: $t_{(14)} = 4.62$, $p = 0.009$). Cerithiidae significantly contributed to the weight of prey items within the stomachs of smaller *S. ocellatus* ($t_{(14)} = 2.58$, $p = 0.036$).

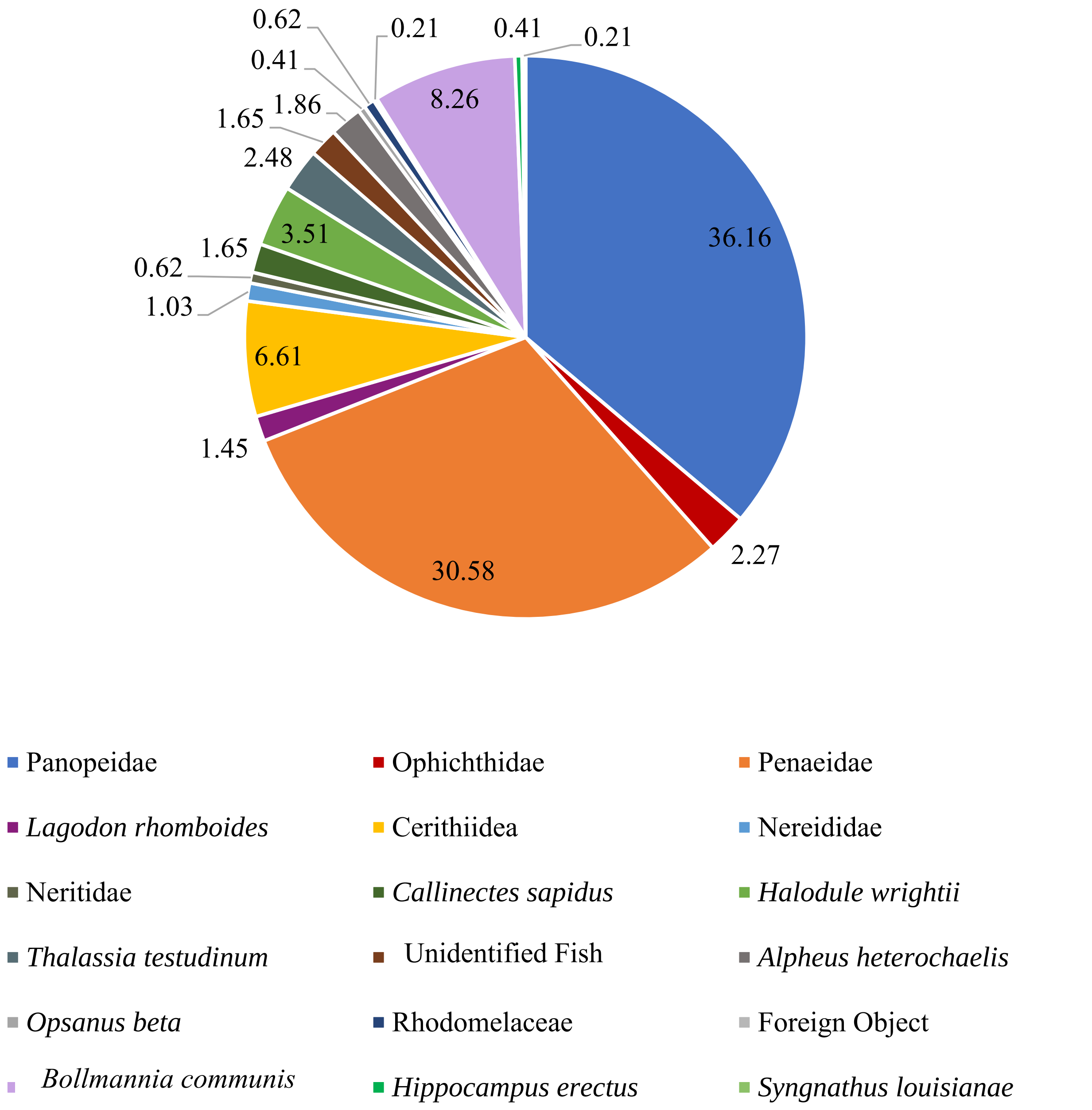

Figure 2. Number percentage (N%) representing abundance of each prey item found within the stomachs of the small size class *Sciaenops ocellatus*. Size class as in Table 1.

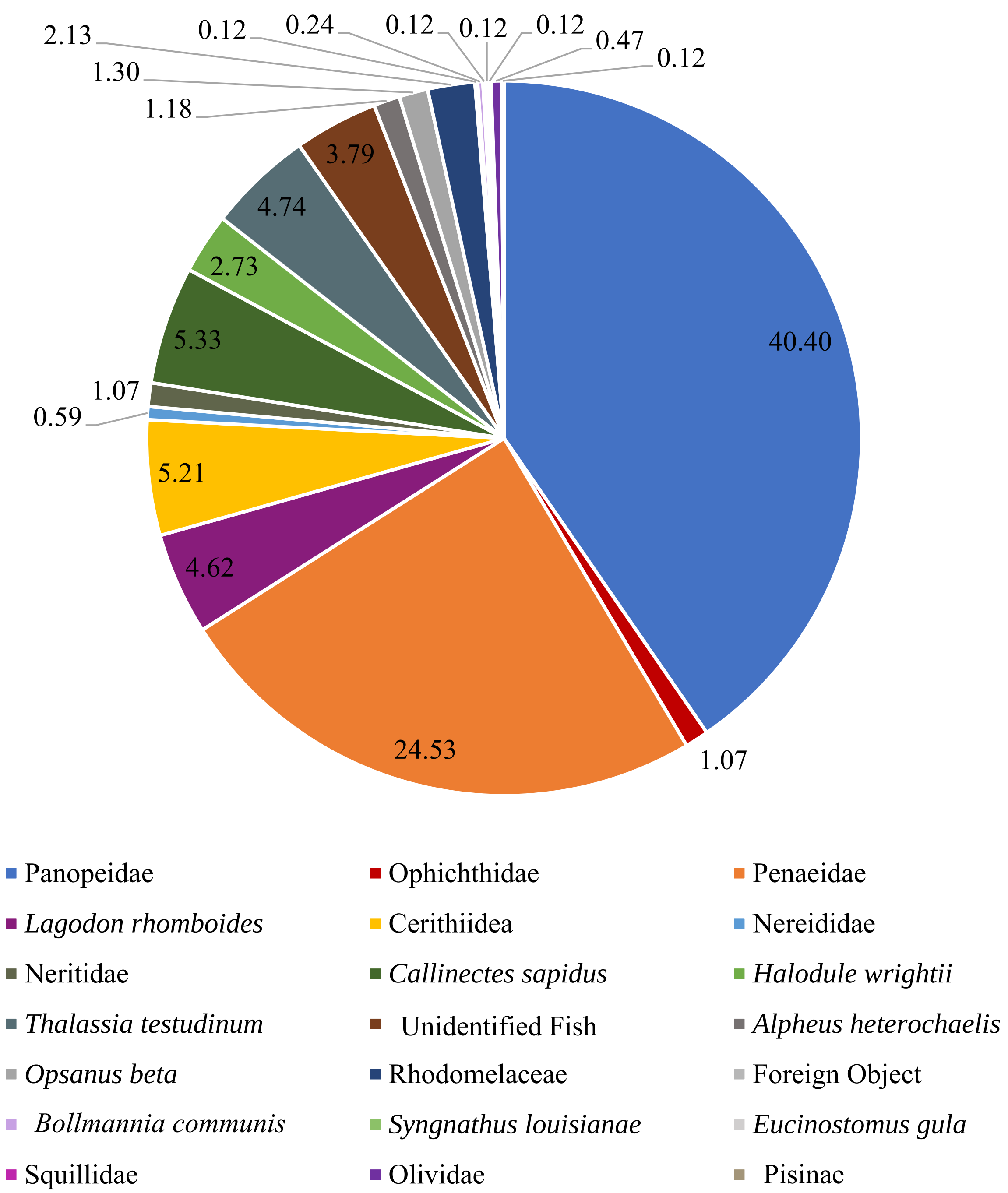

Figure 3. Number percentage (N%) representing abundance of each prey item found within the stomachs of the medium size class *Sciaenops ocellatus*. Size class as in Table 1.

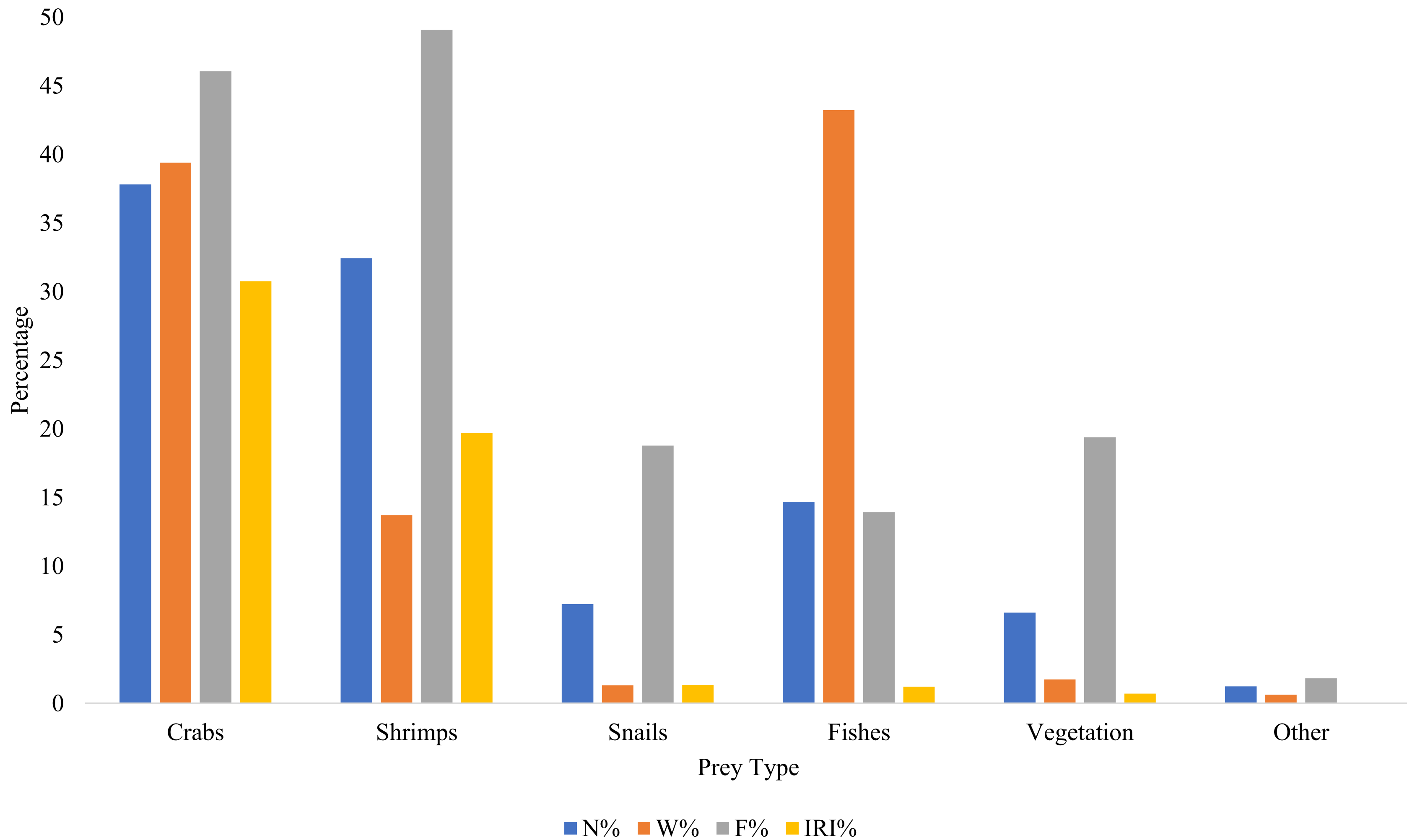

Figure 4. All metrics (number percentage = N%, weight percentage = W%, frequency of occurrence percentage = F%, and index of relative importance percentage = IRI%) for all prey types found within the stomachs of small size class *Sciaenops ocellatus.* Size class as in Table 1.

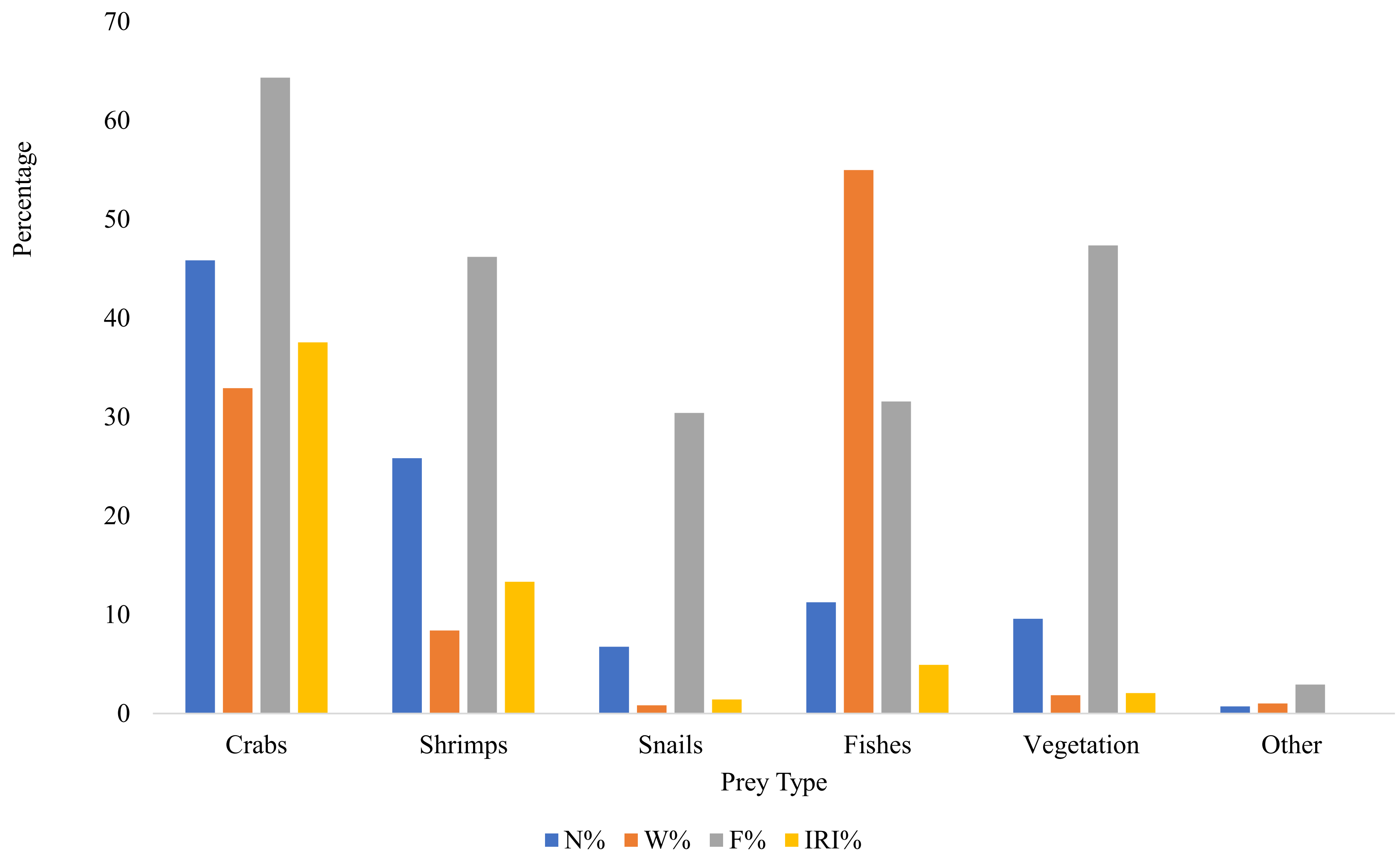

Figure 5. All metrics (number percentage = N%, weight percentage = W%, frequency of occurrence percentage = F%, and index of relative importance percentage = IRI%) for all prey types found within the stomachs of medium size class *Sciaenops ocellatus.* Size class as in Table 1.

Site and Diet

Panopeidae were the most abundant prey item found in the stomachs of *S. ocellatus* that were captured at both HB (39.83%) and SB (38.06%) followed by Penaeidae (28.24% and 25.51%) (Table 4, Figures 6 and 7). All major prey types were very similar between fish captured in both sites (Figures 8 and 9). Panopeidae occurred in 51.08% of all stomachs containing food from fish captured in HB and 43.65% in those from SB (Table 4). *Callinectes sapidus* was the third most abundant prey item for fish from HB (7.23%), while Cerithiidae were the third most abundant for fish from SB (6.00%) (Table 4, Figures 6 and 7). There were no significant differences in total plant material between sites but the stomachs from *S. ocellatus* collected in SB did have significantly more *H. wrightii* present than those from HB (N%: $t_{(14)} = 3.65$, $p = 0.003$), accounted for more weight (W%: $t_{(14)} = 2.16$, $p = 0.048$), occurred more frequently (F%: $t_{(14)} = 3.82$, $p = 0.002$), and was more important (IRI%: $t_{(14)} = 3.83$, $p = 0.002$).

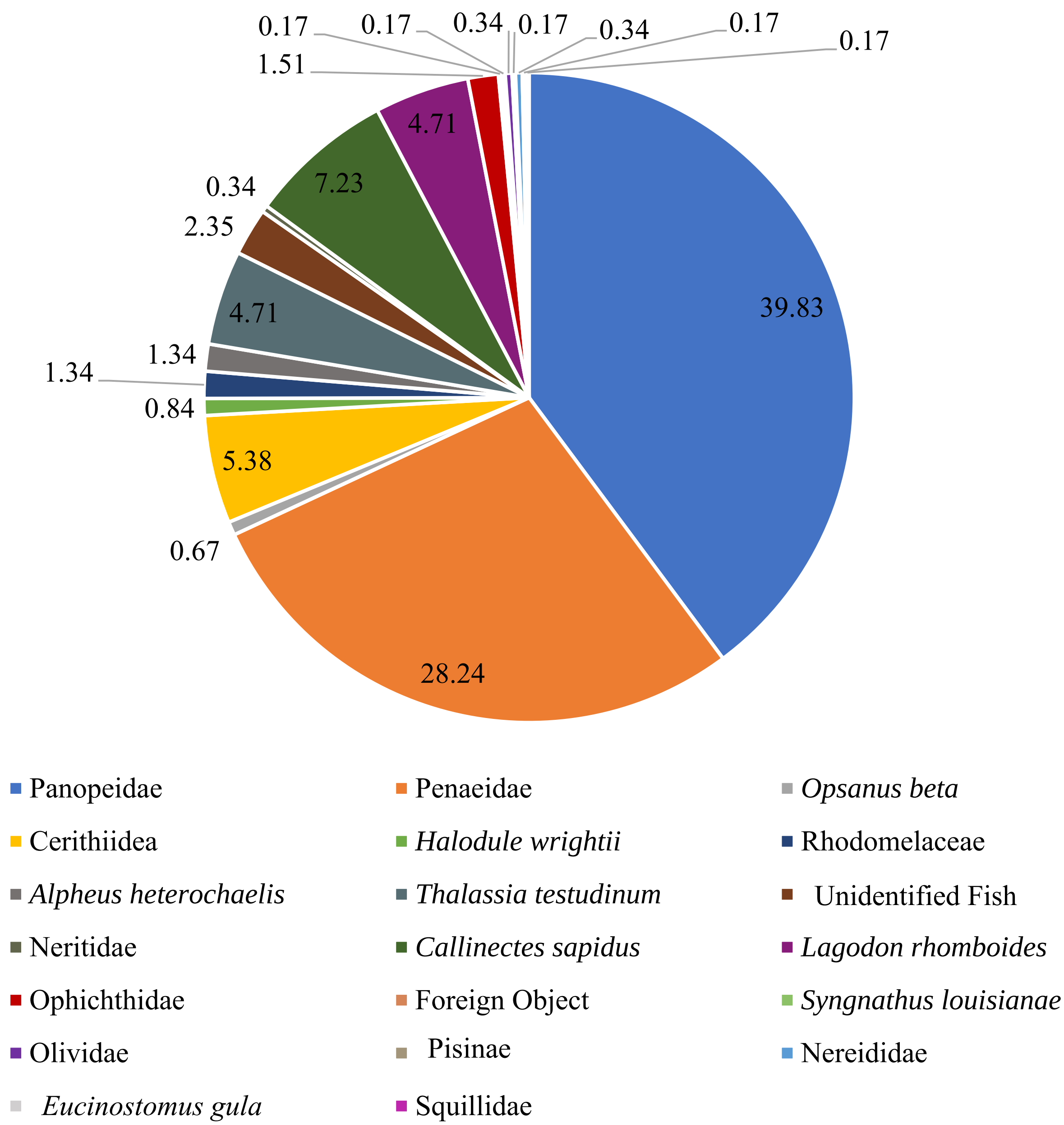

Figure 6. Number percentage (N%) representing abundance of each prey item found within the stomachs of *Sciaenops ocellatus* found in Holly Beach.

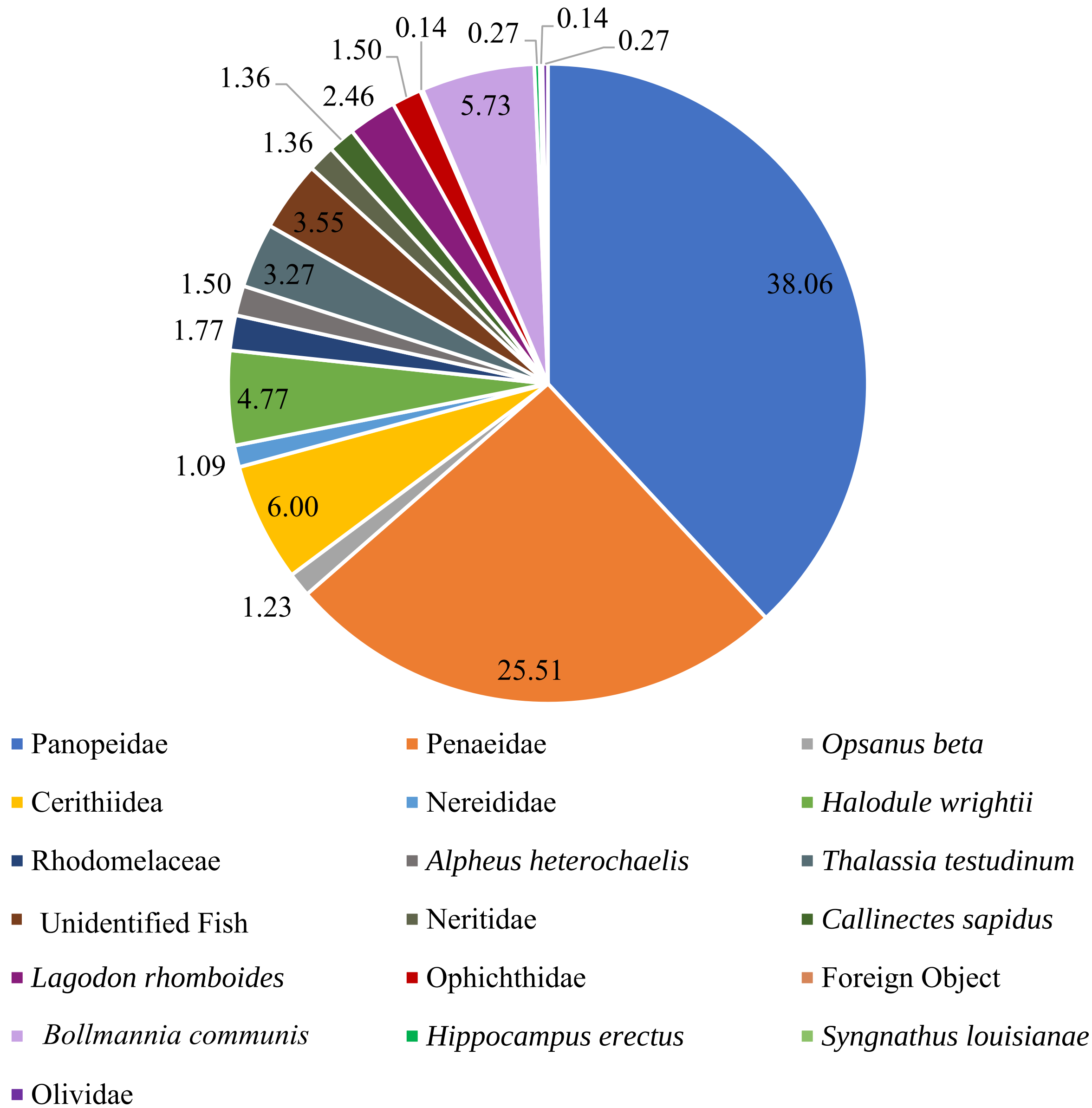

Figure 7. Number percentage (N%) representing abundance of each prey item found within the stomachs of *Sciaenops ocellatus* found in South Bay.

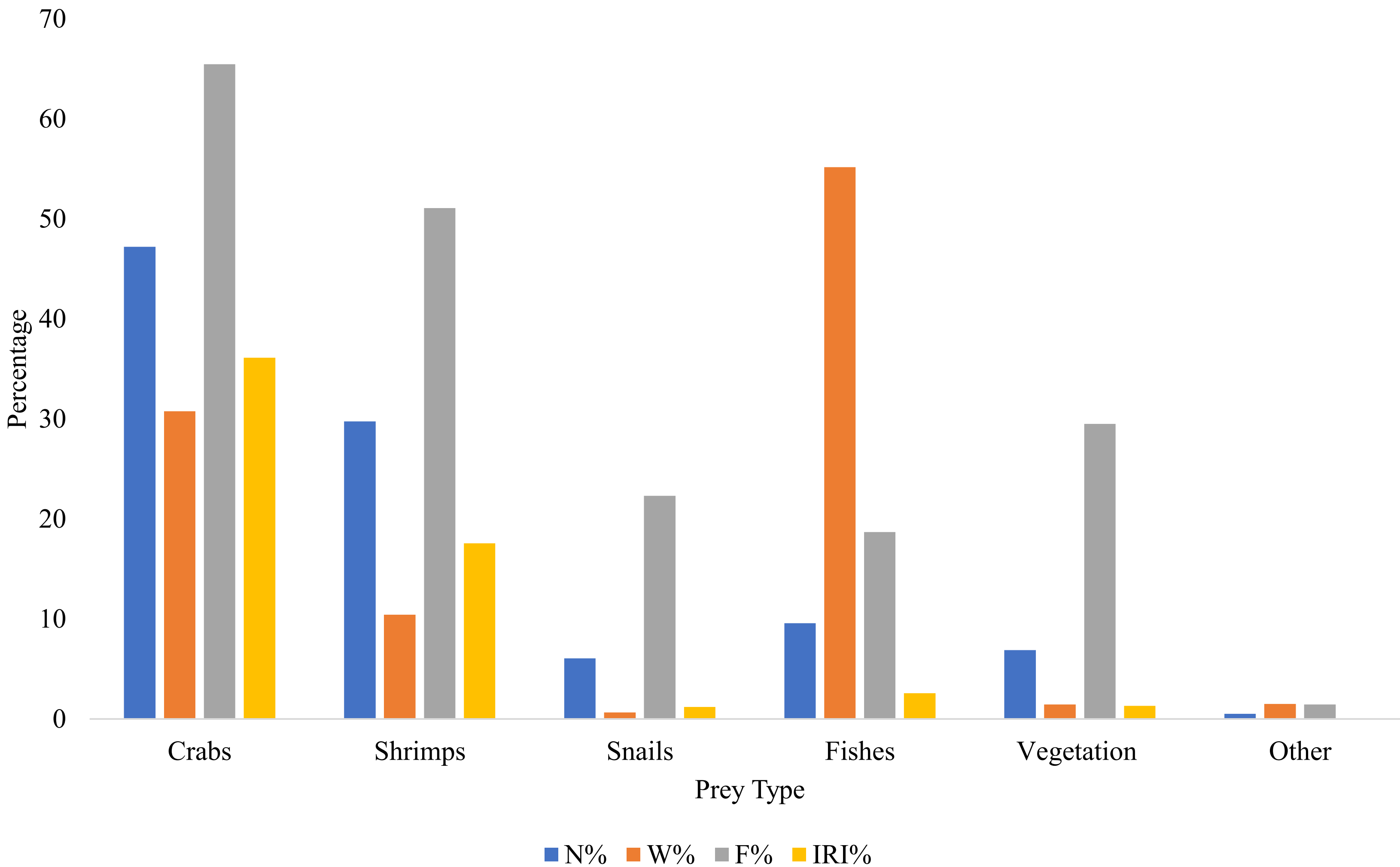

Figure 8. All metrics (number percentage = N%, weight percentage = W%, frequency of occurrence percentage = F%, and index of relative importance percentage = IRI%) for all prey types found within the stomachs of *Sciaenops ocellatus* found in Holly Beach.

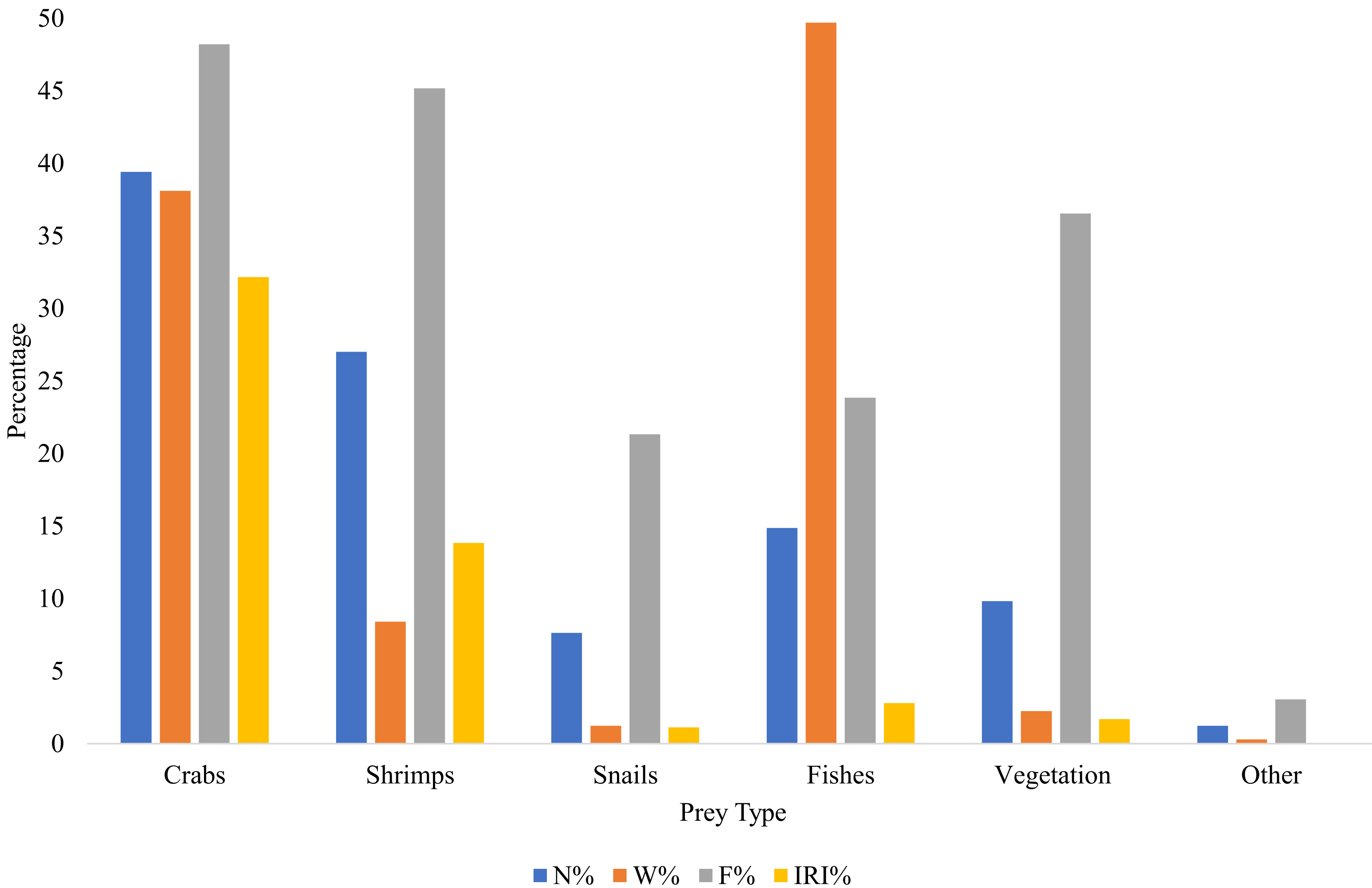

Figure 9. All metrics (number percentage = N%, weight percentage = W%, frequency of occurrence percentage = F%, and index of relative importance percentage = IRI%) for all prey types found within the stomachs of *Sciaenops ocellatus* found in South Bay.

Quarter and Diet

Crabs were the most important prey type for Q2 (85.23%), Q3 (25.53%), and Q4 (11.28%) with Panopeidae being the most important prey item for Q2 and Q4 (85.20% and 11.23%) (Table 5). Crabs were significantly more important in Q2 than Q4 as per the Tukey test (ANOVA, $F_{0.05\,(3,12)} = 5.499$, $p = 0.013$), but there were no significant differences among the other Qs. Shrimps were the most important in Q1 (36.55%) with Penaeidae as the most abundant (42.01%) (Table 5, Figures 10 and 14). Panopeidae was the most abundant prey item in Q2 (Table 5, Figure 11), crabs exceeded 60% for all metrics (Figure 15). Penaeidae was also the most abundant prey item in Q3 and Q4 (Table 5, Figures 12 and 13), shrimps have a more variable contribution to the metrics of the IRI% (Figures 16 and 17). The third most important prey item in Q1 and Q4 was *L. rhomboides* (5.07% and 5.18%) occurring in 8.77% and 8.91% of stomachs and contributing to 50.45% and 50.02% of the weight (Table 5). Cerithiidae was the third most important prey item for *S. ocellatus* captured in Q2 (2.16%) occurring in 25.56% of the stomachs and contributing 0.76% to weight (Table 5). The third most important prey item for Q3 were *C. sapidus* (4.07%) (Table 5). *Callinectes sapidus* occurred in 22.73% of stomachs from Q3 and contributed 5.76% to the weight (Table 5). *Callinectes sapidus* were significantly more important, most frequently found and more abundant in Q3 stomachs than the rest of the other Qs as per the Tukey test (ANOVA, IRI%: $F_{0.05\,(3,12)} = 6.599$, $p = 0.007$; F%: $F_{0.05\,(3,12)} = 10.310$, $p = 0.021$; N%: $F_{0.05\,(3,12)} = 6.599$, $p = 0.001$).

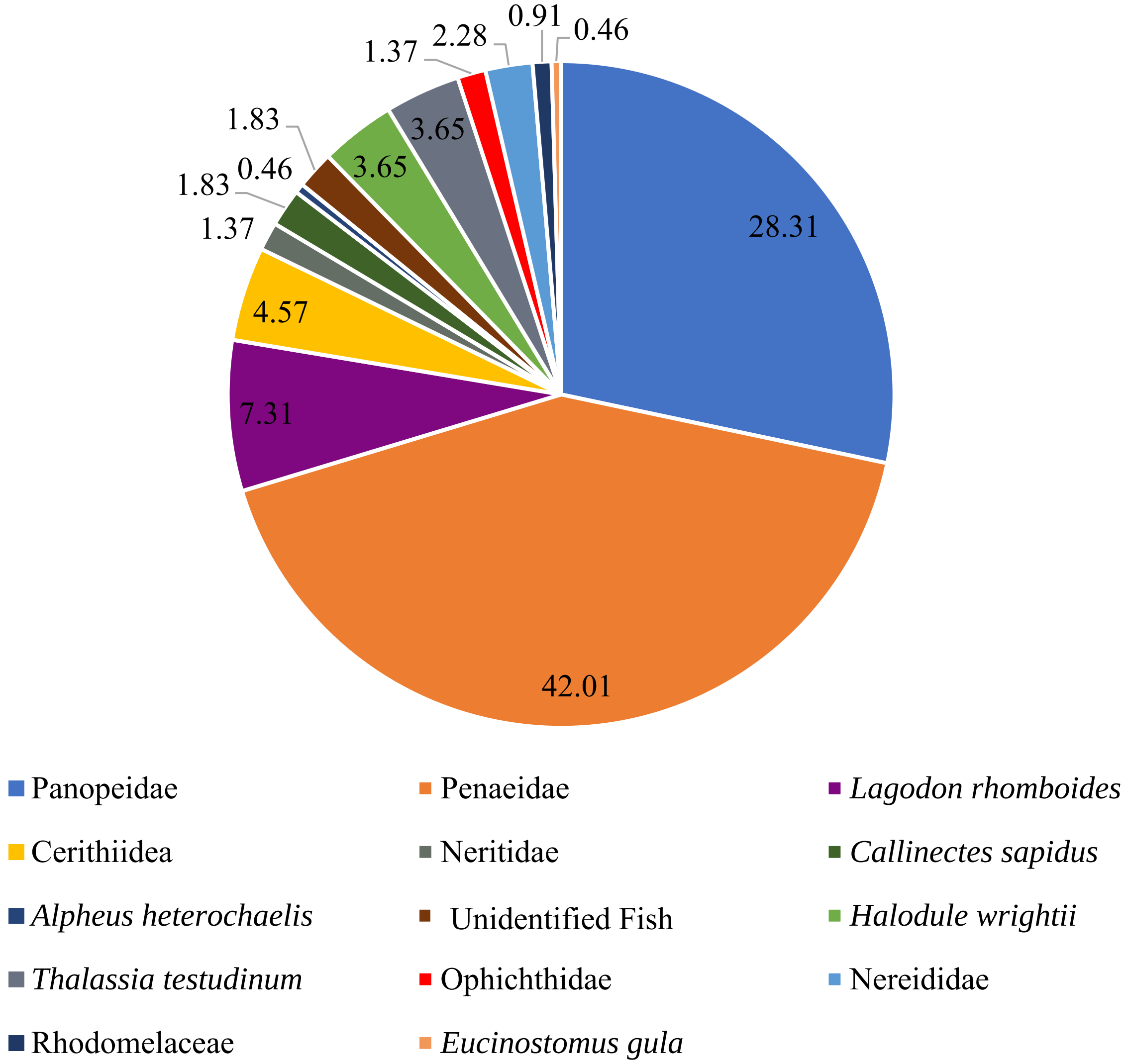

Figure 10. Number percentage (N%) representing abundance of each prey item found within the stomachs of *Sciaenops ocellatus* found in Quarter 1 (October-December 2020).

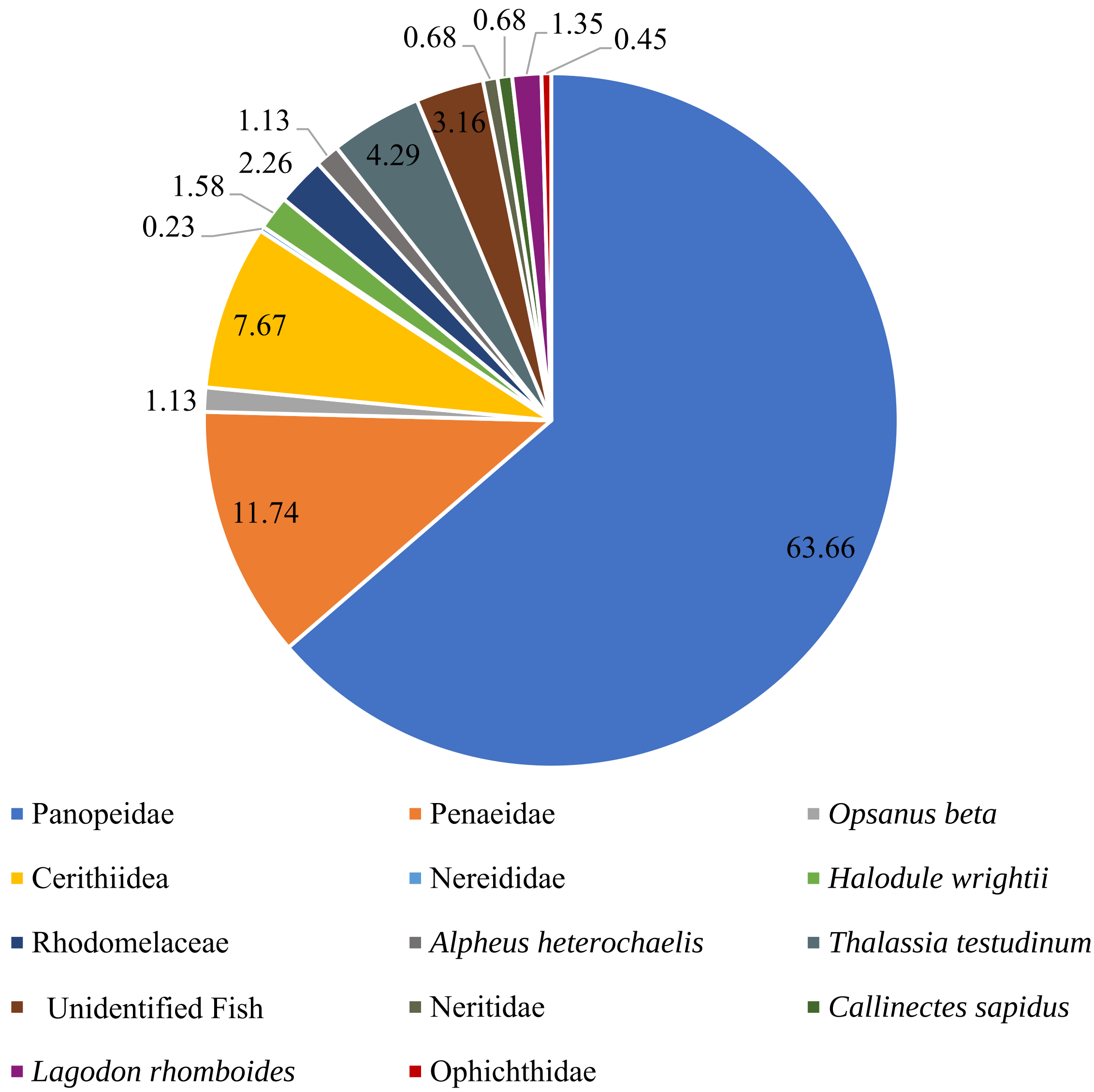

Figure 11. Number percentage (N%) representing abundance of each prey item found within the stomachs of *Sciaenops ocellatus* found in Quarter 2 (January-March 2021).

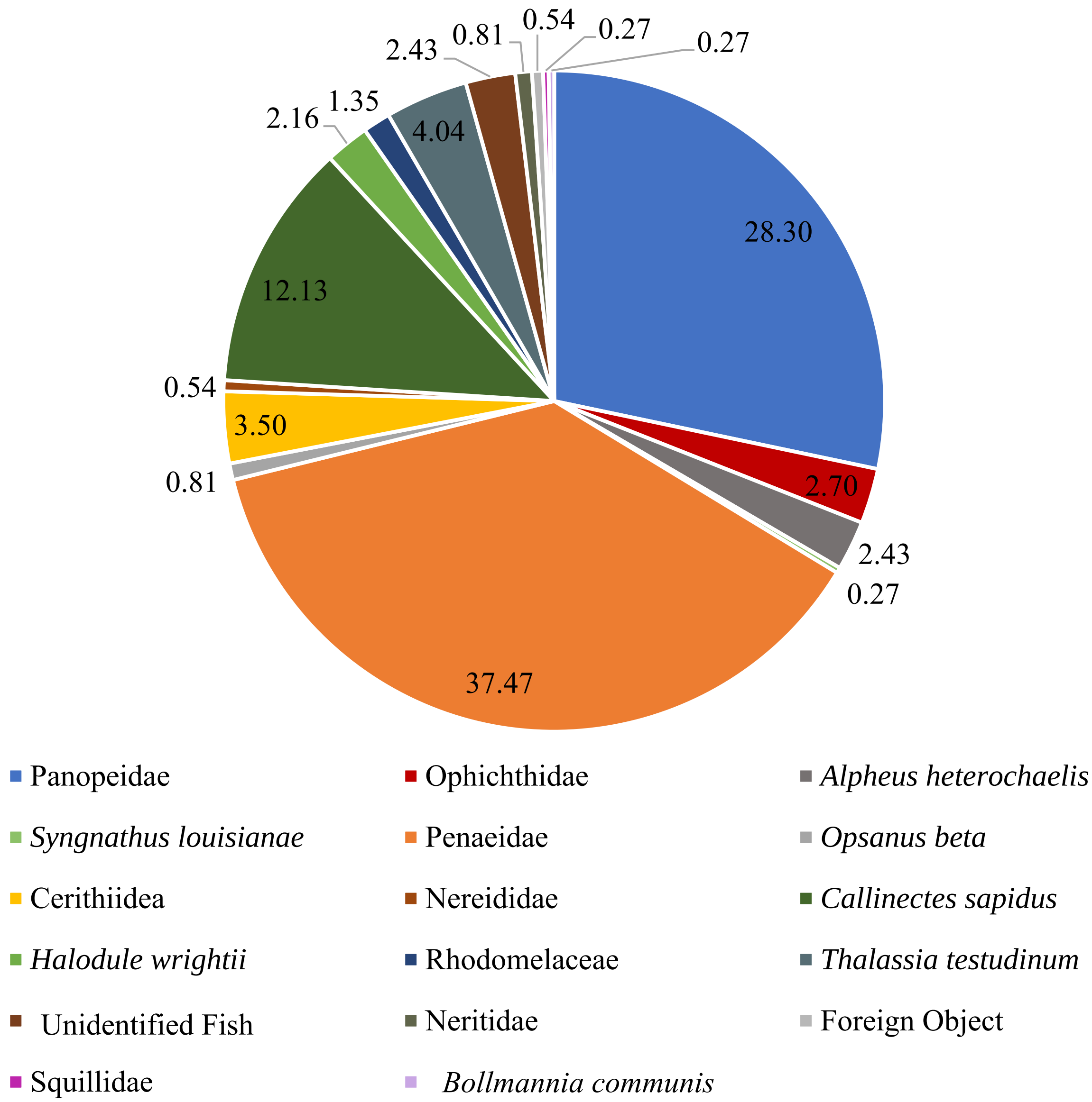

Figure 12. Number percentage (N%) representing abundance of each prey item found within the stomachs of *Sciaenops ocellatus* found in Quarter 3 (April-June 2021).

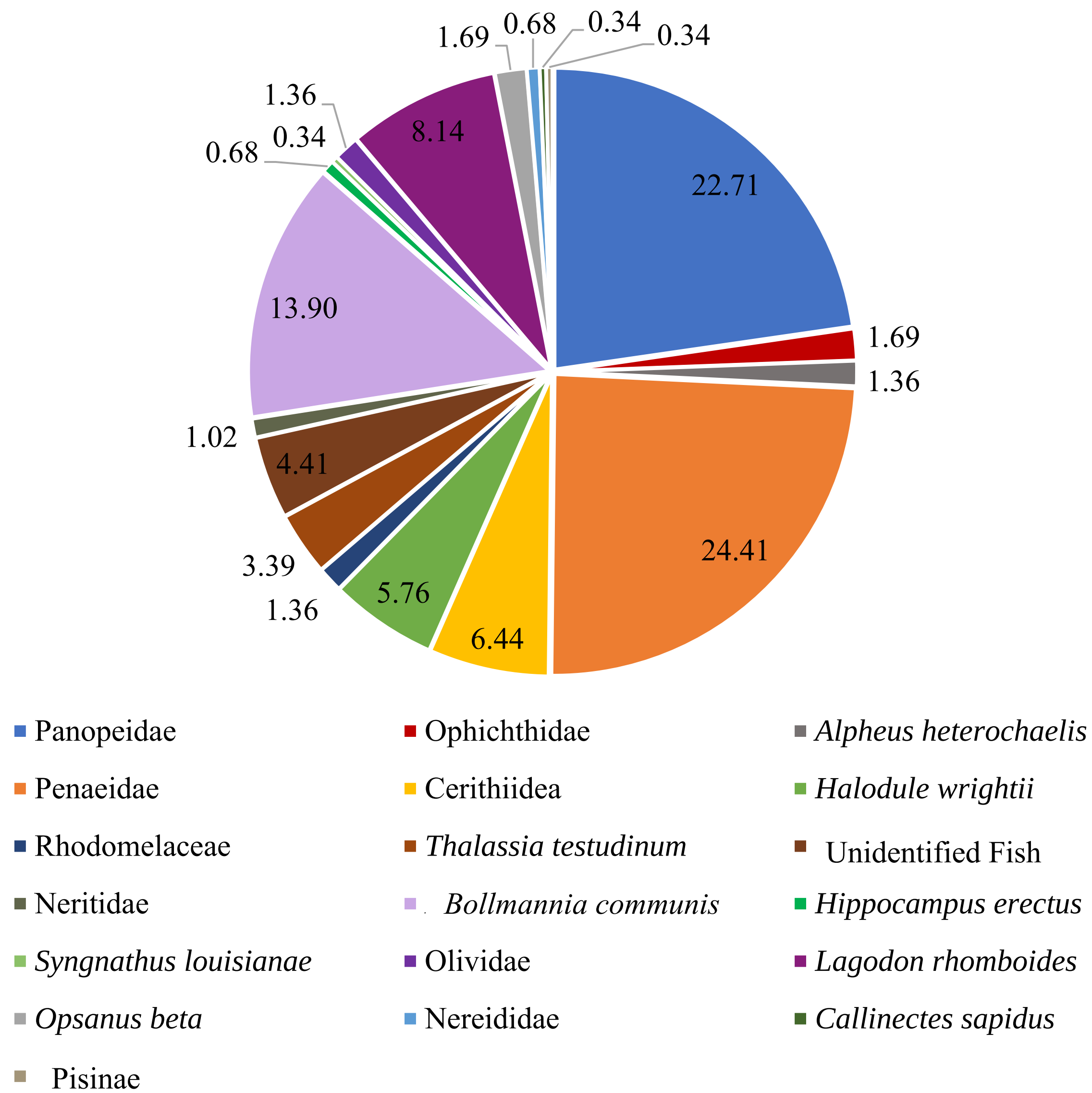

Figure 13. Number percentage (N%) representing abundance of each prey item found within the stomachs of *Sciaenops ocellatus* found in Quarter 4 (July-September 2021).

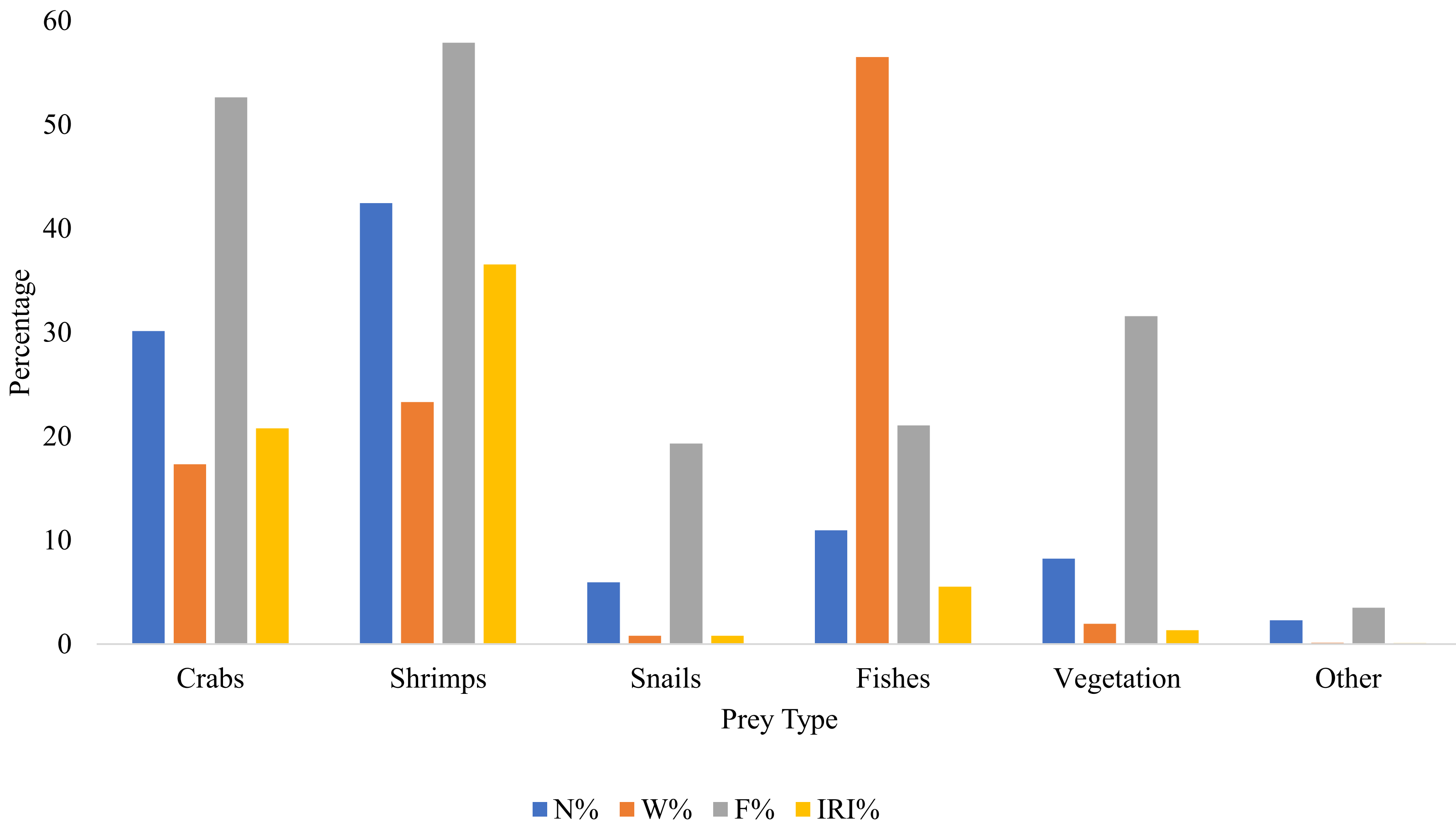

Figure 14. All metrics (number percentage = N%, weight percentage = W%, frequency of occurrence percentage = F%, and index of relative importance percentage = IRI%) for all prey types found within the stomachs of *Sciaenops ocellatus* found in Quarter 1 (October-December 2020).

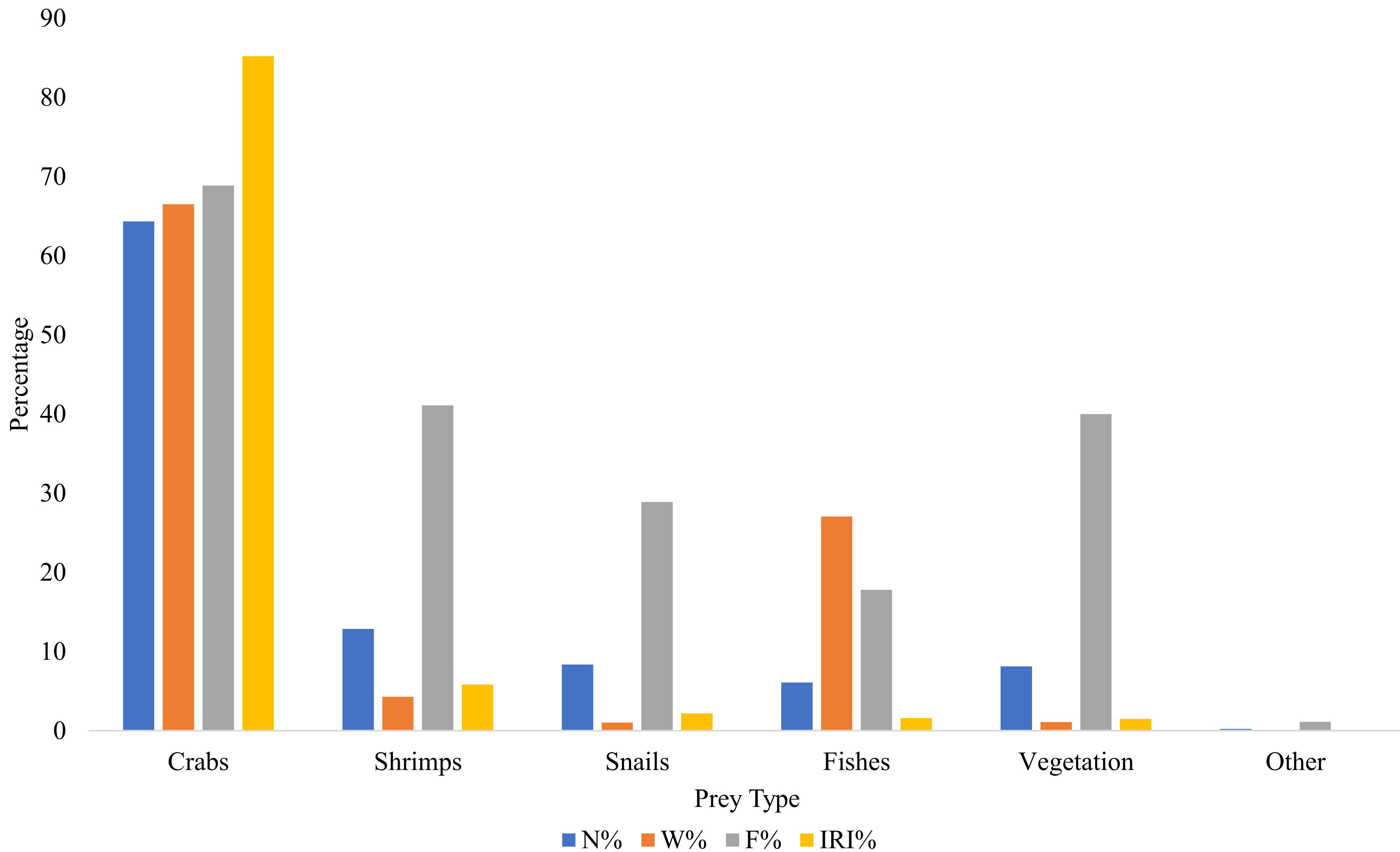

Figure 15. All metrics (number percentage = N%, weight percentage = W%, frequency of occurrence percentage = F%, and index of relative importance percentage = IRI%) for all prey types found within the stomachs of *Sciaenops ocellatus* found in Quarter 2 (January-March 2021).

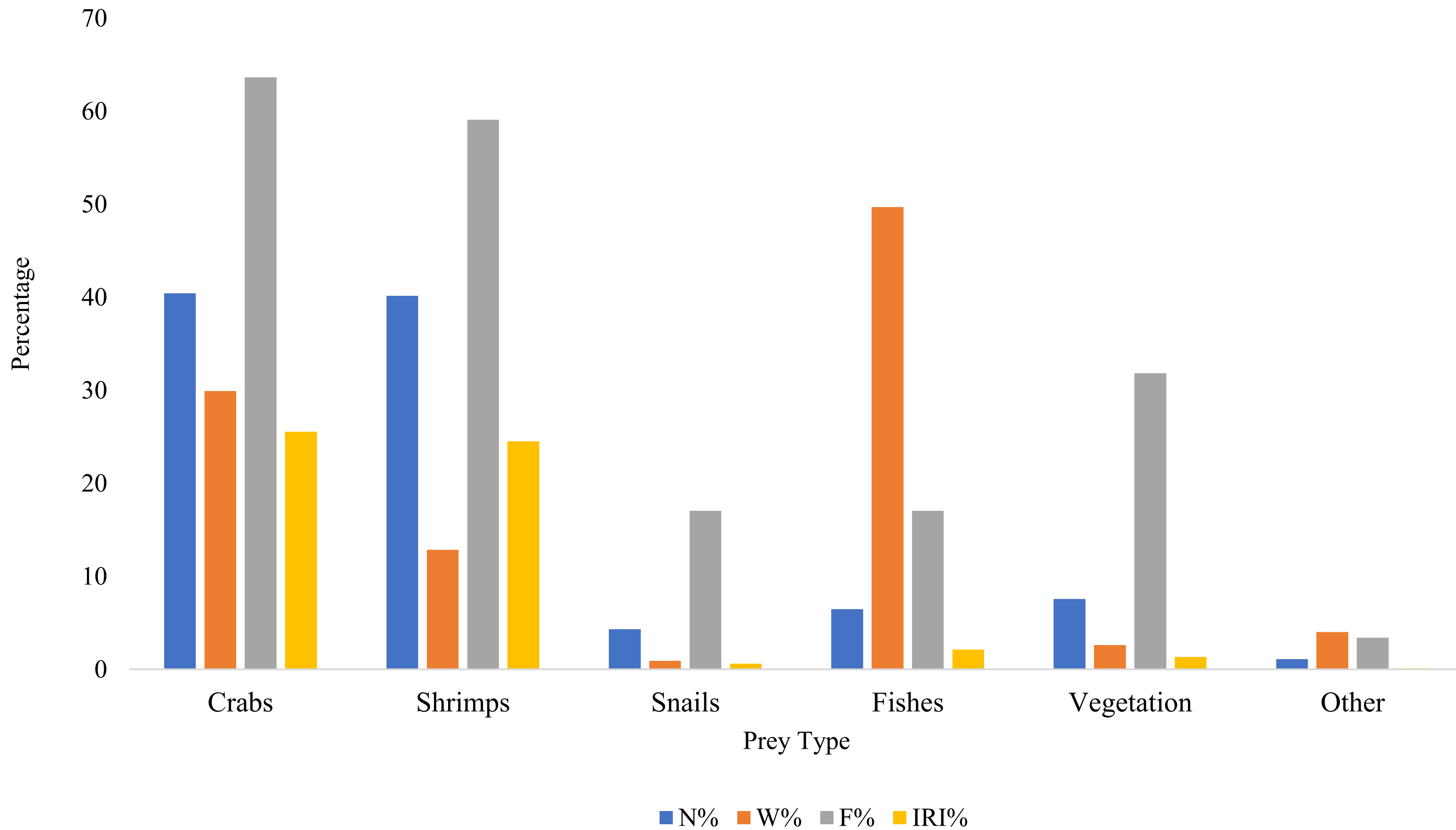

Figure 16. All metrics (number percentage = N%, weight percentage = W%, frequency of occurrence percentage = F%, and index of relative importance percentage = IRI%) for all prey types found within the stomachs of *Sciaenops ocellatus* found in Quarter 3 (April-June 2021).

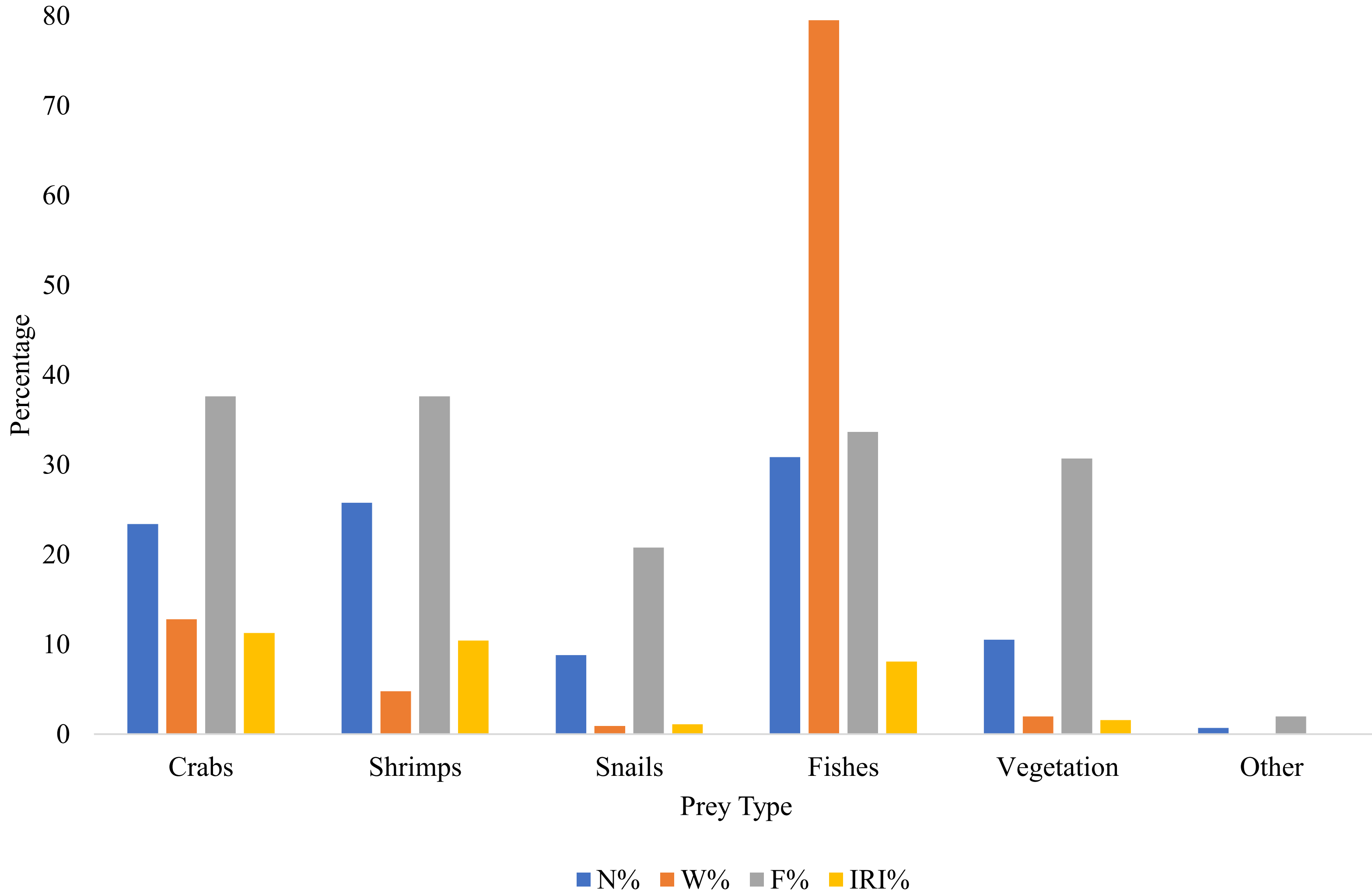

Figure 17. All metrics (number percentage = N%, weight percentage = W%, frequency of occurrence percentage = F%, and index of relative importance percentage = IRI%) for all prey types found within the stomachs of *Sciaenops ocellatus* found in Quarter 4 (July-September 2021).

Stable Isotopes

For $\delta^{13}C$ and $\delta^{15}N$, tissue samples were taken from a total of 80 *S. ocellatus*. For each Q, five fish from each size class and site (total of ten) were used. In all four Qs, *S. ocellatus* are feeding around the 4th trophic level (Mean $\delta^{15}N$: 11.54 ± 1.04‰) with those collected in HB (Mean $\delta^{15}N$: 12.09 ± 1.04‰) showing slightly higher signatures than those collected in SB (Mean $\delta^{15}N$: 10.99 ± 0.70‰) (Figures 18-21). The $\delta^{13}C$ signatures for juvenile *S. ocellatus* were significantly different among Qs (ANOVA, $F_{0.05\ (3,64)} = 9.59$, $p = 0.000$), size class (ANOVA, $F_{0.05\ (1,64)} = 20.19$, $p = 0.000$), and site (ANOVA, $F_{0.05\ (1,64)} = 6.71$, $p = 0.012$). Tukey's test indicated that *S. ocellatus* $\delta^{13}C$ signatures in Q3 at both sites and sizes are significantly depleted compared to the other three Qs (Figures 18-21).

Sciaenops ocellatus $\delta^{15}N$ signatures were similar among Qs ($F_{0.05\ (3,64)} = 0.014$, $p = 0.998$) and between size class ($F_{0.05\ (1,64)} = 2.80$, $p = 0.099$) but were significantly different between sites ($F_{0.05\ (1,64)} = 35.58$, $p = 0.000$), with HB being larger. There was also a significant interaction effect among Qs, size class, and site for $\delta^{15}N$ ($F_{0.05\ (3,64)} = 4.58$, $p = 0.006$).

Prey item stable isotopes were similar between sites and Qs. Panopeidae $\delta^{13}C$ signatures were significantly more depleted in HB (ANOVA, $F_{0.05\ (1,59)} = 8.59$, $p = 0.01$) than SB. Penaeidae $\delta^{13}C$ signatures were also more depleted in HB (ANOVA, $F_{0.05\ (1,47)} = 4.19$, $p = 0.05$) than SB and significantly less depleted in Q4 than any other of the three Qs (ANOVA, $F_{0.05\ (3,47)} = 25.76$, $p < 0.000$).

Panopeidae that were partially digested in stomachs and Panopeidae that were collected live at the sites did show some significant differences in $\delta^{15}N$ signatures ($t_{(14)} = -3.09$, $p = 0.008$) and *L. rhomboides* ($t_{(1)} = 86.73$, $p = 0.007$). For Silver Jenny (*Eucinostomus gula*), there was a significant difference in both $\delta^{15}N$ and $\delta^{13}C$ signatures ($t_{(1)} = 13.52$, $p = 0.047$; $t_{(1)} = -17.35$, $p = 0.037$, respectively). The $\delta^{13}C$ signatures for acidified sediment samples were significantly more depleted (Mean $\delta^{13}C$: -14.02‰) than those that were not acidified (Mean $\delta^{13}C$: -5.89‰) ($t_{(18)} = -17.65$, $p = 0.000$).

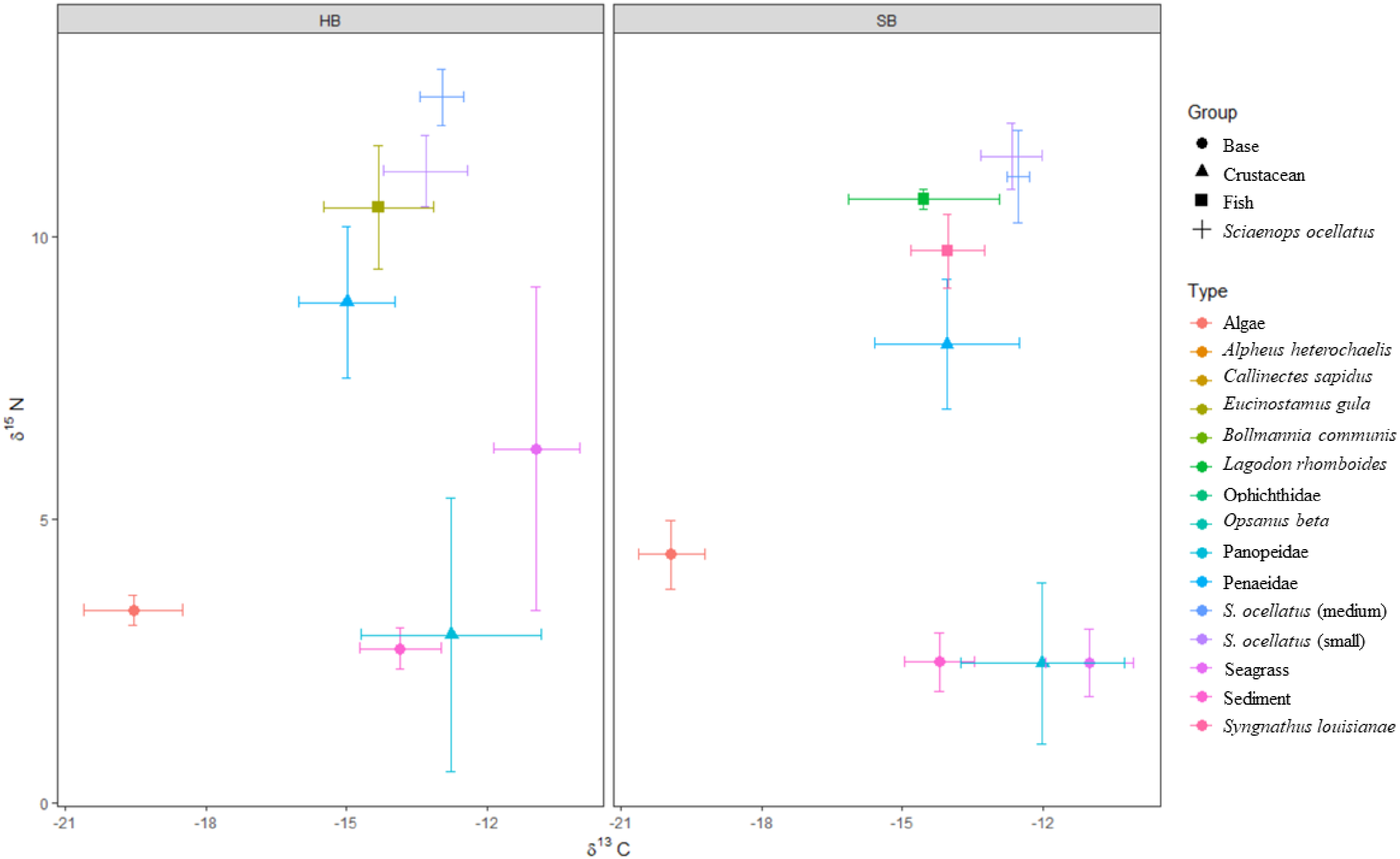

Figure 18. Mean δ^{13}C (‰) and δ^{15}N (‰) biplot ± standard deviation (represented by the bars) for *Sciaenops ocellatus* in both size classes (small and medium) in each sample site (Holly Beach: HB and South Bay: SB) alongside their respective prey items (fish, crustacean) and other components (base) that might play a role in the isotope signatures of the fish (seagrasses, algae, and sediment) for Quarter 1 (October-December 2020). Sizes as in Table 1.

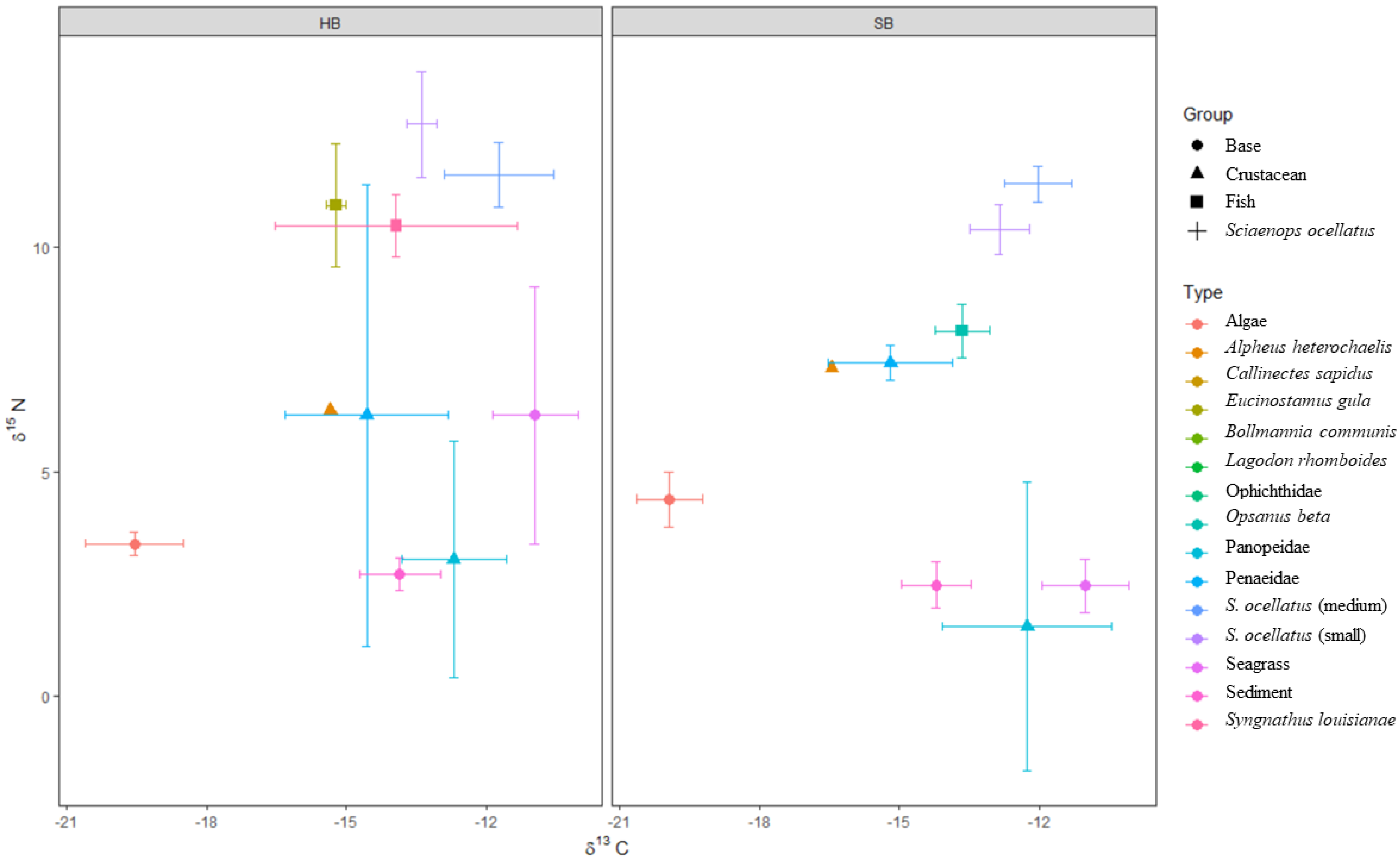

Figure 19. Mean δ^{13}C (‰) and δ^{15}N (‰) biplot ± standard deviation (represented by the bars) for *Sciaenops ocellatus* in both size classes (small and medium) in each sample site (Holly Beach: HB and South Bay: SB) alongside their respective prey items (fish, crustacean) and other components (base) that might play a role in the isotope signatures of the fish (seagrasses, algae, and sediment) for Quarter 2 (January-March 2021). Sizes as in Table 1.

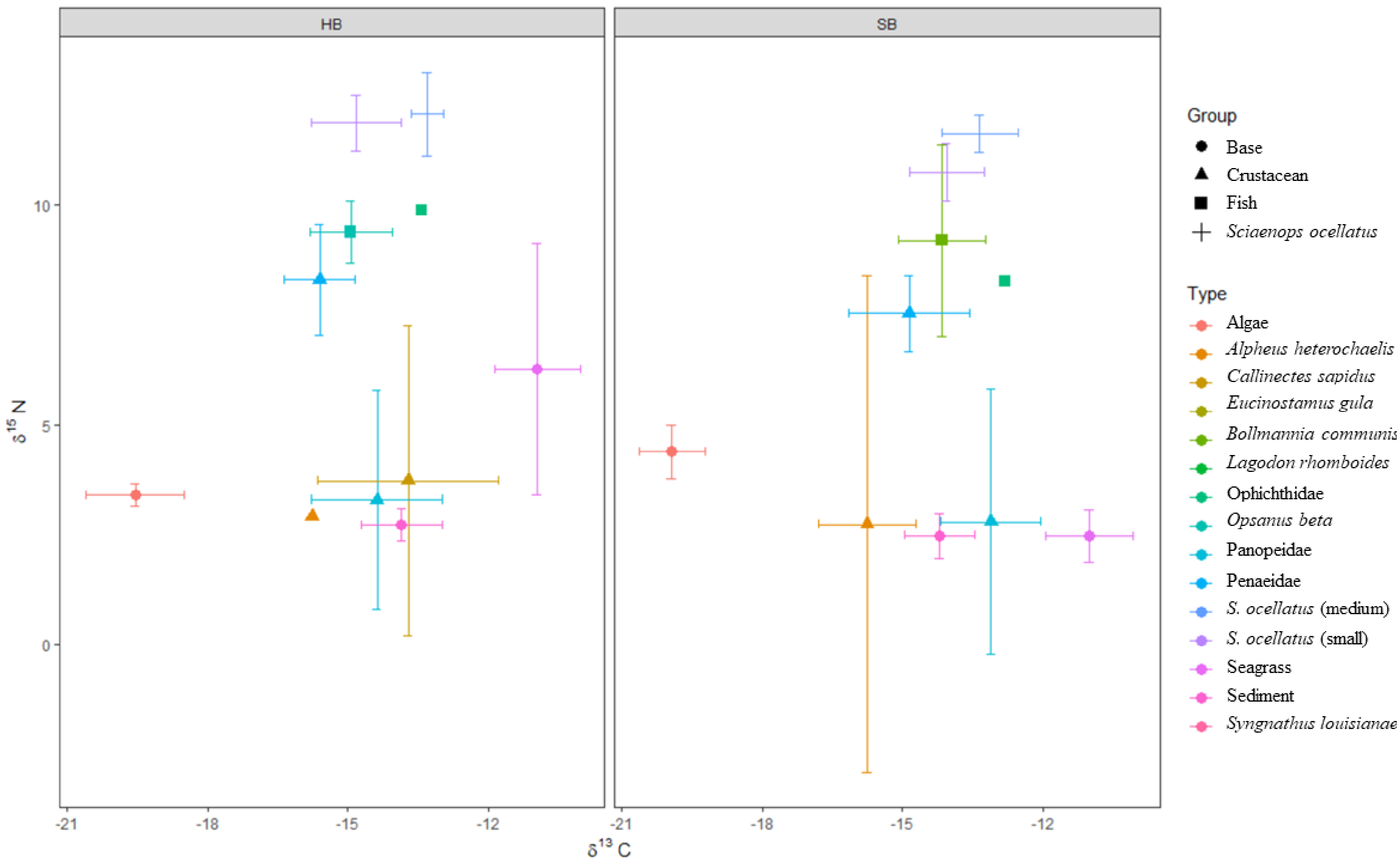

Figure 20. Mean δ^{13}C (‰) and δ^{15}N (‰) biplot ± standard deviation (represented by the bars) for *Sciaenops ocellatus* in both size classes (small and medium) in each sample site (Holly Beach: HB and South Bay: SB) alongside their respective prey items (fish, crustacean) and other components (base) that might play a role in the isotope signatures of the fish (seagrasses, algae, and sediment) for Quarter 3 (April-June 2021). Sizes as in Table 1.

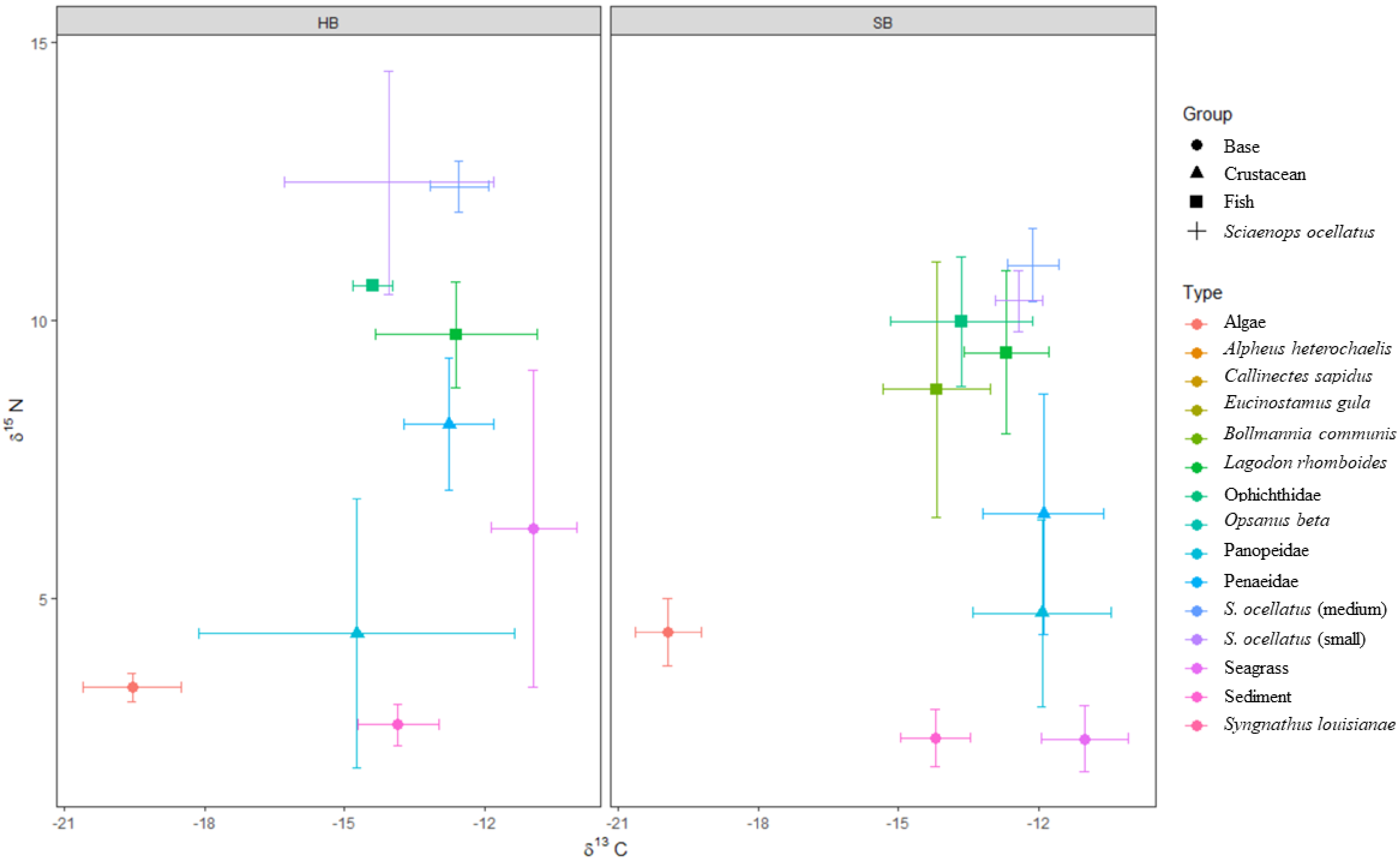

Figure 21. Mean $\delta^{13}C$ (‰) and $\delta^{15}N$ (‰) biplot ± standard deviation (represented by the bars) for *Sciaenops ocellatus* in both size classes (small and medium) in each sample site (Holly Beach: HB and South Bay: SB) alongside their respective prey items (fish, crustacean) and other components (base) that might play a role in the isotope signatures of the fish (seagrasses, algae, and sediment) for Quarter 4 (July-September 2021). Sizes as in Table 1.

CHAPTER IV

DISCUSSION

For the juvenile *S. ocellatus* found in all Qs, both sites, and size classes, crustaceans were the most prevalent and important food item. This is a pattern that has been noted by many (Facendola and Scharf 2012; Herzka and Holt 2000; Llansó et al. 1998; Malinowski et al. 2019; Overstreet and Heard 1978). Such pattern can also be linked to the availability of these prey types within the LLM as many shrimps and crabs were abundant throughout the year during the bag seine events (data not shown) in conjunction with gillnetting.

Though there were no significant differences in much of the diets between size classes, rejecting hypotheses 1 (diets will be different between size classes (small and medium)), the medium-sized *S. ocellatus* found in both sites throughout the year did have more fishes in their stomachs compared to the small size class. This was expected as *S. ocellatus* have been noted to eat larger prey items and fishes in adulthood once reaching larger sizes (Facendola and Scharf 2012; Overstreet and Heard 1978). The medium size class *S. ocellatus* also significantly had more vegetation present within their stomachs than the small size. Because the presence of vegetation within the stomachs is most likely due to bycatch due to preying upon benthic species living within or on vegetated bottoms of the bay and lagoon, it makes sense that the larger fish that have greater gape sizes would naturally ingest more by foraging on prey items.

There was an expectation for more vegetation to appear in the stomachs of *S. ocellatus* in SB compared to HB, but there was no significant difference between the two except for *H. wrightii* compared to other grasses being significantly more abundant in the stomachs of fish from SB. This can be a result of SB containing a higher presence of overall seagrass than HB (pers. obs.). It makes sense that the individuals that were caught have a variety of seagrasses in their stomachs, particularly within SB given that *S. ocellatus* have been noted to, especially in their 1st year, be found in heterogeneous areas that transition from different substrates and vegetation (Whitfield 2017) and some studies have seen a difference in fish assemblages based on the type of habitats near seagrass meadows, showing a lesser presence in habitats surrounded by or near algae compared to seagrasses (Sogard and Able 1991).

Crabs were significantly the most important prey type for Q2 and Q4 for both size classes and sites compared to Q1 and Q3. Given that Q2 represents winter and Q4 summer, this contrasts to Facendola and Scharf (2012) but follows the patterns observed by Llansó et al. (1998), Overstreet and Heard (1978), Pattillo et al. (1997), and Scharf and Schlight (2000). Following the freeze that occurred in south Texas in February 2021, large fish kills occurred which could be a reason for the *S. ocellatus* to be relying more upon crustaceans, like crabs, during the winter months. Interestingly, *C. sapidus* were significantly more important in Q3 than all other Qs which corresponds with the crabs' peak spawning periods in the Gulf of Mexico occurring March through April (Anderson et al. 2017), as well as occurring right after the freeze event. Thus, likely *S. ocellatus* are taking advantage of *C. sapidus* aggregations to feed upon which support the 3rd hypothesis (diet will change throughout the year (quarters) given prey availability and abundance). Scharf and Schlicht (2000) also noted *C. sapidus* as an important prey item during the spring seasons, while Overstreet and Heard (1978) found this species to be important during the spring and summer months.

The $\delta^{13}C$ signatures for *S. ocellatus* were more depleted in the small size class compared to medium, in HB compared to SB, and Q3 compared to the rest of the year. This is not surprising as the gut content analyses revealed that medium-sized *S. ocellatus* significantly consumed more vegetation than those of the smaller size class, even if it was as a by-catch. A pattern that was also expected for the sites as SB has a higher presence of seagrasses overall within the area compared to HB (pers. obs.). Malinowski et al. (2019) also noted these same patterns off the Gulf of Mexico in Florida.

Though there was an expectation of competition and resource partitioning between predator fishes of different sizes as reported by Kroetz, Drymon and Powers (2017), this study's results did not show any significant difference in diet for *S. ocellatus* of either size class residing within the same location. There were also no significant differences among Qs for $\delta^{15}N$ signatures of *S. ocellatus*, but $\delta^{15}N$ for HB was significantly higher (12.09 ± 1.04‰) than those for SB (10.00 ± 0.70). This can be attributed to *S. ocellatus* in HB consuming more types of higher trophic level prey items such as the Gulf Toadfish (*Opsanus beta*), *E. gula*, Pipefish (*Syngnathus louisianae*), and *L. rhomboides*. Also consistent with the gut content analyses showing that *L. rhomboides* was the 3rd most important prey item for *S. ocellatus* collected in HB. Given the bag seine collection data (65 bag seine casts in HB and 57 casts in SB), more *L. rhomboides* were caught in HB (6,394) than SB (4, 401). This could be the reason for higher abundances of fishes found in the diets of *S. ocellatus* in HB than SB causing for those fish to be feeding at higher trophic levels. Given the structure of both sites, HB is in a much more open part of the lagoon potentially allowing higher numbers of fishes as it provides for more fish movement within the habitat. Though significantly higher $\delta^{15}N$ values for fish found in HB compared to SB, there were no significant differences in overall diet based on gut content analyses rejecting the 2nd hypothesis (diet composition will differ between the two sites).

Other studies also noted differences in feeding for *S. ocellatus* residing within different sites (Kroetz, Drymon and Powers 2017; Peters and McMichael 1987), and even noted that diets will be heavily influenced by the type of resources that are most found within a specific area compared to another (Overstreet and Heard 1978). Site fidelity may also be an explanation for differences in diets based on site. Reyier et al. (2011) found that adult *S. ocellatus* off the Atlantic Ocean in Florida had high site fidelity from December-June in 2006 and 2007 (visiting 2.1 to 2.9 stations per month, on average) both before and after their spawning periods (March-June and November-February) usually returning or staying near their release sites. Osburn, Matlock, and Green (1982) also reported minimal movement (<10 km ranges from original tagging site) among most recaptured sub-adult *S. ocellatus* (51.9-80.8%), staying within one estuary or bay system (>77% recaptured *S. ocellatus*) along the Texas coast from November 1975 to September 1978. From other tagging studies done in Texas, *S. ocellatus* will not move more than about 4.8 km from where they were tagged showing that they will remain in the same area until mature (TPWD 2022b). Given that the areas sampled within the LLM (HB and SB) are estimated to be around 15-17 km apart, it is expected that the *S. ocellatus* found in this study are showing site fidelity and not moving from HB to SB (or vice versa) during the entire sampling period. However, it is evident that a proper telemetry study is needed.

There was also a significant interaction effect for $\delta^{15}N$ among size class, site, and Qs indicating that all three factors may play a role in determining the diet of *S. ocellatus*. *Sciaenops ocellatus* that are larger can eat more of a diverse set of prey items (varying in sizes) or prey items within higher trophic levels which can be influenced based on resource availability given time of the year and location. In this study, larger fish (medium size) in HB had higher $\delta^{15}N$ values than those in SB with the highest values in Q1.

Panopeidae and Penaeidae $\delta^{13}C$ signatures were significantly different between sites which correspond with the significantly different $\delta^{13}C$ findings for *S. ocellatus* (more enriched values in SB compared to HB) and the observation of higher presence of seagrasses in SB compared to HB. Selleslagh et al. (2015) also noted this difference in crustacean signatures. Penaeidae $\delta^{13}C$ were also significantly different in Q4 which coincides with the summer seasons (July – September). During summer months, there are higher levels of productivity by primary producers (such as seagrasses) (Metz, Harris, and Arrington 2020) as seagrasses experience growth and there is an increase in biomass that can explain the enrichment in $\delta^{13}C$ signatures.

Some of the partially digested prey items found within *S. ocellatus* stomachs had significantly different stable isotope signatures compared to those same prey items that were collected lives at the sites ($\delta^{15}N$: Panopeidae, *L. rhomboides*, and *E.* gula; $\delta^{13}C$: *E. gula*). These differences show that there were some effects due to digestion in isotope fractionation which has been reported by Perkins (2014). The $\delta^{13}C$ signatures for acidified sediment samples were significantly more depleted (Mean $\delta^{13}C$: -14.02‰) than those that were not acidified (Mean $\delta^{13}C$: -5.89‰), thus acidification was needed for all the sediment samples to remove carbonates. Reported results are based on acidified samples.

This study was conducted to better understand the feeding habits of an important recreational fish within the Gulf of Mexico during its juvenile years. The *S. ocellatus* that were collected were expected to have differing diets based on site, size class, and Q based on prey availability and resource partitioning. The results did not show any intraspecific competition between *S. ocellatus* of different size classes, nor did they show a large shift in diet throughout the year. Most of the juvenile *S. ocellatus* did have more than one taxon in their stomachs at any given time, implying a more generalist feeding strategy but did show a preference for benthic species (mostly crustaceans) which has been noted by before (Facendola and Scharf 2012; Kroetz, Drymon and Powers 2017; Llansó et al. 1998; Overstreet and Heard 1978, Pattillo et al. 1997; Scharf and Schlight 2000).

Given the increasing threats to estuaries and the relevant species that use these systems as a nursery, it is important to understand how changing environmental conditions will impact these habitats and the resources that estuaries provide. This study allows for a look into how a top predator within the coastal trophic web has the potential to adapt feeding strategies based on what resources may or may not become available throughout the year or based on location. Importantly, in this study sample sizes for isotopic analyses were limited to reduce costs, thus only giving a narrow insight on the trophic position of juvenile *S. ocellatus* within the LLM. Moving forward, a larger set of juveniles (possibly increased number of size classes) and a wider range of sites will give a deeper understanding of their diets.

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APPENDIX

APPENDIX

Table 6. Index of relative importance (IRI%) and associated metrics (number (N), number percentage (N%), weight percentage (W%), frequency of occurrence percentage (F%)) for *Sciaenops ocellatus* prey items found by size class (small = S1; medium = S2), sample site (South Bay = SB; Holly Beach = HB), and quarter (Quarter 1 = Q1; Quarter 2 = Q2; Quarter 3 = Q3; Quarter 4 = Q4). Quarters and fish sizes as in Table 1. Bold and regular font used as in Table 3

Site/Size/Q	Prey Type	N	%N	%W	%F	%IRI
SB S1 Q1						
	Crabs	**16**	**40.00**	**31.52**	**45.45**	**24.71**
	Callinectes sapidus	1	2.50	2.27	9.09	0.43
	Panopeidae	15	37.50	29.26	36.36	24.28
	Shrimps	**11**	**27.50**	**10.54**	**36.36**	**13.83**
	Penaeidae	11	27.50	10.54	36.36	13.83
	Snails	**4**	**10.00**	**3.03**	**36.36**	**2.86**
	Cerithiidae	3	7.50	1.72	27.27	2.52
	Neritidae	1	2.50	1.30	9.09	0.35
	Fishes	**2**	**5.00**	**43.79**	**18.18**	**4.44**
	Lagodon rhomboides	1	2.50	36.74	9.09	3.57
	Ophichthidae	1	2.50	7.06	9.09	0.87
	Plants/Algae	**2**	**5.00**	**9.70**	**18.18**	**2.67**
	Halodule wrightii	2	5.00	9.70	18.18	2.67
	Other	**5**	**12.50**	**1.42**	**18.18**	**2.53**
	Nereididae	5	12.50	1.42	18.18	2.53
SB S2 Q1						
	Crabs	**24**	**29.63**	**13.63**	**58.82**	**22.15**
	Callinectes sapidus	1	1.23	0.36	5.88	0.09
	Panopeidae	23	28.40	13.27	52.94	22.06
	Shrimps	**26**	**32.10**	**9.05**	**58.82**	**20.99**
	Alpheus heterochaelis	1	1.23	0.46	5.88	0.10
	Penaeidae	25	30.86	8.59	52.94	20.89
	Snails	**7**	**8.64**	**0.87**	**29.41**	**1.51**
	Cerithiidae	5	6.17	0.45	17.65	1.17
	Neritidae	2	2.47	0.41	11.76	0.34
	Fishes	**16**	**19.75**	**75.24**	**23.53**	**6.09**
	Lagodon rhomboides	12	14.81	69.76	5.88	4.98
	Ophichthidae	1	1.23	0.68	5.88	0.11

Table 6, cont.

	Unidentified Fish	3	3.70	4.80	11.76	1.00
	Plants/Algae	**8**	**9.88**	**1.21**	**47.06**	**3.31**
	Halodule wrightii	6	7.41	1.13	35.29	3.01
	Thalassia testudinum	2	2.47	0.08	11.76	0.30
HB S1 Q1						
	Crabs	**15**	**46.88**	**50.11**	**58.33**	**56.58**
	Panopeidae	15	46.88	50.11	58.33	56.58
	Shrimps	**13**	**40.63**	**16.94**	**41.67**	**23.99**
	Penaeidae	13	40.63	16.94	41.67	23.99
	Snails	**2**	**6.25**	**0.93**	**16.67**	**1.20**
	Cerithiidae	2	6.25	0.93	16.67	1.20
	Fishes	**2**	**6.25**	**32.01**	**16.67**	**3.19**
	Lagodon rhomboides	1	3.13	29.75	8.33	2.74
	Ophichthidae	1	3.13	2.26	8.33	0.45
HB S2 Q1						
	Crabs	**11**	**16.67**	**8.09**	**47.06**	**7.97**
	Callinectes sapidus	2	3.03	0.23	11.76	0.38
	Panopeidae	9	13.64	7.86	35.29	7.59
	Shrimps	**43**	**65.15**	**55.71**	**82.35**	**99.53**
	Penaeidae	43	65.15	55.71	82.35	99.53
	Fishes	**4**	**6.06**	**34.45**	**23.53**	**4.11**
	Eucinostomus gula	1	1.52	4.10	5.88	0.33
	Lagodon rhomboides	2	3.03	26.25	11.76	3.44
	Unidentied Fish	1	1.52	4.10	5.88	0.33
	Plants/Algae	**8**	**12.12**	**1.75**	**47.06**	**4.15**
	Rhodomelaceae	2	3.03	0.14	11.76	0.37
	Thalassia testudinum	6	9.09	1.60	35.29	3.77
SB S1 Q2						
	Crabs	**18**	**35.29**	**19.23**	**41.67**	**22.72**
	Panopeidae	18	35.29	19.23	41.67	22.72
	Shrimps	**23**	**45.10**	**14.09**	**58.33**	**28.83**
	Alpheus heterochaelis	2	3.92	2.54	4.17	0.27
	Penaeidae	21	41.18	11.55	54.17	28.56
	Snails	**5**	**9.80**	**1.69**	**12.50**	**1.44**
	Cerithiidae	5	9.80	1.69	12.50	1.44
	Fishes	**2**	**3.92**	**64.47**	**8.33**	**2.85**
	Opsanus beta	1	1.96	64.36	4.17	2.76
	Unidentified Fish	1	1.96	0.11	4.17	0.09
	Plants/Algae	**3**	**5.88**	**0.52**	**12.50**	**0.45**

Table 6, cont.

	Rhodomelaceae	1	1.96	0.11	4.17	0.09
	Thalassia testudinum	2	3.92	0.41	8.33	0.36
SB S2 Q2						
	Crabs	**149**	**68.35**	**74.08**	**72.73**	**98.85**
	Callinectes sapidus	1	0.46	0.17	3.03	0.02
	Panopeidae	148	67.89	73.91	69.70	98.83
	Shrimps	**16**	**7.34**	**2.93**	**33.33**	**2.57**
	Alpheus heterochaelis	2	0.92	0.18	6.06	0.07
	Penaeidae	14	6.42	2.76	27.27	2.50
	Snails	**20**	**9.17**	**1.30**	**36.36**	**2.52**
	Cerithiidae	17	7.80	0.82	27.27	2.35
	Neritidae	3	1.38	0.48	9.09	0.17
	Fishes	**13**	**5.96**	**20.65**	**27.27**	**2.70**
	Lagodon rhomboides	1	0.46	0.09	3.03	0.02
	Opsanus beta	4	1.83	19.02	9.09	1.90
	Unidentified Fish	8	3.67	1.53	15.15	0.79
	Plants/Algae	**19**	**8.72**	**1.04**	**57.58**	**2.02**
	Halodule wrightii	4	1.83	0.19	12.12	0.25
	Rhodomelaceae	7	3.21	0.18	21.21	0.72
	Thalassia testudinum	8	3.67	0.67	24.24	1.05
	Other	**1**	**0.46**	**0.00**	**3.03**	**0.01**
	Nereididae	1	0.46	0.00	3.03	0.01
HB S1 Q2						
	Crabs	**49**	**61.25**	**43.11**	**88.24**	**84.81**
	Callinectes sapidus	1	1.25	0.24	5.88	0.09
	Panopeidae	48	60.00	42.87	82.35	84.72
	Shrimps	**10**	**12.50**	**1.40**	**35.29**	**3.77**
	Alpheus heterochaelis	1	1.25	0.09	5.88	0.08
	Penaeidae	9	11.25	1.31	29.41	3.69
	Snails	**7**	**8.75**	**0.63**	**41.18**	**3.86**
	Cerithiidae	7	8.75	0.63	41.18	3.86
	Fishes	**9**	**11.25**	**53.46**	**17.65**	**4.81**
	Lagodon rhomboides	5	6.25	41.44	5.88	2.81
	Unidentified Fish	4	5.00	12.02	11.76	2.00
	Plants/Algae	**5**	**6.25**	**1.39**	**29.41**	**1.57**
	Halodule wrightii	1	1.25	0.05	5.88	0.08
	Thalassia testudinum	4	5.00	1.35	23.53	1.49
HB S2 Q2						
	Crabs	**69**	**73.40**	**88.96**	**81.25**	**120.79**

Table 6, cont.

	Callinectes sapidus	1	1.06	0.37	6.25	0.09
	Panopeidae	68	72.34	88.59	75.00	120.70
	Shrimps	**8**	**8.51**	**7.17**	**37.50**	**5.88**
	Penaeidae	8	8.51	7.17	37.50	5.88
	Snails	**5**	**5.32**	**0.41**	**25.00**	**1.43**
	Cerithiidae	5	5.32	0.41	25.00	1.43
	Fishes	**3**	**3.19**	**2.30**	**12.50**	**0.34**
	Ophichthidae	2	2.13	1.20	6.25	0.21
	Unidentified Fish	1	1.06	1.10	6.25	0.14
	Plants/Algae	**9**	**9.57**	**1.16**	**56.25**	**2.52**
	Halodule wrightii	2	2.13	0.10	12.50	0.28
	Rhodomelaceae	2	2.13	0.07	12.50	0.28
	Thalassia testudinum	5	5.32	0.99	31.25	1.97
SB S1 Q3						
	Crabs	**13**	**20.00**	**24.96**	**33.33**	**7.88**
	Callinectes sapidus	3	4.62	14.35	11.11	2.11
	Panopeidae	10	15.38	10.61	22.22	5.78
	Shrimps	**36**	**55.38**	**60.48**	**66.67**	**64.59**
	Alpheus heterochaelis	2	3.08	4.78	7.41	0.58
	Penaeidae	34	52.31	55.70	59.26	64.00
	Snails	**2**	**3.08**	**1.21**	**7.41**	**0.16**
	Cerithiidae	1	1.54	0.47	3.70	0.07
	Neritidae	1	1.54	0.74	3.70	0.08
	Fishes	**5**	**7.69**	**2.47**	**7.41**	**0.75**
	Ophichthidae	5	7.69	2.47	7.41	0.75
	Plants/Algae	**8**	**12.31**	**3.02**	**29.63**	**1.83**
	Halodule wrightii	4	6.15	1.45	14.81	1.13
	Rhodomelaceae	1	1.54	0.50	3.70	0.08
	Thalassia testudinum	3	4.62	1.06	11.11	0.63
	Other	**1**	**1.54**	**7.86**	**3.70**	**0.35**
	Foreign Object	1	1.54	7.86	3.70	0.35
SB S2 Q3						
	Crabs	**12**	**19.35**	**17.90**	**81.82**	**19.72**
	Callinectes sapidus	3	4.84	3.93	18.18	1.59
	Panopeidae	9	14.52	13.97	63.64	18.13
	Shrimps	**39**	**62.90**	**18.32**	**54.55**	**44.30**
	Penaeidae	39	62.90	18.32	54.55	44.30
	Snails	**3**	**4.84**	**1.58**	**27.27**	**0.95**
	Cerithiidae	2	3.23	0.82	18.18	0.74

Table 6, cont.

	Neritidae	1	1.61	0.75	9.09	0.22
	Fishes	**3**	**4.84**	**55.27**	**27.27**	**10.71**
	Bollmannia communis	1	1.61	0.77	9.09	0.22
	Unidentified Fish	2	3.23	54.49	18.18	10.49
	Plants/Algae	**5**	**8.06**	**6.94**	**45.45**	**2.56**
	Halodule wrightii	2	3.23	5.54	18.18	1.59
	Rhodomelaceae	2	3.23	1.17	18.18	0.80
	Thalassia testudinum	1	1.61	0.23	9.09	0.17
HB S1 Q3						
	Crabs	**23**	**63.89**	**36.89**	**57.14**	**34.70**
	Callinectes sapidus	3	8.33	0.71	21.43	1.94
	Panopeidae	20	55.56	36.18	35.71	32.76
	Shrimps	**6**	**16.67**	**1.57**	**42.86**	**7.82**
	Penaeidae	6	16.67	1.57	42.86	7.82
	Snails	**1**	**2.78**	**0.30**	**7.14**	**0.22**
	Cerithiidae	1	2.78	0.30	7.14	0.22
	Fishes	**4**	**11.11**	**60.68**	**21.43**	**5.13**
	Ophichthidae	2	5.56	2.88	7.14	0.60
	Opsanus beta	1	2.78	56.47	7.14	4.23
	Unidentified Fish	1	2.78	1.33	7.14	0.29
	Plants/Algae	**2**	**5.56**	**0.56**	**14.29**	**0.87**
	Thalassia testudinum	2	5.56	0.56	14.29	0.87
HB S2 Q3						
	Crabs	**102**	**49.04**	**30.97**	**83.33**	**36.10**
	Callinectes sapidus	36	17.31	6.13	33.33	7.81
	Panopeidae	66	31.73	24.84	50.00	28.29
	Shrimps	**68**	**32.69**	**9.85**	**61.11**	**16.91**
	Alpheus heterochaelis	7	3.37	1.98	13.89	0.74
	Penaeidae	60	28.85	7.48	44.44	16.14
	Squillidae	1	0.48	0.40	2.78	0.02
	Snails	**10**	**4.81**	**0.90**	**25.00**	**1.15**
	Cerithiidae	9	4.33	0.79	22.22	1.14
	Neritidae	1	0.48	0.11	2.78	0.02
	Fishes	**12**	**5.77**	**51.07**	**19.44**	**2.45**
	Ophichthidae	3	1.44	0.15	2.78	0.04
	Opsanus beta	2	0.96	43.29	2.78	1.23
	Syngnathus louisianae	1	0.48	0.02	2.78	0.01
	Unidentified Fish	6	2.88	7.60	11.11	1.17
	Plants/Algae	**13**	**6.25**	**2.26**	**36.11**	**1.73**

Table 6, cont.

	Halodule wrightii	2	0.96	0.09	5.56	0.06
	Rhodomelaceae	2	0.96	0.03	5.56	0.06
	Thalassia testudinum	9	4.33	2.13	25.00	1.61
	Other	**3**	**1.44**	**4.95**	**5.56**	**0.18**
	Foreign Object	1	0.48	4.87	2.78	0.15
	Nereididae	2	0.96	0.08	2.78	0.03
SB S1 Q4						
	Crabs	**42**	**27.45**	**48.48**	**36.17**	**27.46**
	Panopeidae	42	27.45	48.48	36.17	27.46
	Shrimps	**42**	**27.45**	**21.77**	**46.81**	**18.42**
	Alpheus heterochaelis	4	2.61	5.80	2.13	0.18
	Penaeidae	38	24.84	15.98	44.68	18.24
	Snails	**10**	**6.54**	**2.15**	**17.02**	**1.20**
	Cerithiidae	9	5.88	2.06	14.89	1.18
	Neritidae	1	0.65	0.10	2.13	0.02
	Fishes	**47**	**30.72**	**25.98**	**19.15**	**4.31**
	Hippocampus erectus	2	1.31	0.31	2.13	0.03
	Bollmannia communis	40	26.14	21.10	8.51	4.02
	Ophichthidae	2	1.31	1.02	2.13	0.05
	Syngnathus louisianae	1	0.65	0.69	2.13	0.03
	Unidentified Fish	2	1.31	2.85	4.26	0.18
	Plants/Algae	**12**	**7.84**	**1.62**	**25.53**	**1.75**
	Halodule wrightii	10	6.54	1.54	21.28	1.72
	Rhodomelaceae	1	0.65	0.06	2.13	0.02
	Thalassia testudinum	1	0.65	0.03	2.13	0.01
SB S2 Q4						
	Crabs	**15**	**23.81**	**12.11**	**40.74**	**9.80**
	Callinectes sapidus	1	1.59	8.93	3.70	0.39
	Panopeidae	14	22.22	3.18	37.04	9.41
	Shrimps	**5**	**7.94**	**1.17**	**14.81**	**1.35**
	Penaeidae	5	7.94	1.17	14.81	1.35
	Snails	**5**	**7.94**	**0.73**	**14.81**	**0.44**
	Cerithiidae	2	3.17	0.11	7.41	0.24
	Neritidae	1	1.59	0.13	3.70	0.06
	Olividae	2	3.17	0.49	3.70	0.14
	Fishes	**21**	**33.33**	**82.52**	**59.26**	**16.97**
	Bollmannia communis	1	1.59	0.16	3.70	0.06
	Lagodon rhomboides	4	6.35	32.90	11.11	4.36
	Ophichthidae	2	3.17	1.05	7.41	0.31

Table 6, cont.

	Opsanus beta	4	6.35	32.78	7.41	2.90
	Unidentified Fish	10	15.87	15.62	29.63	9.33
	Plants/Algae	**15**	**23.81**	**3.39**	**51.85**	**6.20**
	Halodule wrightii	7	11.11	1.15	25.93	3.18
	Rhodomelaceae	1	1.59	0.05	3.70	0.06
	Thalassia testudinum	7	11.11	2.19	22.22	2.96
	Other	**2**	**3.17**	**0.08**	**7.41**	**0.24**
	Nereididae	2	3.17	0.08	7.41	0.24
HB S1 Q4						
	Crabs	**7**	**25.93**	**51.16**	**38.46**	**29.65**
	Panopeidae	7	25.93	51.16	38.46	29.65
	Shrimps	**16**	**59.26**	**44.93**	**46.15**	**48.09**
	Penaeidae	16	59.26	44.93	46.15	48.09
	Snails	**4**	**14.81**	**3.91**	**30.77**	**5.76**
	Cerithiidae	4	14.81	3.91	30.77	5.76
HB S2 Q4						
	Crabs	**5**	**9.62**	**2.10**	**35.71**	**2.65**
	Panopeidae	4	7.69	0.75	28.57	2.41
	Pisinae	1	1.92	1.34	7.14	0.23
	Shrimps	**13**	**25.00**	**1.53**	**42.86**	**11.37**
	Penaeidae	13	25.00	1.53	42.86	11.37
	Snails	**7**	**13.46**	**0.58**	**28.57**	**1.57**
	Cerithiidae	4	7.69	0.23	14.29	1.13
	Neritidae	1	1.92	0.13	7.14	0.15
	Olividae	2	3.85	0.23	7.14	0.29
	Fishes	**23**	**44.23**	**94.80**	**64.29**	**51.95**
	Lagodon rhomboides	20	38.46	79.19	42.86	50.42
	Ophichthidae	1	1.92	0.27	7.14	0.16
	Opsanus beta	1	1.92	10.57	7.14	0.89
	Unidentified Fish	1	1.92	4.77	7.14	0.48
	Plants/Algae	**4**	**7.69**	**1.00**	**28.57**	**1.24**
	Rhodomelaceae	2	3.85	0.66	14.29	0.64
	Thalassia testudinum	2	3.85	0.34	14.29	0.60

Table 7. C, N, C/N, δ13C (‰) and δ15N (‰) for *Sciaenops ocellatus* in both size classes (small and medium), in each sample site (Holly Beach: HB and South Bay: SB) and in each quarter (1-4). Quarters and fish sizes as in Table 1.

Organism	Site	Quarter	Size	C	N	C/N	δ^{15}N	δ^{13}C
Sciaenops ocellatus	HB	1	Small	40.00	12.01	3.33	10.91	-14.58
Sciaenops ocellatus	HB	1	Small	42.54	12.71	3.35	10.51	-12.44
Sciaenops ocellatus	HB	1	Small	42.43	12.86	3.30	11.58	-13.26
Sciaenops ocellatus	HB	1	Small	44.11	13.49	3.27	10.75	-12.54
Sciaenops ocellatus	HB	1	Small	41.13	12.32	3.34	12.03	-13.71
Sciaenops ocellatus	HB	1	Medium	43.28	13.29	3.26	12.39	-13.34
Sciaenops ocellatus	HB	1	Medium	42.63	12.78	3.33	12.46	-12.53
Sciaenops ocellatus	HB	1	Medium	42.83	13.00	3.29	11.68	-12.46
Sciaenops ocellatus	HB	1	Medium	44.50	13.71	3.25	12.73	-13.02
Sciaenops ocellatus	HB	1	Medium	41.65	12.58	3.31	13.04	-13.47
Sciaenops ocellatus	SB	1	Small	45.02	13.88	3.24	10.79	-12.08
Sciaenops ocellatus	SB	1	Small	46.10	14.08	3.27	12.14	-13.06
Sciaenops ocellatus	SB	1	Small	43.38	13.19	3.29	11.15	-12.43
Sciaenops ocellatus	SB	1	Small	43.30	13.13	3.30	11.10	-12.17
Sciaenops ocellatus	SB	1	Small	44.81	13.31	3.37	11.92	-13.63
Sciaenops ocellatus	SB	1	Medium	43.54	13.14	3.31	11.65	-12.58
Sciaenops ocellatus	SB	1	Medium	49.41	15.29	3.23	11.60	-12.91
Sciaenops ocellatus	SB	1	Medium	45.40	14.34	3.17	10.34	-12.27
Sciaenops ocellatus	SB	1	Medium	45.66	13.88	3.29	9.98	-12.49
Sciaenops ocellatus	SB	1	Medium	43.00	13.05	3.29	11.65	-12.39
Sciaenops ocellatus	SB	2	Small	41.35	12.36	3.34	10.10	-12.83
Sciaenops ocellatus	SB	2	Small	39.80	11.91	3.34	9.82	-12.93
Sciaenops ocellatus	SB	2	Small	38.04	11.35	3.35	10.10	-11.98
Sciaenops ocellatus	SB	2	Small	44.85	13.45	3.33	11.12	-12.77
Sciaenops ocellatus	SB	2	Small	44.41	13.31	3.34	10.77	-13.78
Sciaenops ocellatus	SB	2	Medium	45.14	13.28	3.40	11.22	-12.19
Sciaenops ocellatus	SB	2	Medium	36.61	10.89	3.36	10.84	-12.88
Sciaenops ocellatus	SB	2	Medium	38.47	11.29	3.41	11.89	-12.32
Sciaenops ocellatus	SB	2	Medium	45.41	13.52	3.36	11.35	-10.95
Sciaenops ocellatus	SB	2	Medium	40.33	12.18	3.31	11.67	-11.77
Sciaenops ocellatus	HB	2	Small	38.61	11.52	3.35	12.41	-13.22
Sciaenops ocellatus	HB	2	Small	35.91	10.63	3.38	11.49	-12.87
Sciaenops ocellatus	HB	2	Small	43.74	13.14	3.33	11.87	-13.53
Sciaenops ocellatus	HB	2	Small	45.92	13.66	3.36	13.60	-13.68
Sciaenops ocellatus	HB	2	Small	44.79	13.41	3.34	14.28	-13.59
Sciaenops ocellatus	HB	2	Medium	43.62	13.01	3.35	11.05	-12.69
Sciaenops ocellatus	HB	2	Medium	44.59	13.27	3.36	11.86	-12.25

Table, 7, cont.

Sciaenops ocellatus	HB	2	Medium	42.84	12.73	3.36	11.16	-10.62
Sciaenops ocellatus	HB	2	Medium	44.23	13.05	3.39	12.75	-12.79
Sciaenops ocellatus	HB	2	Medium	43.61	13.01	3.35	11.17	-10.29
Sciaenops ocellatus	SB	3	Small	42.29	13.68	3.09	10.51	-13.08
Sciaenops ocellatus	SB	3	Small	42.92	13.79	3.11	11.02	-14.25
Sciaenops ocellatus	SB	3	Small	37.20	11.84	3.14	11.20	-15.25
Sciaenops ocellatus	SB	3	Small	40.57	12.93	3.14	11.23	-14.01
Sciaenops ocellatus	SB	3	Small	44.09	14.22	3.10	9.70	-13.71
Sciaenops ocellatus	SB	3	Medium	41.54	13.37	3.11	11.00	-12.53
Sciaenops ocellatus	SB	3	Medium	44.05	14.23	3.10	11.50	-13.00
Sciaenops ocellatus	SB	3	Medium	44.56	14.09	3.16	11.71	-14.66
Sciaenops ocellatus	SB	3	Medium	44.62	14.22	3.14	12.16	-13.51
Sciaenops ocellatus	SB	3	Medium	42.49	13.64	3.11	11.70	-13.06
Sciaenops ocellatus	HB	3	Small	46.62	14.75	3.16	12.59	-15.57
Sciaenops ocellatus	HB	3	Small	46.87	14.85	3.16	11.35	-15.09
Sciaenops ocellatus	HB	3	Small	44.51	14.09	3.16	12.09	-13.48
Sciaenops ocellatus	HB	3	Small	45.65	14.66	3.11	12.17	-14.22
Sciaenops ocellatus	HB	3	Small	44.88	14.43	3.11	11.07	-15.74
Sciaenops ocellatus	HB	3	Medium	44.31	14.03	3.16	11.44	-13.04
Sciaenops ocellatus	HB	3	Medium	44.69	14.16	3.16	11.52	-13.05
Sciaenops ocellatus	HB	3	Medium	44.28	14.08	3.14	13.38	-13.72
Sciaenops ocellatus	HB	3	Medium	39.62	12.66	3.13	11.21	-13.06
Sciaenops ocellatus	HB	3	Medium	43.72	14.03	3.12	12.75	-13.61
Sciaenops ocellatus	HB	4	Small	44.96	14.67	3.06	11.14	-13.55
Sciaenops ocellatus	HB	4	Small	45.83	14.44	3.17	11.64	-11.53
Sciaenops ocellatus	HB	4	Small	43.15	13.87	3.11	10.61	-12.43
Sciaenops ocellatus	HB	4	Small	44.72	14.39	3.11	15.50	-16.33
Sciaenops ocellatus	HB	4	Small	43.45	14.10	3.08	13.51	-16.38
Sciaenops ocellatus	HB	4	Medium	41.80	13.83	3.02	12.00	-12.19
Sciaenops ocellatus	HB	4	Medium	44.72	14.37	3.11	11.96	-13.07
Sciaenops ocellatus	HB	4	Medium	45.21	14.48	3.12	12.28	-13.15
Sciaenops ocellatus	HB	4	Medium	45.45	14.60	3.11	12.90	-11.63
Sciaenops ocellatus	HB	4	Medium	44.31	14.33	3.09	12.89	-12.66
Sciaenops ocellatus	SB	4	Small	43.92	13.98	3.14	9.74	-11.74
Sciaenops ocellatus	SB	4	Small	43.89	14.48	3.03	10.88	-12.49
Sciaenops ocellatus	SB	4	Small	44.32	14.32	3.09	10.74	-12.09
Sciaenops ocellatus	SB	4	Small	44.78	14.33	3.12	9.75	-13.04
Sciaenops ocellatus	SB	4	Small	45.22	14.56	3.11	10.61	-12.74
Sciaenops ocellatus	SB	4	Medium	43.29	13.85	3.13	11.71	-12.74
Sciaenops ocellatus	SB	4	Medium	43.32	13.86	3.13	10.52	-12.32

Table 7, cont.

Sciaenops ocellatus	SB	4	Medium	44.48	14.29	3.11	10.30	-11.65
Sciaenops ocellatus	SB	4	Medium	44.37	14.23	3.12	10.74	-11.45
Sciaenops ocellatus	SB	4	Medium	46.05	14.63	3.15	11.68	-12.44

Table 8. C, N, C/N, δ13C (‰) and δ15N (‰) for the prey items found in the *Sciaenops ocellatus* collected for stable isotope analyses in both size classes (small and medium), in each sample site (Holly Beach: HB and South Bay: SB) and each quarter (1-4). Quarters and fish sizes as in Table 1.

Organism	Site	Quarter	Size	C	N	C/N	$\delta^{15}N$	$\delta^{13}C$
Panopeidae	HB	1	Medium	30.64	5.88	5.21	6.65	-14.95
Panopeidae	HB	1	Small	30.64	5.88	5.21	6.65	-14.95
Syngnathus louisianae	SB	1	Small	33.89	10.57	3.21	10.30	-13.52
Penaeidae	HB	1	Medium	42.72	13.07	3.27	8.23	-16.40
Penaeidae	HB	1	Small	42.72	13.07	3.27	8.23	-16.40
Eucinostomus gula	HB	1	Small	44.76	14.01	3.19	9.73	-15.14
Panopeidae	SB	1	Medium	22.58	3.26	6.93	3.10	-12.69
Panopeidae	SB	1	Small	22.58	3.26	6.93	3.10	-12.69
Syngnathus louisianae	SB	1	Medium	37.39	10.57	3.54	9.01	-13.43
Penaeidae	SB	1	Medium	41.39	11.68	3.54	6.73	-12.08
Penaeidae	SB	1	Small	41.39	11.68	3.54	6.73	-12.08
Lagodon rhomboides	SB	1	Medium	42.04	13.30	3.16	10.78	-15.69
Panopeidae	HB	1	Small	20.00	2.13	9.40	1.35	-13.28
Penaeidae	HB	1	Small	43.91	10.62	4.14	10.15	-15.27
Penaeidae	HB	1	Small	41.45	11.91	3.48	9.77	-13.26
Eucinostomus gula	HB	1	Small	34.10	9.81	3.48	11.29	-13.49
Panopeidae	HB	1	Small	19.38	2.08	9.32	4.35	-11.60
Penaeidae	HB	1	Small	40.68	8.50	4.78	7.79	-14.92
Panopeidae	HB	1	Small	15.45	1.06	14.58	0.35	-10.00
Penaeidae	HB	1	Medium	42.89	12.09	3.55	7.82	-14.16
Penaeidae	HB	1	Medium	42.20	10.85	3.89	11.60	-14.95
Panopeidae	HB	1	Medium	33.35	5.25	6.35	2.97	-14.61
Panopeidae	HB	1	Medium	16.85	1.38	12.25	0.99	-10.34
Penaeidae	HB	1	Medium	34.59	7.79	4.44	7.10	-15.12
Panopeidae	HB	1	Medium	20.21	2.46	8.20	2.34	-11.75
Penaeidae	HB	1	Medium	41.42	10.56	3.92	9.00	-15.61
Panopeidae	HB	1	Medium	22.08	3.44	6.42	0.97	-13.34
Penaeidae	HB	1	Medium	40.62	10.24	3.97	8.68	-13.80
Panopeidae	SB	1	Small	22.83	2.70	8.45	2.82	-12.47
Syngnathus louisianae	SB	1	Small	32.41	8.24	3.93	10.39	-13.80
Penaeidae	SB	1	Small	40.32	11.81	3.41	8.44	-15.50
Syngnathus louisianae	SB	1	Small	33.97	9.71	3.50	10.30	-13.38
Penaeidae	SB	1	Small	41.37	11.16	3.71	9.02	-14.32
Penaeidae	SB	1	Small	44.54	11.43	3.90	8.23	-14.94
Syngnathus louisianae	SB	1	Small	34.75	10.05	3.46	9.13	-15.11
Panopeidae	SB	1	Medium	15.46	1.08	14.32	0.08	-8.13

Table 8, cont.

Panopeidae	SB	1	Medium	22.98	2.78	8.27	4.57	-12.68
Syngnathus louisianae	SB	1	Medium	30.94	5.31	5.82	9.33	-14.93
Panopeidae	SB	1	Medium	21.23	2.16	9.85	1.46	-13.25
Lagodon rhomboides	SB	1	Medium	41.20	12.42	3.32	10.53	-13.41
Penaeidae	SB	1	Medium	42.56	11.96	3.56	9.84	-15.92
Penaeidae	SB	1	Medium	36.22	8.34	4.34	7.70	-13.49
Panopeidae	SB	1	Medium	19.22	2.00	9.60	2.11	-12.22
Panopeidae	HB	2	Small	19.37	2.29	8.47	3.70	-11.90
Penaeidae	HB	2	Small	44.59	12.45	3.58	9.73	-15.34
Eucinostomus gula	HB	2	Small	40.98	11.69	3.51	11.88	-15.36
Panopeidae	HB	2	Small	19.57	2.36	8.30	0.84	-12.25
Panopeidae	HB	2	Small	21.77	2.53	8.59	0.62	-14.12
Alpheus heterochaelis	HB	2	Small	28.21	4.61	6.11	6.35	-15.34
Panopeidae	HB	2	Small	19.18	1.93	9.96	4.74	-13.23
Panopeidae	HB	2	Small	20.55	2.69	7.64	2.67	-11.28
Panopeidae	HB	2	Medium	18.62	2.01	9.29	1.01	-12.31
Panopeidae	HB	2	Medium	19.68	2.56	7.70	1.80	-12.17
Panopeidae	HB	2	Medium	18.43	1.57	11.74	2.14	-11.68
Syngnathus louisianae	HB	2	Medium	28.13	7.82	3.60	9.97	-12.09
Panopeidae	HB	2	Medium	25.50	3.05	8.36	-0.13	-15.24
Panopeidae	HB	2	Medium	24.40	3.10	7.87	3.65	-13.32
Penaeidae	HB	2	Medium	37.93	5.89	6.44	-1.37	-16.66
Penaeidae	SB	2	Small	44.34	11.86	3.74	8.06	-16.23
Opsanus beta	SB	2	Small	45.21	15.17	2.98	8.31	-13.91
Panopeidae	SB	2	Small	18.84	2.72	6.93	4.69	-9.50
Penaeidae	SB	2	Small	40.88	9.99	4.09	7.54	-16.71
Panopeidae	SB	2	Small	18.89	1.70	11.11	-2.05	-12.76
Penaeidae	SB	2	Small	42.16	10.48	4.02	7.25	-15.32
Panopeidae	SB	2	Medium	22.05	3.03	7.28	2.66	-13.61
Alpheus heterochaelis	SB	2	Medium	34.26	6.59	5.20	7.32	-16.45
Panopeidae	SB	2	Medium	21.72	2.55	8.52	-1.37	-13.81
Panopeidae	SB	2	Medium	15.48	1.02	15.18	-0.98	-9.28
Panopeidae	SB	2	Medium	15.51	1.63	9.52	-0.95	-12.56
Opsanus beta	SB	2	Medium	41.62	12.43	3.35	8.59	-14.06
Panopeidae	HB	2	Small	34.61	10.31	3.36	7.79	-12.39
Syngnathus louisianae	HB	2	Medium	40.15	11.28	3.56	10.95	-15.76
Penaeidae	HB	2	Small	39.46	12.18	3.24	8.32	-13.12
Eucinostomus gula	HB	2	Small	43.08	13.54	3.18	9.96	-15.07
Panopeidae	SB	2	Small	22.44	3.14	7.16	5.20	-13.25
Penaeidae	SB	2	Small	40.15	10.87	3.69	7.13	-13.83

Table 8, cont.

Opsanus beta	SB	2	Small	42.12	12.41	3.39	7.46	-12.97
Panopeidae	HB	2	Medium	34.61	10.31	3.36	7.79	-12.39
Penaeidae	HB	2	Medium	39.46	12.18	3.24	8.32	-13.12
Panopeidae	SB	2	Medium	22.44	3.14	7.16	5.20	-13.25
Penaeidae	SB	2	Medium	40.15	10.87	3.69	7.13	-13.83
Panopeidae	HB	3	Small	15.11	3.51	4.30	7.69	-13.06
Penaeidae	HB	3	Small	28.50	5.26	5.42	6.50	-15.43
Callinectes sapidus	HB	3	Small	20.97	2.49	8.44	2.69	-15.11
Panopeidae	HB	3	Small	22.93	3.42	6.71	1.69	-14.61
Penaeidae	HB	3	Small	46.12	12.79	3.61	8.14	-15.53
Panopeidae	HB	3	Small	20.23	2.58	7.83	2.97	-14.63
Ophichthidae	HB	3	Small	35.86	10.35	3.46	9.87	-13.42
Opsanus beta	HB	3	Small	36.36	11.41	3.19	9.87	-15.55
Panopeidae	HB	3	Small	20.98	2.58	8.14	2.29	-13.36
Penaeidae	HB	3	Small	34.31	7.72	4.45	6.61	-16.95
Panopeidae	HB	3	Medium	16.23	1.77	9.16	0.96	-12.95
Callinectes sapidus	HB	3	Medium	18.41	1.85	9.96	1.53	-11.36
Alpheus heterochaelis	HB	3	Medium	23.88	3.52	6.78	2.91	-15.75
Panopeidae	HB	3	Medium	27.18	4.28	6.35	1.61	-16.27
Penaeidae	HB	3	Medium	43.19	10.18	4.24	9.06	-16.00
Panopeidae	HB	3	Medium	23.53	2.75	8.55	0.87	-14.69
Callinectes sapidus	HB	3	Medium	27.40	3.27	8.37	1.43	-16.31
Panopeidae	HB	3	Medium	17.75	1.88	9.43	2.22	-12.19
Penaeidae	HB	3	Medium	39.52	10.01	3.95	9.04	-15.78
Callinectes sapidus	HB	3	Medium	20.09	2.71	7.42	1.85	-13.49
Panopeidae	HB	3	Medium	28.24	4.22	6.69	2.52	-14.09
Ophichthidae	SB	3	Small	30.30	8.78	3.45	8.25	-12.80
Penaeidae	SB	3	Small	44.01	11.31	3.89	8.84	-15.69
Panopeidae	SB	3	Small	19.18	2.37	8.09	4.63	-11.00
Penaeidae	SB	3	Small	45.33	11.85	3.83	8.18	-15.66
Panopeidae	SB	3	Small	20.44	2.22	9.21	0.89	-13.54
Penaeidae	SB	3	Small	41.97	8.80	4.77	7.96	-16.10
Panopeidae	SB	3	Small	23.25	2.84	8.19	-0.56	-14.22
Alpheus heterochaelis	SB	3	Small	22.47	3.12	7.20	-1.27	-16.49
Penaeidae	SB	3	Small	46.88	9.59	4.89	7.64	-16.36
Panopeidae	SB	3	Small	19.20	2.29	8.38	0.76	-13.46
Penaeidae	SB	3	Small	42.29	9.90	4.27	8.23	-14.99
Panopeidae	SB	3	Medium	16.06	2.03	7.91	4.83	-11.70
Penaeidae	SB	3	Medium	45.00	12.36	3.64	6.67	-12.43
Panopeidae	SB	3	Medium	22.47	2.98	7.54	1.33	-12.88

Table 8, cont.

Bollmannia communis	SB	3	Medium	38.72	10.33	3.75	7.65	-14.82
Penaeidae	SB	3	Medium	44.56	11.29	3.95	7.75	-14.62
Panopeidae	SB	3	Medium	22.72	2.46	9.24	1.38	-14.15
Penaeidae	SB	3	Medium	43.34	11.67	3.71	7.92	-15.38
Panopeidae	SB	3	Medium	19.51	2.19	8.91	-0.20	-12.58
Penaeidae	SB	3	Medium	43.74	11.22	3.90	7.13	-12.51
Panopeidae	HB	3	Small	29.21	3.99	7.32	6.66	-16.11
Penaeidae	HB	3	Small	38.84	11.97	3.24	9.37	-14.74
Opsanus beta	HB	3	Small	41.12	13.22	3.11	8.88	-14.31
Callinectes sapidus	HB	3	Medium	37.66	9.96	3.78	10.60	-14.28
Panopeidae	SB	3	Small	24.90	5.99	4.16	7.41	-13.76
Penaeidae	SB	3	Small	40.70	12.77	3.19	6.22	-14.85
Callinectes sapidus	HB	3	Small	38.08	11.20	3.40	4.23	-11.68
Bollmannia communis	SB	3	Medium	46.45	13.95	3.33	10.73	-13.49
Alpheus heterochaelis	SB	3	Small	40.40	12.24	3.30	6.72	-15.02
Panopeidae	HB	3	Medium	29.21	3.99	7.32	6.66	-16.11
Penaeidae	HB	3	Medium	38.84	11.97	3.24	9.37	-14.74
Panopeidae	SB	3	Medium	24.90	5.99	4.16	7.41	-13.76
Penaeidae	SB	3	Medium	40.70	12.77	3.19	6.22	-14.85
Panopeidae	HB	4	Small	37.71	4.71	8.01	0.69	-20.07
Penaeidae	HB	4	Small	49.65	14.59	3.40	6.34	-12.51
Penaeidae	HB	4	Small	45.91	11.88	3.86	8.10	-11.48
Penaeidae	HB	4	Small	47.45	13.66	3.47	6.90	-12.38
Panopeidae	HB	4	Small	23.22	2.73	8.51	6.03	-11.11
Panopeidae	HB	4	Small	20.48	2.33	8.79	3.07	-12.69
Penaeidae	HB	4	Small	53.85	14.48	3.72	10.54	-14.15
Penaeidae	HB	4	Medium	46.85	13.39	3.50	7.86	-12.86
Lagodon rhomboides	HB	4	Medium	47.03	14.14	3.33	9.84	-10.34
Ophichthidae	HB	4	Medium	42.87	8.61	4.98	10.56	-14.09
Penaeidae	HB	4	Medium	45.52	13.04	3.49	7.03	-11.23
Penaeidae	HB	4	Medium	38.92	10.89	3.57	7.96	-12.42
Lagodon rhomboides	HB	4	Medium	43.31	12.98	3.34	9.34	-11.43
Penaeidae	HB	4	Medium	44.58	12.63	3.53	8.46	-12.94
Lagodon rhomboides	HB	4	Medium	43.95	13.45	3.27	10.41	-13.58
Penaeidae	HB	4	Medium	43.04	12.66	3.40	7.90	-12.42
Lagodon rhomboides	HB	4	Medium	45.32	12.93	3.51	8.33	-14.71
Panopeidae	SB	4	Small	20.11	2.63	7.65	5.98	-11.30
Panopeidae	SB	4	Small	26.66	2.60	10.25	4.32	-13.63
Penaeidae	SB	4	Small	45.07	12.82	3.52	7.88	-13.11
Panopeidae	SB	4	Small	19.62	2.54	7.72	3.49	-10.31

Table 8, cont.

Penaeidae	SB	4	Small	43.99	12.60	3.49	8.41	-13.09
Bollmannia communis	SB	4	Small	39.84	11.84	3.36	5.71	-12.28
Panopeidae	SB	4	Small	20.92	2.62	7.98	2.44	-9.66
Penaeidae	SB	4	Small	44.32	12.80	3.46	7.55	-13.46
Bollmannia communis	SB	4	Small	32.77	9.51	3.45	6.89	-15.33
Panopeidae	SB	4	Medium	16.15	1.69	9.56	2.45	-11.08
Lagodon rhomboides	SB	4	Medium	44.79	13.84	3.24	10.83	-13.68
Panopeidae	SB	4	Medium	30.62	5.48	5.59	7.05	-11.68
Panopeidae	SB	4	Medium	21.78	3.84	5.67	4.73	-13.81
Ophichthidae	SB	4	Medium	40.90	12.68	3.23	9.16	-12.57
Bollmannia communis	SB	4	Medium	45.49	12.57	3.62	10.84	-14.11
Penaeidae	SB	4	Medium	45.65	13.44	3.40	6.93	-11.48
Lagodon rhomboides	SB	4	Medium	42.34	12.63	3.35	9.52	-12.51
Penaeidae	SB	4	Medium	47.71	13.82	3.45	7.99	-11.05
Panopeidae	HB	4	Small	26.05	5.08	5.13	6.01	-14.88
Penaeidae	HB	4	Small	43.55	13.14	3.31	9.14	-13.95
Lagodon rhomboides	HB	4	Medium	44.66	14.02	3.19	10.78	-12.98
Ophichthidae	HB	4	Medium	39.18	11.40	3.44	10.68	-14.68
Panopeidae	SB	4	Small	47.01	14.67	3.20	6.06	-12.93
Penaeidae	SB	4	Small	27.08	5.17	5.24	3.40	-10.52
Bollmannia communis	SB	4	Small	45.19	13.41	3.37	10.16	-14.60
Lagodon rhomboides	SB	4	Medium	44.39	14.06	3.16	7.90	-11.87
Ophichthidae	SB	4	Medium	37.88	11.12	3.41	10.79	-14.71
Panopeidae	HB	4	Medium	26.05	5.08	5.13	6.01	-14.88
Penaeidae	HB	4	Medium	43.55	13.14	3.31	9.14	-13.95
Panopeidae	SB	4	Medium	47.01	14.67	3.20	6.06	-12.93
Penaeidae	SB	4	Medium	27.08	5.17	5.24	3.40	-10.52
Bollmannia communis	SB	4	Medium	45.19	13.41	3.37	10.16	-14.60

BIOGRAPHICAL SKETCH

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