10-23-2015

Biodiversity and Ecological Dynamics of Sciophilous Benthic Communities on Artificial Plates: Emphasis on Reef Sponges

Caidra Elizabeth Hassanzada
Nova Southeastern University, caidrarice@hotmail.com

HALMOS COLLEGE OF NATURAL SCIENCES AND OCEANOGRAPHY

Biodiversity and Ecological dynamics of sciophilous benthic communities on artificial plates: Emphasis on reef sponges

By

Caidra Elizabeth Hassanzada

Submitted to the Faculty of the
Oceanographic Center
in partial fulfillment of the requirements for
the degree of Master of Science with a specialty in:

Marine Biology and Environmental Science

Nova Southeastern University

October, 2015

Thesis of
Caidra Elizabeth Hassanzada

Submitted in Partial Fulfillment of the Requirements for the Degree of

Masters of Science:

Marine Biology and Marine Science

Caidra Elizabeth Hassanzada
Nova Southeastern University
Halmos College of Natural Sciences and Oceanography

October, 2015

Approved:

Thesis Committee

Major Professor :______________________________
Bernhard Riegl, Ph.D.

Committee Member :___________________________
Maria Cristina Diaz, Ph.D.

Committee Member :___________________________
Jose Victor Lopez, Ph.D.

Table of Contents

Acknowledgments:

Thank you to Andia Chavez-Fonegra for providing me with the opportunity to do a thesis. Your support and guidance has been invaluable during this process. Thank you to my thesis advisor Dr. Reigl for providing me with a lab, and for pushing me to be my best. Thank you to my committee member Dr. Lopez for providing me with the many materials, and valuable insights that played a big part in the completion of my thesis. To my closest advisor, professor, and friend Christina, thank you for everything you have done. You have been there every step of the way for which I am forever grateful for. Your constant support has helped me become not only a better scientist but also a better person. Thank you to Dr. Edlin Castro Guerra for your assistance with the statistical analysis of this paper.

Thank you to the divers Zach Ostroff, Keri O'Neil, Naoko Kurata, and Brian Ettinger and the photographers Dusty Marshall, Ana Gonzales, and Keri O'Neil.

Thank you to my husband and mother for their ongoing advise, patience, and support these past few years. It is because of you that I have come so far.

Finally, I would like to thank Nova Southeastern University faculty and staff for providing me with the resources and knowledge to make this all possible.

Abstract:

Low light intensity habitats harbor unique sciophilous benthic communities and are a source of novel and unique sponge fauna. However, the community structure of these habitats is poorly studied to date. Thus, this study attempts to understand the composition and structure of sciophilous sponge populations in southeast Florida. Fifty limestone plates were placed on a shallow reef in Fort Lauderdale for two years (2010-2012). To identify the sponge community and their patterns over time, all plates were photographed at the end of each year. Then, samples were taken from each of the live sponge specimens observed on the plates and processed in the laboratory for taxonomical identification. A total of 45 different sponge species were found, the majority corresponding to the Poecilosclerida Order. Eighteen were identified to species level, twenty-two to genus, and five were undetermined. Eight sponges constitute new records to Florida, and four are potentially new species. The most dominant species include *Oscarella sp.1, Dysidea etheria, Mycale sp.1, Halisarca caerula* and *Tedania ignis*. Species richness significant varied among years, and species cover among sectors (inner and outer reef). However, sponge assemblages were similar between years with slightly variation between sectors. This study found a diverse and complex composition and structure of sponges that is quite distinct from the sponge assemblages on the open reefs. A guide of the biodiversity of cryptic sponge species was created to facilitate further studies in low light intensity habitats.

Keywords: Encrusting Sponges, Sponge assemblages, Species Richness, Cryptic Habitat

List of Figures

List of Tables:

1.0 Introduction:

Coral reefs represent one of the most bio diverse and ecologically productive tropical marine environment on the planet (Diaz, 2011). While many parts of this ecosystem have been heavily studied, there are still other portions where research has only begun to brush the surface, this is the case of cryptic habitats in which sciophilous benthic communities thrive (Ruetzler et al, 2014) (Van Soest, 2009). Sciophilous benthic communities are populations of organisms that grow better in areas of low light intensity or shade, and include bacteria, red algae and a wide array of invertebrate phyla such as sponges, ascidians, and bryozoans. The distribution of sciophilous communities, is not limited to light deficient areas of the deeper parts of the ocean. Contrary, a wide variety of these communities can be found in the shallower parts of a reef and hidden within crevices, undersides of plate-shaped corals, and rubble among others (Buss, 1979).

As the degradation of coral reefs has increased over the past century "artificial growth plates" have begun to play an important role in the study and restoration of reef environments (Baine, 2001). The use of artificial plates allows scientists to look at recruitment, growth, competition, and survival rate of benthic species such as corals and invertebrates, and thus deduce the best way to increase their populations on both natural and artificial reefs (Baine, 2001). Plates are also useful to study the possible roles that certain benthic groups beside corals play in building a reef, and help us to understand what the most important structural components of a reef environment are (Baine, 2001).

Sponges play an important role in coral reefs both structurally and functionally (Bell, 2008). Millions of years of evolution have provided them with unique properties including the ability to impact the carbonate framework, water filtering capabilities which can alter the water column and chemical and physical attributes which make them strong space competitors (Bell, 2008). With an overall diversity greater than all coral groups, and in some cases algae combined, and a living biomass that may exceed all other epibenthos in certain areas, sponges are formidable creatures in their own right (Diaz and Rutzler, 2001). Sponges can be found all across the globe in a variety of shapes and forms and are not solely constricted to the tropics (Bell, 2008). They can be found all over a reef from the top of the reef crest, to shaded crevices, to the deeper parts of the reef environment (references). Sponges limited to such shaded environments are known as cryptic or sciophilous sponges. These sponges tend to have a less robust form compared to other reef sponges and their low ability to block the sun's harmful rays restricts them to areas of low light intensity (Bickford, 2007). Recently it was demonstrated that cryptic reef habitats occupied by sponges are major sinks of dissolved organic matter, thus being essential in the Carbon and other geobiochemical cycles in this ecosystem (Jasper M. de Goeij et al, 2008) (Jasper M. de Goeij et al, 2013). Overall very few studies have been conducted on the community structure of these communities, for example Kobluk and Van Soest (1989) produced an annotated list of 92 species from cave sponges in reefs in the Netherlands Antilles, and Meesters et al., (1991) analyzed the abundance of major groups of organisms in these sites. Recently, two taxonomic studies on sciophilous sponges at Belize Ruetzler et al., (2014) and the Netherland Antilles Van Soest, (2009) demonstrated the importance of these habitats as a source of novel and unique sponge fauna and included more than fourteen new species.

Thus, considering the lack of studies on cryptic habitats and the potential biodiversity that they hide, the present study attempts to determine the composition and structure of sciophilous sponge populations in a shallow reef in southeast Florida. This study includes the use of artificial substrates (limestone plates) as an approach that facilitates the recruitment and manipulation of the sciophilous benthic communities, and that simultaneously avoid disturbance to the already established communities in the environment.

2.0 Materials and Methods:

2.1 Artificial Plate Setup-

On July 15, 2010 fifty 20 x 20 cm limestone plates were placed at twenty three feet on the shallow terrace reef in Fort Lauderdale, Florida, USA (N26 08 530, W-80 05 794, Figure 1). Five divers took the plates and placed them randomly on the reef in groups of five. Five of these groups were placed on the inside of the reef, and the other five groups on the outside of the reef, they were all fifteen meters apart (Figure 2). Plates were tagged and attached with cable ties to PVC pipes that were hammered into the substrate (Figure 4).

2.2 Plate photographing

The plates were left down on the reef for two years and photos of the shaded part of the plates were taken on August 30, 2011 and July 5, 2012. For the first years, pictures were taken when plates were still on the reef. On the second year, photos of the plates were also taken inside aquarium tanks after collection. Sponges in each photograph were outlined in pen and categorized, later each sponge cover was obtained using the CPCE program (Kohler et al. 2006).

2.3 Sponge sampling for identification

Between August 7 and 13th of 2012, all plates were removed from the Fort Lauderdale reef and placed in a small cooler where they were then transported by boat to the wet laboratory at the Oceanographic Center. Plates were then submerged into five (12.5 by 30 by 12.8 inch) glass salt-water tanks, where they were maintained for another three weeks. In order to increase water quality and oxygen flow, the water in the tanks was replaced twice a day. The, individual plates were placed in small trays with salt water and placed under a dissecting microscope, sponge samples were collected from live specimens and observations of color, texture, and growth forms were register to help with further species identification. Sponge samples were fixed with 95% ethanol and placed in test tubes for further taxonomical identification. Plates, then were dried under the sun for a week, and placed in plastic bags to preserve dried tissues with spicules.

2.4 Taxonomic determinations

To digest sponge tissue, samples of each sponge were taken from the fixed specimens, and placed in a 24 well plate with Clorox. After 24 hours, drops of Clorox with sponge skeleton (spicules) were placed on slides and observed under a compound microscope. Spicules from each sponge were identified, photographed, and recorded on identification forms, and each spicule type was measured (n=10-25). A systematic study of all samples was carried out in the lab with Dr. Maria Cristina Diaz, together we were able to identify up to the genus and in some cases the species level. Various literature sources including the World Porifera Database were used. For five of the sponges that we had only gotten to genus, more detailed descriptions of visual characteristics and spicule measurements (n=25 per spicule type) were taken. In order to corroborate identification and evaluate if they are new species, samples were send to experts. Two species that lack any skeleton *Oscarella sp*, and *Halisarca caerulea* were identified solely on their unique external appearance.

2.5 Sponge species abundances

Once the identification of each sponge was completed, the photographs of the top and bottom of each plate, for both years, were placed into Coral Point Count with Excel Extensions. The area covered and the number of individuals for each species was calculated. This data was used to estimate species richness, abundance, and to compare community composition between the inner and outer reef, and between both years of study. These calculations were then placed into excel. Appendix 1-X represents all the tables build.

2.6 Data analysis

The expected richness of sponges was projected using Species Accumulation Curve and 999 permutations of samples (Primer 7) with data from 2011 and 2012. Differences between sectors of the reef (inner and outer) and years (2011 and 2012) were evaluated with a two-way crossed model using univariate analysis of variance (ANOVA) for richness, and abundance of sponges, and a distance based multivariate analysis of variance (PERMANOVA) for assemblage structure (Anderson et al. 2008). For this, a dissimilarity matrix was constructed using the Bray-Curtis coefficient of similarity for the square roots of the abundances of each species (Clarke 1993). The transformation was used to down-weight the importance of highly abundant species on the estimation of similarities, and to increases the relative importance of rare species. The statistical significance of each term in the ANOVA and PERMANOVA were obtained using a random subset of 999 permutations of residuals under a reduced model. Differences in richness and abundances are shown using means plots, while differences in assemblage structure are represented using canonical analysis of principal coordinates (CAP) (Anderson & Willis 2003). Shade plot and SIMPER analyses were used to identify the most important species contributing to the pattern of differences detected (Clarke et al. 2014). All these analyses were carried out with the software PRIMER v7 and PERMANOVA add-on (PRIMER-E Ltd, Plymouth, UK). These analyses were carried with the advice and/or help of Dr. Andia Chaves Fonnegra at NSU, USA, and Dr. Edlin Castro Guerra at Universidad de Oriente, Margarita, Venezuela). Both collaborators will be co-authors on a paper describing the ecological results of this study.

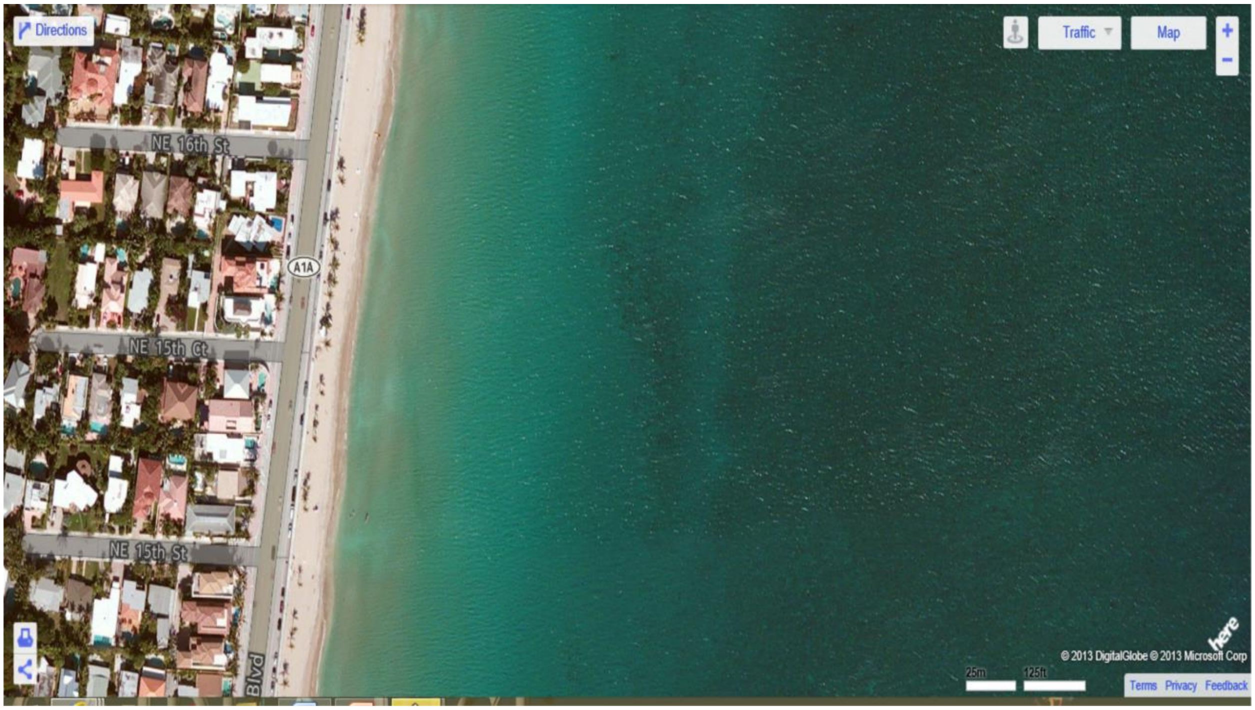


Figure 1: Arial view of study site.

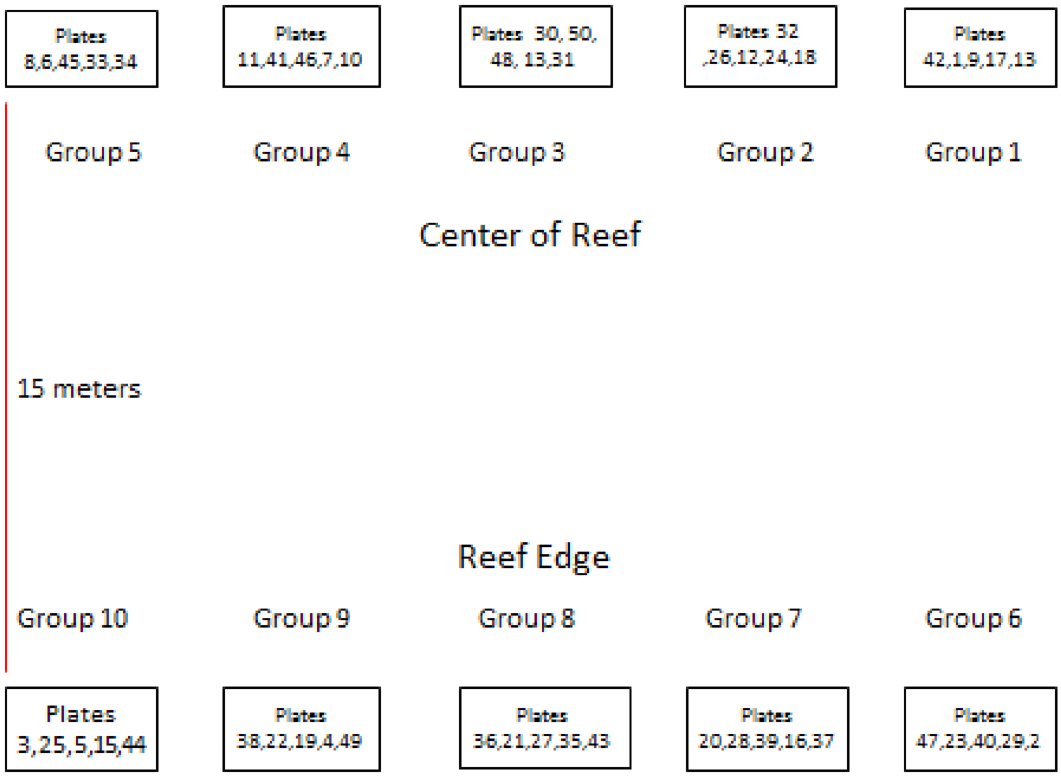


Figure 2: Arrangement and distribution of plate setup on the reef. Plate numbers are represented in the boxes which were distributed into ten groups between the inner and outer reef.

Bottom Top

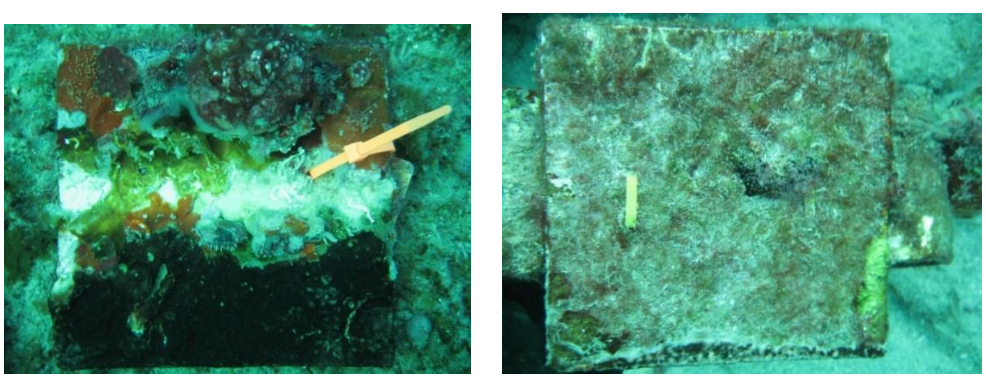


Figure 3: Underwater photographs of the upper and the lower side of the plates, showing recruited organisms.

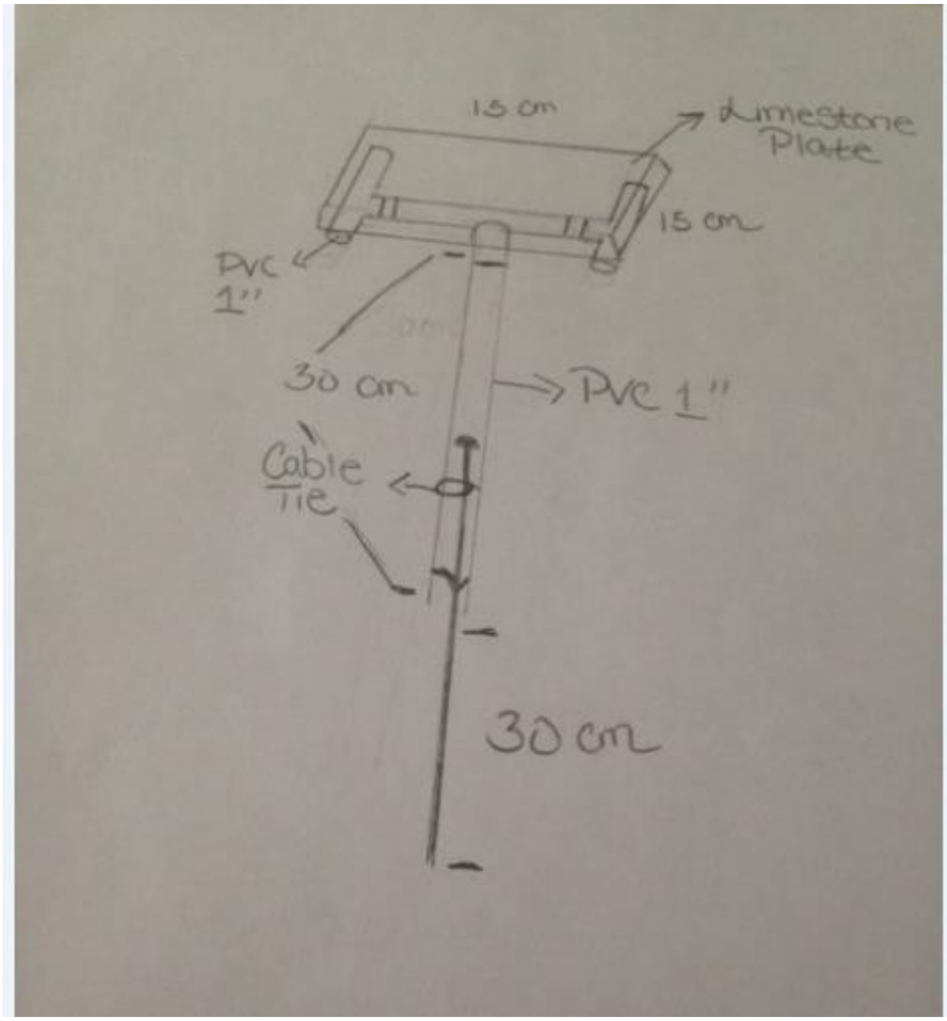


Figure 4: Schematic of anchoring of plates

3.0 Results:

3.1 Taxonomic results

3.11 Sponge species associated to artificial sciophilous habitats in Fort Lauderdale Florida

From a total of 45 distinct sponges encountered on the plates, 40 were studied taxonomically. Thirty three sponges belonged to the Class Demospongiae, two to the Class Homoscleromorpha, and five to the class Calcarea (Table 1). Eighteen sponges were identified to species level, and eight of them constitute new additions to the sponge fauna of Florida (World Porifera Database) including (World Porifera Database). This includes *Halisarca caerula (*Vacelet & Donadey, 1987), *Aplysilla rosea* (Barrois, 1876), *Chelonaplysilla betinensis* (Zea and Vansoest), *Chelonaplysilla erecta* (Tsurnamal, 1967), *Myrmikeoderma laminatum* (Rützler, Piantoni, Van Soest & Díaz, 2014), *Strongylacidon rubra* (Van Soest, 1984), *Clathria affinis* (Carter, 1880), and *Clathria compechae* (Hooper, 1996). In addition, four new sponges are proposed as new species and their descriptions are included in the next section. Other 22 sponges were identified to genus, and five more were not identified taxonomically due to lack of sufficient skeletal material and little external morphological distinctness. None of the sponges were found growing on the top of the plates.

Table 1. Sponges reported from sciophilous habitats in Florida from artificial plates placed in shallow water coral reefs in Fort Lauderdale. Taxa denominations and distribution follows Porifera classification from World Porifera Database (August 2015) and Morrow & Cardenas, (2015).

Taxa (**CLASS**, SUBCLASS, **Order**, family, *species*)	Distribution	Authorship	Reference
HOMOSCLEROMORPHA			

Homosclerophorida			
Oscarellidae			
Oscarella sp. 1	Florida	ND	Collin et al., (2005)
DEMOSPONGIAE			
Subclass CERACTINOMORPHA			
Dendroceratida			
Darwinellidae			Van Soest (1980)
Aplysilla rosea	France, Mediterranean Sea, North Atlantic	Barrois, 1876	
Chelonaplysilla betinensis	Caribbean	Zea and Van Soest, 1986	Zea and Van Soest (1986)
Chelonaplysilla erecta	Caribbean, Brazil, Gulf of Mexico	Tsurnamal, 1967	Van Soest (1978)
Dictyoceratida			
Dysideidae			
Dysidea etheria	France, Gulf of Mexico, North Atlantic, Red Sea	De Laubenfels, 1936	Van Soest (1984)
Subclass HETEROSCLEROMORPHA			
Chondrillida			
Chondrilliidae			
Chondrilla caribensis	Caribbean, Belize	Rutzler,Duran, and Piantoni, 2007	Rutzler,Duran, and Piantoni (2007)
Halisarcidae			

Halisarca caerulea	Caribbean, Belize, Venezuela, Panama	Vacelet and Donadey, 1987	Collin et al., (2005)
Clionaida			
Clionaidae			
Cliona sp. 1	Florida	ND	Pang (1973)
Suberitida			
Suberitiadae			
Terpios fugax	Belize, Caribbean, Indian Ocean, North Atlantic	Duchassaing and Michelotti, 1864	Ruetzler (1986)
Axinellida			
Heteroxydidae			
Myrmekioderma laminatum	Madagascar	Rützler, Piantoni, Van Soest & Díaz, 2014	Ruetzler et al (2014)
Poecilosclerida			
Chondropsidae			
Batzella sp.1	Florida	ND	Van Soest (1984)
Batzella sp. 2	Florida	ND	Van Soest (1984)
Chondropsis sp. 1	Florida	ND	Van Soest (1984)
Strongylacidon rubra	Caribbean, Gulf of Mexico	Van Soest, 1984	Van Soest (1984)
Coelosphaeridae			
Lissodendoryx sp. 1	Florida	ND	Ruetzler et al., (2007)

<u>Hymedesmiidae</u>			
Hymedesmia sp.1	Florida	Van Soest, 1984	Van Soest (1984)
<u>Iotrochotidae</u>			
Iotrochota birotulata	Caribbean, Florida, Greater Antilles, Brazil, Belize	Higgin, 1877	Van Soest, (1984)
<u>Microcionidae</u>			
Clathria affinis	Carribean, Belize, Mexico, Indian Ocean	Carter, 1880	Van Soest (1984)
Clathria calla	Cuba, Florida, Caribbean, Brazil	De Laubenfels, 1934	Van Soest (1984)
Clathria campecheae	Caribbean, North Atlantic	Hooper, 1996	Ruetzler et al (2014)
Clathria echinata	Caribbean, Bermuda, Netherlands	Alcolado, 1984	Ruetzler et al (2014)
Clathria spinosa	Caribbean, Florida, Bahamas	Wilson, 1902	Van Soest (1984)
Clathria sp. 1	Florida	ND	Van Soest (1984)
Clathria sp. 2	Florida	ND	Van Soest (1984)
Clathria sp. 3	Florida	ND	Van Soest (1984)
Clathria sp. 4	Florida	ND	Van Soest (1984)
<u>Mycalidae</u>			
Mycale laevis	Caribbean, Gulf of Mexico, Belize, Greater Antilles	Carter, 1882	Van Soest (1984)

Mycale laxissma	Carribean, Florida, Gulf of Mexico, Netherlands	Duchassaing and Michelotti, 1864	Van Soest, (1984)
Mycale sp.1	Florida	ND	Van Soest (1984)
Mycale sp.2	Florida	ND	Van Soest (1984)
Mycale sp. 3	Florida	ND	Van Soest, (1984)
<u>Tedaniidae</u>			
Tedania ignus	Florida, Caribbean, Gulf of Mexico, Greater Antilles	Duchassaing and Michelotti, 1864	Van Soest (1984)
Tedania sp. 1	Florida	ND	Van Soest (1984)
Tedania sp. 2	Florida	ND	Van Soest (1984)
CALCAREA			
Clathrinida			
<u>Clathrinidae</u>			
Clathrina sp.	France, Gulf of Mexico, North Atlantic, Red Sea	Montagu, 1814	Van Soest, (1984)
Calcareous sp.1	Florida	ND	Klautau and Valentine (2003)
Calcareous sp. 2	Florida	ND	Klautau and Valentine (2003)
Calcareous sp. 3	Florida	ND	Klautau and Valentine (2003)

Calcareous sp. 4	Florida	ND	Klautau and Valentine (2003)

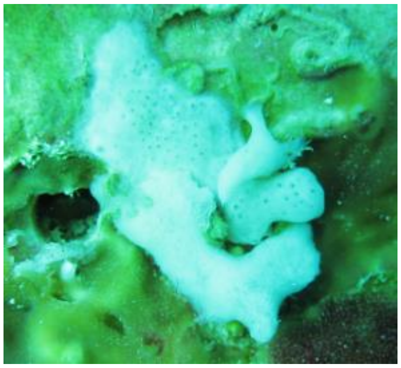
3.12 Synoptic guide to sponge species inhabiting sciophilous artificial substrate in South Florida

Below a diagnostic characterization for all species is given in the form of a synoptic guide of the sciophilous species encountered. The following guide intends to provide external diagnostic characteristics that would allow a non-expert to identify species encountered in sciophilous habitats in South Florida. Several species are extremely similar externally despite belonging to different genera and even orders. Therefore, we mention the spicule composition, and in some cases their size range if those characteristics are necessary to distinguish them.

This guide will facilitate future ecological studies of these communities

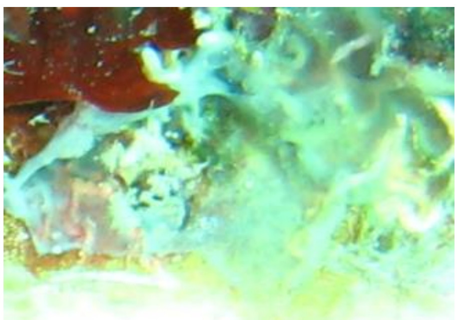
***Oscarella sp*. 1**

Identification- Thin encrusting, canals with rope like pattern on the surface. Cream to light brown in color. Smooth surface and soft consistency. Oscules 1-2 mm in diameter. No spicules.
Distribution- Bottom of limestone plates
Notes- Photo by A. Chavez-Fonegra. Identification based on lack of skeleton, and external appearance which is very similar to an undescribed species of *Oscarella* from the Caribbean.



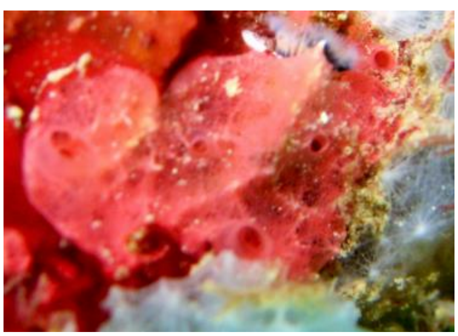
Chondrilla caribensis

Identification- Thin to thick encrusting forming sheets and mounds. Yellow, to brown, and white in color. Smooth surface with a tough consistency. Small oscules (1-3 mm) scattered on mounds. Spicules are spherasters (20-25 um across).
Distribution- Coral reefs
Notes- Photo by A. Chavez-Fonegra.



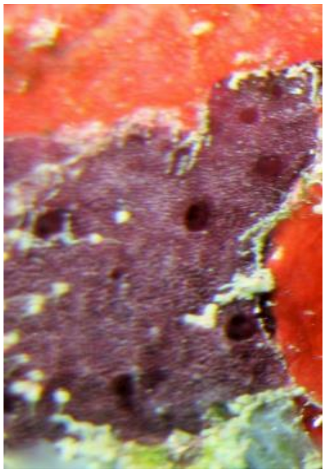
Halisarca caerulea

Identification- Thin encrusting (1-2 mm thick). Blue to violet or white. Smooth and slimy surface with thin canals (1 mm wide) converging on star shaped oscules (2-3 mm in diameter). No spicular skeleton.
Distribution- On dead coral
Notes- Photo by A. Chavez-Fonegra. New addition to the sponge fauna of Florida via the World Porifera Database.



Aplysilla rosea

Identification- Thin to thick encrusting. Conulose surface. Bright pink in color. Soft and fluffy in consistency. Oscules (2-3 mm in diameter), with collared membrane. Spicules absent.
Distribution- Bottom of limestone plates
Notes- Photo by A. Chavez-Fonegra. New to the sponge fauna of Florida via the World Porifera Database.

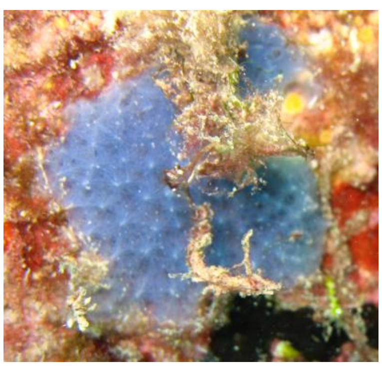


Chelonaplysilla betinensis

Identification- Thin to thick encrusting. Light to dark purple. Surface smooth, soft. Large oscules (2-5 mm in diameter) randomly distributed. Does not have proper spicules.
Distribution- Reefs and rocky substrates
Notes- Photo by A. Chavez-Fonegra. New to the sponge fauna of Florida via the World Porifera Database.

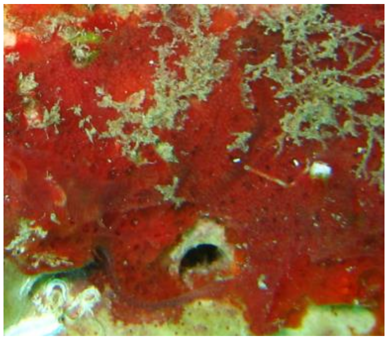
Chelonaplysilla erecta

Identification- Thin encrusting to lobate (0-3 cm high).Black. Conulose surface, conules (0.7-1.4 mm high). Soft and flexible. Irregularly spaced oscules (0.6-1.6 mm wide). Does not have proper spicules.
Distribution- Reefs and rocky substrates, occasionally mangrove roots.
Notes- Photo by A. Chavez-Fonegra. New to the sponge fauna of Florida via the World Porifera Database.



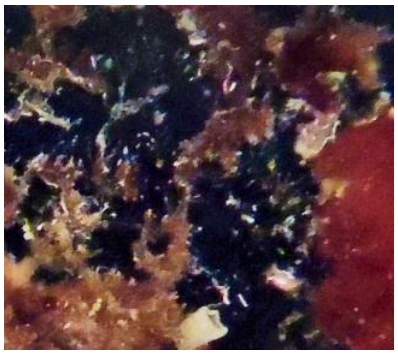
Dysidea etheria

Identification- Thin crust to small cushions (3mm to 10cm diameter). Pale violet to blue. Soft with a conulose surface. Conules (1-2mm high, 1-2mm apart). Few oscules (.5cm wide). Does not have proper spicules.
Distribution: Common, vertical hard substrates and occasionally grows on mollusk shells.
Notes: Photo by A. Chavez-Fonegra



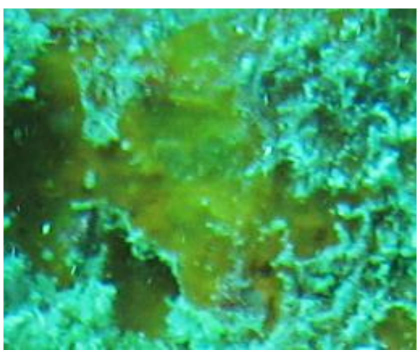
Cliona sp. 1

Identification- Thin encrusting with a porous surface. Dark veins run throughout the sponge with a white sheen on top. Bright red in color. Smooth surface with a soft consistency. Oscules not present. Spicules include tylostyles (275-287.5 x 3-5 um) tylostyle heads (6-7.5 um), and microrhabds (12.5 to 17.5 x 1 um).
Distribution- Bottom of limestone plates.
Notes- Photo taken by A. Chavez-Fonegra.



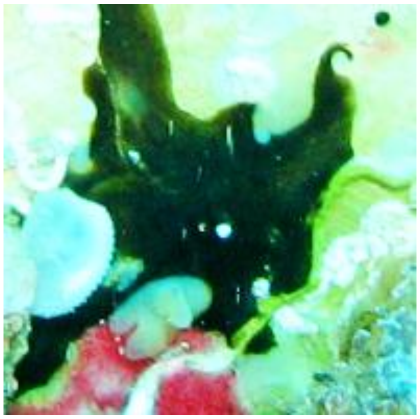
Terpios fugax

Identification- Thin encrusting (1mm) in thickness. Dark black to blue in color. Smooth surface with a soft consistency. Minute oscules. Spicules include tylostyles with flattened, lobed tyles (170-360 um).
Distribution- Bottom of limestone plates.
Notes- Photo taken by A. Chavez-Fonegra



Myrmekioderma laminatum

Identifcation- Thin encrusting. Orange in color. Smooth surface with a soft consistency. Oscules (1-2 mm in diameter) scattered in low abundance. Spicules include large oxea (680-1000 um), acanthoxeas (226-410 um), and raphids (110 um).
Distribution- Bottom of limestone plates.
Notes- Photo taken by A. Chavez-Fonegra. New addition to the sponge fauna of Florida via the World Porifera Database.

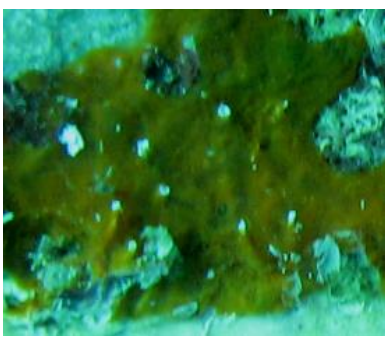


Batzella sp. 1

Identification- Thick encrusting to cushion. Black with white sheen on surface. Soft in consistency. Smooth surface pierced by ostia. Large oscules randomly distributed (2-4 mm in diameter). Spicules include long thin strongyles (147-205 x 2-3 um).
Distribution- Bottom of limestone plates
Notes- Photo by A. Chavez-Fonegra

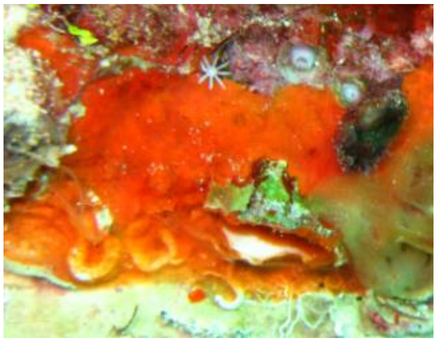
Batzella sp. 2

Identification- Thin encrusting. Brown to gold in color. Smooth surface with a soft consistency. No oscules present. Spicules include strongyles (200-215 x 5-6 um).
Distribution- Bottom of limestone plates.
Notes- Photo taken by A. Chavez-Fonegra



Chondropsis sp. 1

Identification- Thin encrusting with a smooth, porous surface. Bright orange. Soft and fluffy in consistency. Oscules not visible. Spicules include thin strongyles (180-190 x 2-3 um), two size classes of sigmas with the larger (32.5 x 2-3 um) and the smaller (27 x 1 um), and thin chela with reduced teeth (12 x .5 um).
Distribution- Bottom of limestone plates
Notes- Photo by A. Chavez-Fonegra

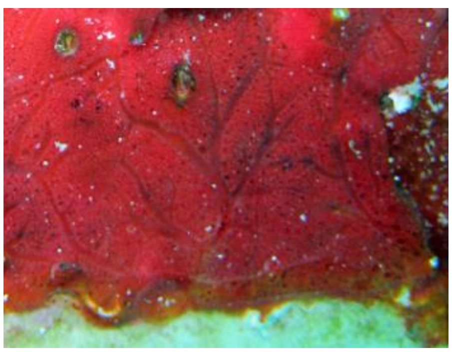


Strongylacidon rubra

Identification- Thin encrusting with a porous surface. Dark to light orange in color. Smooth surface with a soft consistency. Oscules not visible. Spicules include strongyles (167-200 um) and two sizes of sigmas with the larger being (20-30 um) and the smaller (9-15 um).
Distribution- Bottom of limestone plates
Notes- Photo taken by A.Chavez-Fonegra. New addition to the sponge fauna of Florida via the World Porifera Database.

Lissodendoryx sp. 1

Identification- Thin encrusting with a porous surface. Orange in color. Micro-conulose with a soft consistency. Oscules not visible. Spicules include tylotes (187-225x 2-5 um), strongyles (187-240 x 5-10 um), and thin microspined oxea (87-140 x 1-2 um).
Distribution- Bottom of limestone plates.
Notes- Photo by A. Chavez-Fonegra



Hymedesmia sp. 1

Identification- Thin to thick encrusting with dark veins running throughout and a porous surface. Conulose surface. Red in color. Soft and fuzzy surface. Oscules not visible. Spicules include ancanthostyles (125 x 5 um), oxea (275-287 x 9-10 um),tylostyles (250-300 x 3 um), strongyles (250 x 3-5 um), and isochela (22.5 x 5 um).
Distribution- Florida
Notes- Photo by A. Chavez-Fonegra

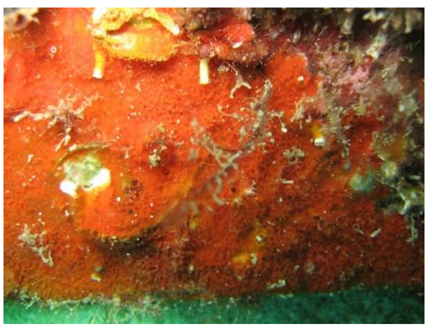
Iotrochota birotulata

Identification- Encrusting to branching (1-5 cm wide) with a conulose surface. Black with green patches. Consistency touch yet compressible. Oscules (1-3 mm diameter). Spicules include strongyles (146-230 um), styles (142-242 um), and birotulates (10-15 um).
Distribution- Reefs, mangroves, and seagrass
Notes- Photo by A. Chavez-Fonegra

Clathria affinis

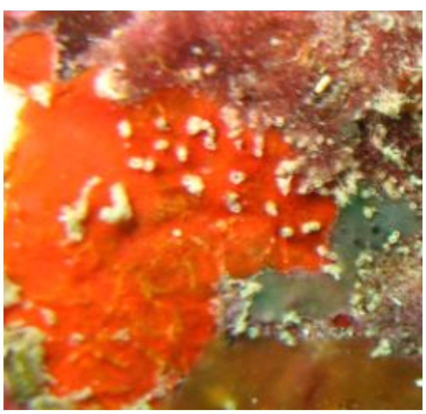
Identification- Thin encrusting. Orange in color. Smooth surface. Soft. Small oscules (1-2 mm in diameter). Spicules include tylostyles with microspined heads (342-538 um), styles with acanthoses head (178-602 um), acanthostyles (85-107 um), palmate isochela (18-20 um), and toxa (114-190 um).
Distribution- Coral reefs and rocky substrates
Notes- Photo by A. Chavez-Fonegra. New addition to the sponge fauna of Florida via the World Porifera Database.

Clathria calla



Identification- Thin to thick encrusting with a porous surface. Bright orange in color. Conulose surface with a spongy consistency. Oscules not visible. Spicules include tylostyles (186-266 um), echinating styles (114-228 um), palmate isochela (16-25 um), and toxa in two size categories with the larger (95-169 um), and the smaller (27-42 um).
Distribution- Bottom of limestone plates
Notes- Photo by A. Chavez-Fonegra

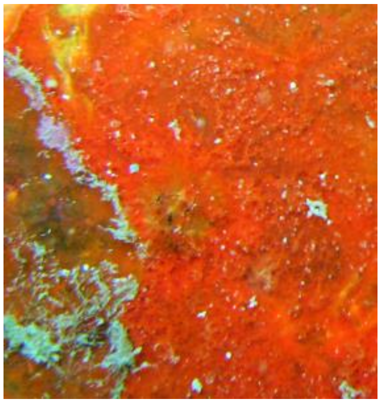
Clathria campecheae



Identification- Thin encrusting with a porous surface. Smooth surface with a soft consistency. Orange in color. No oscules. Spicules include styles with spiny heads (400-880 um), subtylostyles with microspined heads (230-660 um), acanthostyles (70-190 um), palmate isochela (12-17um), and toxa (42-380 um).
Distribution- Bottom of limestone plates.
Notes- Photo by A. Chavez-Fonegra. New to the sponge fauna of Florida via the World Porifera Database.

Clathria echinata

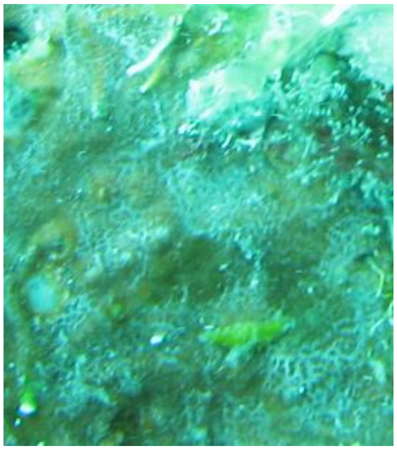
Identification- Thin encrusting with a porous surface. Bright red to orange in color. Conulose surface with a soft consistency. Oscules (1-2 mm in diameter). Spicules include styles (150-550 um), subtylostyles (210-450 um), toxa (190-280 um),raphide-like toxas (60-90 um), and cleistochelas (9-13um).
Distribution- Bottom of limestone plates.
Notes- Photo by A. Chavez-Fonegra.



Clathria spinosa
Identification-Thin encrusting with a porous surface. Micro-conulose surface. Red to orange. Rough in consistency. Oscules (1-2 mm in diameter). Spicules include tylostyles (215-293 um), styles with blunt heads (169-410 um), palmate isochela (13-18 um), toxa in two size categories with the smaller (22-71 um) and the larger (200-273 um).
Distribution- Florida
Notes- Photo by A. Chavez-Fonegra

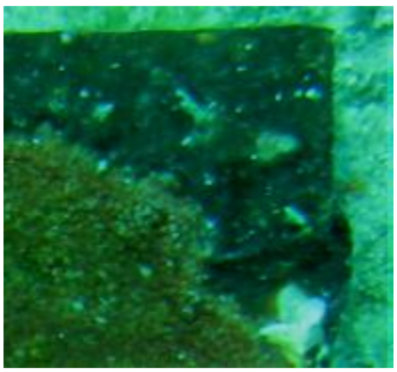
Clathria sp. 1

Identification- Thin encrusting to cushion with a porous surface. Bright orange. Conulose surface. Soft in consistency. Oscules not visible. Spicules include styles (187-265 x 10 um), styloides (100-150 x 5 um), strongyles (232-250 x 7-8 um), toxa in two size classes with the larger (140 x 5 um), and the smaller (60 x 3 um), and palmate isochela (30 x 2 um).
Distribution- Bottom of limestone plates
Notes- Photo by A. Chavez-Fonegra



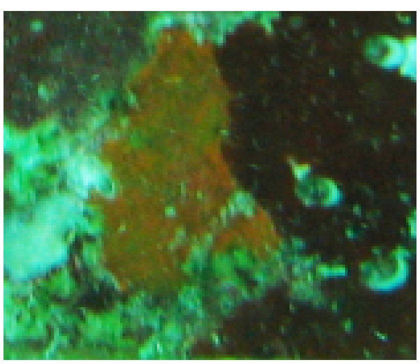
Clathria sp. 2

Identification- Thin encrusting with white veins running throughout. Peach with a white sheen on surface. Soft. Smooth surface. Oscules not observed. Spicules include oxea (190-240 x 2-5 um), two sizes of acanthostyles with the larger (130-200 x 5-8 um), and the smaller (60-90 x 3-5 um), and two size classes of isochela with the larger (25-30 um), and the smaller (12-15 um).
Distribution- Bottom of limestone plates
Notes- Photo by A. Chaves-Fonegra



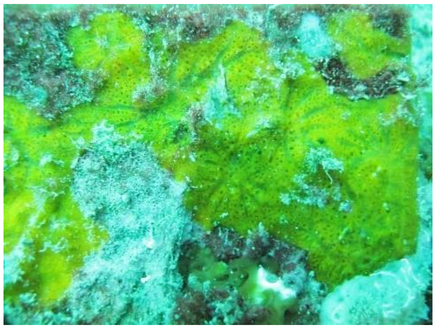
Clathria sp. 3

Identifcation- Thin encrusting with a porous surface. Black to dark brown in color. Conulose surface with a soft consistency. Osucles (1-2 mm in diameter) scattered. Spicules include two size classes of styles with the larger (360-450 x 5-8 um) and the smaller (180-280 x 2-3 um), and isochela(12-15 um).
Distribution- Bottom of limestone plates
Notes- Photo by A. Chavez-Fonegra



Clathria sp. 4

Identification- Thin encrusting with a porous surface. Orange in color. Conulose surface with a soft consistency. No oscules present. Spicules include two size classes of acanthostyles with the larger (110-150 x 5-8 um) and the smaller (60-80 x 3-5 um), two size classes of styles with the larger (260-320 x 5-6 um) and the smaller (125-200 x 2-3 um), subtylostyles (350-400 um x 8-10 um), and isochela (25-30 um).
Distribution- Bottom of limestone plates.
Notes- Photo by A. Chavez-Fonegra.



Mycale laevis

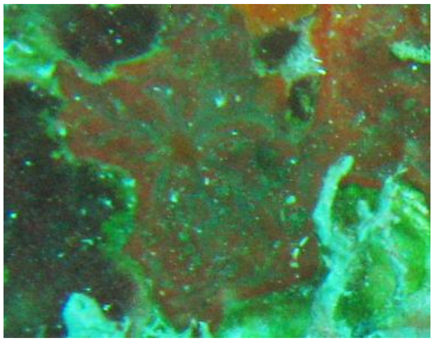
Identification- Think to thickly encrusting (5 cm thick) with canals. Orange to yellow. Smooth, porous surface with canals converging on oscules. Fragile yet compressible. Round oscules (2-4 mm wide) elevated by transparent collar membrane. Spicules include styles and strongylostyles (475-570 um), anisochela (68-84 um), sigmas (12-34 um), and trichodragmata (52-72 um).
Distribution- Coral reefs and hard bottom. Under edges of plate like stony coral.
Notes- Photo by A. Chavez-Fonegra.

Mycale laxissima

Identification- Thin encrusting, low massive, or tubular. (< 5 cm thick). Range from black, purple, orange, or cream. Conulose surface (1-5 mm high) covered in white membrane. Tough and flexible. Oscules (1-10 mm across). Spicules include subtylostyles (200-240 um), sigmas(70-80 um), and inisochela (16-23 um).
Distribution- Coral reefs, occasionally in mangrove peat.
Notes- Exudes a sticky mucus. Photo by A.Chavez-Fonegra

Mycale sp. 1

Identification- Thin encrusting. Takes on many different shades of orange or red. Smooth porous surface. Soft in consistency. Oscules not visible. Spicules include long thin mycalostyles with elongated heads (260-308 x 2-3 um), and wiggly tylostlyes (260-308 x 3-5 um). Microscleres absent.
Distribution- Bottom of limestone plates
Notes- Photo by A. Chaves-Fonegra

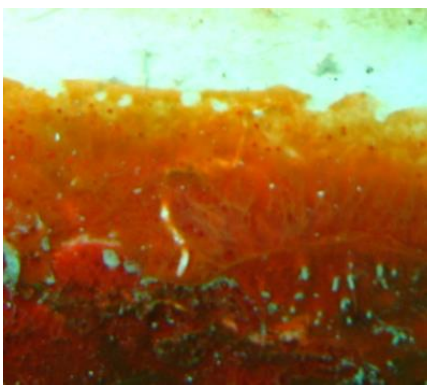


Mycale sp. 2

Identification- Thin encrusting with a porous surface. Thick veins throughout creating leaf like pattern. Smooth surface. Red in color. Soft in consistency. No oscules apparent. Spicules include subtylostyles (260-287 x3-5 um), toxa (50-87 um), anisochela (), and two size classes of sigma with the larger (75-87 um) and the smaller (12-20 um).
Distribution- Bottom of limestone plates
Notes- Photo by A. Chavez-Fonegra

Mycale sp. 3

Identification- Thin encrusting with a porous surface. Bright red in color with a white sheen. Smooth with a soft consistency. Oscules (1-3 mm in diameter). Spicules include sigma(77-87 um), toxa (50-87 um), subtylostyles (275-287 x 3-8 um), and anisochela (17-20 um).
Distribution- Bottom of limestone plates.
Notes- Photo by A. Chavez-Fonegra

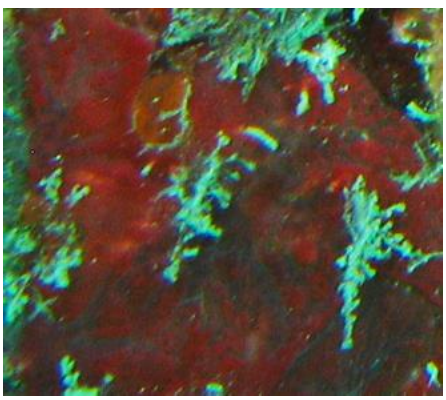


Tedania ignis

Identification- Encrusting to lobate (up to 15 cm thick) with a smooth surface. Bright red to orange in color. Soft and easily torn. Oscules found on top of lobes (1-2 mm wide). Spicules include tylotes (180-248 um), styles (202-281 um), onychaetes in two size categories with the larger (154-247 um) and the smaller (30-95 um).
Distribution- Shallow reefs, sea grass bed, mangroves
Notes- Photo by A. Chaves-Fonegra

Tedania sp. 1

Identification- Thin to thick encrusting. Dark to light brown or orange. Smooth surface and soft in consistency. Small oscules (1-2 mm in diameter). Spicules include strongyles (175-200 x 3-5 um), onychaete (87-125 x 1 um), and tylotes (187-237 x 2-3 um).
Distribution- Bottom of limestone plates
Notes- Photo by A. Chaves-Fonegra



Tedania sp. 2

Identification- Thin encrusting with a porous surface. Thick black vein like patterns run throughout. Dark red in color. Smooth with a soft consistency. No oscules present. Spicules include thin microspined onychaete (122-162 x 1 um), strongyles (225-250 x 5-8 um), and thin tylotes (175-212 x 2-3 um).
Distribution- Bottom of limestone plates
Notes- Photo by A. Chavez-Fonegra

***Clathrina sp.* 1**

Identification- Thin encrusting to a flat cushion (1-3 cm diameter). Surface is smooth with some protruding spicules, a reticulation of thin tubes. Yellow. Soft yet delicate consistency. One single central oscule. Spicules are triactines (60-120 um).
Distribution- Shallow subtidal under rocks and overhangs.
Notes- Photo by A. Chaves-Fonegra. New addition to the sponge fauna of Florida via the World Porifera Database.

Calcarea sp. 1

Identification- Thin to thick encrusting. Surface is smooth and porous. Cream to light yellow. Soft in consistency. Oscules not visible.
Distribution- Florida
Notes- Photo by A. Chavez-Fonegra

3.13. Taxonomic description of four common sciophilous sponge species, currently undescribed.

Among the 22 species that were identified only to genus level, only five occurred more than once on our artificial plates. Of those, four species are described here in more detail, as a preamble to evaluate if they constitute new species to science.

Order: Poecilosclerida

Family: Chondropsidae

Genus: *Batzella sp. 1*

Material studied:

Coordinates:N26.08.530/ W80.05.794.Collected by Andia Chavez-Fonegra and Caidra Rice on 9/15/14. 23 ft deep.

SHAPE AND SIZE- Thin encrusting, to cushion less than five millimeters in thickness

COLOR (EXTERNAL/INTERNAL)-.Black/black

SURFACE- Smooth and pierced by ostia

CONSISTENCY- Soft

APERTURES (OSCULES, AND OSTIA) - Round oscules 1.2 mm in diameter. Small ostia regularly present throughout the surface.

ODOR, MUCUS, EXHUDATE-not observed

SKELETAL ELEMENTS- Thin strongyles 147-205 um in length, 2-3 um in width.

SKELETAL ARRAGEMENT- not observed

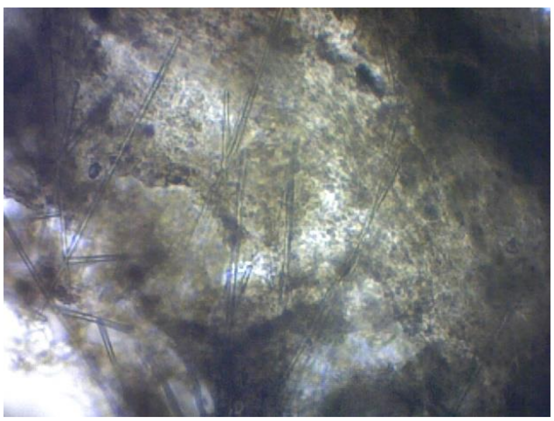
ECOLOGY- Common, found under nine limestone plates. It persisted from year one to year two on some plates.

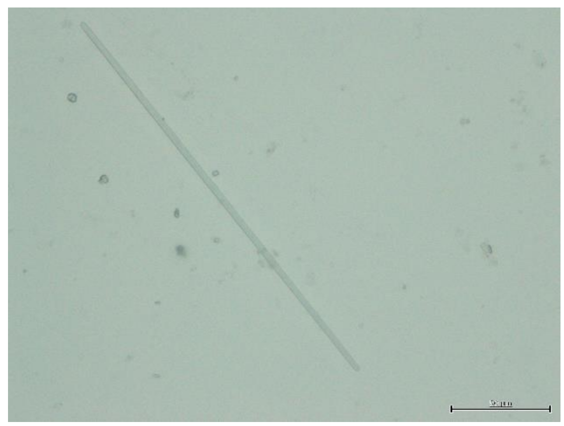
REMARKS- Batzella has ten species worldwide, three of which are Caribbean species: *B.rubra*, *B. rosea*, and *B. fusca*. *Batzella Fusca* is described by Van Soest as the only known dark colored

Caribbean *Batzella* species. It has a thin crust (less than .5 mm), dark brown in color with purple veins. Spicules include strongyles (213-277 um). Our specimen is thicker and lacks the purple veins. Van Soest 2009 discusses *Strongylacidon bermudae* (De Laubenfels, 1950) as a similar species which lacks microscleres but has a dark coloration. We considered that, and our species differs from *S. bermudae* in having much smaller osculae, lacking a conulose surface, and it has a white sheen to the surface.

Figure 5: Skeletal representation of *Batzella sp.1*, A. cross section of a specimen showing sparse arrangement of spicules, B. photo of a strongyle.

A. B.





Order: Poecilosclerida

Family: Mycalidae

Genus*: Mycale sp.1*

Material studied:

Coordinates:N26.08.530/ W80.05.794.Collected by Andia Chavez-Fonegra and Caidra Rice on 9/15/14. 23 ft deep.

SHAPE AND SIZE- Thin encrusting

COLOR (EXTERNAL/INTERNAL) – Ranging from orange to red

SURFACE- Smooth, porous

CONSISTENCY- Soft

APERTURES (OSCULES, AND OSTIA) –none

ODOR, MUCUS, EXHUDATE- not observed

SKELETAL ELEMENTS- Spicules include long thin mycalostyles with elongated heads (260-308 x 2-3 um), and flexuous tylostlyes (260-308 x 3-5 um). Microscleres absent.

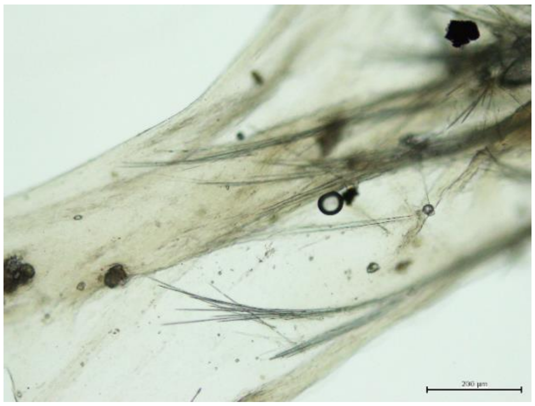
SKELETAL ARRAGEMENT- not observed

ECOLOGY- Common, found on the bottom of 19 limestone plates

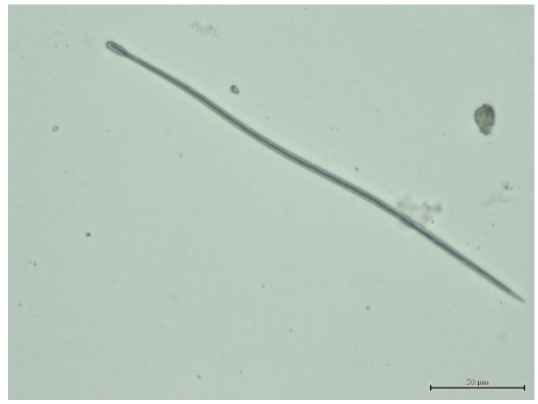
REMARKS- This species has unique flexuous tylostyles, with elongated heads, and thick spicular filaments, and it lacks of any microclere component. We consulted Dr. Rob Van Soest (Naturalis, Netherlands) to aid in the identification of this species. He has seen this sponge on both sides of the Atlantic and he suggested that this species as an awkward "reduced" *Mycale*. The skeleton with loose spicule tracts is reminiscent of Mycalidae. However, the only proof of its *Mycale* affinities must await the genetic study of this species.

Figure 6. Skeletal reprensetation *Mycale sp.1*. A. cross section of sparse arrangement of spicules. B. Mycalostyle

A.



B.



Order: Poecilosclerida

Family: Mycalidae

Genus: ***Mycale sp. 2***

Material studied:

Coordinates: N26.08.530/ W80.05.794.Collected by Andia Chavez-Fonegra and Caidra Rice on 9/15/14. 23 ft deep.

SHAPE AND SIZE- Thin encrusting with red veins throughout

COLOR (EXTERNAL/INTERNAL) - Red

SURFACE- Smooth, porous

CONSISTENCY- Soft

APERTURES (OSCULES, AND OSTIA) – not apparent

ODOR, MUCUS, EXHUDATE- not observed

SKELETAL ELEMENTS- Spicules include subtylostyles (260-287.5 x3-5 um), toxa (50-87um), anisochela (5-7 um), and two size classes of sigma with the larger (75-87 um) and the smaller (12-20 um).

SKELETAL ARRAGEMENT- not observed

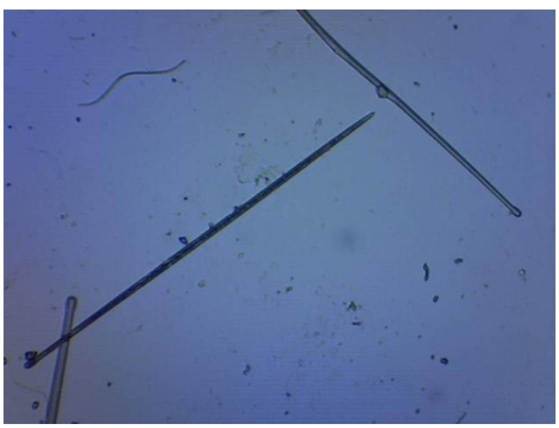
ECOLOGY- Common, found on the bottom of four limestone plates

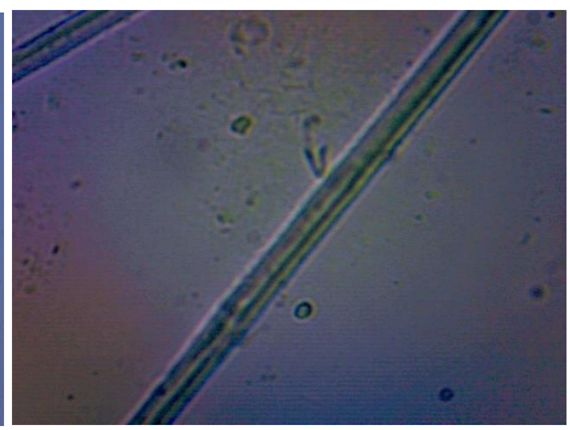
REMARKS- The combination of a red intense color and corrugareted surface is atypical of common Caribbean *Mycale* species. The most recent studies of sciophilous sponges (Van Soest, 2009; Ruetzler et al., 2014) do not depict any species with these characteristics. Consultation of a specialist on this sponge group (Dr. Hajdu) will be carried out. Possibly a careful comparison and genetic study will be necessary to determine it status.

Figure 7. Skeletal representation *Mycale sp.2.* A. Mycalostyles. B. Mycalostyles and sigma. C. Mycalostyles and toxa, D. Anisochela

A. B.

C **D.**





Order: Poecilosclerida

Family: Tedaniidae

Genus: *Tedania sp. 1*

Material studied:

Coordinates:N26.08.530/ W80.05.794. Collected by Andia Chavez-Fonegra and Caidra Rice on 9/15/14. 23 ft deep.

SHAPE AND SIZE- Thin to thick encrusting

COLOR (EXTERNAL/INTERNAL) - Dark to light brown

SURFACE- Smooth

CONSISTENCY- Soft

APERTURES (OSCULES, AND OSTIA) – small oscules (1-2mm in diameter)

ODOR, MUCUS, EXHUDATE- not observed

SKELETAL ELEMENTS- Spicules include strongyles (175-200 x 3-5 um), onychaete (87-125 x 1 um), and tylotes (187-237 x 2-3 um).

SKELETAL ARRAGEMENT- not observed

ECOLOGY- Common, found on the bottom of five limestone plates

REMARKS- This species have the typical spicule complement of the two other Caribbean species *Tedania ignis* and *Tedania klaussi.* The brown color of most specimens seem consistently different with the two other Caribbean species. However this morphology could represent a younger stage of one of these species. Therefore, genetic and longer term studies would be required to determine its specific distinctness.

Figure 8. Skeletal representation *Tedania sp.1.* A. Strongyles and onychaete. B. Tylote

A. B.

3.2. Ecological Results

3.21. Frequency of Occurrence of Sponge Species on the Underside of Artificial Plates

Forty five species were distinguished among the 50 plates placed in the inner and outer areas of the reef. Most species occurred only once (twenty six) while only eighteen species are found in two or more plates. The most common species were: *Oscarella sp.1, Dysidea etheria, Mycale sp.1, Halisarca caerula,* and *Tedania ignis* which were found on ten or more plates (Table 2).

Table 2: Frequency of appearance of sponges per species that was encountered in each recruitment plate for 2011, and 2012.

Species	# of plates 2011	# of plates 2012
Oscarella sp. 1	11	28
Dysidea etheria	7	20
Mycale sp. 1	10	19
Halisarca caerula	5	17
Tedania ignis	2	10
Batzella sp. 1	3	9
Clathria affinis	2	6
Chelonaplysilla erecta	6	5
Tedania sp. 1	3	6
C. betinensis	1	5
Mycale sp. 2	4	4
Terpios fugax	1	3
Lissodendoryx sp. 1	2	3
Mycale laevis	1	2
Clathria compecheae	1	2
Mycale laxissima	0	2
Aplysilla rosea	1	2
Iotrochota birotulata	2	2
Clathria sp. 3	0	1
Chondrilla caribensis	1	1
Batzella sp. 2	0	1
Clathrina coriacea	0	1
Clathria sp. 1	1	1
Chondropsis sp. 1	1	1

M. laminatum	0	1
Clathria calla	0	1
Calcareous sp. 2	0	1
Clathria echinata	0	1
Strongylacidon rubrum	1	1
Clathria sp. 4	0	1
Hymedesmia sp. 1	0	1
Clathria spinosa	0	1
Cliona sp. 1	1	1
Tedania sp. 2	0	1
Mycale sp. 3	0	1
Clathria sp. 2	0	2
Calcareous sp. 1	0	1
Oscarella sp. 2	0	1
Calcareous sp. 3	0	1
Calcareous sp. 4	0	1

3.22. Species richness and Area Coverage: Species Area Curve and Anova

During the two-year study the expected richness of sponge fauna reached a maximum number of forty five species. The species area curve did not reach a plateau, suggesting a greater potential for the number of species to increase in the studied area (Figure 9).

Significant differences in species richness was found among years, richness was higher in 2012 than in 2011, but not among sectors of the reef (Figure 10, Table 3). However, differences in sponge cover were significant among the inner and outer reef, with higher values for the inner reef, but not between years (Figure 11, Table 4).

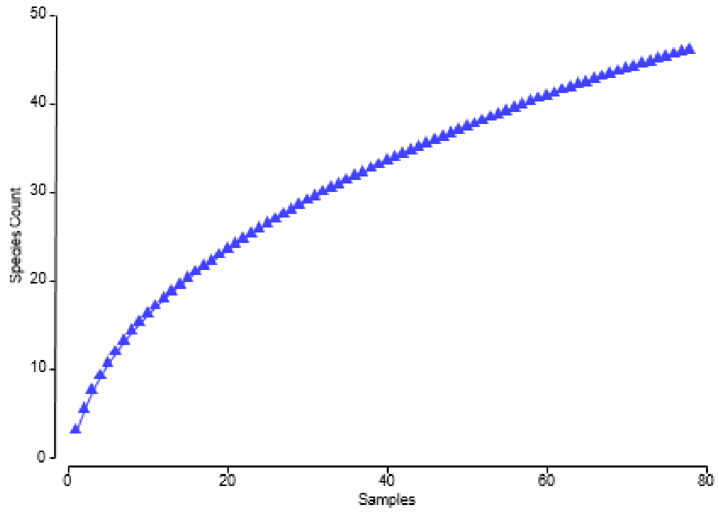


Figure 9. Species accumulation curve with 2011 and 2012 data

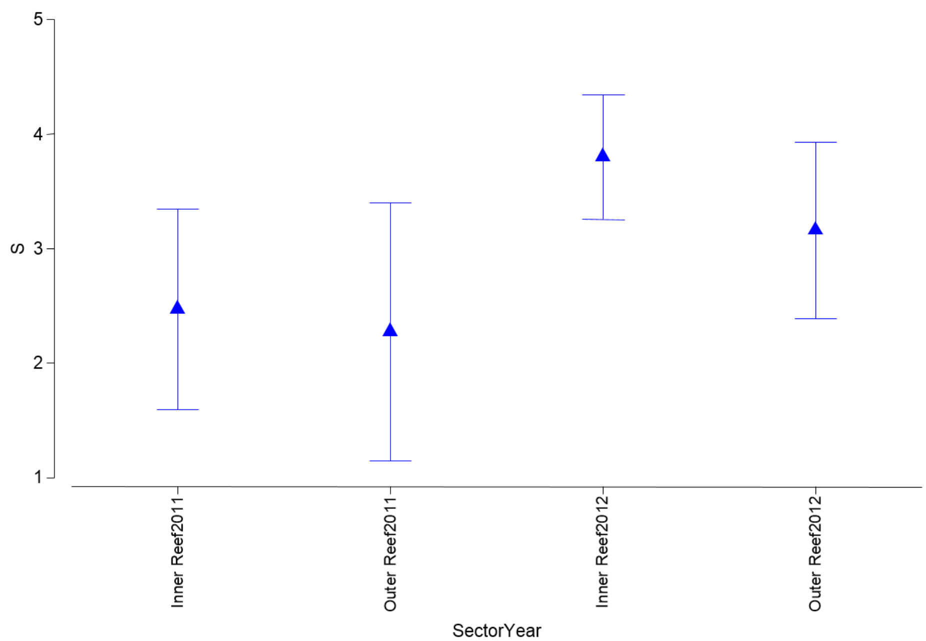


Figure 10. Average (±SD) of species richness per plate at two reef sectors (inner and outer) for 2011, and 2012.

Table 3. ANOVA of richness values comparing sectors, years, and sectors x years (p-value obtained with 999 permutations under the reduced model).

Source	df	SS	MS	F	P(perm)	
Sector	1	3.06	3.06	1.132	0.286	ns
Year	1	21.39	21.39	7.923	0.005	<0.05
Sector x Year	1	0.86	0.86	0.315	0.583	ns
Res	74	199.78	2.70			
Total	77	226.37				

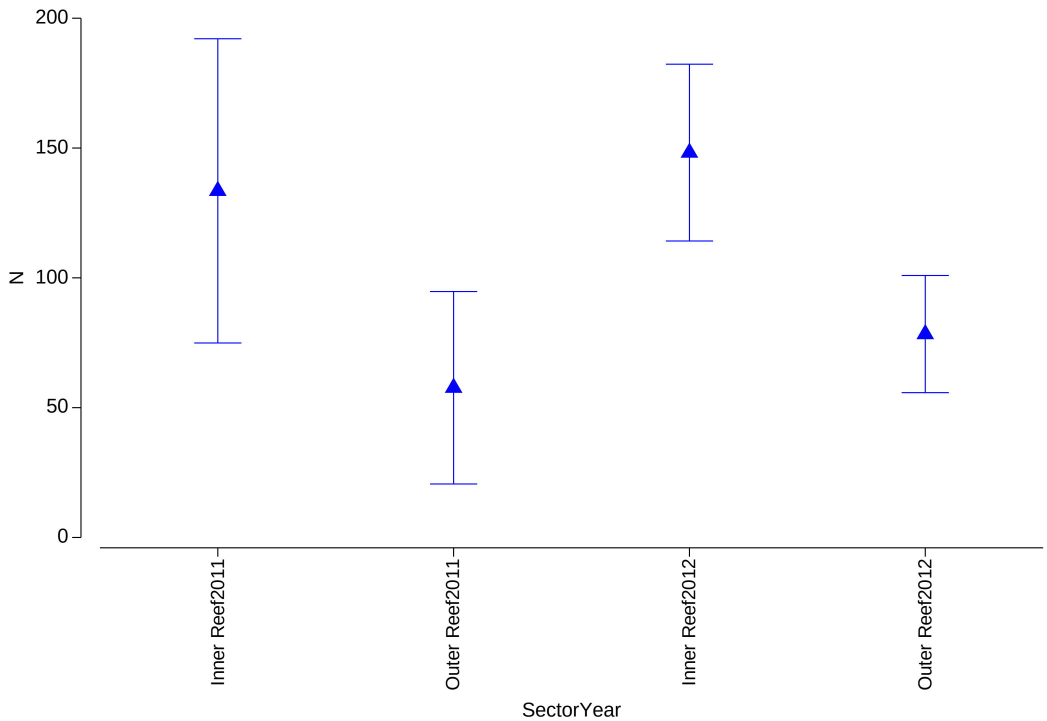


Figure 11. Average (±SD) of sponge cover per plate at two reef sectors (inner and outer) for 2011 and 2012.

Table 4. ANOVA of area coverage values comparing sectors, years, and sectors x years (p-value obtained with 999 permutations under the reduced model).

Source	df	SS	MS	F	P(perm)	
Sector	1	92451	92451	14.454	0,001	<0.05
Year	1	5455.8	5455.8	0.853	0,362	ns
Sector x Year	1	153.8	153.8	0.024	0,862	ns
Res	74	4.73E+05	6396.2			
Total	77	5.74E+05				

3.23. Sponge species assemblages

Sponge species assemblages based on species cover did not vary between reef sectors or years with an ANOSIM (Figure 12). However, a slight variation between reef sectors was detected with the two way PERMANOVA analysis (Figure 13).

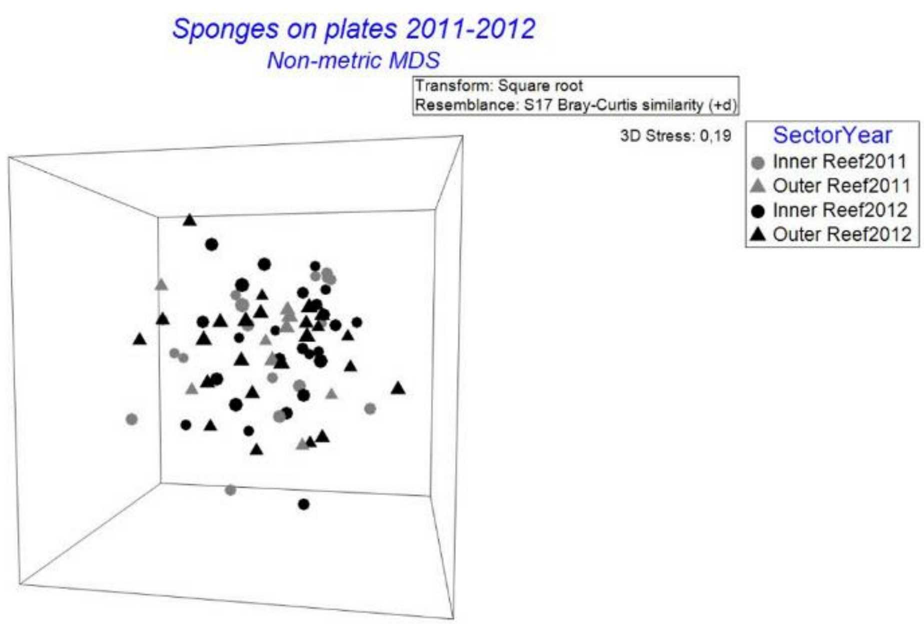


Figure 12. Non-metric MDS analysis of sponge assemblages per plate between years and between two reef sectors (inner and outer).

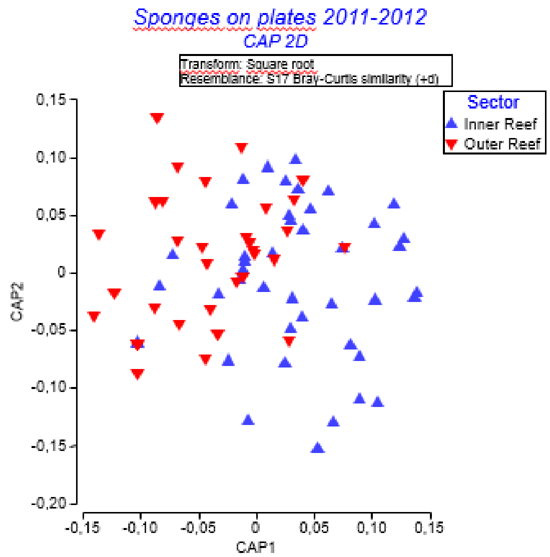


Figure 13. PERMANOVA analysis of sponge assemblages per recruitment plate between years and between two reef sectors (two way cross dessing).

3.24. Relative abundance of Sponges

Ten species including *Mycale sp.1, Oscarella sp. 1, Halisarca caerula, Dysidea etheria, Tedana ignis, Tedania sp. 1, Chelonaplysilla erecta, Batzella sp. 1, Mycale sp. 2*, and *Mycale laxissima* were the main contributors to the differences between the inner and the outer reef sponge fauna associated to the underside of the recruitment plates (Table 5).

The inner reef had a higher abundance of *Mycale sp. 1* than the outer reef, and this species was the main factor that contribute to distinguish both sectors (Table 5, Figure 14). In addition, *Mymekioderma laminatum, Terpios fugax, Mycale laevis*, and *Cliona* sp. were only found on the inner reef plates. Three species, *Mycale sp.1, Dysidea etheria*, and *Tedania* sp. 1 presented the highest abundance in the inner reef covering up to 300 cm2 per plate. In the outer reef, *Halisarca caerula* had the highest abundance reaching values up to 80 cm2 (Figure 15).

Species richness between 2011 and 2012 showed that all sponges present in 2011 were also in 2012, but not all species in 2012 were found in 2011 (Figure 14). New species found in 2012 include *Batzella sp. 2, Mycale laevis*, and *Terpios fugax* among others. Abundance also increased in 2012 when compared to 2011(Figure 14).

Table 5. Simper analysis of species contributions to the dissimilarity within sectors (inner and outer reef).

Groups Inner Reef & Outer Reef		Average dissimilarity = 86,15				
	Inner Reef	Outer Reef				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Mycale sp. 1	4,05	1,18	14,69	0,83	17,05	17,05
Oscarella sp. 1	2,92	2,86	13,28	0,91	15,42	32,47
Halisarca caerula	0,75	1,2	5,96	0,62	6,92	39,39
Dysidea etheria	1,18	0,87	5,61	0,72	6,51	45,89
Tedania ignus	0,81	0,94	5,12	0,51	5,94	51,84
Tedania sp. 1	1,23	0,52	5,11	0,41	5,93	57,76
Chelonaplysilla erecta	0,54	0,93	4,13	0,55	4,8	62,56
Batzella sp. 1	0,19	0,89	2,92	0,48	3,39	65,95
Mycale sp. 2	0,66	0,39	2,84	0,38	3,29	69,25
Mycale laxissima	0,37	0,27	2,21	0,22	2,56	71,81

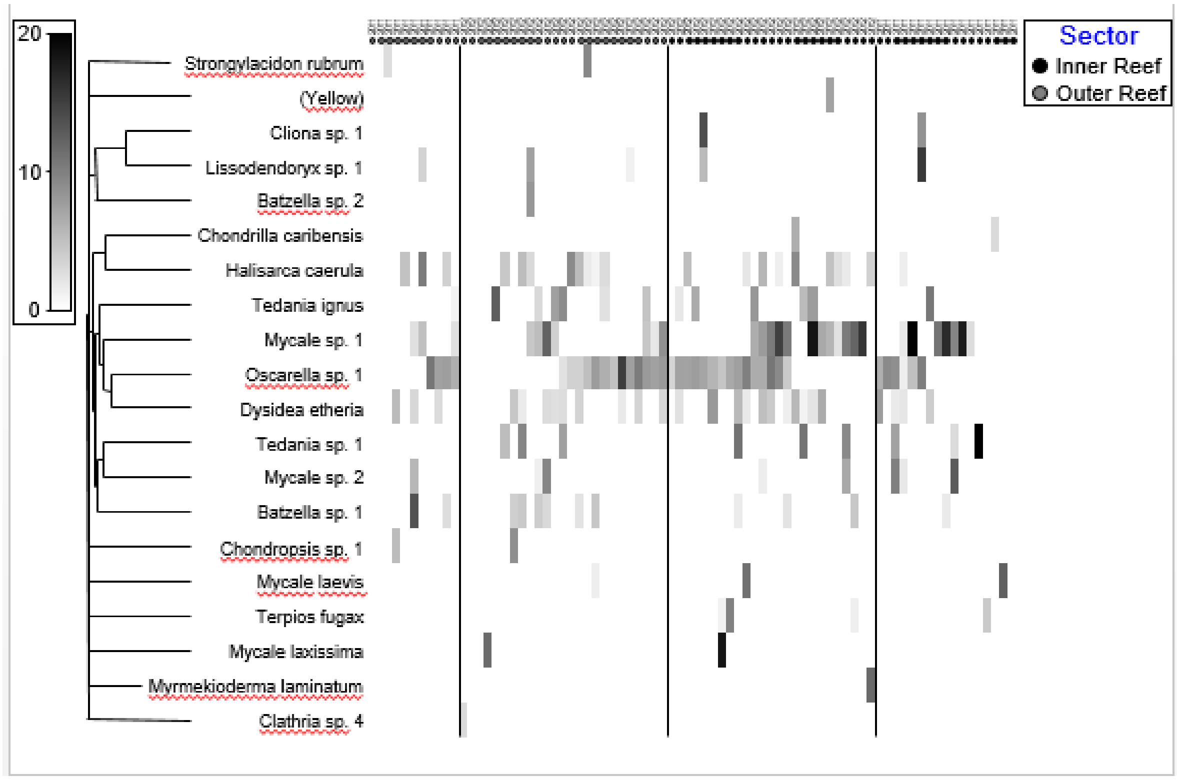
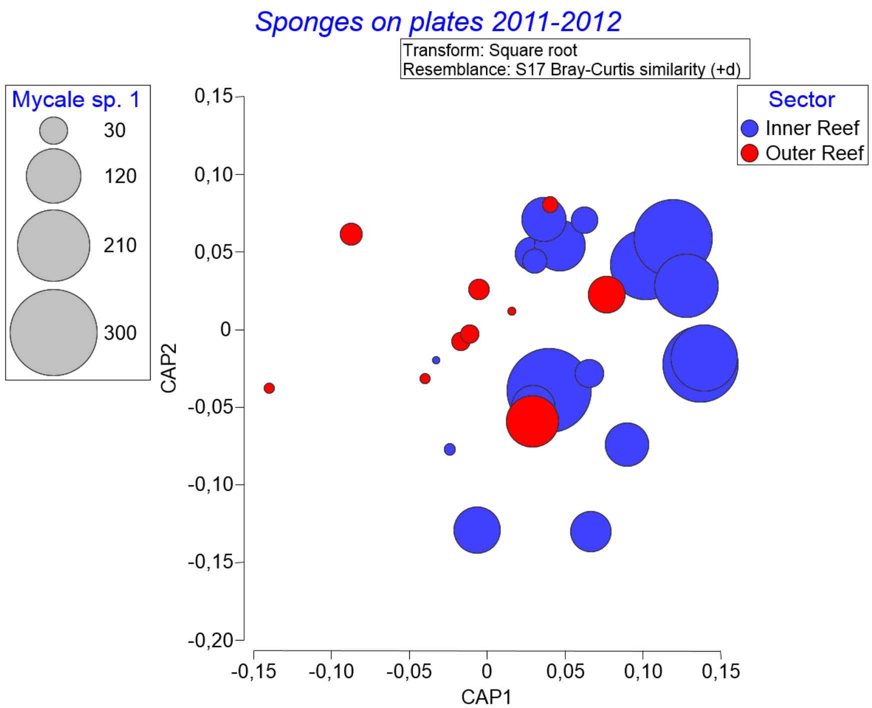
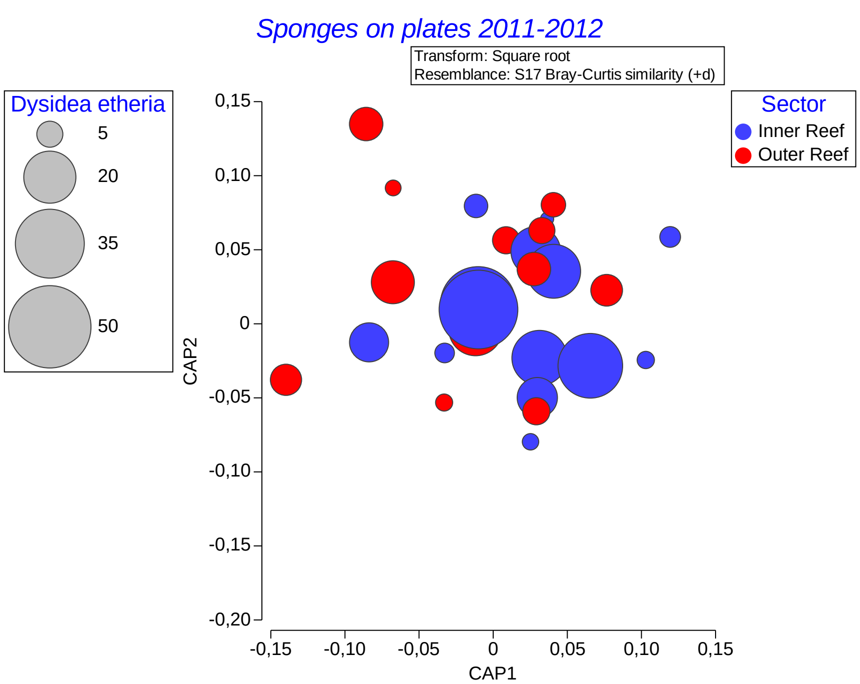


Figure 14. Sponge occurrence on plates 2011-2012 represented by a shade plot, which is a visual display of the data matrix itself, with rows being the 20 most abundant species and columns the 78 plates. Rectangles represent the presence of a species and the grey shading that increase in intensity. White denotes absence of that species in the sample and the full black represents the maximum abundance in the matrix. The cluster projected with row represents similarity based on species frequency of appearances in the plates This plot helps in identifying the contribution of species to the pattern of difference between sectors

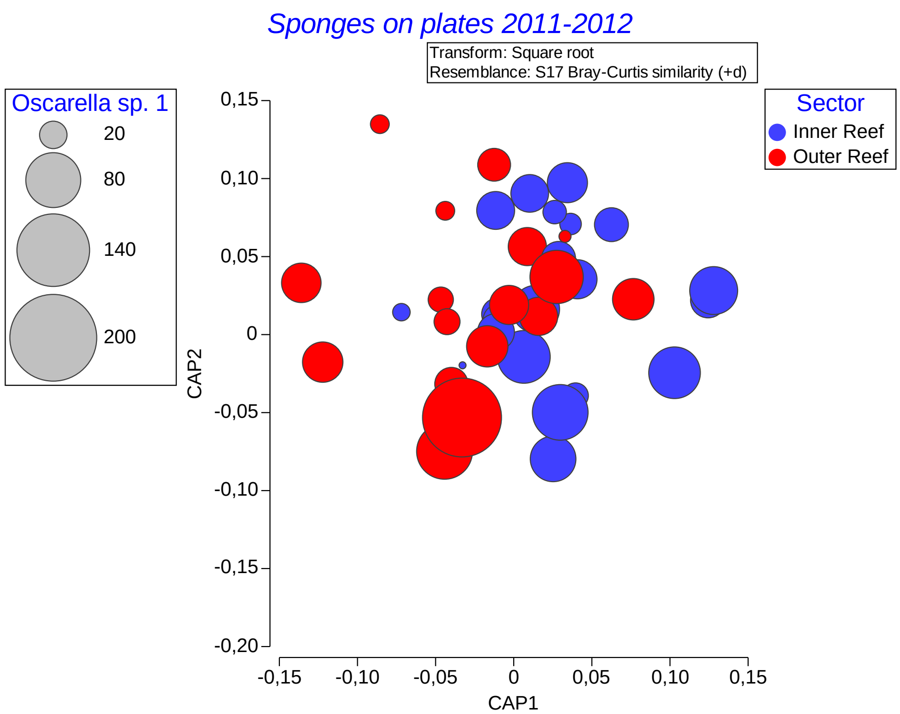
A.


Sponges on plates 2011-2012
Transform: Square root
Resemblance: S17 Bray-Curtis similarity (+d)
Mycale sp. 1
30
120
210
300
Sector
Inner Reef
Outer Reef
0,15
0,10
0,05
0
-0,05
-0,10
-0,15
-0,20
CAP2
-0,15
-0,10
-0,05
0
0,05
0,10
0,15
CAP1

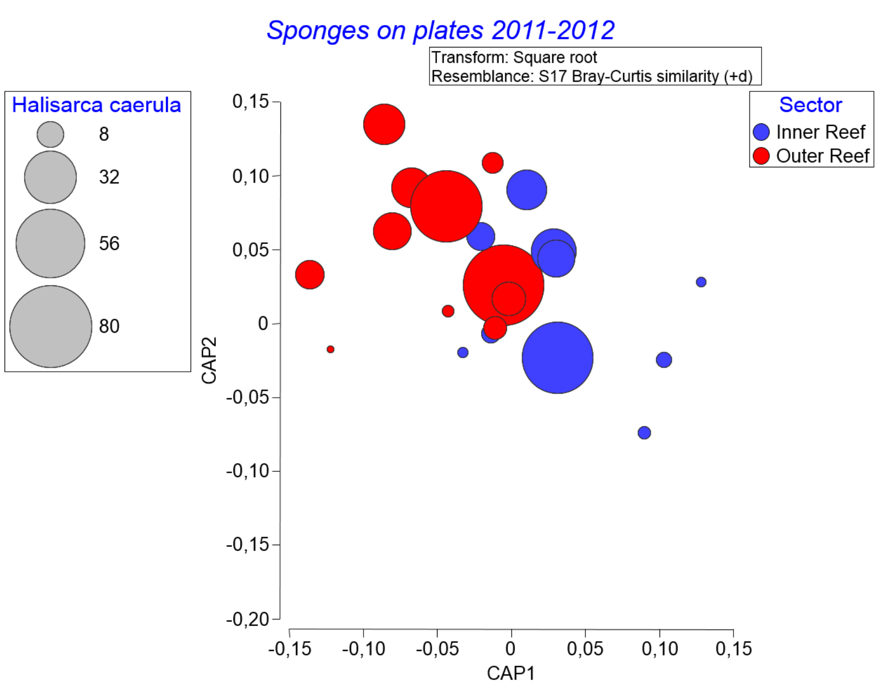
B.


Sponges on plates 2011-2012
Transform: Square root
Resemblance: S17 Bray-Curtis similarity (+d)
Dysidea etheria
5
20
35
50
Sector
Inner Reef
Outer Reef
0,15
0,10
0,05
0
-0,05
-0,10
-0,15
-0,20
CAP2
-0,15
-0,10
-0,05
0
0,05
0,10
0,15
CAP1

C.


Sponges on plates 2011-2012
Transform: Square root
Resemblance: S17 Bray-Curtis similarity (+d)
Oscarella sp. 1
20
80
140
200
Sector
Inner Reef
Outer Reef
0,15
0,10
0,05
0
-0,05
-0,10
-0,15
-0,20
CAP2
-0,15
-0,10
-0,05
0
0,05
0,10
0,15
CAP1

D.


Sponges on plates 2011-2012
Transform: Square root
Resemblance: S17 Bray-Curtis similarity (+d)
Halisarca caerula
8
32
56
80
Sector
Inner Reef
Outer Reef
0,15
0,10
0,05
0
-0,05
-0,10
-0,15
-0,20
CAP2
-0,15
-0,10
-0,05
0
0,05
0,10
0,15
CAP1

E.

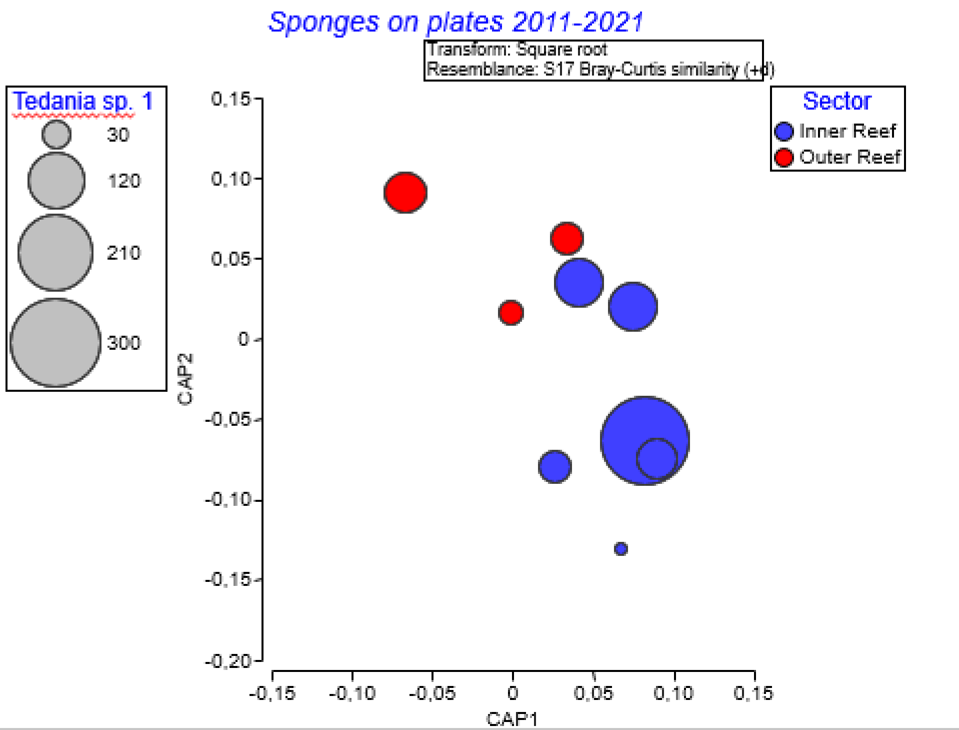


Figure 15: Cap plot of area coverage for five of the most common sponge species in the inner and outer reef sectors at a Fort Lauderdale reef studied between 2011 and 2012. A) *Mycale sp. 1*, B) *Dysidea etheria*, C). *Oscarella sp*, D). *Halisarca careula*, E). *Tedania sp. 1*.

4.0 Discussion:

4.1 Taxonomy of sciophilous sponges associated to artificial reefs:

This is the first study of sponges inhabiting habitats on artificial plates in southeast Florida, and contributes to describe and understand biodiversity of the cryptic habitats in shallow coral reefs. In the Greater Caribbean Sea, two studies have explored the sponge biodiversity of cryptic habitats in the past five years. Van Soest (2009) characterized fifty six species from rubble and caverns in the Dutch islands of Curacao, Aruba and Bonaire describing thirteen new species to science. Ruetzler et al., (2014) described one hundred and twenty two species from rubble, the underside of coral colonies, and other cryptic habitats from Belize Barrier reef with fourteen new species. The present study detected fort five different species with eight new records of sponge species in Florida, and four potential new species.

Sciophilous sponges are still understudied due to the difficulty for divers to reach cryptic habitats and collect sponges in their intact shapes. Although we did our best to identify all collected species, there is a high possibility that we have undescribed species among the twenty two species that were identified to genus. The four potential new species described in this study (*Mycale* sp.1, *Mycale* sp.2, *Batella* sp. 1, and *Tedania* sp. 1.) are in process to confirm. For these species sub-samples along with spicule photos and in depth descriptions will be sent to experts in each particular taxonomic group. The other eighteen species that were described only to genus might be unique morphotypes of known species or might represent young specimens lacking a complete set of skeletal elements found in the adults (Zea, 1993).

The sponge fauna found on the underside of the plates are very similar to that found in other cryptic habitats on Caribbean reefs (Ruetzler et al, 2014). This assemblages are dominated by thin encrusting sponges (not tubes, branches, cups, or massive as in the open reef or in the mangroves). The Poecilosclerida genera (*Mycale, Tedania, Hymedesmia*, *Batzella*, and *Clathria*) are the most diversified in this habitat. This could suggest a preferential recruitment of Poecilosclerida on cryptic or scipholious habitats. Among the most common species, only six are found in open reefs or other habitats (i.e *Tedania ignis* and *Dysidea etheria* that inhabit both mangrove roots and seagrass beds) (Diaz, 2011). Therefore the majority of the species recorded under the plates are cryptic specialized species.

Forty five species on the underside fifty plates placed on the reef may seem like a small number compared to the species richness of an open reef which has species in the hundreds. However when you look at the total area represented by the 50 plates (2 m2), then the number of sponges found is relatively high (Alcolado, 1999; Gochfeld et al, 2007; Villamizar et al, 2013; Zea, 2001).

4.2 Ecological Patterns

4.21 Sponge species frequency of occurrence on the underside of artificial plates:

Sixty percent of the species encountered on the underside of the experimental plates were found only in one plate during the entire study. This pattern of low frequency for most species is common for sponges inhabiting open reef habitats and mangroves (Diaz, 2011; Diaz and Ruetzler, 2009). The low larvae recruitment rate described for reef sponges (Zea, 1993a) could be an explanation for this pattern of species occurrence where most species are rare, and the number of species increase as more time for recruitment is allowed.

4.22 Structure and dynamics of sponge populations:

The species accumulation curve (figure 9) never reached a plateau, indicating that if we increase the number of plates or the area studied more species will be recorded for this type of environment. In comparison, previous studies in cryptic and light exposed environments found that species richness is never stable (Zea, 1993).

Species richness on the plates increased significantly from 2011 to 2012. This may indicate that recruitment is accumulative through the years and that sponge assemblages in cryptic habitats might be dynamic through time in terms of composition (Becerro, et al, 2012). Partial mortality and unpredictable recruitment in artificial plates were found to produces unpredictable patterns in this type of benthic assemblages (Sutherland and Karlson, 1977).

Sponge area coverage was higher in the inner than in the outer reef. This is possible due to a higher growth and settlement of sponges in the inner reef, and demonstrated variation within a small spatial scale. A study done by Zea on recruitment of sponges onto artificial plates found that recruitment of sponges was higher and mortality of younger sponges lower in plates that were closer to adult sponge aggregations (Zea, 1993). The outer reef is also possibly a less suitable habitat for sponges due that this sector is the edge of the reef next to a sand patch, where higher sedimentation levels could have played a role in reducing sponge cover (Nunez et al., 2012). In addition, potential larvae sources might also be greater on the inner reef, since little to no potential larvae source is available on the sand patches between the reefs (Villamizar et al., 2013). Besides sedimentation and larval source abundance, it is also possible, that cryptic sponge assemblages are limited and/or modulated by environmental and biological factors such as hydrodynamics, (Zea, S. 1993; Nunez et al, 2012).

In the present study, *Mycale sp. 1, Dysidea etheria*, and *Tedania sp. 1* dominated on the inner reef plates while *Halisarca caerulea* dominanted on the outer reef plates. Thus not only did they vary in size but also sectors of the reef. The fact that a handful of species dominated in terms of area coverage, indicates a possible spatial competitive superiority of those dominant species compared to the rest. This competitive ability might be composed of higher growth rates and/or allelochemistry (Jackson and Buss, 1975; Wulff, 2006). A study done in 2005 found that while the over-growth ability of a species is dependent on sponge morphology, the ability to resist overgrowth is associated with the production of allelochemicals (Engel and Pawlik, 2005).

Limestone plates were useful to encounter cryptic sponges, and facilitated the manipulation of thin encrusting species. The plates represented a form of shaded artificial substratum for sponges to settle on (Ruetzler et al, 2014; Zea, 1993; Sutherland and Karlson, 1977). Therefore, this experimental approach could be useful to study sciophious species and their implications in other reef processes. Simultaneously, the methodological approach used in the study avoid disturbance to the already established communities in the environment. Further studies of sponge recruitment in cryptic artificial habitats could include larger plates distributed between three reef tracts, and a lengthier period of submersion with a more in depth study of the plates from year to year.

5.0 Conclusion:

This study added eight species of sponges to the previously recorded Florida sponge fauna and four possible new species to science. This relatively large number of rare species, which cannot be readily found in the sponge regional (Greater Caribbean) literature invites to explore natural cryptic habitats as a source of novel biodiversity.

An in depth guide of the cryptic sponge species found in this study has also been created. This guide will be used to help facilitate further studies on cryptic sponges.

Artificial limestone plates were useful to study recruitment and development of cryptic sponge assemblages, demonstrating a diverse and complex assemblage quite distinct from the sponge assemblages on the open reefs. Cryptic sponge assemblages varied in small spatial scale within the reef depending on the area of the reef (inner or outer rim) where they are located, and probably due to certain physicochemical (sediment, water dynamics) and biological (larvae abundance) factors. Further studies are required to understand the life histories of the sciophilous sponge species, and successional patterns in these communities.

Literature Cited:

Alcolado P.M. (1999) Comunidades de Esponjas de los Arrecifes del Archipielelago Sabana-Camaguey, Cuba. € Boletin de Investigaciones Marino Costeras, 28, 95–124.

Anderson MJ, Gorley RN, Clarke KR (2008) PERMANOVA for PRIMER: Guide to Software and Statistical Methods. PRIMER-E Ltd, Plymouth, UK

Anderson MJ, Willis TJ (2003) Canonical analysis of principal coordinates: a useful method of constrained ordination for ecology. Ecology 84:511-525

Baine, Mark. "Artificial reefs: a review of their design, application, management and performance." *Ocean and Coastal Managment*. 44.3-4 (2001): 241-259. Web. 4 Apr. 2014. <http://www.sciencedirect.com/science/article/pii/S0964569101000485>.

Becerro, Mikel A, Maria J Uriz, Manuel Maldonado, and Xavier Turon. *Advances in Marine Biology; Advances in Sponge Science: Phylogeny, Systematics, Ecology*. Vol. 61. London: Elsevier, 2012. Print.

Bell, James.J. "The Functional Roles of Marine Sponges." *Estuarian, Coastal and Marine Science*. 79.3 (2008): 341-353. Print. <http://www.sciencedirect.com/science/article/pii/S0272771408002023>.

Bickford, David, David J. Lohman, Navjot S. Sodhi, Peter K.L Ng, Rudolf Meier, Kevin Winker, Krista K. Ingram, and Indraneil Das. "Cryptic species as a window on diversity and conservation." *Trends in Ecology & Evolution* 22 (2207): 148-155. Print.

Buss, L.W., and J.B.C Jackson. "Competitive Networks: Nontransitive Competitive Relationships in Cryptic Coral Reef Environments." *American Naturalist*. 113.2 (1979): n. page. Print.

Clarke KR (1993) Non-parametric multivariate analyses of changes in community structure. Aust J Ecol 18:117-143

Clarke KR, Tweedley JR, Valesini FJ (2014) Simple shade plots aid better long-term choices of data pre-treatment in multivariate assemblage studies. J Mar Biol Ass U K 94:1-16]

De Goeij, Jasper M, Herbert Van Den Berg, Martine M Van Ostveen, Eric H. G Epping, and Fleur C Van Duyl. "Major Bulk Dissolved Organic Carbon (DOC) Removal by Encrusting Coral Reef Cavity Sponges." *Marine Ecological Progress Series* 357 (2008): 139-51. Print.

De Goeij, Jasper M, Dick Van Oevelen, Mark A. J Vermeij, Ronald Osinga, Jack J Middelburg, Anton F De Goeij, and Wim Admiraal. "Surviving in a Marine Desert: The Sponge Loop Retains Resources Within Coral Reefs." *Science* 324.6154 (2013): 108-10. Web. 2015. <https://www.sciencemag.org/content/342/6154/108.figures-only>.

Diaz, Maria Cristina, and Klaus Rutzler. "BIODIVERSITY OF SPONGES: BELIZE AND BEYOND, TO THE GREATER CARIBBEAN." *Too Precious to Drill: the Marine Biodiversity of Belize, Palomares and Pauly*: 57-65. Print.

Diaz, Cristina. "Mangrove and Coral Reef Sponge Faunas: Untold Stories about Shallow Water Porifera in the Caribbean." *Hydrobiologia* (2011): 1-12. Print.

Diaz, Cristina M., and Klaus Rutzler. "SPONGES: AN ESSENTIAL COMPONENT OF CARRIBEAN CORAL REEFS." *Bulletin of Marine Science*. 69.2 (2001): 535-546. Web. 4 Apr. 2014. <http://fishingdown.org/conference/belize/Belize_Scientific_papers/Diaz_etal2001_lp.pdf>.

Engel, Sebastian, and Joseph.R Pawlik. "Interactions Among Florida Reef Sponges. I. Reef Habitats." *Marine Ecology Progress Series*. 303. (2005): 133-144. Web. 31 Mar. 2014. <http://people.uncw.edu/pawlikj/2005MEPSEngel1.pdf>.

Gochfeld D.J., Schloder C., Thacker R.W. (2007) Sponge community structure and disease prevalence on coral reefs in Bocas del Toro, Panama. Porıfera Research:

Biodiversity, Innovation and Sustainability, Serie Livros 28. Museu Nacional, Rio de Janeiro: 335–343.

Gonzalez-Riviero, Manuel, Laith Yakob, and Peter J. Mumby. "The role of sponge competition on coral reef alternative steady states." *Ecological Modeling*. 222. (2011): 1847-1853. Print. <http://www.marinespatialecologylab.org/wp-content/uploads/2010/11/Gonzalez-Rivero-et-al-2011-EcoMod1.pdf>.

Jackson, J.B.C, and Leo Buss. "Alleopathy and spatial competition among coral reef invertebrates." *PNAS*. 72.12 (1975): 510-5163. Web. 4 Apr. 2014. <http://www.pnas.org/content/72/12/5160.short>.

Hooper, John.N.A, and Rob.W.M Van Soest. *Systema Porifera. A guide to the classification of sponges*. 1st. New York: Kluwer Academic/Plenum Publishers, 2002. Print.

Kohler, K.E. and S.M. Gill, 2006. Coral Point Count with Excel extensions (CPCe): A Visual Basic program for the determination of coral and substrate coverage using random point count methodology. Computers and Geosciences, Vol. 32, No. 9, pp. 1259-1269, DOI:10.1016/j.cageo.2005.11.009.

Klautau, M.; Valentine, C. (2003). Revision of the genus *Clathrina* (Porifera, Calcarea). *Zool. J. Linn. Soc. 139(1)*: 1-62. Print.

Kobluk, David R, and R.W.M Van Soest. "Cavity-Dwelling Sponges in a Southern Caribbean Coral Reef and Their Paleontological Implications." *Bulletin of Marine Science* 44.3 (1989): 1207-235. Web. 2015. <http://www.ingentaconnect.com/content/umrsmas/bullmar/1989/00000044/00000003/ar t00012>.

Meesters, E., R. Knijn, P. Willemson, R. Pennartz, G. Roebers, and R. W. M Van Soest. "Sub-rubble Communities of Curacao and Bonaire Coral Reefs." *Coral Reefs* (1991): 189-97. Web. 2015. <http://www.researchgate.net/publication/225258801_Sub-

rubble_communities_of_Curaao_and_Bonaire_coral_reefs>.

Morrow C.; Cárdenas P. (2015). Proposal for a revised classification of the Demospongiae (Porifera). *Frontiers in Zoology*. 12:7., *available online at* http://www.frontiersinzoology.com/content/12/1/7

Nunez, Flores M, Quintal JG Rodriguez, and Christina M Diaz. "Sponges (porifera) Distribution along a Depth Gradient in a Coral Reef, Parque Nacional San Esteban, Carabobo, Venezuela." *Revisita De Biologia Tropical* (2010). Web. 2015. <http://www.ncbi.nlm.nih.gov/pubmed/21302530>.

Pawlik J.R., Henkel T.P., McMurray S.E., Lopez-Legentil S.,Loh T.-L., Rohde S. (2008) Patterns of sponge recruitment and growth on a shipwreck corroborate chemical defense resource trade-off. Marine Ecology Progress Series, 368,137–143.

Perkol-Finkel, S., and Y. Benayahu. "Differential recruitment of benthic communities on neighboring artificial and natural reefs." *Journal of Experimental Marine Biology and Ecology* 340 (): 25-39. Print.

Rützler, Klaus 1986. Phylum Porifera (Sponges). In: Sterrer, Wolfgang, *Marine Fauna and Flora of Bermuda: A Systematic Guide to the Identification of Organisms.* New York: John Wiley & Sons, pp.111-127.

Schleier, Ulrike. "Statistical tools for monitoring benthic communities." *Senckenbergiana maritima* (1998): 63-76. Print.

Sutherland, John P, and Ronald H Karlson. "Development and Stability of the Fouling Community at Beaufort, North Carolina." *Ecological Monographs* 47.4 (1977): 425-46. Print.

Van Soest, R.W.M. 1978. Marine sponges from Curaçao and other Caribbean localities. Part I. Uitgaven van de Natuurwetenschappelijke Studiekring voor Suriname en de Nederlandse Antillen. No. 94. Studies on the Fauna of Curaçao and other Caribbean Islands 56 (179): 1–94.

Van Soest, R.W. M. "Marine Sponges from Curaçao and Other Caribbean Localities. Part III. Poecilosclerida." *Studies on the Fauna of Curaçao and Other Caribbean Islands* 66.199 (1984): 1-167. Print.

Van Soest, R.W.M; Boury-Esnault, N.; Hooper, J.N.A.; Rützler, K.; de Voogd, N.J.; Alvarez de Glasby, B.; Hajdu, E.; Pisera, A.B.; Manconi, R.; Schoenberg, C.; Janussen, D.; Tabachnick, K.R., Klautau, M.; Picton, B.; Kelly, M.; Vacelet, J.; Dohrmann, M.; Cristina Díaz, M.; Cárdenas, P. (2014) World Porifera database. Accessed at http://www.marinespecies.org/porifera on 2014-03-31

Villamizar, Estrella, Maria Diaz, Klaus Rutzler, and Renato De Nobraga. "Biodiversity, Ecological Structure, and Change in the Sponge Community of Different Geomorphological Zones of the Barrier Fore Reef at Carrie Bow Cay, Belize." *Marine Ecology* (2013): 1-10. Web. 2015.
<file:///C:/Users/C/Downloads/Villamizar_et_al_2013
Belize Barrier reef (3).pdf>.

Wulff, JanieL. "Ecological interactions of marine sponges." *Canadian Journal of Zoology*. 84.2 (2006): 146-166. Web. 4 Apr. 2014. <http://www.nrcresearchpress.com/doi/abs/10.1139/z06-019

Zea, Sven. 1992. Estimation of desmosponge (Porifera, Demospongiae) larval settlement rates from short-term recruitment rates: Preliminary experiments. Helgoländer Meeresuntersuchungen. Volume 46, Issue 3, pp 293-300

Zea, Sven. "Recruitment of Demosponges (Porifera, Demospongiae) in Rocky and Coral Reef Habitats of Santa Marta, Columbia Caribbean." *Marine Ecology* (1993): 1-21. Print.

Zea Sven. (2001) Patterns of sponge (Demospongiae) distribution in remote oceanic reef complexes of the Southwestern Caribbean. Revista de la Academia Colombiana de Ciencias, 25, 579–592.

Zurr, A.F., Ieno, E.N. & Smith, G.M. 2007. Analyzing Ecological Data. New York, New York: Springer Science.