Miami-Dade County Artificial Reef Program
Re-Evaluation of Module and Boulder Reefs —2019 (FWC Grant 18107)

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PROJECT BACKGROUND

Numerous pre-fabricated concrete modules and boulders have been deployed offshore of Miami-Dade County for a variety of purposes including mitigation, fisheries enhancement, and recreational diving. Through previous Florida Fish and Wildlife Conservation Commission (FWC) grants, several Miami-Dade County module and boulder reefs were evaluated from 2006 to 2009. This project surveyed benthic and fish assemblages on five boulder reefs and two module reefs to document any changes in community structure over the last decade and evaluate the success of these artificial reefs.

Site Description

The seven monitored reefs with varying characteristics are located within five permitted artificial reef sites throughout Miami-Dade County (Figure 1).

Site Abbr.	ANCB	GDBB	PMBR & PMBP	SIMM & SIMB	PMAM
Tons of Limerock Boulders	1,050	850	120,000	1,500	---
Description	Multi-layered row	3 multi-layered piles	Multi-layered row and piles	Scattered single layer along with 50 modules	495 modules ~25' apart
Reef Goal	Enhance fishing opportunities	Enhance diving and fishing opportunities	Mitigation for dredging impacts	Mitigation for dredging impacts	Mitigation for dredging impacts
Approx. Footprint (m²)	869	520	59,950	18,581	32,516
Depth (ft)	56	43	45	68	25
Max Relief (ft)	10	13	10	5	5
Year Deployed (Age at Survey)	1995 (25)	2005 (14)	1996 (23)	1993 (26)	1996 (23)
Previous Grant Monitoring					
FWC Grant #	6121	6121	6121	7015	8253
Year	2006-2007	2006-2007	2006-2007	2007-2008	2009
Age Then	11.5	2	10.5	15	13

Figure 1. Location and details of artificial reefs.

METHODOLOGY

Both the previous and current grant surveys utilized the same methodology. Current grant surveys were conducted January 2019 - March 2019.

Benthic Assessment—Quadrat Photo Method:

- 200 non-overlapping quadrats (40 cm x 50 cm) at a fixed distance, per site (= 40 m² per site).
- Digital photographs analyzed through Coral Point Count Software Program (Kohler and Gill, 2006).
- 20 random points overlaid on each digital photograph. Substrate/organism beneath each point identified to lowest possible taxonomic level to provide relative % cover of each benthic taxa or substrate.

Figure 2. Quadrat photographing.

Fish Assessment—Modified Bohnsack and Bannerot (1986) Method:

- Fish within a 15m-diameter cylinder of water at each sample location were assessed.
- Surveying diver swam in a circular pattern throughout the cylinder (opposed to remaining stationary) recording the species observed in the first five minutes.
- Surveying diver continued swimming in the circle pattern until the species present in the first five minutes were enumerated and the sizes estimated.
- 'Visiting' and/or 'transient' species observed after five minutes were also recorded.
- Only 'resident' species (Bohnsack et al. 1994) observed within the first five minutes were used in statistical analysis. However, all gamefish species were reported.
- Number of surveys was tailored to the specific reef site based on size, to allow for independent, non-overlapping surveys and varied due to the number of rounds able to be completed with the different levels of grant funding. Each survey area was approximately 176m².
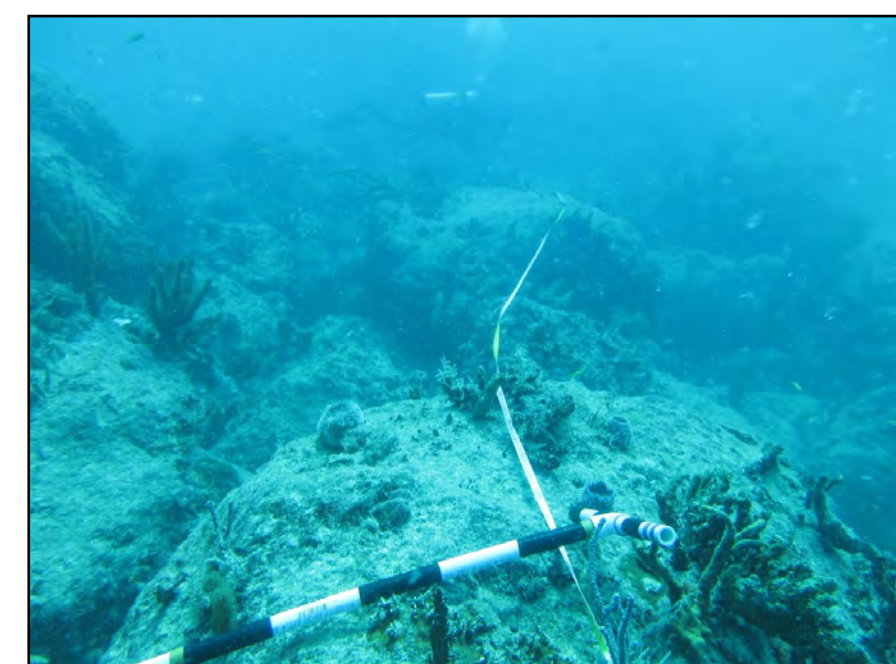

Figure 3. Fish survey within 15m-diameter cylinder.

RESULTS-BENTHIC ASSESSMENTS

Diversity

Shannon Diversity Index (H') and Pielou's Evenness measure (J') were calculated based on the percent cover of benthic assemblages at each reef. Module site SIMM maintained the highest diversity in both sampling periods. Conversely, the lowest diversity of all sites in both sampling periods was observed at ANCB. All sites showed low taxonomic evenness as benthic cover was dominated by overwhelming coverage of turf algae.
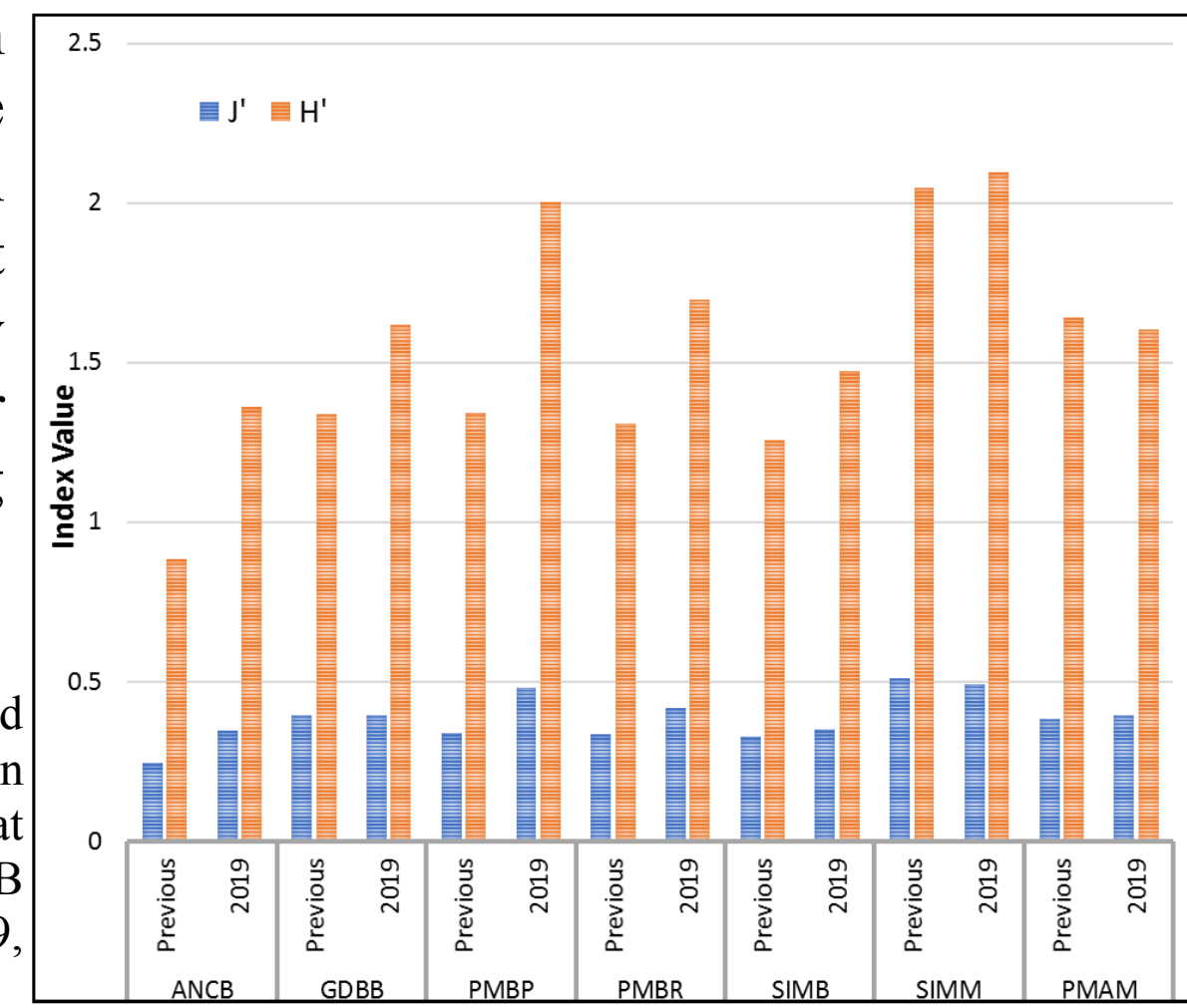

Figure 4. Shannon Diversity Index (H') and Pielou's Evenness (J') measure for each reef. In previous grant monitoring, 28.8m² was surveyed at ANCB, GDBB, PMBP, and PMBR, 40m² at SIMB and SIMM, and 102.2m² at PMAM. In the 2019, 40m² was surveyed at each site.

Relative Percent Cover—Major Categories

Boulder Reefs

All five boulder reefs were dominated by algae cover in both sampling periods. Porifera (sponges) were the second highest percent cover on all boulder sites except PMBP in the previous sampling and all sites except PMBP and PMBR in 2019. All boulder sites showed an increase in porifera percent cover in 2019 except the low relief site SIMB. Octocoral (soft coral) cover was higher in 2019 on all boulder sites except PMBR. Scleractinian (hard coral) and Milleporidae (fire coral) cover was also higher in 2019 at all five boulders sites. The youngest site, GDBB, had a drop in Ascidian (tunicate) coverage showing a shift in the colonization of the boulders.

Category	ANCB Prev.	ANCB 2019	GDBB Prev.	GDBB 2019	PMBP Prev.	PMBP 2019	PMBR Prev.	PMBR 2019	SIMB Prev.	SIMB 2019
Algae	84.67	76.39	84.14	71.41	79.90	63.91	76.54	74.70	79.86	60.00
Porifera	12.43	15.72	10.68	16.80	10.49	11.81	5.14	8.65	12.67	9.92
Octocorallia	0.00	1.19	0.00	2.84	4.33	14.63	11.73	9.84	1.12	2.56
Scleractinia	1.14	2.74	0.04	2.26	3.57	5.14	4.04	4.27	1.69	2.98
Milleporidae	0.15	0.54	0.24	1.42	0.42	0.92	0.38	0.76	0.32	0.68
Zoanthidae	0.00	0.05	0.00	0.06	0.04	0.03	0.04	0.00	0.00	0.00
Ascidaria	0.00	0.00	3.38	0.06	0.00	0.03	0.11	0.03	1.34	0.18
Other live	0.63	0.30	0.08	0.00	0.49	0.24	0.23	0.03	2.20	0.29
Dead Organisms	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Substrate	0.99	3.04	1.45	5.15	0.27	3.24	1.79	1.73	0.80	23.34

Table 1. Relative percent (%) cover of major benthic categories at the five boulder sites. In previous grant monitoring, 28.8m² was surveyed at ANCB, GDBB, PMBP, and PMBR while 40m² was surveyed at SIMB. In the 2019, 40m² was surveyed at each site.

Module Reefs

SIMM and PMAM module sites were dominated by algae cover in both sampling periods. Porifera were second highest in percent cover on the module sites during both sampling periods with considerably higher cover than boulders sites. Octocoral cover remains low on both module sites but cover was greater at both sites in 2019 than previous sampling. Scleractinian cover on both module sites was higher than octocoral cover in both sampling periods. SIMM showed a higher scleractinian cover in 2019, while PMAM showed a lower percent cover than in previous monitoring periods.

Category	SIMM Prev.	SIMM 2019	PMAM Prev.	PMAM 2019
Algae	64.74	59.89	74.75	71.88
Porifera	24.68	20.07	18.01	19.52
Octocorallia	0.40	2.97	0.04	0.62
Scleractinia	2.99	6.35	4.57	2.02
Milleporidae	5.28	4.66	0.80	0.49
Zoanthidae	0.08	0.39	0.09	0.24
Ascidaria	0.99	0.11	0.37	0.46
Other live	0.76	0.80	0.45	1.40
Dead organisms	0.00	0.11	0.64	0.00
Substrate	0.08	4.66	0.28	3.37

Table 2. Relative percent cover of major benthic categories at the module sites. In previous grant monitoring, 102.2m² was surveyed at PMAM and 40m² at SIMM. In the 2019, 40m² was surveyed at each site.

Similarity

The module site PMAM showed the greatest similarity between sampling periods at 38.2%. Differing percent cover of a variety of algae (Blue-green, Coralline, unidentified macro, and *Wrangelia argus*) contributed to the dissimilarity between sampling periods at all five boulders sites. A higher abundance of the sponge, *Diplastrella* species, on ANCB, PMBP, PMBR, and SIMB in the previous sampling than the 2019 sampling also contributed to the difference.
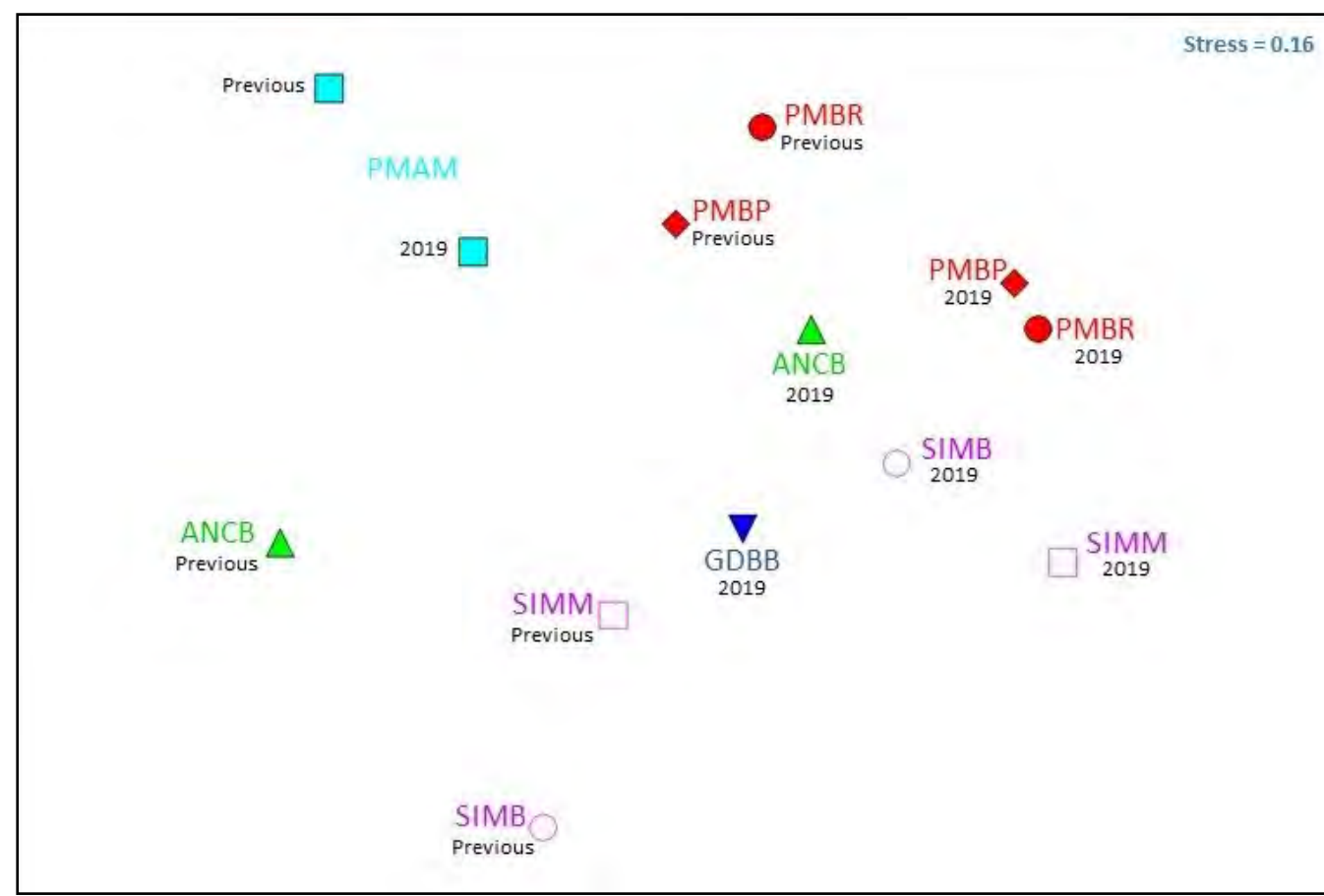

Figure 5. Multi-dimensional scaling (MDS) plot depicting Bray-Curtis similarity values between sites and sampling periods for the relative percent composition of benthic species, substrate, and sand. Previous sampling of GDBB not shown as reef was only 2-years old and substantially different from the older reefs.

RESULTS-FISH ASSESSMENTS

Species Richness

The highest total number of fish species observed during the previous grant monitoring occurred at PMBP and PMBR with 67 and 66 species respectively. However, during the current monitoring, SIMM and GDBB had the highest total species richness with 64 and 60, respectively. The single layer boulders SIMB had the fewest species in both previous and current monitoring with 41 and 45 species respectively.
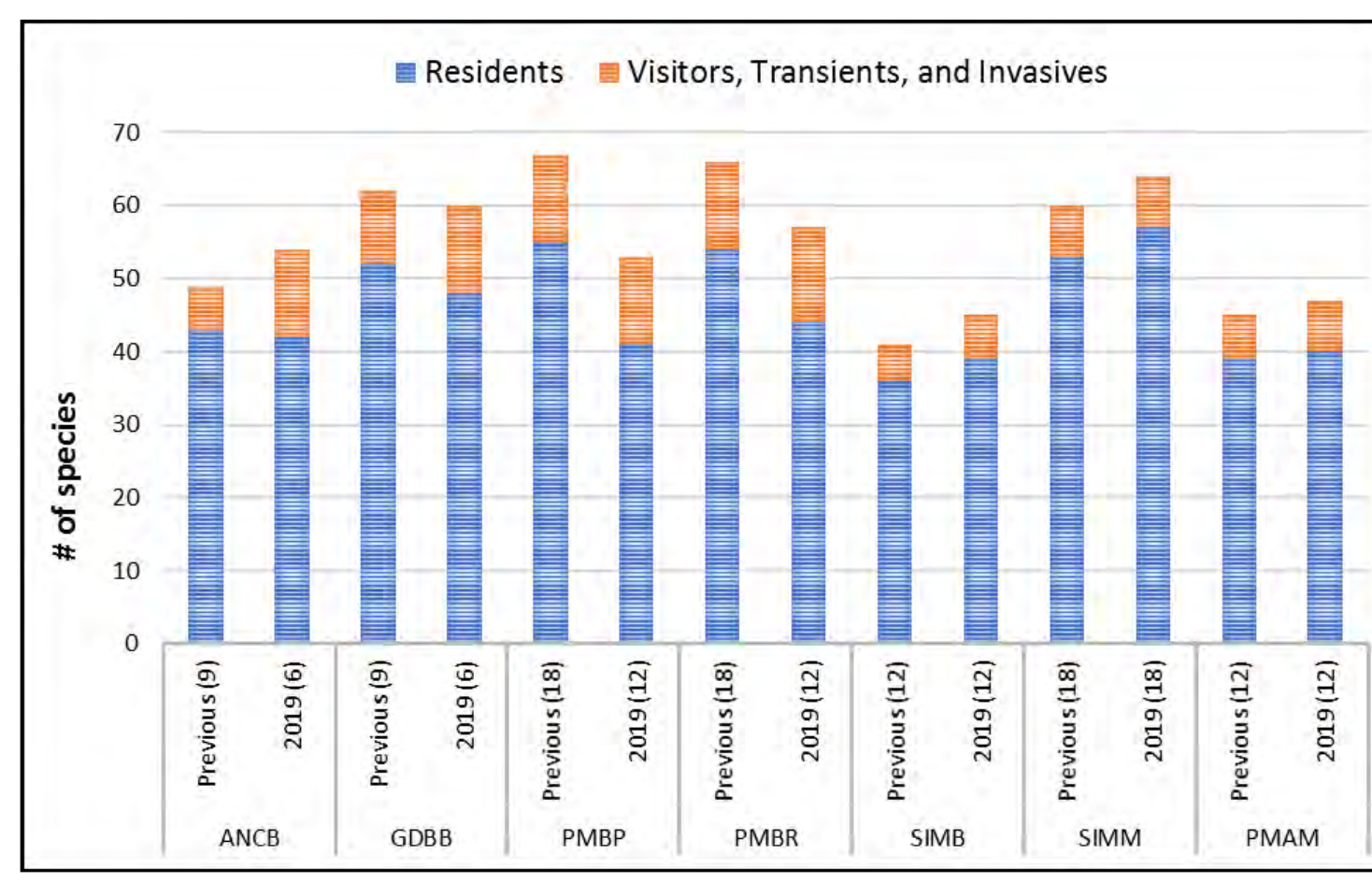

Figure 6. Total number of fish species observed across all surveys at five boulder and two module reefs. Number of surveys varies and is listed in parenthesis.

Diversity

PMBP and PMBR had the highest Shannon Diversity Index (H') values as well as the highest Pielou's Evenness measure (J') values of all reefs during both grant periods. The lowest diversity and evenness measure were observed at ANCB and GDBB during both grant periods. These two sites had large numbers of a single species, *Haemulon aurolineatum* (Tomtates) which decreased the diversity and evenness measures.
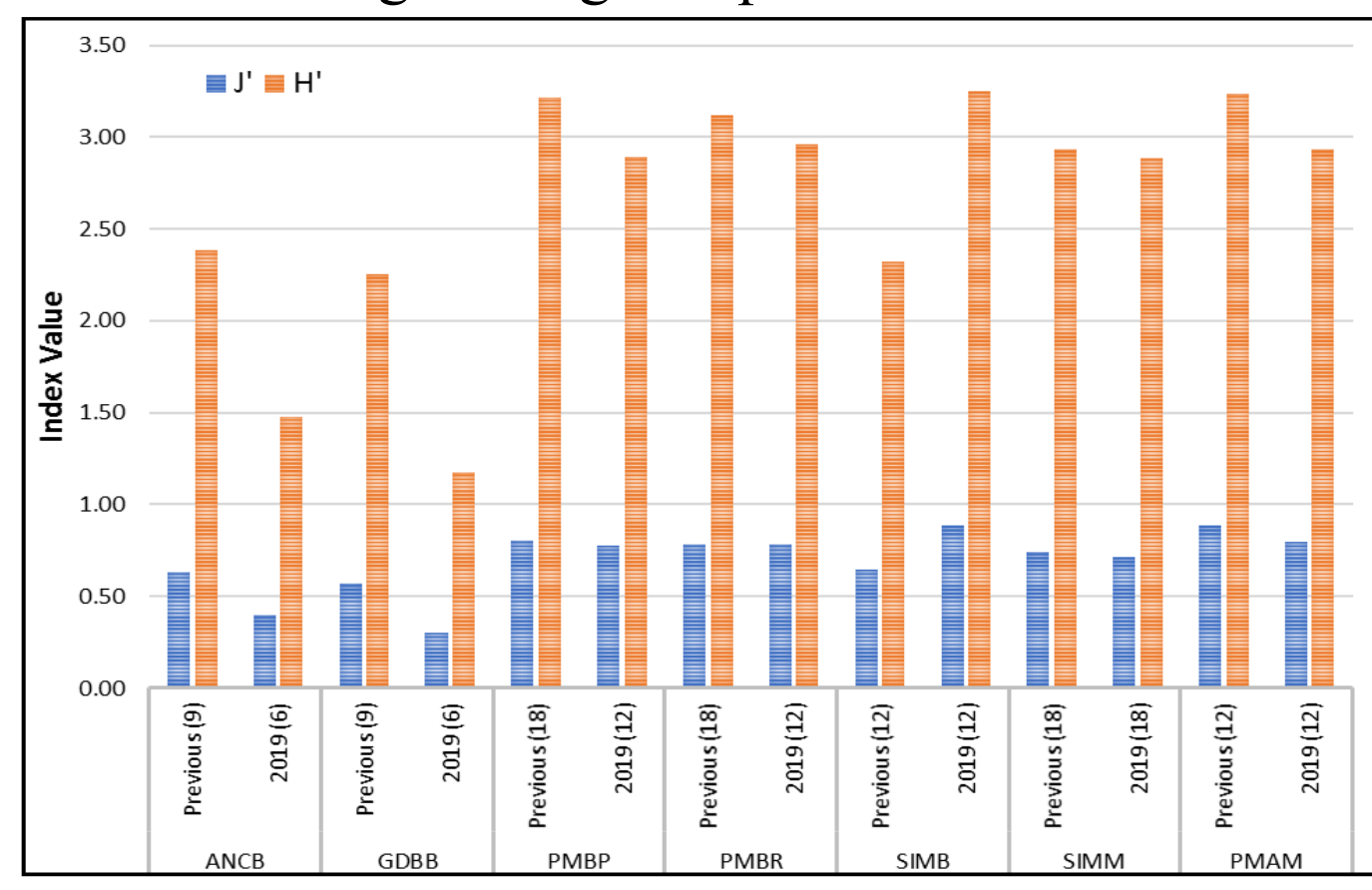

Figure 7. Average Shannon Diversity Index (H') and Pielou's Evenness measure (J') for the resident fish assemblages on each reef. Number of surveys varies and is listed in parenthesis.

Density

As with diversity and evenness values, schools of *H. aurolineatum* (Tomtates) played a large role in resident fish density especially at ANCB and GDBB where resident fish density was the highest with 8.91 individuals/m² across all surveys at ANCB and 14.87 individuals/m² at GDBB in 2019. At the other sites the abundance of *H. aurolineatum* was lower and the observed density of all resident fish was <2 individuals/m² in both monitoring periods. SIMM density was lower in 2019 as result of fewer *Coryphopterus personatus* (Masked goby).
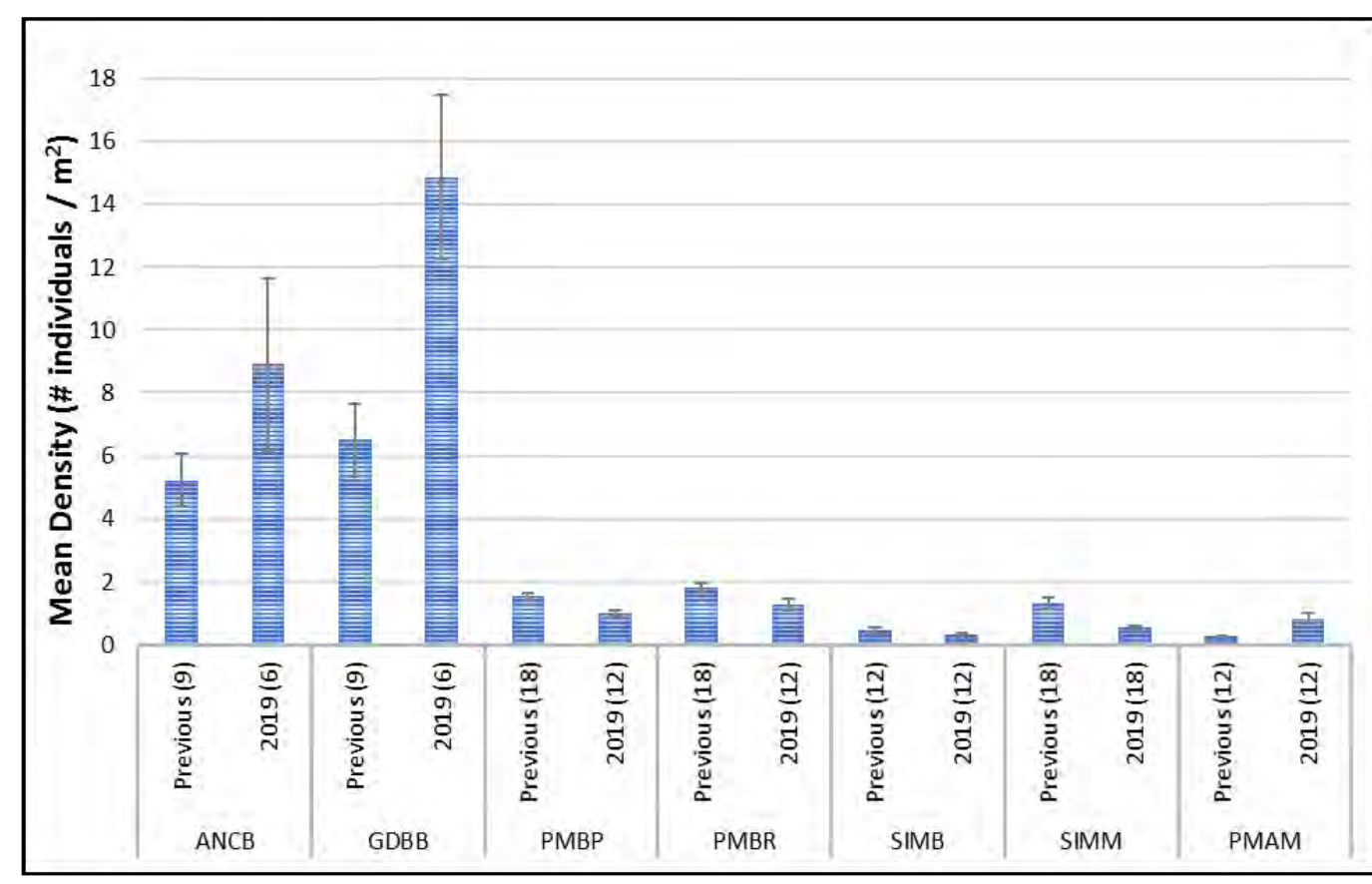

Figure 8. Average resident fish density (individuals/m²) for each grant period at the five boulder and two module reefs. Standard deviation bars plotted. Number of surveys varies and is listed in parenthesis.

Family Composition

On ANCB and GDBB in both the sampling periods, a large percentage of the resident fish belonged to the Haemulidae (grunts) family. Haemulidae was nearly absent on the low relief SIMB boulders, however this site was dominated by Labridae (wrasses) in both grant periods. Labridae were also common at the other six monitored sites. Pomacentridae, Gobiidae, Scaridae, and Tetraodontidae were also relatively abundant at all the sites, but at the ANCB and GDBB sites the percent composition was skewed by the large number of Haemulidae individuals.
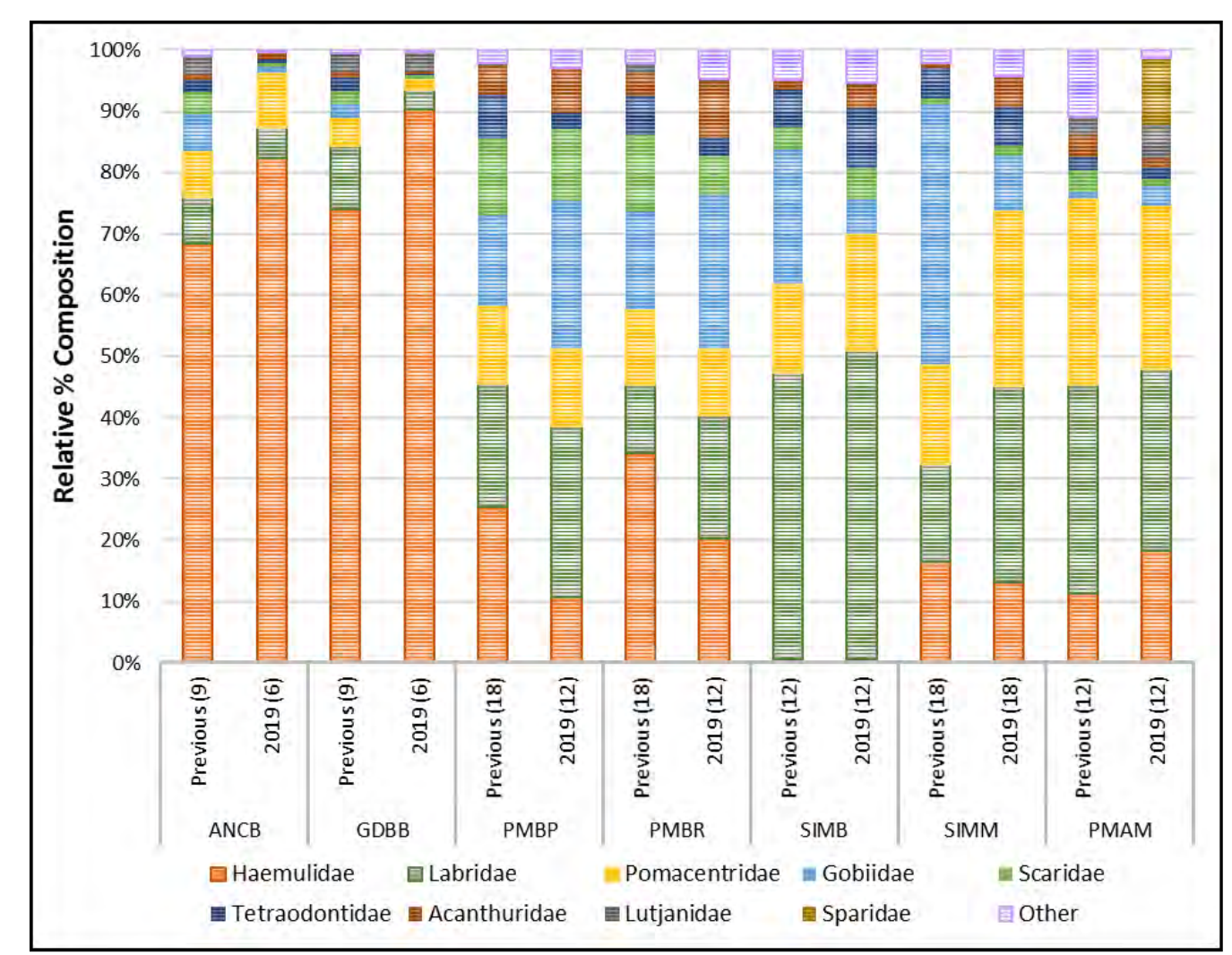

Figure 9. Relative percent composition (%) of resident individuals by major family constituents across all survey at each site for each grant period. Number of surveys varies and is listed in parenthesis.

SPORTFISH & INVASIVE SPECIES

Sport and regulated fish species including jacks, groupers, snappers, and hogfish were observed on the boulder and module reefs in the previous grant periods and in 2019. In the previous grant periods, a total of 24 different sport or regulated fish species were observed while in 2019 only 18 were observed. Although the majority of observed sport and regulated fish species were smaller than current FWC harvesting regulations, individuals of seven regulated species were ≥ harvesting slot size ranges (Table 3). The invasive Lionfish (*Pterois volitans*) was not observed during the previous grant monitoring but at least one individual was observed at all sites in 2019.

Species	Total	# Individuals Harvestable Size	Minimum Legal Size cm/in	Reef Site
Caranx crysos (Blue runner jack)	1	---	bag limit	PMAM
Lutjanus analis (Mutton snapper)	20	1	45.7 / 18	PMBP
Lutjanus apodus (Schoolmaster snapper)	12	4	25.4 / 10	PMBP
Lutjanus synagris (Lane snapper)	451	2	20.3 / 8	GDBB PMBP
Ocyurus chrysurus (Yellowtail snapper)	131	5	30.5 / 12	PMBR PMBP SIMM
Ginglymostoma cirratum (Nurse shark)	3	1	137 / 54	PMBP
Cephalopholis cruentata (Graysby grouper)	43	---	bag limit	All
Epinephelus guttatus (Red hind grouper)	1	---	bag limit	ANCB
Mycteroperca bonaci (Black grouper)	4	2	61.0 / 24	GDBB ANCB
Sphyraena barracuda (Great Barracuda)	4	2	38.1-91.4 15-36	ANCB

Table 3. FWC regulated fish species observed during the 2019 grant monitoring with at least one individual above regulation size or present with bag limit.

CONCLUSION & MANAGEMENT RECOMMENDATIONS

This study demonstrated that all seven reefs provide habitat that has supported abundant and diverse benthic and fish assemblages. Based on the broad project objectives, each of the artificial reefs succeeded at meeting the goals for which they were constructed. The following management recommendations are offered as general guidelines for future artificial reef development within Miami-Dade County:

- Define measures for determining success of mitigation artificial reefs with comparisons to the representative habitats.
- Construct boulder reefs with high relief (>8ft) and small footprint to maximize fish density.
- Construct boulder reefs with high relief (>8ft) and larger footprints to minimize dominance of large schools of grunts and maximize fish diversity, evenness measures, and more even family composition.
- Construct high relief (>8ft) to maximize the presence of gamefish species.
- Construct low relief reefs to better mimic natural/hardbottom habitat without a goal of fishery enhancement.
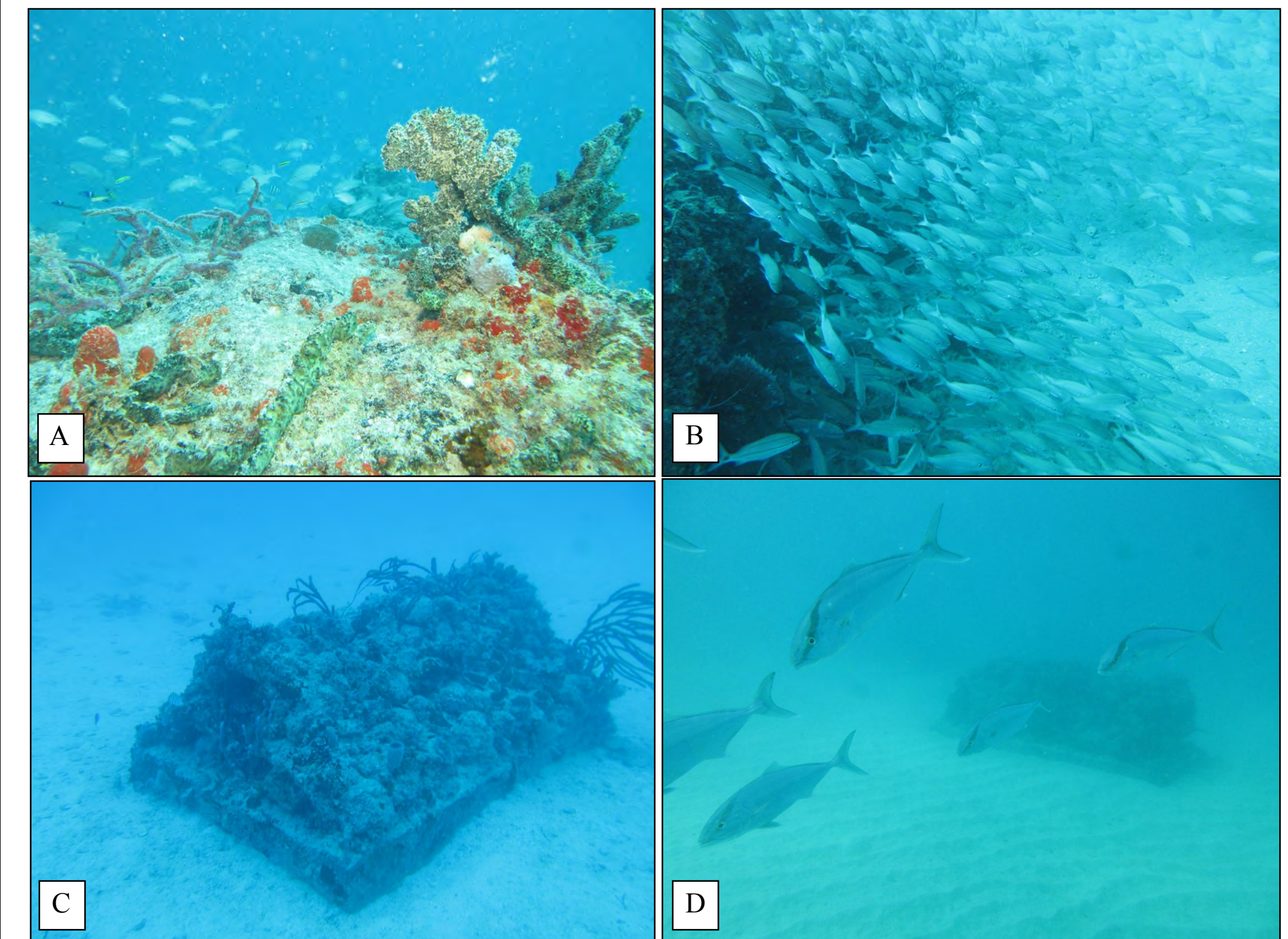

Figure 10. A) Porifera abundance at ANCB (February 2019); B) *Haemulon aurolineatum* (Tomtates) at GDBB (January 2019); C) Module at SIMM (March 2019); D) *Seriola dumerili* (Greater amberjack) under legal harvesting size at PMAM (January 2019).

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For more information on Miami-Dade County's Artificial Reef Program:
http://www.miamidade.gov/environment/reefs-artificial.asp

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