4-28-2020

A Survey of the Order Tetraodontiformes on Coral Reef Habitats in Southeast Florida

Anne C. Sevon
Nova Southeastern University, as3040@nova.edu

Capstone of
Anne C. Sevon

Submitted in Partial Fulfillment of the Requirements for the Degree of

Master of Science
M.S. Marine Environmental Sciences
M.S. Coastal Zone Management

Nova Southeastern University
Halmos College of Natural Sciences and Oceanography

April 2020

Approved:
Capstone Committee

Major Professor: Dr. Kirk Kilfoyle

Committee Member: Dr. Bernhard Riegl

HALMOS COLLEGE OF NATURAL SCIENCES AND OCEANOGRAPHY

A SURVEY OF THE ORDER TETRAODONTIFORMES ON CORAL REEF HABITATS IN SOUTHEAST FLORIDA

By

Anne C. Sevon

Submitted to the Faculty of
Halmos College of Natural Sciences and Oceanography
in partial fulfillment of the requirements for
the degree of Master of Science with a specialty in:

Marine Environmental Science and
Coastal Zone Management

Nova Southeastern University

May 2020

Table of Contents

List of Figures

List of Tables

List of Appendices

List of Acronyms

APRD	Aggregated Patch Reefs-Deep
BFZ	Bahamas Fault Zone
CPDP	Colonized Pavement-Deep
CPSH	Colonized Pavement-Shallow
DPRC	Deep Ridge Complex
FIA	Fishery-Independent Assessment
FDEP	Florida Department of Environmental Protection
FRRP	Florida Reef Resilience Program
FRT	Florida Reef Tract
GIS	Geographic Information System
LIRI	Linear Reef-Inner
LIRM	Linear Reef-Middle
LIRO	Linear Reef-Outer
NCRMP	National Coral Reef Monitoring Program
NOAA	National Oceanographic and Atmospheric Administration
NSU	Nova Southeastern University
PSU	Primary Sampling Unit
PTCH	Patch Reefs
RGDP	Ridge-Deep
RGSH	Ridge-Shallow
RVC	Reef fish Visual Census
SAS	Statistical Analysis Software
SCRS	Scattered Rock in Unconsolidated Sediment
SEFCREMP	Southeast Florida Coral Reef Evaluation and Monitoring Project
SEFCRI	Southeast Florida Coral Reef Initiative
SE FRT	Southeast Florida Reef Tract
SPGR	Spur and Grove
SSU	Second-stage Sample Unit
TTX	Tetrodotoxin

Abstract

The economy of south Florida relies, in part, on the recreation and tourism industries; both of which are integrally linked to Florida's coastal ecosystems. These ecosystems provide tourists the opportunity to explore mangroves and the Everglades, enjoy local beaches, and experience the ocean with fishing charters, scuba diving adventures, and snorkeling. One of the major attractions for tourists is the Florida Reef Tract (FRT), which includes multiple coral reef and hardbottom habitats that extend from St. Lucie Inlet through the Florida Keys and into the Dry Tortugas. The FRT has been a major part of research because a wide range of anthropogenic factors, such as impaired water quality (sedimentation, turbidity, nutrient loading), overfishing, ship groundings and anchor damage, and coastal construction, are causing the overall health of it to degrade. Some recent fisheries-independent habitat-based monitoring studies have focused on collecting data to assess population size and size-class structure of commercially and recreationally important coral reef fish species, such as members of the grouper-snapper complex, throughout the FRT to help improve management decisions. In the process, data for all other members of the reef fish community, including some historically less-frequently studied or often overlooked species, has also been collected to be used to better understand their population status and life histories on the reefs of southeast Florida. One group of fishes that has not received much attention is the order Tetraodontiformes. This order is comprised of fishes that are characterized by having many unique attributes, including distinct anatomical features, defensive strategies, specialized swimming mechanisms, and behavioral tendencies. The purpose of this study was to conduct an in-depth evaluation of the most commonly occurring species from each of the families from the order Tetraodontiformes that are represented within the reef fish community of southeast Florida, along with a few other species of special interest. Tetraodontiformes were chosen because of the lack of research within the past few years, this study focused specifically on the geographical distribution, depth, and habitat associations of these species throughout the region. Nine species in total were selected from a large dataset that was previously collected in south Florida from 2012 to 2016. Each of the species was tested to see differences in benthic habitats, depth, and local coral reef ecoregions. Results showed that all these species had differences within the eleven benthic habitats used in analysis. A few species showed differences in mean density between shallow and deep habitats, and other species showed significant differences between the five ecoregions. Other studies have shown a general increase in reef fish density from north to south for the fish assemblage regions, and these results, in part, agree with that trend. This project was a small indication of where Tetraodontiformes are found in south Florida by habitats, depths, and ecoregions and could help with further management decisions that affect coral reef fish as well as the FRT.

Keywords
Tetraodontiformes, coral reef fish, multispecies assessment, reef monitoring, Florida Reef Tract

1.0 Introduction

The Florida Reef Tract (FRT) is the third largest barrier reef system in the world, stretching across approximately 595 km of coastline from Martin County (St. Lucie Inlet) in the north through the Florida Keys and into the Dry Tortugas in the south (Finkl and Andrews, 2008; Brandt et al., 2009; Walker and Gilliam, 2013; Fisco, 2016; Ames, 2017). Southeast Florida's economy relies, in a large part, on two important industries, recreation and tourism, which includes reef-related activities such as fishing, diving, and boating (Brandt et al., 2009; Gregg, 2013). There are now over six million people in south Florida, with more moving into the area every year (Florida Population, 2018; Lirman et al., 2019). The proximity of the FRT to this large and growing population has inevitably resulted in a variety of chronic and acute anthropogenic impacts to reef resources (Ferro et al., 2005; Banks et al., 2008; Jordan et al., 2010; Behringer et al., 2011; Gregg, 2013; Miller et al., 2016). Some of these impacts include: overfishing, coastal construction, hurricane damage, ship groundings and anchor damage, water pollution and other water quality issues that have led to coral disease and algal blooms (Ault et al., 1998; Ferro et al., 2005; Banks et al., 2008; Mora, 2008; Jordan et al., 2010; Behringer et al., 2011; Walker et al., 2012; Gregg, 2013; Fisco, 2016; Miller et al., 2016; Ames, 2017; Kilfoyle et al., 2018). Because of the combined influence of these many issues, the general state of coral reef health in southeast Florida has been in steady decline for many years (Hughes, 1994; Brandt et al., 2009; Behringer et al., 2011; Gregg, 2013; Kilfoyle et al., 2018).

Coral reef fish are affected in many ways from these impacts, such as loss or degradation of habitats due to coastal construction, loss of structure and shelter from hurricanes and repeated acute impacts (anchor damage, ship groundings, etc.), and selective overfishing which not only leads to fewer fish, but also create changes in trophic structure (removal of primary predators and dominant herbivores, i.e. parrotfish) and food availability (Ault et al., 1998; Banks et al., 2008; Ault et al., 2009; Behringer et al., 2011; Gregg, 2013; Miller et al., 2016; Lirman et al., 2019). While the decline in coral reef health, mainly concerning stony corals and other members of the benthic community, has been routinely documented through a number of annual monitoring programs, such as the Southeast Florida Coral Reef Evaluation and Monitoring Project (SEFCREMP) and the Florida Reef Resilience Program (FRRP), the effect of these changes on coral reef fishes have been poorly studied and baseline information has been limited. A few studies, such as Ettinger et al. (2001) and Ferro et al. (2005) conducted research to examine both the abundance and distribution of reef fishes on the three natural reef tracts in Broward County. Ettinger et al. (2001) provided baseline data for determining changes in the local fish populations between the three reef tracts in which Ferro et al. (2005) inventoried the fish assemblages at regular intervals along and across these three reef tracts for the length of the Broward County coastline. By continuing efforts on these assessments, other studies have shown changes in the composition and density of reef fish assemblages in south Florida (Ault et al., 1998; Ettinger et al., 2001; Ault et al., 2005; Kilfoyle et al., 2018; Safiq et al., 2018). Ault et al. (1998) originally indicated Florida Keys reef fish populations were heavily fished for past decades because total fishing efforts increased. The data suggested changes in composition of the biomass and abundance of the reef fish community, since the grouper and snappers declined, some species of grunts increased in relative abundance (Ault et al., 1998). Ettinger et al. (2001) indicated an overall difference in abundance and species richness among the three reef tracts located in Broward County, fewer species and total fish were found on the inshore reef compared to both the middle and offshore reef tracts. Safiq et al. (2018) researched homogenization of fish assemblages off the coast of Florida. They showed fish assemblages shifted in composition through time in a spatially complex manner but without experiencing large changes in species richness thus they concluded that the shifts in assemblage similarity they observed were driven mostly by species losses (Safiq et al., 2018).

Fisheries-independent research on coral reef fishes of the southern portion of the FRT (Florida Keys to the northern border of Biscayne National Park) was initiated in 1979 by the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries (Bohnsack and Bannerot, 1986; Ault et al., 1998; Brandt et al., 2009). The Dry Tortugas were added to the survey domain in 1999; but until 2012 there was no large-scale assessment of reef fish resources of the northern FRT (Ault et al., 1998; Brandt et al., 2009; Kilfoyle et al., 2018). In 2004, the Southeast Florida Coral Reef Initiative (SEFCRI), a multi-agency partnership that consists of federal, state, county agencies and local stakeholder groups, identified a large data gap and confirmed the need for fisheries-independent monitoring to be extended into the southeast Florida region in order to obtain baseline data and enable better informed management decisions. By 2008 the need for this management tool was once again identified, however, the contractors only found "snapshot" fishery-independent datasets in two of the four counties within the four-county SEFCRI region

(Kilfoyle et al., 2018). Besides Ferro et al. (2005), these datasets focused on artificial reef fish populations and were only collected for one to two years, thus the decision to develop a multi-year fishery-independent baseline assessment program was recommended to be able to determine fish status and trends off southeast Florida (Kilfoyle et al., 2018).

In 2011, Nova Southeastern University received funding to develop a training program aimed at building the capacity to conduct this large-scale assessment of coral reef fish populations in southeast Florida (Kilfoyle et al., 2018). The tiered, randomly stratified, habitat-based survey design and point-count sampling methodology that was developed, refined, and employed for many years in the Florida Keys and Dry Tortugas was also implemented in this assessment of the northern FRT (Smith et al., 2011). The data from both regions can be combined to analyze the entire FRT as a holistic unit (Ault and Franklin, 2011). This project and the parent project in the Florida Keys were collectively known as the RVC (Reef fish Visual Census) Project. In 2018 the funding and monitoring effort for southeast Florida became part of the National Coral Reef Monitoring Program (NCRMP), which, in addition to coral reef fishes, also focuses on stony corals and other members of the benthic community in all coral reef habitats from the jurisdictional waters of the United States and associated territories worldwide (NOAA Coral Program, 2014). The NCRMP project now surveys the entire FRT on a biennial basis.

1.1 Background

The coral reef and hardbottom habitats of southeast Florida are known for their diverse fish fauna, which is similar to reef fish assemblages in the Florida Keys and elsewhere in the Caribbean, but is also unique due to regional changes in habitat characteristics, as well as the influence of colder water from the north (Ferro et al., 2005; Arena et al., 2007; Brandt et al., 2009; Walker and Gilliam, 2013; Humann and Deloach, 2014; Kilfoyle et al., 2018). The influx of colder water in the northern FRT through seasonal changes and upwelling events effectively creates a transitional zone between the subtropical south and temperate north and serves to hinder coral growth and reef formations off the coast of Martin County, FL and further north (Walker and Gilliam, 2013; Fisco, 2016; Lirman et al., 2019).

The driving force behind many, if not most, large-scale monitoring programs has traditionally been to obtain data on fisheries-important species, namely groupers (Serranidae) and snappers

(Lutjanidae) in the southeast (Ault et al., 1998; Ault et al, 2005; Brandt et al., 2009; Kilfoyle et al., 2018; Lirman et al., 2019). Historically, the intense commercial and rising recreational fishing pressures have resulted in unsustainable exploitation rates for 70% of the 'snapper-grouper complex' (Ault et al., 1998; Ault et al, 2005; Lirman et al., 2019). While the southeast Florida fishery-independent baseline assessment (FIA) obtained data on all species encountered, the survey design focused on gathering data on a selection of eight regionally commercially and recreationally important fisheries species on which to perform a more rigorous statistical analysis, which included several members of the snapper-grouper complex. Those species were Gray Snapper (*Lutjanus griseus*), Mutton Snapper (*Lutjanus analis*), Yellowtail Snapper (*Ocyurus chrysurus*), and Red Grouper (*Epinephelus morio*), as well as the Bluestriped Grunt (*Haemulon sciurus*), White Grunt (*Haemulon plumieri*), Hogfish (*Lachnolaimus maximus*), and Gray Triggerfish (*Balistes capriscus)*. Even though the economically important species were the primary target, the same level of information (abundance, size class) was collected for all species encountered.

Florida coral reef fisheries include over five hundred species, including over three hundred that are reef-associated, and thousands of invertebrates, including corals, sponges, shrimps, crabs, and lobsters (Lirman et al., 2019). During the recent southeast Florida FIA, a total of 305 species from 70 families were recorded throughout the northern FRT during five years of data collection (Kilfoyle et al., 2018). This work echoes the findings of previous regional reef fish work, and the data shows that most coral reef habitats in southeast Florida are primarily dominated by grunts (Haemulidae), wrasses (Labridae), and damselfishes (Pomacentridae) (Ault et al., 1998; Ettinger et al., 2001; Jordan et al., 2004; Ferro et al., 2005; Arena et al., 2007; Grober-Dunsmore et al., 2007; Fisco, 2016, Kilfoyle et al., 2018). Although the Gray Triggerfish was included among the eight target species chosen for the southeast Florida FIA, the order Tetraodontiformes (e.g. Pufferfishes, Boxfishes, Filefishes, Triggerfishes) is a commonly encountered group of fishes that has remained relatively poorly studied on the reefs of southeast Florida. With this massive dataset from Kilfoyle et al., (2018), the information collected for the Tetraodontiformes may solidify a baseline for future studies on these and other poorly studied fish.

This order, Tetraodontiformes, is comprised of multiple families that are unique amongst other members of the reef fish community for a variety of reasons, such as their anatomical features, defensive strategies, swimming mechanisms, and behavioral tendencies (Randall and Millington, 1990; Wainwright and Turingan, 1997; Hove et al., 2001; Alfaro et al., 2007; Potter and Howell, 2011; Fraser et al., 2012; Santini et al., 2013; Stump et al., 2018). The diversity of adult fish size spans in orders of magnitude, from pufferfish that are only a few grams to the Ocean Sunfish (*Mola mola*) that may exceed two thousand kilograms (Alfaro et al., 2007).

Anatomical features such as body structure, skeletal evolutions, jaw/mouth formations, as well as spines that can be "triggered", vary between families in the order of Tetraodontiformes. The body structures found in Molidae and Balistidae are laterally compressed to the ones found in Tetraodontidae and Ostraciidae. As for skeletal evolution, Tetraodontiformes reflect strong developments toward reduction, simplification, and/or loss of skeletal elements, although many muscles, especially in the cranial region, have undergone extensive duplication (Alfaro et al., 2007). Pufferfish are known to be a morphologically derived group of teleosts due to a lack of pelvic fins, ribs, and lower pharyngeal jaws, a reduced number of vertebrae, and absence of various carinal bones (Fraser et al., 2012). Pufferfish are also known to exhibit a distinctive parrot-like beaked jaw (Fraser et al., 2012), while triggerfish are known for small mouths that contain strong jaws with eight chisel-like teeth in an outer row, buttressed by an inner row of six teeth (Randall and Millington, 1990). The common name "triggerfish" is derived from the fish's ability to lock its stout first dorsal spine into an erect position with the smaller second spine, the latter is the "trigger" because one can 'unlock' the first spine by depressing the second (Randall and Millington, 1990).

As for defensive strategies, a major theme of Tetraodontiformes evolution is mechanical defense and various lineages possess elaborate inflation mechanisms, heavily armored scale plates, and/or spiny dermal processes and dorsal fins (Alfaro et al., 2007; Stump et al., 2018). Two families, Tetraodontidae and Diodontidae, are notable for their multiple defenses including inflation and the use of potent toxins to deter predation (Wainwright and Turingan, 1997; Stump et al., 2018). Pufferfish possess significant modifications of the pectoral girdle and head that function in the pumping mechanism, as well as lacking ribs to permit the extreme shape change that accompanies inflation (Wainwright and Turingan, 1997). This inflation is used as a defensive behavior by deterring predation by making themselves too large for potential predators (Wainwright and Turingan, 1997; Stump et al., 2018). Diodontids are also equipped with bony spines that are formed from modified dermal scales that stand erect when the fish is inflated (Wainwright and Turingan, 1997).

Some fishes in this order are known as ostraciiform swimmers, which means the body is rigid and incapable of lateral flexibility, so pectoral, second dorsal, and anal fins are used for maneuvering and stabilization (Hove et al., 2001; Tyler et al., 2014). Hove et al. (2001) demonstrated that at most swimming speeds ostraciid fishes mainly utilize the dorsal, anal, and pectoral fins for propulsion, while the caudal fin assists in steering and is the main force for propulsion during bursts of higher speeds. There was a stereotype that these fish were slow and clumsy, however it was proven to be untrue by Hove et al. (2001) because they found that boxfishes used coordinated, synchronized movements of five fins, the two pectoral fins, the dorsal, anal, and caudal fins to produce a wide repertoire of controlled swimming movements.

A few behavioral tendencies found within the Tetraodontiformes include aggression and foraging techniques. There are two behaviors, “water-blowing” and “coughing,” that are widespread in the Tetraodontiformes and show similarities with inflation (Wainwright and Turingan, 1997). Several species blow strong jets of water out of their mouth and use the flowing water to manipulate their environment, this water blowing is used by many species to manipulate prey, expose buried prey, or clean prey fouled by sediment, and by others in nest construction (Wainwright and Turingan, 1997). In comparison, the coughing behavior is used to forcefully expel unwanted material from the mouth and is commonly used during feeding, when the digestible portions of prey are separated from pieces of exoskeleton or other material (Wainwright and Turingan, 1997). On a completely different note, the Ocean Sunfish (*Mola mola*) are named for the common behavior of lying on their sides near the surface, appearing to “sunbathe”, which has been suggested to be a mechanism of thermal recharging after deep dives in cold water (Potter and Howell, 2011).

Tetraodontiformes is found to be an interesting order because of all these similarities and differences found within the families. However, some of these species are hunted for food while others are sought out for photos by divers and photographers or for research on toxins in the medicinal field (Malpezzi et al., 1997; Matsumara, 1998; Griffith and Pizzini, 2002).

Regulations have recently changed in the southeast United States for the Gray Triggerfish (*Balistes capriscus*) which is a commercially and recreationally important reef fish in southeast Florida and the Gulf of Mexico (Runde et al., 2019). These regulations include new recreational and commercial fishery minimum size limits, recreational bag limits, as well as annual catch limits (NOAA, 2018). The Gray Triggerfish and other triggerfish species are also important to fisheries in other coastal regions of the North and South Atlantic (Runde et al., 2019). These species, Gray Triggerfish and Ocean Triggerfish (*Canthidermis sufflamen*), are frequently caught by freedivers and scuba divers, as well as hook-and-line anglers in the United States. Queen Triggerfish (*Balistes vetula*) are commercially important in the Caribbean, Brazil, and Bermuda (Liu et al., 2015; Monterey Bay Aquarium, 2017). In other areas of the Caribbean, such as Puerto Rico, boxfish and cowfish filets are a local delicacy known as 'chapín,' which is commonly sold in local restaurants and markets (Griffith and Pizzini, 2002). Other species are also known to be edible, such as the Scrawled Filefish (*Aluterus scriptus*) and Orangespotted Filefish (*Cantherhines macroceros*) but are not considered 'sporting' to harvest due to slow swimming speed and limited maneuverability. Although there are no reports of local consumption in Florida, Ocean Sunfish are found to be a valued food fish in Asia and comprise a large portion of bycatch in Pacific and Mediterranean commercial fisheries (Potter and Howell, 2011).

There are many more commonly known species of Tetraodontiformes frequently sighted on the coral reefs and hardbottom habitats of the FRT in addition to these potentially exploited species within Tetraodontiformes. These species, such as the Sharpnose Pufferfish (*Canthigaster rostrata*) and others, are popular with scuba divers, underwater photographers, and aquarists. Fish retailers/distributors offer different species from the families of Balistidae, Ostraciidae, Monacanthidae, and Tetraodontidae as well as many others (LiveAquaria, 2018; Saltwaterfish.com, 2019.). These retailers catch fish and other organisms in local waters to breed and sell at local aquarium retailers or sell online and send through the mail (LiveAquaria, 2018; Saltwaterfish.com, 2019).

Other families, such as Diodontidae and Tetraodontidae, are known for having paralyzing toxins in their skin, yet are considered a delicacy in some areas of the world (Ahasan et al., 2004; Fall et al., 2013). These two families, as well as Molidae, are known to be commonly consumed due to scarcity of groupers, breams, barracudas, snappers, etc. in households in West Africa (Fall et al., 2013). Despite careful preparation, toxins have caused deaths due to ingesting these fish in Asia, Japan, Singapore, Hong Kong, and Australia (Ahasan et al., 2004). The United States has prohibited the import of certain types of pufferfish (known as *fugu* in Japan), and only import to Japanese restaurants whose chefs are certified by their country to prepare the dish (Fall et al., 2013). The neurotoxin, tetrodotoxin (TTX) is found in gonads, liver, skin, and intestines of these fish, is heat-stable and water-soluble, so boiling or frying will not inactivate the toxin (Islam et al., 2011; Fall et al., 2013). Even cooked correctly, these fish may kill human-beings within an hour of eating (Ahasan et al., 2004; Fall et al., 2013). Symptoms of the poisoning begins with a paresthesia that begins within ten to forty-five minutes after ingestion, followed by tingling, vomiting, dizziness, anxiety, and weakness that then can lead to ascending paralysis and even death (Ahasan et al., 2004; Islam et al., 2011; Fall et al., 2013).

1.2 Statement of Purpose

The purpose of this study was to conduct an in-depth evaluation of multiple members of the order Tetraodontiformes in southeast Florida, focusing on their distribution, depth, and habitat associations throughout the region. This was accomplished by utilizing data collected during the Southeast Florida Coral Reef Fishery-Independent Baseline Assessment: 2012 – 2016 (Kilfoyle et al., 2018) project, which surveyed reef fishes from all natural hardbottom and coral reef habitats in the southeast Florida region for an initial study period of five years. This study focused on the five families from the order Tetraodontiformes that are present in the dataset: Balistidae, Diodontidae, Monacanthidae, Ostraciidae, and Tetraodontidae. This analysis utilized the five local ecoregions as defined in Walker (2012) and Walker and Gilliam (2013): Martin, North Palm Beach, South Palm Beach, Deerfield, and Broward-Miami. Comparisons were made for the selected species between local ecoregions, habitats, and depth to see if there are any detectable patterns in their geographical distribution, habitat associations, cross-shelf/depth-associated, or latitudinal gradients. The results of this study may help reef managers to make better informed decisions about these species in the future and may also inspire more in-depth research on the subject.

1.3 Selected Species

Tetraodontiformes are known to be globally distributed in tropical and temperate seas as well as freshwaters (Stump et al., 2018). There are at least 30 species from 6 families within the Tetraodontiformes that are known from the western Atlantic and Greater Caribbean (Böhlke and

Chaplin, 1993; Humann and Deloach, 2014). These six families include: Balistidae (Triggerfishes), Diodontidae (Porcupinefishes), Molidae (Ocean Sunfishes), Monacanthidae (Filefishes), Ostraciidae (Boxfishes), and Tetraodontidae (Pufferfishes). Each of these families, excluding Molidae, is represented by at least one species in the southeast Florida FIA dataset (Table 1) (Kilfoyle et al., 2018). Between 2012 to 2016, a total of 1,238,951 fish were counted between a total of 1,360 sites (PSUs) (Kilfoyle et al., 2018). Of these fish, a total of 25 species from Tetraodontiformes were counted from the families found within the dataset: 4 from Balistidae, 5 from Diodontidae, 8 from Monacanthidae, 5 from Ostraciidae, and 3 from Tetraodontidae (Table 1).

Table 1. *All species from Tetraodontiformes found within the 2012-2016 southeast Florida FIA dataset. The nine species used for this project have an asterisk (*) next to the common name. $\bar{P}$ is the mean percent occurrence per SSU and $\bar{D}$ is the mean density (fishes/SSU) (found in Appendix 3 in Kilfoyle et al., 2018) for each species.*

Family	*Species (Scientific Name)*	Common Name	$\bar{P}$	$\bar{D}$
Balistidae	*Balistes capriscus*	Gray Triggerfish*	0.41	1.46
Balistidae	*Balistes vetula*	Queen Triggerfish*	0.02	0.02
Balistidae	*Canthidermis sufflamen*	Ocean Triggerfish	0.03	0.02
Balistidae	*Melichthys niger*	Black Durgon	0.0004	0.0002
Diodontidae	*Chilomycterus antennatus*	Bridled Burrfish	0.0004	0.0002
Diodontidae	*Chilomycterus atinga*	Spotted Burrfish	0.001	0.0006
Diodontidae	*Chilomycterus schoepfii*	Striped Burrfish	0.002	0.002
Diodontidae	*Diodon holocanthus*	Balloonfish*	0.07	0.04
Diodontidae	*Diodon hystrix*	Porcupinefish	0.001	0.001
Monacanthidae	*Aluterus monoceros*	Unicorn Filefish*	0.02	0.05
Monacanthidae	*Aluterus schoepfii*	Orange Filefish	0.02	0.02
Monacanthidae	*Aluterus scriptus*	Scrawled Filefish*	0.17	0.17
Monacanthidae	*Cantherhines macrocerus*	Whitespotted Filefish	0.03	0.02
Monacanthidae	*Cantherhines pullus*	Orangespotted Filefish*	0.12	0.08
Monacanthidae	*Monacanthus ciliatus*	Fringed Filefish	0.006	0.003
Monacanthidae	*Monacanthus tuckeri*	Slender Filefish	0.04	0.03
Monacanthidae	*Stephanolepis hispidus*	Planehead Filefish	0.04	0.03
Ostraciidae	*Acanthostracion polygonia*	Honeycomb Cowfish	0.09	0.05
Ostraciidae	*Acanthostracion quadricornis*	Scrawled Cowfish	0.1	0.07
Ostraciidae	*Lactophrys bicaudalis*	Spotted Trunkfish	0.01	0.008
Ostraciidae	*Lactophrys trigonus*	Trunkfish	0.009	0.005
Ostraciidae	*Lactophrys triqueter*	Smooth Trunkfish*	0.11	0.07
Tetraodontidae	*Canthigaster rostrata*	Sharpnose Pufferfish*	0.8	2.61
Tetraodontidae	*Sphoeroides spengleri*	Bandtail Pufferfish*	0.11	0.08
Tetraodontidae	*Sphoeroides testudineus*	Checkered Puffer	0.006	0.004

Within this dataset, the most commonly encountered species from the order Tetraodontiformes included: Sharpnose Pufferfish (*Canthigaster rostrata*), Gray Triggerfish (*Balistes capriscus*), Scrawled Filefish (*Aluterus scriptus*), Orangespotted Filefish (*Cantherhines pullus*), and Smooth Trunkfish (*Lactophrys triqueter*) (Kilfoyle et al., 2018). A more in-depth evaluation of the status of these fish and others from Tetraodontiformes in southeast Florida is needed to better understand what contribution they are making to local reef fish communities, what influence they may have on local reefs, and how their populations levels may or may not be changing in response to anthropogenic influences in the region. The rationale for researching these selected species was that they had the highest mean percent occurrence ($\bar{P}$ ≥0.10): Sharpnose Pufferfish ($\bar{P}$=0.8), Gray Triggerfish ($\bar{P}$=0.41), Scrawled Filefish ($\bar{P}$=0.17), Orangespotted Filefish ($\bar{P}$=0.12), Smooth Trunkfish ($\bar{P}$=0.11), and Bandtail Pufferfish ($\bar{P}$=0.11) (Table 1 and Figure 1). The reason for including the other three species (Queen Triggerfish, Unicorn Filefish, and Balloonfish) was to look at similarities or differences between benthic habitat distribution as well as ecoregion distributions for species within the same families. Balloonfish had the highest percent occurrence within Diodontidae but was the only species with sufficient numbers to run statistics; all other species of Diodontidae had a percent occurrence less than $\bar{P}$=0.002 (Figure 1).

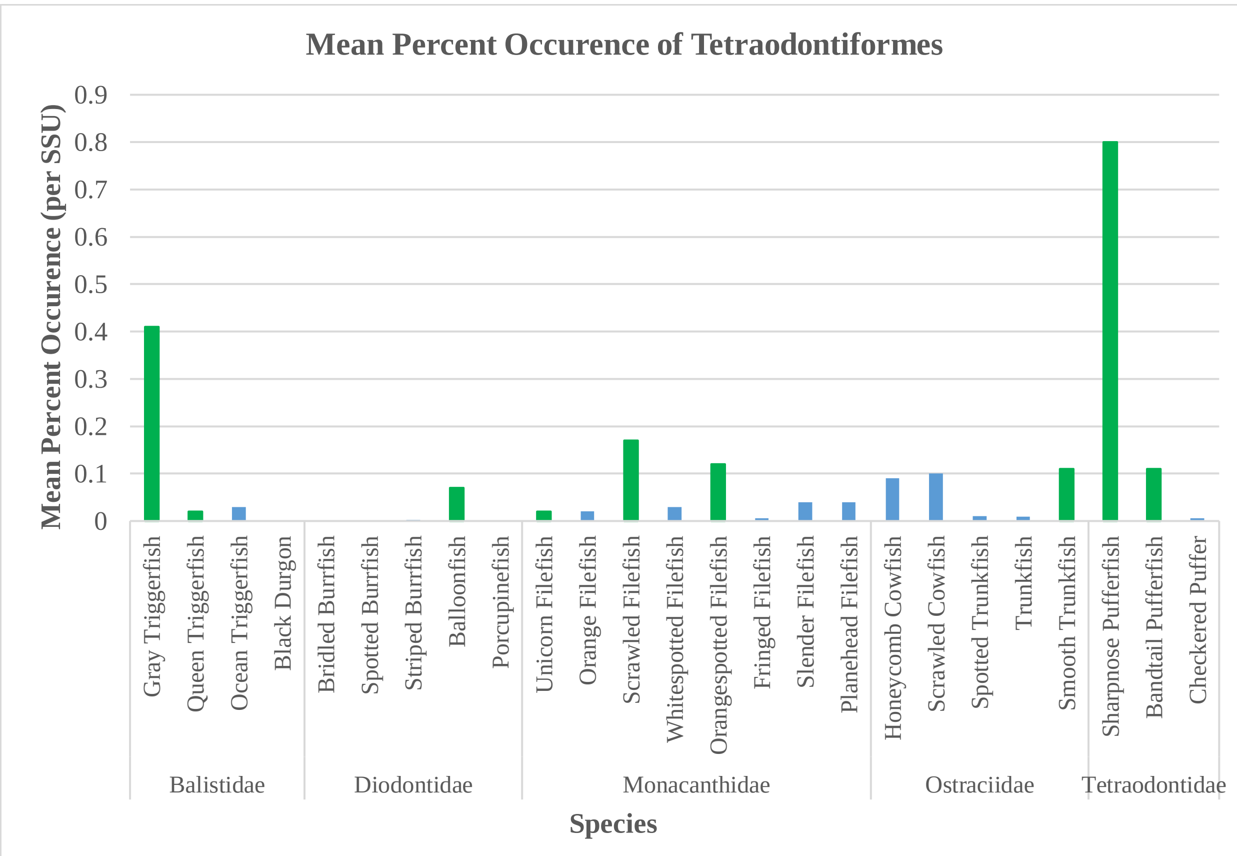

Figure 1. *Mean percent occurrence for each species from Tetraodontiformes found within the 2012-2016 southeast Florida FIA dataset. The selected species for this project are green.*

Gray Triggerfish (*Balistes capriscus*)

Gray Triggerfish, members of the family Balistidae, are found in both temperate and tropical waters throughout the western and eastern Atlantic Ocean, from Nova Scotia to Argentina (Figure 3) (Simmons and Szedlmayer, 2012; Humann and Deloach, 2014). The distribution also extends to the Gulf of Mexico (Figure 3). This species is associated with artificial reef structures and natural hardbottom substrate from 4 to 25 meters (Simmons and Szedlmayer, 2012; Humann and Deloach, 2014). Adults eat benthic invertebrates including crabs, sea urchins, shrimp, sand dollars, lobsters, and mollusks since they have a small mouth with a strong jaw and specialized teeth used to crush and chisel holes into their hard-shell prey (Randall and Millington, 1990; NOAA, 2018). The juveniles feed on hydroids, barnacles, and polychaetes. Like other Tetraodontiformes, these fish sometimes use a direct stream of water over a sandy ocean habitat to expose food (NOAA, 2018).

The Gray Triggerfish is a laterally compressed fish with tough, leathery skin with scales on the front half of the body that are large and plate-like, while the scales on the posterior are smooth (Figure 2) (Randall and Millington, 1990). Triggerfish receive their name from the spines on the two dorsal fins. The first dorsal fin has three spines that erect into a locked position for use as predator-defense or an anchoring device, and the second dorsal fin is located directly opposite of the anal fin (Randall and Millington, 1990; NOAA, 2018). For the Gray Triggerfish, the dorsal and anal fins are the primary means of locomotion, used by flapping back and forth in unison to propel the fish through the water. These fish are known for their aggressive behavior towards other fish as well as scuba divers.

Triggerfish establish territories during spawning season from April to August, build nests in the sand, and entice the females into the nest to spawn. After circling one another tightly in the nest and changing colors, the female will deposit an average around 770,000 eggs (Randall and Millington, 1990; Simmons and Szedlmayer, 2012; NOAA, 2018). Gray Triggerfish display parental care by having the female fan and blow on the eggs while only swimming off the nest to briefly chase potential egg predators away (Simmons and Szedlmayer, 2012).

Figure 2. *A Gray Triggerfish with the spine slightly erect (taken from Humann and Deloach, 2014).*

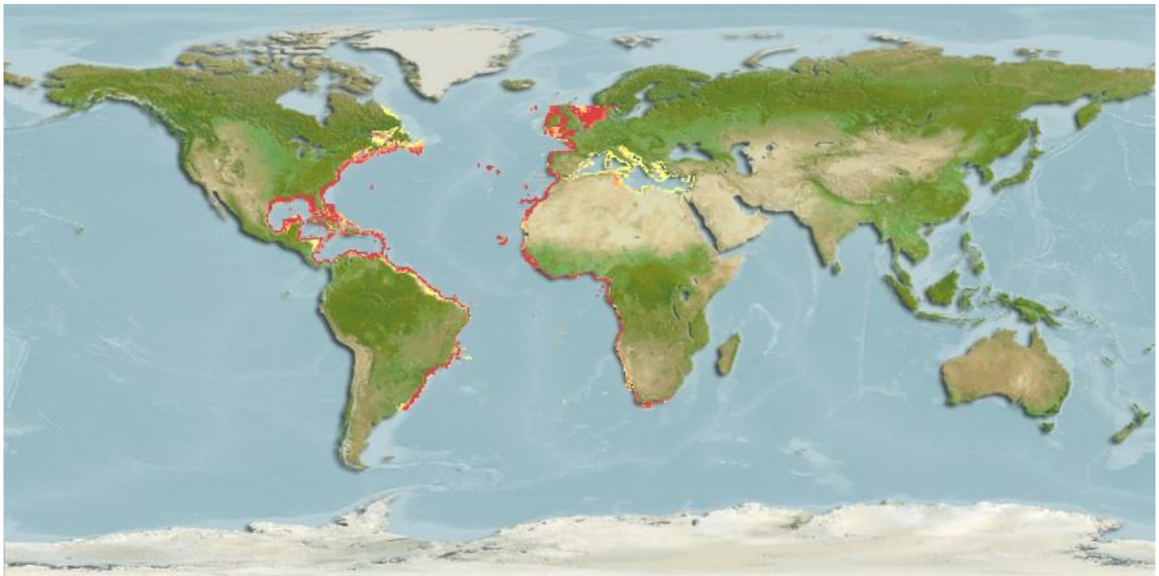

Figure 3. *Range of Gray Triggerfish (created on Aquamaps.org).*

Queen Triggerfish (*Balistes vetula*)

Queen Triggerfish, also in the family Balistidae, are mostly found over rocky surfaces within 100 meters deep and in shallow waters close to sandy beaches along coasts of the Atlantic Ocean (Figure 5) (Albuquerque et al., 2011; Humann and Deloach, 2014). Like the Gray Triggerfish, the Queen Triggerfish is a large, oval-shaped, laterally compressed fish with small eyes located toward the top of the head (Figure 4). The anterior dorsal fin possesses two spines used to lock the fish into a crevice during the night. In addition, Queen Triggerfish have special membranes located just posterior to the pectoral fins which are used to produce a throbbing sound that is audible to other fish as a warning to stay away (Bester, 2017b).

Queen Triggerfish have distinctive coloration of greenish to bluish gray along the back, orange-yellow on the lower portion of the head and abdomen, with two wide diagonal curved bright blue bands extending from the snout to below and in front of the pectoral fins (Figure 4) (Humann and Deloach, 2014; Bester, 2017b). The lower band is continuous with a blue ring around the lips (Figure 4). A broad blue bar is also displayed across the caudal peduncle and blue sub-marginal bands are visible in the median fins (Figure 4). Queen Triggerfish are commonly reported at total lengths of approximately 30 centimeters (Bester, 2017b). They reach maturity at approximately 23 to 27 centimeters fork length and have a lifespan of at least 7 years and possibly up to 13 years.

The diet of the Queen Triggerfish contains primarily benthic invertebrates, macroalgae, bivalves, crabs, starfish, sea cucumbers, shrimp, and polychaetes. These triggerfish are known to prey on sea urchins by creating water currents that overturn the urchin, making it vulnerable to predation by exposing the underside where the spines are short (Bester, 2017b).

Similar to the Gray Triggerfish, the Queen Triggerfish males establish territories to attract several females. The nests are built by moving fins rapidly or creating a current by blowing water with the mouth near the bottom to create sand bowls (Bester, 2017b). After a courtship ritual, the eggs are released into these bowls (Bester, 2017b). Triggerfish are known to be extremely defensive around these nests. Reproduction occurs year-round, peaking in the fall and again in the winter (Bester, 2017b).

Figure 4. *A Queen Triggerfish showing the distinct colors of the head and abdomen, the bright blue bands can be seen extending from the snout to below the pectoral fin while the lower band is located around the lips (taken from Humann and Deloach, 2014).*

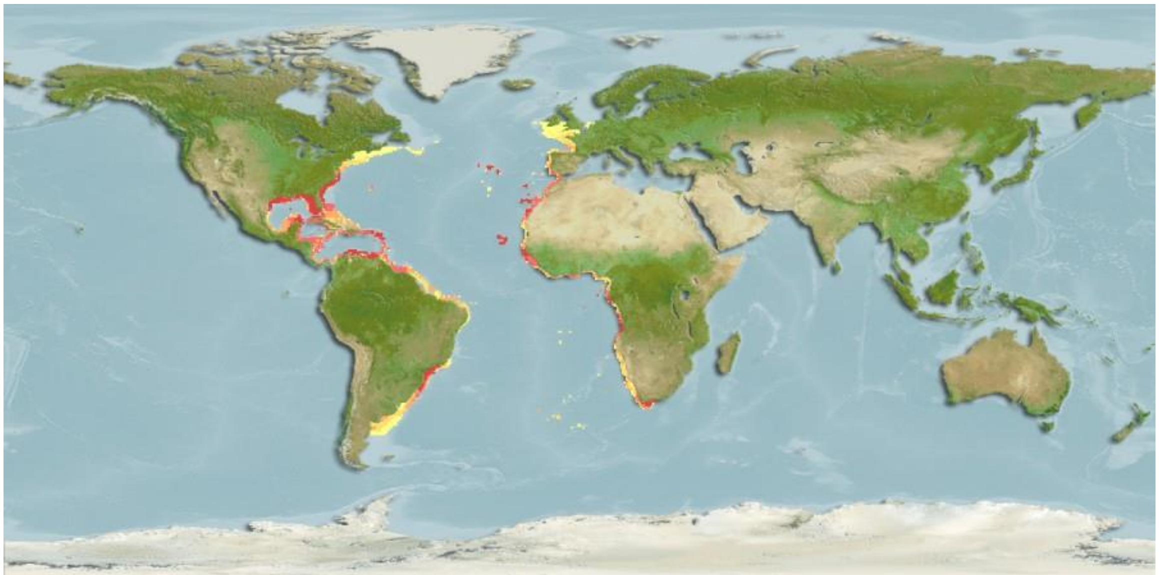

Figure 5. *Range of Queen Triggerfish (created on Aquamaps.org).*

Balloonfish (*Diodon holocanthus*)

The Balloonfish are part of the family Diodontidae known as porcupinefish. Porcupinefish are capable of inflation by taking water into their body when threatened or stressed. Balloonfish are distinguished by the large dark markings on the sides and back that dominate the color pattern and small black spots found in between the markings (Figure 6) (Humann and Deloach, 2014; Patton, 2018). These fish are found on shallow reefs among mangroves and in open bottom areas, including seagrass beds and rocky substrates along coasts around the world (Figure 7) (Humann and Deloach, 2014; Patton, 2018). They rest on or swim slowly near the bottom while blending with the background in depths ranging from 2 to 100 meters (Humann and Deloach, 2014; Patton, 2018). Since they are nocturnal predators, they can be found hiding in crevices during the day (Patton, 2018). Their teeth are fused together into a single unit to create a strong beak-like mouth capable of cracking the shells of snails, sea urchins, and hermit crabs (Patton, 2018).

During spawning season, afternoon or early evening, one or two males approach a female who remains motionless at the bottom (Sakamoto and Suzuki, 1978). The males press their snouts against the belly of the female to incite her with their courtship behavior, the female is then slowly pushed upwards towards the surface of the water by the males (Sakamoto and Suzuki, 1978; Patton, 2018). After repetition of these activities, the female spawns her eggs just below the surface of the water while the eggs are fertilized simultaneously by the males (Sakamoto and Suzuki, 1978). Spawning always takes place between one female and four or five males, occurring at night (Sakamoto and Suzuki, 1978).

Figure 6. *A Balloonfish showing the color pattern of large dark markings with smaller black spots in between (taken from Humann and Deloach, 2014).*

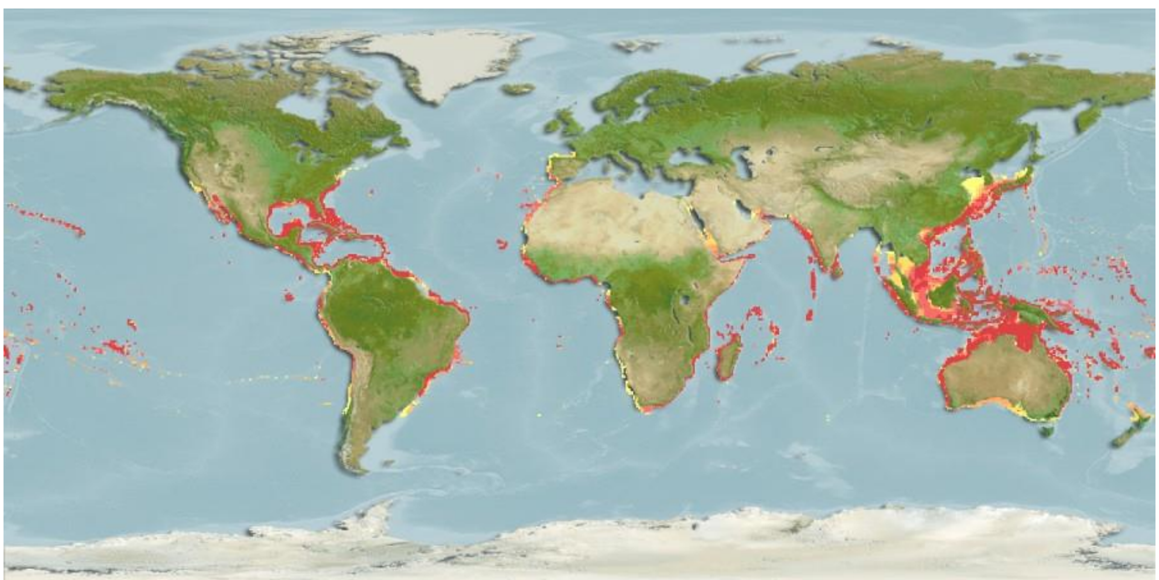

Figure 7. *Range of Balloonfish (created on Aquamaps.org).*

Unicorn Filefish (*Aluterus monoceros*)

Unicorn Filefish, also known as the unicorn leatherjacket, belong to the family Monacanthidae. These fish are circumglobally distributed in tropical and subtropical seas (Figure 9) (Allen and Erdmann, 2012). They are a reef-associated fish occurring in the continental shelf down to 50 meters depth (Ghosh et al., 2011; Allen and Erdmann, 2012; Humann and Deloach, 2014). Adults are occasionally found in shallow water at steep drop-offs or sandflats adjacent to deep-water reefs (Matsuura et al., 2015a). Unicorn Filefish are an epipelagic fish found solitary, in pairs, or occasionally in groups of five or six (Ghosh et al., 2011). These filefish spawn at bottom sites prepared and guarded by the males, once hatched the juveniles are found in the pelagic with jelly fish that bring them close to reefs in deeper water (Ghosh et al., 2011). Meanwhile, the adults will eventually nest on sand flats adjacent to reefs in deep water or form large schools under weed-rafts (Ghosh et al., 2011).

The Unicorn Filefish are described as pale gray to brown with a dark reticulated pattern marked with pale to dark spots, while some large adults are often grayish to silver without markings (Figure 8) (Humann and Deloach, 2014). Like other Monacanthidaes, the Unicorn Filefish is omnivorous with a diet of benthic microalgae, benthic crustaceans, as well as hydroids.

Figure 8. *An adult Unicorn Filefish with the grayish to silver color with no markings (taken from Humann and Deloach, 2014).*

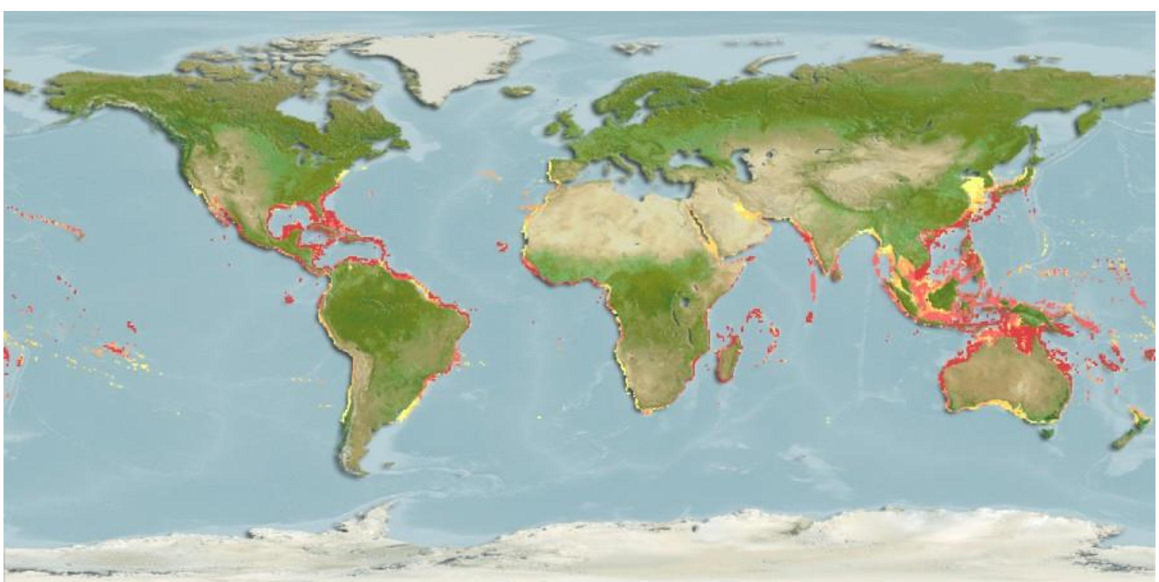

Figure 9. *Range of Unicorn Filefish (created on Aquamaps.org).*

Scrawled Filefish (*Aluterus scriptus*)

The Scrawled Filefish, also found in the family Monacanthidae, has an elongated oval, flat body with a small upturned mouth, broomlike tail, and weak fins (Figure 10) (Humann and Deloach, 2014; Bester, 2017a). It has a plain brown color with bright irregular blue lines and black spots throughout the body (Figure 10). Like the triggerfish, if threatened, the Scrawled Filefish hides in crevices and extends the large spine on its head and the smaller one under its belly to wedge itself into the small space. This filefish is associated with lagoons, seaward reefs, and may be found in subtropical waters at depths from 3 to 120 meters, but most commonly seen in the range of 3 to 20 meters (Figure 11) (Bester, 2017a).

Scrawled Filefish feed on algae, seagrass, hydrozoans, gorgonians, colonial anemones, and tunicates (Bester, 2017a). These fish breed in groups consisting of one male with two to five females. The females lay demersal eggs in safe areas while the males fertilize the eggs (Bester, 2017a). Then, either the male or female will guard these eggs from predators and attack intruders that approach too closely (Bester, 2017a).

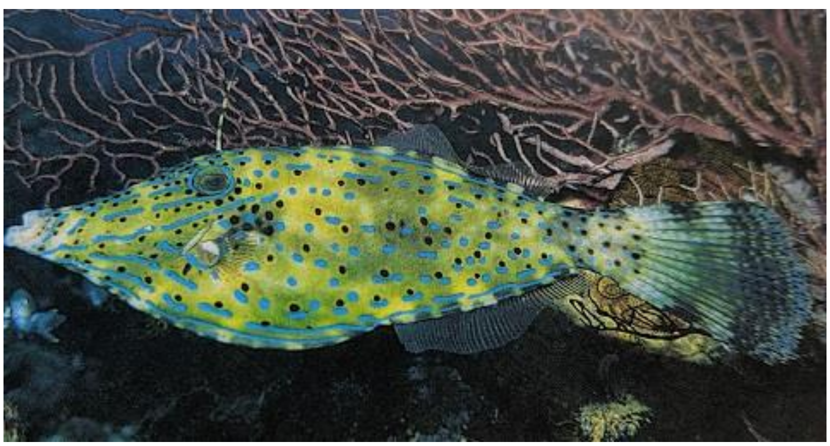

Figure 10. *A Scrawled Filefish with the yellow body, blue lines, and black spots (taken from Humann and Deloach, 2014).*

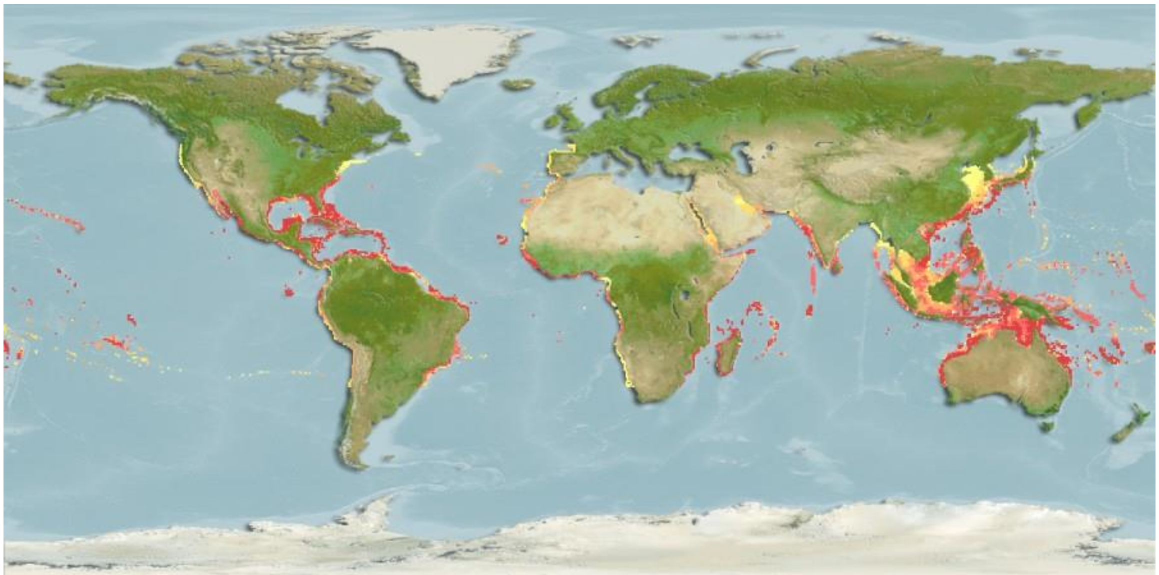

Figure 11. *Range of Scrawled Filefish (created on Aquamaps.org).*

Orangespotted Filefish (*Cantherhines pullus*)

The final fish in the family Monacanthidae used for this project, the Orangespotted Filefish, is commonly found from 1 to 50 meters, in shallow waters around coral and rocky reefs along the coasts in the Atlantic Ocean (Figure 13) (Matsuura et al., 2015b). These solitary filefish remain near the bottom often hiding in tangles of branching corals or gorgonians (Matsuura et al., 2015b). They are commonly found in south Florida, the Caribbean, the Bahamas, Gulf of Mexico, north of Massachusetts, south of Bermuda, and south of Brazil (Figure 13) (Humann and Deloach, 2014). Young Orangespotted Filefish are pelagic and highly important food items in the diets of large fish such as tunas and billfish (Matsuura et al., 2015b).

Orangespotted Filefish display narrow, broken yellow to orange stripes that converge near the tail base (Figure 12). They can change to solid brown, darken, or even become pale (Humann and Deloach, 2014). The juveniles have small, widely separated, orangish spots aligned to form three to four stripes on the side of the fish (Humann and Deloach, 2014). Both adults and juveniles feed on bottom growth, primarily sponge and algae. Their stomachs have been found to contain tunicates, bryozoans, and other sessile benthic invertebrates (Matsuura et al., 2015b). Like other members of Monacanthidae, the Orangespotted Filefish spawn with one male to multiple females. The females will lay eggs in a depression on the bottom of the defined territory for the males to fertilize.

Figure 12. *An Orangespotted Filefish showing the yellow/orange stripes (taken from Humann and Deloach, 2014).*

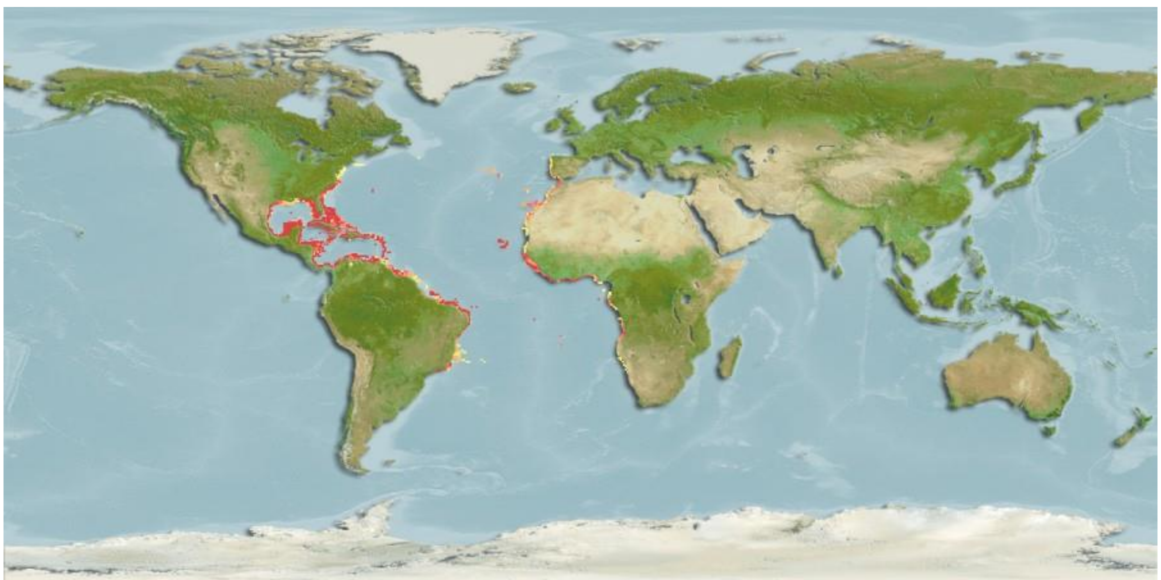

Figure 13. *Range of Orangespotted Filefish (created on Aquamaps.org).*

Smooth Trunkfish (*Lactophrys triqueter*)

The one fish selected for this project from the family Ostraciidae, the boxfishes, is the Smooth Trunkfish. The Smooth Trunkfish is a neo-tropical reef-dwelling fish (Figure 15), found in less than 50 meters of water, that has a rigid, bony carapace consisting of hexagonal plates (or scutes) which encases about two-thirds of its body (Figure 14) (Tyler, 1980; Bartol et al., 2003). This carapace, that is predominantly triangular in cross-section, has one dorsal and two prominent ventro-lateral keels that limits body movements (Figure 14). These fish rely heavily on complex combinations of movement of their five fins for swimming (Bartol et al., 2003).

Smooth Trunkfish have a dark body covered with white spots and distinctive dark areas around their mouths and at the base of the pectoral fin (Figure 14) (Humann and Deloach, 2014). These fish are the only member of the Ostraciidae that do not possess a spine above the eyes and/or near the anal fin (Humann and Deloach, 2014). Smooth Trunkfish are found on coral/rocky reefs, either solitary or in small groups (Leis et al., 2015). They feed on a variety of small bottom invertebrates such as mollusks, crustaceans, worms, sessile tunicates, and sponges exposed by a jet of water ejected through the mouth (Leis et al., 2015). Like other Tetraodontiformes, the Smooth Trunkfish releases toxins for defense while under stress.

Figure 14. *A Smooth Trunkfish with white spots and hexagonal plates (taken from Humann and Deloach, 2014).*

Figure 15. *Range of Smooth Trunkfish (created on Aquamaps.org).*

Sharpnose Pufferfish (*Canthigaster rostrata*)

Sharpnose Pufferfish, part of the family Tetraodontidae, are small omnivorous fish that live in shallow waters of the Caribbean (Figure 17) usually on coral reefs, seagrass beds, mangrove creeks, as well as artificial reefs (Humann and Deloach, 2014; Shao et al, 2014a). These fish are commonly found on the back reef, reef flat, and fore reef zones of the coral reefs to at least 40 meters depth (Moura and Castro, 2002; Shao et al, 2014a). The diet contains small crabs, shrimps, worms, small invertebrates, algae, and seagrasses (Shao et al, 2014a). Like other puffers, the Sharpnose Pufferfish can inflate their bodies as a defense against predators.

Named for their large pointed snout, Sharpnose Pufferfish have small dorsal and anal fins positioned toward the posterior end of the body and a prominent caudal fin (Figure 16) (Sikkel, 1990; Moura and Castro, 2002). The colors vary from a pale yellow to white with bright blue spots on the sides (Figure 16) (Sikkel, 1990; Moura and Castro, 2002). The edges of the caudal fin have thick dark borders that distinguish the Sharpnose Pufferfish from other species (Moura and Castro, 2002). These pufferfish are territorial and coexist with other Sharpnose Pufferfish in a very complex social structure. The females will defend a small permanent territory, and the males defend a larger territory that encompasses several of the smaller female territories (Shao et al, 2014a).

Figure 16. *Sharpnose Pufferfish with the pale yellow color on the side with bright blue spots (taken from Humann and Deloach, 2014).*

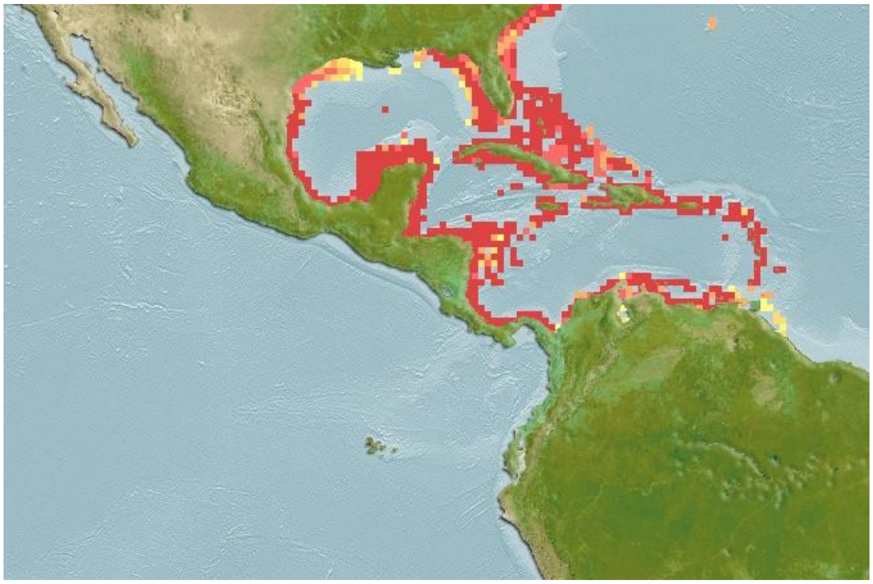

Figure 17. *Range of Sharpnose Pufferfish (created on Aquamaps.org).*

Bandtail Pufferfish (*Sphoeroides spengleri*)

The Bandtail Pufferfish, a member of the Tetraodontidae family, is found in coastal areas in the Caribbean to the southern waters off the coast of Brazil (Figure 19). They are a diurnal, generally solitary species found in shallow waters over reefs, rubble, and in seagrass beds to depths about 45 meters (Humann and Deloach, 2014; Shao et al., 2014b). Juveniles feed on amphipods and isopods but adults feed on brachyuran crabs, bivalves, and gastropods. Bandtail Pufferfish are oviparous fish, in which the females lay the eggs and the males fertilize them.

Bandtail Pufferfish have a tough skin covered with small spine-like scales and a beak-like dental plate divided by a median suture (Figure 18). They have a very distinctive row of dark blotches from mouth to tail and two dark bands on the tail (Figure 18) (Humann and Deloach, 2014). These pufferfish have a slit-like gill opening anterior to the base of the pectoral fin, no pelvic fins, no fin spines, a single short dorsal fin, and no ribs. They can inflate their abdomens with water when frightened or disturbed. Like other pufferfish, Bandtail Pufferfish are capable of producing and accumulating toxins, such as tetrodotoxin and saxitoxin in the skin, gonads, and liver (Shao et al., 2014b).

Figure 18. *A Bandtail Pufferfish with the row dark blotches from the mouth to the tail (taken from Humann and Deloach, 2014).*

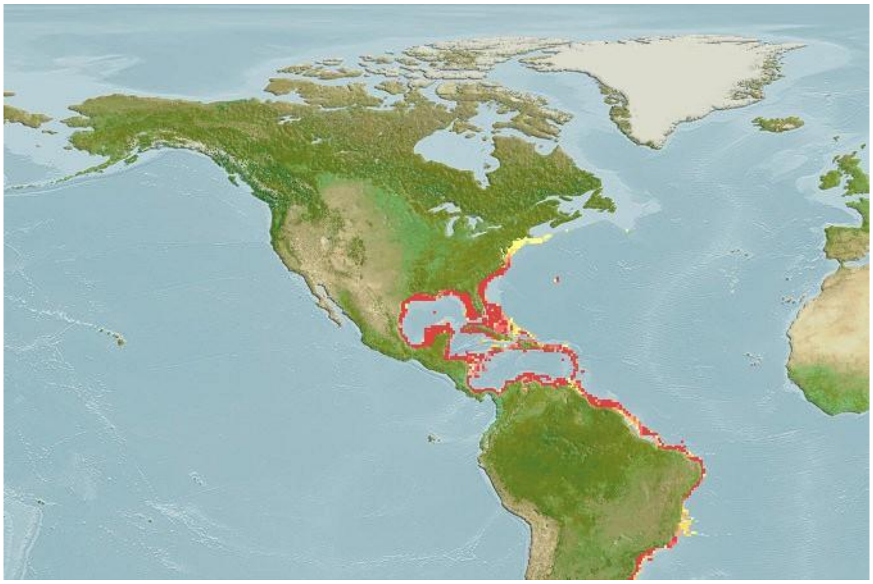

Figure 19. *Range of Bandtail Pufferfish (created on Aquamaps.org).*

1.4 Benthic Habitats

In recent years the SE FRT has been divided into specific cross-shelf habitat types based on the relationships between reef fish assemblage metrics (abundance, richness, etc.) and Geographic Information System (GIS) topographic metrics for multiple habitats (Walker et al., 2008; Walker, 2012; Walker and Gilliam, 2013). The benthic habitats used in this specific project, as well as others referenced, were adopted and modified from the NOAA hierarchical classification scheme used in Puerto Rico and the U.S. Virgin Islands (Kendall et al., 2001; Walker et al., 2008; Walker, 2012; Walker and Gilliam, 2013; Fisco, 2016). Listed below are the habitats used and their descriptions from inshore to offshore. The shallow habitats occur less than 10 meters water depth while the deep habitats occur between 10 to 33 meters.

Shallow Habitats:

- Colonized Pavement-Shallow (CPSH): consists of colonized pavement in water shallower than 10 meters (Walker and Gilliam, 2013). This habitat includes rubble in many areas, but the consolidated rubble fields are found less frequently in shallow water. Inshore of the ridge-complexes, limited rubble is found, and a wide, contiguous area of pavement is encountered. This area has variable sand cover due to shifts with wave energy in response to weather. Some of the colonized pavement will always be covered by shifting sand and the density of colonization will be highly variable (Walker and Gilliam, 2013).
- Ridge-Shallow (RGSH): consists of ridges found in water shallower than 10 meters near shore. They are geomorphologically distinct, but their benthic cover remains similar to shallow colonized pavement communities on the surrounding hard grounds (Walker and Gilliam, 2013).
- Linear Reef-Inner (LIRI): is a distinct, relatively continuous reef that runs parallel to the shore consisting of a rich coral reef assemblage and crests in approximately 8 meters depth (Fisco, 2016).
- Patch Reefs (PTCH): consists of coral or hardbottom formations that are isolated from other coral reef formations by sand, seagrass, or other habitats and that have no organized structural axis relative to the contours of the shore or shelf edge (Walker, 2012).
- Scattered Rock in Unconsolidated Sediment (SCRS): consists of primarily sand bottom with scattered rocks that are too small to be delineated individually and were less than 10 percent cover of submerged vegetation. This habitat was not used for the analysis in this study.

Deep Habitats:

- Linear Reef-Middle (LIRM): is a distinct, relatively continuous, linear, parallel to the shore reef that consists of a rich coral reef assemblage which crests in approximately 15 meters depth (Fisco, 2016).

- Colonized Pavement-Deep (CPDP): is a flat, low relief habitat, composed of solid carbonate rock with coverage of macroalgae, hard coral, gorgonians, and other sessile invertebrates that are dense enough to partially obscure underlying substrate in water deeper than 10 meters (Fisco, 2016). This habitat includes a transition zone from colonized pavement to consolidated colonized rubble on the deep reefs.
- Linear Reef-Outer (LIRO): is a linear coral formation oriented parallel to the shore or shelf edge. It is a distinct, relatively continuous, reef that follows the contours of the shore/shelf edge and crests in approximately 16 meters depth. This habitat consists of a rich coral reef assemblage that lives on relic morphology and includes a back reef, reef crest, and spur and groove (Fisco, 2016).
- Spur and Groove (SPGR): is a reef habitat with alternating sand and coral formations that are oriented perpendicular to the shore or bank/shelf escarpment (Fisco, 2016). The coral formations (spurs) have a high vertical relief compared to pavement with sand channels and are separated from each other by 1 to 5 meters of sand or bare hardbottom (grooves), although the height and width of these elements may vary considerably (Fisco, 2016).
- Aggregated Patch Reefs-Deep (APRD): is a clustered patch reef that individually are too small or too close together to map separately.
- Ridge-Deep (RGDP): consists of a linear, often parallel to the shore, low relief feature that mostly occurs deeper than 25 meters. It consists of hardbottom with sparse benthic communities in most parts likely due to variable and shifting rubble and sand cover.
- Deep Ridge Complex (DPRC): is a complex of hardbottom ridges found in deep water. These features reside in depth from 20 to 35 meters and are presumed to be of cemented beach dune origin (Fisco, 2016). Most of this habitat consists of low cover, deep assemblages dominated by small gorgonians, sponges, and macroalgae, but denser areas exist, especially near areas of higher relief (Fisco, 2016). In between ridges, some areas may have contained large areas of shifting unconsolidated sediments.

1.5 Local Coral Reef Ecoregions

Walker (2012) and Walker and Gilliam (2013) defined six local coral reef ecoregions: Martin, North Palm Beach, South Palm Beach, Deerfield, Broward-Miami, and Biscayne. This project's data analysis used five of the local ecoregions as data analysis strata to investigate regional differences and provided an ecosystem-based context for the order of Tetraodontiformes (Figure 20). The Biscayne Coral Reef Ecoregion was not used for this analysis since it was not within the survey domain and other partners sampled the ecoregion. These are the five local ecoregions defined by Walker (2012) and Walker and Gilliam (2013) used in the data analysis:

- Martin: is the region extending from southern Martin County just north of the end of the DPRC to the northern border of Martin County (Walker and Gilliam, 2013; Fisco, 2016). A few of the shallow hardbottom habitats (CPSH and RGSH) occur near the St. Lucie Inlet (Walker and Gilliam, 2013; Fisco, 2016). This region also contained large mobile sand dunes that appeared to moderately or completely bury portions of the DPRC (Walker and Gilliam, 2013; Fisco, 2016).
- North Palm Beach: is the largest region spanning approximately 32 km of coastline from the south of Palm Beach Harbor at the Bahamas Fault Zone (BFZ) to the northern extent of the DPRC (Figure 20) (Walker, 2012; Fisco, 2016). This region contains four major habitat types: Ridge Complex, Patch Reef, Ridge-Deep, and Sand (listed above as SCRS) (Walker, 2012).
- South Palm Beach: is the fourth largest ecoregion and spans approximately 36 km of coastline from the BFZ south to Boca Raton (Walker, 2012; Fisco, 2016). This region contains five major habitat types: Ridge Complex, Patch Reef, Linear Reef-Outer, Ridge-Deep, and Scattered Rock in Unconsolidated Sediment.
- Deerfield: is the smallest of the ecoregions and spans approximately 15 km of the coastline of mainland SE Florida from its southern boundary of the Hillsboro Inlet to the northern end of the Linear Reef-Middle habitat at Boca Raton (Figure 20) (Walker, 2012; Fisco, 2016).
- Broward-Miami: is the second largest ecoregion and extends about 48 km along the coast of mainland SE Florida (Walker, 2012; Fisco, 2016). This ecoregion is bounded by the Hillsboro Inlet in the north and Government Cut to the south (Figure 20).

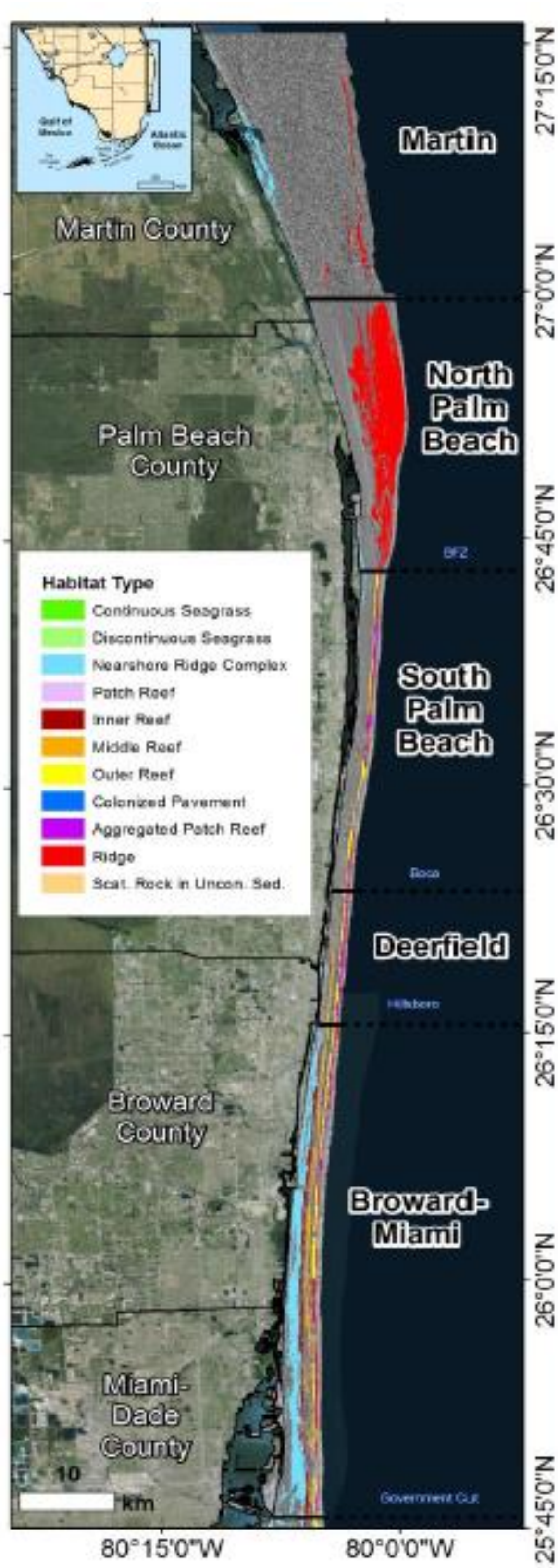

Figure 20. *Map of the five local coral reef ecoregions, including the habitat types, along the northern Florida Reef Tract (taken from Fisco, 2016).*

2.0 Hypotheses

This project utilized data previously collected during the Southeast Florida Coral Reef Fishery Independent Baseline Assessment: 2012 – 2016 (Kilfoyle et al., 2018) project. With the data already acquired, this project tested multiple hypotheses related to distribution and habitat associations for selected species from the families of Balistidae, Diodontidae, Monacanthidae, Ostraciidae, and Tetraodontidae throughout the survey domain. To compare regional distributions, the five local coral reef ecoregions defined by Walker (2012) and Walker and Gilliam (2013) were used. Given apparent differences in size, morphology, feeding behavior, diet, and behavioral tendencies, the author hypothesized that one or more of the selected species:

1. Exhibited differences in mean densities between benthic habitats.
2. Exhibited differences in mean densities between different depths.
3. Exhibited differences in mean densities between local ecoregions.

3.0 Materials and Methods

The primary goal of the Southeast Florida Coral Reef Fishery-Independent Baseline Assessment: 2012–2016 was to implement a habitat based, tiered, fishery-independent sampling protocol and create a regionally comparable dataset to determine the current status of coral reef fish populations (Kilfoyle et al., 2018). Given the identical survey design, the long existing RVC program data from the Florida Keys and Dry Tortugas can be combined with the new southeast Florida dataset to examine reef fish community changes throughout the entire FRT. Fisco (2016) conducted some of the initial work looking at the northern FRT in a similar regional breakdown of the fish assemblages by utilizing this dataset. However, the research looked at the whole coral reef fish community, not exclusively focusing on a small order such as Tetraodontiformes. This project is not a continuation of Fisco's analysis which is the reason for using the ecoregions defined by Walker (2012) and Walker and Gilliam (2013) and not the coral reef assemblages defined by Fisco (2016). Ames (2017) conducted work looking at the FRT by utilizing this dataset under the guidance of Dr. Brian Walker by identifying ecologically-relevant boundaries specific to reef fish assemblages of the FRT, including the Florida Keys and Dry Tortugas, while comparing to historical divisions. Specific to the northern FRT, research conducted by Walker (2012) and

Walker and Gilliam (2013) defined and described the coral reef ecoregions from southeast Florida that will be used in this analysis.

This project utilized the previously created analysis-ready dataset from the Baseline Assessment with data collected during the years 2012-2016 by Kilfoyle et al. (2018). The fully compiled dataset collected from all the partner agencies includes data from 2012, 2013, 2014, 2015, and 2016 and the data from these years, came from a total of 232, 325, 308, 209, and 286 sites (PSUs) sampled, respectively. In total, 1,360 sites (PSUs) were surveyed over the course of 5,290 dives during the five year period (Kilfoyle et al., 2018).

3.1 Study Area

The FRT stretches from Martin County, the most northern point, to the south-western extent of the Dry Tortugas (Finkl and Andrews, 2008; Walker and Gilliam, 2013; Fisco, 2016; Ames, 2017). The focus of this study is the northern FRT, or the southeast Florida region that includes Martin, Palm Beach, Broward, and Miami-Dade Counties (Figures 20 and 21). Data collected was from all hardbottom and reef habitats between the northern boundary of Martin County to Government Cut in Miami-Dade County (Figures 20 and 21). These sites included marine benthic hardbottom habitats shallower than 33 meters.

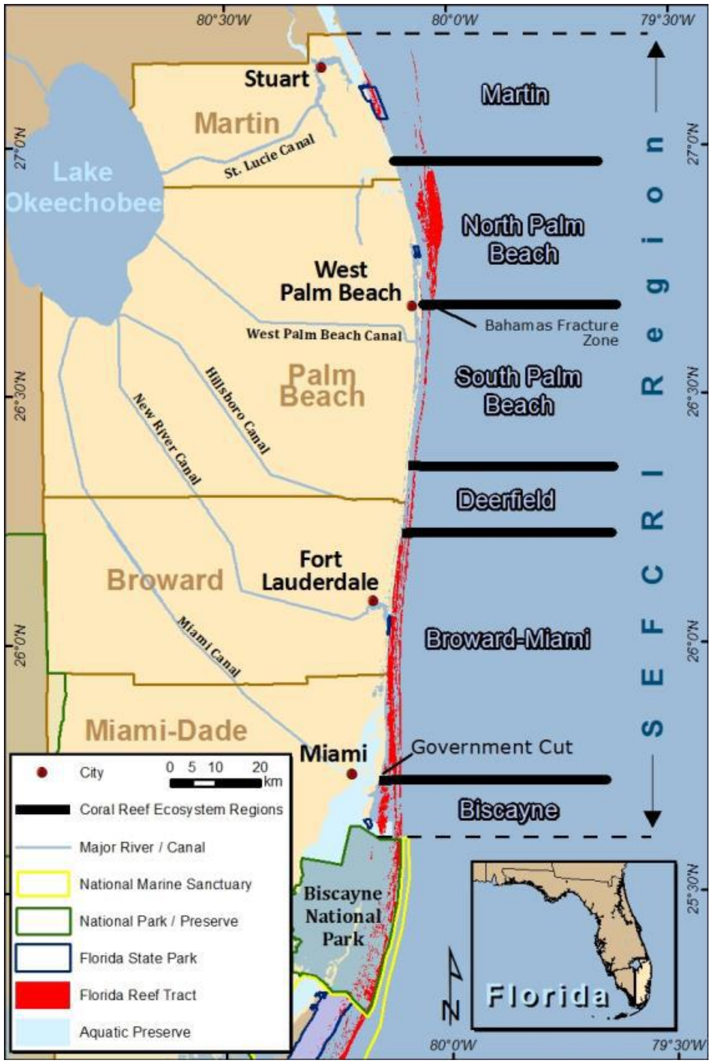

Figure 21. *Map of study area showing the local ecoregions (taken from Kilfoyle et al., 2018).*

3.2 Data Collection

The most common method for assessing populations of coral reef fishes has become the stationary point-count (Bohnsack and Bannerot, 1986). During a stationary point-count survey, a scuba diver establishes a location in the center of an imaginary cylinder 15 meters in diameter (Figure 22). This cylinder includes the column of water extending from the seabed to the ocean surface. During the first 5 minutes of the survey the diver notes all species that are observed within the cylinder. During the second 5 minutes, the diver begins to note the number (N) and the minimum, maximum, and mean sizes (cm) for all species of the previously recorded species, while still adding new species as they enter the survey area. Special effort was made to record size and abundance data for commercially/recreationally important species (i.e. groupers, snappers, hogfish, etc.) that may leave the survey area when the diver enter the area. After all species have been enumerated, the diver then does a rapid habitat assessment that includes benthic topography, percentages of major biotic and abiotic cover categories, and vertical relief.

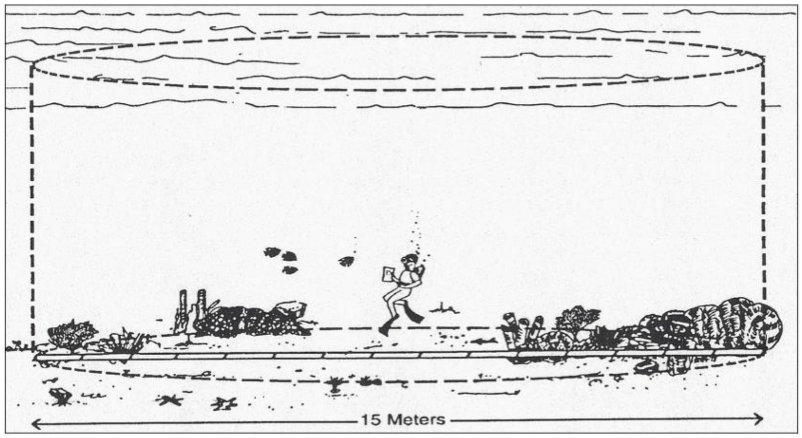

Figure 22. *Diagram of the 15 m cylinder with Reef fish Visual Census surveyor in center (taken from Brandt et al., 2009).*

3.3 Data Entry

After the survey each diver consulted with their buddy on the boat to make sure they agreed on the habitat data, to discuss the fish that were observed, and to help discover any questionable data entries before the next step (data entry). Each diver entered their own data upon returning from the field. After each season of data collection, the lead data project manager generated proofing sheets for every survey diver to aid in finding and correcting errors in the dataset (Kilfoyle et al., 2018). Once all errors were identified and corrected, a final version of the data was submitted to NSU for the final data merge and verification procedures (Kilfoyle et al., 2018). The RVC Annual Master Spreadsheet consisted of merged ASCII (American Standard Code for Information Interchange) sample, substrate, and species data outputs from the RVC data entry program along with a combined version of the Boat/Field and Water Quality/Environmental logs, each becoming one of four individual worksheets within the completed RVC Annual Master Spreadsheet file (Kilfoyle et al., 2018). The Master Spreadsheet was submitted to a quality assurance procedure to cross check data entered and then continued through an initial analysis process to generate an 'analysis-ready dataset.' The data used for this project came from the analysis-ready dataset after it went through SAS (Statistical Analysis Software) to calculate density and percent occurrence of each species by habitat and ecoregion.

3.4 Survey Design

The primary sampling unit (PSU) is a 100 meter x 100 meter cell that was further subdivided into four 50 meter x 50 meter grid cells (Figure 23). Within two of those 50 meter x 50 meter cells were placed the secondary sampling units (SSU). At each second-stage data collection point, a pair of non-destructive visual surveys (stationary point-counts) were conducted by a buddy team of 2 scuba divers. The data from each pair of surveys was then combined during the analysis to create an arithmetic mean SSU density based on the survey area (177 m^2) which could then be upscaled to the PSU level. The map strata were used to optimize survey locations for the targeted species, a purely randomized design would take many more surveys to acquire necessary data on the desired species, while this target design was more efficient (Kilfoyle et al., 2018).

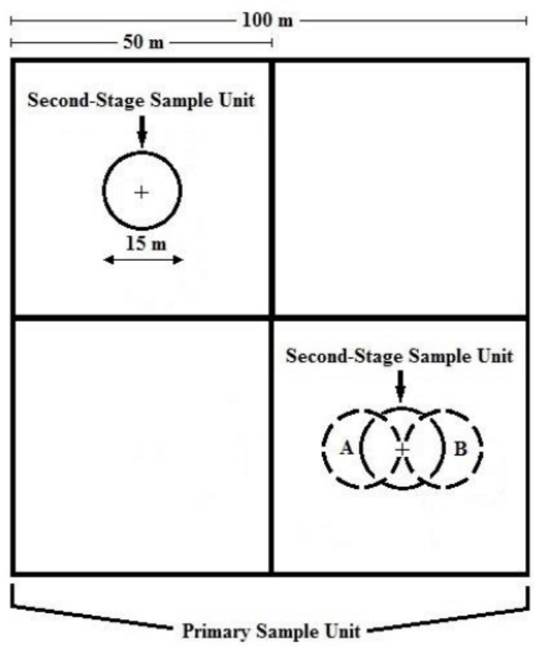

Figure 23. *Illustration of Primary Sample Unit (PSU) and Second-Stage Sample Units (SSU). Selection of two individual target SSU was accomplished by a randomization of the 4 cells within the PSU. The dashed circles represent a buddy pair (A and B) (taken from Kilfoyle et al., 2018).*

3.5 Statistical Analysis

To explore the regional distribution of the selected species, the author focused on a descriptive ecological analysis that included species inventory for each species, their corresponding mean density by habitat, depth, and ecoregion. To address the hypotheses, all tests were performed using the statistical program R. The first test used was the Shapiro-Wilks to test all data for normality. Because the results were significant, the data was not normally distributed.

Due to the non-normal distribution, a Kruskal-Wallis test was used to determine significance of the populations between the benthic habitats and ecoregions. The Kruskal-Wallis test was used because it is a non-parametric method for testing whether samples originate from the same distribution. For the species showing significance, a post-hoc analysis was used to further find where the significance occurred. For all results and descriptive analysis, Microsoft Excel was used to produce graphs.

4.0 Results

Although there were occasional exceptions, fishes from the order Tetraodontiformes generally contributed a very small percentage of the total number of fishes present in reef fish communities from all habitats. From 2012 to 2016 there were 1,238,951 fishes counted (all species and habitats combined), 12,837 of which were from Tetraodontiformes (1.03% of the total) (Kilfoyle et al., 2018). The nine species focused on for this project were counted a total of 12,131 times, which accounted for 94.5% of the total number of Tetraodontiformes counted within those five years. The other sixteen species contributed the remaining 5.5%. From those nine species, the Sharpnose Pufferfish were counted the most, 7,442, while the Queen Triggerfish were counted the least, 38 (Table 2).

Table 2. *The total counts for the nine selected species.*

Species	Count
Sharpnose Pufferfish	7,442
Gray Triggerfish	3,286
Scrawled Filefish	463
Orangespotted Filefish	249
Bandtail Pufferfish	233
Smooth Trunkfish	212
Balloonfish	121
Unicorn Filefish	87
Queen Triggerfish	38

4.1 Mean Density in Benthic Habitats

Throughout the southeast FRT the eleven benthic habitats had different amounts of sampling effort (i.e. total number of fish counts) applied to them (Table 3). Four of the benthic habitats were considered shallow: Ridge-Shallow (RGSH), Colonized Pavement-Shallow (CPSH), Linear Reef-Inner (LIRI), and Patch Reefs (PTCH) while the other seven were deep: Deep Ridge Complex (DPRC), Linear Reef-Middle (LIRM), Linear Reef-Outer (LIRO), Aggregated Patch Reefs-Deep (APRD), Ridge-Deep (RGDP), Spur and Groove (SPGR), and Colonized Pavement-Deep (CPDP). DPRC was the most sampled (had the most fish counts), 381, while PTCH had the least, 32. DPRC had the highest yearly mean for each habitat, 76.2, when LIRM and RGSH were the next highest means, 70.6 and 70.4, respectively (Table 3). Since PTCH was sampled the least, the yearly mean was the least, 6.4.

Table 3. *The total and mean number of SSU for each of the benthic habitats from 2012 to 2016.*

		Benthic Habitat	**Total**	**Mean**
Shallow	RGSH	Ridge-Shallow	352	70.4
	CPSH	Colonized Pavement-Shallow	237	47.4
	LIRI	Liner Reef-Inner	215	43.0
	PTCH	Patch Reefs	32	6.4
Deep	DPRC	Deep Ridge Complex	381	76.2
	LIRM	Linear Reef-Middle	353	70.6
	LIRO	Linear Reef-Outer	214	42.8
	APRD	Aggregated Patch Reefs-Deep	211	42.2
	RGDP	Ridge-Deep	177	35.4
	SPGR	Spur and Groove	162	32.4
	CPDP	Colonized Pavement-Deep	93	18.6

Within the five year study period, each benthic habitat was sampled a different amount each year (Figure 24). RGSH had the most samples counted between all the habitats, within all five years, in 2013. PTCH had the least samples counted between all the habitats, for three years: 2014, 2015, and 2016. For each of the benthic habitats, the highest sampling in APRD occurred in 2013, for CPDP in 2013, CPSH in 2012, DPRC in 2014, LIRI in 2014, LIRM in 2014, LIRO in 2014, PTCH in 2012, RGDP in 2013, RGSH in 2013, and SPGR was the same in 2013 and 2014.

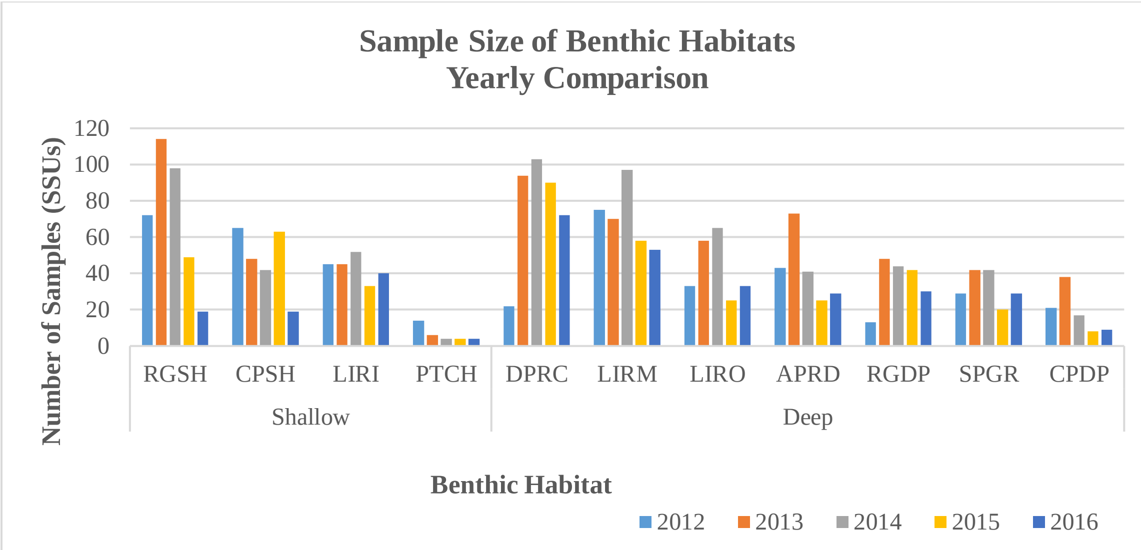

Figure 24. *The total samples (SSUs) for each of the benthic habitats by year.*

When all of the selected species were combined to find the total mean density, $\overline{D}$ (fishes/SSU) within each benthic habitat throughout 2012 to 2016, the results appeared that the PTCH habitat had a higher mean density then the other habitats, even though it was sampled the least (Figure 25). RGSH and CPSH had relatively similar mean densities, meanwhile APRD, RGDP, SPGR, LIRM, and LIRO had similar results between habitats. Results show that the higher densities of all the selected Tetraodontiformes were more commonly found in the deeper habitats, with the exception of PTCH (Figure 25).

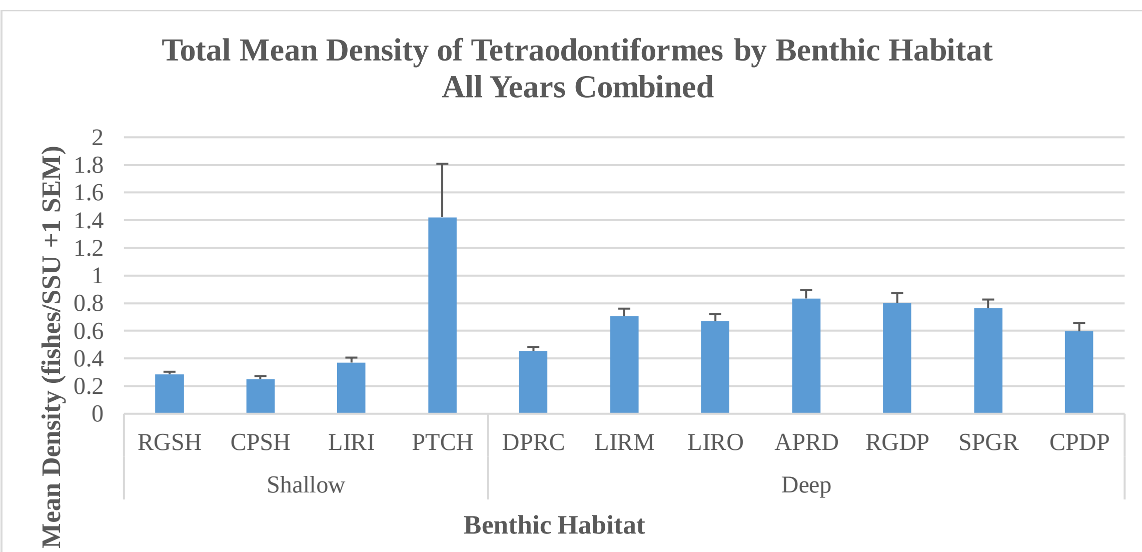

Figure 25. *Total mean density for all selected Tetraodontiformes combined by benthic habitat; all years (2012 to 2016) combined [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=930)].*

By analyzing the total mean densities of all the selected species by year, it would appear, with the exception of 2012, that the PTCH habitat had the highest total mean density within all of the years (Figures 26 and 27). Due to the relatively higher mean density compared to the other habitats, PTCH was separated to show the relationship of the other habitats to each other (Figures 26 and 27). Within the five years, it would appear that the mean densities were very similar, for example, in 2012, APRD appeared to have a higher mean density but could be relatively similar to RGDP and LIRO. 2013 appeared to have similar densities found within LIRM, APRD, LIRO, and SPGR. For 2014, similarities occurred between SPGR, APRD, and RGDP. In 2015 RGDP appeared to have a high mean density that was similar to LIRM. With a few exceptions, such as PTCH as a whole habitat, DPRC in 2012, and LIRM in 2016, it would appear that the selected species were more commonly found in the deeper habitats (Figure 26). Between all five years, it would appear that 2016 had the most species seen during the sampling efforts, excluding LIRM and PTCH that seemed to have lower mean densities than other years.

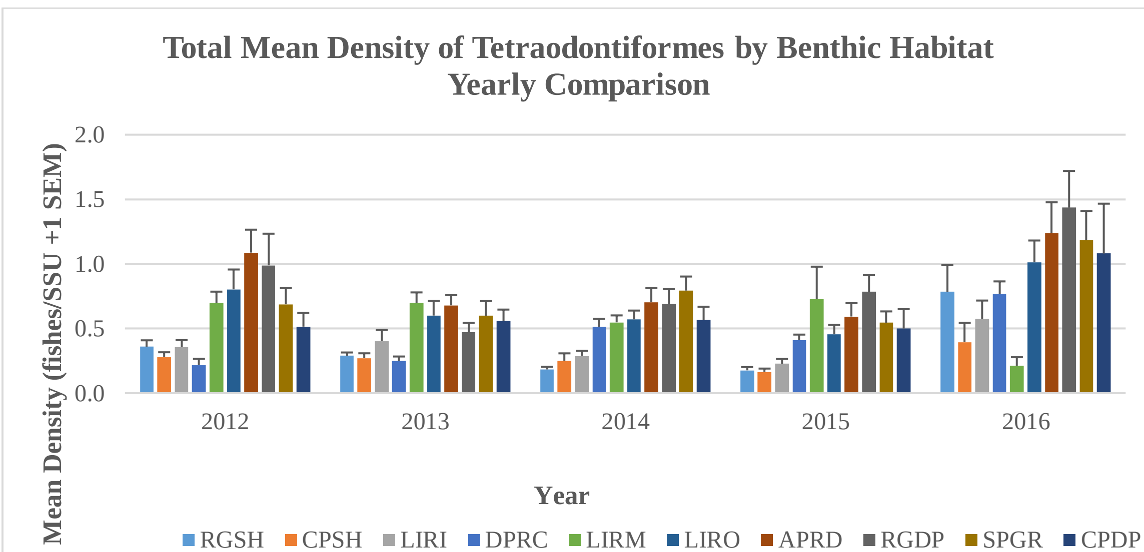

Figure 26. *Total mean density for all selected Tetraodontiformes combined for habitats (except PTCH) by year [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=930)].*

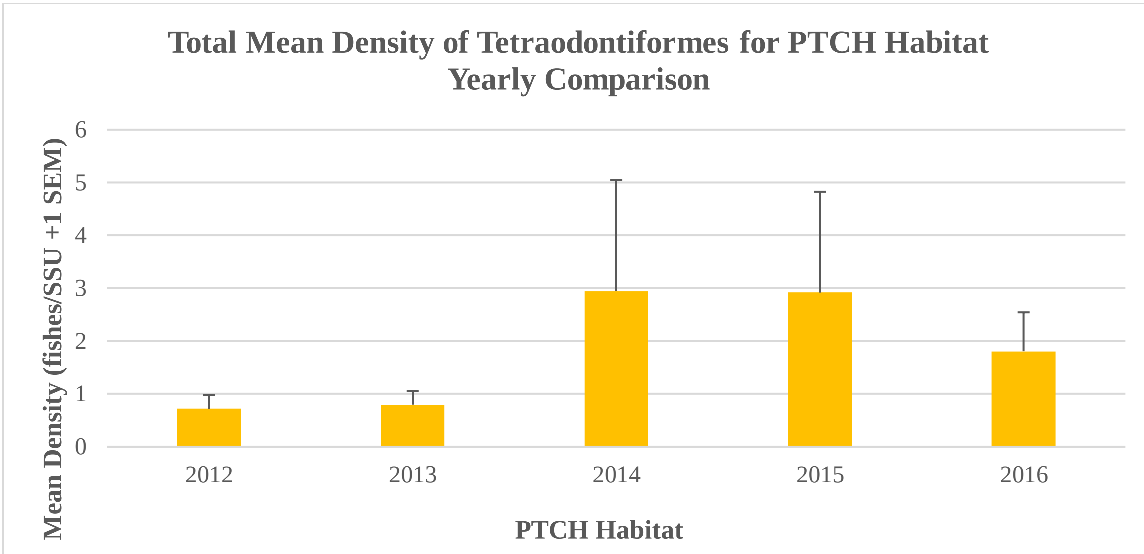

Figure 27. *Total mean density for all selected Tetraodontiformes combined for PTCH by year [PTCH (N=32)].*

The Sharpnose Pufferfish appears to have a higher mean density, in nine of the eleven benthic habitats, excluding PTCH, DPRC, and RGDP because the Gray Triggerfish appears to have a higher mean density within those three habitats (Figures 28, 29, 30 and 31). Multiple species appeared to have higher mean densities occur in PTCH: Gray Triggerfish, Sharpnose Pufferfish, Scrawled Filefish, Orangespotted Filefish, and Smooth Trunkfish (although the latter was characterized by high standard error in this habitat) (Figures 28 and 29). Both the Queen Triggerfish and the Sharpnose Pufferfish appeared to have high mean densities in APRD, although that lead is marginal for the Queen Triggerfish (Figures 30 and 31). As for the other species, results show that Scrawled Filefish appear to have high mean densities found within LIRO and SPGR, Orangespotted Filefish appear to have similar mean densities found within APRD, CPDP, LIRO, and SPGR, meanwhile Bandtail Pufferfish appear to have high mean densities found in CPSH, RGSH, LIRM, CPDP, and APRD (Figures 29 and 31). Unicorn Filefish were not found in the shallow habitats and appeared to have high mean densities found within LIRO, DPRC, and APRD (Figures 29 and 31). The Queen Triggerfish was also not found in RGSH, CPSH, and PTCH, but occurred in LIRI (Figures 29 and 31).

Within the PTCH benthic habitat, the Gray Triggerfish appeared to have had a higher mean density found between all the selected species throughout all the habitats ($\overline{D}$=7.547) (Figure 28). Excluding the habitats that had zero mean densities, it appeared that the least mean density was the Queen Triggerfish found in LIRI.

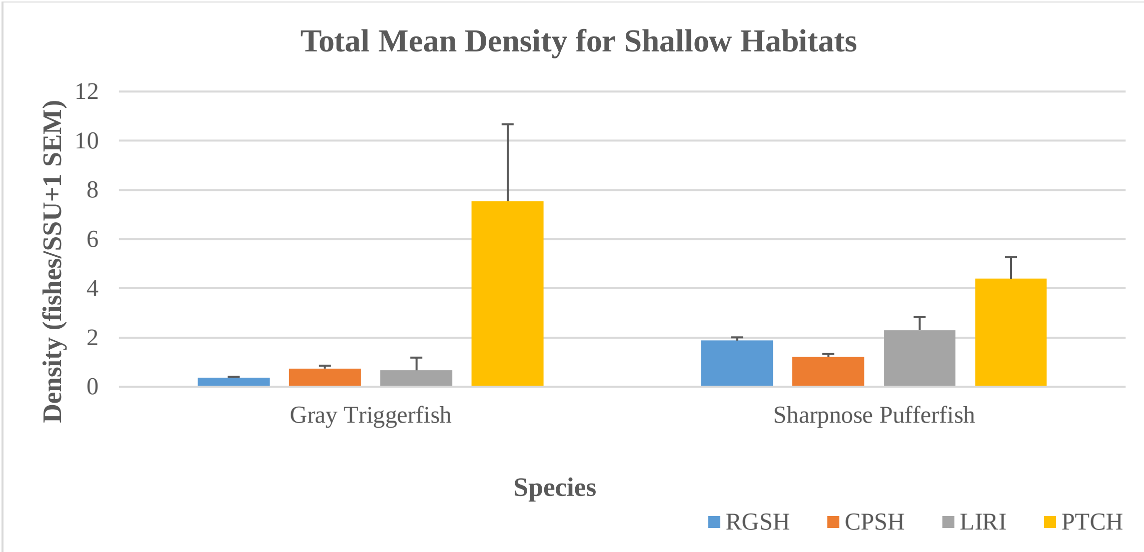

Figure 28. *Total mean densities for the Gray Triggerfish and Sharpnose Pufferfish for the shallow habitats throughout 2012 to 2016 [RGSH (N=352), CPSH (N=237) LIRI (N=215), and PTCH (N=32)].*

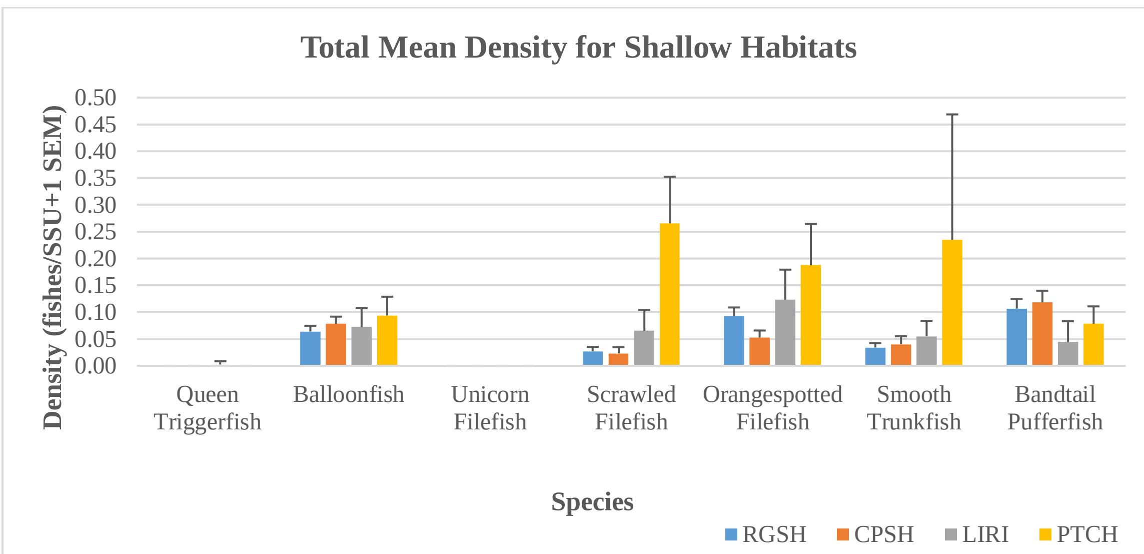

Figure 29. *Total mean densities for the Queen Triggerfish, Balloonfish, Unicorn Filefish, Scrawled Filefish, Orangespotted Filefish, Smooth Trunkfish and Bandtail Pufferfish for the shallow habitats throughout 2012 to 2016 [RGSH (N=352), CPSH (N=237), LIRI (N=215), and PTCH (N=32)].*

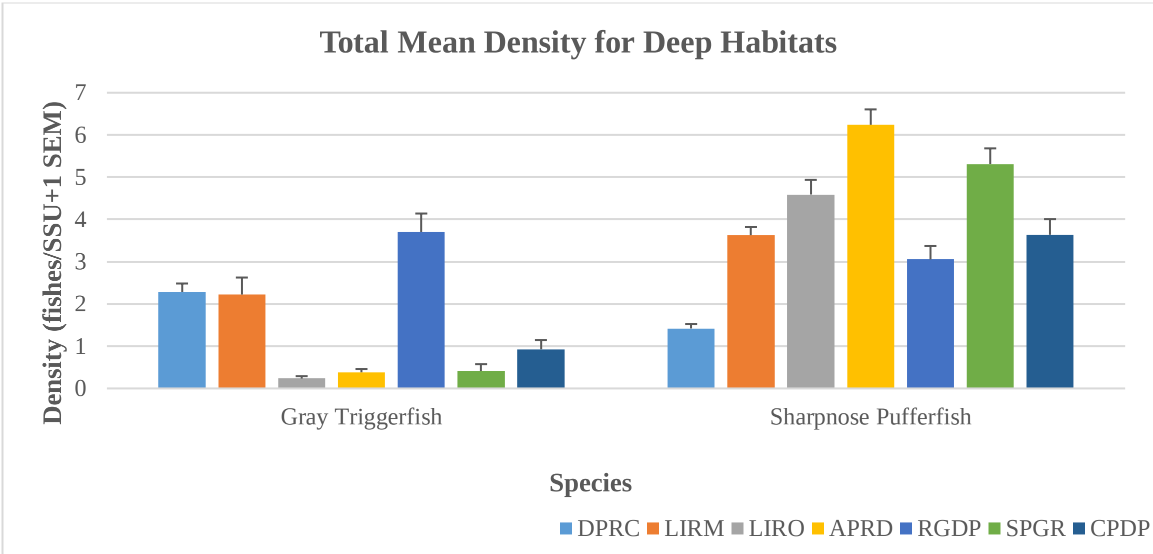

Figure 30. *Total mean densities for the Gray Triggerfish and Sharpnose Pufferfish for the deep habitats throughout 2012 to 2016 [DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=930)].*

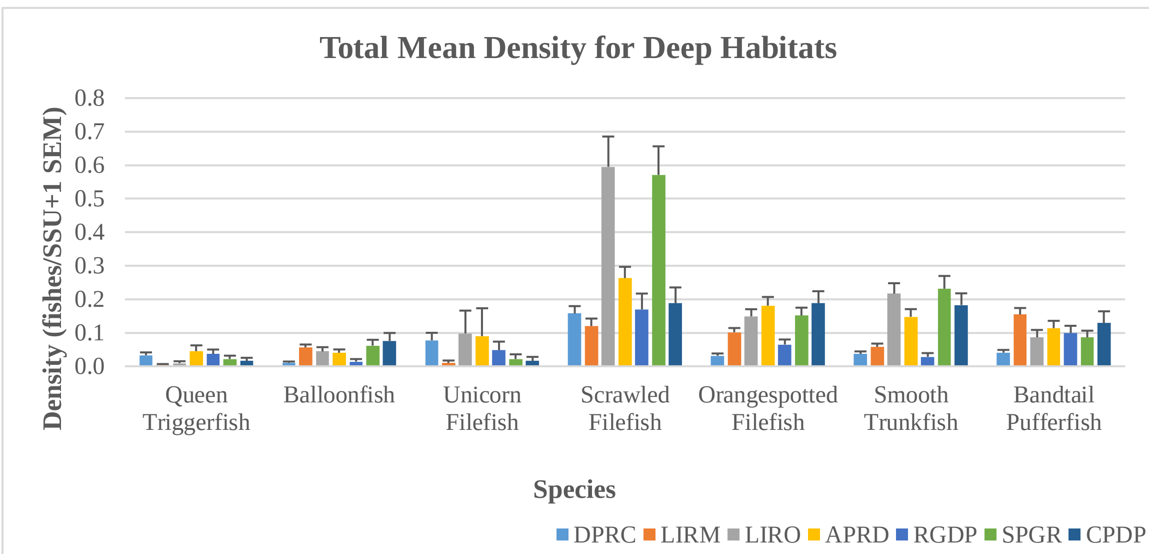

Figure 31. *Total mean densities for the Queen Triggerfish, Balloonfish, Unicorn Filefish, Scrawled Filefish, Orangespotted Filefish, Smooth Trunkfish, and Bandtail Pufferfish for the deep habitats throughout 2012 to 2016 [DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=930)].*

Six of the nine species, Gray Triggerfish, Queen Triggerfish, Scrawled Filefish, Orangespotted Filefish, Smooth Trunkfish, and Sharpnose Pufferfish showed significance ($P<0.05$) in the Kruskal-Wallis test. This significance indicates that their populations within the eleven benthic habitats were not identical. The other three species (Balloonfish, Unicorn Filefish, and Bandtail

Pufferfish) may not have given a significant result due to their small sample sizes (see Table 2, page 45).

For the six species showing significance, a post-hoc analysis was completed to show where the significance occurred. The Gray Triggerfish had the highest significance and showed differences between 23 of 55 pairings between the benthic habitats (Appendix 7). Between these habitats, the Gray Triggerfish showed the highest significant difference for LIRO and PTCH, suggesting that the mean density had significant difference since LIRO was one of the least and PTCH appeared to have the highest mean density for this species. The Smooth Trunkfish had the next highest significance showing significance between 22 of the 55 pairings. Of the six species, the Queen Triggerfish showed the least significant difference between the habitats with differences occurring between 10 of 55 pairings.

4.2 Mean Density in Depth Categories

Each of the eleven benthic habitats had different amounts of sampling effort applied to them, thus the depths were also sampled with different amounts (Figure 32). The total sites sampled for the shallow depth category was 839 while the deep depth category was sampled 1,591 times. 2013 and 2014 were the only years that the deep habitats were sampled more than 400 times. 2013 was sampled 423 times meanwhile 2014 was sampled 409 times. During 2012, the deep habitats were sampled 236 times, meanwhile in 2015, they were sampled 268 times, and then in 2016, a total of 255 times. The shallow sites were sampled more than 200 times in only one year, 2013. For both 2012 and 2014, the shallow sites were sampled a total of 196 times, while in 2015 sampling only occurred in the shallow sites 149 times, and then even less in 2016 with a total of 82 times.

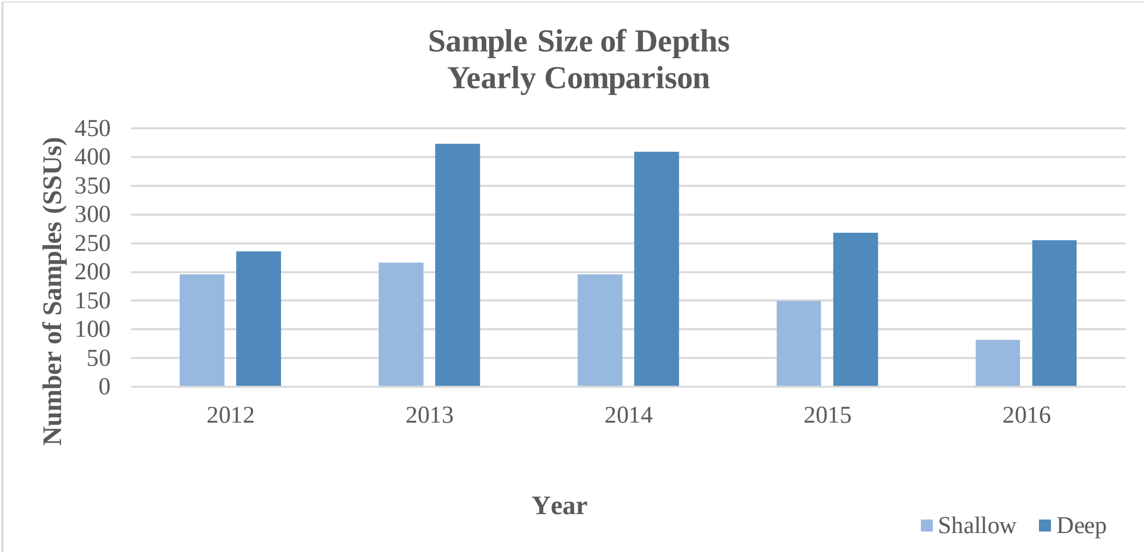

Figure 32. *The total samples (SSUs) for each depth by year.*

Since only two depth categories were chosen, shallow and deep, analysis for the selected species did not include a Kruskal-Wallis test but only descriptive statistics. While looking at the total mean density (all selected species combined), the deep depth had a mean density, $\overline{D}$=0.668, while the shallow depth had a mean density of $\overline{D}$=0.340 (Figure 33).

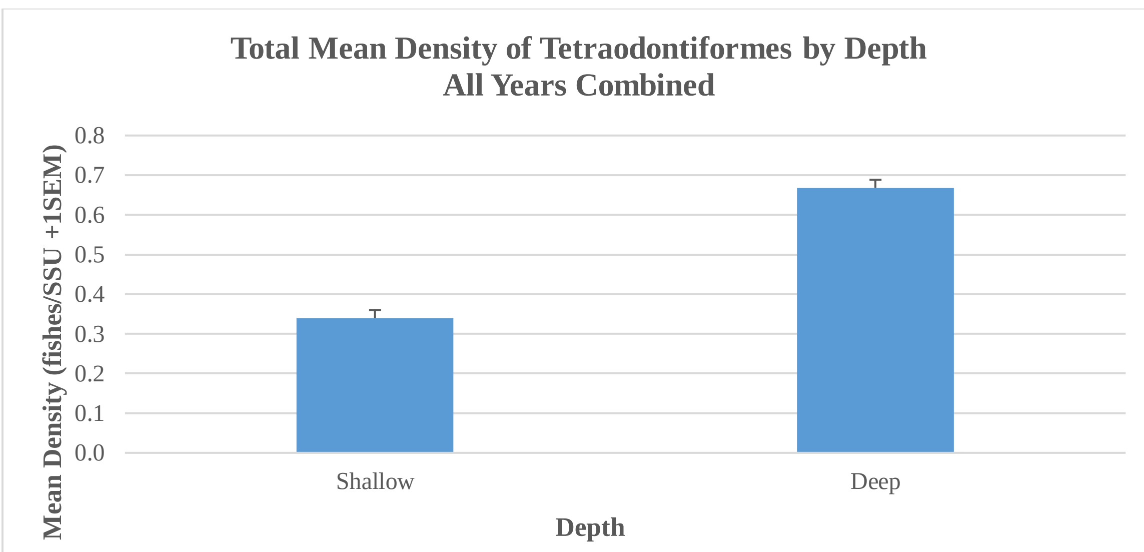

Figure 33. *Total mean density for all selected Tetraodontiformes combined for depths throughout 2012 to 2016 [Shallow (N=839), Deep (N=1,591)].*

Analyzing the two depth categories within each year showed that the shallow depth habitat had a small range of mean densities (excluding 2016) of 0.20 to 0.36, meanwhile the mean density of the selected species in 2016 was higher than 0.60 (Figure 34). For the deep habitats, the range of mean densities (once again excluding 2016), appeared to be within 0.50 to 0.75. 2016 appeared to have a higher mean density, much higher than the other years (Figure 34). When looking at the differences between 2015 to 2016, it seemed that the mean density doubled for both habitats (Figure 34).

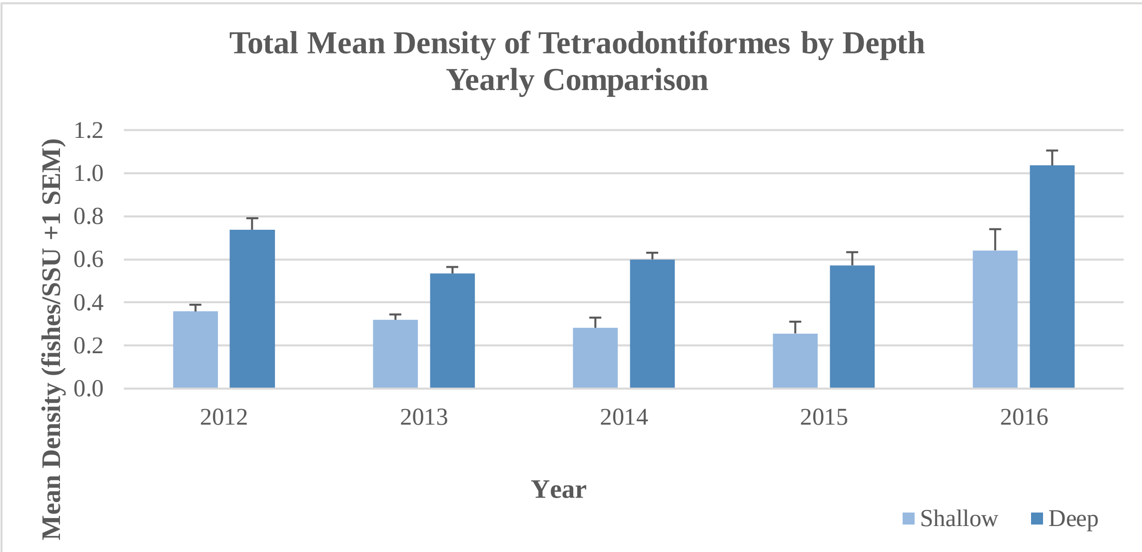

Figure 34. *Total mean density for all selected Tetraodontiformes combined by year and depth [Shallow (N=839), Deep (N=1,591)].*

The results for depth categories show that both the Gray Triggerfish and the Sharpnose Pufferfish had higher mean densities compared to the other seven species (Figure 35). The other seven species had similar mean densities, excluding Scrawled Filefish in the deep category (Figure 36). The Scrawled Filefish appeared to have a higher mean density than the six species (Queen Triggerfish, Balloonfish, Unicorn Filefish, Orangespotted Filefish, Smooth Trunkfish, and Bandtail Pufferfish), of which, could potentially show a significant difference (Figure 36). Each species selected, except the Balloonfish, appeared to have a higher mean density in the deep category (Figures 35 and 36). The Sharpnose Pufferfish appears to have a higher mean density found within all the selected species in the deep category ($\overline{D}$=3.683), meanwhile it appears the Queen Triggerfish had a lower mean density found in the shallow category ($\overline{D}$=0.0006). Unicorn Filefish were never found within any of the shallow habitats (Figure 36).

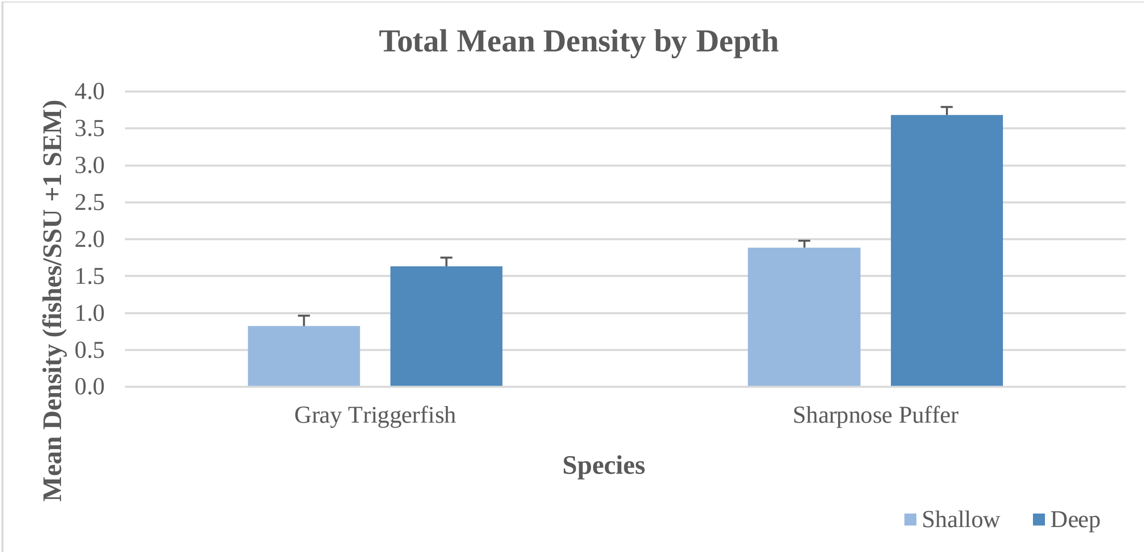

Figure 35. *Total mean densities for the Gray Triggerfish and Sharpnose Pufferfish for the shallow habitats throughout 2012 to 2016 [Shallow (N=839), Deep (N=1,591)].*

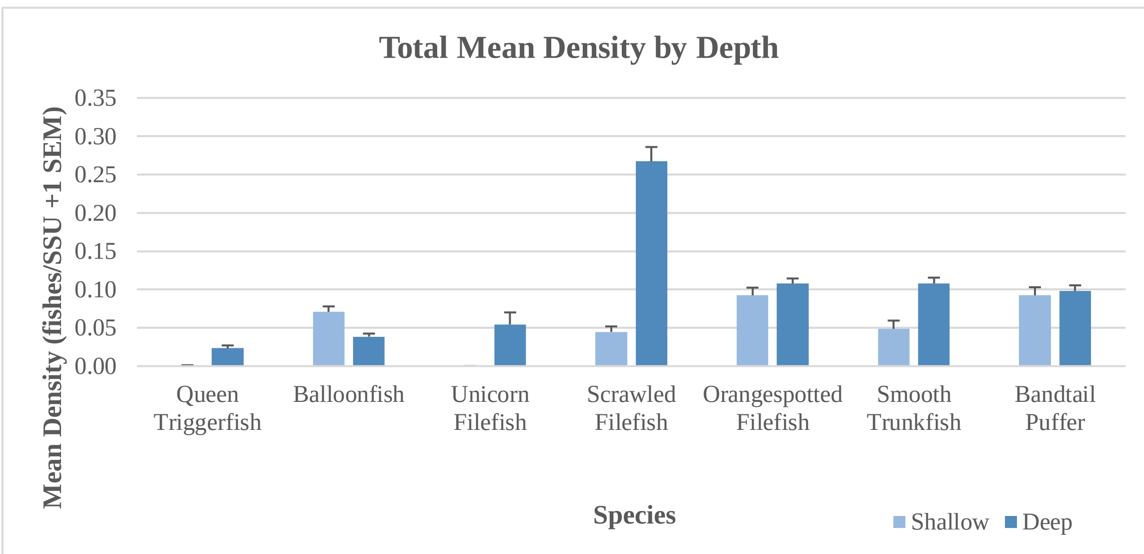

Figure 36. *Total mean densities for the Queen Triggerfish, Balloonfish, Unicorn Filefish, Scrawled Filefish, Orangespotted Filefish, Smooth Trunkfish, and Bandtail Pufferfish for the depths throughout 2012 to 2016 [Shallow (N=839), Deep (N=1,591)].*

4.3 Mean Density in Ecoregions

Similar to the habitat and depth sampling, each of the ecoregions were not sampled equally during 2012 to 2016. These differences in sampling distribution occurred between the ecoregions due to different amounts of coral reef and hardbottom habitats within the sampling depth range, as well as differences in the total area for each ecoregion. Broward-Miami was sampled the most throughout the five years, with a yearly mean of 250 times, while Martin was sampled the least, with a yearly mean of 42.4 times (Table 4). Both Deerfield and South Palm Beach were sampled relatively similar with means around 57 times, while North Palm Beach had a mean of 79.2 times (Table 4).

Table 4. *The total and mean SSU for each of the ecoregions from 2012 to 2016.*

Ecoregion	Total	Mean
Broward-Miami	1250	250
Deerfield	286	57.2
South Palm Beach	283	56.6
North Palm Beach	396	79.2
Martin	212	42.4

Throughout the five years, Broward-Miami was always sampled the most each year (Figure 37). The most sampling in Broward-Miami was in 2013, 320 times, while the least sampling was in 2016, 158 times. For Deerfield, South Palm Beach, and North Palm Beach, 2013 had the most samples within the ecoregions, 90, 78, and 106, respectively. As for Martin, 2014 had the most sampling, 78.

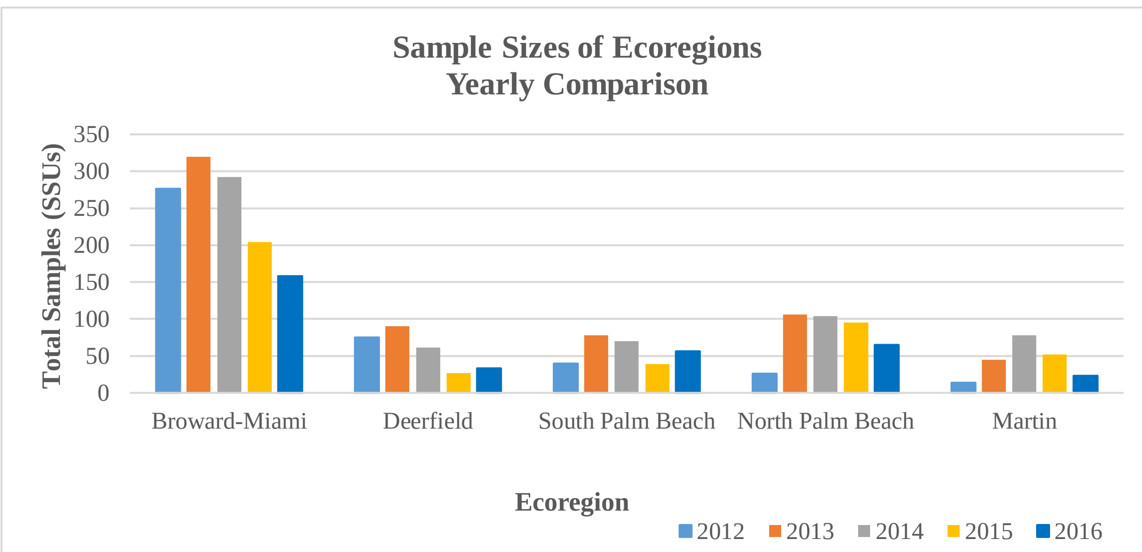

Figure 37. *The total samples (SSUs) for each ecoregion by year.*

As for the ecoregions, it appeared that South Palm Beach had a higher total mean density (of all selected species combined) throughout 2012 to 2016 (Figure 38). Martin appeared to have the least meanwhile North Palm Beach was very similar (Figure 38). The results appeared to show that South Palm Beach had a higher mean density, excluding 2012, found in the ecoregions for each year (Figure 39). In 2012, Deerfield appeared to have a slightly higher mean density compared to

South Palm Beach but very marginal. All ecoregions, excluding Deerfield (which had a higher mean density found in 2012), appeared to have a higher mean density within sampling of 2016. It appeared, with the exceptions of all sampling in 2016, all mean densities of South Palm Beach, and Deerfield in 2012, that all mean densities were found to be around 0.505 or less (Figure 39).

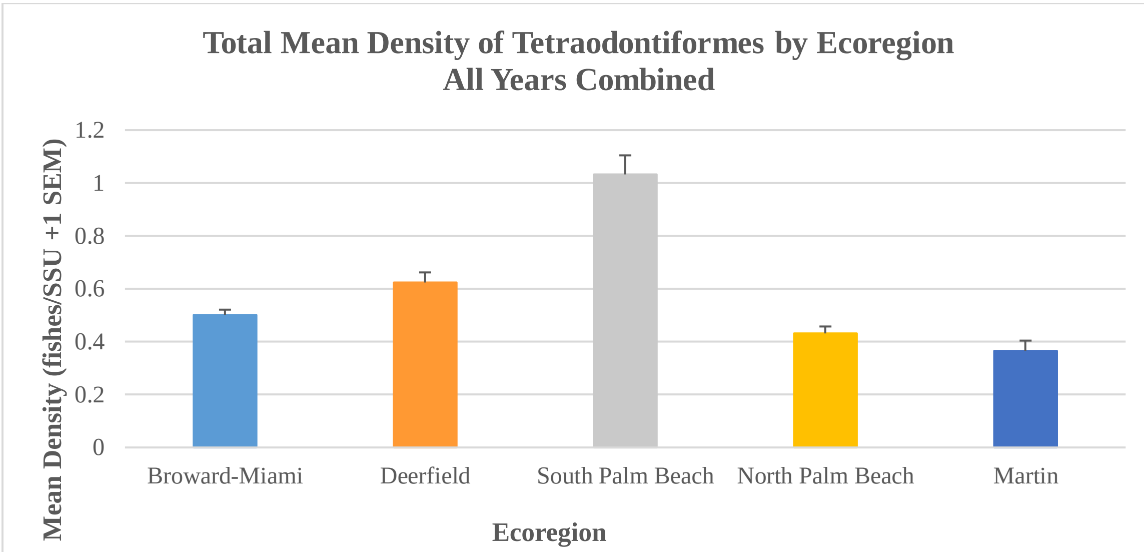

Figure 38. *Total mean density for all selected Tetraodontiformes combined for ecoregions throughout 2012 to 2016 [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

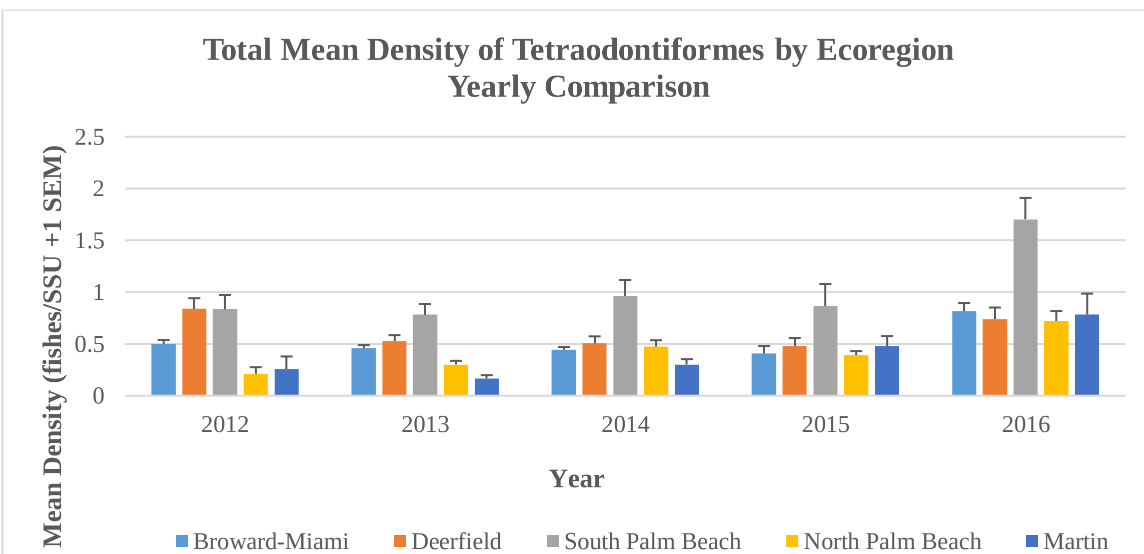

Figure 39. *Total mean density for all selected Tetraodontiformes combined by year and ecoregions [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

Overall, the Sharpnose Pufferfish appeared to have a higher mean density in South Palm Beach (Figures 40 and 41). Sharpnose Pufferfish appeared to have high mean densities in South Palm Beach, Deerfield, and Broward, while the Gray Triggerfish appeared to have high mean densities found in the Martin, South Palm Beach, and North Palm Beach ecoregions (Figures 40 and 41). The Queen Triggerfish appeared to have similar mean densities found within all ecoregions excluding Broward-Miami. Balloonfish appeared to have high mean densities found in Deerfield, Broward-Miami, and South Palm Beach, meanwhile the Unicorn Filefish was not found in Deerfield and appeared to have high mean densities in North and South Palm Beach (Figure 41). For both species Orangespotted Filefish and Smooth Trunkfish, results appeared to show very similar high mean densities within the South Palm Beach and Deerfield ecoregions. As for the Scrawled Filefish, the results are very apparent that the South Palm Beach had a high mean density (Figure 41).

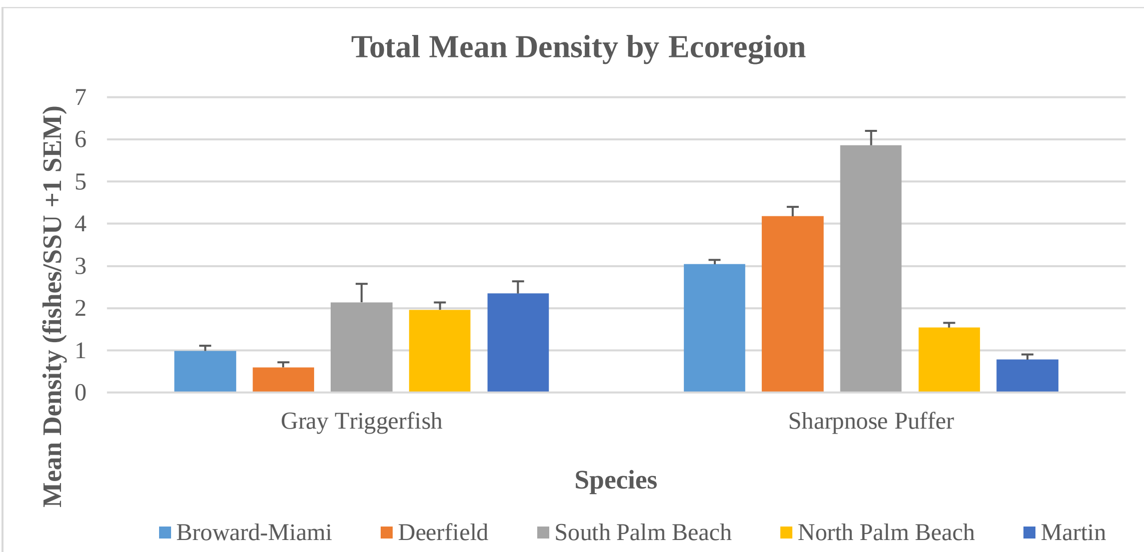

Figure 40. *Total mean densities for the Gray Triggerfish and Sharpnose Pufferfish for the ecoregions throughout 2012 to 2016 [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

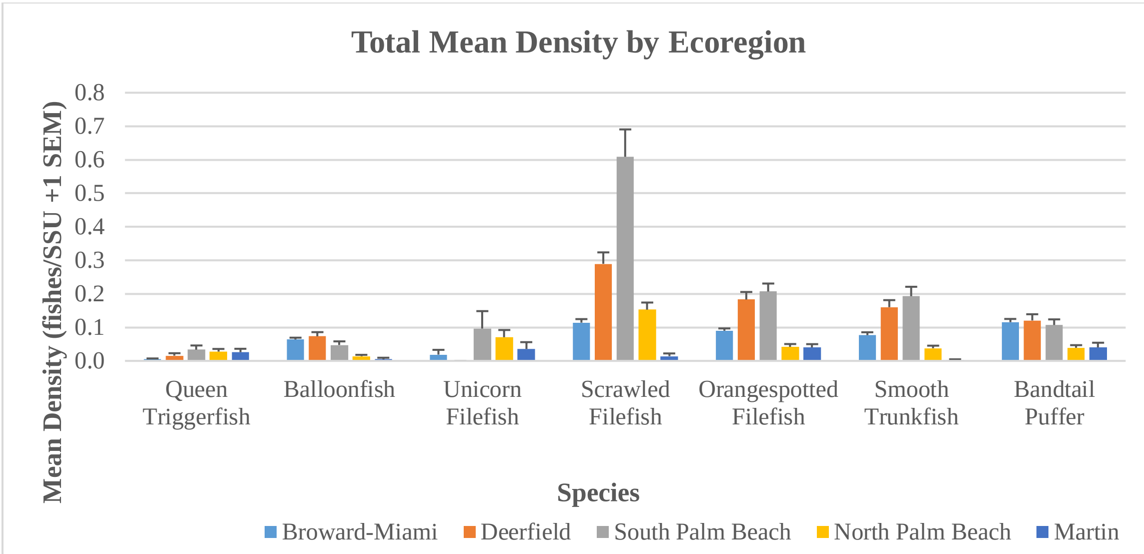

Figure 41. *Total mean densities for the Queen Triggerfish, Balloonfish, Unicorn Filefish, Scrawled Filefish, Orangespotted Filefish, Smooth Trunkfish, and Bandtail Pufferfish Pufferfish for the ecoregions throughout 2012 to 2016 [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

Seven of the nine selected species: Gray Triggerfish, Balloonfish, Scrawled Filefish, Orangespotted Filefish, Smooth Trunkfish, Sharpnose Pufferfish, and Bandtail Pufferfish showed significance ($P<0.05$) in the Kruskal-Wallis test. The Smooth Trunkfish showed the most significance while the Bandtail Pufferfish showed the least significance. These seven species were tested with a post-hoc analysis to determine where the significance was found, all of which, showed significant differences with the Martin ecoregion. Most of the species showed a significant difference between Deerfield and Martin or with one of the Palm Beach ecoregions. Six of these species: Gray Triggerfish, Scrawled Filefish, Balloonfish, Orangespotted Filefish, Smooth Trunkfish, and Sharpnose Pufferfish all had a significant difference between Deerfield and Martin. All but one, the Scrawled Filefish, showed a significant difference between one of the ecoregions with North Palm Beach. As for South Palm Beach ecoregion, all species, excluding the Balloonfish, showed significant differences with other ecoregions. The Gray Triggerfish only showed significant differences with the Deerfield ecoregion. Four of the fish: Balloonfish, Smooth Trunkfish, Sharpnose Pufferfish, and Bandtail Pufferfish showed significant differences between Broward-Miami and Martin.

5.0 Discussion

Both hypotheses, that one or more species would exhibit differences in mean densities between benthic habitats or local ecoregions, were accepted because multiple species showed significant differences in the Kruskal-Wallis statistical test. The sample sizes were too small to run analytical statistics for the second hypothesis, which focused on depth, but several differences could be seen within the descriptive statistics. The nine selected species account for 0.98% of the total fish population, so even though the results between benthic habitats and ecoregions show significance, it is on an extremely small scale. The results mainly indicate if a species were present within the benthic habitat, depth, or ecoregion, however, there could be many reasons these species were seen or not seen.

5.1 Benthic Habitats

Since six of the selected species showed significant differences between benthic habitats, the first hypothesis that one or more species would exhibit differences in mean densities between benthic habitats is accepted. Each of these species may have shown differences within a few habitats for various reasons. As to the reasons why, the fish found in the habitats could be simply due to random chance, more protective areas/refuge availability, prey availability, or areas to spawn. For some species, such as the larger and more mobile species (i.e. triggerfishes and filefishes), these fish may not have been residents of the sampling area and were just passing through the area during sampling. SCRS was not used in the analysis because of lack of sampling. SCRS was only found within two of the ecoregions, Broward-Miami and Martin, and was only sampled three times in 2013 of which none of the selected species were seen within the habitat.

Both the Sharpnose Pufferfish and Gray Triggerfish appeared to have a higher mean density for all the benthic habitats. Because different amounts of sampling effort were applied to each of the habitats that were sampled, the numbers may tend to show significance in habitats that were poorly sampled, or vice-versa, no significance in habitats sampled frequently. For example, the Gray Triggerfish appeared to have a higher mean density within PTCH, $\overline{D}$=7.547, but the habitat was only sampled a total of 32 times within the five years. In 2014 and 2015, the Gray Triggerfish had a mean density over 20 fishes/SSU for the PTCH habitat, of which this habitat was only sampled 4 times thus giving it a high error bar (Figure 42).

The Gray Triggerfish showed a significant difference (*P<0.05*) between all the habitats. Most of these differences occurred between the habitats with the lower mean densities, such as LIRO, APRD, SPGR, and RGSH and the higher mean densities, such as PTCH, RGDP, DPRC, and LIRM (Figure 42). The most significant difference occurred between LIRO-PTCH as well as LIRO-RGDP due to the vast difference of the mean densities.

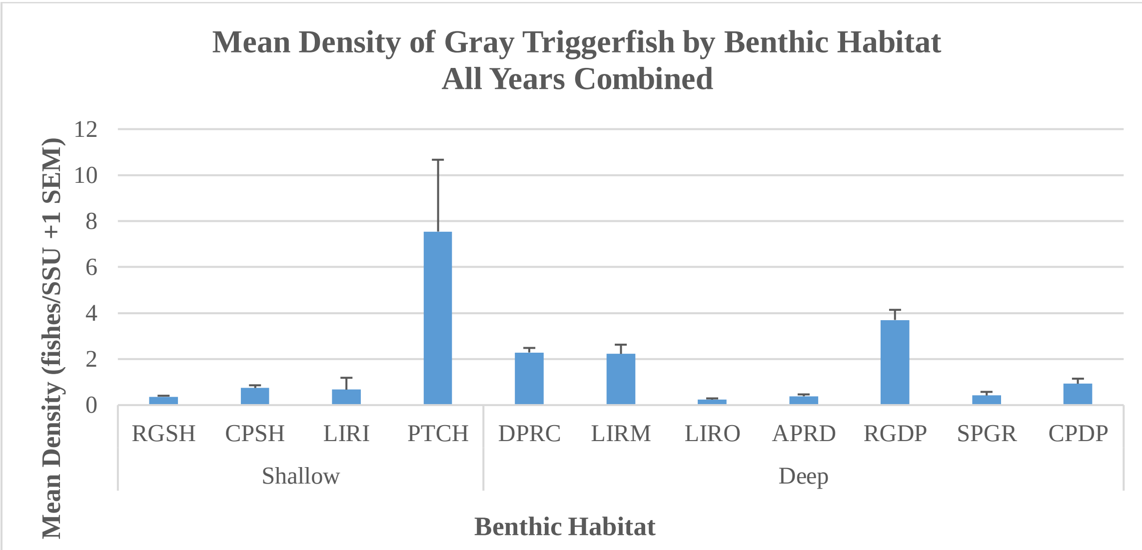

Figure 42. *Gray Triggerfish total mean density (fishes/SSU) by benthic habitats throughout 2012 to 2016 [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

When analyzing the mean densities for the Gray Triggerfish for each year, besides the PTCH habitat, this species was more commonly found in the deep habitats (Figures 43 and 44). In 2015, the Gray Triggerfish appeared to have a higher density found within LIRM and RGDP, meanwhile in 2016 they were more commonly found in DPRC and RGDP (Figure 43). In comparison with the linear reefs, the inner (LIRI) and outer (LIRO) were very similar, excluding LIRI in 2016 which appeared to have a higher mean density, meanwhile the LIRM had a higher mean density throughout all the years (Figure 43).

It seems that Gray Triggerfish were more commonly seen in the years 2014 and 2015 throughout all habitats. There were a few occasions during sampling where large aggregations of small individuals (>15 cm) were recorded in the shallow habitats, PTCH especially (Figure 44) (Kilfoyle et al., 2018). Without data analysis, it seemed that larger individuals were more commonly seen in the deeper habitats. Throughout literature, these fish have been found in shallow waters over hardbottom on reefs or rocky areas, meanwhile juveniles have been known to be associated with floating rafts of seaweed (Kilfoyle et al., 2018).

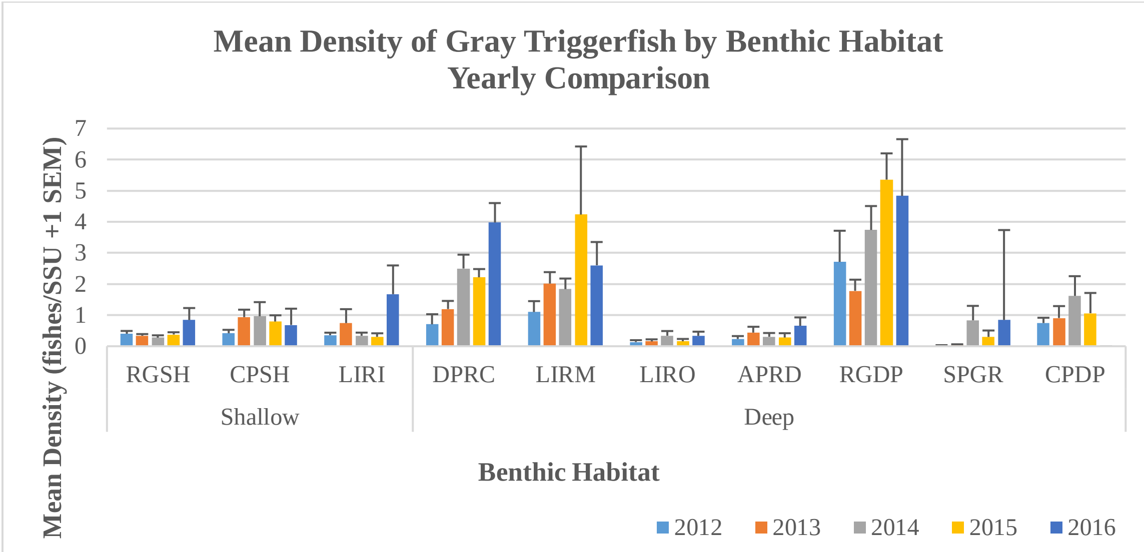

Figure 43. *Gray Triggerfish mean density (fishes/SSU) for benthic habitats, excluding PTCH, by year [RGSH (N=352), CPSH (N=237), LIRI (N=215),), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

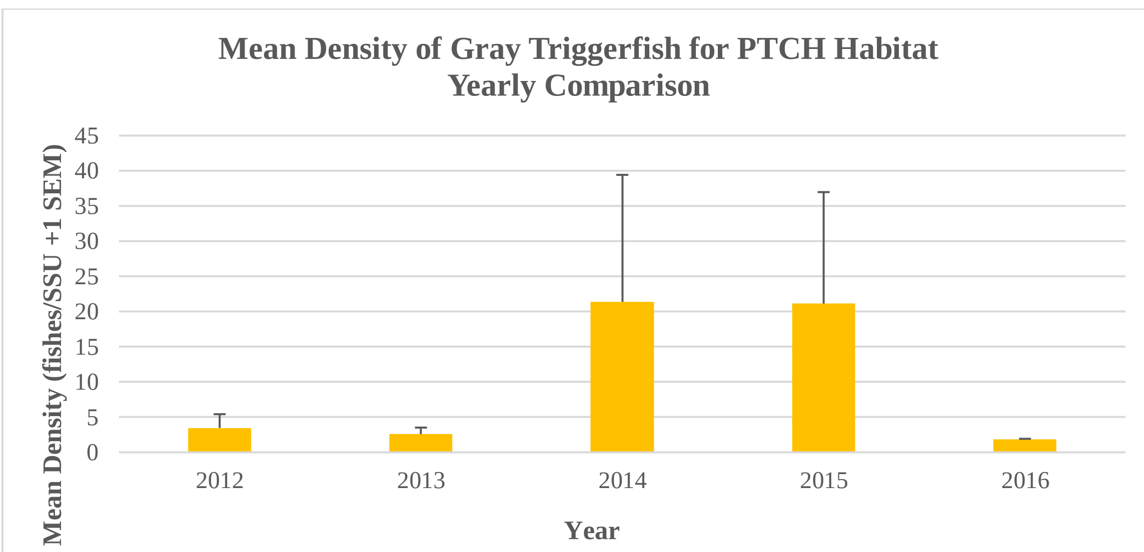

Figure 44. *Gray Triggerfish total mean density (fishes/SSU) for PTCH by year [PTCH (N=32)].*

As for the Queen Triggerfish, the results were a little different than the Gray Triggerfish besides substantially lesser mean densities. The Queen Triggerfish were only found in a shallow habitat (LIRI) in one year, 2014 (Figure 46), whereas they were well represented in the deeper habitats, even if sporadically. The Queen Triggerfish had significant differences between the habitats that had a 0 mean density (such as RGSH, CPSH, and PTCH) to the habitats that had, for this species, high mean densities (APRD, DPRC, and RGDP) (Figure 45). The only habitats that showed significance where fish were seen within both habitats was between DPRC-LIRI. These results show that, even if sporadically, the Queen Triggerfish are commonly found in deeper waters, which agrees with literature.

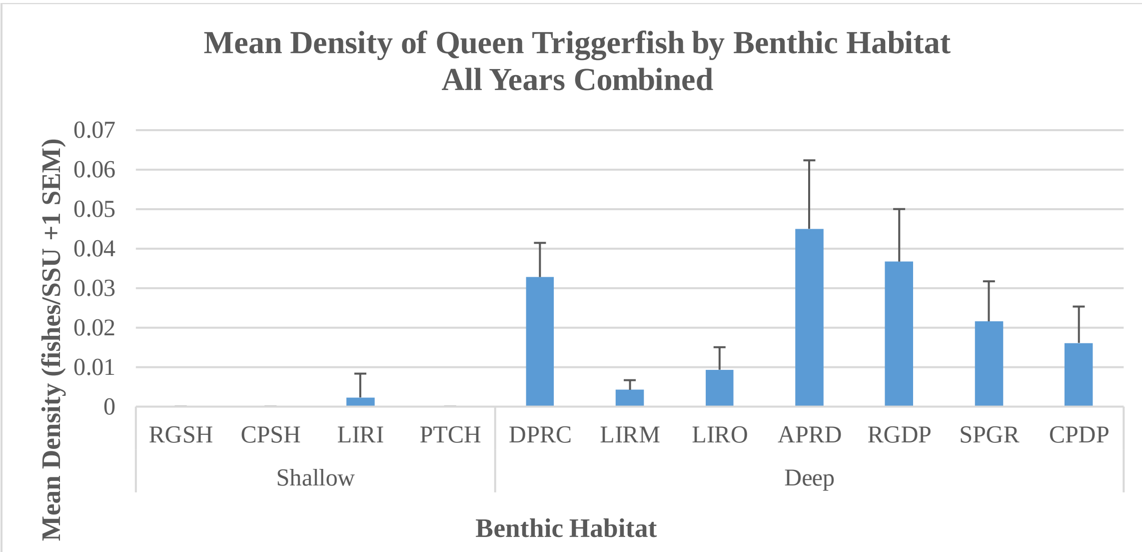

Figure 45. *Queen Triggerfish total mean density (fishes/SSU) by benthic habitats throughout 2012 to 2016 [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

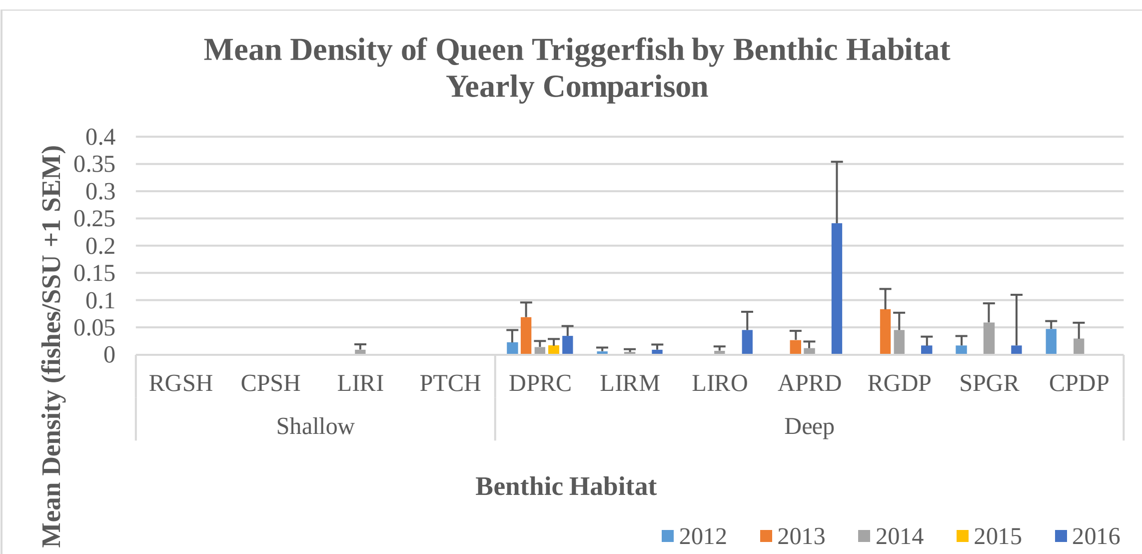

Figure 46. *Queen Triggerfish mean density (fishes/SSU) for benthic habitats by year [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

For the three filefish tested, both Scrawled and Orangespotted Filefish showed significant differences between the benthic habitats. Unicorn Filefish did not but that could be because the low numbers in the dataset as well as not being seen within any of the shallow habitats (Figure 47). The Unicorn Filefish was not seen every year in every habitat, did not have consistent densities within any of the habitats, and was seen the most in 2016 in LIRO, even though it has a high error bar (Figure 48). It would appear with these results, that Unicorn Filefish are more commonly found within deeper habitats.

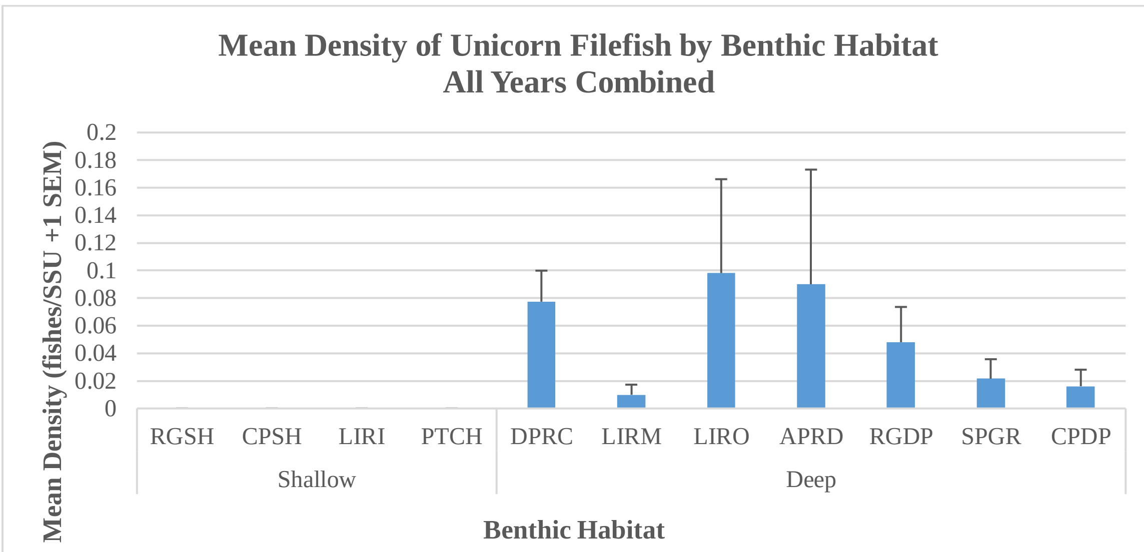

Figure 47. *Unicorn Filefish total mean density (fishes/SSU) by benthic habitats throughout 2012 to 2016 [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

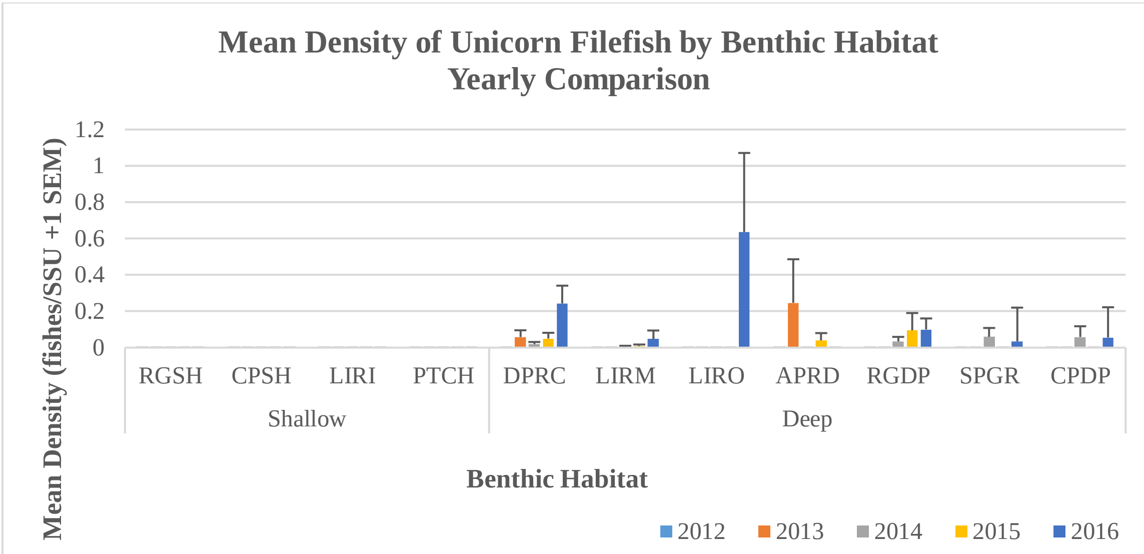

Figure 48. *Unicorn Filefish mean density (fishes/SSU) for benthic habitats by year [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

Scrawled Filefish were ranked the 3rd highest species counted (N=463) of the selected Tetraodontiformes, almost double the amount of Orangespotted Filefish (N=249), ranking the 4th highest. Scrawled Filefish appeared to have a higher mean density found in LIRO, meanwhile the Orangespotted Filefish appeared to have a higher mean in CPDP, although very similarly to PTCH and APRD (Figures 49 and 50). It is much more noticeable that the Scrawled Filefish was more commonly found in the deeper habitats while the Orangespotted Filefish was seen throughout all benthic habitats, with much smaller mean densities. Both species had very similar mean densities found within both LIRM and CPDP. Meanwhile, the Unicorn Filefish had a comparable mean density of LIRM but in LIRO, which was one of the species highest mean densities while LIRM was the least (Figure 48).

As for the habitats that had significant differences for Scrawled Filefish and Orangespotted Filefish, like other species, differences appeared between the habitats with lower and higher mean densities. Both species had multiple significant differences ($P<0.05$) between habitats with CPSH, for example CPDP, APRD, SPGR, as well as LIRO. Another similar significant difference for both species occurred between DPRC-LIRO. Both species had these differences due to CPSH having a lower mean density than the other habitats. Scrawled Filefish had differences occur between LIRO-LIRI as well as SPGR-RGSH meanwhile Orangespotted Filefish had differences occur between APRD-DPRC as well as LIRI-CPSH (Figures 49 and 50). Because Scrawled

Filefish had higher mean densities in general, the species had more significant differences than Orangespotted Filefish. For example, Scrawled Filefish also had significant differences occur between deep habitats, such as LIRM-LIRO, and LIRM-SPGR (Figure 49).

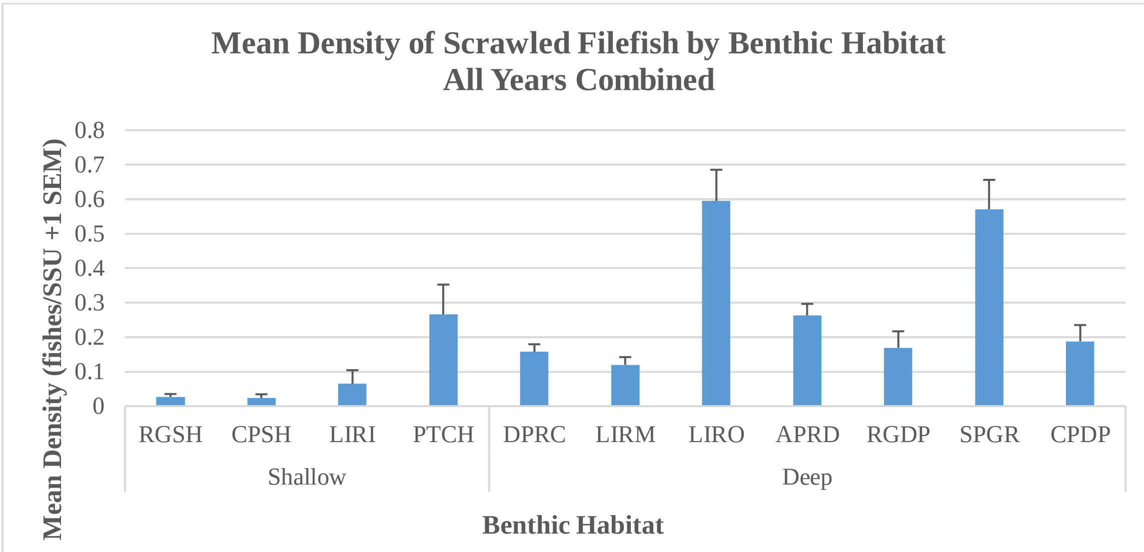

Figure 49. *Scrawled Filefish total mean density (fishes/SSU) by benthic habitats throughout 2012 to 2016 [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

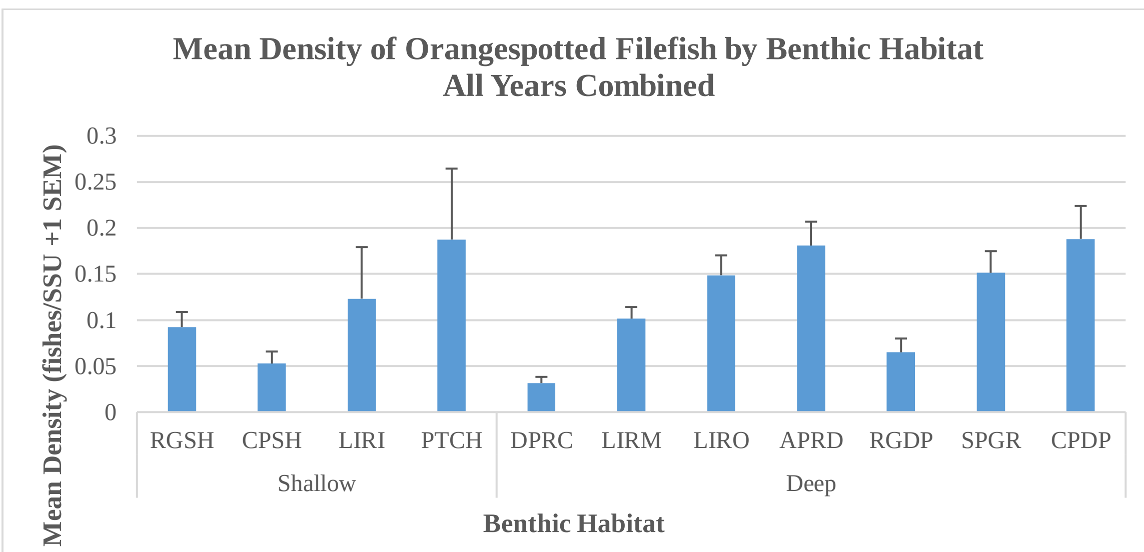

Figure 50. *Orangespotted Filefish total mean density (fishes/SSU) by benthic habitats throughout 2012 to 2016 [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

The Orangespotted Filefish had higher mean densities found within RGSH, CPSH, and LIRI than the Scrawled Filefish (Figures 51 and 52). Of these habitats, the Scrawled Filefish was only seen three of the five years in CPSH, meanwhile the Orangespotted Filefish was seen four years. The Orangespotted Filefish was seen all five years in the RGSH meanwhile the Scrawled Filefish was seen four of the five years (Figures 51 and 52). These results could show within the three selected filefish, Orangespotted Filefish tend to be more common in the local shallow habitats than the other species found in the same family.

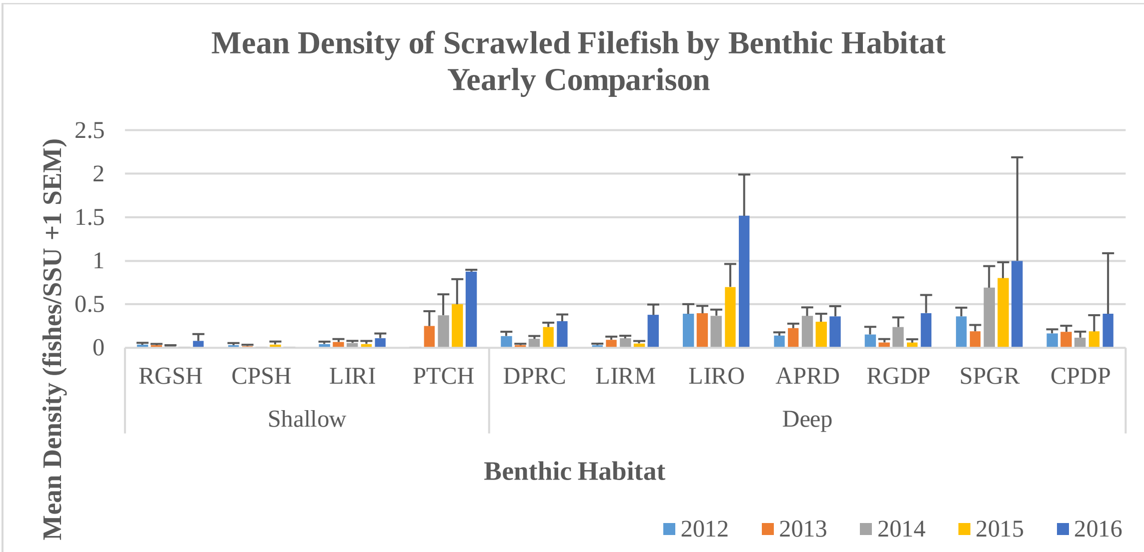

Figure 51. *Scrawled Filefish mean density (fishes/SSU) for benthic habitats by year [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

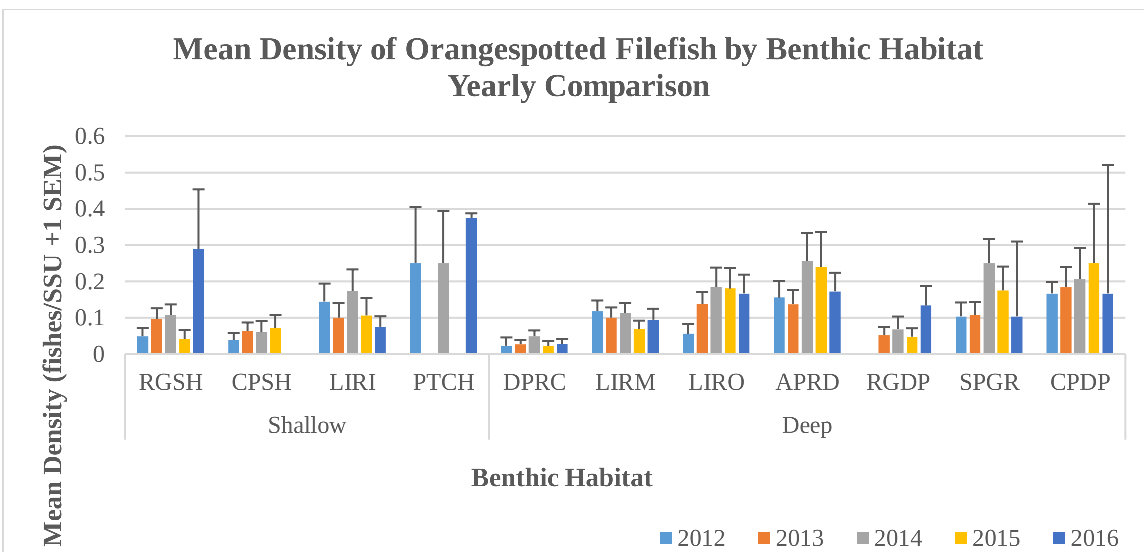

Figure 52. *Orangespotted Filefish mean density (fishes/SSU) for benthic habitats by year [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

Smooth Trunkfish are normally found solitary or in small groups swimming in the sand, or close to the coral reefs (Leis et al., 2015), which supports that the highest density, even though it has the greatest error bar, was found in the PTCH habitat (Figure 53). The PTCH habitat mean density is comparable to the mean densities of the LIRO, SPGR, and CPDP habitats, which all consist of reefs, colonized pavement, or sandy bottoms in between portions of reefs. Significant differences came from the shallower habitats compared to the deeper habitats, such as RGSH-APRD, CPSH-CPDP, as well as others. Even though the differences occurred mainly between the shallow and deep habitats, differences did occur between the deep habitats, such as DPRC-LIRO, LIRM-LIRO, and others (Figure 53) (Appendix 7).

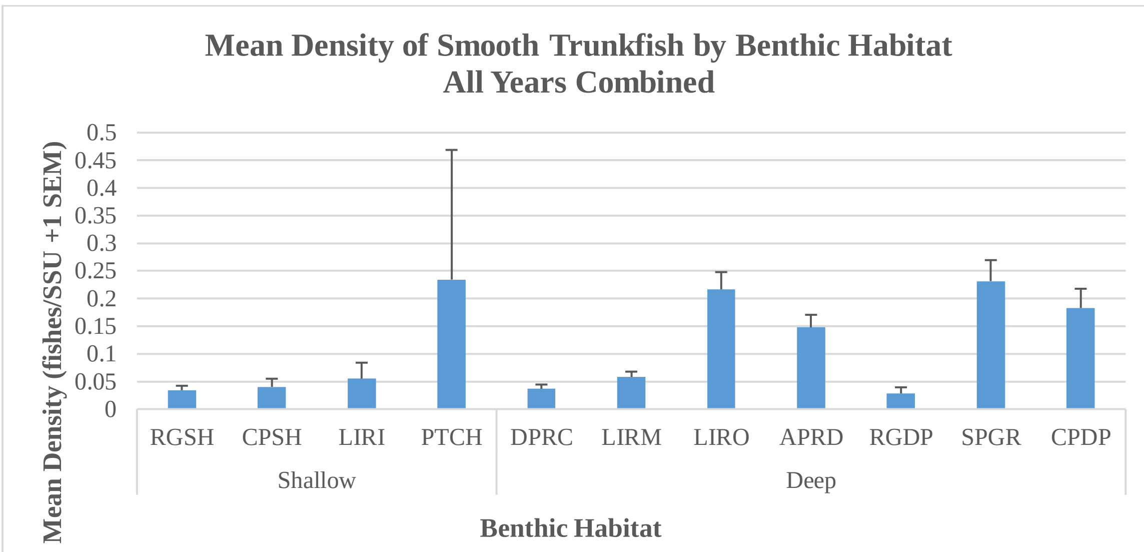

Figure 53. *Smooth Trunkfish total mean density (fishes/SSU) by benthic habitats throughout 2012 to 2016 [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

For the Smooth Trunkfish, it appeared that the highest mean density occurred within 2016 in the PTCH habitat (Figure 55). Since this species was only found within the one year, it could explain the high error bar for this habitat (Figure 53). Once again because of the large range, the figures were separated to compare the mean densities between the other habitats (Figures 54 and 55). Excluding PTCH, CPDP appeared to have a high mean density in 2016 as well (Figure 54). Within the five years sampled, the densities found within LIRO and SPGR were consistent, meanwhile CPDP had a large difference between 2015 and 2016 (Figure 54).

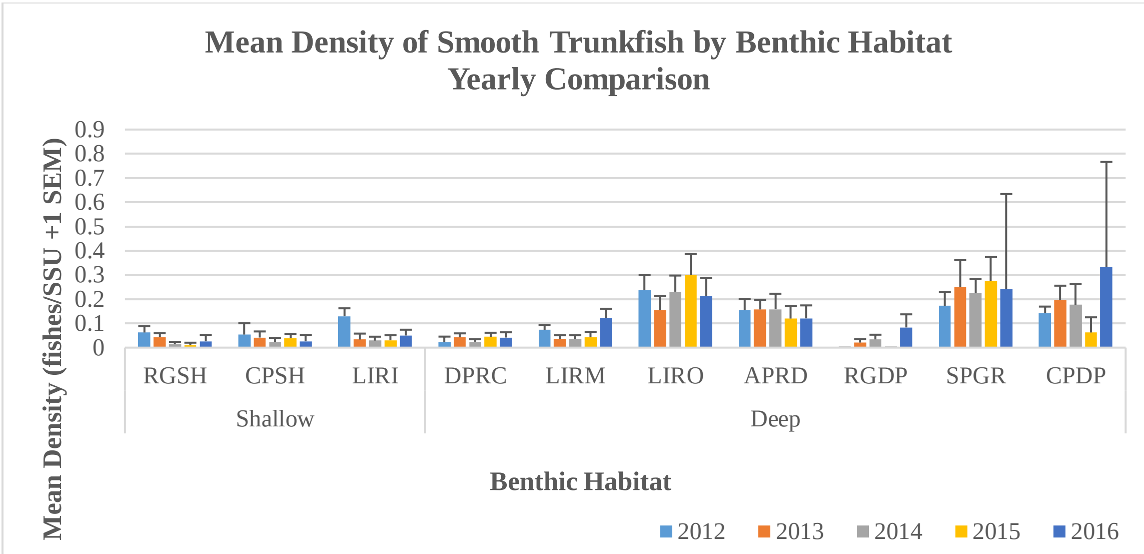

Figure 54. *Smooth Trunkfish mean density (fishes/SSU) by benthic habitats, excluding PTCH, and year [RGSH (N=352), CPSH (N=237), LIRI (N=215), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

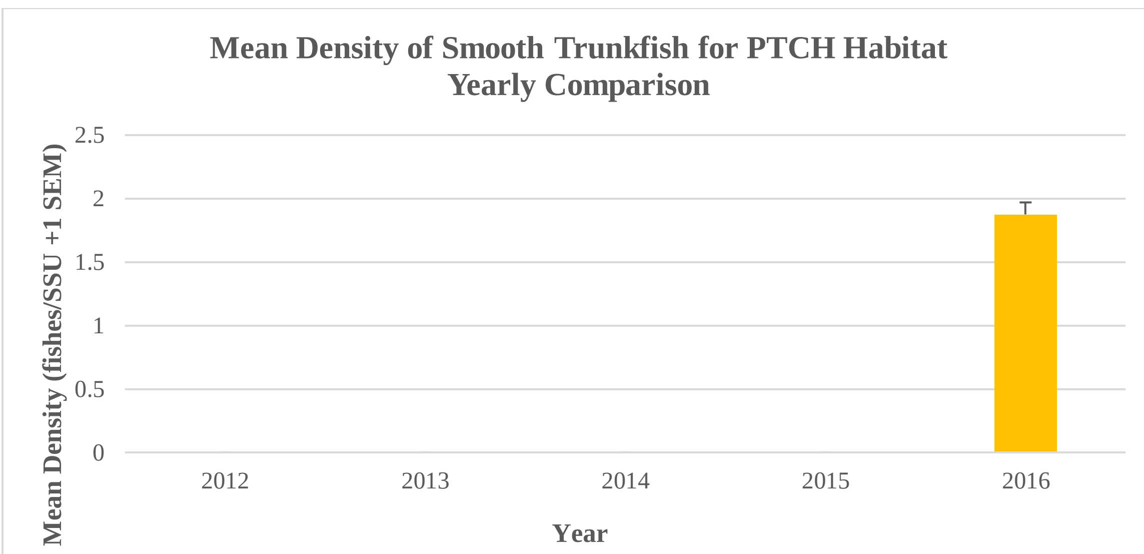

Figure 55. *Smooth Trunkfish total mean density (fishes/SSU) for PTCH by year [PTCH (N=32)].*

The Bandtail Pufferfish did not show any significant differences within the eleven benthic habitats, while the Sharpnose Pufferfish did. Even though these two species are in the same family, their mean densities varied within different habitats (Figures 56 and 57). The Sharpnose Pufferfish appeared to have high densities within APRD, SPGR, and PTCH while the Bandtail Pufferfish had high (for the species) mean densities within LIRM, CPDP, and CPSH (Figures 56 and 57). Significant differences occurred mostly with APRD and SPGR due to the higher mean densities (Figure 56). The only significant difference that the PTCH habitat had a significance between a deep habitat was with DPRC, mostly all the other significant differences occurred with deep habitats to shallow habitats.

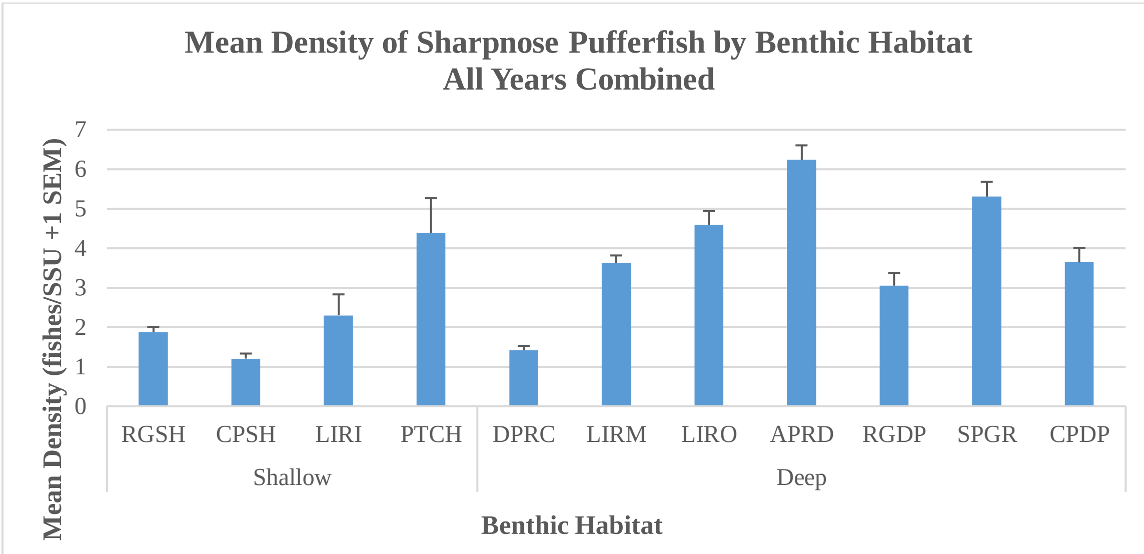

Figure 56. *Sharpnose Pufferfish total mean density (fishes/SSU) by benthic habitats throughout 2012 to 2016 [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

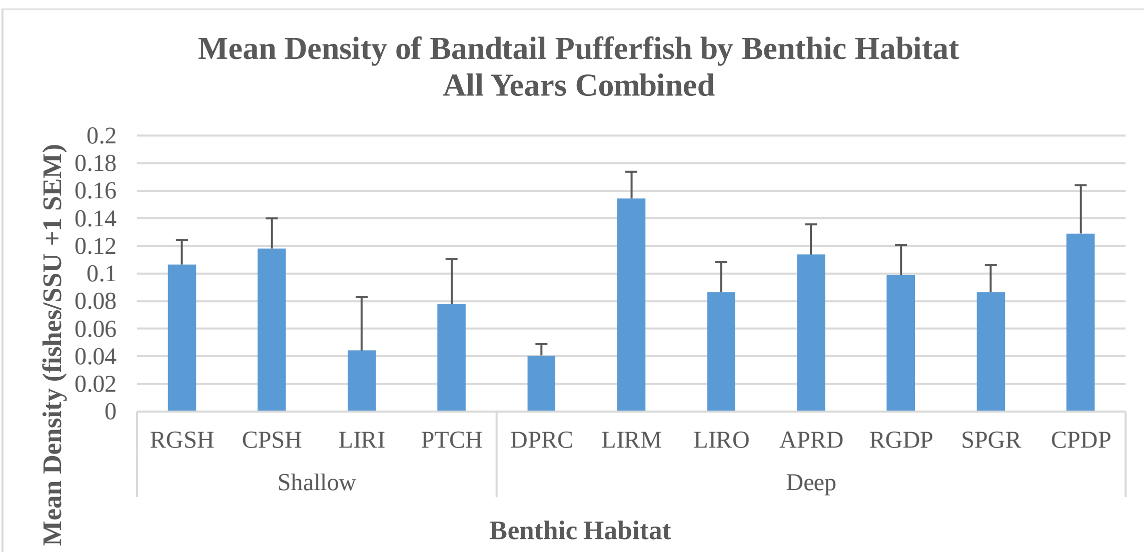

Figure 57. *Bandtail Pufferfish total mean density (fishes/SSU) by benthic habitats throughout 2012 to 2016 [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

Each of the pufferfish were found within all the benthic habitats. Both, however, appeared to have one of their highest mean densities found in PTCH in 2016 (Figures 58 and 59). Sharpnose Pufferfish were seen much more often than the Bandtail Pufferfish and much more common within all habitats in 2016 than other years (Figure 58). The Sharpnose Pufferfish appeared to have lower mean densities found within the habitats, excluding PTCH, in 2015. Some of these densities appeared to be almost half the density found in 2016. It almost appears that the populations were declining within the years, besides PTCH, and then vastly increased in 2016 (Figure 58).

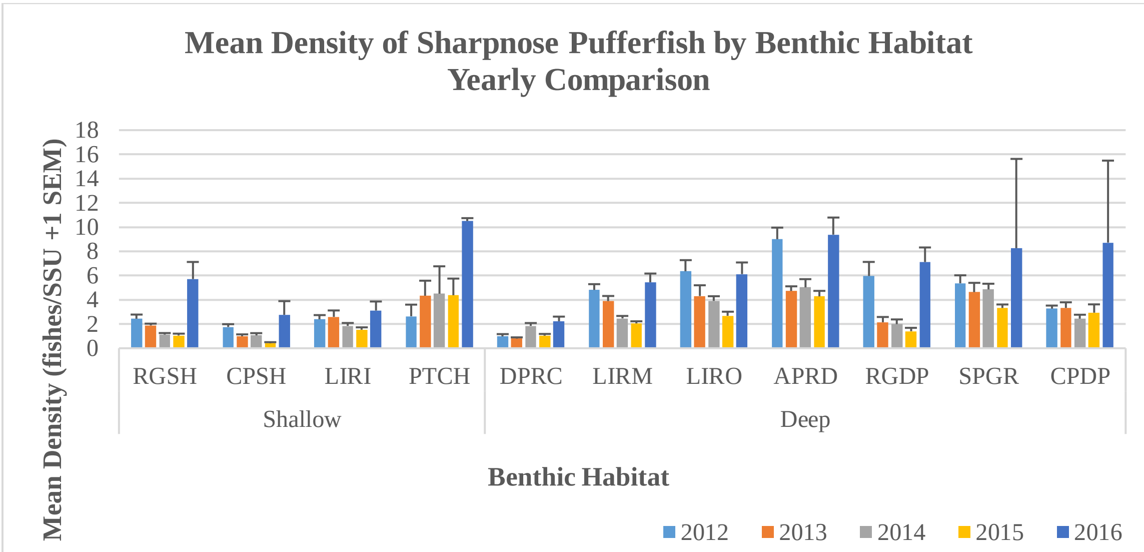

Figure 58. *Sharpnose Pufferfish mean density (fishes/SSU) for benthic habitats by year [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

The Bandtail Pufferfish were more sporadic meanwhile the Sharpnose Pufferfish seemed to have higher densities found in the deeper habitats, such as APRD and SPGR (Figures 58 and 59). Unlike the Sharpnose Pufferfish, the Bandtail Pufferfish seemed to have declining populations within some habitats in 2016 (RGSH, CPSH, DPRC, LIRO, SPGR, and CPDP) (Figure 59). This may just be a coincidence, or this may be a small inclination that this species is becoming less common in the local waters.

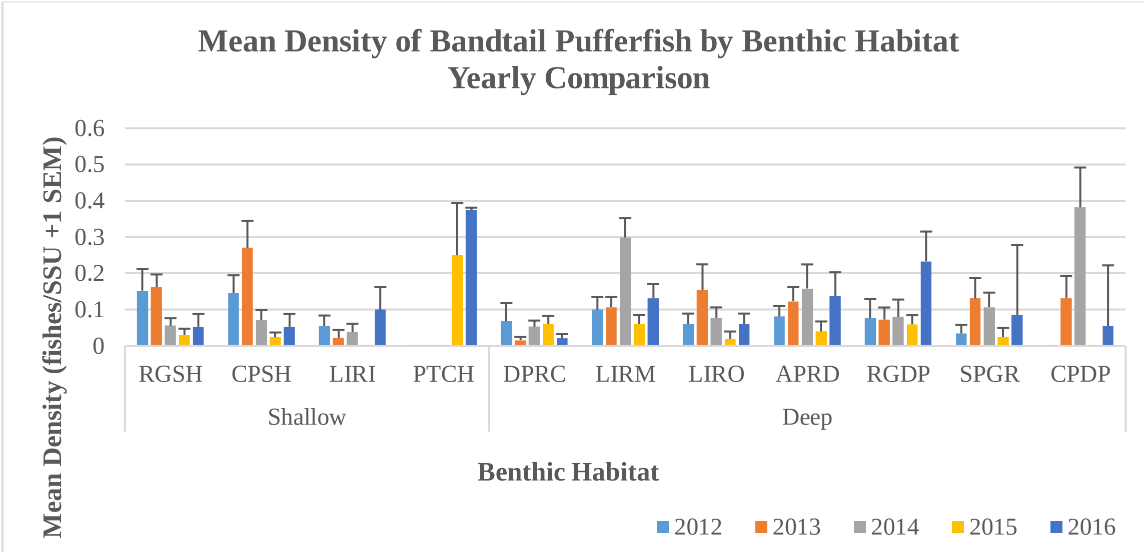

Figure 59. *Bandtail Pufferfish mean density (fishes/SSU) for benthic habitats by year [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

The only fish tested within the Diodontidae family, the Balloonfish, did not show any significant differences between the benthic habitats. The Balloonfish was one of the few species found in every habitat with similar mean densities (Figure 60). It would appear that Balloonfish were more commonly found within the shallow habitats than the deep habitats, with the exception of CPDP (Figure 60).

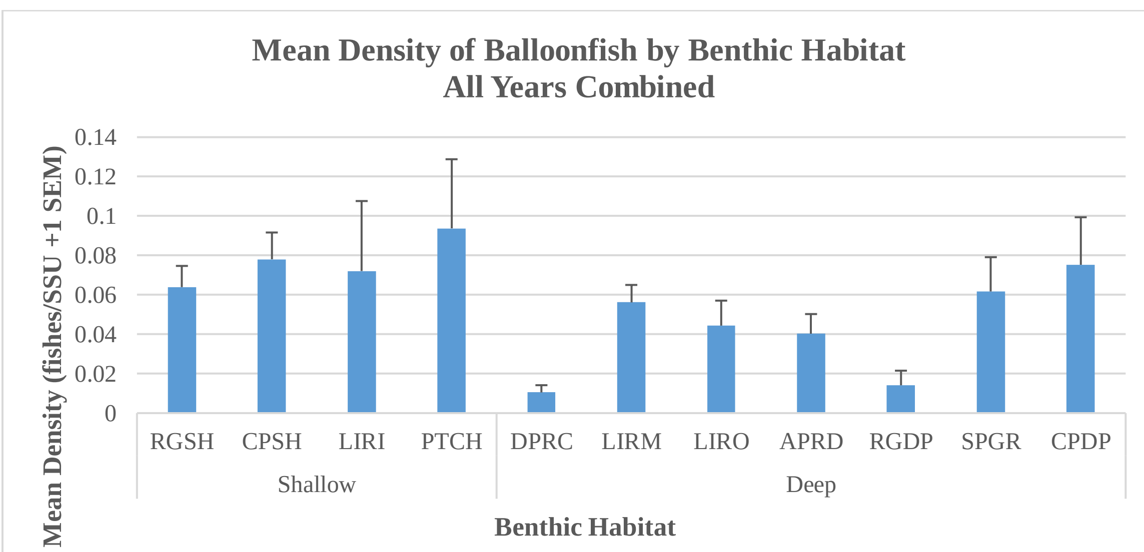

Figure 60. *Balloonfish total mean density (fishes/SSU) by benthic habitats throughout 2012 to 2016 [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

For the Balloonfish, the PTCH habitat appeared to have the highest mean density throughout 2012 to 2016, which is noteworthy because it was only found within the PTCH habitat two of the five years (Figure 61). In 2016, the Balloonfish appeared to have the highest mean density for the species ($\overline{D}$=0.375) with a small error bar. If each year was used in analysis, the Balloonfish may have shown significant differences between the habitats, but since the total mean density was used, the species did not show any differences.

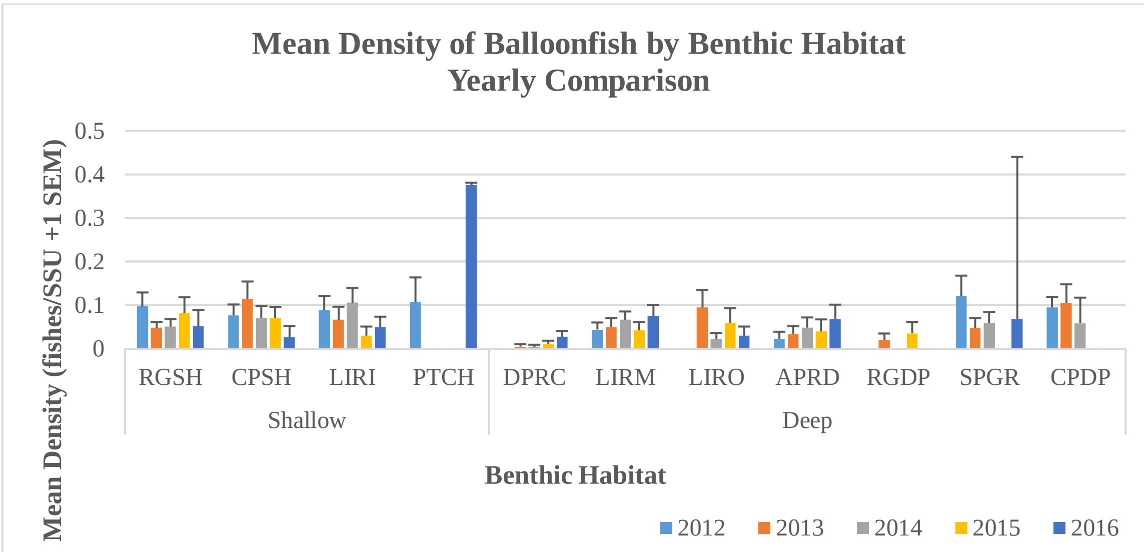

Figure 61. *Balloonfish mean density (fishes/SSU) for benthic habitats by year [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

Even though there were differences between the habitats, most of the species seemed to have been counted within the benthic habitats with more coral reef structures. These structures included coral or hardbottom formations, habitats with alternating sand and coral formations, or ridges. For example, all the selected species were found in LIRM which is defined as a distinct, relatively continuous, linear, shore-parallel reef consisting of a rich coral reef assemblage that crests in approximately 15 meters depth. This habitat type probably contains areas for protection from predators, major portions of diets, as well as areas for dens to spawn.

One common tendency that appeared throughout the results was that a few species had high mean densities found in the PTCH habitat (e.g. Gray Triggerfish, Orangespotted Filefish, Smooth Trunkfish, Sharpnose Pufferfish, and Balloonfish). This is interesting because there was such a small sample size within the fish counts for this habitat, but these five species caused a high total mean density of all the species in 2013 and 2014 (see Figure 25, page 47).

As for the larger more mobile species, another reason they are commonly found in the deeper habitats would be the ontogenetic shift. Habitat use often reflects behavioral decisions associated with the demands of foraging, avoiding predators, as well as reproducing, however as these species change during ontogeny (i.e. due to increases in body size) their habitat needs also change (Dahlgren and Eggleston, 2000). These species often shift habitats to meet these changing needs. Ontogenetic habitat shifts are common for mobile marine species whose post-larvae settle from the pelagic environment to benthic habitats that serve as early juvenile nurseries (Dahlgren and Eggleston, 2000). This shift could justify that the selected species, Gray Triggerfish, Queen Triggerfish, Unicorn Filefish, Scrawled Filefish, Smooth Trunkfish, and Sharpnose Pufferfish were more commonly seen in the deeper benthic habitats.

There could be many reasons as to why the fish were found here, but also reasons why they were not found in certain habitats. Another example would be that all the selected species had low mean densities in CPSH, which is defined as consisting of colonized pavement in water shallower than 10 meters with limited rubble in a wide area inshore of the ridge-complexes. The low mean densities could be justified because there is no protection from predators for the selected species, or because of the rubble, no places for spawning. Each habitat has advantages for the species to be there as well as disadvantages, these results just show that some species were found in some places as opposed to others.

5.2 Depth

The second hypothesis was if one or more selected species exhibited differences in mean densities between different depths. All Tetraodontiformes are observed throughout literature to be at depths of 120 meters but are commonly found in shallower depths. Because of this large range suggested in the literature, it is reasonable to believe that the Tetraodontiformes do not necessarily have significant differences between depths and are commonly found throughout all depths. Some of these species have different depth ranges that change with age and maturity of the fish, such as juveniles commonly found in shallower waters as opposed to the adults in deeper habitats.

Because of how the data was sorted, only two depth categories were used through the descriptive analysis, shallow and deep. The shallow depth category contained the benthic habitats that were less than 10 meters in depth: RGSH, CPSH, LIRI, and PTCH. Meanwhile, the deep category contained the benthic habitats that were 10 to 33 meters: DPRC, LIRM, LIRO, APRD, RGDP, SPGR, and CPDP.

All selected species, excluding the Balloonfish, had higher mean densities found within the deep depth category (see Figures 35 and 36, page 55). Each species showed different characteristics within their mean densities throughout the five years in the depth categories. The most apparent distinctions occurred with the Gray Triggerfish and Sharpnose Pufferfish species.

The Gray Triggerfish was found to have a higher mean density within the deep depth for all five years (Figure 62). As previously discussed, the Gray Triggerfish were more commonly seen within the deeper habitats which would explain the results within the two depth categories. The mean densities found within the shallows seemed to have slowly risen throughout the five years (Figure 62).

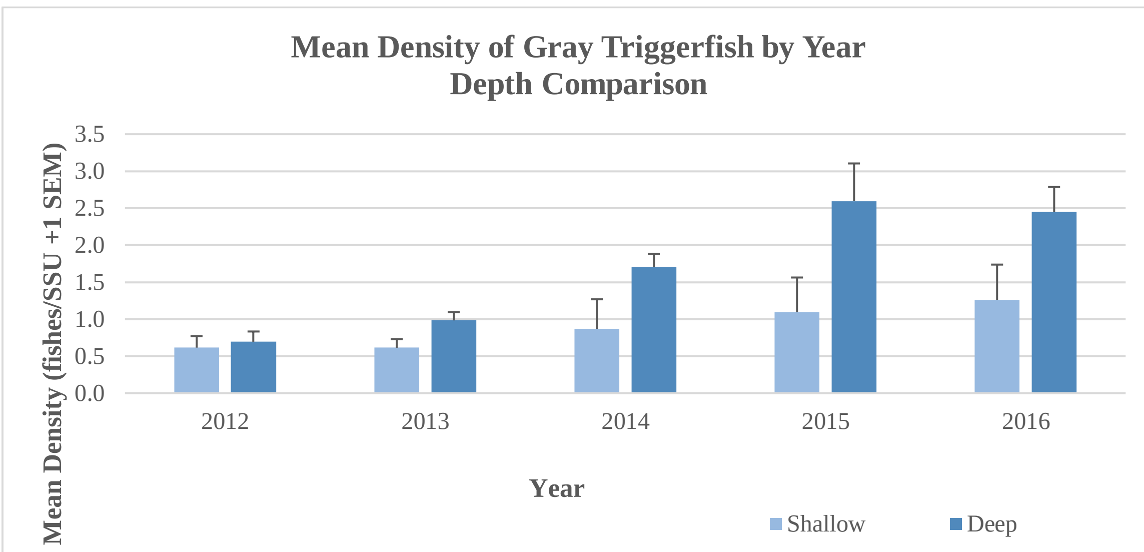

Figure 62. *Gray Triggerfish mean density (fishes/SSU) for depth by year, benthic habitats combined [Shallow (N=839), Deep (N=1,651)].*

Previously shown, Queen Triggerfish were only found in one shallow habitat, LIRI, in 2014 (see Figure 46, page 63). Because of the low occurrence in the shallow habitats, the Queen Triggerfish are more commonly found in the deeper depths of our local waters. Even though statistics were not run, it would appear that this species may show a significant difference between the two depths (i.e. 2016) (Figure 63). One more thing to note, in 2015, the species had a mean density of less than $\overline{D}$=0.01, meanwhile it increased by almost five times in 2016 (Figure 63). Similar to other species 2016 was one of the years for Queen Triggerfish to have a higher mean density.

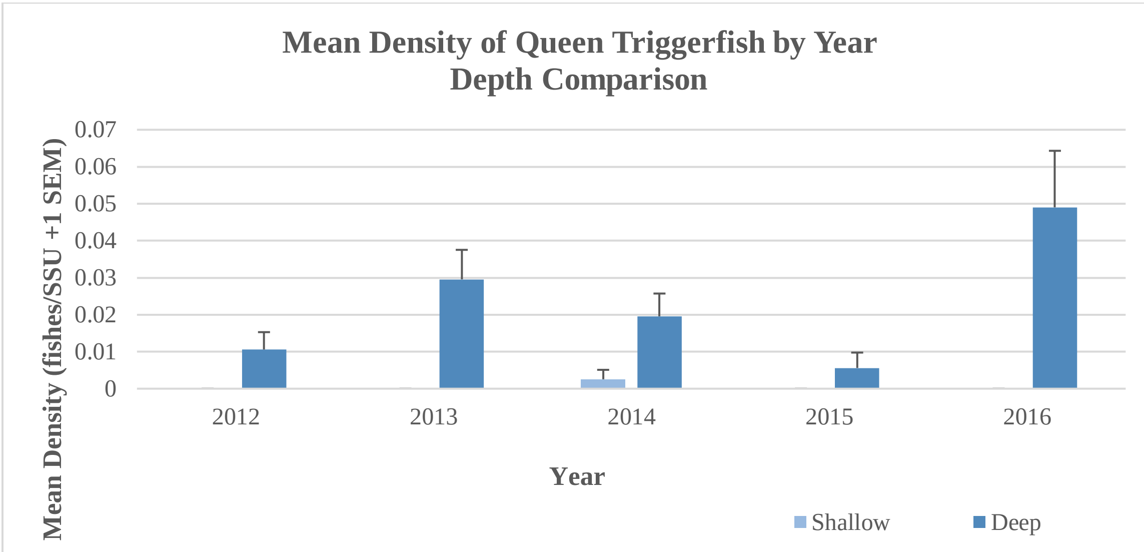

Figure 63. *Queen Triggerfish mean density (fishes/SSU) for depth by year [Shallow (N=839), Deep (N=1,651)]*

The Balloonfish was the only selected species that had a higher mean density in the shallow depth every year compared to the deep depth (Figure 64). From 2013 to 2016, the Balloonfish had consistent shallow depth mean densities, which could indicate that this species is more commonly found in the shallower depths on the reef. While diving in the local waters, from personal experience, it is more common to see these Balloonfish on shallow reef dives compared to the deeper artificial reefs.

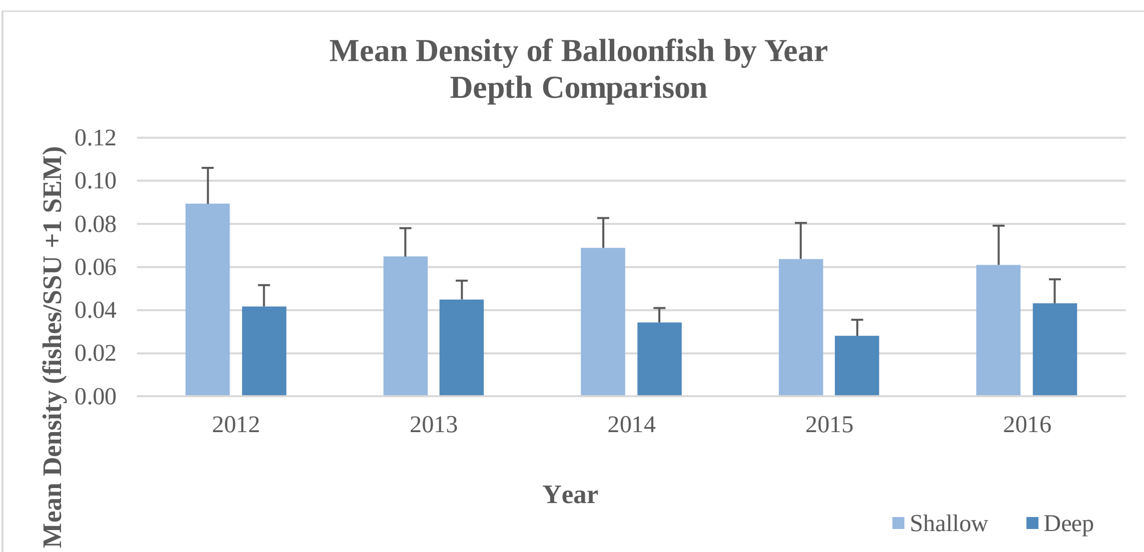

Figure 64. *Balloonfish mean density (fishes/SSU) by depth and year [Shallow (N=839), Deep (N=1,651)].*

All the filefish showed similar results for the depth categories, in which they all had higher mean densities found in the deep than the shallow, except for the Orangespotted Filefish in 2016. Although not statistically tested, Scrawled Filefish may show significant differences between the two depth categories, especially in 2016 due to the large range of the mean densities (Figure 65). The Unicorn Filefish were only seen in the deeper habitats, thus were only seen within the deep category (Figure 66). 2016 showed a higher mean density for the Unicorn Filefish within all the years, which is reasonable since the species was found in the most benthic habitats that year (see Figure 48, page 65).

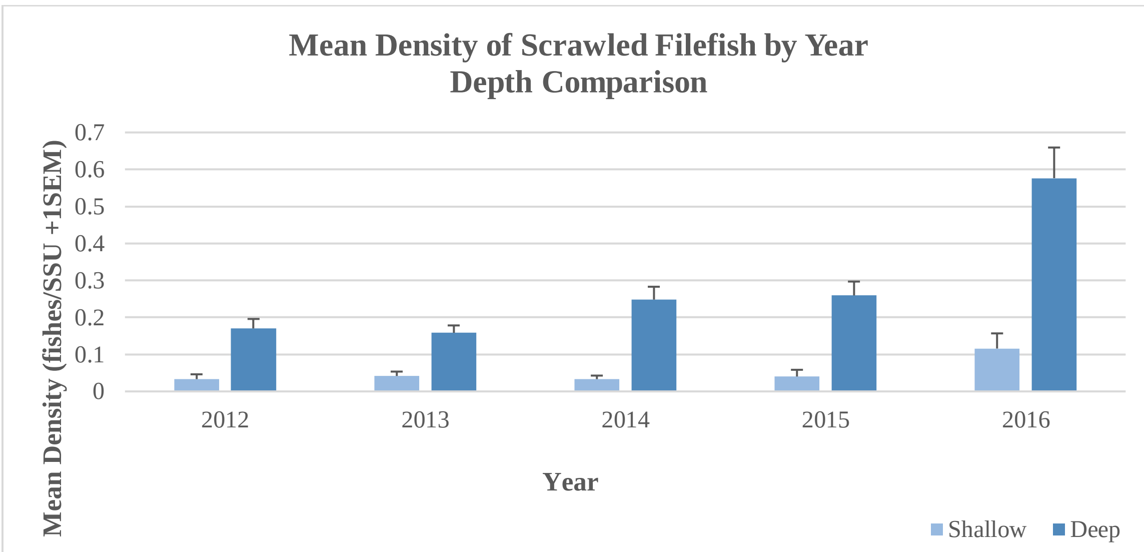

Figure 65. *Scrawled Filefish mean density (fishes/SSU) by depth and year [Shallow (N=839), Deep (N=1,651)].*

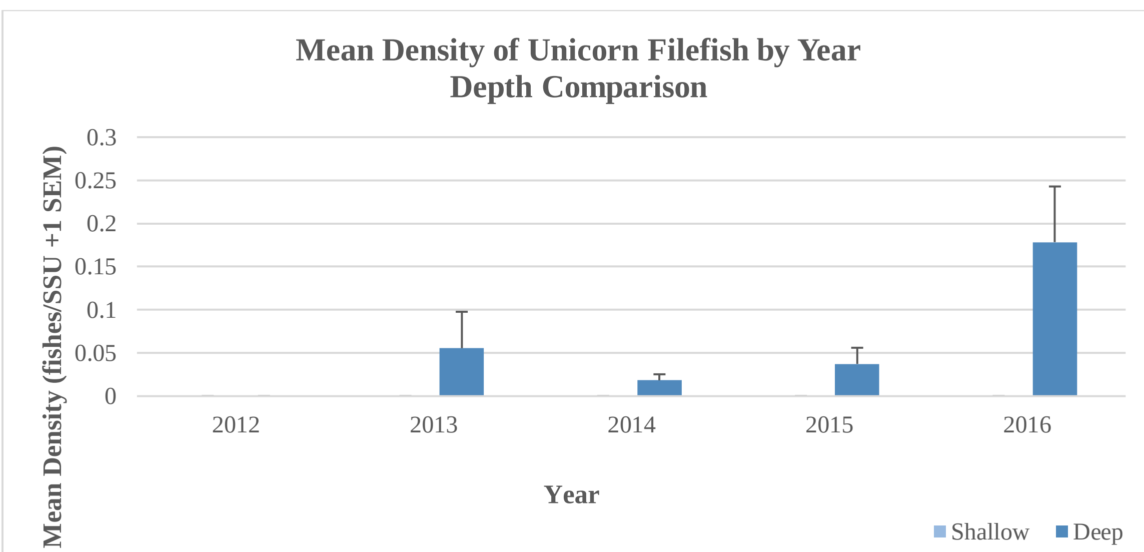

Figure 66. *Unicorn Filefish mean density (fishes/SSU) by depth and year [Shallow (N=839), Deep (N=1,651)].*

When comparing the benthic habitats, it appeared that the Orangespotted Filefish was more common in the shallow habitats than the other filefish (see Figure 52, page 67). However, when looking at the depth categories, it appears that the Orangespotted Filefish are more commonly found in the deeper habitats (Figure 67). The mean densities found within the deeper habitats were more consistent meanwhile the shallow habitats had larger ranges, especially the years that Orangespotted Filefish were seen within PTCH habitat (2012, 2014, and 2016).

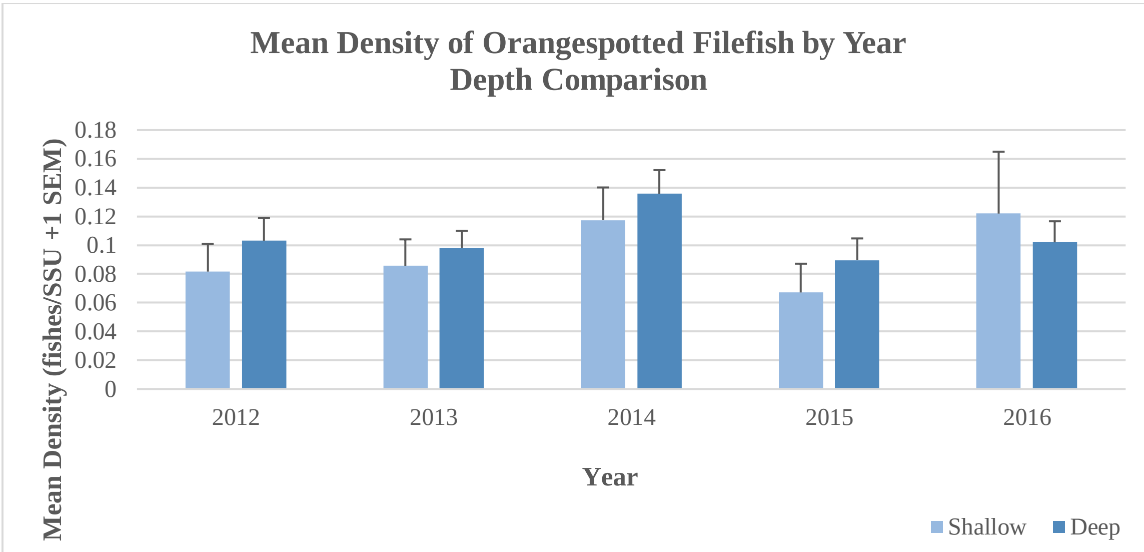

Figure 67. *Orangespotted Filefish mean density (fishes/SSU) by depth and year [Shallow (N=839), Deep (N=1,651)].*

Smooth Trunkfish had a higher mean density in the deep category, except for 2016 when the mean densities were very similar, $\overline{D}$=0.128 in the shallow and $\overline{D}$=0.127 in the deep. In comparison to the other years, the Smooth Trunkfish were rarely seen in the shallow depths except 2016 (Figure 68). This year may have a high mean density because of the low number of fish counts within the PTCH habitat, which was also indicated by a high error bar (see Figure 53, page 68). With the exception of the PTCH habitat, it is reasonable to say that the Smooth Trunkfish are more commonly found in the deeper habitats.

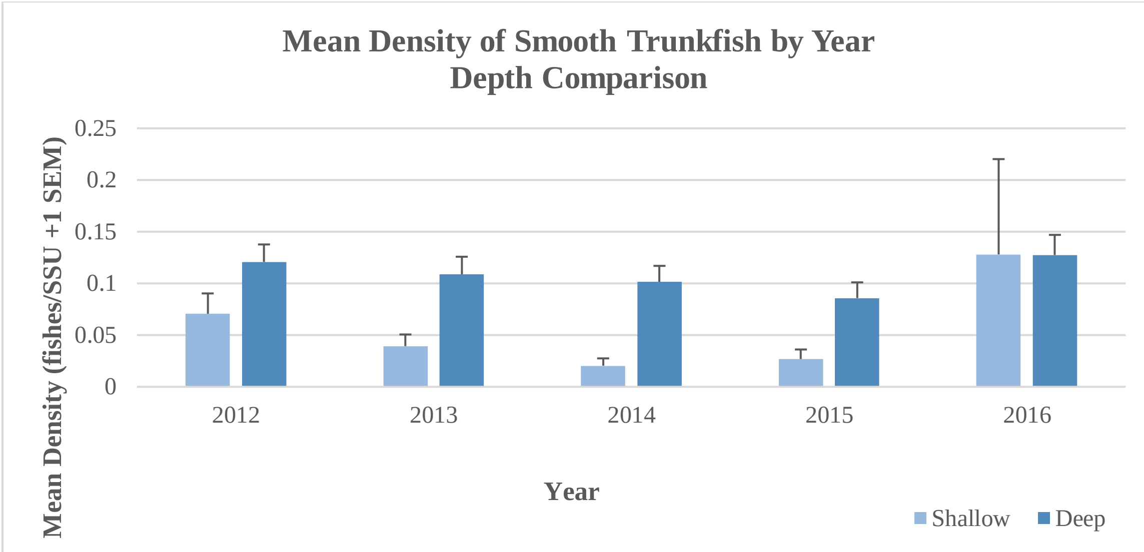

Figure 68. *Smooth Trunkfish mean density (fishes/SSU) by depth and year [Shallow (N=839), Deep (N=1,651)].*

Most Tetraodontidae are known to be found in shallow waters to 40 meters. From the results, both the Sharpnose Pufferfish and Bandtail Pufferfish appeared to be more commonly found in the deeper waters (Figures 69 and 70). However, the Bandtail Pufferfish exhibited greater variability and was seen within the shallower depths more in 2012 and 2013 (Figure 70). From the benthic habitat results, it would be reasonable to believe there are significant differences found within the Sharpnose Pufferfish depth results, for example between the two depths in 2012 and 2016 (Figure 69). It appears that the mean densities decreased from 2012 to 2015 and then increased for both shallow and deep in 2016 (Figure 69). As shown within the benthic habitats, it almost seems like the Sharpnose Pufferfish populations were slowly declining, excluding the PTCH habitat, and then increased in 2016.

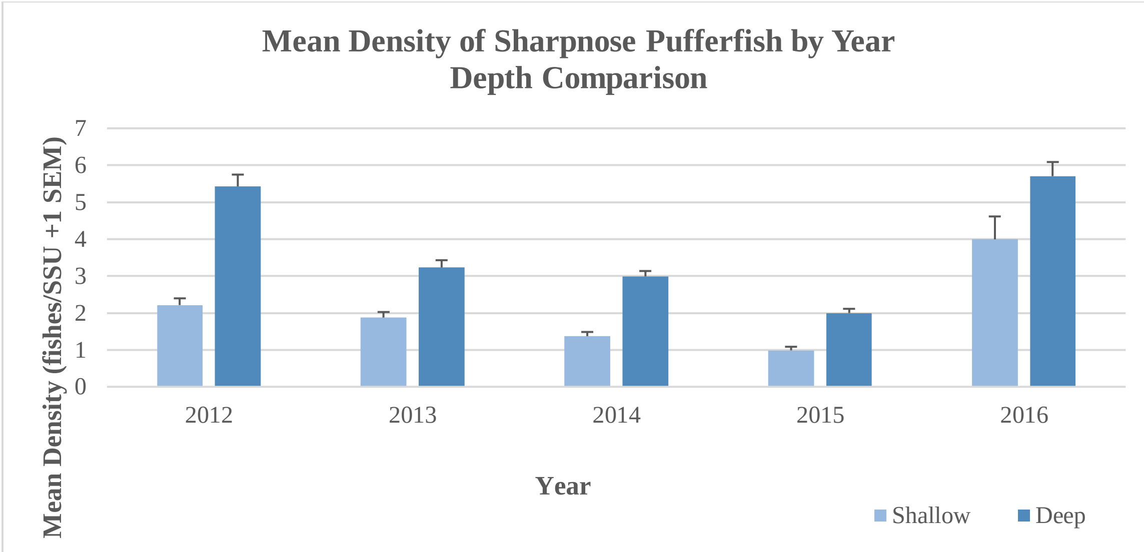

Figure 69. *Sharpnose Pufferfish mean density (fishes/SSU) by depth and year [Shallow (N=839), Deep (N=1,651)].*

Since the Bandtail Pufferfish did not show any significant differences between the habitats, it would be acceptable to believe there are no significant differences found between the two depths. The species may potentially have a significant difference found in 2014 since the mean density for the deep is high compared to the shallow (Figure 70). In 2014, the Bandtail Pufferfish appeared to have a large increase of mean density for the deep, but then a drastic decrease the following year (Figure 70). These two species, the Sharpnose Pufferfish and Bandtail Pufferfish come from the same family but do not have distinctive similar results to habitats or depths.

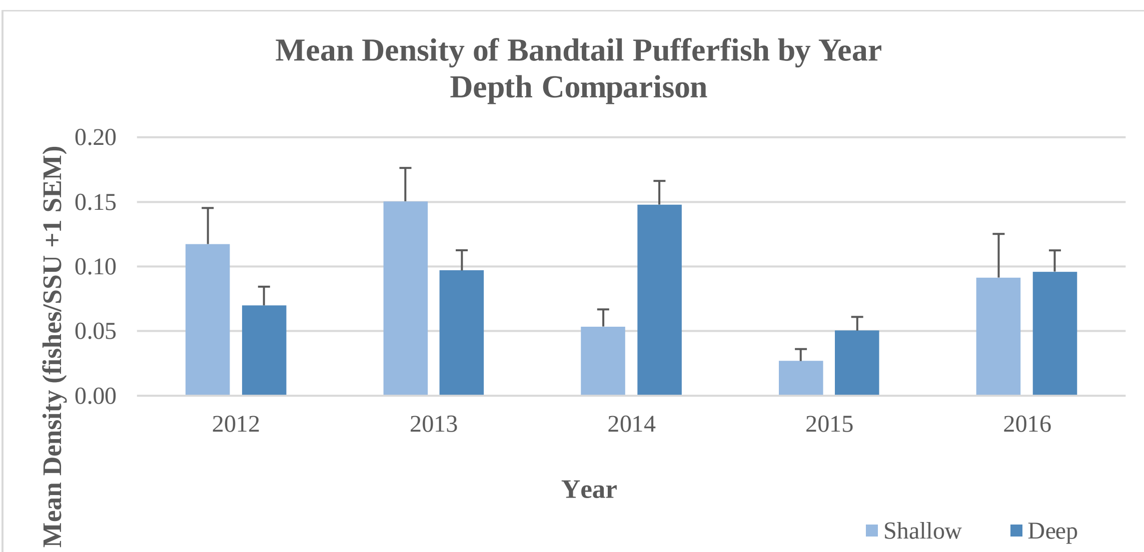

Figure 70. *Bandtail Pufferfish mean density (fishes/SSU) by depth and year [Shallow (N=839), Deep (N=1,651)].*

The results for the depths coincide with the results from the benthic habitats. If the species were more commonly found in the deeper habitats, it would be assumed they were more common in the deeper depth. Each of the species showed different tendencies towards the depth, when looking at the results some species potentially could show significance (i.e. Gray Triggerfish in 2015, Sharpnose Pufferfish in 2012 or 2016). Without data analysis there is no definite answer for the significance but could be deducted by the given graphs.

5.3 Ecoregions

Since seven of the species (Gray Triggerfish, Balloonfish, Scrawled Filefish, Orangespotted Filefish, Smooth Trunkfish, Sharpnose Pufferfish, and Bandtail Pufferfish) showed significant differences between ecoregions, the third hypothesis was accepted since these species did not have identical distributions throughout the five ecoregions. These species showed significance in the Kruskal-Wallis test meanwhile the Queen Triggerfish and Unicorn Filefish did not. Each of the ecoregions have different attributes. First, each ecoregion has a different distribution of benthic habitats found within the ecoregion (Table 5). Second, each ecoregion had various depths and third, the overall areas for each ecoregion was different. Because of these differences, the selected species may have portrayed higher distributions in certain ecoregions, but as established, it may be coincidence where these fish were found.

Table 5. *The percent of the benthic habitats sampled within each of the ecoregions.*

	Broward-Miami	Deerfield	South Palm Beach	North Palm Beach	Martin
RGSH	19.2	4.6	11.0	3.5	25.5
CPSH	14.3	8.1	0.7	2.8	10.4
LIRI	17.2	0.0	0.0	0.0	0.0
PTCH	0.9	0.4	3.5	2.0	0.0
SCRS	0.1	0.0	0.0	0.0	1.0
DPRC	0.0	0.0	0.0	90.2	11.3
LIRM	21.3	30.4	0.0	0.0	0.0
LIRO	7.8	18.2	22.3	0.0	0.0
APRD	6.2	21.7	23.7	1.0	0.0
RGDP	2.0	1.1	13.8	0.0	51.9
SPGR	6.2	10.5	19.4	0.0	0.0
CPDP	4.8	5.2	5.7	0.5	0.0

Each ecoregion is different, the largest ecoregion, North Palm Beach contained 6 of the 11 benthic habitats, the majority being DPRC (Table 5). North Palm Beach was one of two ecoregions to contain DPRC, which would indicate if selected species were found in DPRC, it would be most likely found in the North Palm Beach or Martin ecoregions. Because DPRC had a larger footprint in North Palm Beach then in the Martin ecoregion, the species would have a higher probability to have been found in North Palm Beach. The second largest ecoregion, Broward-Miami, was comprised of all 11 benthic habitats, the most being LIRM with 21%. Martin was the least sampled (N=212) and was comprised of the fewest habitats, which may perhaps be an explanation as to why there were not as many species from this order seen within this ecoregion as were seen elsewhere. South Palm Beach had 8 habitats while Deerfield had 9.

Of the ecoregions, Broward-Miami was more equally divided between shallow (52%) and deep (48%) habitats (Table 5). The other ecoregions, Deerfield, South Palm Beach, and North Palm Beach consisted of more than 80% deep habitats. Martin also had more deep habitats, even though it was about 63% deep habitats compared to 37% shallow habitats. Thus, the results from the tests of benthic habitats also coincide with the results from the ecoregions.

Broward-Miami was sampled the most (N=1250) and being the second largest ecoregion, it was to be anticipated that the species would be present within this ecoregion the most, due to having all 11 benthic habitats and other studies showing the shift of coral reef fish from the northern waters to the southern waters (Fisco, 2016; Kilfoyle et al., 2018). However, it was not shown within the results for some of these selected species. For example, both triggerfishes had higher mean densities found in Martin than Broward-Miami.

Gray Triggerfish showed significant differences with Deerfield due to a low mean density found within the ecoregion. The Gray Triggerfish had a lower mean density found within the Deerfield ecoregion while the Martin ecoregion had the highest (Figure 71). Deerfield was significantly different from Martin, North Palm Beach and South Palm Beach. Once again, Martin was sampled the least, but had similar mean densities to the mean densities found in North and South Palm Beach, which could suggest the Gray Triggerfish were more common in the northern ecoregions.

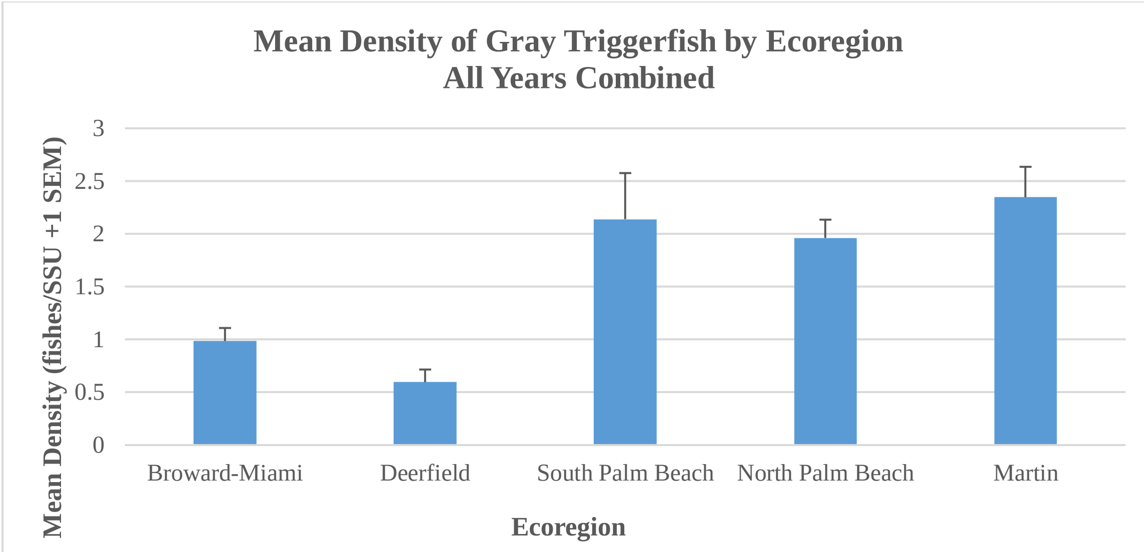

Figure 71. *Gray Triggerfish total mean density (fishes/SSU) by ecoregions throughout 2012 to 2016 [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

Throughout 2012 to 2016, Deerfield had a mean density less than $\overline{D}$=1.00 each year (Figure 72), meanwhile other ecoregions such as South Palm Beach, North Palm Beach, and Martin had two or more mean densities greater than $\overline{D}$=2.00 (Figure 72). For 2014 and 2015 it appeared that the Gray Triggerfish had high mean densities within South Palm Beach, which could be explained by the high mean densities within the PTCH habitat, since South Palm Beach had the highest percent of PTCH (see Table 5, page 81).

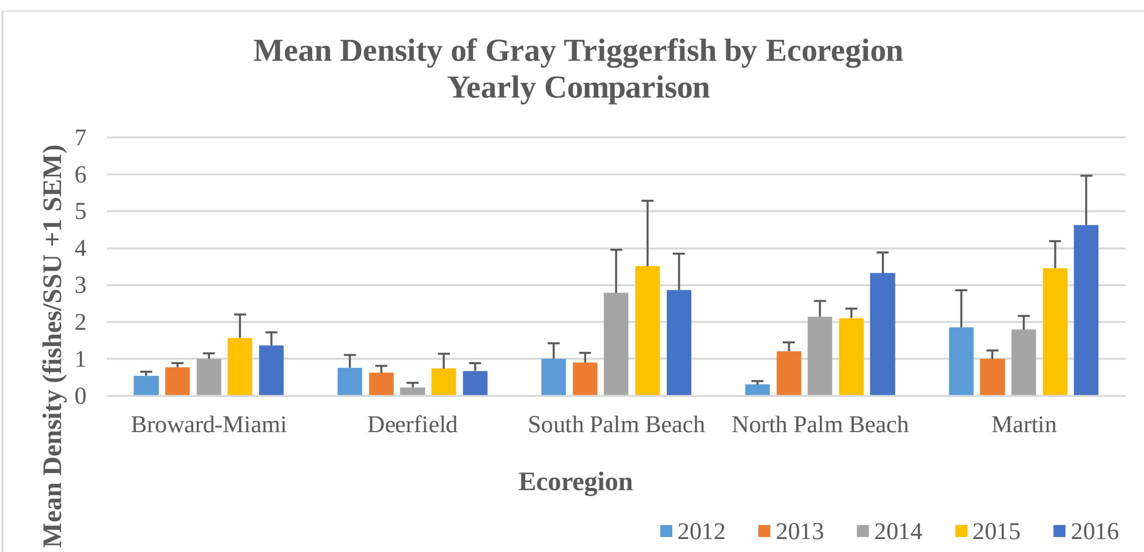

Figure 72. *Gray Triggerfish total mean density (fish/SSU) for each ecoregion by year [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

The Queen Triggerfish was one of the two species to not show significance in the Kruskal-Wallis test when testing against the five ecoregions. As discussed before, this species was not present within the shallow habitats, besides one year in LIRI, which explains a lower mean density found in Broward-Miami (Figure 73). One of the highest (for the species) mean density occurred within the APRD habitat, which consists of almost 24% of South Palm Beach, which could justify the high mean density found in this ecoregion (Figure 73).

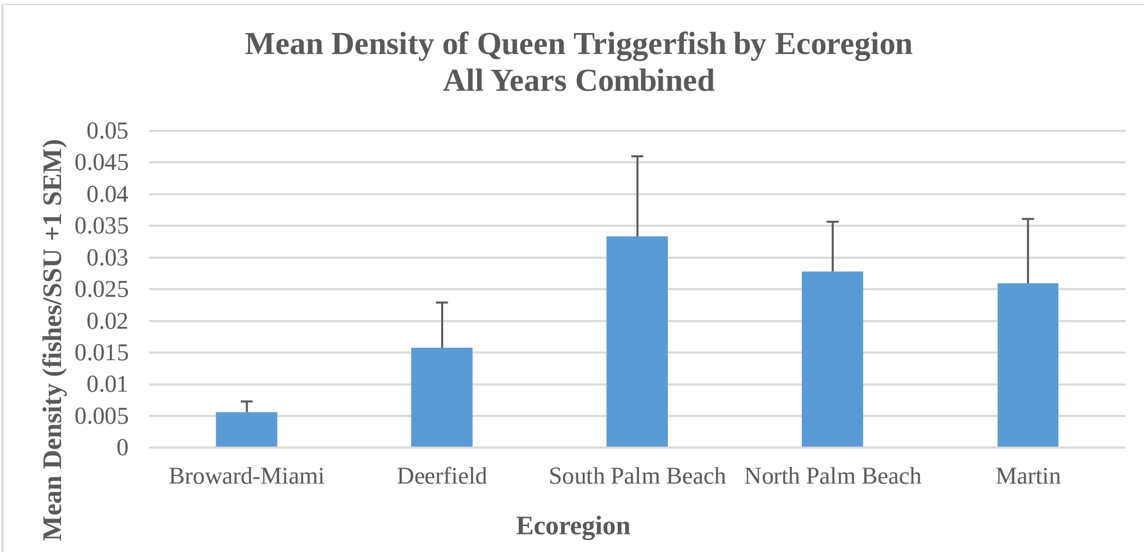

Figure 73. *Queen Triggerfish total mean density (fishes/SSU) for each ecoregion throughout 2012 to 2016 [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

When analyzing each year for the ecoregions for the Queen Triggerfish, it is very apparent that South Palm Beach has a high mean density in 2016 because of the high mean density within the PTCH habitat (Figure 74). The next high mean density appears to be found in North Palm Beach in 2013, which coincides with the high mean density found in DPRC. Meanwhile, also in 2013, Martin appears to have a high mean density, of which RGDP is more than 50% of this ecoregion, thus giving the Queen Triggerfish a high mean density.

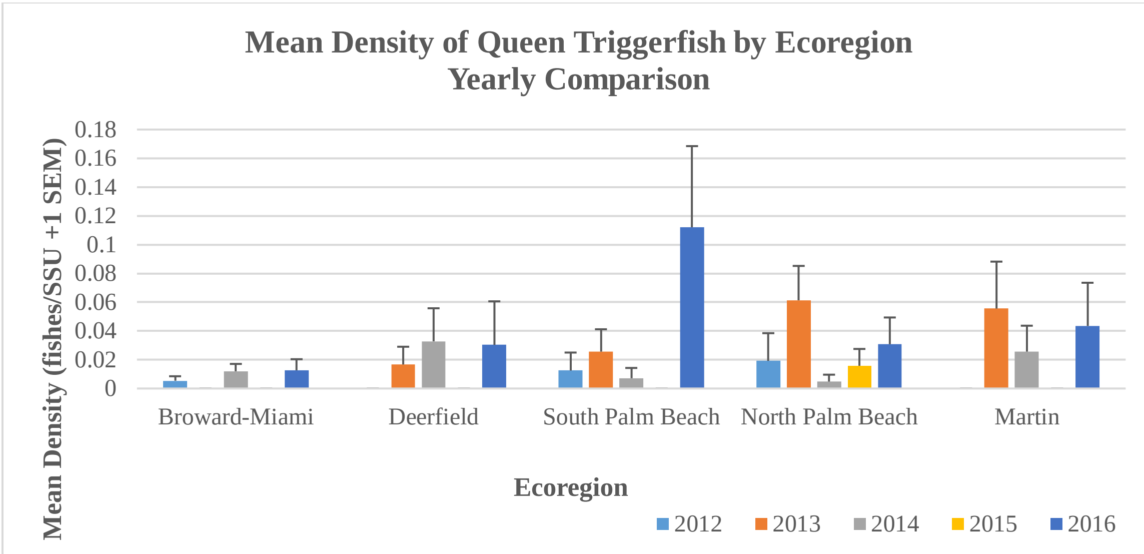

Figure 74. *Queen Triggerfish total mean density (fish/SSU) for each ecoregion by year [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

The Scrawled Filefish showed significant differences between South Palm Beach with Broward-Miami and Martin ecoregions, as well as the Deerfield and Martin ecoregions (Figure 75). Similar to other species, the Scrawled Filefish had a low mean density found within the Martin ecoregion. Unlike other species, Scrawled Filefish appeared to have a high mean density found within the LIRO and SPGR habitats, thus giving it a high mean density in South Palm Beach, not necessarily because a high mean density found in PTCH (Figure 75). This species was commonly found in the deeper habitats, which would be a reason it is found more commonly in the South Palm Beach and Deerfield ecoregions (Figure 75).

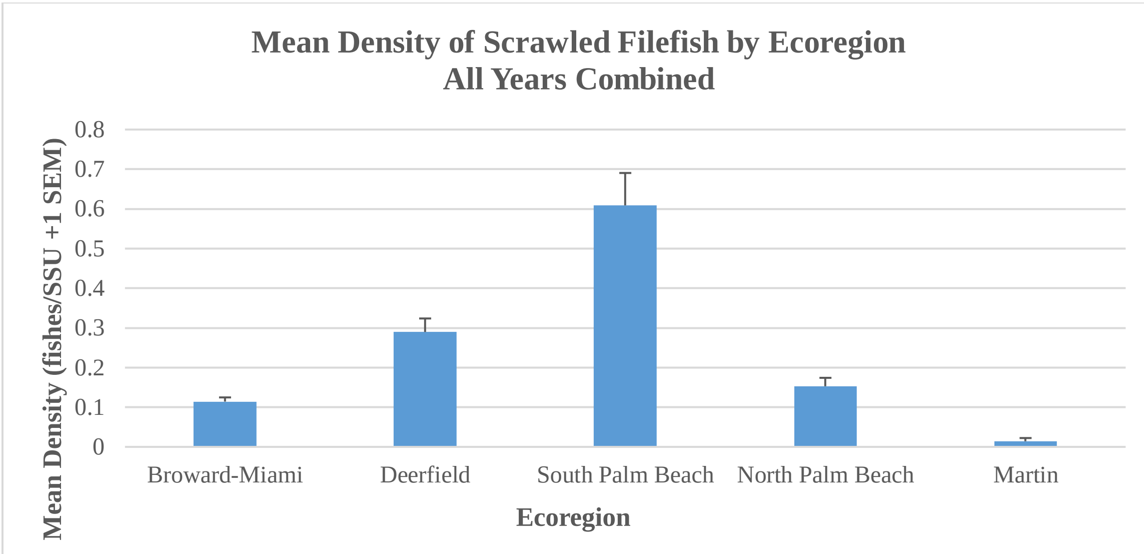

Figure 75. *Scrawled Filefish total mean density (fishes/SSU) for each ecoregion throughout 2012 to 2016 [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

Scrawled Filefish were only found within the Martin habitat two years, 2012 and 2014, thus giving it a low mean density compared to the other ecoregions (Figure 76). This species was counted the most in 2016 within all the ecoregions, excluding Martin (Figure 76). South Palm Beach appeared to have a higher mean density each year compared to the other ecoregions, meanwhile the mean density was similar to the Deerfield ecoregion in 2012 and 2013, but still higher in South Palm Beach.

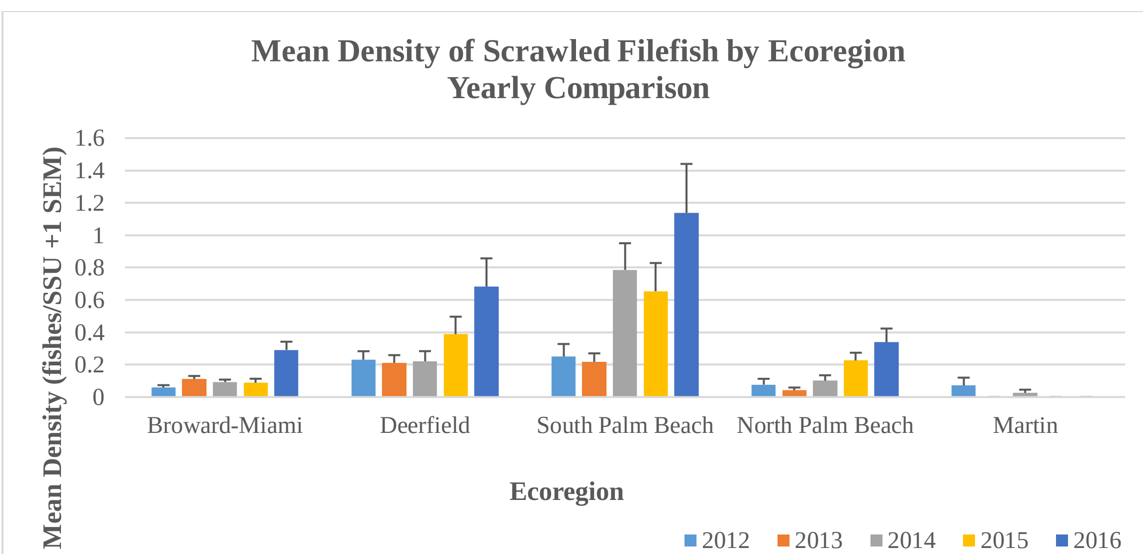

Figure 76. *Scrawled Filefish mean density (fishes/SSU) by year for each ecoregion [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

Similar to the Scrawled Filefish, the Orangespotted Filefish had significant differences between the South Palm Beach and Martin ecoregions, as well as the Deerfield and Martin ecoregions (Figure 77). Contrasting to the other filefish, the Orangespotted Filefish showed significant differences between North Palm Beach with Deerfield and South Palm Beach (Figure 77).

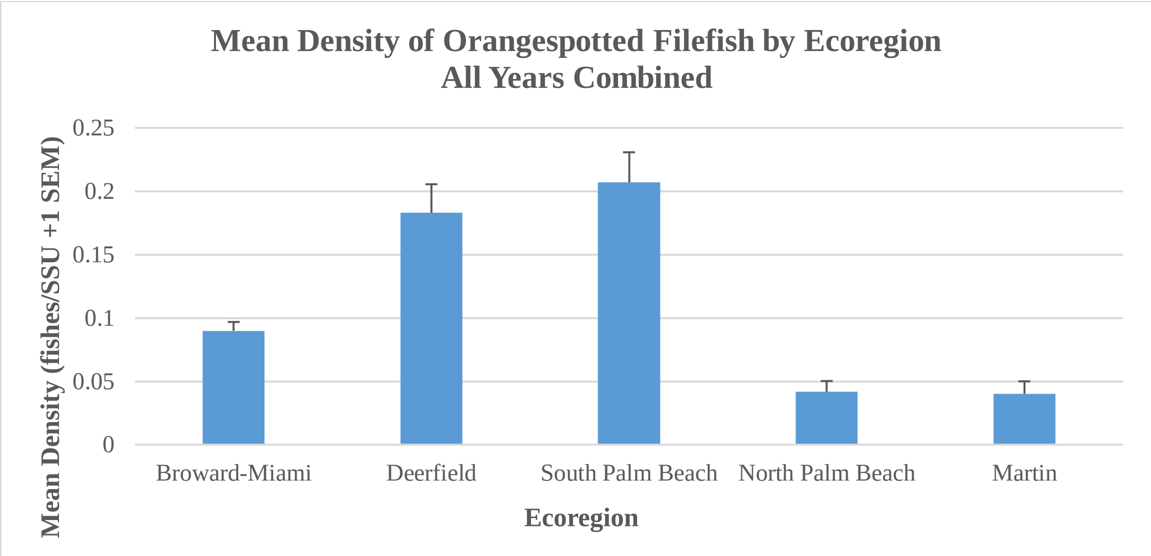

Figure 77. *Orangespotted Filefish total mean density (fishes/SSU) for each ecoregion throughout 2012 to 2016 [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

Orangespotted Filefish appeared to have a higher mean density found in 2014 within four of the five ecoregions (Figure 78). Between the three filefish species, Orangespotted Filefish seemed to have been more common in the shallow habitats than the other two. However, Broward-Miami does not represent a high mean density found within the shallow habitats (Figure 78). Orangespotted Filefish were seen the least in the DPRC habitat, since it is about 90% of North Palm Beach, the low mean density found in DPRC could justify the low mean density found in the North Palm Beach ecoregion.

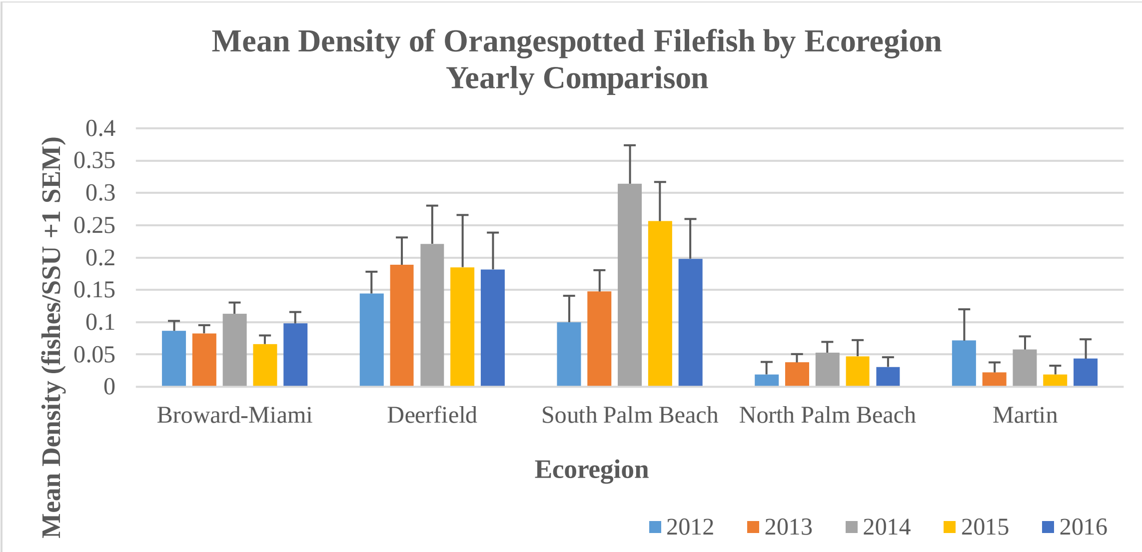

Figure 78. *Orangespotted Filefish total mean density (fish/SSU) for each ecoregion by year [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

The other selected species to not show significance within the Kruskal-Wallis test against the five ecoregions was the Unicorn Filefish. This could be because of the small numbers within the dataset or because the species were not found within the Deerfield ecoregion (Figure 79). Unicorn Filefish appeared to have a high mean density found in South Palm Beach, considering the high error bar (Figure 79). Since it was not seen within the shallow habitats, it is reasonable that this species was found within the deeper ecoregions.

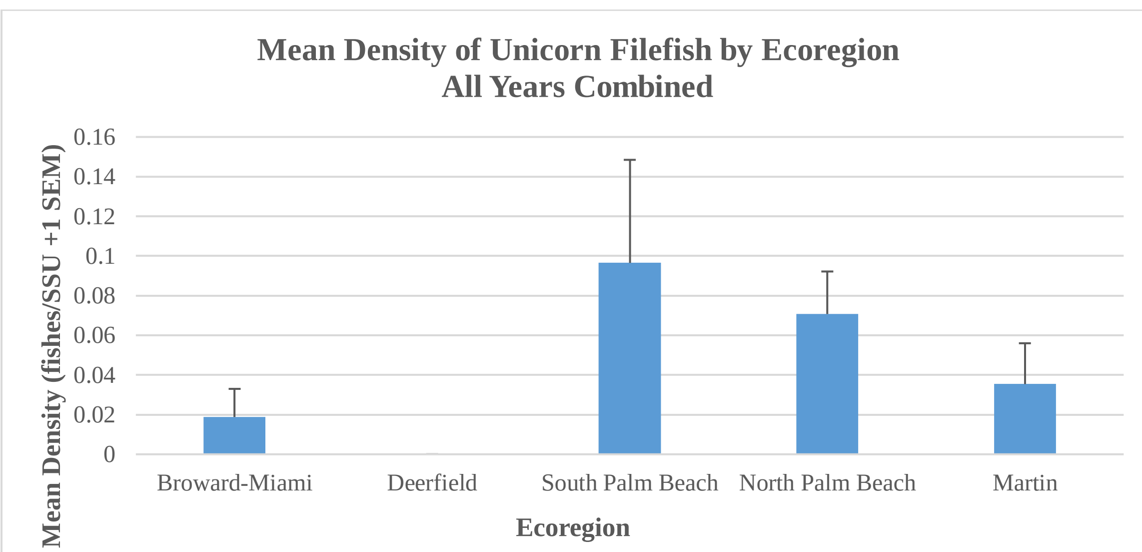

Figure 79. *Bandtail Pufferfish total mean density (fishes/SSU) for each ecoregion throughout 2012 to 2016 [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

Unicorn Filefish were never seen in 2012 (Figure 80). This species appears to have high mean densities found within 2016 in the South Palm Beach and North Palm Beach ecoregions (Figure 80). Unicorn Filefish appeared to have a high mean density found within LIRO in 2016 which could explain the high mean density found in South Palm Beach the same year. Out of the 11 benthic habitats, Unicorn Filefish were seen four years (the most for the species) in DPRC which could explain the high mean density found in North Palm Beach.

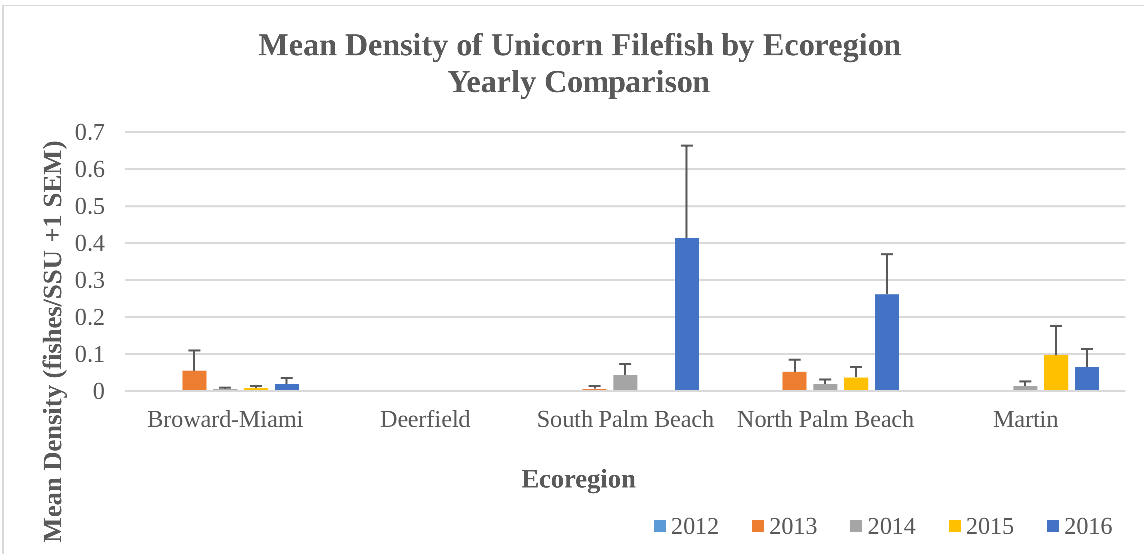

Figure 80. *Unicorn Filefish total mean density (fish/SSU) for each ecoregion by year [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

Balloonfish were the only species to have a higher mean density found within the shallow depth compared to the deep depth within all five years. This species showed significant differences between Martin with Broward-Miami and Deerfield, as well as North Palm Beach with Broward-Miami and Deerfield due to the low mean densities found in Martin and North Palm Beach (Figure 81). Broward-Miami had the highest percentage of shallow habitats, which allows the conclusion that this ecoregion has one of the highest (for the species) mean densities.

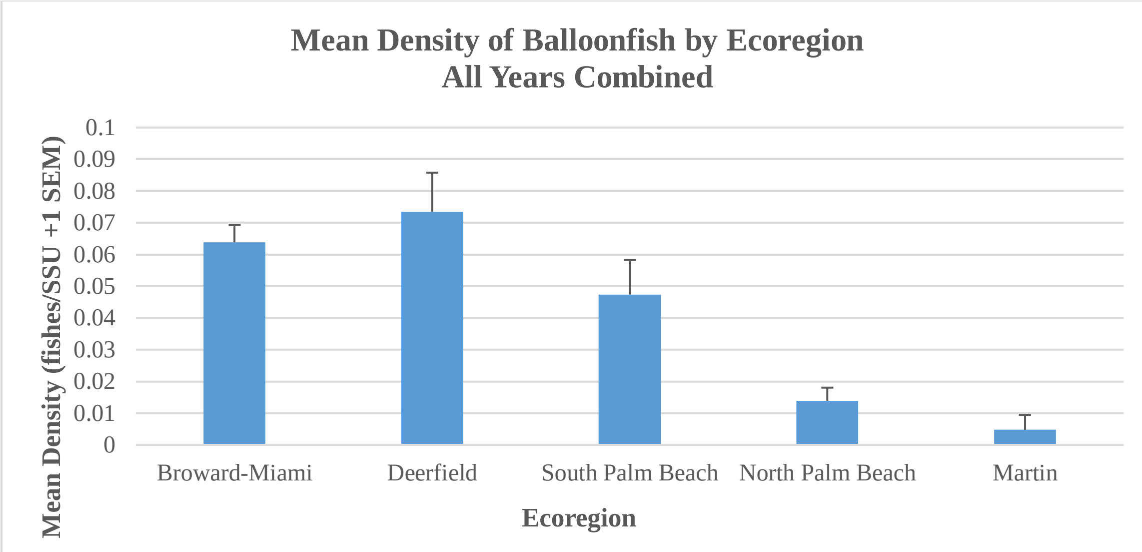

Figure 81. *Balloonfish total mean density (fishes/SSU) for each ecoregion throughout 2012 to 2016 [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

The reason Balloonfish had significant differences with the Martin ecoregion is that this species was only seen one year, 2012, within the ecoregion (Figure 82). Deerfield appeared to have a higher mean density because the species had the highest mean density found in 2012. Compared to other habitats, Broward-Miami included the only consistent mean densities found within the ecoregions for the Balloonfish (Figure 82).

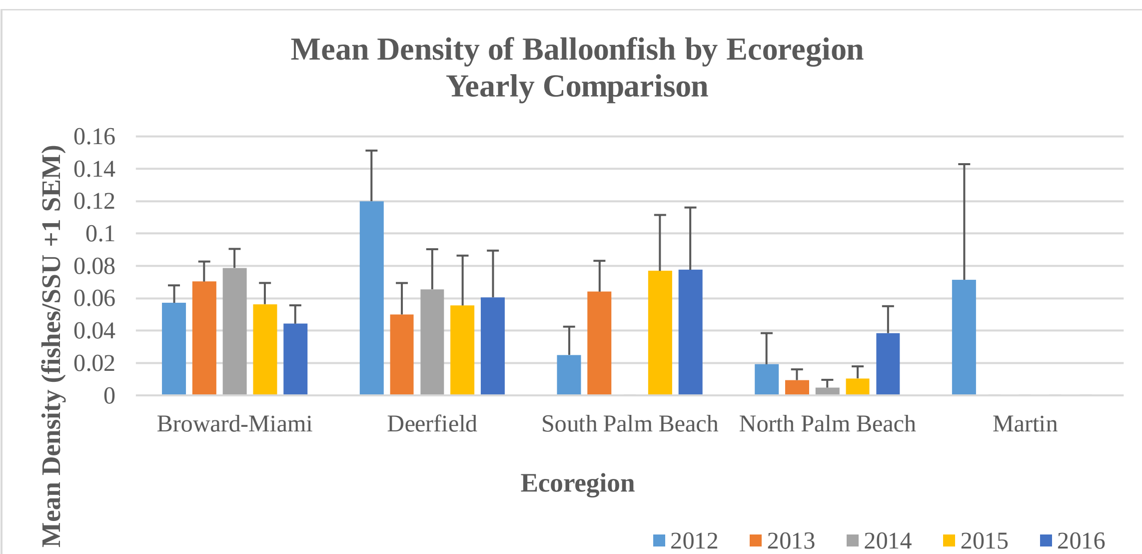

Figure 82. *Balloonfish mean density (fishes/SSU) for each ecoregion by year [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

The Smooth Trunkfish had the highest significance between the selected species when testing against the five ecoregions. This species had significant differences found between the Martin ecoregion with Broward-Miami, Deerfield, and South Palm Beach ecoregions (Figure 83). Other differences occurred between North Palm Beach with Deerfield and South Palm Beach.

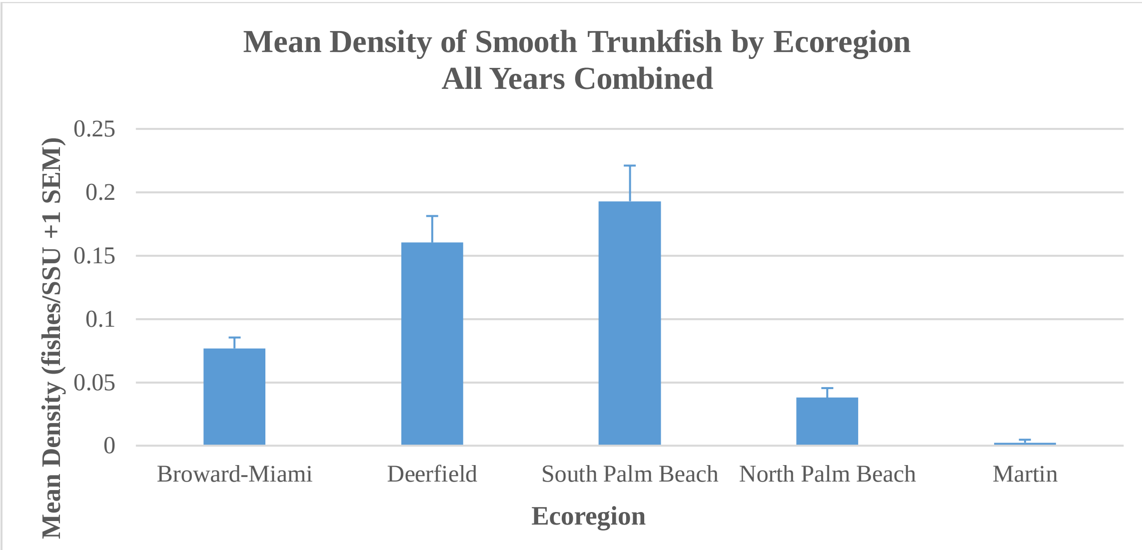

Figure 83. *Smooth Trunkfish total mean density (fishes/SSU) for each ecoregion throughout 2012 to 2016 [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

The Smooth Trunkfish was only seen one year in the Martin ecoregion, 2014, meanwhile was seen every year in the other ecoregions (Figure 84). Similar to other species, the Smooth Trunkfish had a high mean density found within PTCH in 2016 thus having a high mean density in South Palm Beach (Figure 84).

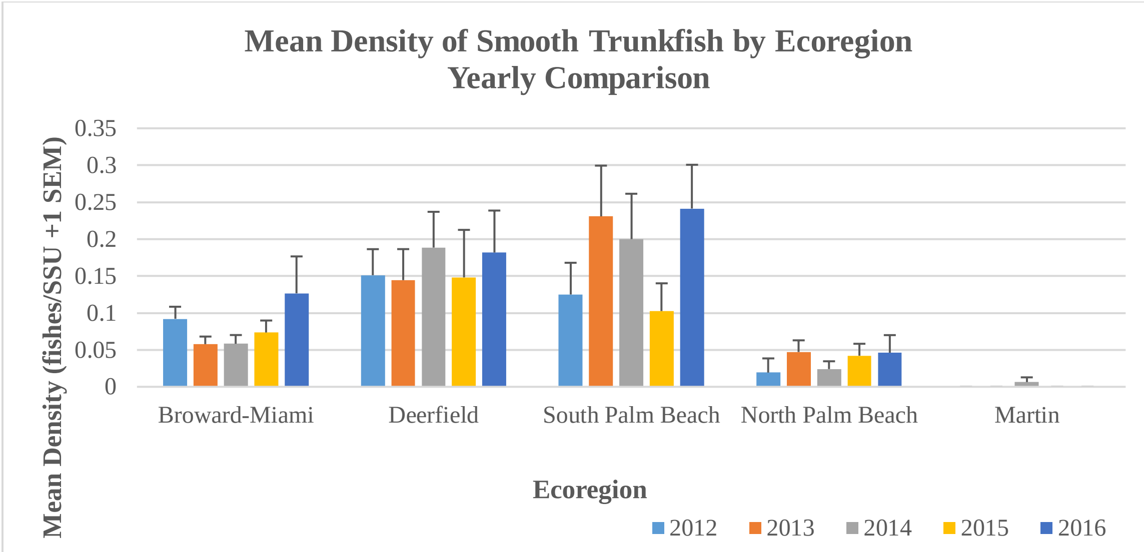

Figure 84. *Smooth Trunkfish total mean density (fish/SSU) for each ecoregion by year [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396) and Martin (N=212)].*

Between the selected species, the Sharpnose Pufferfish showed very similar results as the Smooth Trunkfish, just with larger numbers due to higher counts (Figures 83 and 85). The Sharpnose Pufferfish and the Smooth Trunkfish had (for the species) the highest mean density found in South Palm Beach and the lowest found in Martin (Figures 83 and 85). All significant differences for the Sharpnose Pufferfish occurred between the same habitats Smooth Trunkfish had differences for. Such as, Martin with South Palm Beach, Deerfield, and Broward-Miami as well as North Palm Beach with South Palm Beach and Deerfield.

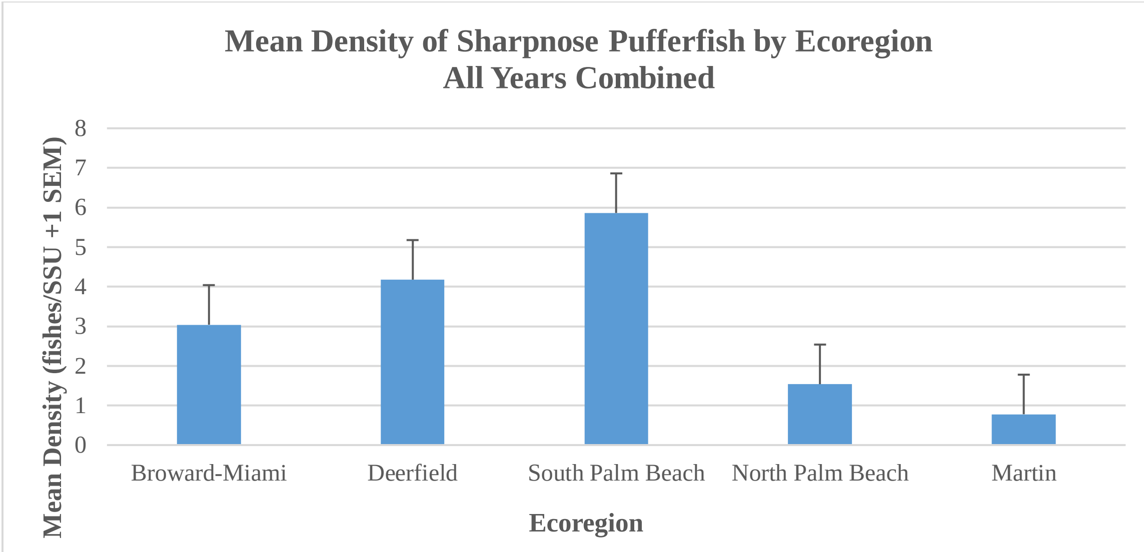

Figure 85. *Sharpnose Pufferfish total mean density (fishes/SSU) for each ecoregion throughout 2012 to 2016 [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

As discussed before, the results from Sharpnose Pufferfish show a decline in mean densities from 2012 to 2015, however, the Martin ecoregion seems to do the contrary (Figure 86). 2012 appears to have a small mean density compared to 2015, and then the mean density increases in 2016 (Figure 86). Consistent with other species, Sharpnose Pufferfish had a high mean density found within the PTCH habitat in 2016 and shows a high mean density within South Palm Beach. This species also had high mean densities found within APRD, LIRO, and SPGR, which combine to be the majority of the South Palm Beach ecoregion. Besides PTCH, the Sharpnose Pufferfish had low (for the species) mean densities found within three of the four shallow habitats, which could be the reason Broward-Miami ecoregion did not have a high mean density.

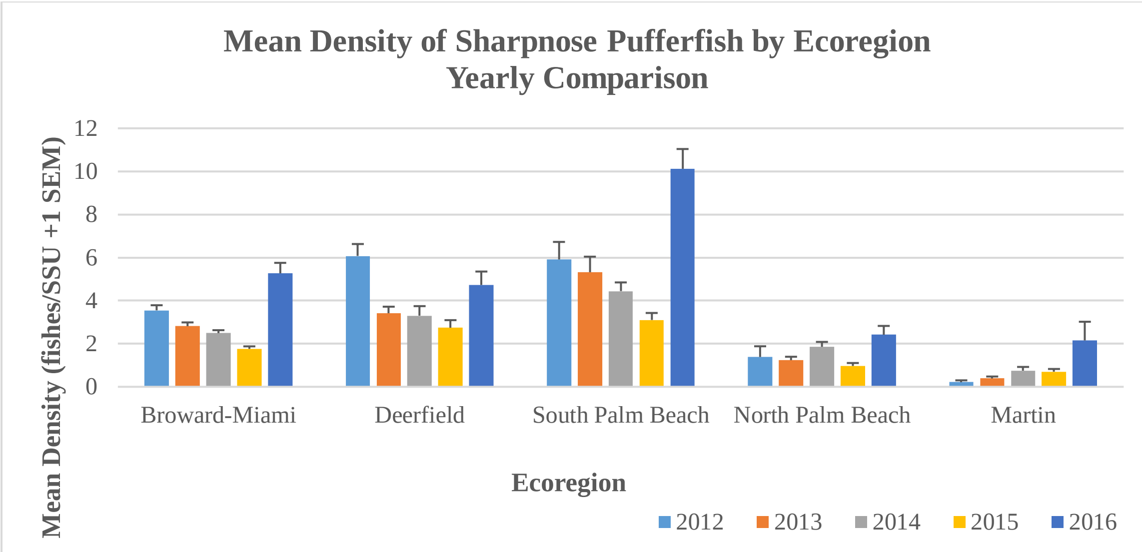

Figure 86. *Sharpnose Pufferfish total mean density (fish/SSU) for each ecoregion by year [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

The other species tested from Tetraodontidae, the Bandtail Pufferfish, had significant differences between Martin with Broward-Miami and South Palm Beach, as well as Broward-Miami with North Palm Beach (Figure 87). Bandtail Pufferfish did not have significant differences found with Deerfield, even though it was the ecoregion with the largest range of mean densities (Figure 88). In 2014, this species had the highest mean density found within the Deerfield ecoregion meanwhile the other years were never larger than $\overline{D}$=0.106 (Figure 88).

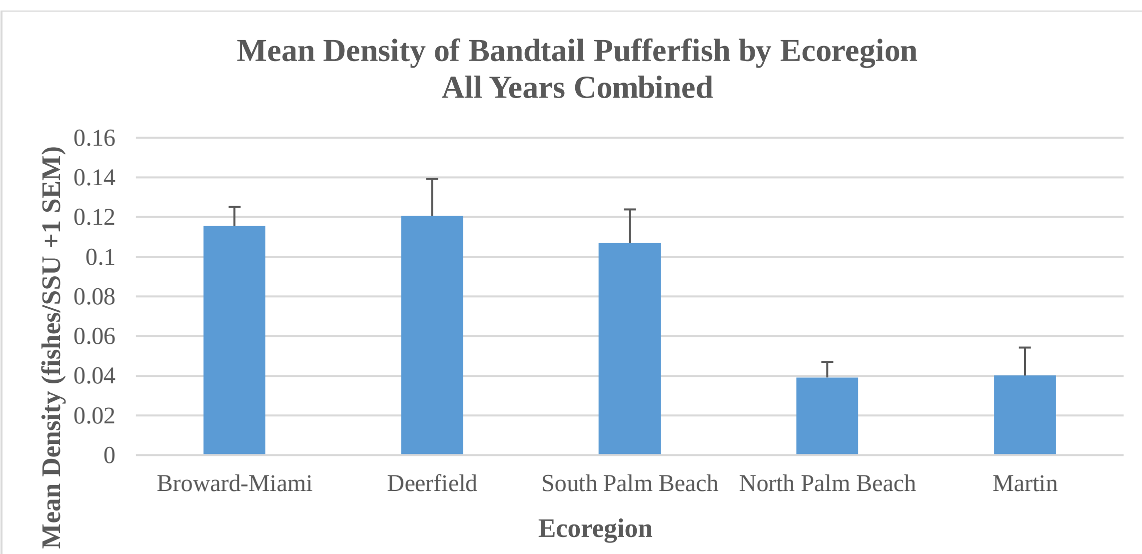

Figure 87. *Bandtail Pufferfish total mean density (fishes/SSU) for each ecoregion throughout 2012 to 2016 [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

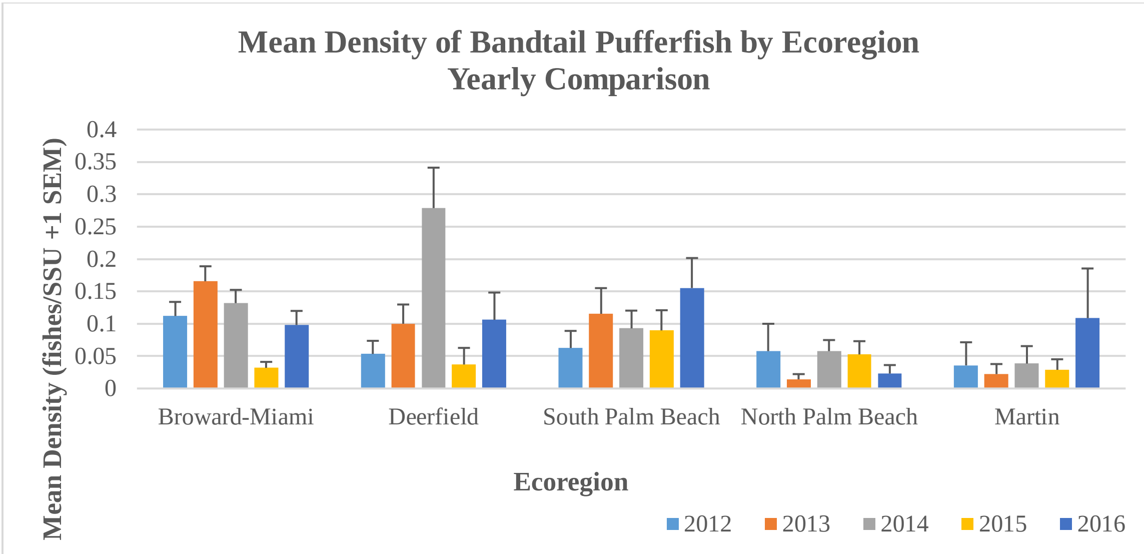

Figure 88. *Bandtail Pufferfish total mean density (fish/SSU) for each ecoregion by year [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

Recent studies have shown a general increase of coral reef fishes from north to south (Fisco, 2016; Kilfoyle et al., 2018). This study shows that a few of the selected species, the Smooth Trunkfish, the Sharpnose Pufferfish, Balloonfish, and the Bandtail Pufferfish show an increase from north to south. However, these fish do not show the highest mean density in Broward-Miami but in the South Palm Beach ecoregion, south of the Martin ecoregion. A few species, Sharpnose Pufferfish, Smooth Trunkfish, Orangespotted Filefish, and Balloonfish, had the least mean densities found in the Martin ecoregion. Overall, these species have more tropical tendencies and their numbers greatly diminish once they cross the Bahamas Fault Zone (BFZ) into cooler waters. The Martin ecoregion is just north of the BFZ where the shelf widens northward and the Florida current diverges from the coast (Walker, 2012). Because of this divergence, it carries the warmest waters into the Gulf Stream which allows colder northern water to come to the coast (Walker, 2012). Eddies form causing frequent upwelling that fluctuates the water temperature, which has been implicated as a cause for latitudinal differences in benthic communities (Walker and Gilliam, 2013; Lirman et al., 2019) which could be the reason as to why these coral reef fish are shown to be further south than the Martin ecoregion.

Three species, the Gray Triggerfish, Scrawled Filefish, and Sharpnose Pufferfish, showed differences with other ecoregions, these included: North Palm Beach, South Palm Beach and Deerfield. All three of these ecoregions consisted of different benthic habitats, but all included PTCH, and RGDP. South Palm Beach also had LIRO while Deerfield had LIRM and LIRO. These variations of benthic habitats within these ecoregions could indicate the three species' differences to these ecoregions. For example, the Sharpnose Pufferfish showed high mean densities in LIRM and RGSH, which could indicate the presence in the South Palm Beach and Deerfield ecoregions.

All species showed variations between the benthic habitats, depths, and ecoregions. Five of the selected species showed significant differences between the benthic habitats as well as the ecoregions. Two species, the Balloonfish and the Bandtail Pufferfish, only showed significant differences between the ecoregions, but none within the habitats. The Queen Triggerfish only showed significance between the benthic habitats but none within the ecoregions meanwhile the Unicorn Filefish was the only selected species to not show any significant differences between either category. Most of these selected species had their highest densities to be found within 2016. Gray Triggerfish were the only species to show a decline of mean densities from 2015 to 2016. Scrawled Filefish showed an increase of mean density throughout the five year timespan. The other species had a variation, such as the Sharpnose Pufferfish declining from 2012 to 2015 but then tremendously increasing in 2016. Both the Queen Triggerfish and Bandtail Pufferfish had increasing mean densities from 2012 to 2014, the lowest (for their species) mean density in 2015 but then an increase for 2016.

Since the Gray Triggerfish was the 2nd highest ranked species for this project (N=3,286), this species was one of the five that showed significant differences within benthic habitats and ecoregions. The Gray Triggerfish appeared to have the highest mean density found within the PTCH habitat between all species, even though it had a high error bar. This species was found more common within the deeper habitats, such as RGDP and LIRM. So, with descriptive statistics, it would appear there is a significant difference found within the shallow and deep depths. As for the ecoregions, the Gray Triggerfish were more common within the northern ecoregions, also recognized to be the ecoregions with more deeper habitats.

The other triggerfish selected, the Queen Triggerfish, only showed significance between the benthic habitats, not within the ecoregions. This species was more common within all deep habitats, appearing only one year within LIRI. Similar to the Gray Triggerfish, the Queen Triggerfish showed in the results to be more common within the deep depth. As for the ecoregions, even though it was not statistically proven, the results showed the Queen Triggerfish appeared to be more common in the northern ecoregions.

The only selected species from Diodontidae, Balloonfish, was one of the two species to show significance between ecoregions, but not the benthic habitats. Results show from the benthic habitat densities that this species was more common in the shallow habitats besides one deep habitat, CPDP. Compared to the other species, Balloonfish had more consistent mean densities found, excluding a few of the deep habitats such as DPRC and RGDP. Of which, these two habitats were considered two habitats with high mean densities for other species. When discussing the second hypothesis, Balloonfish were the only species to appear with a higher density every year in the shallow depth compared to the deeper depth. For the ecoregions, Balloonfish had significant differences occur between Martin and Broward-Miami as well as Deerfield. Compared to other species, Balloonfish were one to show high mean densities in the southern ecoregions compared to the northern ecoregions.

Of the three filefish selected for this project, the Unicorn Filefish was seen the least on the local reefs (N=38). Most likely due to this small sample size, this species did not show any significant differences within the benthic habitats or the ecoregions. Of the three filefish, the Unicorn Filefish was the only one within the family to be found only in the deep habitats, which could suggest this species is more commonly found within deep waters. However, more sampling needs to be done to provide statistical results.

The other two filefish showed significant differences within the benthic habitats and the ecoregions. Of the two, Scrawled Filefish was seen more, so the species showed more significance within the habitats and ecoregions than the Orangespotted Filefish. For the Scrawled Filefish, it appeared that more significant differences were from high mean densities from the deep habitats to the shallow habitats that had lesser mean densities. Meanwhile the Orangespotted Filefish had significant differences occur between deep habitats as well as with shallow habitats to other shallow habitats. For the ecoregions, the highest mean for both species was found in South Palm Beach compared to the lowest which was found in Martin. Of the three filefish, Orangespotted Filefish were more commonly seen in the shallows compared to the other two species.

Smooth Trunkfish were one of the few species that had a high mean density found within PTCH, however, the only difference was that Smooth Trunkfish were only found here one year, 2016. As for the other benthic habitats, the Smooth Trunkfish were more commonly found within the deeper habitats, such as SPGR and LIRO. The Smooth Trunkfish showed a similar pattern of results to the Sharpnose Pufferfish when testing within the ecoregions. For the species, the highest mean density appeared to have been found in South Palm Beach, the next highest mean density was found in Deerfield, then Broward-Miami. North Palm Beach was next meanwhile Martin was the least density found for both the Smooth Trunkfish and the Sharpnose Pufferfish. Both species had significant differences found between the Martin ecoregion with Broward-Miami, Deerfield, and South Palm Beach ecoregions.

Of the two Tetraodontidae, the Sharpnose Pufferfish was seen more and had significant differences found within the benthic habitats and ecoregions. Since it was the highest counted selected species (N=7,442), it was a common occurrence to see this species on all fish counts (80% occurrence). In comparison, the Bandtail Pufferfish had an 11% occurrence within the fish counts. Because of this, the Sharpnose Pufferfish showed more significant differences within the habitats meanwhile the Bandtail Pufferfish did not show any. While comparing the mean densities of the Bandtail Pufferfish, the species had high mean densities found in LIRM, CPDP, and CPSH. Meanwhile the Sharpnose Pufferfish had high mean densities found within APRD, SPGR, and LIRO. Both species had a low mean density found within DPRC. As for the ecoregions, the Sharpnose Pufferfish seemed to have more similarities with the Smooth Trunkfish than the Bandtail Pufferfish, although both pufferfish did seem to have low mean densities found within the North Palm Beach and Martin ecoregions.

6.0 Conclusion

The Tetraodontiformes chosen for this project displayed differences between habitat, depth, and ecoregions which allowed the acceptance of each hypotheses. In conclusion, these results agree with the limited amount of literature available for these species. All Tetraodontiformes were found in habitats with large coral reef assemblage structures, while low densities were found in shallow habitats without much reef structure. Tetraodontiformes are found to 120 meters depth, which could be the reason as to why not all species showed differences between the two depth categories used in this study. Lastly, these results agree with the known density of coral reef fish increase from north to south, not particularly to Broward-Miami, but there was a noticeable increase of mean densities found in South Palm Beach from Martin. If the data from the Florida Keys or even the Dry Tortugas were used, the results may have shown more latitudinal differences.

The Gray Triggerfish and Sharpnose Pufferfish were the species to show evident differences while others were not so noticeable. Because these species had very apparent differences, they could be considered indicator species in future studies. Of course, since the Gray Triggerfish is now becoming increasingly valuable and more frequently harvested, it is important to continue monitoring these species (Kilfoyle et al., 2018). This study as well as Kilfoyle et al., (2018) showed that comparison of Gray Triggerfish densities by reef fish assemblage region indicated that most of the population resided in deeper habitats, with a general increase in density moving north. Meanwhile other species, such as Balloonfish, reside in shallower, more southern ecoregions. These species within Tetraodontiformes are globally distributed in tropical and temperate seas as well as freshwaters (Stump et al., 2018), so their small diversity in the local waters of south Florida is just a small distribution that could influence other research if there is continuous monitoring.

6.1 Future research

The next step should be a full comparison of the mean densities to verify they were statistically different from each other. Another idea to consider in the future would be the inter-annual variations and temporal fluctuations of these selected species. The RVC data was collected during the summer throughout early fall. Looking at specific months could show if there are differences over depth or habitats in different intervals throughout the year. This could also relate to when these species start spawning, or if any social behaviors change as the water temperature begins cooling. Since these selected species showed an increase, excluding Gray Triggerfish, of mean densities in 2016, it would be interesting to add the data from the sampling of 2018. The sampling is now biennial, so once sampling is completed in future years the data could be added to continue this research. This could show that the reefs are slowly improving, or not, and these coral reef fish populations are increasing.

More research concerning the social behavior and reproductive habits of the Tetraodontiformes is also needed. Recent studies focus on major perciform groups, such as pomacentrids, labrids, scarids, pomacanthids, and chaetodontids, leaving other groups virtually ignored. One of the reasons I chose the order of Tetraodontiformes is because little is known about pufferfish concerning any aspect of their social behavior or reproductive habits. This project was to summarize the distribution of these fish in the local waters of south Florida but studying more about the diets, social behaviors, and reproductive behaviors could help with policies or even more literature for the local waters. Tetraodontiformes may not be one of the major orders but are still important to the local coral reefs and should not be ignored.

7.0 Acknowledgments

I am very grateful for both of my advisors, Dr. Kirk Kilfoyle and Dr. Bernhard Riegl, for the opportunity to work on this project. Their patience throughout this whole project was extremely appreciated.

I am also very grateful for the support from my family and friends throughout the course of my graduate degree program, I would not have been able to make it this far without their love and support.

8.0 References

Albuquerque, C.Q., Martins, A.S., Oliveira Lette, N.J., Araujo, J.N., and A.M. Ribeiro. 2011. Age and Growth of the Queen Triggerfish *Balistes vetula* (Tetraodontiformes, Balistidae) of the Central Coast of Brazil. Brazilian Journal of Oceanography 59(3):231-239.

Alfaro, M.E., Santini, F., and C. D. Brock. 2007. Do Reefs Drive Diversification in Marine Teleosts? Evidence from the Pufferfishes and Their Allies (Order Tetraodontiformes). *Evolution* 61(9):2104-2126.

Allen, G. R., and M. V. Erdmann. 2012. Reef Fishes of the East Indies. Tropical Reef Research. 1292 p.

Arena, P.T., Jordan, L.K.B., and R.E. Spieler. 2007. Fish Assemblages on Sunken Vessels and Natural Reefs in Southeast Florida, USA. Hydrobiologia, vol. 580, 157-171.

Ahasan, H.A.M.N., Mamun, A.A., Karim, S.R., Bakar, M.A., Gazi, E.A., and C.S. Bala. 2004. Paralytic Complications of Puffer Fish (Tetrodotoxin) Poisoning. Singapore Med Journal. 45 (2):73-74.

Ault, J.S., Bohnsack, J.A. and G.A. Meester. 1998. A Retrospective (1979 - 1996) Multispecies Assessment of Coral Reef Fish Stocks in the Florida Keys. Fishery Bulletin 96 (3):20.

Ault, J.S., and E.C. Franklin. 2011. Fisheries resource status and management alternatives for the southeast Florida region. Report to FDEP. Miami Beach, Florida. 105 p.

Banks, K.E., Riegl, B.M., Richards, V.P., Walker, B.K., Helmle, K.P., Jordan, L.K.B., Phipps, J., Shivji, M., Spieler, R.E. and R.E. Dodge. 2008. The Reef Tract of Continental Southeast Florida (Miami-Dade, Broward, and Palm Beach Counties, USA). In: Riegl B. and R.E. Dodge (eds.) Coral Reefs of the USA. Springer-Verlag, Dordrecht, 175-220.

Bartol, I. K., Gharib, M., Weihs, D., Webb, P. W., Hove, J. R., and M. S. Gordon. 2003. Hydrodynamic stability of swimming in ostraciid fishes: role of the carapace in the Smooth Trunkfish *Lactophrys triqueter* (Teleostei: Ostraciidae). The Journal of Experimental Biology 206:725-744

Behringer, D.C., Swett, R.A. and T.K. Frazer. 2011. Determining Coral Reef Impacts Associated with Boat Anchoring and User Activity in Southeast Florida. Florida Department of Environmental Protection – Coral Reef Conservation Program, Miami Beach, Florida. 66 p.

Bester, C. 2017a. Aluterus scriptus. Florida Museum. Retrieved from https://www.floridamuseum.ufl.edu/discover-fish/species-profiles/aluterus-scriptus/ (October 1, 2019)

Bester, C. 2017b. Balistes vetula. Florida Museum. Retrieved from https://www.floridamuseum.ufl.edu/discover-fish/species-profiles/balistes-vetula/ (September 12, 2019)

Böhlke, J.E., and C.C.G. Chaplin. 1993. Fishes of the Bahamas and adjacent tropical waters. 2nd edition. University of Texas Press, Austin. 771 p.

Bohnsack, J.A., and S.P. Bannerot. 1986. A Stationary Visual Census Technique for Quantitatively Assessing Community Structure of Coral Reef Fishes. Edited by U S Department of Commerce; National Oceanic and Atmospheric Administration. NOAA Tech.Report NMFS (41): 15.

Brandt, M.E., Zurcher, N., Acosta, A., Ault, J.S., Bohnsack, J.A., Feeley, M.W., Harper, D.E., Hunt, J., Kellison, T., McClellan, D.B., Patterson, M.E. and S.G. Smith. 2009. A cooperative multi-agency reef fish monitoring protocol for the Florida Keys coral reef ecosystem. Natural Resource Report NPS/SFCN/NRR – 2009/150. National Park Service, Fort Collins, Colorado.

Dahlgren, C.P., and D.B Eggleston. 2000. Ecological Processes Underlying Ontogenetic Habitat Shifts in a Coral Reef Fish. Ecology 81 (8):2227-2240.

Dooley, J. K. 1968. Young Filefishes. Cantherhines Macrocerus and C. Pullus. Copeia 4, 863-867.

Ettinger, B.D., Gilliam, D.S., Jordan, L.K.B., Sherman, R.L., and R.E. Spieler. 2001. The Coral Reef Fishes of Broward County Florida, Species and Abundance: A Work in Progress. Gulf and Caribbean Fisheries Institute 52:748-756.

Fall, M., Mbengue, M., Diouf, K. G., and H Koussaye. 2013. Technical note on the health risks associated with consumption of fish *Tetraodontidae*, *Diodontidae*, and *Molidae* in Sengal. American Journal of Research Communication 1 (3):61-67.

Ferro, F., Jordan, L.K.B. and R.E. Spieler. 2005. Spatial variability of the coral reef fish assemblages offshore Broward County, Florida. NOAA Technical Memorandum NMFS-SEFSC-532. 73 p.

Finkl, C.W, and J.L. Andrews. 2008. Shelf Geomorphology along the Southeast Florida Atlantic Continental Platform: Barrier Coral Reefs, Nearshore Bedrock, and Morphosedimentary Features. Journal of Coastal Research 24 (4):823–49.

Fisco, D. 2016. Reef Fish Spatial Distribution and Benthic Habitat Associations on the Southeast Florida Reef Tract. Master's Thesis. Nova Southeastern University. Retrieved from NSUWorks. (408)

Florida Population. 2018. Retrieved from http://worldpopulationreview.com/states/florida/ (November 20, 2018)

Fraser, G.J., Britz, R., Hall, A., Johanson, Z., and M.M. Smith. 2012. Replacing the first-generation dentition in pufferfish with a unique beak. Proceedings of the National Academy of Sciences of the United States of America 109(21):8179-8184.

Ghosh, S. R., Thangavelu, G. M., Dhokia, H. K., Zala, M. S., Savaria, Y.D., Polara, J. P., and A. A. Ladani. 2011. Sudden emergence of fishery and some aspects of biology and population dynamics of *Aluterus Monoceros* (Linnaeus, 1758) at Veraval. Indian J Fish 58(1):31-34.

Gregg, K. 2013. Literature review and synthesis of land-based sources of pollution affecting essential fish habitats in southeast Florida. Report Prepared for: NOAA Fisheries Southeast Region – Habitat Conservation Division, West Palm Beach, Florida. 55 p.

Grober-Dunsmore, R., Frazer, T.K., and W.J. Lindberg. 2007. Reef fish and habitat relationships in a Caribbean seascape: the importance of reef context. Coral Reefs 26:201-2016.

Griffith, D. and M.V. Pizzini. 2002. Fishers at Work, Workers at Sea. Philadelphia, Pennsylvania. Temple University Press. 280 p.

Houghton, J.D.R., T.K. Doyle, Davenport, J., and G.C. Hays. 2006. The ocean sunfish Mala mola: Insights into distribution, abundance and behaviour in the Irish Sea and Celtic Seas. Journal of the Marine Biological Association of the United Kingdom 86:1237-1243.

Hove, J.R., O'Bryan, L.M., Gordon, M.S., Webb, P.W., and D. Weihs. 2001. Boxfishes (Teleostei: Ostraciidae) as a model system for fishes swimming with many fins: kinematics. The Journal of Experimental Biology 204:1459-1471.

Hughes, T. P. 1994. Catastrophes, Phase-Shifts, and Large-Scale Degradation of a Caribbean Coral-Reef. Science 265:1547-1551.

Humann, P. and N. Deloach. 2014. Reef Fish Identification. 4th edition. Jacksonville, Florida USA: New World Publications, Inc. 548 p.

Islam, Q.T., Razzak, M.A., Islam, M.A., Bari, M.I., Basher, A., Chowdhury, F.R., Sayeduzzaman, A.B.M., Ahasan, H.A.M.N., Faiz, M.A., Arakaw, O., Yotsu-Yamashita, M., Kuch, U., and D. Mebs. 2011. Puffer fish poisoning in Bangladesh: clinical and toxicological results from large outbreaks in 2008. Transactions of the Royal Society of Tropical Medicine and Hygiene 105 (2):74-80.

Jordan, L.K.B., Gilliam, D.S., Sherman, R.L., Arena, P.T., Harttung, F.M., Baron, R.M., and R. E. Spieler. 2004. Spatial and Temporal Recruitment Patterns of Juvenile Grunts (Haemulon spp.) in South Florida. Marine & Environmental Sciences Faculty Proceedings, Presentations, Speeches, Lectures. 65.

Jordan, L.K.B., Banks, K.W., Fisher, L.E., Walker, B.K., and D.S. Gilliam. 2010. Elevated sedimentation on coral reefs adjacent to a beach nourishment project. Marine Pollution Bulletin 60, 261-271.

Kaschner, K., Kesner-Reyes, K., Garilao, C., Rius-Barile, J., Rees, T., and R. Froese. 2016. AquaMaps: Predicted range maps for aquatic species. World Wide Web electronic publication, www.aquamaps.org, Version 08/2016.

Kendall, M.S., Monaco, M.E., Buja., K. R., Christensen, J.D., Kruer, C.R., Finkbeiner, M., and R.A. Warner. 2001. Methods Used to Map the Benthic Habitats of Puerto Rico and the US Virgin Islands. Edited by National Oceanic and Atmospheric Administration. Silver Spring, MD: http://biogeo.nos.noaa.gov/projects/mapping/caribbean/startup.htm.

Kilfoyle, A.K., Walker, B.K., Gregg, K., Fisco, D.P., and R.E. Spieler. 2017. Southeast Florida Coral Reef Fishery-Independent Baseline Assessment: 2012-2016 Summary Report. National Oceanic and Atmospheric Administration. 121 p.

Kopp, D., Bouchon-Navaro, Y., Louis, M., Mouillot, D., and C. Bouchon. 2010. Herbivorous Fishes and the Potential of Caribbean Marine Reserves to Preserve Coral Reef Ecosystems. Aquatic Conservation: Marine and Freshwater Ecosystems 20 (5): 516–24. doi:10.1002/aqc.1118.

Leis, J.L., Matsuura, K., Shao, K.-T., Hardy, G., Zapfe, G., Liu, M., Jing, L., Robertson, R. and J, Tyler. 2015. *Lactophrys triqueter* (errata version published in 2017). The IUCN Red List of Threatened Species 2015: e.T190363A115315495. http://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T190363A1949373.en. Retrieved on 02 October 2019.

Lirman, D., Ault, J.S., Fourqurean, J.W., and J.J. Lorenz. 2019. Chapter 17 – The Coastal Marine Ecosystem of South Florida, United States. World Seas: An Environmental Evaluation (Second Edition), Volume 1: Europe, the Americas and West Africa. 427-444.

Liu, J., Zapfe, G., Shao, K.-T., Leis, J.L., Matsuura, K., Hardy, G., Liu, M. and J, Tyler. 2015. *Balistes capriscus* (errata version published in 2016). The IUCN Red List of Threatened Species 2015: e.T193736A97662794. Retrieved on 09 January 2020.

LiveAquaria. N.d. Marine fish. Retrieved from https://www.liveaquaria.com/category/15/marine-fish (November 13, 2018)

Malpezzi, E.L.A., De Freitas, J.C., and F. T. Rantin. (1997). Occurrence of toxins, other than paralysing type, in the skin of tetraodontiformes fish. Toxins (35):1, 57 – 65.

Matsuura, K. 2014. Taxonomy and systematics of tetraodontiform fishes: a review focusing primarily on progress in the period from 1980 to 2014. Ichthyol Res 62, 72-113.

Matsuura, K., Motomura, H., Tyler, J., and R. Robertson. 2015a. *Aluterus monoceros* (errata version published in 2017). The IUCN Red List of Threatened Species 2015: e.T16404943A115353437. http://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T16404943A16509717.en. Retrieved on 26 September 2019.

Matsuura, K., Tyler, J. and R. Robertson. 2015b. *Cantherhines pullus* (errata version published in 2017). The IUCN Red List of Threatened Species 2015: e.T16431606A115356802. http://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T16431606A16510017.en. Retrieved on 01 October 2019.

Miller, M.W., Karazsia, J., Groves, C.E., Griffin, S., Moore, T., Wilber, P., and K. Gregg. 2016. Detecting sedimentation impacts to coral reefs resulting from dredging the Port of Miami, Florida USA. PeerJ 4:e2711; DOI 10.7717/peerj.2711.

Monterey Bay Aquarium. 2017. Seafood Watch - Queen Triggerfish. Monterey Bay Aquarium Foundation. 78 p.

Mora, C. 2008. A Clear Human Footprint in the Coral Reefs of the Caribbean. Proceedings of the Royal Society B: Biological Sciences 275 (1636): 767–73. doi:10.1098/rspb.2007.1472.

Moura, R. L., and R. M. C. Castro. 2002. Revision of Atlantic Sharpnose Pufferfishfishes (Tetraodontiformes: Tetraodontidae: *Canthigaster*), with description of three new species. Proceedings of the Biological Society of Washington. 115(1):32-50.

NOAA Coral Program. 2014. National Coral Reef Monitoring Plan. Silver Spring, MD, NOAA Coral Reef Conservation Program.40 p.

NOAA. 2017. NOAA's National Coral Reef Monitoring Program. Retrieved from: https://www.coris.noaa.gov/monitoring/ (October 8, 2018)

NOAA. 2018. About our agency. Retrieved from: https://www.noaa.gov/about-our-agency (October 8, 2018)

NOAA. 2018. Gray Triggerfish. Retrieved from: https://www.fisheries.noaa.gov/species/gray-triggerfish (June 8, 2019)

Patton, C. 2018. "Discover Fishes, Balloonfish." Florida Museum. Retrieved from: https://www.floridamuseum.ufl.edu/discover-fish/species-profiles/diodon-holocanthus/ (June 8, 2019)

Potter, I.F., and W.H. Howell. 2011. Vertical movement and behavior of the ocean sunfish, *Mola mola*, in the northwest Atlantic. Journal of Experimental Marine Biology and Ecology 396 (2):138-146.

Randall, J.E., and J.T. Millington. 1990. Triggerfish bite – a little-known marine hazard. Journal of Wilderness Medicine 1:79-85.

Runde, B.J., Rudershausen, P.J., Sauls, B., Mikles, C.S., and J.A. Buckel. 2019. Low discard survival of gray triggerfish in the southeastern US hook-and-line fishery. Fisheries Research 219:105313.

Safiq A.D., Lockwood J.L., Brown J.A. 2018. Homogenization of Fish Assemblages Off the Coast of Florida. In: Rozzi R. et al. (eds) From Biocultural Homogenization to Biocultural Conservation. Ecology and Ethics 3:289-300.

Sakamoto, T. and K. Suzuki. 1978. Spawning Behavior and Early Life History of the Porcupine Puffer, *Diodon holocanthus,* in Aquaria. Japanese Journal of Ichthyology 24(4): 261-270.

Santini, F., Sorenson, L., Marcroft, T., Dornburg, A. and M.E. Alfaro. 2013. A multilocus molecular phylogeny of boxfishes (Aracanidae, Ostraciidae; Tetraodontiformes). Molecular Phylogenetics and Evolution 66:153-160.

Shao, K., Liu, M., Jing, L., Hardy, G., Leis, J.L. and K. Matsuura. 2014a. *Canthigaster rostrata*. The IUCN Red List of Threatened Species 2014: e.T193793A2277707. http://dx.doi.org/10.2305/IUCN.UK.2014-3.RLTS.T193793A2277707.en. Retrieved on 02 October 2019.

Shao, K., Liu, M., Jing, L., Hardy, G., Leis, J.L. and Matsuura, K. 2014b. *Sphoeroides spengleri*. The IUCN Red List of Threatened Species 2014: e.T193630A2249897. http://dx.doi.org/10.2305/IUCN.UK.2014-3.RLTS.T193630A2249897.en. Retrieved on 01 October 2019.

Salwaterfish.com. N.d. Saltwater fish. Retrieved from https://www.saltwaterfish.com/category-saltwater-fish_puffers (November 13, 2018)

Sikkel, P. C. 1990. Social organization and spawning in the Atlantic Sharpnose Pufferfish, *Canthigaster rostrate* (Tetraodontidae). Environmental Biology of Fishes 27:234-254.

Simmons, C. M., and S. T. Szedlmayer. 2012. Territoriality, reproductive behavior, and parental care in Gray Triggerfish, Balistes capriscus, from the northern Gulf of Mexico. Bulletin of Marine Science 88(2):197–209.

Stump, E., Ralph, G.M., Comeros-Raynal, M.T., Matsuura, K., and K.E. Carpenter. 2018. Global conservation status of marine pufferfishes (Tetraodontiformes: Tetraodontidae). Global Ecology and Conservation. 14: e00388.

Tyler, J.C., Johnson, G., Jawad, L., and E.B. Brothers. 2014. A developmentally “tail-less” adult cowfish, Lactoria cornuta, from Oman (Ostraciidae, Tetraodontiformes). Proceedings of the Biological Society of Washington 127(2):311-322.

Wainwright, P.C., and R.G. Turingan. 1997. Evolution of Pufferfish Inflation Behavior. Evolution 51(2):506-518.

Walker, B. K. 2008. A Model Framework for Predicting Reef Fish Distributions Across the Seascape Using GIS Topographic Metrics and Benthic Habitat Associations. In Proceedings of the 11th International Coral Reef Symposium. Ft. Lauderdale, Florida.

Walker, B.K., 2012. Spatial Analyses of Benthic Habitats to Define Coral Reef Ecosystem Regions and Potential Biogeographic Boundaries along a Latitudinal Gradient. PLoS ONE 7 (1): e30466.

Walker, B.K., Gilliam, D.S., Dodge, R.E., and J. Walczak. 2012. Dredging and shipping impacts on southeast Florida coral reefs. Proceedings of the 12th International Coral Reef Symposium, 19A Human Impacts on Coral Reefs: General Session, Cairns, Australia, 9-13.

Walker, B.K, and D. S. Gilliam. 2013. Determining the Extent and Characterizing Coral Reef Habitats of the Northern Latitudes of the Florida Reef Tract (martin County). PLoS ONE 8 (11): e80439.

Walker, B.K., Riegl, B.M., and R.E. Dodge. 2008. Mapping Coral Reef Habitats in Southeaster Florida Using a Combined Technique Approach. Journal of Coastal Research 24(5): 1138-50.

9.0 Appendices

Appendix 1. *The total counts for each of the species found in the baseline dataset from Kilfoyle et al. (2018) for the Tetraodontiformes throughout the five years. Selected species have an asterisk (*) next to the common name.*

Family	***Species (Scientific Name)***	**Common Name**	**Total**
Balistidae	*Balistes capriscus*	Gray Triggerfish*	3286
Balistidae	*Balistes vetula*	Queen Triggerfish*	38
Balistidae	*Canthidermis sufflamen*	Ocean Triggerfish	47
Balistidae	*Melichthys niger*	Black Durgon	1
Diodontidae	*Chilomycterus antennatus*	Bridled Burrfish	1
Diodontidae	*Chilomycterus atinga*	Spotted Burrfish	2
Diodontidae	*Chilomycterus schoepfii*	Striped Burrfish	6
Diodontidae	*Diodon holocanthus*	Balloonfish*	121
Diodontidae	*Diodon hystrix*	Porcupinefish	17
Monacanthidae	*Aluterus monoceros*	Unicorn Filefish*	87
Monacanthidae	*Aluterus schoepfii*	Orange Filefish	36
Monacanthidae	*Aluterus scriptus*	Scrawled Filefish*	463
Monacanthidae	*Cantherhines macrocerus*	Whitespotted Filefish	53
Monacanthidae	*Cantherhines pullus*	Orangespotted Filefish*	249
Monacanthidae	*Monacanthus ciliatus*	Fringed Filefish	7
Monacanthidae	*Monacanthus tuckeri*	Slender Filefish	96
Monacanthidae	*Stephanolepis hispidus*	Planehead Filefish	87
Ostraciidae	*Acanthostracion polygonia*	Honeycomb Cowfish	139
Ostraciidae	*Acanthostracion quadricornis*	Scrawled Cowfish	176
Ostraciidae	*Lactophrys bicaudalis*	Spotted Trunkfish	22
Ostraciidae	*Lactophrys trigonus*	Trunkfish	13
Ostraciidae	*Lactophrys triqueter*	Smooth Trunkfish*	212
Tetraodontidae	*Canthigaster rostrata*	Sharpnose Pufferfish*	7442
Tetraodontidae	*Sphoeroides spengleri*	Bandtail Pufferfish*	234
Tetraodontidae	*Sphoeroides testudineus*	Checkered Puffer	8

Appendix 2. *Total sample sizes for the eleven benthic habitats: APRD, CPDP, CPSH, DPRC, LIRI, LIRM, LIRO, PTCH, RGDP, RGSH, and SPGR for each year, as well as the total for the five years, and yearly mean. The asterisk (*) is next to the habitat SCRS (Scattered rock in Unconsolidated Sediment) because it needs to be noted it was not used in analysis. It was not used since it was sampled three times in 2013 and none of the selected species were counted within it.*

	2012	2013	2014	2015	2016	Total	Mean
APRD	43	73	41	25	29	211	42.2
CPDP	21	38	17	8	9	93	18.6
CPSH	65	48	42	63	19	237	47.4
DPRC	22	94	103	90	72	381	76.2
LIRI	45	45	52	33	40	215	43
LIRM	75	70	97	58	53	353	70.6
LIRO	33	58	65	25	33	214	42.8
PTCH	14	6	4	4	4	32	6.4
RGDP	13	48	44	42	30	177	35.4
RGSH	72	114	98	49	19	352	70.4
SCRS*	0	3	0	0	0	3	0.6
SPGR	29	42	42	20	29	162	32.4

Appendix 3. *The total mean density (fishes/SSU) for each species throughout 2012 to 2016 in the shallow benthic habitats [RGSH (N=352), CPSH (N=237), LIRI (N=215), and PTCH (N=32)].*

MEAN DENSITY	**RGSH**	**CPSH**	**LIRI**	**PTCH**
Gray Triggerfish	0.366	0.741	0.670	7.547
Queen Triggerfish	0.000	0.000	0.002	0.000
Balloonfish	0.064	0.078	0.072	0.094
Unicorn Filefish	0.000	0.000	0.000	0.000
Scrawled Filefish	0.027	0.023	0.065	0.266
Orangespotted Filefish	0.092	0.053	0.123	0.188
Smooth Trunkfish	0.034	0.040	0.055	0.234
Sharpnose Puffer	1.877	1.207	2.302	4.391
Bandtail Puffer	0.107	0.118	0.044	0.078
STANDARD ERROR	**RGSH**	**CPSH**	**LIRI**	**PTCH**
Gray Triggerfish	0.0405	0.1192	0.5178	3.1219
Queen Triggerfish	0.0000	0.0000	0.0060	0.0000
Balloonfish	0.0108	0.0136	0.0355	0.0351
Unicorn Filefish	0.0000	0.0000	0.0000	0.0000
Scrawled Filefish	0.0083	0.0113	0.0393	0.0869
Orangespotted Filefish	0.0164	0.0131	0.0560	0.0770
Smooth Trunkfish	0.0081	0.0149	0.0289	0.2344
Sharpnose Puffer	0.1325	0.1268	0.5298	0.8764
Bandtail Puffer	0.0179	0.0218	0.0388	0.0326

Appendix 4. *The total mean density (fishes/SSU) for each species throughout 2012 to 2016 in the deep benthic habitats [DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)].*

MEAN DENSITY	DPRC	LIRM	LIRO	APRD	RGDP	SPGR	CPDP
Gray Triggerfish	2.287	2.224	0.236	0.382	3.702	0.417	0.927
Queen Triggerfish	0.033	0.004	0.009	0.045	0.037	0.022	0.016
Balloonfish	0.010	0.056	0.044	0.040	0.014	0.062	0.075
Unicorn Filefish	0.077	0.010	0.098	0.090	0.048	0.022	0.016
Scrawled Filefish	0.157	0.120	0.595	0.263	0.169	0.571	0.188
Orangespotted Filefish	0.031	0.102	0.149	0.181	0.065	0.151	0.188
Smooth Trunkfish	0.037	0.058	0.217	0.148	0.028	0.231	0.183
Sharpnose Puffer	1.420	3.626	4.592	6.242	3.054	5.309	3.642
Bandtail Puffer	0.041	0.154	0.086	0.114	0.099	0.086	0.129

STANDARD ERROR	DPRC	LIRM	LIRO	APRD	RGDP	SPGR	CPDP
Gray Triggerfish	0.197	0.403	0.055	0.082	0.440	0.157	0.222
Queen Triggerfish	0.009	0.002	0.006	0.017	0.013	0.010	0.009
Balloonfish	0.004	0.009	0.013	0.010	0.007	0.017	0.024
Unicorn Filefish	0.022	0.007	0.068	0.083	0.026	0.014	0.012
Scrawled Filefish	0.022	0.022	0.090	0.034	0.048	0.085	0.047
Orangespotted Filefish	0.007	0.013	0.022	0.026	0.015	0.024	0.036
Smooth Trunkfish	0.008	0.010	0.031	0.023	0.011	0.038	0.035
Sharpnose Puffer	0.108	0.193	0.346	0.363	0.317	0.374	0.364
Bandtail Puffer	0.008	0.019	0.022	0.022	0.022	0.020	0.035

Appendix 5. *All selected species mean density (fishes/SSU) for each year, standard error, and graphs for the benthic habitats [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)]. Note: SCRS was not used during analysis.*

Gray Triggerfish							
MEAN DENSITY		2012	2013	2014	2015	2016	
Shallow	RGSH	0.4005	0.3377	0.2755	0.3776	0.8421	0.3660
	CPSH	0.4179	0.9375	0.9643	0.7937	0.6842	0.7412
	LIRI	0.3556	0.7444	0.3365	0.3030	1.6750	0.6698
	PTCH	3.4643	2.5833	21.3750	21.1250	1.8750	7.5469
	SCRS		0.0000				0.0000
Deep	DPRC	0.7045	1.1968	2.5000	2.2167	3.9792	2.2874
	LIRM	1.1000	2.0143	1.8351	4.2328	2.6038	2.2238
	LIRO	0.1364	0.1552	0.3385	0.1600	0.3333	0.2360
	APRD	0.2325	0.4384	0.3049	0.2800	0.6552	0.3815
	RGDP	2.7115	1.7813	3.7386	5.3571	4.8333	3.7020
	SPGR	0.0172	0.0357	0.8333	0.3000	0.8448	0.4167
	CPDP	0.7460	0.9079	1.6176	1.0625	0.0000	0.9265

STANDARD ERROR		2012	2013	2014	2015	2016	
Shallow	RGSH	0.0912	0.0538	0.0754	0.0722	0.3863	0.0405
	CPSH	0.1100	0.2385	0.4538	0.2004	0.5232	0.1192
	LIRI	0.0804	0.4482	0.1006	0.1129	0.9233	0.5178
	PTCH	1.9573	0.9347	18.0455	15.8474	0.0488	3.1219
	SCRS		0.0000				0.0000
Deep	DPRC	0.3251	0.2603	0.4438	0.2649	0.6240	0.1974
	LIRM	0.3502	0.3685	0.3419	2.1905	0.7472	0.4030
	LIRO	0.0587	0.0665	0.1504	0.0748	0.1353	0.0548
	APRD	0.0946	0.1881	0.1208	0.1387	0.2719	0.0825
	RGDP	1.0015	0.3594	0.7691	0.8443	1.8244	0.4401
	SPGR	0.0172	0.0264	0.4644	0.2065	2.8912	0.1575
	CPDP	0.1699	0.3827	0.6353	0.6508	0.0000	0.2216

Appendix 5. *(continued)*

Queen Triggerfish							
MEAN DENSITY		2012	2013	2014	2015	2016	
Shallow	RGSH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	CPSH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	LIRI	0.0000	0.0000	0.0096	0.0000	0.0000	0.0023
	PTCH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	SCRS		0.0000				0.0000
Deep	DPRC	0.0227	0.0691	0.0146	0.0167	0.0347	0.0328
	LIRM	0.0067	0.0000	0.0052	0.0000	0.0094	0.0042
	LIRO	0.0000	0.0000	0.0077	0.0000	0.0455	0.0093
	APRD	0.0000	0.0274	0.0122	0.0000	0.2414	0.0450
	RGDP	0.0000	0.0833	0.0455	0.0000	0.0167	0.0367
	SPGR	0.0172	0.0000	0.0595	0.0000	0.0172	0.0216
	CPDP	0.0476	0.0000	0.0294	0.0000	0.0000	0.0161

STANDARD ERROR		2012	2013	2014	2015	2016	
Shallow	RGSH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	CPSH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	LIRI	0.0000	0.0000	0.0096	0.0000	0.0000	0.0060
	PTCH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	SCRS		0.0000				0.0000
Deep	DPRC	0.0227	0.0268	0.0108	0.0124	0.0180	0.0087
	LIRM	0.0067	0.0000	0.0052	0.0000	0.0094	0.0024
	LIRO	0.0000	0.0000	0.0077	0.0000	0.0335	0.0057
	APRD	0.0000	0.0166	0.0122	0.0000	0.1127	0.0173
	RGDP	0.0000	0.0375	0.0318	0.0000	0.0167	0.0133
	SPGR	0.0172	0.0000	0.0349	0.0000	0.0928	0.0101
	CPDP	0.0143	0.0000	0.0294	0.0000	0.0000	0.0092

Appendix 5. *(continued)*

Balloonfish							
MEAN DENSITY		2012	2013	2014	2015	2016	
Shallow	RGSH	0.0972	0.0482	0.0510	0.0816	0.0526	0.0639
	CPSH	0.0769	0.1146	0.0714	0.0714	0.0263	0.0781
	LIRI	0.0889	0.0667	0.1058	0.0303	0.0500	0.0721
	PTCH	0.1071	0.0000	0.0000	0.0000	0.3750	0.0938
	SCRS		0.0000				0.0000
Deep	DPRC	0.0000	0.0053	0.0049	0.0111	0.0278	0.0105
	LIRM	0.0444	0.0500	0.0670	0.0431	0.0755	0.0562
	LIRO	0.0000	0.0948	0.0231	0.0600	0.0303	0.0444
	APRD	0.0233	0.0342	0.0488	0.0400	0.0690	0.0403
	RGDP	0.0000	0.0208	0.0000	0.0357	0.0000	0.0141
	SPGR	0.1207	0.0476	0.0595	0.0000	0.0690	0.0617
	CPDP	0.0952	0.1053	0.0588	0.0000	0.0000	0.0753

STANDARD ERROR		2012	2013	2014	2015	2016	
Shallow	RGSH	0.0323	0.0139	0.0170	0.0367	0.0362	0.0108
	CPSH	0.0251	0.0401	0.0273	0.0249	0.0263	0.0136
	LIRI	0.0329	0.0302	0.0346	0.0211	0.0240	0.0355
	PTCH	0.0569	0.0000	0.0000	0.0000	0.0063	0.0351
	SCRS		0.0000				0.0000
Deep	DPRC	0.0000	0.0053	0.0049	0.0078	0.0136	0.0037
	LIRM	0.0162	0.0207	0.0189	0.0186	0.0248	0.0089
	LIRO	0.0000	0.0398	0.0131	0.0332	0.0211	0.0127
	APRD	0.0162	0.0178	0.0235	0.0277	0.0326	0.0100
	RGDP	0.0000	0.0146	0.0000	0.0264	0.0000	0.0074
	SPGR	0.0474	0.0229	0.0253	0.0000	0.3714	0.0174
	CPDP	0.0243	0.0428	0.0588	0.0000	0.0000	0.0241

Appendix 5. *(continued)*

Unicorn Filefish							
MEAN DENSITY		2012	2013	2014	2015	2016	
Shallow	RGSH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	CPSH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	LIRI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	PTCH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	SCRS		0.0000				0.0000
Deep	DPRC	0.0000	0.0585	0.0194	0.0500	0.2431	0.0774
	LIRM	0.0000	0.0000	0.0052	0.0086	0.0472	0.0099
	LIRO	0.0000	0.0000	0.0000	0.0000	0.6364	0.0981
	APRD	0.0000	0.2466	0.0000	0.0400	0.0000	0.0900
	RGDP	0.0000	0.0000	0.0341	0.0952	0.1000	0.0480
	SPGR	0.0000	0.0000	0.0595	0.0000	0.0345	0.0216
	CPDP	0.0000	0.0000	0.0588	0.0000	0.0556	0.0161

STANDARD ERROR		2012	2013	2014	2015	2016	
Shallow	RGSH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	CPSH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	LIRI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	PTCH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	SCRS		0.0000				0.0000
Deep	DPRC	0.0000	0.0369	0.0118	0.0317	0.0979	0.0224
	LIRM	0.0000	0.0000	0.0052	0.0086	0.0472	0.0074
	LIRO	0.0000	0.0000	0.0000	0.0000	0.4348	0.0680
	APRD	0.0000	0.2397	0.0000	0.0400	0.0000	0.0831
	RGDP	0.0000	0.0000	0.0252	0.0952	0.0606	0.0256
	SPGR	0.0000	0.0000	0.0488	0.0000	0.1857	0.0141
	CPDP	0.0000	0.0000	0.0588	0.0000	0.1667	0.0120

Appendix 5. *(continued)*

Scrawled Filefish							
MEAN DENSITY		2012	2013	2014	2015	2016	
Shallow	RGSH	0.0347	0.0307	0.0204	0.0000	0.0789	0.0270
	CPSH	0.0308	0.0208	0.0000	0.0397	0.0000	0.0232
	LIRI	0.0444	0.0667	0.0577	0.0455	0.1125	0.0651
	PTCH	0.0000	0.2500	0.3750	0.5000	0.8750	0.2656
	SCRS		0.0000				0.0000
Deep	DPRC	0.1364	0.0319	0.1019	0.2389	0.3056	0.1575
	LIRM	0.0311	0.0929	0.1082	0.0517	0.3774	0.1199
	LIRO	0.3889	0.3966	0.3692	0.7000	1.5152	0.5950
	APRD	0.1395	0.2260	0.3659	0.3000	0.3621	0.2630
	RGDP	0.1538	0.0625	0.2386	0.0595	0.4000	0.1695
	SPGR	0.3621	0.1905	0.6905	0.8000	1.0000	0.5710
	CPDP	0.1667	0.1842	0.1176	0.1875	0.3889	0.1882

STANDARD ERROR		2012	2013	2014	2015	2016	
Shallow	RGSH	0.0228	0.0143	0.0100	0.0000	0.0789	0.0083
	CPSH	0.0242	0.0146	0.0000	0.0326	0.0000	0.0113
	LIRI	0.0267	0.0341	0.0224	0.0335	0.0522	0.0393
	PTCH	0.0000	0.1708	0.2394	0.2887	0.0216	0.0869
	SCRS		0.0000				0.0000
Deep	DPRC	0.0486	0.0148	0.0340	0.0501	0.0776	0.0220
	LIRM	0.0166	0.0357	0.0304	0.0266	0.1196	0.0224
	LIRO	0.1125	0.0850	0.0696	0.2630	0.4750	0.0904
	APRD	0.0384	0.0516	0.0988	0.0913	0.1161	0.0336
	RGDP	0.0874	0.0383	0.1108	0.0389	0.2068	0.0475
	SPGR	0.0989	0.0722	0.2481	0.1828	1.1877	0.0852
	CPDP	0.0458	0.0691	0.0682	0.1875	0.6972	0.0471

Appendix 5. *(continued)*

Orangespotted Filefish							
MEAN DENSITY		2012	2013	2014	2015	2016	
Shallow	RGSH	0.0486	0.0965	0.1071	0.0408	0.2895	0.0923
	CPSH	0.0385	0.0625	0.0595	0.0714	0.0000	0.0527
	LIRI	0.1444	0.1000	0.1731	0.1061	0.0750	0.1233
	PTCH	0.2500	0.0000	0.2500	0.0000	0.3750	0.1875
	SCRS		0.0000				0.0000
Deep	DPRC	0.0227	0.0266	0.0485	0.0222	0.0278	0.0315
	LIRM	0.1178	0.1000	0.1134	0.0690	0.0943	0.1015
	LIRO	0.0555	0.1379	0.1846	0.1800	0.1667	0.1488
	APRD	0.1550	0.1370	0.2561	0.2400	0.1724	0.1809
	RGDP	0.0000	0.0521	0.0682	0.0476	0.1333	0.0650
	SPGR	0.1034	0.1071	0.2500	0.1750	0.1034	0.1512
	CPDP	0.1667	0.1842	0.2059	0.2500	0.1667	0.1882

STANDARD ERROR		2012	2013	2014	2015	2016	
Shallow	RGSH	0.0225	0.0291	0.0292	0.0246	0.1636	0.0164
	CPSH	0.0199	0.0241	0.0305	0.0355	0.0000	0.0131
	LIRI	0.0493	0.0408	0.0597	0.0475	0.0286	0.0560
	PTCH	0.1550	0.0000	0.1443	0.0000	0.0121	0.0770
	SCRS		0.0000				0.0000
Deep	DPRC	0.0227	0.0116	0.0162	0.0135	0.0136	0.0068
	LIRM	0.0295	0.0280	0.0269	0.0228	0.0303	0.0126
	LIRO	0.0268	0.0321	0.0532	0.0569	0.0518	0.0215
	APRD	0.0465	0.0393	0.0764	0.0963	0.0513	0.0259
	RGDP	0.0000	0.0223	0.0348	0.0229	0.0532	0.0150
	SPGR	0.0383	0.0363	0.0665	0.0656	0.2061	0.0236
	CPDP	0.0312	0.0547	0.0864	0.1637	0.3536	0.0358

Appendix 5. *(continued)*

Smooth Trunkfish							
MEAN DENSITY		2012	2013	2014	2015	2016	
Shallow	RGSH	0.0625	0.0439	0.0153	0.0102	0.0263	0.0341
	CPSH	0.0538	0.0417	0.0238	0.0397	0.0263	0.0401
	LIRI	0.1296	0.0333	0.0288	0.0303	0.0500	0.0550
	PTCH	0.0000	0.0000	0.0000	0.0000	1.8750	0.2344
	SCRS		0.0000				0.0000
Deep	DPRC	0.0227	0.0426	0.0243	0.0444	0.0417	0.0367
	LIRM	0.0733	0.0357	0.0361	0.0431	0.1226	0.0581
	LIRO	0.2374	0.1552	0.2308	0.3000	0.2121	0.2165
	APRD	0.1550	0.1575	0.1585	0.1200	0.1207	0.1477
	RGDP	0.0000	0.0208	0.0341	0.0000	0.0833	0.0282
	SPGR	0.1724	0.2500	0.2262	0.2750	0.2414	0.2315
	CPDP	0.1429	0.1974	0.1765	0.0625	0.3333	0.1828

STANDARD ERROR		2012	2013	2014	2015	2016	
Shallow	RGSH	0.0260	0.0160	0.0087	0.0102	0.0263	0.0081
	CPSH	0.0467	0.0251	0.0166	0.0172	0.0263	0.0149
	LIRI	0.0326	0.0246	0.0163	0.0211	0.0240	0.0289
	PTCH	0.0000	0.0000	0.0000	0.0000	0.0948	0.2344
	SCRS		0.0000				0.0000
Deep	DPRC	0.0227	0.0163	0.0106	0.0170	0.0216	0.0077
	LIRM	0.0206	0.0155	0.0151	0.0223	0.0379	0.0096
	LIRO	0.0616	0.0580	0.0668	0.0866	0.0755	0.0313
	APRD	0.0465	0.0401	0.0640	0.0523	0.0535	0.0228
	RGDP	0.0000	0.0146	0.0192	0.0000	0.0541	0.0111
	SPGR	0.0570	0.1108	0.0570	0.0992	0.3924	0.0380
	CPDP	0.0266	0.0582	0.0851	0.0625	0.4330	0.0349

Appendix 5. *(continued)*

Sharpnose Pufferfish							
MEAN DENSITY		2012	2013	2014	2015	2016	
Shallow	RGSH	2.4351	1.8860	1.1276	1.0510	5.7105	1.8774
	CPSH	1.7538	0.9896	1.0595	0.4365	2.7632	1.2067
	LIRI	2.3889	2.5889	1.8462	1.5303	3.1125	2.3023
	PTCH	2.6429	4.3333	4.5000	4.3750	10.5000	4.3906
	SCRS		0.0000				0.0000
Deep	DPRC	0.9773	0.7979	1.8495	1.0389	2.2292	1.4199
	LIRM	4.8111	3.8929	2.4639	2.0517	5.4434	3.6256
	LIRO	6.3535	4.3103	3.9077	2.6800	6.1212	4.5919
	APRD	9.0039	4.7260	5.0244	4.2800	9.3793	6.2425
	RGDP	5.9615	2.1458	1.9886	1.4048	7.1167	3.0537
	SPGR	5.3621	4.6310	4.8571	3.3250	8.2586	5.3086
	CPDP	3.2699	3.3289	2.4412	2.9375	8.7222	3.6416

STANDARD ERROR		2012	2013	2014	2015	2016	
Shallow	RGSH	0.3459	0.1464	0.1261	0.1545	1.4133	0.1325
	CPSH	0.2315	0.1579	0.1884	0.0674	1.1280	0.1268
	LIRI	0.3488	0.5319	0.2376	0.1946	0.7469	0.5298
	PTCH	0.9571	1.2428	2.2638	1.3750	0.2410	0.8764
	SCRS		0.0000				0.0000
Deep	DPRC	0.1903	0.1018	0.2316	0.1425	0.3816	0.1083
	LIRM	0.4800	0.4206	0.2027	0.1733	0.7224	0.1927
	LIRO	0.9197	0.8876	0.3874	0.3365	0.9606	0.3464
	APRD	0.9511	0.3850	0.6801	0.4556	1.4096	0.3633
	RGDP	1.1636	0.4338	0.3907	0.2801	1.2015	0.3167
	SPGR	0.6588	0.7661	0.4692	0.2885	7.3686	0.3742
	CPDP	0.2536	0.4632	0.3262	0.6842	6.7644	0.3639

Appendix 5. *(continued)*

Bandtail Pufferfish							
MEAN DENSITY		2012	2013	2014	2015	2016	
Shallow	RGSH	0.1528	0.1623	0.0561	0.0306	0.0526	0.1065
	CPSH	0.1462	0.2708	0.0714	0.0238	0.0526	0.1181
	LIRI	0.0556	0.0222	0.0385	0.0000	0.1000	0.0442
	PTCH	0.0000	0.0000	0.0000	0.2500	0.3750	0.0781
	SCRS		0.0000				0.0000
Deep	DPRC	0.0682	0.0160	0.0534	0.0611	0.0208	0.0407
	LIRM	0.1000	0.1071	0.2990	0.0603	0.1321	0.1544
	LIRO	0.0606	0.1552	0.0769	0.0200	0.0606	0.0864
	APRD	0.0814	0.1233	0.1585	0.0400	0.1379	0.1137
	RGDP	0.0769	0.0729	0.0795	0.0595	0.2333	0.0989
	SPGR	0.0345	0.1310	0.1071	0.0250	0.0862	0.0864
	CPDP	0.0000	0.1316	0.3824	0.0000	0.0556	0.1290

STANDARD ERROR		2012	2013	2014	2015	2016	
Shallow	RGSH	0.0590	0.0350	0.0204	0.0173	0.0362	0.0179
	CPSH	0.0487	0.0744	0.0273	0.0135	0.0362	0.0218
	LIRI	0.0285	0.0222	0.0232	0.0000	0.0625	0.0388
	PTCH	0.0000	0.0000	0.0000	0.1443	0.0063	0.0326
	SCRS		0.0000				0.0000
Deep	DPRC	0.0498	0.0091	0.0168	0.0221	0.0119	0.0082
	LIRM	0.0355	0.0286	0.0537	0.0248	0.0385	0.0194
	LIRO	0.0288	0.0698	0.0295	0.0200	0.0288	0.0220
	APRD	0.0285	0.0400	0.0663	0.0277	0.0652	0.0219
	RGDP	0.0521	0.0333	0.0486	0.0253	0.0821	0.0220
	SPGR	0.0239	0.0567	0.0401	0.0250	0.1922	0.0199
	CPDP	0.0000	0.0616	0.1096	0.0000	0.1667	0.0350

Appendix 6. *The results of the Kruskal-Wallis test for each species within the eleven benthic habitats. Each species showing significance (P<0.05) has an asterisk (*) next to the value.*

Species	P-value
Gray triggerfish	0.00001*
Queen triggerfish	0.0179*
Balloonfish	0.0696
Unicorn Filefish	0.0673
Scrawled filefish	0.0001*
Orangespotted filefish	0.0021*
Smooth trunkfish	0.0001*
Sharpnose pufferfish	0.0006*
Bandtail puffer	0.4886

Appendix 7. *All tables produced after the post-hoc analysis for each of the species that showed significance when tested against the eleven benthic habitats [RGSH (N=352), CPSH (N=237), LIRI (N=215), PTCH (N=32), DPRC (N=381), LIRM (N=353), LIRO (N=214), APRD (N=211), RGDP (N=177), SPGR (N=162), and CPDP (N=93)]. The righthand columns shows the levels of significance obtained (significance shown with an asterisk (*) when P<0.05).*

Gray Triggerfish	P-Value
LIRO - PTCH	0.0001*
LIRO - RGDP	0.0001*
APRD - PTCH	0.0007*
LIRM - LIRO	0.0008*
PTCH - SPGR	0.0008*
APRD - RGDP	0.0009*
RGDP - SPGR	0.0010*
PTCH - RGSH	0.0024*
DPRC - LIRO	0.0025*
RGDP - RGSH	0.0029*
APRD - LIRM	0.0048*
LIRM - SPGR	0.0054*
LIRI - PTCH	0.0065*
LIRI - RGDP	0.0077*
APRD - DPRC	0.0129*
LIRM - RGSH	0.0136*
DPRC - SPGR	0.0144*
CPDP - PTCH	0.0244*
CPDP - RGDP	0.0285*
LIRI - LIRM	0.0314*
CPSH - PTCH	0.0330*
DPRC - RGSH	0.0330*
CPSH - RGDP	0.0382*
DPRC - LIRI	0.0694

Queen Triggerfish	P-Value
CPSH - DPRC	0.0016*
DPRC - PTCH	0.0016*
DPRC - RGSH	0.0016*
DPRC - LIRI	0.0070*
CPSH - RGDP	0.0367*
PTCH - RGDP	0.0367*
RGDP - RGSH	0.0367*
APRD - CPSH	0.0481*
APRD - PTCH	0.0481*
APRD - RGSH	0.0481*
CPSH - SPGR	0.0507
DPRC - LIRM	0.0507
PTCH - SPGR	0.0507
RGSH - SPGR	0.0507
CPDP - DPRC	0.0820
DPRC - LIRO	0.1016
LIRI - RGDP	0.1039
APRD - LIRI	0.1302
LIRI - SPGR	0.1360
CPDP - CPSH	0.1547
CPDP - PTCH	0.1547
CPDP - RGSH	0.1547
CPSH - LIRO	0.1789
LIRO - PTCH	0.1789

Scrawled Filefish	P-Value
CPSH - LIRO	0.00004*
CPSH - SPGR	0.0001*
LIRO - RGSH	0.0001*
RGSH - SPGR	0.0003*
LIRI - LIRO	0.0024*
CPSH - PTCH	0.0026*
APRD - CPSH	0.0038*
LIRI - SPGR	0.0052*
PTCH - RGSH	0.0064*
APRD - RGSH	0.0092*
CPDP - CPSH	0.0103*
LIRM - LIRO	0.0115*
CPDP - RGSH	0.0226*
LIRM - SPGR	0.0226*
CPSH - RGDP	0.0244*
DPRC - LIRO	0.0314*
CPSH - DPRC	0.0484*
RGDP - RGSH	0.0495*
LIRI - PTCH	0.0542
DPRC - SPGR	0.0568
LIRO - RGDP	0.0607
APRD - LIRI	0.0709
DPRC - RGSH	0.0914
RGDP - SPGR	0.1034

Appendix 8. *(continued)*

CPSH - LIRO	0.0725
CPDP - LIRM	0.0934
CPDP - LIRO	0.0934
CPSH - LIRM	0.1189
CPDP - DPRC	0.1795
APRD - CPSH	0.2065
CPSH - DPRC	0.2210
CPSH - SPGR	0.2210
LIRI - LIRO	0.2286
APRD - CPDP	0.2523
CPDP - SPGR	0.2690
CPSH - RGSH	0.3639
DPRC - PTCH	0.3639
LIRO - RGSH	0.3744
DPRC - RGDP	0.3960
CPDP - RGSH	0.4298
APRD - LIRI	0.5022
LIRI - SPGR	0.5276
CPSH - LIRI	0.5537
LIRM - PTCH	0.5670
LIRO - SPGR	0.5670
APRD - LIRO	0.5941
LIRM - RGDP	0.6078
CPDP - LIRI	0.6357
APRD - RGSH	0.7224
DPRC - LIRM	0.7372
LIRI - RGSH	0.7521
RGSH - SPGR	0.7521
CPDP - CPSH	0.9057
PTCH - RGDP	0.9528
APRD - SPGR	0.9685

LIRO - RGSH	0.1789
CPSH - LIRM	0.2269
DPRC - SPGR	0.2269
LIRM - PTCH	0.2269
LIRM - RGSH	0.2269
APRD - DPRC	0.2357
DPRC - RGDP	0.2833
CPDP - LIRI	0.3371
LIRI - LIRO	0.3640
LIRM - RGDP	0.3784
APRD - LIRM	0.4425
LIRI - LIRM	0.4560
LIRM - SPGR	0.4560
CPDP - RGDP	0.5052
LIRO - RGDP	0.5316
APRD - CPDP	0.5800
CPDP - SPGR	0.5955
APRD - LIRO	0.6037
LIRO - SPGR	0.6186
CPSH - LIRI	0.6433
LIRI - PTCH	0.6433
LIRI - RGSH	0.6433
CPDP - LIRM	0.8301
LIRM - LIRO	0.8376
RGDP - SPGR	0.8922
APRD - RGDP	0.9101
APRD - SPGR	0.9820
CPDP - LIRO	0.9979
CPSH - PTCH	1.0000
CPSH - RGSH	1.0000
PTCH - RGSH	1.0000

CPSH - LIRM	0.1098
CPDP - LIRO	0.1188
CPDP - LIRI	0.1387
LIRM - PTCH	0.1581
CPDP - SPGR	0.1892
LIRM - RGSH	0.1892
APRD - LIRM	0.1960
APRD - LIRO	0.2172
LIRI - RGDP	0.2441
LIRO - PTCH	0.2647
CPSH - LIRI	0.2776
DPRC - PTCH	0.3000
APRD - SPGR	0.3236
CPDP - LIRM	0.3334
APRD - DPRC	0.3586
DPRC - LIRI	0.3743
PTCH - SPGR	0.3850
LIRI - RGSH	0.4240
PTCH - RGDP	0.4472
LIRM - RGDP	0.5147
APRD - RGDP	0.5211
CPDP - DPRC	0.5537
LIRI - LIRM	0.6077
CPDP - PTCH	0.6569
DPRC - LIRM	0.7076
APRD - CPDP	0.7446
CPDP - RGDP	0.7521
CPSH - RGSH	0.7747
DPRC - RGDP	0.7822
LIRO - SPGR	0.8051
APRD - PTCH	0.9057

Orangespotted Filefish	**P-Value**
CPDP - DPRC	0.0003*
APRD - DPRC	0.0005*
CPDP - CPSH	0.0021*
APRD - CPSH	0.0034*
CPDP - RGDP	0.0050*
DPRC - LIRO	0.0054*
DPRC - SPGR	0.0064*
APRD - RGDP	0.0079*
DPRC - PTCH	0.0151*
CPSH - LIRO	0.0237*
DPRC - LIRI	0.0250*
CPSH - SPGR	0.0277*
LIRO - RGDP	0.0472*
RGDP - SPGR	0.0542

Smooth Trunkfish	**P-Value**
RGDP - SPGR	0.0005*
PTCH - SPGR	0.0006*
LIRO - RGDP	0.0008*
LIRO - PTCH	0.0010*
RGSH - SPGR	0.0018*
LIRO - RGSH	0.0029*
DPRC - SPGR	0.0036*
CPSH - SPGR	0.0039*
CPDP - RGDP	0.0043*
CPDP - PTCH	0.0049*
DPRC - LIRO	0.0055*
CPSH - LIRO	0.0060*
LIRI - SPGR	0.0102*
CPDP - RGSH	0.0125*

Sharpnose Puffer	**P-Value**
APRD - DPRC	0.0003*
APRD - CPSH	0.0006*
DPRC - SPGR	0.0011*
CPSH - SPGR	0.0019*
DPRC - LIRO	0.0033*
DPRC - PTCH	0.0033*
CPSH - LIRO	0.0054*
CPSH - PTCH	0.0054*
APRD - LIRI	0.0092*
APRD - RGSH	0.0103*
CPDP - DPRC	0.0188*
DPRC - LIRM	0.0232*
LIRI - SPGR	0.0244*
RGSH - SPGR	0.0271*

Appendix 9. *(continued)*

CPSH - PTCH	0.0567
CPDP - LIRM	0.0692
DPRC - RGSH	0.0708
CPDP - RGSH	0.0723
DPRC - LIRM	0.0739
CPSH - LIRI	0.0858
APRD - LIRM	0.0952
APRD - RGSH	0.0992
PTCH - RGDP	0.1033
LIRI - RGDP	0.1494
CPDP - LIRI	0.1730
CPSH - RGSH	0.1993
CPSH - LIRM	0.2063
APRD - LIRI	0.2246
CPDP - PTCH	0.2400
APRD - PTCH	0.3045
RGDP - RGSH	0.3139
LIRM - LIRO	0.3186
LIRM - RGDP	0.3234
LIRO - RGSH	0.3283
LIRM - SPGR	0.3482
RGSH - SPGR	0.3585
CPDP - SPGR	0.3795
CPDP - LIRO	0.4125
DPRC - RGDP	0.4238
APRD - SPGR	0.4650
APRD - LIRO	0.5019
LIRM - PTCH	0.5210
PTCH - RGSH	0.5339
LIRI - LIRO	0.5871
CPSH - DPRC	0.6007
LIRI - SPGR	0.6285
LIRI - LIRM	0.6497
LIRI - RGSH	0.6640
LIRO - PTCH	0.7222
PTCH - SPGR	0.7671
CPSH - RGDP	0.7822
LIRI - PTCH	0.8512
APRD - CPDP	0.8823
LIRO - SPGR	0.9528
LIRM - RGSH	0.9842

APRD - RGDP	0.0143*
LIRI - LIRO	0.0151*
APRD - PTCH	0.0160*
CPDP - DPRC	0.0219*
CPDP - CPSH	0.0237*
LIRM - SPGR	0.0283*
APRD - RGSH	0.0363*
LIRM - LIRO	0.0400*
CPDP - LIRI	0.0517
APRD - DPRC	0.0593
APRD - CPSH	0.0634
CPDP - LIRM	0.1163
APRD - LIRI	0.1234
LIRM - RGDP	0.1992
LIRM - PTCH	0.2134
APRD - LIRM	0.2439
APRD - SPGR	0.3044
LIRM - RGSH	0.3532
LIRI - RGDP	0.3636
APRD - LIRO	0.3741
LIRI - PTCH	0.3848
DPRC - LIRM	0.4709
CPSH - LIRM	0.4894
CPDP - SPGR	0.5338
CPSH - RGDP	0.5535
DPRC - RGDP	0.5735
CPSH - PTCH	0.5802
LIRI - RGSH	0.5802
DPRC - PTCH	0.6007
CPDP - LIRO	0.6284
APRD - CPDP	0.6855
LIRI - LIRM	0.7074
RGDP - RGSH	0.7222
DPRC - LIRI	0.7296
CPSH - LIRI	0.7520
PTCH - RGSH	0.7520
CPSH - RGSH	0.8126
DPRC - RGSH	0.8357
LIRO - SPGR	0.8900
PTCH - RGDP	0.9685
CPSH - DPRC	0.9764

CPDP - CPSH	0.0285*
CPSH - LIRM	0.0347*
LIRI - LIRO	0.0531
LIRI - PTCH	0.0531
DPRC - RGDP	0.0555
LIRO - RGSH	0.0581
PTCH - RGSH	0.0581
CPSH - RGDP	0.0790
APRD - RGDP	0.0896
APRD - LIRM	0.1795
CPDP - LIRI	0.1795
RGDP - SPGR	0.1795
CPDP - RGSH	0.1927
APRD - CPDP	0.2065
LIRI - LIRM	0.2065
LIRM - RGSH	0.2210
DPRC - RGSH	0.2955
LIRO - RGDP	0.3047
PTCH - RGDP	0.3047
DPRC - LIRI	0.3141
LIRM - SPGR	0.3237
CPDP - SPGR	0.3639
LIRI - RGDP	0.3639
CPSH - RGSH	0.3744
RGDP - RGSH	0.3851
CPSH - LIRI	0.3960
APRD - LIRO	0.5021
APRD - PTCH	0.5021
LIRM - LIRO	0.5021
LIRM - PTCH	0.5021
CPDP - LIRO	0.5537
CPDP - PTCH	0.5537
CPDP - RGDP	0.6641
APRD - SPGR	0.7224
LIRM - RGDP	0.7224
LIRO - SPGR	0.7521
PTCH - SPGR	0.7521
CPSH - DPRC	0.8745
CPDP - LIRM	0.9371
LIRI - RGSH	0.9685
LIRO - PTCH	1.0000

Appendix 10. *Total sample sizes categorized by shallow and deep.*

	2012	**2013**	**2014**	**2015**	**2016**	**Total**
Shallow	196	216	196	149	82	839
Deep	236	423	409	268	255	1591
	432	639	605	417	337	

Appendix 11. *The selected species combined mean density (fishes/SSU) for each year, the total mean, and the standard error for the two depth categories [Shallow (N=839) and Deep (N=1,591)].*

All Selected Species						
MEAN DENSITY	2012	2013	2014	2015	2016	
Shallow	0.3578	0.3189	0.2820	0.2562	0.6416	0.3398
Deep	0.7376	0.5340	0.5998	0.5721	1.0359	0.6680

STANDARD ERROR	2012	2013	2014	2015	2016	
Shallow	0.03147	0.02517	0.04738	0.05445	0.09852	0.02015
Deep	0.05317	0.03050	0.03085	0.06125	0.06921	0.02055

Appendix 12. *All selected species mean density (fishes/SSU) for each year, mean density and standard error for the two depth categories [Shallow (N=839) and Deep (N=1,591)].*

Gray Triggerfish						
MEAN DENSITY	2012	2013	2014	2015	2016	
Shallow	0.6148	0.6134	0.8699	1.0940	1.2622	0.8224
Deep	0.6945	0.9835	1.7042	2.5951	2.4471	1.6319

STANDARD ERROR	2012	2013	2014	2015	2016	
Shallow	0.1556	0.1163	0.3987	0.4691	0.4758	0.1413
Deep	0.1388	0.1099	0.1792	0.5099	0.3391	0.1184

Queen Triggerfish						
MEAN DENSITY	2012	2013	2014	2015	2016	
Shallow	0.0000	0.0000	0.0026	0.0000	0.0000	0.0006
Deep	0.0106	0.0296	0.0196	0.0056	0.0490	0.0233

STANDARD ERROR	2012	2013	2014	2015	2016	
Shallow	0.0000	0.0000	0.0026	0.0000	0.0000	0.0006
Deep	0.0047	0.0080	0.0062	0.0042	0.0153	0.0038

Appendix 13. *(continued)*

Balloonfish						
MEAN DENSITY	2012	2013	2014	2015	2016	
Shallow	0.0893	0.0648	0.0689	0.0638	0.0610	0.0709
Deep	0.0417	0.0449	0.0342	0.0280	0.0431	0.0385

STANDARD ERROR	2012	2013	2014	2015	2016	
Shallow	0.0167	0.0132	0.0138	0.0167	0.0182	0.0070
Deep	0.0099	0.0087	0.0067	0.0075	0.0111	0.0039

Unicorn Filefish						
MEAN DENSITY	2012	2013	2014	2015	2016	
Shallow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Deep	0.0000	0.0556	0.0183	0.0373	0.1784	0.0544

STANDARD ERROR	2012	2013	2014	2015	2016	
Shallow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Deep	0.0000	0.0422	0.0070	0.0187	0.0645	0.0157

Scrawled Filefish						
MEAN DENSITY	2012	2013	2014	2015	2016	
Shallow	0.0332	0.0417	0.0332	0.0403	0.1159	0.0447
Deep	0.1702	0.1584	0.2482	0.2593	0.5765	0.2672

STANDARD ERROR	2012	2013	2014	2015	2016	
Shallow	0.0131	0.0119	0.0096	0.0181	0.0410	0.0071
Deep	0.0257	0.0199	0.0348	0.0376	0.0828	0.0187

Orangespotted Filefish						
MEAN DENSITY	2012	2013	2014	2015	2016	
Shallow	0.0816	0.0856	0.1173	0.0671	0.1220	0.0924
Deep	0.1031	0.0981	0.1357	0.0896	0.1020	0.1077

STANDARD ERROR	2012	2013	2014	2015	2016	
Shallow	0.0193	0.0184	0.0228	0.0200	0.0430	0.0101
Deep	0.0157	0.0119	0.0165	0.0151	0.0146	0.0067

Appendix 14. *(continued)*

Smooth Trunkfish						
MEAN DENSITY	2012	2013	2014	2015	2016	
Shallow	0.0706	0.0394	0.0204	0.0268	0.1280	0.0487
Deep	0.1208	0.1087	0.1015	0.0858	0.1275	0.1078

STANDARD ERROR	2012	2013	2014	2015	2016	
Shallow	0.0197	0.0113	0.0071	0.0093	0.0922	0.0108
Deep	0.0169	0.0171	0.0155	0.0152	0.0195	0.0077

Sharpnose Pufferfish						
MEAN DENSITY	2012	2013	2014	2015	2016	
Shallow	2.2134	1.8750	1.3724	0.9866	3.9939	1.8860
Deep	5.4272	3.2305	2.9890	1.9981	5.7039	3.6831

STANDARD ERROR	2012	2013	2014	2015	2016	
Shallow	0.1818	0.1501	0.1126	0.0979	0.6192	0.0932
Deep	0.3198	0.1983	0.1470	0.1140	0.3833	0.1081

Bandtail Pufferfish						
MEAN DENSITY	2012	2013	2014	2015	2016	
Shallow	0.1173	0.1505	0.0536	0.0268	0.0915	0.0924
Deep	0.0699	0.0969	0.1479	0.0504	0.0961	0.0981

STANDARD ERROR	2012	2013	2014	2015	2016	
Shallow	0.0279	0.0258	0.0132	0.0093	0.0337	0.0106
Deep	0.0145	0.0156	0.0183	0.0106	0.0164	0.0074

Appendix 15. *Total sample sizes for the five ecoregions: Broward-Miami, Deerfield, South Palm Beach, North Palm Beach, and Martin for each year, the total for the five years, and yearly mean.*

	Broward-Miami	Deerfield	South Palm Beach	North Palm Beach	Martin	Total
2012	276	75	40	26	14	431
2013	320	90	78	106	45	639
2014	292	61	70	104	78	605
2015	204	27	39	95	52	417
2016	158	33	56	65	23	335
Total	1250	286	283	396	212	2427
Mean	250	57.2	56.6	79.2	42.4	

Appendix 16. *All the mean densities (fishes/SSU) for each of the selected species for each year, mean density, and the standard error for the ecoregions [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)].*

Gray Triggerfish						
MEAN DENSITY	2012	2013	2014	2015	2016	
Broward-Miami	0.5517	0.7750	1.0086	1.5735	1.3671	0.9851
Deerfield	0.7644	0.6278	0.2295	0.7407	0.6818	0.5956
South Palm Beach	1.0063	0.9038	2.7929	3.5128	2.8707	2.1395
North Palm Beach	0.3077	1.2123	2.1490	2.1105	3.3231	1.9609
Martin	1.8571	1.0000	1.7949	3.4615	4.6304	2.3467

STANDARD ERROR	2012	2013	2014	2015	2016	
Broward-Miami	0.1044	0.1145	0.1458	0.6334	0.3566	0.1237
Deerfield	0.3459	0.1871	0.1262	0.4015	0.2062	0.1199
South Palm Beach	0.4195	0.2643	1.1665	1.7741	0.9830	0.4366
North Palm Beach	0.0964	0.2393	0.4241	0.2552	0.5623	0.1738
Martin	1.0061	0.2325	0.3712	0.7308	1.3341	0.2887

Queen Triggerfish						
MEAN DENSITY	2012	2013	2014	2015	2016	
Broward-Miami	0.0054	0.0000	0.0120	0.0000	0.0127	0.0056
Deerfield	0.0000	0.0167	0.0328	0.0000	0.0303	0.0157
South Palm Beach	0.0125	0.0256	0.0071	0.0000	0.1121	0.0333
North Palm Beach	0.0192	0.0613	0.0048	0.0158	0.0308	0.0278
Martin	0.0000	0.0556	0.0256	0.0000	0.0435	0.0259

STANDARD ERROR	2012	2013	2014	2015	2016	
Broward-Miami	0.0031	0.0000	0.0051	0.0000	0.0077	0.0017
Deerfield	0.0000	0.0124	0.0230	0.0000	0.0303	0.0072
South Palm Beach	0.0125	0.0155	0.0071	0.0000	0.0564	0.0126
North Palm Beach	0.0192	0.0239	0.0048	0.0117	0.0186	0.0079
Martin	0.0000	0.0327	0.0180	0.0000	0.0300	0.0101

Appendix 12. *(continued)*

Balloonfish						
MEAN DENSITY	2012	2013	2014	2015	2016	
Broward-Miami	0.0572	0.0703	0.0788	0.0564	0.0443	0.0638
Deerfield	0.1200	0.0500	0.0656	0.0556	0.0606	0.0734
South Palm Beach	0.0250	0.0641	0.0000	0.0769	0.0776	0.0474
North Palm Beach	0.0192	0.0094	0.0048	0.0105	0.0385	0.0139
Martin	0.0714	0.0000	0.0000	0.0000	0.0000	0.0047

STANDARD ERROR	2012	2013	2014	2015	2016	
Broward-Miami	0.0108	0.0124	0.0117	0.0131	0.0113	0.0055
Deerfield	0.0313	0.0194	0.0247	0.0308	0.0288	0.0124
South Palm Beach	0.0174	0.0190	0.0000	0.0346	0.0385	0.0109
North Palm Beach	0.0192	0.0066	0.0048	0.0074	0.0167	0.0041
Martin	0.0714	0.0000	0.0000	0.0000	0.0000	0.0047

Unicorn Filefish						
MEAN DENSITY	2012	2013	2014	2015	2016	
Broward-Miami	0.0000	0.0547	0.0051	0.0074	0.0190	0.0188
Deerfield	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
South Palm Beach	0.0000	0.0064	0.0429	0.0000	0.4138	0.0965
North Palm Beach	0.0000	0.0519	0.0192	0.0368	0.2615	0.0707
Martin	0.0000	0.0000	0.0128	0.0962	0.0652	0.0354

STANDARD ERROR	2012	2013	2014	2015	2016	
Broward-Miami	0.0000	0.0547	0.0038	0.0055	0.0161	0.0142
Deerfield	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
South Palm Beach	0.0000	0.0064	0.0301	0.0000	0.2500	0.0520
North Palm Beach	0.0000	0.0328	0.0117	0.0282	0.1080	0.0215
Martin	0.0000	0.0000	0.0128	0.0789	0.0477	0.0206

Appendix 12. *(continued)*

Scrawled Filefish						
MEAN DENSITY	2012	2013	2014	2015	2016	
Broward-Miami	0.0590	0.1109	0.0925	0.0882	0.2911	0.1142
Deerfield	0.2311	0.2111	0.2213	0.3889	0.6818	0.2896
South Palm Beach	0.2500	0.2179	0.7857	0.6538	1.1379	0.6088
North Palm Beach	0.0769	0.0425	0.1010	0.2263	0.3385	0.1528
Martin	0.0714	0.0000	0.0256	0.0000	0.0000	0.0142

STANDARD ERROR	2012	2013	2014	2015	2016	
Broward-Miami	0.0148	0.0195	0.0155	0.0250	0.0510	0.0105
Deerfield	0.0522	0.0480	0.0624	0.1079	0.1752	0.0341
South Palm Beach	0.0780	0.0521	0.1649	0.1744	0.3027	0.0817
North Palm Beach	0.0361	0.0166	0.0337	0.0478	0.0850	0.0213
Martin	0.0485	0.0000	0.0202	0.0000	0.0000	0.0081

Orangespotted Filefish						
MEAN DENSITY	2012	2013	2014	2015	2016	
Broward-Miami	0.0866	0.0828	0.1130	0.0662	0.0981	0.0899
Deerfield	0.1444	0.1889	0.2213	0.1852	0.1818	0.1830
South Palm Beach	0.1000	0.1474	0.3143	0.2564	0.1983	0.2070
North Palm Beach	0.0192	0.0377	0.0529	0.0474	0.0308	0.0417
Martin	0.0714	0.0222	0.0577	0.0192	0.0435	0.0401

STANDARD ERROR	2012	2013	2014	2015	2016	
Broward-Miami	0.0153	0.0125	0.0174	0.0133	0.0177	0.0069
Deerfield	0.0337	0.0422	0.0591	0.0807	0.0568	0.0226
South Palm Beach	0.0408	0.0330	0.0595	0.0606	0.0614	0.0238
North Palm Beach	0.0192	0.0129	0.0166	0.0249	0.0150	0.0086
Martin	0.0485	0.0155	0.0204	0.0135	0.0300	0.0099

Appendix 12. *(continued)*

Smooth Trunkfish						
MEAN DENSITY	2012	2013	2014	2015	2016	
Broward-Miami	0.0921	0.0578	0.0582	0.0735	0.1266	0.0767
Deerfield	0.1511	0.1444	0.1885	0.1481	0.1818	0.1603
South Palm Beach	0.1250	0.2308	0.2000	0.1026	0.2414	0.1930
North Palm Beach	0.0192	0.0472	0.0240	0.0421	0.0462	0.0379
Martin	0.0000	0.0000	0.0064	0.0000	0.0000	0.0024

STANDARD ERROR	2012	2013	2014	2015	2016	
Broward-Miami	0.0164	0.0102	0.0119	0.0162	0.0500	0.0086
Deerfield	0.0353	0.0420	0.0484	0.0644	0.0568	0.0210
South Palm Beach	0.0429	0.0687	0.0614	0.0376	0.0593	0.0281
North Palm Beach	0.0192	0.0158	0.0105	0.0162	0.0238	0.0076
Martin	0.0000	0.0000	0.0064	0.0000	0.0000	0.0024

Sharpnose Pufferfish						
MEAN DENSITY	2012	2013	2014	2015	2016	
Broward-Miami	3.5505	2.8141	2.4914	1.7598	5.2690	3.0400
Deerfield	6.0755	3.4167	3.3033	2.7407	4.7273	4.1771
South Palm Beach	5.9125	5.3205	4.4429	3.1026	10.1207	5.8614
North Palm Beach	1.3846	1.2358	1.8558	0.9684	2.4154	1.5379
Martin	0.2143	0.3889	0.7500	0.7019	2.1522	0.7783

STANDARD ERROR	2012	2013	2014	2015	2016	
Broward-Miami	0.2356	0.1752	0.1378	0.1181	0.4849	0.1033
Deerfield	0.5534	0.3032	0.4417	0.3544	0.6231	0.2238
South Palm Beach	0.8139	0.7199	0.4032	0.3245	0.9181	0.3405
North Palm Beach	0.4972	0.1596	0.2285	0.1367	0.4115	0.1124
Martin	0.0864	0.0883	0.1735	0.1260	0.8680	0.1229

Appendix 12. *(continued)*

Bandtail Pufferfish						
MEAN DENSITY	2012	2013	2014	2015	2016	
Broward-Miami	0.1119	0.1656	0.1318	0.0319	0.0981	0.1155
Deerfield	0.0533	0.1000	0.2787	0.0370	0.1061	0.1206
South Palm Beach	0.0625	0.1154	0.0929	0.0897	0.1552	0.1070
North Palm Beach	0.0577	0.0142	0.0577	0.0526	0.0231	0.0391
Martin	0.0357	0.0222	0.0385	0.0288	0.1087	0.0401

STANDARD ERROR	2012	2013	2014	2015	2016	
Broward-Miami	0.0219	0.0232	0.0205	0.0092	0.0217	0.0096
Deerfield	0.0203	0.0298	0.0624	0.0257	0.0422	0.0186
South Palm Beach	0.0265	0.0397	0.0275	0.0311	0.0464	0.0169
North Palm Beach	0.0423	0.0081	0.0172	0.0205	0.0131	0.0079
Martin	0.0357	0.0155	0.0270	0.0163	0.0767	0.0141

Appendix 17. *The results of the Kruskal-Wallis test for each selected species within the five ecoregions. Each species showing significance (P<0.05) has an asterisk next to the value (*).*

Species	**P-Value**
Gray Triggerfish	0.0235*
Queen Triggerfish	0.4869
Balloonfish	0.0376*
Unicorn Filefish	0.1423
Scrawled Filefish	0.0025*
Orangespotted Filefish	0.0004*
Smooth Trunkfish	0.0003*
Sharpnose Pufferfish	0.0011*
Bandtail Pufferfish	0.0487*

Appendix 18. *All tables produced after the post-hoc analysis for each of the species that showed significance when tested against the ecoregions [Broward-Miami (N=1,250), Deerfield (N=286), South Palm Beach (N=283), North Palm Beach (N=396), and Martin (N=212)]. The righthand columns shows the levels of significance obtained (significance shown with an asterisk (*) when P<0.05.*

Gray Triggerfish	**P-Value**
Deerfield - Martin	0.0040*
Deerfield - South Palm Beach	0.0077*
Deerfield - North Palm Beach	0.0255*
Broward-Miami - Martin	0.1025
Broward-Miami - South Palm Beach	0.1562
Broward-Miami - Deerfield	0.2127
Broward-Miami - North Palm Beach	0.3230
Martin - North Palm Beach	0.5192
North Palm Beach - South Palm Beach	0.6674
Martin - South Palm Beach	0.8299

Balloonfish	**P-Value**
Deerfield - Martin	0.0177*
Broward-Miami - Martin	0.0198*
Deerfield - North Palm Beach	0.0426*
Broward-Miami - North Palm Beach	0.0472*
Martin - South Palm Beach	0.0636
North Palm Beach - South Palm Beach	0.1311
Deerfield - South Palm Beach	0.6047
Broward-Miami - South Palm Beach	0.6352
Martin - North Palm Beach	0.7300
Broward-Miami - Deerfield	0.9656

Scrawled Filefish	**P-Value**
Martin - South Palm Beach	0.0002*
Deerfield - Martin	0.0020*
Broward-Miami - South Palm Beach	0.0433*
Martin - North Palm Beach	0.0645
North Palm Beach - South Palm Beach	0.0645
Broward-Miami - Martin	0.0935
Broward-Miami - Deerfield	0.1559
Deerfield - North Palm Beach	0.2124
Deerfield - South Palm Beach	0.5472
Broward-Miami - North Palm Beach	0.8634

Orangespotted Filefish	**P-Value**
North Palm Beach - South Palm Beach	0.0007*
Deerfield - North Palm Beach	0.0014*
Martin - South Palm Beach	0.0016*
Deerfield - Martin	0.0028*
Broward-Miami - North Palm Beach	0.0896
Broward-Miami - South Palm Beach	0.0937
Broward-Miami - Deerfield	0.1325
Broward-Miami - Martin	0.1382
Martin - North Palm Beach	0.8299
Deerfield - South Palm Beach	0.8635

Smooth Trunkfish	**P-Value**
Martin - South Palm Beach	0.0002*
Deerfield - Martin	0.0003*
North Palm Beach - South Palm Beach	0.0067*
Deerfield - North Palm Beach	0.0098*
Broward-Miami - Martin	0.0252*
Broward-Miami - South Palm Beach	0.1212
Broward-Miami - Deerfield	0.1554
Broward-Miami - North Palm Beach	0.2451
Martin - North Palm Beach	0.2818
Deerfield - South Palm Beach	0.8972

Sharpnose Puffer	**P-Value**
Martin - South Palm Beach	0.0003*
Deerfield - Martin	0.0026*
North Palm Beach - South Palm Beach	0.0046*
Broward-Miami - Martin	0.0228*
Deerfield - North Palm Beach	0.0255*
Broward-Miami - North Palm Beach	0.1326
Broward-Miami - South Palm Beach	0.1829
Martin - North Palm Beach	0.4393
Broward-Miami - Deerfield	0.4651
Deerfield - South Palm Beach	0.5475

Appendix 14. *(continued)*

Bandtail Puffer	**P-Value**
Broward-Miami - North Palm Beach	0.0284*
North Palm Beach - South Palm Beach	0.0317*
Broward-Miami - Martin	0.0391*
Martin - South Palm Beach	0.0434*
Deerfield - North Palm Beach	0.0781
Deerfield - Martin	0.1025
Broward-Miami - Deerfield	0.6674
Deerfield - South Palm Beach	0.6989
Martin - North Palm Beach	0.8974
Broward-Miami - South Palm Beach	0.9657