Sarasota Bay Artificial Reef
Final Monitoring Report

FWC Agreement No. 14022

Prepared for:
Florida Fish and Wildlife Conservation Commission

Prepared by:
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Project No. 63121563
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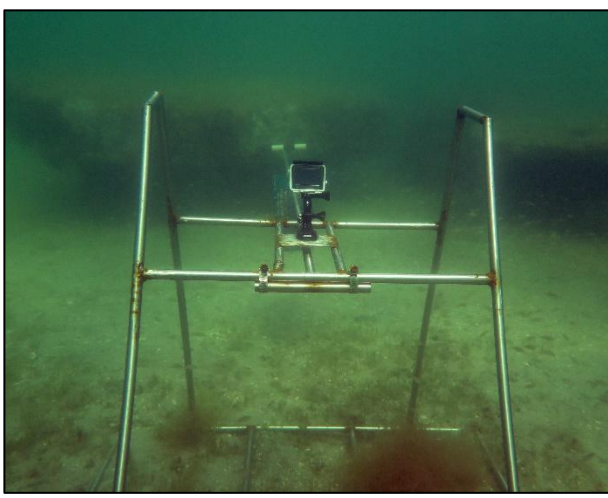


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1.0 Project Background

Sarasota Bay is a 50-mile-long coastal lagoon on the southwest coast of Florida, consisting of one large bay segment (Big Sarasota Bay) and several smaller embayments (Palma Sola Bay, Roberts Bay, Little Sarasota Bay, and Blackburn Bay). Big Sarasota Bay has three passes (Big Sarasota Pass, New Pass, and Longboat Pass). Numerous small tidal creeks enter the Bay along the eastern shoreline, ranging in size from the largest (Phillippi Creek: drainage area of 36,417 acres) to the smallest (Palma Sola Creek: drainage area of 900 acres). The watershed is highly developed and consists of agricultural, residential, commercial, and light industrial land uses. Circulation is primarily driven by tidal exchange with the Gulf of Mexico. Big Sarasota Bay circulation is forced by the tides at Anna Maria Sound, Longboat Pass, New Pass, and Big Pass. Big Sarasota Bay has three tidal tributaries influencing its water quality: Bowlees Creek to the North, Whitaker Bayou to the east and Hudson Bayou to the south.

Big Sarasota Bay, where the artificial reefs monitored in this study are located, is a fairly open embayment, with abundant shallow seagrass meadows fringing the bay's perimeter, and unvegetated sediments, consisting of shell, sand and mud, in the deeper portions. Average depth is 1.8 meters (6 ft), while the deepest parts are 3.7-4.6 m (12-15 ft) deep. Although seawalls are common along the shorelines, they are not as extensive as they are in the smaller bays to the south. The Intracoastal Waterway transects the Big Sarasota Bay, but mostly follows a natural deep water north-south route with limited dredging in the open waters. Very sparse (~ perhaps less than several acres) scattered low relief hardbottom can be found along the SE shoreline from the Van Wezel Performing Arts Hall to Whitaker Gateway Park, but no formal survey of this resource has ever been done. Oyster beds dominate the shallow environments along the eastern shore, predominantly within the mid-bay sections. Many of these oyster bars are co-mingled with shallow seagrasses. Sarasota County estimated seven and a half acres of oysters in Sarasota Bay (Meaux, 2016). SWFWMD reported ~ 24 acres of oysters in Sarasota Bay. Differences in reported acreage between the two studies were due to differences in mapping efforts and target areas (Radabaugh et al., 2019). SWFWMD (2019) reported roughly 3,500 acres of seagrass in lower Sarasota Bay (the region covered in this report). In an earlier study, Culter and Leverone (1993) calculated the aerial coverage of different bottom habitats in lower Sarasota Bay that encompassed the area containing the three artificial reefs in this study. Even though the data are almost 30 years old, this study offers the best understanding of the relative distribution of various habitats within the study area. This section of the bay totaled 9,100 acres of bay bottom. Seagrass meadows contributed 950 acres (10%), disturbed bay bottom comprised 410 acres (5%) and natural bay bottom - sand, shell and mud mixtures - equaled 7,750 acres (85%) of the total. Culter and Leverone (1993) did not include oysters or artificial reefs in their assessment. Oyster and seagrass habitats are within several miles of Hart's and Walker's Reefs; seagrass meadows are within several hundred meters of Sportfish Angler's Club Reef to the west.

Water quality in Big Sarasota Bay has been routinely monitored since 1997 through the Sarasota County Water Quality Monitoring Program (see the Sarasota Bay Water Atlas for data analysis, bay conditions and water quality trends). This program, which uses a stratified random design, conducts monthly sampling for a suite of physical and chemical water quality parameters. Several of these parameters - chlorophyll a, TSS, CDOM and secchi depth - relate to water clarity, which is critically important to the quality of underwater fish censuses used in determining fish assemblages associated with the artificial reefs in the bay. Other sporadic water quality studies have taken place during this time as well, particularly those conducted by Mote Marine Laboratory. These studies served specific purposes and were somewhat constrained by time and location. None of these unique studies comes close to addressing the overall water quality conditions within the bay to the degree that the County's routine program does. Project-specific secchi depth readings were taken during the winter and spring of 2019-2020 from a dock at Marina Jack in downtown Sarasota. These frequent readings were used to decide if conditions (*i.e*., water clarity) were sufficient to conduct reef sampling. These data, and a summary of bay water clarity conditions, are addressed in 2.3.1: Water Clarity section of this report.

Several fisheries monitoring programs and individual studies have been conducted through the years in Sarasota Bay. These include a number of research and monitoring studies by Mote Marine Laboratory (MML), Sarasota County and the Florida Fish and Wildlife Commission (FWC). The Fisheries Independent Monitoring Program (FIM) conducted by the Florida Fish and Wildlife Research Institute (FWRI), was initiated in Sarasota Bay in 2009, and, again, is the most complete and comprehensive fisheries program describing fish composition in the area, and is the most relevant program in which to compare fish utilization of the Bay's artificial reefs with surrounding resident fish communities. (Annual reports are available on the Sarasota Bay website (https://sarasotabay.org/). Two studies (Serviss and Sauers 2003; MML, 2008) investigated fish assemblages on Sarasota Bay artificial reefs. The MML study monitored two reefs in lower Tampa Bay and three reefs in Sarasota Bay. The Sarasota Bay reefs were located in Manatee County waters just two nautical miles north of the reefs surveyed in the current project. Serviss and Sauers, however, surveyed Hart's and Walker's Reefs as well as an additional reef in Sarasota Bay. Finally, Flaherty-Walia et al. (2019) compared fish assemblages among natural hardbottom, artificial reefs and bridge pilings in lower Tampa Bay. Findings from these studies and the present one will be addressed in the Discussion section of this report.

Sarasota County has had an ongoing inshore and offshore artificial reef program since the 1980's. This program is designed to offer boaters, anglers and divers recreational opportunities and to create juvenile fish habitat in an effort to enhance local fisheries. The reefs surveyed in this project - Hart's Family Reef (HFR), Sportfish Angler's Club Reef (SACR), and Walker's Reef (WR) (Figure 1) have a maximum depth of 3.7 m (12 ft) with an overall relief of 1 m (3 ft). These three reefs have had 23 separate deployments consisting of a variety of materials. Early deployments consisted of "materials of opportunity". Since then, approximately 1,353 modules have been deployed. In 2013, state and federal permits were renewed, and these three reef areas subsequently had a series of deployments of the traditional dome-shaped modules as well as newly designed artificial reef modules. The deployments consisted of the following module types: deep cover, layer cake, cube tier, table top, and bay ball modules (Figure 2). Tables 1-3 provide the deployment details for each reef area, including the deployment dates, materials, and number of modules. The earlier deployments (1987-1993) at Hart's Family Reef also included over 2,000 cubic yards of concrete block material.

Table 1. Hart's Family Reef deployment summary of artificial reef materials (FWC, 2020a).

Reef Area	Deploy ID	Deploy Date	Deployment Name	Material Description	# of Modules
Hart's Family Reef	ST0018	06/25/1987	Hart Family Reef (#2) (Bay)	Blocks - cinder blocks	-
	ST0027	05/12/1989	Hart Family Reef (#2) (Bay)	Blocks - 820 cy concrete block	-
	ST0032	03/07/1991	Hart Family Reef (#2) (Bay)	Blocks - 440 cy concrete block	-
	ST0041	02/27/1992	Hart Family Reef (#2) (Bay)	Blocks - 750 cy concrete block	-
	ST0043	04/08/1993	Hart Family Reef (#2) (Bay)	Blocks - broken concrete block reef	-
	ST0070	09/24/1997	Hart Family Reef #2 (Bay)	Reef Ball Bay (75) - 50 others in 9/96	75
	ST0172	06/20/2013	H-1	Reef Ball - small reefballs of various types (deep cover, cube tier)	14
	ST0181	08/11/2015	Girl Scout Site	Reef Ball Mini	6
				Hart's Family Reef Total	95

Table 2. Sportfish Angler's Club Reef deployment summary of artificial reef materials (FWC, 2020a).

Reef Area	Deploy ID	Deploy Date	Deployment Name	Material Description	# of Modules
Sportfish Angler's Club Reef	ST0075	06/25/1998	Sportfish Anglers Reef (Bay)	Reef Ball Bay	150
	ST0171	06/18/2013	Sportifish: A-1	Reef Ball - small reefballs of various types (deep cover)	11
				Sportfish Angler's Club Reef Total	161

Table 3. Walker's Reef deployment summary of artificial reef materials (FWC, 2020a).

Reef Area	Deploy ID	Deploy Date	Deployment Name	Material Description	# of Modules
Walker's Reef	ST0083	10/10/1999	Walker Reef (Bay)	Reef Ball Bay - 20 slabs with 7 bay balls in each slab	140
	ST0082	10/10/1999	Walker Reef (Bay)	Reef Ball Bay - 5 modules with 7 bay balls imbedded with tire chips	35
	ST0081	10/10/1999	Walker Reef (Bay)	Reef Ball Bay - 5 modules with 7 bay balls imbedded with tire chips	35
	ST0080	10/10/1999	Walker Reef (Bay)	Reef Ball Bay - 5 modules with 7 bay balls imbedded with tire chips	35
	ST0079	10/10/1999	Walker Reef (Bay)	Reef Ball Bay - 5 modules with 7 bay balls imbedded with tire chips	35
	ST0085	02/01/2000	Walker Reef (Bay)	Reef Ball Bay - 24 modules; 12 bay and 12 pallet balls	12
	ST0090	06/19/2001	Walker Reef-Center Site (Bay)	Reef Ball Bay	230
	ST0089	06/19/2001	Walker Reef-4H Site (Bay)	Reef Ball Bay	52
	ST0091	07/03/2001	Walker Reef -Nep Site (Bay)	Reef Ball Bay	154
	ST0094	08/13/2002	Walker Reef (Bay)	Reef Ball Bay - 25 lo-pro and 10 oyster balls	300
	ST0170	06/18/2013	Module #1	Reef Ball - small reefballs of various types (deep cover, table top, layer cake)	60
	ST0195	11/19/2018	Younkmon Reef	Bay Balls - 5 bay, 1 pallet	5
	ST0196	12/10/2018	Eternal Reef #6	Bay Balls - 4 bay, 1 pallet	4
				Walker's Reef Total	1097
				All Reef Areas Total	1353

The focus of this study was to map the three artificial reef areas (Hart's Family Reef, Sportfish Angler's Club Reef, and Walker's Reef) using side scan sonar imagery to determine the extent of the artificial reef materials and to aid in selecting the reef fish survey sites and to investigate the fish utilization of the artificial reef modules within these areas using visual fish census techniques. We particularly focused on surveying deep cover reef modules, which were designed with smaller spaces under the ledge to provide sheltered habitat for juveniles of desirable fish species such as gag grouper (*Mycteroperca microlepis*). It was intended that the deep cover design would provide sufficient space for gag grouper (and other shelter loving species) to hide from predators and other disturbances without being startled (as might be the case in structures that are more exposed to the surroundings). This study aimed to determine if these deep cover modules as well as other reef modules are being utilized by gag grouper and other commercially valuable species. Utilization of the reef modules would suggest that the habitat created by the artificial reefs is serving as a refuge for juveniles and likely provides fisheries enhancement.

Sarasota has a vibrant and active recreational boating community, as evidenced by the many boat dealerships, marinas, boat clubs and boat ramps throughout the County. Of the many activities local boaters enjoy, fishing and SCUBA diving at the County's artificial reefs are popular. The county prepares (and periodically updates) an artificial reef brochure describing the name, location, materials and other vital information for each reef. These brochures are widely distributed, and can be found at county offices, tackle and bait shops marinas, as well as online. These brochures provide valuable information to the boating public; however, surveys to assess boaters visiting these reefs, particularly the dozen or so bay and estuarine reefs, have not been conducted. These reefs certainly provide an option for certain sectors of the boating community who may have smaller vessels more suitable to bay conditions or limited time in which to travel to offshore reefs. In any case, a future survey of the number of artificial reef visits would be valuable in providing this information.

Figure 1. Project location.

2.0 Methodology

2.1 Side Scan Sonar Mapping

Side scan sonar mapping activities were conducted by Hyatt Survey Services, Inc. on December 13-15, 2016 and included mapping of the seafloor and artificial reef materials present within the three (3) artificial reef permit areas: Hart's Family Reef, Sportfish Angler's Club Reef, and Walker's Reef to assist in determining survey sites. A side scan sonar system was mounted on a vessel following a predetermined pattern to ensure maximum coverage of permitted area and the artificial reef modules located therein. Data were collected with an Edgetech 6205 combined bathymetry and side scan sonar.

A geo-referenced image mosaic dataset was generated from the side scan sonar imagery acquired during the sampling events that depicts the seafloor and artificial reef materials at each reef area. This dataset met the required 0.267 sq miles (94.68%) of imagery coverage for the three reef areas with an image resolution of at least 1 m (3.28 ft). All side scan sonar data and deliverables were submitted to and approved by SBEP and Florida Fish and Wildlife Commission (FWC) in February 2017. Hyatt's Surveyor's Report detailing the methods and findings is provided as Appendix A. To further understand the side scan results as they pertain to the artificial reef materials, ArcGIS was used to delineate the deployed materials, as interpreted from the side scan sonar data, in order to compare them to the coordinates listed in Tables 1-3.

2.2 Site Selection

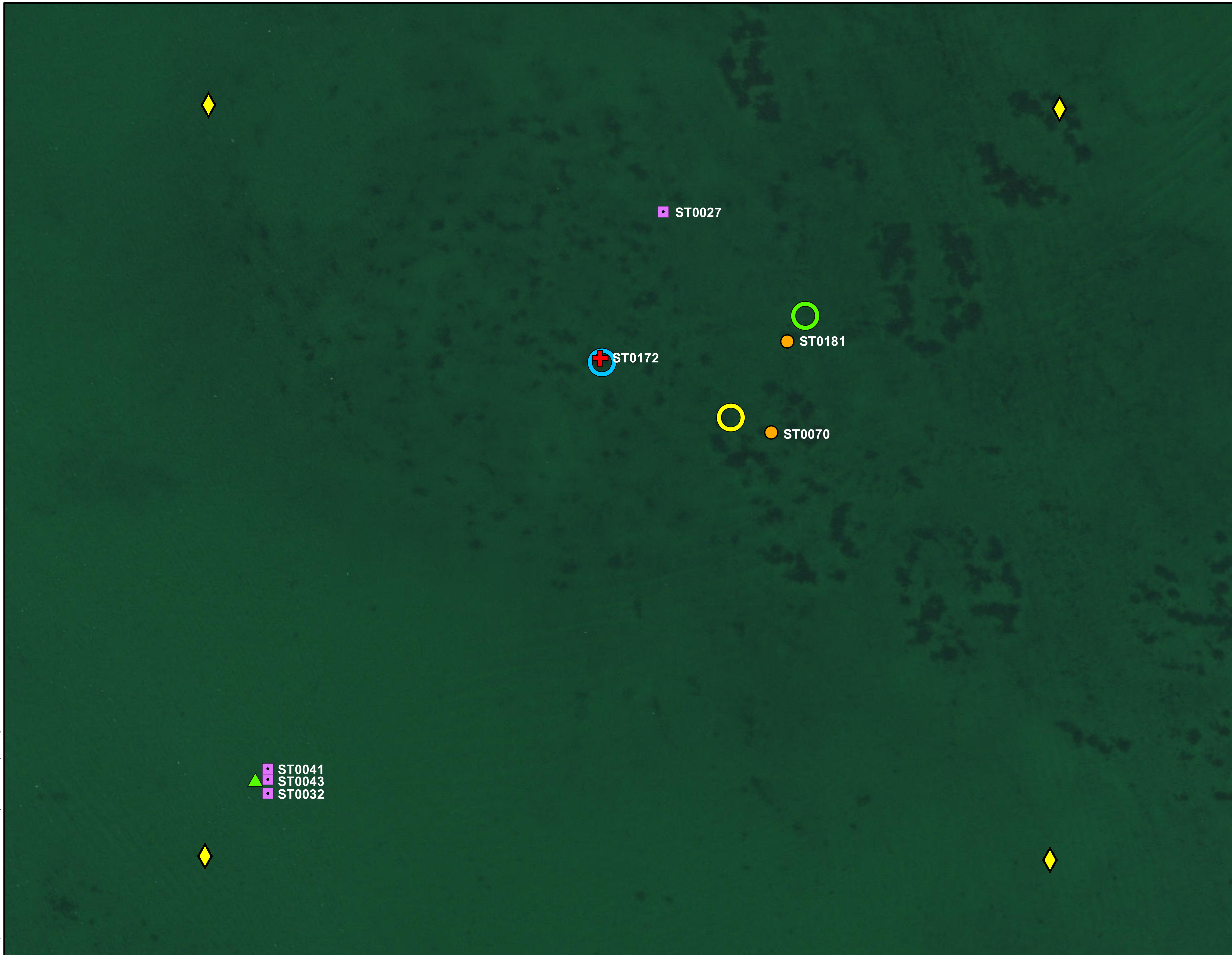
Sites for the reef fish surveys were selected by comparing the side scan sonar data collected by Hyatt and the reef module coordinates provided by SBEP and FWC. Preliminary sites were chosen based on their proximity to the targeted artificial reef modules (deep cover modules) and their location to other deployed modules close in proximity to the deep cover modules. The proposed sites were submitted to SBEP and FWC for review and based on their input the final reef fish survey locations were selected. Three (3) sites were selected in each of the three (3) permit areas (Hart's Family Reef, Walker's Reef, and Sportfish Angler's Club Reef) for a total of nine (9) reef fish survey sites.

Figure 1 shows the location of each of the three permitted artificial reef areas and the reef fish survey sites. Table 4 provides the coordinates for each site and Figures 3-5 show the site locations within each permit area. Walker's Reef is the largest permitted area, covering approximately 157 ac and is located in the center of Sarasota Bay in water depths of approximately 4 m (12-13 ft). Hart's Family Reef is approximately 16 ac in size and is located approximately 1,450 m (0.9 mi) from the eastern shoreline of the bay, with water depths ranging from 3-4 m (11-12 ft). The smallest permitted area is Sportfish Angler's Club Reef which covers approximately 8.5 ac. This reef area is in water depths of approximately 3 m (10-11 ft) and is located approximately 175 m (0.1 mi) from the western shoreline of the bay. It is also closer to New Pass than the other two reef areas; approximately 2,000 m (1.2 mi) northwest of eastern edge of the pass. This proximity to the pass influences the conditions at Sportfish Angler's Club Reef and contributes to typically lower water clarity at this location.

Figure 2. Artificial reef module types, clockwise from top left: layer cake, bay reef ball, cube tier, deep cover, table top (Reef Innovations, 2020). The deep cover is also open under the lip of the top piece, providing an additional option for fish to enter and exit the module than the holes on the base.

Table 4. Locations of the reef fish survey sites. Coordinates are provided in the North American Datum of 1983 (NAD83), State Plane Coordinates, Florida West Zone.

Reef Area	Reef Fish Survey Site	Coordinates	
		Latitude	Longitude
Hart's Family Reef			
	BRUVS1 / UVC	27.368117 N	-82.575164 W
	BRUVS2	27.367961 N	-82.574750 W
	BRUVS3	27.368254 N	-82.574513 W
Sportfish Angler's Club Reef			
	BRUVS1 / UVC	27.351032 N	-82.597939 W
	BRUVS2	27.351263 N	-82.597866 W
	BRUVS3	27.351292 N	-82.598163 W
Walker's Reef			
	BRUVS1 / UVC	27.376840 N	-82.593742 W
	BRUVS2	27.377766 N	-82.595283 W
	BRUVS3	27.381314 N	-82.597110 W



Legend:

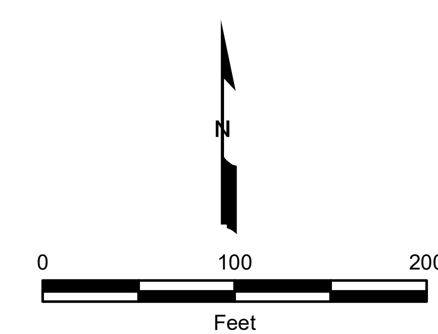
- Permit Site Boundary
- Reefball / Deep Cover Modules
- Cinder Blocks
- Concrete Blocks
- Reefball Modules

Reef Fish Survey Sites

- BRUVS1/UVC
- BRUVS2
- BRUVS3

Notes:

1. Background Imagery is ESRI Basemap, from Sarasota County dated February 10, 2017.
2. Artificial reef module coordinates provided by FWC and SBEP.
3. Reef locations are labeled by Deployment ID provided by FWC (September 2016).

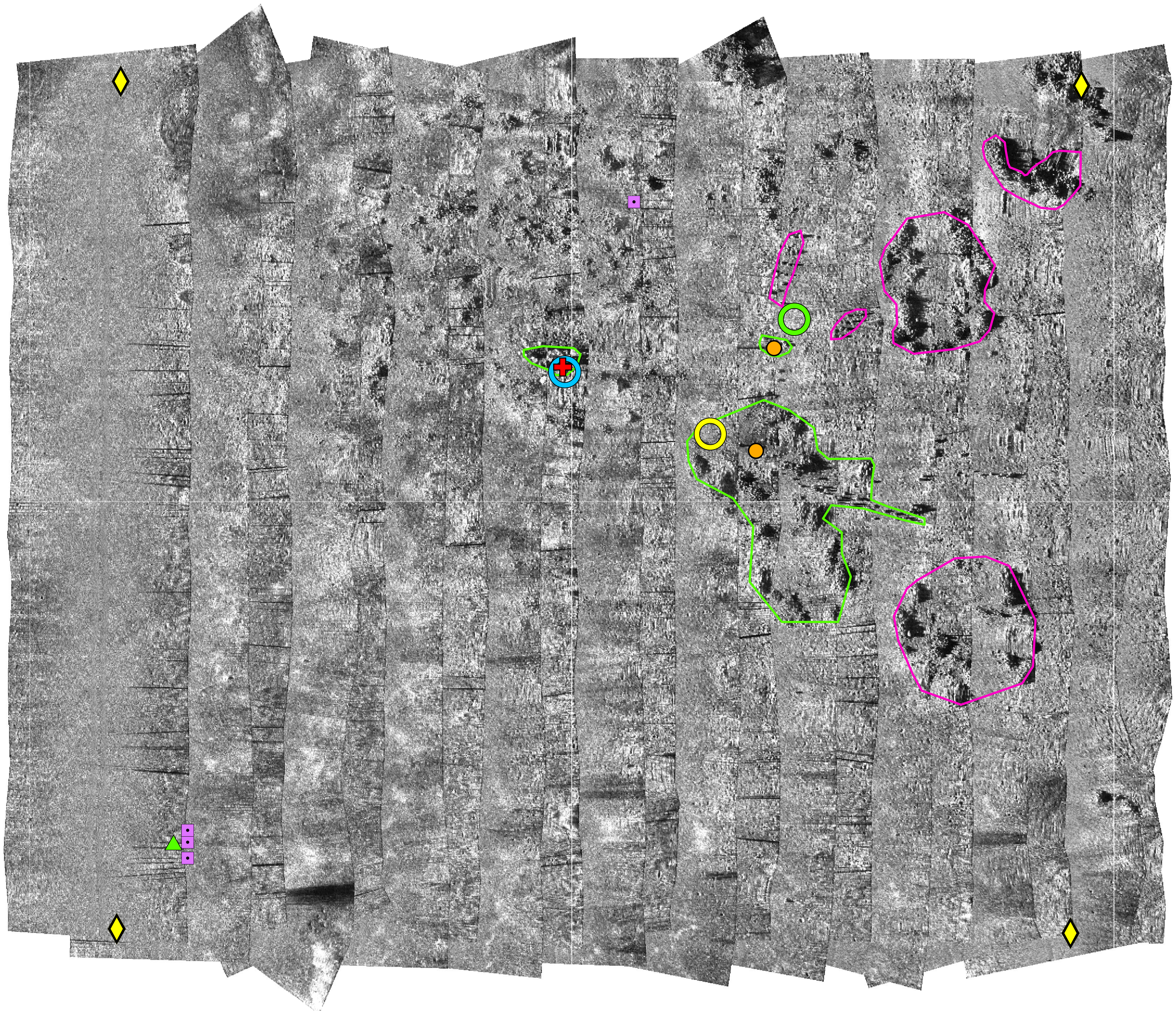


Sarasota Bay Artificial Reef Monitoring Report

FIGURE NUMBER 3a

Hart's Family Reef Reef Fish Survey Sites

APTIM
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102 FAX (561) 391-9116



Legend:

- Permit Site Boundary
- Reefball / Deep Cover Modules
- Cinder Blocks
- Concrete Blocks
- Reefball Modules

Reef Fish Survey Sites

- BRUVS1/UVC
- BRUVS2
- BRUVS3
- Reported Artificial Reef Materials
- Potential Artificial Reef Materials

Notes:

1. Side scan sonar data were collected by Hyatt Survey Service, Inc. on December 13-15, 2016.
2. Artificial reef module coordinates provided by FWC and SBEP.

0 100 200

Feet

Sarasota Bay Artificial Reef Monitoring Report

FIGURE NUMBER 3b

Hart's Family Reef Reef Fish Survey Sites

APTIM

2481 N. W. BOCA RATON BOULEVARD BOCA RATON, FL 33431 PH. (561) 391-8102 FAX (561) 391-9116

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Legend:

Permit Site Boundary
Reefball / Deep Cover Modules
Reefball Modules

Reef Fish Survey Sites

BRUVS1/UVC
BRUVS2
BRUVS3

Notes:

1. Background Imagery is ESRI Basemap, from Sarasota County dated February 10, 2017.
2. Artificial reef module coordinates provided by FWC and SBEP.
3. Reef locations are labeled by Deployment ID provided by FWC (September 2016).

N

0 100 200
Feet

Sarasota Bay Artificial Reef Monitoring Report

FIGURE NUMBER 4a

Sportfish Angler's Club Reef Reef Fish Survey Sites

APTIM
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102 FAX (561) 391-9116

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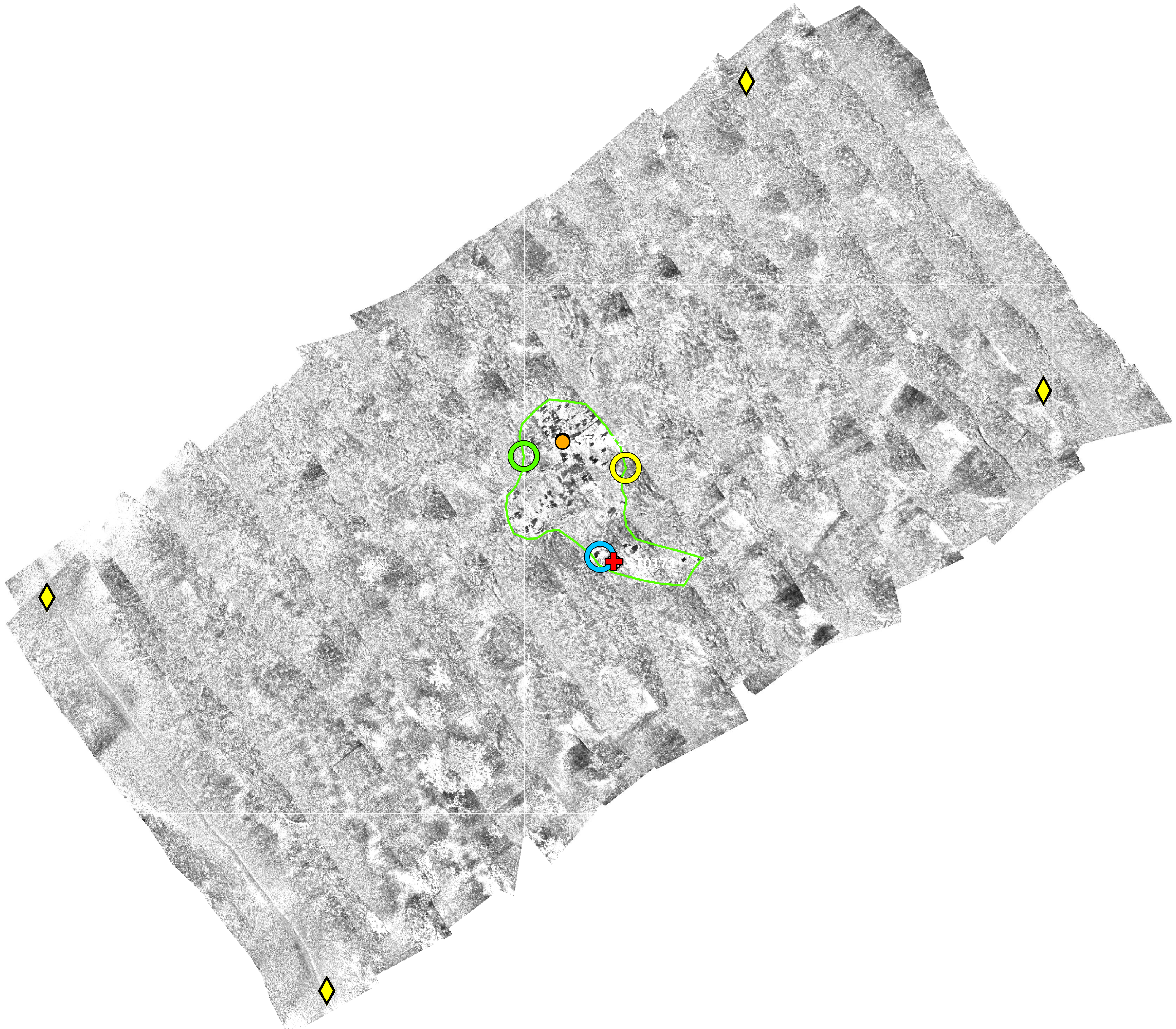

Legend:

- Permit Site Boundary
- Reefball / Deep Cover Modules
- Reefball Modules

Reef Fish Survey Sites

- BRUVS1/UVC
- BRUVS2
- BRUVS3
- Reported Artificial Reef Materials

Notes:

1. Side scan sonar data were collected by Hyatt Survey Service, Inc. on December 13-15, 2016.
2. Artificial reef module coordinates provided by FWC and SBEP.

N

0 100 200

Feet

Sarasota Bay Artificial Reef Monitoring Report

FIGURE NUMBER 4b

Sportfish Angler's Club Reef Reef Fish Survey Sites

APTIM

2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102 FAX (561) 391-9116

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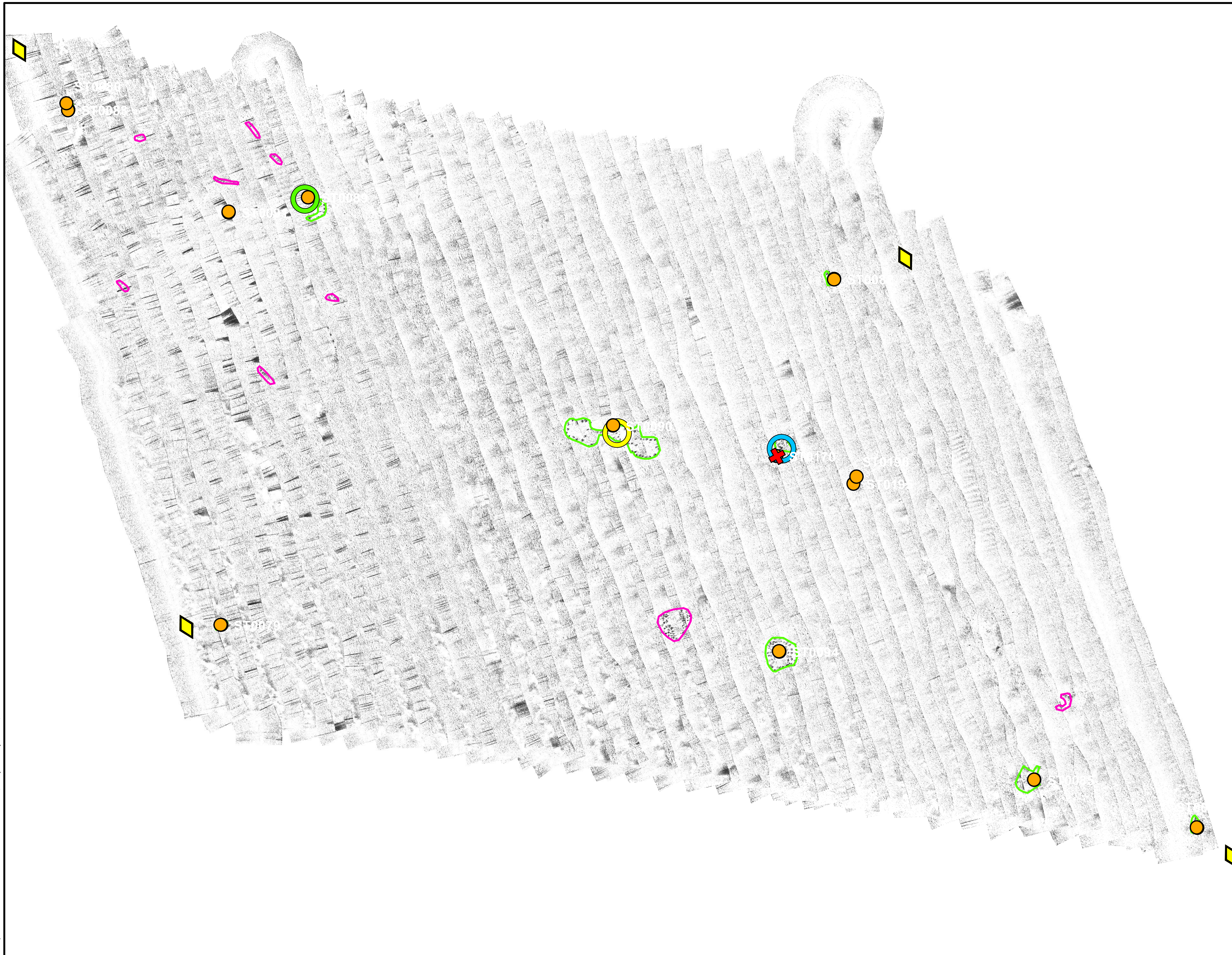

Legend:

- Permit Site Boundary
- Reefball / Deep Cover Modules
- Reefball Modules

Reef Fish Survey Sites

- BRUVS1/UVC
- BRUVS2
- BRUVS3
- Reported Artificial Reef Materials
- Potential Artificial Reef Materials

Notes:

1. Side scan sonar data were collected by Hyatt Survey Service, Inc. on December 13-15, 2016.
2. Artificial reef module coordinates provided by FWC and SBEP.

0 175 350 700
Feet

Sarasota Bay Artificial Reef Monitoring Report

FIGURE NUMBER 5b

Walker's Reef Reef Fish Survey Sites

APTIM
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102 FAX (561) 391-9116

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2.3 Reef Fish Surveys

Reef fish surveys were conducted in order to characterize and compare fish abundance, species richness, and composition at artificial reef locations located within the Hart's Family Reef, Walker's Reef, and Sportfish Angler's Club Reef artificial reef permitted areas (Figures 3-5). The original scope aimed to conduct at least six (6) sampling events at each of the three (3) sites within the three (3) permitted reef areas (6 sampling events x 3 sites = 18 sampling events). However, only nine (9) sampling events (3 sampling events x 3 sites) were able to be conducted due to unforeseen circumstances, including prolonged low underwater visibility (less than 1.8 m (6 ft)), the 2017-2018 red tide event (FWC, 2020b), and the coronavirus (COVID-19) pandemic (CDC, 2020). Table 5 provides the dates of each sampling event and notes two additional attempts that were made.

Table 5. Summary of reef fish survey sampling events.

Sampling Event	Date	Reef Area
1	3/21/2017	Hart's Family / Sportfish Angler's Club
	3/22/2017	Walker's
2 (1st Attempt)[1]	5/15/2017	Hart's Family / Sportfish Angler's Club
	5/16/2017	Walker's
2 (2nd Attempt)[2]	5/30/2017	Hart's Family / Sportfish Angler's Club
	5/31/2017	Sportfish Angler's Club / Walker's
2	2/1/2018	Sportfish Angler's Club / Walker's
	2/2/2018	Hart's Family
3	2/27/2018	Sportfish Angler's Club / Walker's
	2/28/2018	Hart's Family

[1] Visibility conditions are Sportfish Angler's Club and Walker's reef were less than 1.8 m (6 ft).
[2] Visibility conditions at all sites were less than 1.8 m (6 ft).

Underwater visual census (UVC) and baited remote underwater video station (BRUVS) methods were used during sampling events at the reef fish survey sites within the permitted reef areas to identify fish fauna down to the lowest possible taxonomic unit. Detailed UVC and BRUVS methods are provided in Sections 2.3.2 and 2.3.3. The survey conditions and timing required to conduct a sampling event are:

- Underwater horizontal visibility must be at least 1.8 m (6 ft).
- At least 20 days between subsequent sampling events at a reef permit area.
- UVC and BRUVS surveys for a sampling event at a site must be conducted within at most 6 hours of each other.
- At least 60 minutes between UVC surveys and the deployment of BRUVS, with UVC surveys being conducted first.

2.3.1 Water Clarity

To determine if the water clarity conditions were suitable to conduct a monitoring event, weather forecasts were closely monitored and *in situ* water clarity readings were taken prior to mobilization. The forecasts were monitored to avoid sampling after periods of heavy rainfall and high winds that would decrease the underwater visibility. Water clarity readings were taken near the reef areas at the Marina Jack Boat Basin, which is located on the east side of Sarasota Bay, just south of the John Ringling Causeway, located approximately three miles south of Walkers Reef. The readings were taken periodically using a secchi disc and the results were logged. Consecutive daily readings of 1.8 m (6 ft) or greater were targeted to mobilize for a monitoring event. Figure 6 summarizes these daily readings.

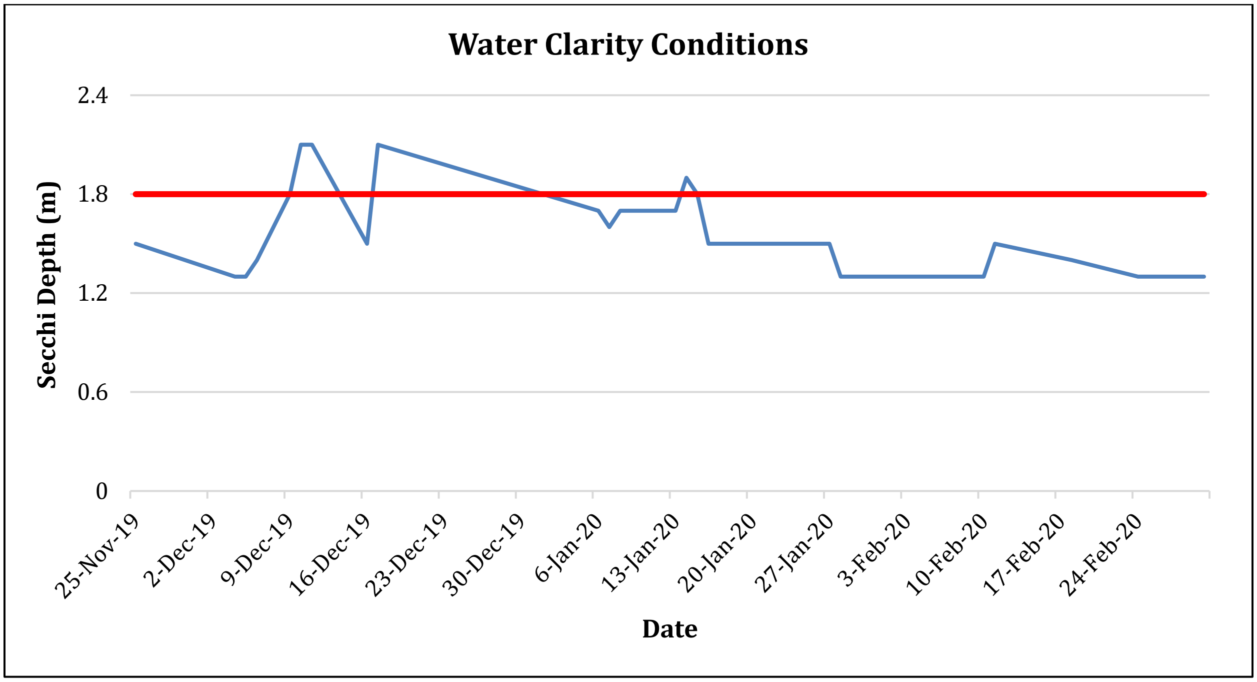


Figure 6. Secchi depth readings at Marina Jack boat dock. Readings taken during morning hours. The red line represents 1.8 m, the minimum requred water clarity to conduct underwater fish surveys.

Sarasota County also conducts monthly water quality monitoring throughout their estuarine waters. A review of this database was conducted to derive recent water clarity conditions for the bay segments that correspond with each of the artificial reefs monitored in this study. The mean monthly water clarity (= mean secchi depth) for each respective bay segment from January 2016 through November 2019 is provided in Table 6.

Table 6. Sarasota County mean monthly water clarity data from January 2016 to November 2019.

Reef Area	Mean Monthly Secchi Depth (m)
Hart's Family Reef	2.0 ± 0.53
Sportfish Angler's Club Reef	2.3 ± 0.66
Walker's Reef	2.5 ± 0.70

While these values are not statistically different (ANOVA, $p > 0.5$), there were observed differences in water clarity among these three reef sites. Our conclusion from both sets of information is that the study was hampered by water clarity limitations not usually seen in this portion of Sarasota Bay.

2.3.2 UVC Methods

The UVC surveys were conducted at one survey site within each of the three reef areas prior to deployment of the BRUVS units during each sampling event. The same site was used for the UVC surveys for all sampling events (Table 4); this site also served as one of the BRUVS sites.

The UVC procedures consisted of stationary observation using a modified Bohnsack and Bannerot (1986) method as well as a roving diver survey technique. Two divers conducted each UVC survey for each sampling event.

For the stationary observation portion, two divers descended to the bottom then swam approximately 5 m (15 ft) opposite (180°) one another. Each diver laid down a transect tape from the anchor (placed adjacent to the deep cover modules; Table 7) as reference to estimate distance. Each diver remained stationary at the sampling location and slowly rotated 360° for a 5-minute interval to obtain a point count of fish fauna. All fish observed within a cylindrical segment of the water column defined by a 3 m (10 ft) radius (or as visibility allowed) around the stationary observer during the 5-minute interval were counted and recorded. Fish were identified to the lowest taxa possible and total counts were conducted to collect abundance data.

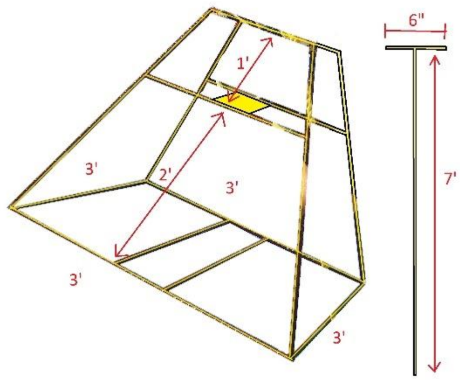
Following the stationary observation, a roving diver survey technique was conducted. Each diver extended the transect tape to 18 m (60 ft) to use as reference during a systematic search of the reef modules or natural habitat within a 9 m (30 ft) radius of the stationary observation point. This ensured each diver searched only within their respective radius. Divers observed fish swimming adjacent to modules and cryptic fish species within the reef materials by looking inside the openings located on the sides and tops of the modules. All fish observed during the 10-minute search interval were identified to the lowest taxa possible and total counts were conducted to collect abundance data.

2.3.3 BRUVS Materials and Methods

Materials

The baited remote underwater video station (BRUVS) units were constructed of stainless steel and were designed with dimensions to meet the required specifications:

- The camera was suspended at least 0.3 m (1 ft) off the bottom and remained stationary.
- A bait arm (shown on the right in the schematic; Figure 7) approximately 2.5 cm (1 in) in diameter extended 1.8 m (6 ft) from the face of the camera housing.
- An object at least 8 cm (3 in) in width (PVC pipe painted black and white) was attached to the end of the bait arm in order to confirm a minimum visibility of at least 1.8 m (6 ft) during BRUVS surveys.
- The bait container was attached on the bait arm approximately 1 m (3-4 ft) from the camera.
- A high definition camera (GoPro Hero4 Silver - 1080p/60 FPS) was mounted on a center platform.



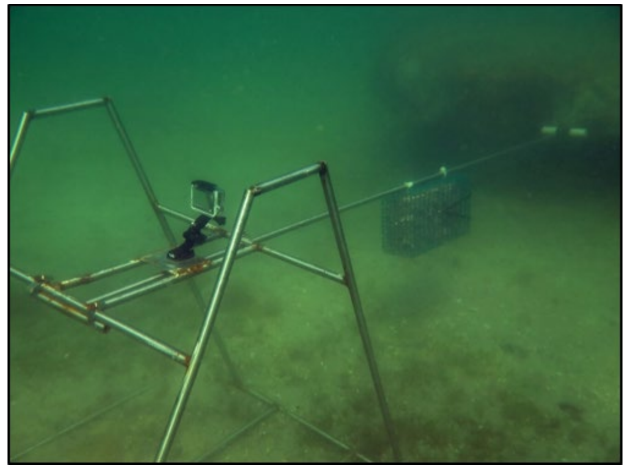


Figure 7. A schematic of the baited remote underwater video station (BRUVS) is shown on the left. One of the BRUVS units used in this study is shown on the right.

Methods

During each sampling event three (3) BRUVS units were deployed concurrently at three (3) survey sites within one reef area at a time. Table 4 provides the locations of each survey site within each reef area. A differential global positioning system (DGPS) antenna connected to a laptop running HYPACK hydrographic survey software was used to initially mark each site and to relocate each site during subsequent monitoring events. The BRUVS units were deployed at the survey sites for at least 60 minutes following completion of the UVC surveys in that same reef area. The following methods were used to deploy the BRUVS units during each sampling event.

- Each BRUVS was baited using a standardized bait method (e.g., menhaden chum enhanced with menhaden oil) and was replenished prior to each deployment.
- After each BRUVS was baited, it was slowly lowered from a vessel by divers in a controlled manner to the target depth.
- Each BRUVS unit was deployed within 10 feet of a listed artificial reef module location. Divers used visual cues and a heading to place each BRUVS unit in the same position for each monitoring event.
- Once in position, the BRUVS started a 15-minute calibration/stabilization period; video data collection was initiated but this 15-minute period was not used in the analysis.
- The BRUVS remained stationary with the camera and bait arm perpendicular to the bay floor such that the target artificial reef material was continually visible in the camera frame.
- Following the calibration period, the BRUVS camera recorded a sampling period of at least 60 minutes.
- Video collected from the BRUVS sampling periods was analyzed in order to count and identify fish fauna down to the lowest possible taxonomic unit. The maximum number of individuals per frame was counted.

Appendix B provides representative photographs of each of the deployed BRUVS units in position at each survey site.

2.4 Statistical Analysis

Fish count data were compiled to assess the abundance and species richness of the reef areas. Species abundance is defined as the mean number of individuals observed over the total number of surveys. Species richness is defined as the mean number of species over the total number of surveys for each reef area. Abundance data for all monitoring events were tested for significant differences among the reef areas and analyses was also used to determine if there were differences among monitoring events within each reef area. Mean species richness data were tested for differences among reef areas. The data were first tested for normality using the Shapiro-Wilk test, then based on this result the data were further analyzed using either the non-parametric Kruskal-Wallis test or a one-way ANOVA. Cases in which significant differences were found within the non-parametric data, a Dunn's test was performed to determine where the differences lie. All tests were conducted using a significance level of 0.05.

To assess the diversity of the reef areas the Shannon-Wiener Diversity Index (H') was used. This index considers both the richness (number of species) and evenness (or dominance) of a population.

3.0 Results

3.1 Side Scan Sonar Data

Hyatt's Surveyor's Report (Appendix A) provides a basic overview of the findings of the side scan sonar mapping effort. Interpretation of the side scan data using ArcGIS evaluated the accuracy of the deployment coordinates listed in Tables 1-3 and provided a better understanding of the extent of artificial reef materials deployed at each of these locations. The materials that corresponded to the FWC deployment coordinates provided by FWC at the start of the project (September 2016) were delineated and labeled as "reported artificial reef materials" and the potential materials that did not correspond to the coordinates were delineated and labeled as "potential artificial reef materials" on Figures 3a, 4b, and 5b.

The permitted area for Hart's Family Reef covers approximately 16 acres, of which approximately 0.5 ac (gross) includes deployed artificial reef materials based on the interpretation of the side scan sonar data. The deployments that included cinder and concrete block were not distinct enough to delineate, therefore, the 0.5 ac only incorporates the deployments that included reef ball and deep cover modules. There are also several unmarked areas inside the permitted area that include potential materials (Figure 3b). Five areas were delineated based on the side scan sonar data that cover 0.7 ac.

Sportfish Angler's Club Reef permitted area is approximately 8.5 ac and includes approximately 0.3 ac (gross) of artificial reef materials. The materials were only observed near the FWC coordinates listed in Tables 1-3 (Figure 4b).

The permitted area for Walker's Reef covers approximately 157 ac, of which approximately 1.2 ac (gross) includes artificial reef materials. Reef materials were observed at all of the FWC coordinates, except at one deployment location (ST0091); however, there are materials approximately 30 m (100 ft) north of these coordinates. There are also several unmarked areas inside of the permitted area that include potential materials (Figure 5b). Nine areas were delineated based on the side scan sonar data that cover 0.4 ac.

3.2 Water Clarity Data

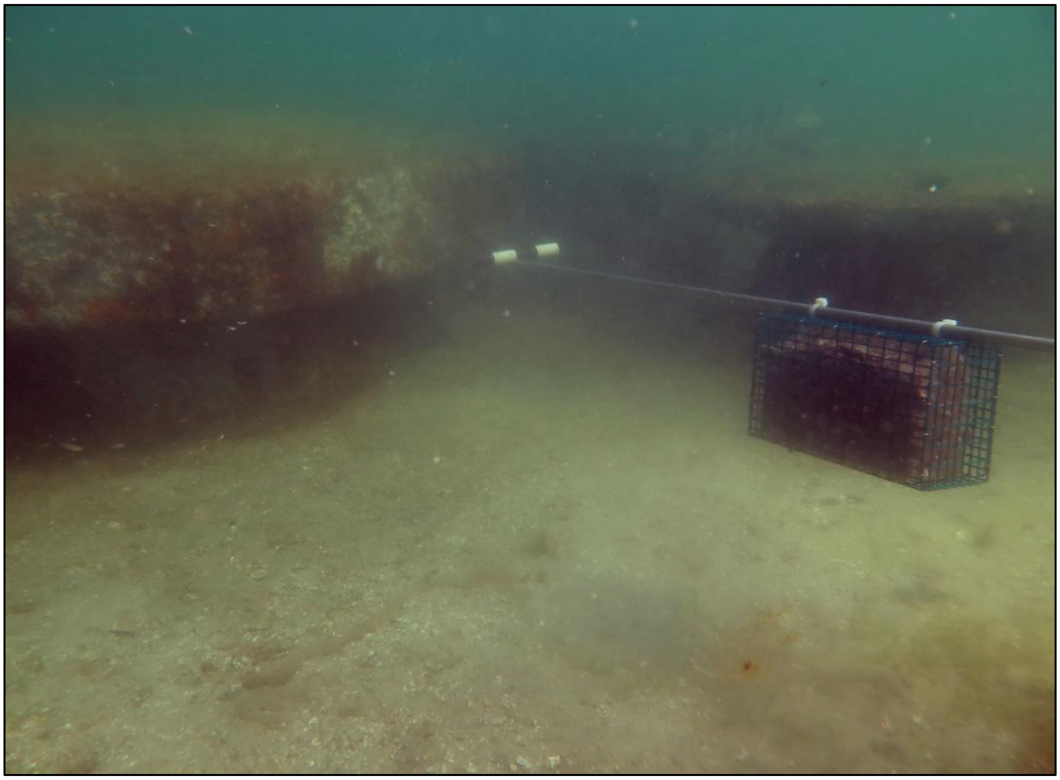
The *in situ* water clarity data are provided in Figure 6. The favorable water clarity conditions aligned with dry weather conditions and light east winds; however, this relationship did not always hold true. The monitoring attempts that were conducted in May 2017 were during similar topside conditions. The summer monitoring attempts were likely affected by increased water temperatures in Sarasota Bay, which affects water clarity, due to increased productivity in the water column.

3.3 Reef Fish Surveys

The reef fish survey sampling events took place between March 2017 and February 2018 as noted in Table 5. Table 7 provides the artificial reef materials and depths observed at each survey site during both the UVC and BRUVS surveys. As noted in Section 2.3.1, the same site within each reef area was designated as the UVC and BRUVS1 site. Artificial reef materials observed during this study included: deep cover reef, reef bay balls, cube tier layer cakes, table top and cinder blocks (Photographs 1-3). All of the modules were observed to be intact and upright, except for one of the deep cover modules at Hart's Family Reef (noted in Table 7), which was undamaged but slightly tipped over (a portion of the module was on top of concrete).

Table 7. Summary of artificial reef materials observed at each reef fish survey site during each monitoring event (2017-2018).

Reef Area	Survey Site	Artificial Reef Materials	Depth (m)	Visibility Range (m)
Hart's Family Reef	BRUVS1 / UVC	BRUVS pointed at 165° at deep cover reef. UVC: bouy anchor near 1 deep cover reef, cinder blocks, cube tier. Second deep cover reef (slightly tipped over) was within 30-ft radius of diver who swam 290° (NW) from anchor. Second diver swam 100°.	4	2-3
	BRUVS2	BRUVS pointed at 230° at cinder blocks. Patchy, low relief materials.	3	
	BRUVS3	BRUVS pointed at 180° at dense patches of cinder blocks.	3	
Sportfish Angler's Club Reef	BRUVS1 / UVC	BRUVS placed between 2 deep cover reefs and pointed at NE at eastern most deep cover reef. UVC: Buoy anchor between 2 deep cover reefs. reef bay balls in 30-ft radius. Divers swam at 250° and 80°.	3	1-2
	BRUVS2	BRUVS pointed at 65° at 3 reef bay balls.	3	
	BRUVS3	BRUVS pointed at 30° at 4 reef bay balls.	3	
Walker's Reef	BRUVS1 / UVC	BRUVS pointed at 330° at deep cover reef, table top reef and reef bay balls. UVC: Buoy anchor adjacent to deep cover reef, table top reef, and reef bay balls. Layer cakes and second deep cover reef in 30-ft radius. Divers swam at 220° and 30°.	4	2-3
	BRUVS2	BRUVS pointed at 180° at 4 reef bay balls. 4 other reef bay balls to east and 2 reef bay balls to west.	4	
	BRUVS3	BRUVS pointed at 270° at 4 reef bay balls. 4 other reef bay balls approx. 4-ft to the south.	4	



Photograph 1. Deep cover (left) and table top (right) modules at the Walker's Reef BRUVS1/UVC survey site (FWC DeployID ST0170).

Photograph 2. Reef bay ball modules and sheepshead (*Archosargus probatocephalus*) at the Walker's Reef BRUVS3 survey site (FWC DeployID ST0089).

Photograph 3. Layer cake modules surrounded by cinder blocks and gray snappers (*Lutjanus griseus*) at Hart's Family Reef observed during the UVC survey (FWC DeployID ST0172).

3.3.1 UVC Fish Census Data

The fish count data recorded during all sampling events at each reef area are provided in Tables 8-10. Part of the aim of this study was to investigate the utilization of the new designed deep cover reef modules by gag groupers (*Mycteroperca microlepis*). During the roving diver portion of the UVC surveys, divers observed gag groupers within these deep cover reefs on several occasions. The roving diver technique allowed the diver to look inside and around the modules for this typically cryptic species. At Walker's Reef, gag groupers were observed within the deep cover reefs as well as within and swimming between the layer cake, bay reef ball, and table top reef modules. During the March 2017 sampling event, 12 gag groupers were observed inside one of the deep cover modules (Table 10). Although collecting fish size data was not within the scope of this project, the diver noted that the larger individuals prevented the smaller individuals from entering the deep cover module.

Table 8. Hart's Family Reef UVC fish census species abundance data. Each UVC sampling event included a stationary (S) and roving (R) diver portion of the survey (species observed at this location highlighted in bold).

Scientific Name	Common Name	Event 1 (Mar 2017)				Event 2 (Feb 2018)				Event 3 (Feb 2018)				Total
		UVC1		UVC2		UVC1		UVC2		UVC1		UVC2		
		S	R	S	R	S	R	S	R	S	R	S	R	
Acanthostracion quadricornis	**Scrawled Cowfish**		1											1
Archosargus probatocephalus	**Sheepshead**	9	35	12	44	1	13		5	2	9	1	4	135
Atherinidae, Clupeidae	**Herring/Silversides**								30		20	30	30	110
Chaetodipterus faber	**Atlantic Spadefish**				2		1				21			24
Epinephelus morio	**Red Grouper**								1					1
Eucinostomus gula	**Silver Jenny**	70	120	250	500									940
Haemulon plumierii	**White Grunt**		1		3									4
***Haemulon* spp.**	**Juvenile Grunt**			12										12
Lutjanus griseus	**Gray (Mangrove) Snapper**	3	6		8					7	6		9	39
Mugil curema	White Mullet													0
Mycteroperca microlepis	**Gag Grouper**		6		5		1		1		2			15
Pareques umbrosus	**Cubbyu (juvenile)**								8					8
Pareques spp.	Highhat/Cubbyu													0
Total		82	169	274	562	1	15	0	45	9	58	31	43	**1289**

Table 9. Sportfish Angler's Club Reef UVC fish census species abundance data. Each UVC sampling event included a stationary (S) and roving (R) diver portion of the survey (species observed at this location highlighted in bold).

Scientific Name	Common Name	Event 1 (Mar 2017)				Event 2 (Feb 2018)				Event 3 (Feb 2018)				Total
		UVC1		UVC2		UVC1		UVC2		UVC1		UVC2		
		S	R	S	R	S	R	S	R	S	R	S	R	
Acanthostracion quadricornis	Scrawled Cowfish													0
Archosargus probatocephalus	Sheepshead													0
Atherinidae, Clupeidae	**Herring/Silversides**				100									100
Chaetodipterus faber	Atlantic Spadefish													0
Epinephelus morio	Red Grouper													0
Eucinostomus gula	Silver Jenny													0
Haemulon plumierii	**White Grunt**												2	2
***Haemulon* spp.**	**Juvenile Grunt**		40		12									52
Lutjanus griseus	Gray (Mangrove) Snapper													0
Mugil curema	**White Mullet**			2										2
Mycteroperca microlepis	**Gag Grouper**		2								1			3
Pareques umbrosus	Cubbyu (juvenile)													0
Pareques spp.	Highhat/Cubbyu													0
Total		0	42	2	112	0	0	0	0	0	1	0	2	**159**

Table 10. Walker's Reef UVC fish census species abundance data. Each UVC sampling event included a stationary (S) and roving (R) diver portion of the survey (species observed at this location highlighted in bold).

Scientific Name	Common Name	Event 1 (Mar 2017)				Event 2 (Feb 2018)				Event 3 (Feb 2018)				Total
		UVC1		UVC2		UVC1		UVC2		UVC1		UVC2		
		S	R	S	R	S	R	S	R	S	R	S	R	
Acanthostracion quadricornis	Scrawled Cowfish													0
Archosargus probatocephalus	**Sheepshead**	4	11	12	23		4	1	6		3	4	2	70
Atherinidae, Clupeidae	**Herring/Silversides**									50	50		30	130
Chaetodipterus faber	Atlantic Spadefish													0
Epinephelus morio	Red Grouper													0
Eucinostomus gula	**Silver Jenny**	300	50	300	500	50	50			10				1260
Haemulon plumierii	White Grunt				1									1
***Haemulon* spp.**	**Juvenile Grunt**	200	300											500
Lutjanus griseus	**Gray (Mangrove) Snapper**		2	1	3								1	7
Mugil curema	White Mullet													0
Mycteroperca microlepis	**Gag Grouper**		2	3	12[1]		3		11		8	2		41
Pareques umbrosus	**Cubbyu (juvenile)**								1					1
***Pareques* spp.**	**Highhat/Cubbyu**				1									1
Total		504	365	316	540	50	57	1	18	60	61	6	33	**2011**

[1] All gag groupers were observed within or adjacent to a deep cover reef module.

Site Abundance

Overall, mean fish abundance across all reef areas and survey sites was 96.1 ± 161.2 fish per survey. This high variation is indicative of the differences observed among reef areas and between survey methods. Figure 8 shows the abundance data by reef area and by survey method (stationary and roving). Across all sites, the roving diver technique recorded a higher count of individuals during all sampling events. Walker's Reef had the highest mean abundance with 167.6 ± 203.7 overall; the stationary method recorded an abundance of 156.2 ± 206.7 and the roving diver method recorded an abundance of 179.0 ± 219.5. Hart's Family Reef had an overall mean abundance of 107.4 ± 164.1; the stationary mean abundance was 66.2 ± 106.4 while the roving diver was 148.7 ± 209.4. Sportfish Angler's Club Reef had the lowest overall mean abundance of 13.3 ± 33.3; the stationary method recorded a mean abundance of 0.3 ± 0.8 and the roving diver was 26.2 ± 45.2.

Although the stationary and roving survey methods have inherent variability (*i.e*. survey interval and area covered), the observations from each method indicated similar results for the reef areas. Walker's Reef recorded the highest abundance, followed by Hart's Family Reef and Sportfish Angler's Club Reef. A Kruskal-Wallis test (df = 2, H = 5.13, p = 0.07) determined that the mean abundance data for all monitoring events were not significantly different among reef areas. This test was also used to determine if there were differences among monitoring events within each reef area. There were no significant differences among events at Hart's Family Reef (df = 2, H = 1.31, p = 0.49) or Walker's Reef (df = 2, H = 1.99, p = 0.34). Significant differences were reported for Sportfish Angler's Club Reef (df = 2, H = 5.58, p = 0.03) and a Dunn's test indicated that the difference was observed between Events 1 and 2 (p =0.1) (Figure 9).

The most abundant species observed was the silver jenny (*Eucinostomus gula*), followed by juvenile grunts (*Haemulon* spp.), herrings/silversides (Atherinidae, Clupeidae), sheepshead (*Archosargus probatocephalus*), gag grouper (*Mycteroperca microlepis*), gray (mangrove) snapper (*Lutjanus griseus*), and Atlantic spadefish (*Chaetodipterus faber*). The remaining species each had less than 10 total observations (Tables 8-10).

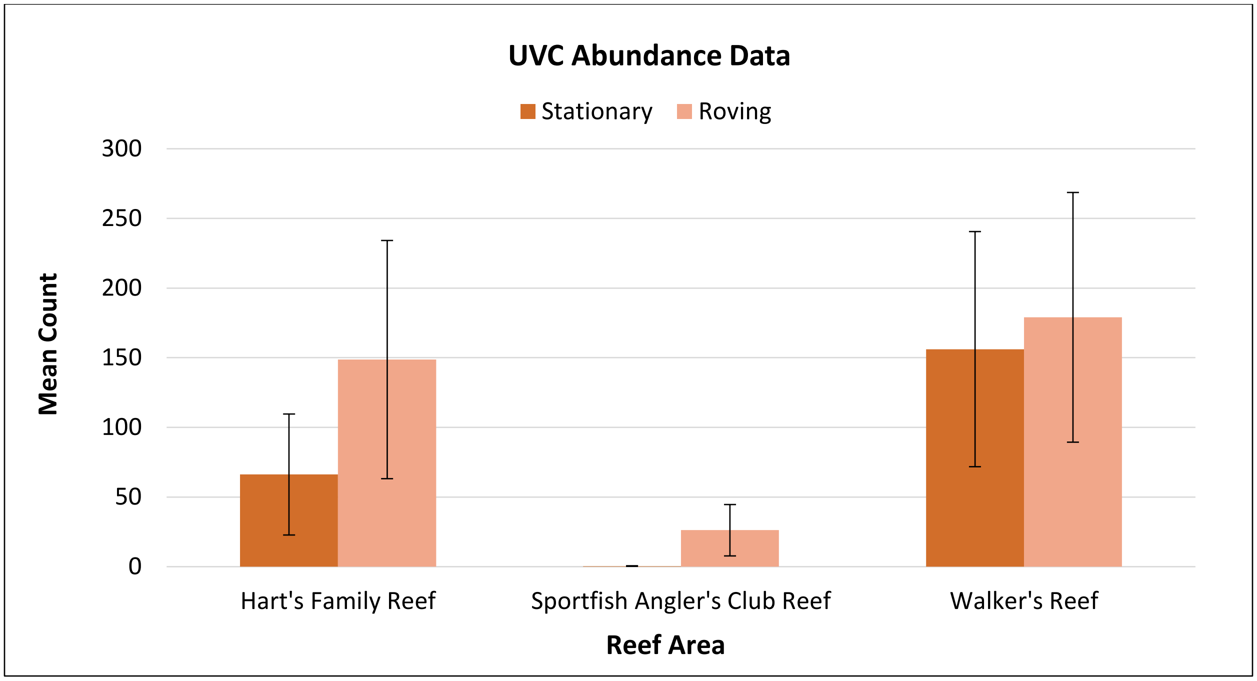


Figure 8. Mean fish counts recorded at each reef area by survey method. Error bars are SE.

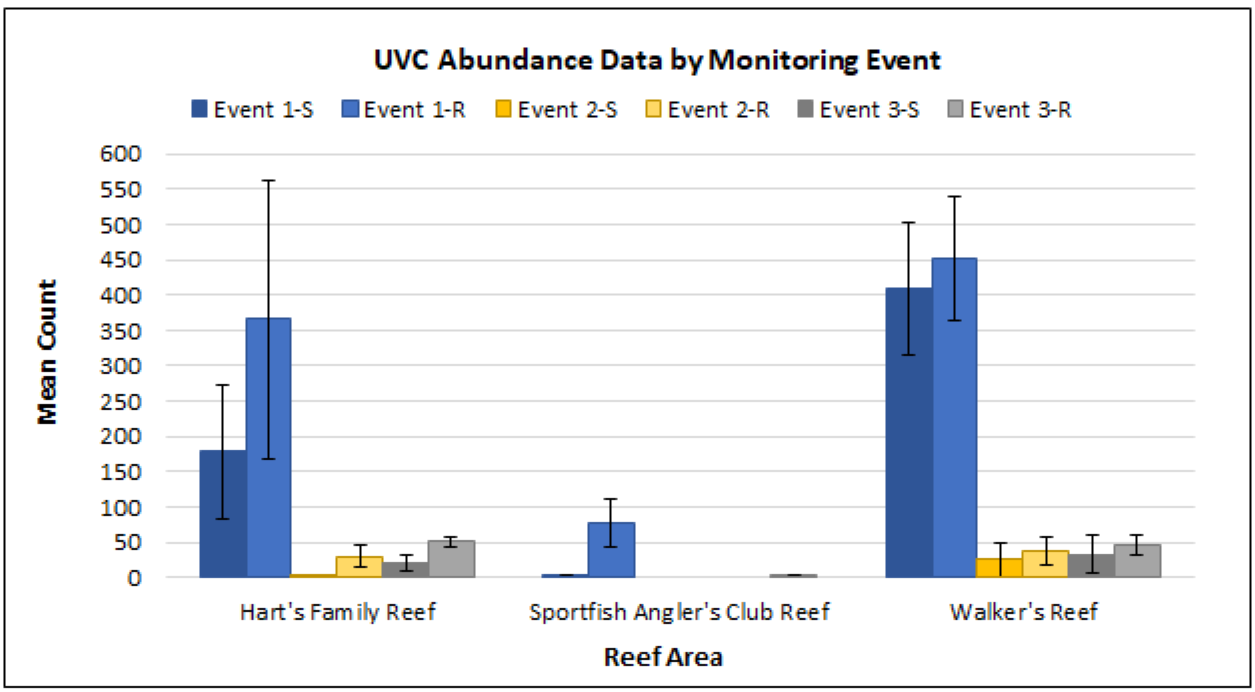


Figure 9. Mean fish counts recorded at each reef area by each monitoring event. Error bars are SE.

Species Richness

A total of 13 species were observed over the course of this study during the UVC surveys. The mean species number observed across all three reef areas was 8.3 ± 3.1 species/site for all sampling events. The highest mean species observations were recorded at Hart's Family Reef (6.3 ± 1.5) and Walker's Reef (5.3 ± 1.5), followed by Sportfish Angler's Club Reef (2.0 ± 2.0). A one-way ANOVA (df = 2, F = 5.35, p = 0.05) determined that the mean species richness data for all monitoring events were not significantly different among reef areas. Figure 10 shows the species richness data by reef area and by survey method (stationary and roving). The roving diver surveys observed a higher number of species across all reef areas similar to the fish count observations described above.

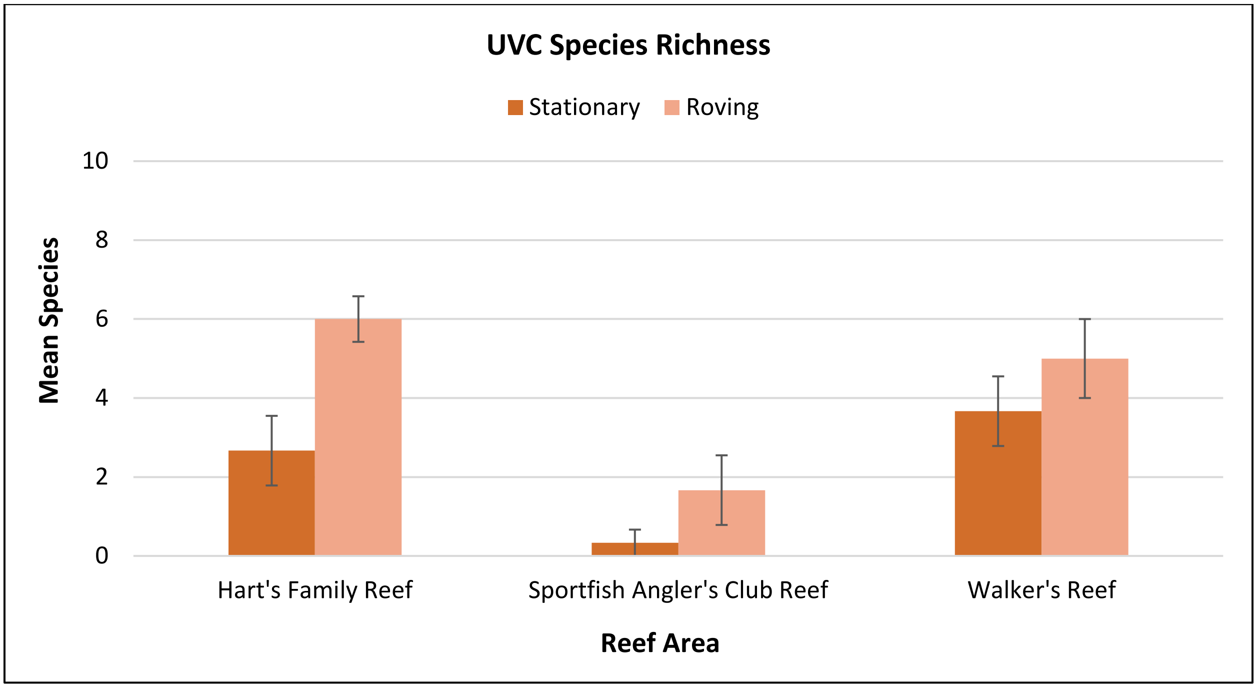


Figure 10. Mean species richness recorded at each reef area by survey method. Error bars are SE.

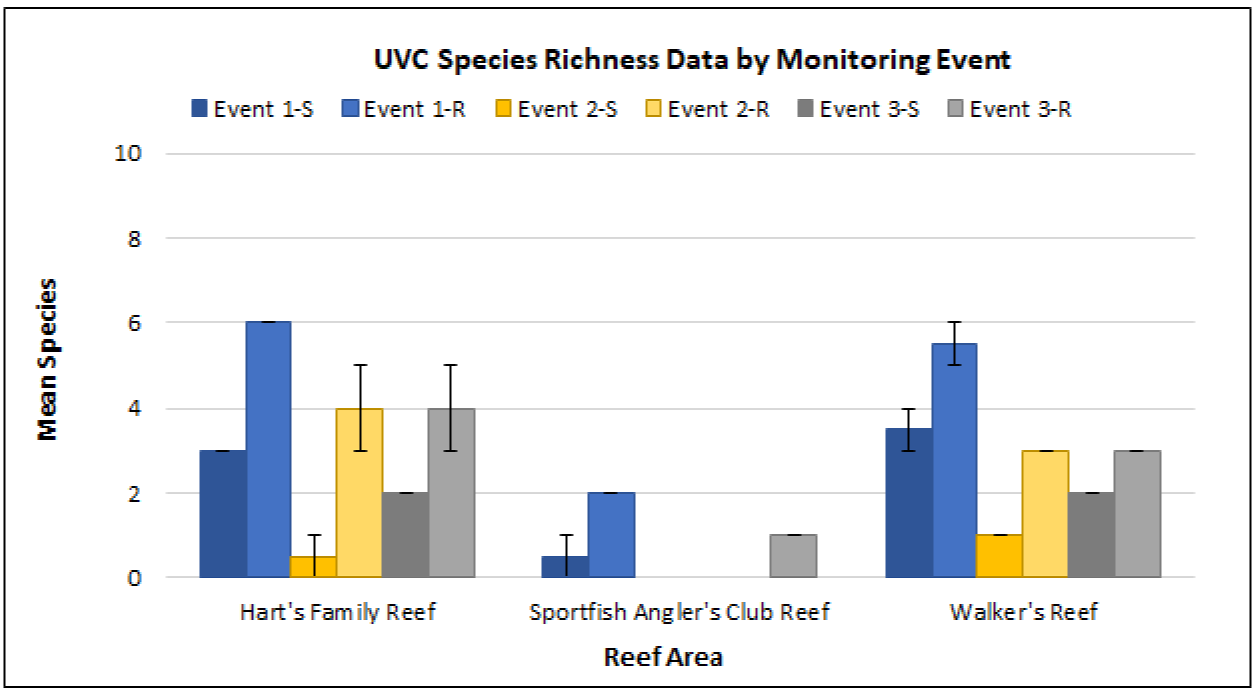


Figure 11. Mean species richness recorded at each reef area by each monitoring event. Error bars are SE.

Comparison between years 2017 (Event 1) and 2018 (Events 2 and 3) also show differences in fish abundance and species richness. Event 1 recorded higher fish counts and species numbers than Events 2 and 3 combined (Figures 9 and 11). Also, although 13 species were observed, the counts were mainly comprised of 7 species, with the smaller species (sliver jenny, juveniles grunts, and herrings/silversides) being the most dominant. Figure 12 provides the Shannon-Wiener diversity index by reef area and by survey site. Overall, the index indicates low diversity within the observed fish assemblages at each reef area. Similar results were observed at Hart's Family Reef (H'=1.01) and Walker's Reef (H'=1.04), while Sportfish Angler's Club Reef (H'=0.84) had the least diverse assemblage. The stationary survey method only recorded 1 species during all sampling events, resulting in a diversity of H'=0.

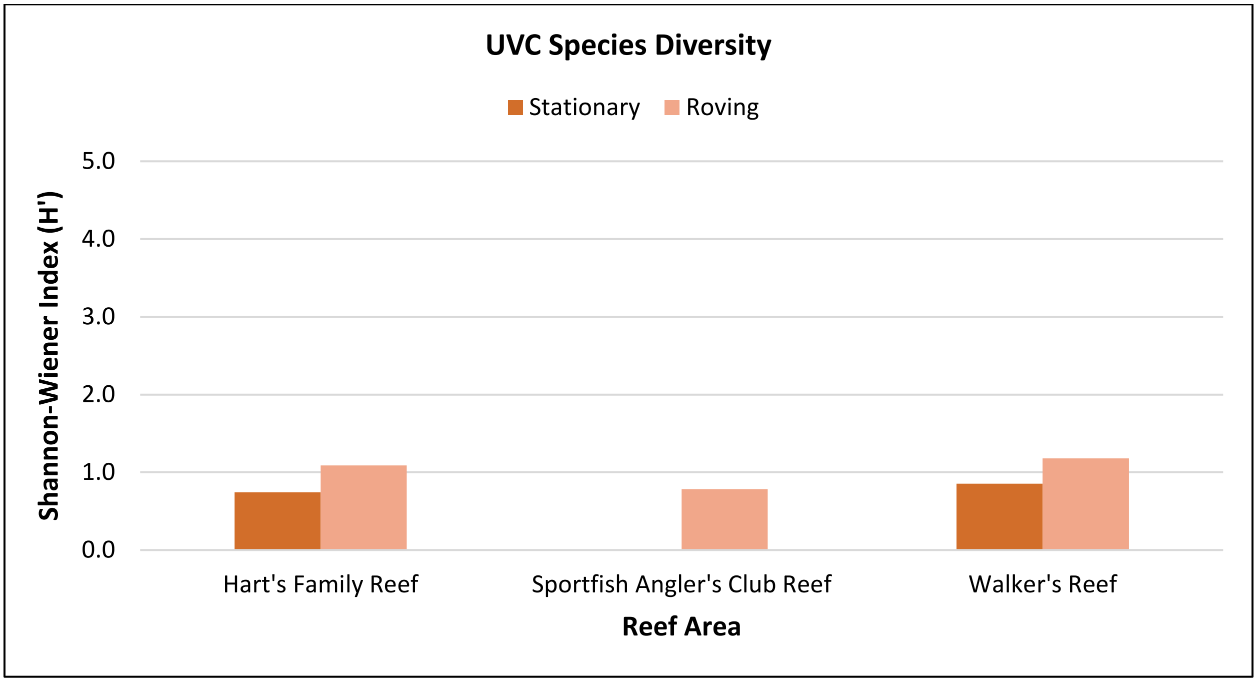


Figure 12. Shannon-Wiener diversity index for each reef area and by survey method.

3.3.2 BRUVS Fish Census Data

Video data were analyzed in order to count and identify fish fauna down to the lowest possible taxonomic unit. Only the video data collected after the 15-minute calibration period were used in the analysis. All videos were 60 minutes in length and were recorded in high definition (1080p/60 FPS). Tables 11-13 provide the fish count data recorded during all sampling events. Walker's Reef recorded the highest number of species (14), followed by Hart's Family Reef (10), then Sportfish Angler's Club Reef (3).

Table 11. Hart's Family Reef BRUVS fish census species abundance data.

Scientific Name	Common Name	Event 1 (Mar 2017)			Event 2 (Feb 2018)			Event 3 (Feb 2018)			Total
		BRUVS 1	BRUVS 2	BRUVS 3	BRUVS 1	BRUVS 2	BRUVS 3	BRUVS 1	BRUVS 2	BRUVS 3	
Acanthostracion quadricornis	Scrawled Cowfish			1		1	2		1	2	7
Aluterus schoepfii	Orange Filefish										0
Archosargus probatocephalus	Sheepshead	1	2	3	1	2					9
Ariopsis felis	Hardhead Catfish								1	2	3
Atherinidae, Clupeidae	Herring/Silversides										0
Chaetodipterus faber	Atlantic Spadefish	16	4	1	3						24
Dasyatis americana	Southern Stingray							1			1
Eucinostomus gula	Silver Jenny	50	22	10	500			20			602
Haemulon plumierii	White Grunt	1	1	3							5
Haemulon spp.	Juvenile Grunt										0
Lutjanus griseus	Gray (Mangrove) Snapper										0
Lutjanus/Haemulon spp.	Snapper/Grunt spp.		3								3
Mycteroperca microlepis	Gag Grouper										0
Sphoeroides sp.	Puffer sp.				1	2			1	2	6
Stephanolepis hispidus	Planehead Filefish					1					1
Total		68	32	18	505	6	2	21	3	6	**661**

Table 12. Sportfish Angler's Club Reef BRUVS fish census species abundance data.

Scientific Name	Common Name	Event 1 (Mar 2017)			Event 2 (Feb 2018)			Event 3 (Feb 2018)			Total
		BRUVS 1	BRUVS 2	BRUVS 3	BRUVS 1	BRUVS 2	BRUVS 3	BRUVS 1	BRUVS 2	BRUVS 3	
Acanthostracion quadricornis	Scrawled Cowfish										0
Aluterus schoepfii	Orange Filefish										0
Archosargus probatocephalus	Sheepshead			2							2
Ariopsis felis	Hardhead Catfish										0
Atherinidae, Clupeidae	Herring/Silversides							30		15	45
Chaetodipterus faber	Atlantic Spadefish							2	1	2	5
Dasyatis americana	Southern Stingray										0
Eucinostomus gula	Silver Jenny										0
Haemulon plumierii	White Grunt										0
Haemulon spp.	Juvenile Grunt										0
Lutjanus griseus	Gray (Mangrove) Snapper										0
Lutjanus/Haemulon spp.	Snapper/Grunt spp.										0
Mycteroperca microlepis	Gag Grouper										0
Sphoeroides sp.	Puffer sp.										0
Stephanolepis hispidus	Planehead Filefish										0
Total		0	0	2	0	0	0	32	1	17	**52**

Table 13. Walker's Reef BRUVS fish census species abundance data.

Scientific Name	Common Name	Event 1 (Mar 2017)			Event 2 (Feb 2018)			Event 3 (Feb 2018)			Total
		BRUVS 1	BRUVS 2	BRUVS 3	BRUVS 1	BRUVS 2	BRUVS 3	BRUVS 1	BRUVS 2	BRUVS 3	
Acanthostracion quadricornis	Scrawled Cowfish		1	1							2
Aluterus schoepfii	Orange Filefish	4	2								6
Archosargus probatocephalus	Sheepshead	10	2	2	3		2				19
Ariopsis felis	Hardhead Catfish									2	2
Atherinidae, Clupeidae	Herring/Silversides									30	30
Chaetodipterus faber	Atlantic Spadefish							7			7
Dasyatis americana	Southern Stingray							1			1
Eucinostomus gula	Silver Jenny	150	15	15	70						250
Haemulon plumierii	White Grunt	2									2
Haemulon spp.	Juvenile Grunt	150	2	10							162
Lutjanus griseus	Gray (Mangrove) Snapper							1			1
Lutjanus/Haemulon spp.	Snapper/Grunt spp.		1								1
Mycteroperca microlepis	Gag Grouper	5		4							9
Sphoeroides sp.	Puffer sp.									1	1
Stephanolepis hispidus	Planehead Filefish										0
Total		321	23	32	73	0	2	9	0	33	**493**

Site Abundance

Overall mean fish abundance across all reef areas and survey sites was 44.7 ± 111.0 fish per survey. Differences observed among the reef areas and among survey sites within each reef area contributed to this high variation. Figure 13 shows the abundance data by reef area and by each survey site (BRUVS unit) within each reef area. Hart's Family Reef recorded the highest mean abundance at 73.4 ± 54.4 followed by Walker's Reef at 54.8 ± 8. Sportfish Angler's Club Reef abundance was drastically lower at 5.8 ± 3.8. At Hart's Family Reef and Walker's Reef the mean fish abundances were notably higher at the BRUVS1 site for both areas. Each of the BRUVS1 sites were adjacent to the newly deployed deep cover reef modules as well as other module types (Table 7).

A Kruskal-Wallis test (df = 2, H = 11.06, $p < 0.01$) determined that the mean abundance data for all monitoring events were significantly different among reef areas across. A Dunn's test indicated that the differences were observed between Hart's Family Reef and Sportfish Angler's Club Reef ($p = 0.02$), as well as, between Walker's Reef and Sportfish Angler's Club Reef ($p < 0.01$). The Kruskal-Wallis test was also used to determine if there were differences among monitoring events within each reef area. There were no significant differences among events at Hart's Family Reef (df = 2, H = 0.70, $p = 0.68$), Walker's Reef (df = 2, H = 2.29, $p = 0.20$), or Sportfish Angler's Club Reef (df = 2, H = 4.04, $p = 0.07$).

The most abundant species observed was the silver jenny (*Eucinostomus gula*), followed by juvenile grunts (*Haemulon* spp.), herrings/silversides (Atherinidae, Clupeidae), Atlantic spadefish (*Chaetodipterus faber*), and sheepshead (*Archosargus probatocephalus*). The remaining species each had less than 10 total observations (Tables 11-13).

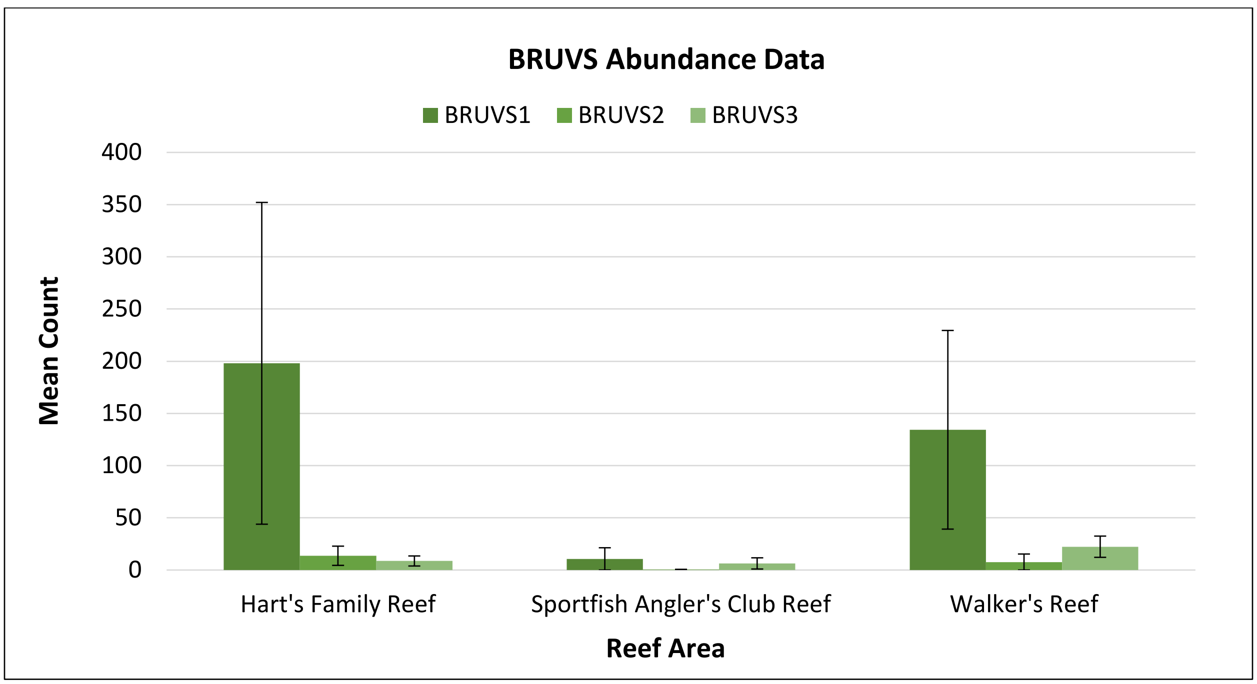


Figure 13. Mean fish counts recorded at each reef area and at each site. Error bars are SE.

Species Richness
A total of 15 species were observed over the course of this study during the BRUVS surveys. The mean species number observed across all three reef areas was 9.0 ± 5.6 species/site for all sampling events; however, this average is mainly driven by Hart's Family Reef and Walker's Reef. Similar mean species observations were recorded at Hart's Family Reef (5.7 ± 0.6) and Walker's Reef (5.3 ± 3.1), followed by Sportfish Angler's Club Reef (1.0 ± 1.0). A Kruskal-Wallis test (df = 2, H = 4.82, p = 0.08) determined that the mean species richness data for all monitoring events were not significantly different among reef areas. Figure 14 shows the species richness data by reef area and by survey site.

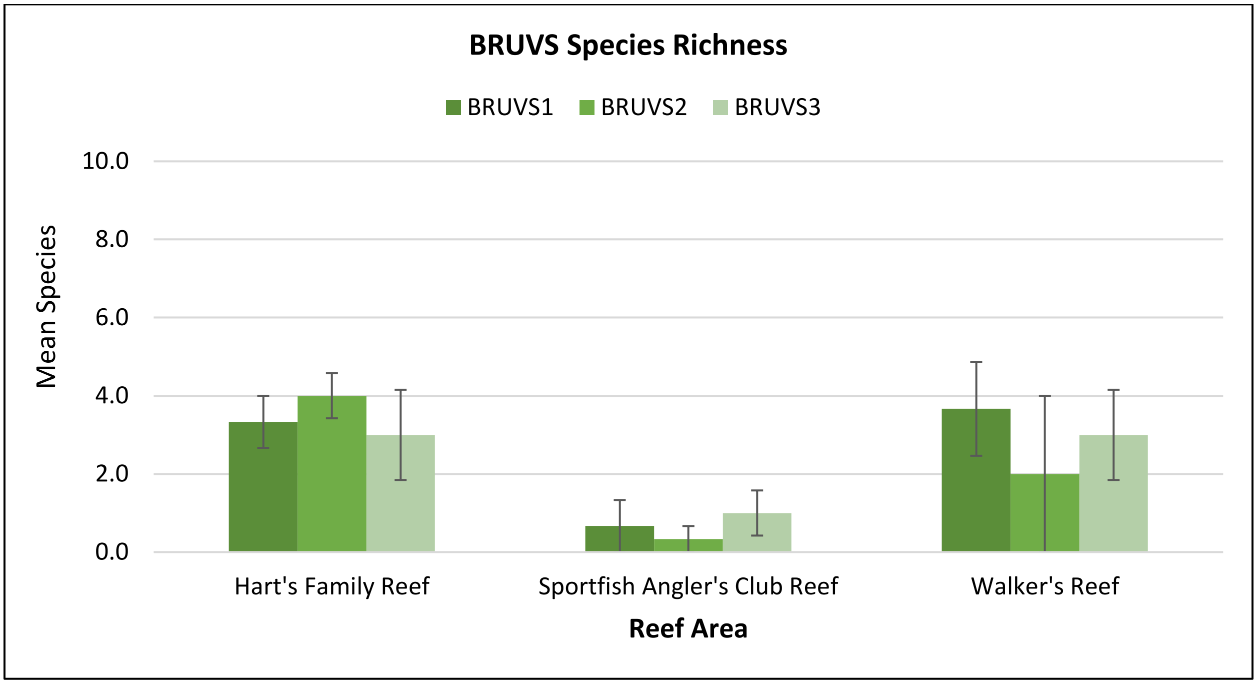


Figure 14. Mean species richness recorded at each reef area and at each site. Error bars are SE.

Comparison between years 2017 (Event 1) and 2018 (Events 2 and 3) does not reveal clear differences in fish abundance and species richness, as both fluctuated among surveys. Also, although 15 species were observed, the counts were dominated by five species, with the smaller species (sliver jenny, juvenile grunts, and herrings/silversides) being most dominant. Figure 15 provides the Shannon-Wiener diversity index by reef area and by survey site. This index takes into account both the species richness and evenness of the community and further illustrates the influence of the observed high abundances of a few species. Overall diversity was low among the observed fish assemblages. Walker's Reef was the most diverse (H'=1.31), followed by Hart's Family Reef (H'=0.46) and Sportfish Angler's Club Reef (H'=0.48).

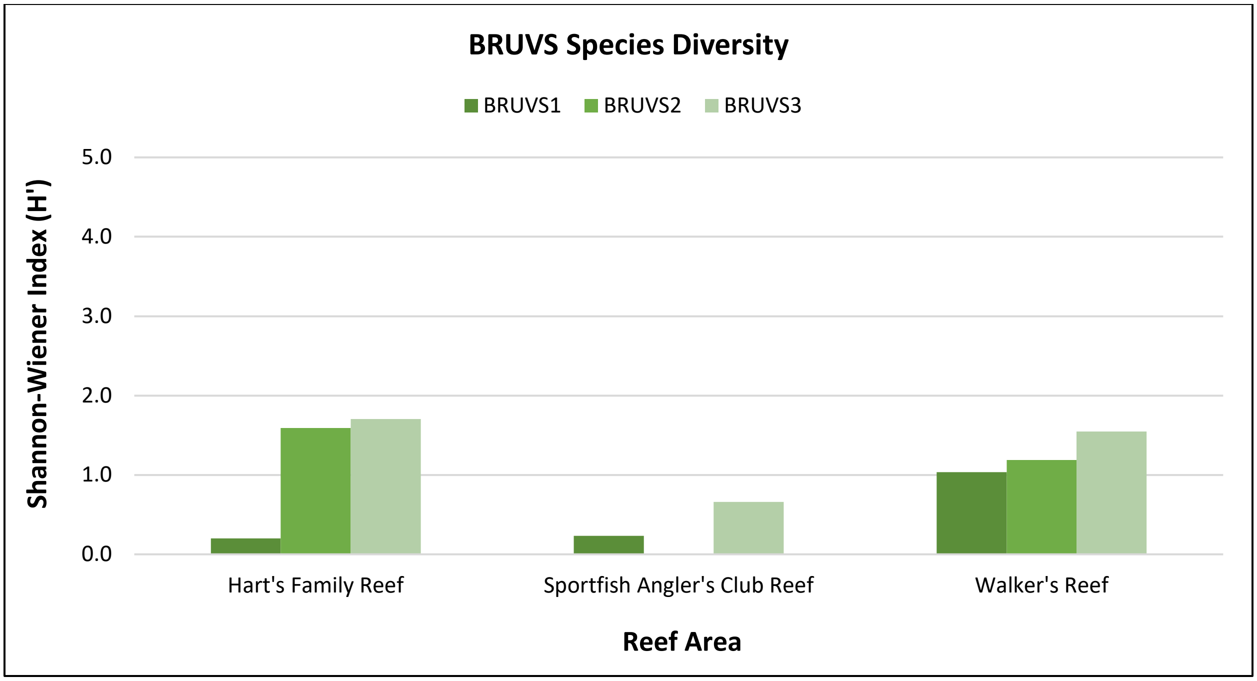


Figure 15. Shannon-Wiener diversity index for each reef area and each site.

A comparison of UVC and BRUVS species richness data shows a high degree of overlap in the species observed; however, there were several species that were only observed in one method and not the other. Table 14 provides the species list and indicates during which survey method each species was observed. Species observed only during the UVC methods included red grouper (*Epinephelus morio*), white mullet (*Mugil curema*), cubbyu/highhat (*Pareques* spp.) and species only observed during the BRUVS surveys included orange filefish (*Aluterus schoepfii*), hardhead catfish (*Ariopsis* felis), southern stingray (*Dasyatis americana*), puffer sp. (*Sphoeroides* sp.), and planehead filefish (*Stephanolepis hispidus*).

Table 14. Comparison of fish species observed during the UVC surveys (S=Stationary; R=Roving) and BRUVS surveys. An "X" denotes that the species was observed.

Scientific Name	Common Name	UVC-S	UVC-R	BRUVS
Acanthostracion quadricornis	Scrawled Cowfish		X	X
Aluterus schoepfii	Orange Filefish			X
Archosargus probatocephalus	Sheepshead	X	X	X
Ariopsis felis	Hardhead Catfish			X
Atherinidae, Clupeidae	Herring/Silversides	X	X	X
Chaetodipterus faber	Atlantic Spadefish		X	X
Dasyatis americana	Southern Stingray			X
Epinephelus morio	Red Grouper		X	
Eucinostomus gula	Silver Jenny	X	X	X
Haemulon plumierii	White Grunt		X	X
Haemulon spp.	Juvenile Grunt	X	X	X
Lutjanus griseus	Gray (Mangrove) Snapper	X	X	X
Lutjanus/Haemulon spp.	Snapper/Grunt spp.			X
Mugil curema	White Mullet	X		
Mycteroperca microlepis	Gag Grouper	X	X	X
Pareques umbrosus	Cubbyu (juvenile)		X	
Pareques spp.	Highhat/Cubbyu		X	
Sphoeroides sp.	Puffer sp.			X
Stephanolepis hispidus	Planehead Filefish			X

4.0 Discussion

4.1 Conclusion and Interpretation of Results

The goal of this study was to document the ecological use and diversity of three artificial reef permit areas within Sarasota Bay (Hart's Family Reef, Sportfish Angler's Club Reef, and Walker's Reef). Although only three of six sampling events were able to be completed, this study contributes useful data on the fish assemblages at artificial reefs within Sarasota Bay.

Overall, 19 species (some were only able to be identified to the genus/family level) were observed over the course of the study during both the UVC and BRUVS fish surveys. The species with highest abundances were the smaller species (silver jenny (*Eucinostomus gula*), juvenile grunts (*Haemulon* spp.), and herrings/silversides (Atherinidae, Clupeidae)) which were typically observed adjacent to the reef modules in larger schools. Species observed within the artificial reef modules included common recreational and economically valuable species, namely gag grouper (*Mycteroperca microlepis*), gray snapper (*Lutjanus* griseus), sheepshead (*Archosargus probatocephalus*), Atlantic spadefish (*Chaetodipterus faber*), and white grunt (*Haemulon plumierii*). Analysis of the BRUVS abundance data showed higher fish counts at the BRUVS1 sites (location of deep cover modules; Table 3) at all reef areas; however, the species richness and diversity analysis determined only a small number of species contributed to the higher abundance.

As mentioned above, the deep cover reef modules were targeted during the reef fish surveys to investigate the utilization of this newer reef design. The UVC methods were more effective in addressing this issue, as the BRUVS only recorded gags at Walker's Reef during the first survey. At both Hart's Family Reef and Walker's Reef, gag groupers were observed within, as well as, swimming in and out of the deep cover reefs. Walker's Reef recorded the highest number of observations (41 individuals) over the course of the study and during one UVC sampling event a diver observed 12 gag groupers in and around a single deep cover module. This species was also observed utilizing reef bay balls Sportfish Angler's Club Reef and layer cake and table top reef modules at Walker's Reef. Gags that were observed swimming between modules made it hard to attribute the observations to a particular module type. The limited surveys precluded the use of any statistical analysis of reef module affinity or preference for any fish species observed in this study. However, the deep cover has the capacity to hold more gag groupers than the other modules, although, on the whole, gags, like other reef fish, regularly swim among all the available material placed on these reefs.

The recreationally and economically valuable species of sheepshead and gray snapper were observed at all three reefs. Sheepshead were the most abundant across all reefs, with the highest count (135 individuals) recorded at Hart's Family Reef during the UVC surveys. Gray snappers were observed at Hart's Family Reef and Walker's Reef but not at Sportfish Angler's Club Reef during either the UVC or BRUVS surveys. Hart's Family Reef again recorded the highest count (39 individuals) during the UVC surveys as compared to the other reef areas. These observations suggest that the artificial reef modules provide valuable habitat for several targeted reef fish species.

Sportfish Angler's Club Reef (SACR), where visibility was often poorest, consistently had lower fish abundance, species richness and diversity compared to Hart's Family Reef and Walker's Reef. The poor visibility primarily affected the stationary UVC and the BRUVS surveys. SACR - the shallowest reef in the system - is located on the southwestern side of Sarasota Bay just north of New Pass. The proximity of this area to New Pass likely factors into the lower visibility. The observation of lower visibility in this part of Sarasota Bay near the flood tidal shoal from New Pass is supported by the biannual seagrass aerial photography flown by SWFWMD. These turbidity plumes are often seen around local passes and are exacerbated by weather conditions. Another possible explanation for fewer fish at SACR is the fact that there is less reef material at this site than HFR or WR. The general impression of SACR by the divers was that the visibility was noticeably lower than the other two reef areas and there was a likely chance that no fish would be observed during portions of the survey due to a combination of typically low visibility and low fish abundance. This relationship between fish abundance/diversity and reef material is a complex issue that was beyond the scope of this project.

A comparison of UVC methods indicated that the roving diving technique resulted in higher fish counts, species richness, and diversity than the stationary method. This is in part due to the inherent differences between to the two methods; the roving method is conducted for a longer time interval, covers a larger search area, and encompasses observations in cryptic areas. Estuarine reef environments are more challenging to conduct visual surveys than their offshore counterparts, primarily due to poorer visibility (water clarity). The underwater visibility ranged from 1.8 to 3.0 m (6-10 ft) and neared 1.2 m (4 ft) at Sportfish Angler’s Club Reef making stationary observations challenging. The roving technique also allowed divers to look inside and around all sides of the modules which aided in the fish count observations. The roving technique is the more appropriate method in an estuarine environment.

The BRUVS survey method, which included using a bait basket and excluded diver interaction, captured several species that were not observed during the UVC methods (Table 14). Two species of filefish, pufferfish, hardhead catfish and a southern stingray were observed on the video data. This suggests that the BRUVS methods are useful in capturing other species that may be either attracted to the bait or too shy to approach divers. Although the roving diver technique is a more effective method to investigate within and around all sides of the modules, the BRUVS method may provide valuable data in understanding the overall fish assemblages utilizing the reef areas. Similar results were determined by Lowery et al., (2011 & 2012), which found that the UVC methods recorded greater fish abundance and species richness and were also able to better observe cryptic species. In addition, BRUVS data in their studies provided valuable information on key recreational species that might not have been captured using the UVC methods. The studies recommend using a multi-method approach utilizing both methods in order to gain a more comprehensive understanding of the fish assemblages.

4.2 Comparison of Reef Module Designs

The ongoing artificial reef program in Sarasota Bay has included 23 deployments consisting of approximately 1,353 modules (primarily reefball designs) and materials of opportunity (*i.e.* concrete/cinder blocks) in Hart's Family Reef, Sportfish Angler's Club Reef, and Walker's Reef permitted areas. The side scan sonar imagery shows the extent of these deployments and the complexity they add to the seafloor. The deployments at Hart’s Family Reef and Walker’s Reef included a greater number and variation of artificial reef modules and spanned a larger portion of the permitted areas as compared to Sportfish Angler’s Club Reef. At all three survey sites within Sportfish Angler’s Club Reef area, only reef bay balls were observed alongside the two deep cover reef modules. Due to the variety of module types at the deployment locations, it was difficult to draw a direct comparison among module types; however, the spatial extent and variety of materials at Hart’s Family Reef and Walker’s Reef as compared to Sportfish Angler’s Club Reef suggests that the coverage and complexity of materials may support a more abundant and species rich fish assemblage. A similar conclusion was drawn by Serviss and Sauers (2003).

The survey sites at Walker's Reef included the deep cover, table top, layer cake, and reef bay ball modules. The Hart's Family Reef survey sites included the deep cover and cube tier modules and dense patches of cinder blocks. The modules and low relief concrete provided substrate for an established community of octocorals (*Leptogorgia virgulata*), sponges (*Cliona celata*), macroalgae (ex. *Caulerpa*, *Codium*, *Hypnea*), and tunicates. In addition, the modules at Sportfish Angler's Club Reef were encrusted with a less established community consisting of turf algae, sponges, and tunicates. This assorted layout of module type and growth of epizootics and epiphytic algae may have influenced the observed fish assemblages at these two reef areas. Also, the larger coverage of reef materials in these reef areas provides greater structural complexity and may aid in connectivity among these habitats and with natural habitats such as seagrass beds.

4.3 Comparison of Findings with Other Studies

Several other relevant reef and estuarine fisheries studies have been conducted in the area that provide comparisons and insights to the results of the current study. In 2003, Serviss and Sauers conducted a survey of fish assemblages from a variety of Sarasota Bay habitats, including Walker's and Hart's Family artificial reefs. The FWRI Fisheries-Independent Monitoring Program (FIM) has conducted long-term monitoring of nekton populations within the Sarasota Bay estuary since 2009. Blackburn et al., 2008 conducted a study in 2006-2007 in Sarasota and Tampa Bay to evaluate the influence of the number of artificial reefs and habitat on fish colonization. Finally, Flaherty-Walia et al. (2019) conducted a survey of several hardbottom habitats in lower Tampa Bay which also included artificial reefs.

Serviss and Sauers (2003) sampled Hart's and Walker's artificial reefs in February and June of 2002. They used both underwater point census and linear transect visual methods. General observations mentioned in this study were: 1) sampling was conducted following a severe red tide in 2001, 2) sampling in February 2002 was hampered by a thick cover- up to 0.5 m in depth- of drift algae, and 3) sampling in June 2002 was limited by low visibility. These environmental conditions and differences in sampling methods render statistical comparisons between studies inappropriate, but general observations on species richness and abundance of select species can be useful in discerning if these reefs are continuing to harbor relatively similar species or if any shifts have occurred over time. Twenty seven species were enumerated. The finding that Clupeids, larval fish and pinfish (*Lagodon rhomboides*) dominated fish abundance in both studies is not surprising, as these fish are ubiquitous in most estuarine fisheries programs. Tomtates (*Haemulon aurolineatum*) were the fourth most abundant taxa, with nearly 6,000 early juveniles being observed in February, 2002. This was an interesting observation for two reasons; 1) none were found in the current study, and 2) Flaherty-Walia et al. (2019), who found 76 tomtates, mentioned that this was the first time this species was captured in Tampa Bay by a fisheries monitoring program. Serviss and Sauers also reported gag groupers in their surveys: 17 in February and 58 in June. Class size ranged from juveniles through sub-adults to adults, with individuals tending toward the larger size classes. How sizes were determined during their surveys was not explained. Although collecting fish size data was not within the scope of the current project, divers noted that larger gags prevented smaller individuals from entering the deep cover modules.

The FIM monitoring sampling protocols call for using seine nets and otter trawls to collect nekton samples to determine fish community structure within different embayments of the Sarasota Bay system. These embayments, or zones, are: Palma Sola Bay, Sarasota Bay, Roberts Bay, Little Sarasota Bay, and Blackburn Bay. For purposes of this report, comparisons are focused on FIM data from the Sarasota Bay zone. Of the three gear types used (21.3 m bay seine, 183 m seine and 6.1 m trawl), the bay seine is the most appropriate gear type to make comparisons with the current study. While the 6.1 m trawl samples deeper water usually associated with Hart's Family and Walker's Reefs, they avoid any hard substrate and target demersal fish and invertebrates from unvegetated bay bottoms. Many of these species may not be typically associated with reef structure. The most recent and applicable (2017 and 2018) FIM monitoring reports concluded that the most dominant species were smaller taxa, including mojarra (*Eucinostomus* spp.), pinfish (*Lagodon rhomboides*), bay anchovy (*Anchoa mitchilli*), rainwater killifish (*Lucania parva*), and scaled sardine (*Harengula jaguana*). These results support similar observations made during this study that the most abundant species recorded were typically smaller sized species. In the Sarasota Bay zone there was an overall decrease in total individuals collected in the samples from 2017 to 2018 similar to the UVC data collected during this study. However, for all zones combined the total number of individuals slightly increased during this period. The BRUVS data for this study did not reveal a clear decline in fish abundance between 2017 and 2018. Therefore, the variability in both the FIM monitoring and this study may be attributed to several factors including methods used, location, and environmental conditions.

In 2006-2007, Blackburn et al. (2008) conducted an artificial reef monitoring study in Sarasota and Tampa Bay evaluating the influence of the number of artificial reefs and habitat on fish colonization. This study focused on a series of reef ball deployments at reefs within Manatee County waters, although three of the reefs were just north of the county line and only a few nautical miles away from the reefs surveyed in this project. The data for this study were collected by divers conducting visual surveys over parallel transects along the reef ball modules. Their findings indicate that the larger reef sites (number of reef balls per site) had higher fish abundance and species richness but lower densities. Our study also had similar results in that the areas with greater amounts and types of reef modules (Hart's Family Reef and Walker's Reef) also had higher fish abundance and species richness than the reef (SAFR) with less material.

Blackburn et al., 2008 also suggested that reef proximity to the Gulf of Mexico may have played a role in the composition and distribution of the species observed. Tampa Bay sites served as sub-adult/adult finfish habitats, while the Sarasota Bay sites were mainly comprised of juvenile finfish and invertebrates. In the current project, however, sub-adult and adult gag grouper were not found at SACR. MML surveys were conducted quarterly which revealed a seasonality to fish and invertebrate assemblages. That study was not restricted by visibility constraints that limited our surveys to winter and early spring months when water clarity was highest. Therefore, we were not able to analyze our findings by seasonality. Finally, the Blackburn et al. (2008) study had a different focus than this one; they were interested in seeing if different arrays of reef balls (4, 8, 16, and 32 reef ball arrays) could impact fish assemblages, which they did. However, those reefs did not have the variety of materials that the present study did. This study was focused on the type of material - not the quantity of material - in determining which was best suited for use in Sarasota Bay. We conclude that the deep covers serve as the best module to accommodate juvenile gag grouper in our estuary.

Finally, Flaherty-Walia et al. (2019) recently conducted a survey of several hardbottom habitats, including artificial reefs, in lower Tampa Bay. Data were collected by BRUVS deployed from the boat (as compared to diver deployed BRUVS in this study). That team, as part of the FWC FIM program, were interested in comparing their results with the traditional methods used by the FIM program throughout Florida's estuaries. Their results were limited to observations on fish species encountered during BRUVS deployments and were primarily used to augment fish species not typically found in traditional surveys. Their main conclusion regarding artificial reefs in lower Tampa Bay was that white grunts were found in higher abundance than on other hardened habitats (natural hardbottom and bridge pilings). They also concluded that habitat was more influential than season in determining fish structure. No other analyses of fish composition were presented. In the present study, numerous juvenile grunts and a few adult white grunts were observed at Walker's reef in March 2017 while a few juvenile grunts were observed at Hart's Family Reef during the same period. No grunts were observed during subsequent surveys.

4.4 Problems that Limited the Results of the Project

This project faced several obstacles over the course of the monitoring period. The first obstacle was water clarity within the Bay. All of our sampling was conducted during the late winter/early spring period when water clarity is typically best within the estuary. Warm water primary productivity within the water column during the rest of the year resulted in poor water clarity, making it impossible to meet the 1.8 m (6 ft) visibility requirement for this project. Even at times when visibility met the 6 ft threshold at Hart's and Walker's Reefs, visibility was reduced at Sportfish Angler's Club Reef, thus requiring the field crew to abandon the survey. Regular secchi depth readings were made near downtown Sarasota to ascertain if conditions were suitable for sampling (see Table 6 in Section 2.3.1). Only three occasions in December 2019 met the criteria for sampling this past year.

An extensive and prolonged red tide engulfed southwest Florida from October 2017 to February 2019. This episode was particularly severe within Sarasota Bay. Massive fish kills were observed and reported throughout the press and reflected in FIM sampling data (Tim MacDonald, personal communication). Discussions with the FWC project team led to the decision to cease sampling until fish communities rebounded in the Bay. The winter and spring sampling opportunity in 2019 was lost to this red tide event.

Finally, the coronavirus (COVID-19) pandemic hit the United States in late February/early March 2020 which, among other things, placed restrictions on travel and personal interactions. City of Sarasota boat ramps closed, and hotels and food services severely restricted. These precautions effectively prevented teams from conducting any field work during the spring and coincided with the expiration of the FWC grant associated with this project.

4.5 Recommendations for Future Artificial Reef Development in Sarasota Bay

The roving diver survey method was most appropriate in observing fish populations within and surrounding the artificial reef modules. Being mobile in limited visibility conditions enabled divers a better opportunity to observe and count fish. Future monitoring would benefit by increasing the survey sample size using the roving diver method. Additionally, visual surveys that provide an estimate of fish size would provide insight into the temporal scale of different size classes using these reef structures, particularly gag grouper which utilize estuarine habitats early in their life history.

Despite the reduced monitoring events due to the obstacles mentioned above, the Sarasota Bay Estuary Program intends to continue monitoring these artificial reefs - as well as additional bay reefs in Manatee County waters - for the next several years. We will use the same methods as the current project to maintain continuity. Data and findings from future monitoring will be shared with FWC and at regional and state artificial reef workshops and conferences. SBEP partnered with Taylor Engineering and Reef Innovations to design and build the next version of deep cover reef modules that would be easier to build and deploy. Appendix C shows the version SBEP selected for future deployments. SBEP will support twelve additional deep reef modules to be deployed at the six mid bay reefs.

Finally, the SBEP technical advisory committee has discussed and recommended collaborations with local fisheries programs (Mote Marine Laboratory, New College, UF IFAS Marine Extension) that tag and monitor fish movement throughout the estuary and coastal waters. These collaborations would involve tagging gag grouper found on these bay reefs and following their movements to the offshore reefs and fishery. This effort could reinforce that vital link between bay habitats and Gulf of Mexico fisheries, thus providing additional support for the importance and value of estuarine artificial reefs. The advances in reef module design will optimize these benefits to the fishery.

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Appendix A

Hyatt Survey Services, Inc. Surveyor's Report

Surveyor's Report

Survey #16-2068
Sarasota Bay Artificial Reefs
Hydrographic Survey
Sarasota County, Florida

Requested By:
CB&I
Boca Raton, Florida

Prepared By:
Hyatt Survey Services, Inc.
11007 8th Avenue East
Bradenton, Florida 34212
Phone #: (941) 748-4693
Licensed Business No. 7203

INTRODUCTION

This project is a hydrographic survey for CB&I in support of artificial reef monitoring in Sarasota County, Florida.

All survey data was collected in accordance with the technical requirements as provided by CB&I. Data was further constrained by technical requirements provided by USACE's Engineering Manual 1110-2-1003.

Data was collected with an Edgetech 6205 combined bathymetry and side scan sonar. The fieldwork for this survey was conducted from December 13-15th, 2016. The data was analyzed and processed from January 1-15th, 2017.

Horizontal and Vertical Datum, Control Monumentation

The scope of work required all monuments to be referenced to the North American Datum of 1983 (NAD83) 2011 adjustment, State Plane Coordinates, Florida West Zone.

NGS (National Geodetic Survey) control point designation "K 700" (PID DL1783) was utilized for the project. The control was recovered in good condition as noted.

METHODS AND PROCEDURES

Equipment: All upland data was collected with a Trimble 5700, 5800 or R8 dual-frequency GPS system with automated data collection (Trimble Survey Controller TSC2, or TSC3). Hydrographic survey data was collected with an Edgetech 6205 combined multibeam and side scan sonar system. All upland data was processed with Trimble Business Center, AutoCAD Civil 3D 2016. The multibeam bathymetry was processed with Hypack 2016 and the side scan sonar imagery was processed with Chesapeake Technologies Sonar Wiz.

Data Collection: Standard procedures defined in USACE EM 1110-2-1003 were followed during data collection. Patch tests were performed to calculate roll, pitch, yaw and latency corrections for multibeam bathymetry data collection. RTK GPS was used to calculate tide corrections. A tidal benchmark was set at the 10th Street Boat Ramp. This tidal benchmark was observed each day prior to data collection to ensure proper corrections were being received at the boat.

Data Processing: Hypack multibeam processing software (MBMAX64) and Chesapeake Technologies side scan processing software SonarWiz was used to process the data. The side scan deliverables were output to typical GIS files (PRJ, TFW, DBF, SHP and TIF) that should permit ease of use in traditional GIS software. Bathymetry was collected but not included in the deliverables.

Spatially Valid Data Cells (Cell Size = 0.5'x0.5')	
Walker's Reef	6813093
Hart's Family Reef	691288
Sportfish Angler's Club Reef	365490

PROJECT NOTES

Delays: No project delays were encountered.

Rights of Entry: General rights of entry were granted under FL Statute Title XXXII, Ch. 472.029.

Project Issues: No issues to report.

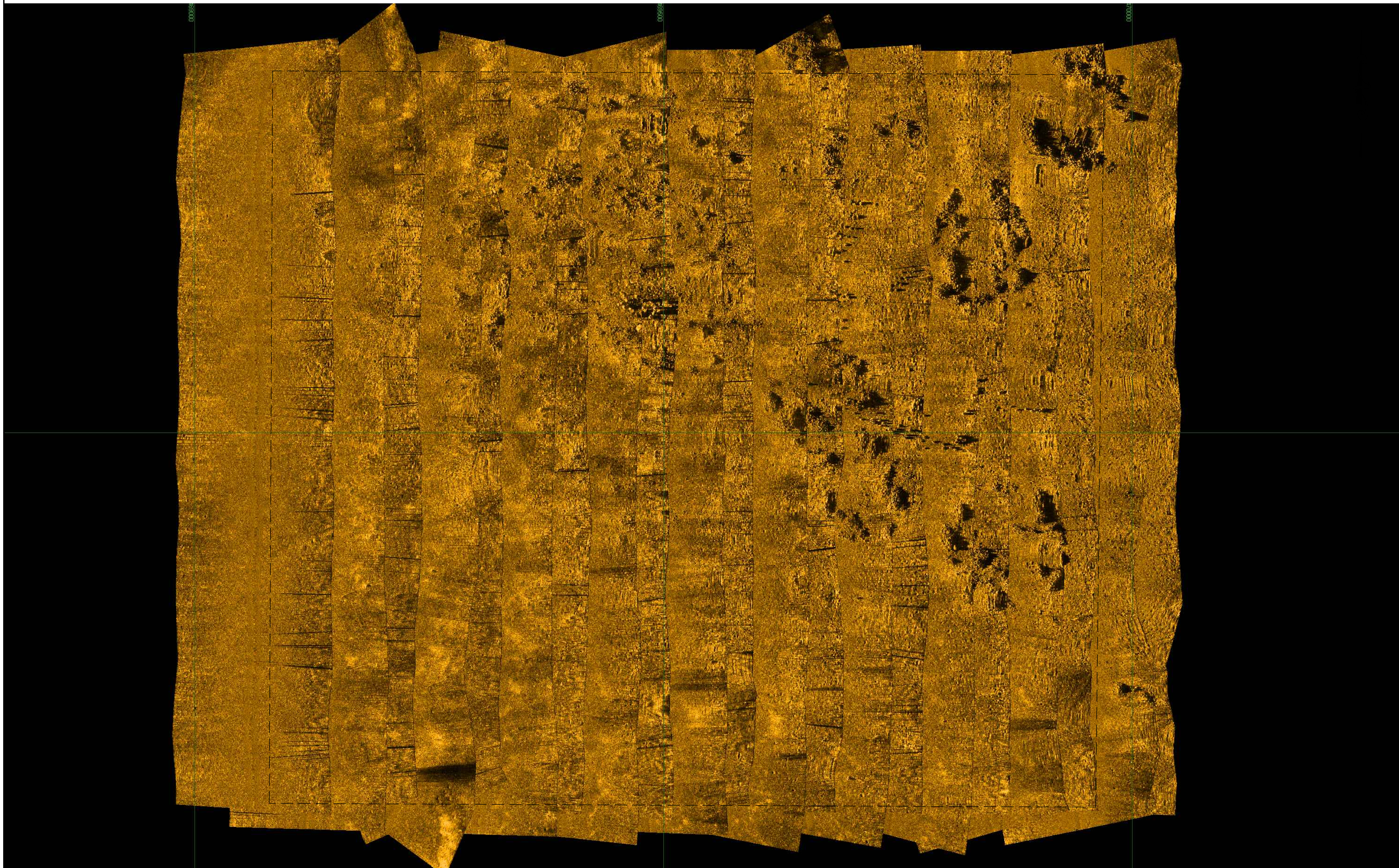
CERTIFICATION

This is to certify that this report and survey have been performed in accordance with the Minimum Technical Standards as set forth by the Florida Board of Surveyors and Mappers per Florida Administrative Code 5J-17 and USACE project requirements. The map associated with this report is by reference made a part hereof and the map is not valid without this report and vice versa.

Signed ______________________________ Date: 1/27/17 ______________

Shane Alan Christy, P.S.M. No. 7100

Not valid unless signed and sealed by a Florida Licensed Surveyor and Mapper



HYDROGRAPHIC SURVEY
SARASOTA BAY ARTIFICIAL REEF MONITORING
SARASOTA COUNTY, FLORIDA
HART'S FAMILY REEF - SIDE SCAN

NO.	REVISION DESCRIPTION	BY	DATE

PROJECT #	16-2068	
SURVEY #	16-2068	
SECTION TWN RNG		
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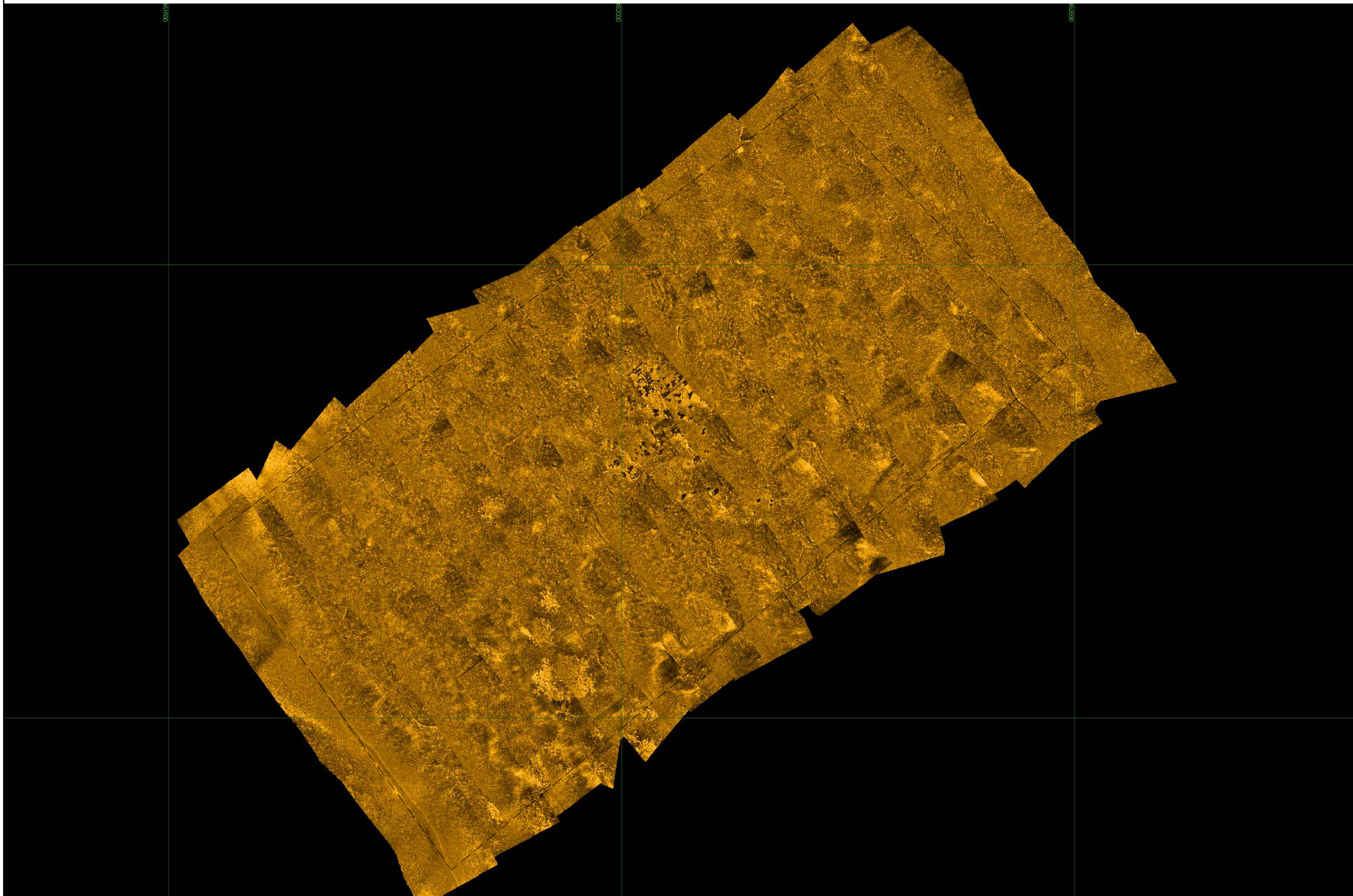
SURVEYED	HYATT	12/2016
DESIGNED		
DRAWN	SC	
CHECKED	RH	

SHEET 1 OF 4



HYDROGRAPHIC SURVEY
SARASOTA BAY ARTIFICIAL REEF MONITORING
SARASOTA COUNTY, FLORIDA
SPORTFISH ANGLER'S CLUB REEF - SIDE SCAN

NO.	REVISION DESCRIPTION	BY	DATE

PROJECT #	16-2068
SURVEY #	16-2068
SECTION TWN RNG	
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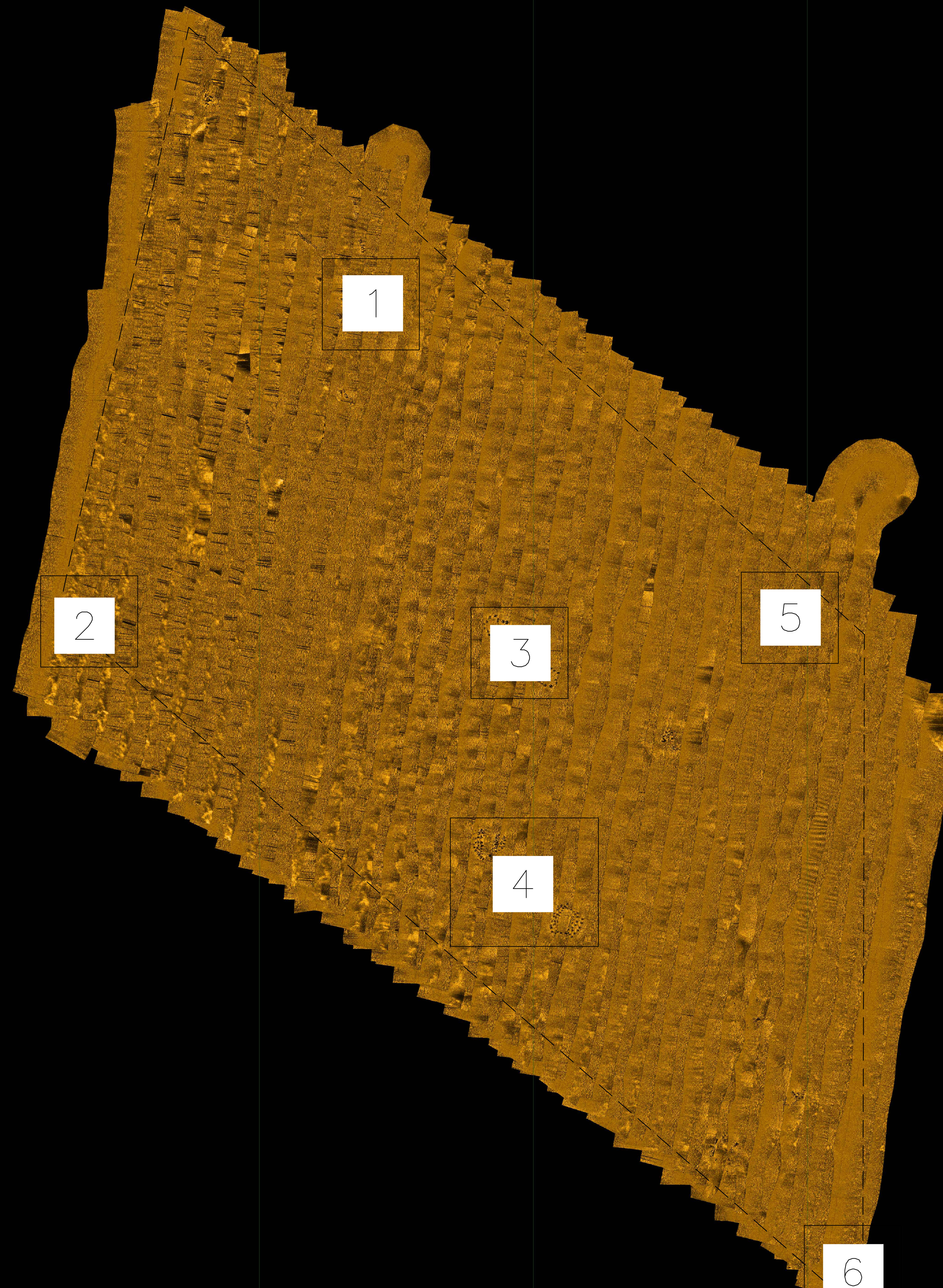
SURVEYED	HYATT	12/2016
DESIGNED		
DRAWN	SC	
CHECKED	RH	

SHEET 2 OF 4



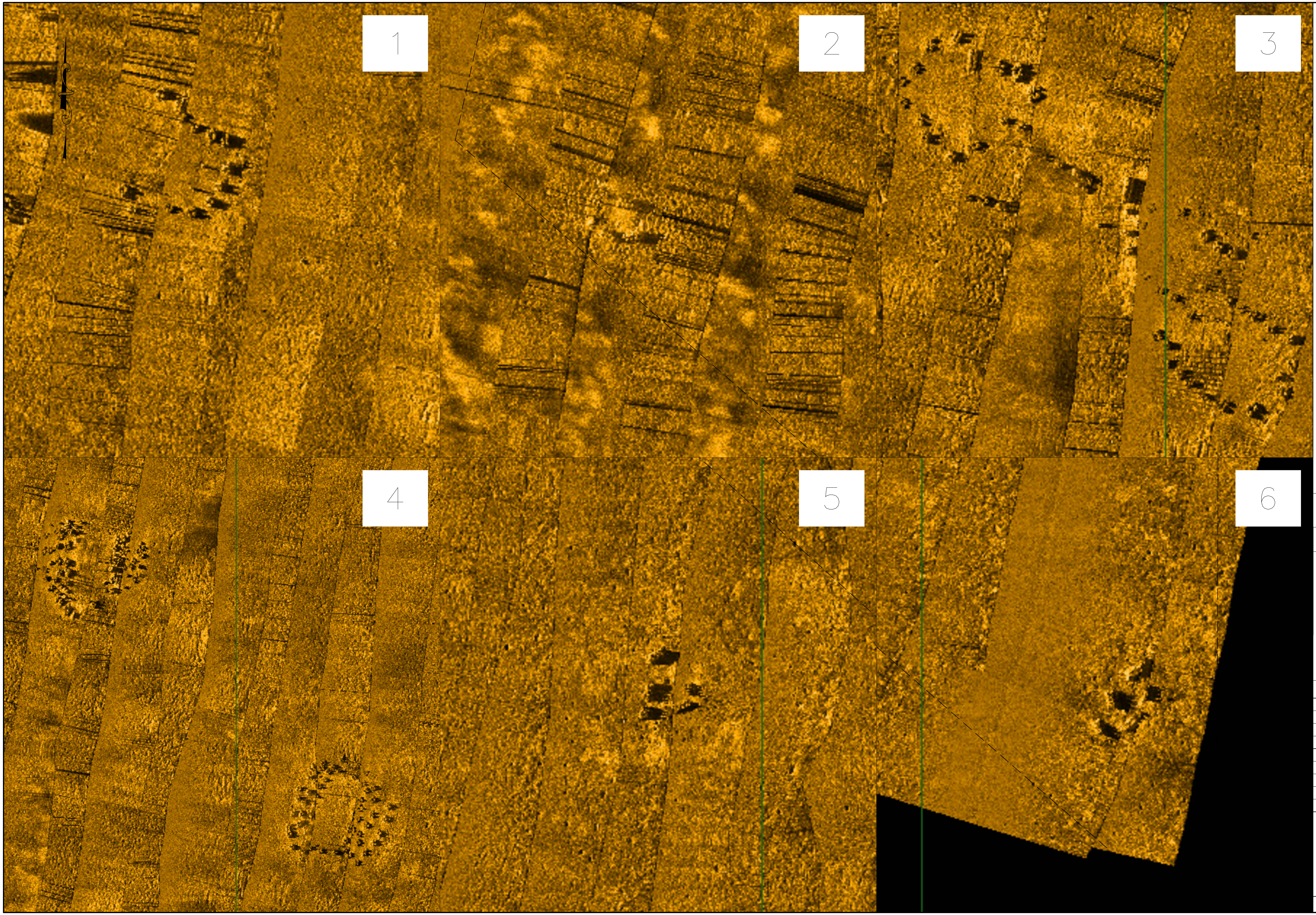
HYDROGRAPHIC SURVEY
SARASOTA BAY ARTIFICIAL REEF MONITORING
SARASOTA COUNTY, FLORIDA

WALKER'S REEF - SIDE SCAN

NO.	REVISION DESCRIPTION	BY	DATE

PROJECT #	16-2068	
SURVEY #	16-2068	
SECTION TWN RNG		
SCALE	1" = 250'	
SURVEYED	HYATT	12/2016
DESIGNED		
DRAWN	SC	
CHECKED	RH	

SHEET 3 OF 4



HYDROGRAPHIC SURVEY
SARASOTA BAY ARTIFICIAL REEF MONITORING
SARASOTA COUNTY, FLORIDA

WALKER'S REEF - SIDE SCAN

NO.	REVISION DESCRIPTION	BY	DATE

PROJECT #	16-2068
SURVEY #	16-2068
SECTION TWN RNG	
SCALE	1" = 30'

SURVEYED	HYATT	12/2016
DESIGNED		
DRAWN	SC	
CHECKED	RH	

SHEET 4 OF 4

Appendix B

Representative Photographs of the Deployed BRUVS Units

Representative Photographs of the Deployed BRUVS Units

Hart's Family Reef

Figure 1. Hart's Family Reef - BRUVS1 site.

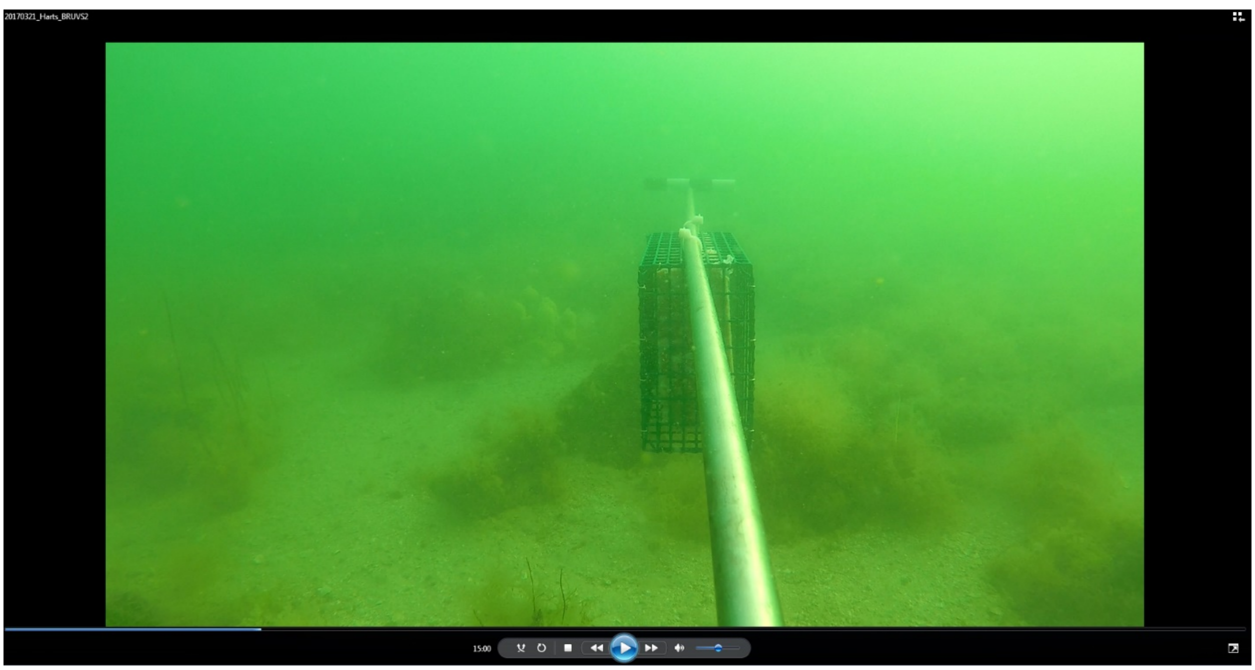


Figure 2. Hart's Family Reef – BRUVS2 site.

Figure 3. Hart's Family Reef – BRUVS3 site.

Sportfish Angler's Club Reef

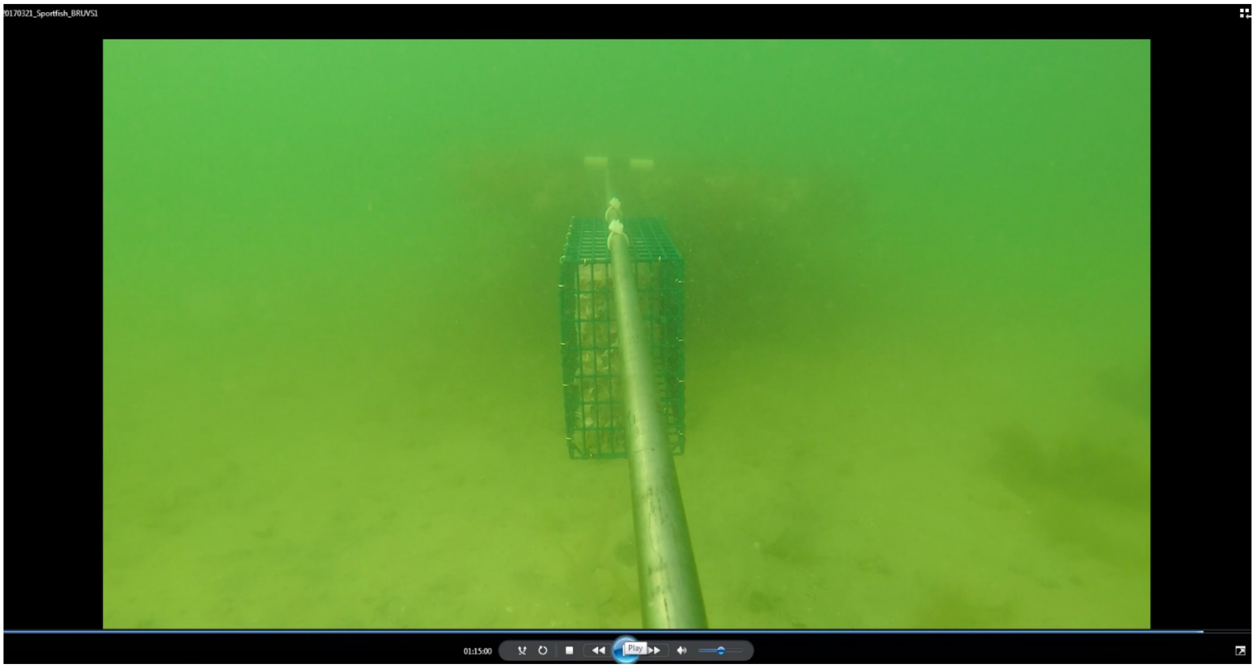


Figure 4. Sportfish Angler's Club Reef - BRUVS1 site.

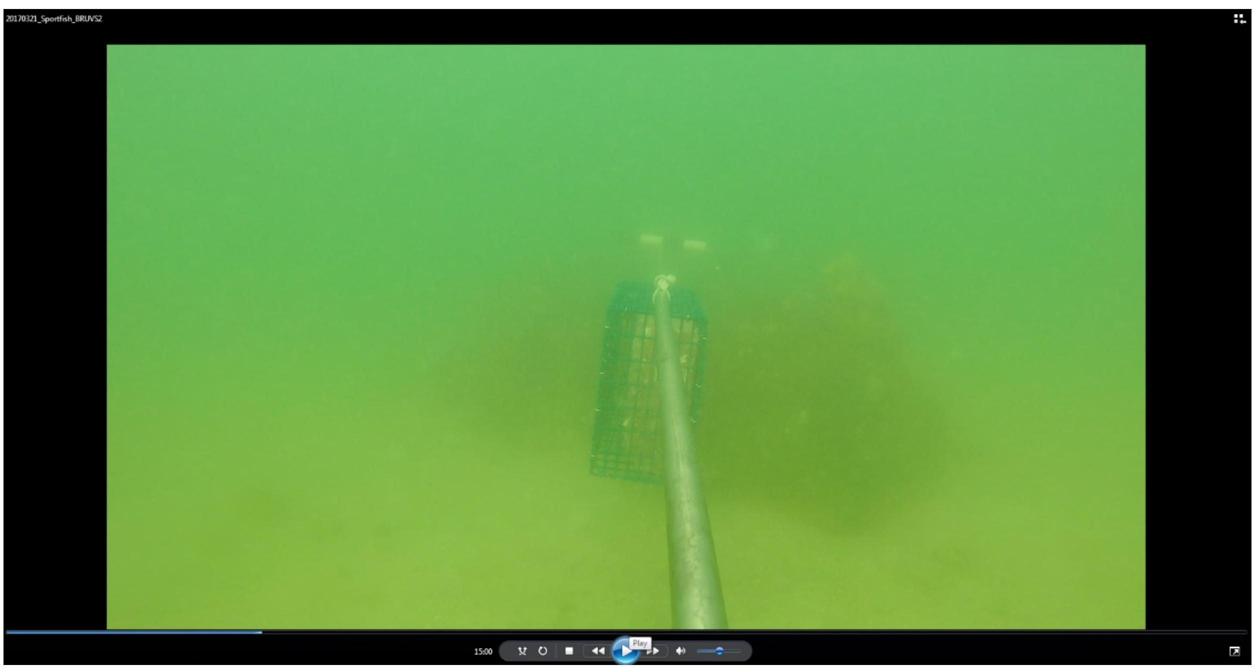


Figure 5. Sportfish Angler's Club Reef – BRUVS2 site.

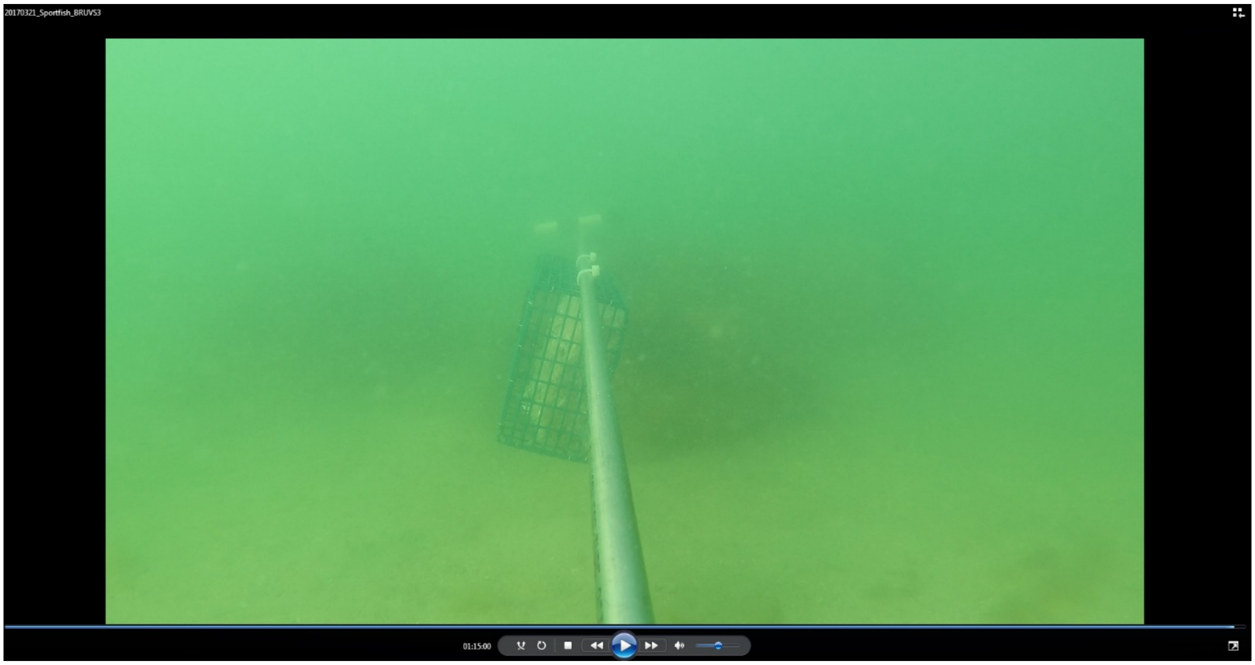


Figure 6. Sportfish Angler's Club Reef – BRUVS2 site.

Walker’s Reef

Figure 7. Walker's Reef - BRUVS1 site.

Figure 8. Walker's Reef - BRUVS2 site.

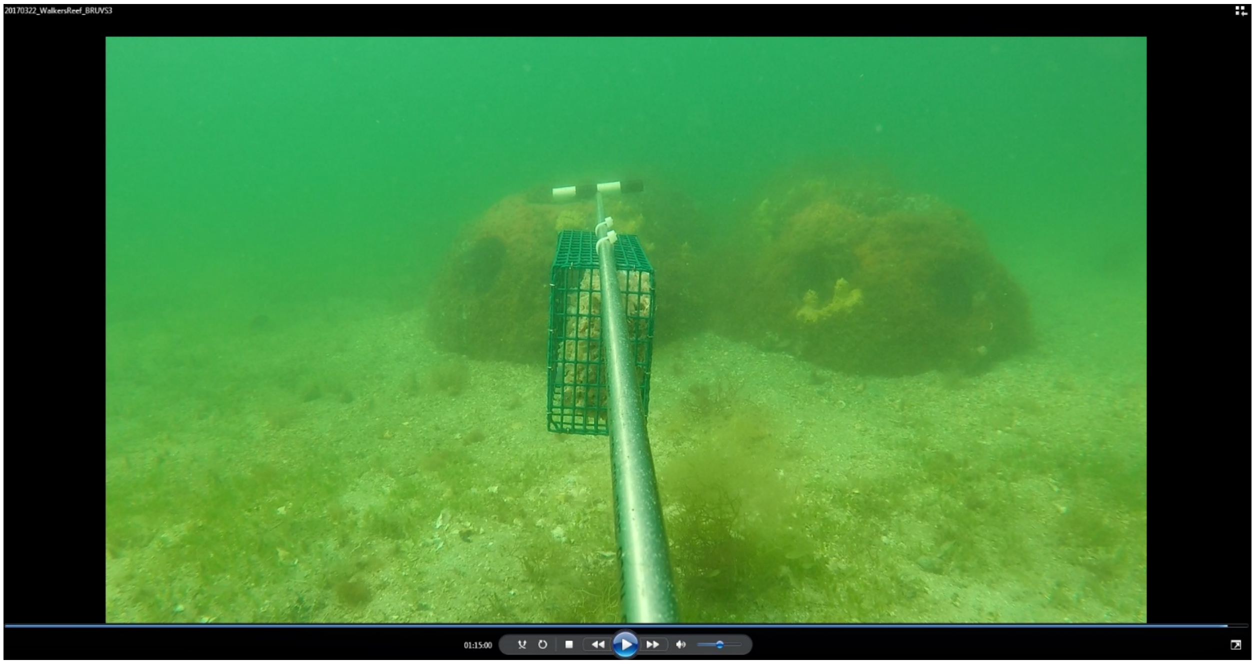
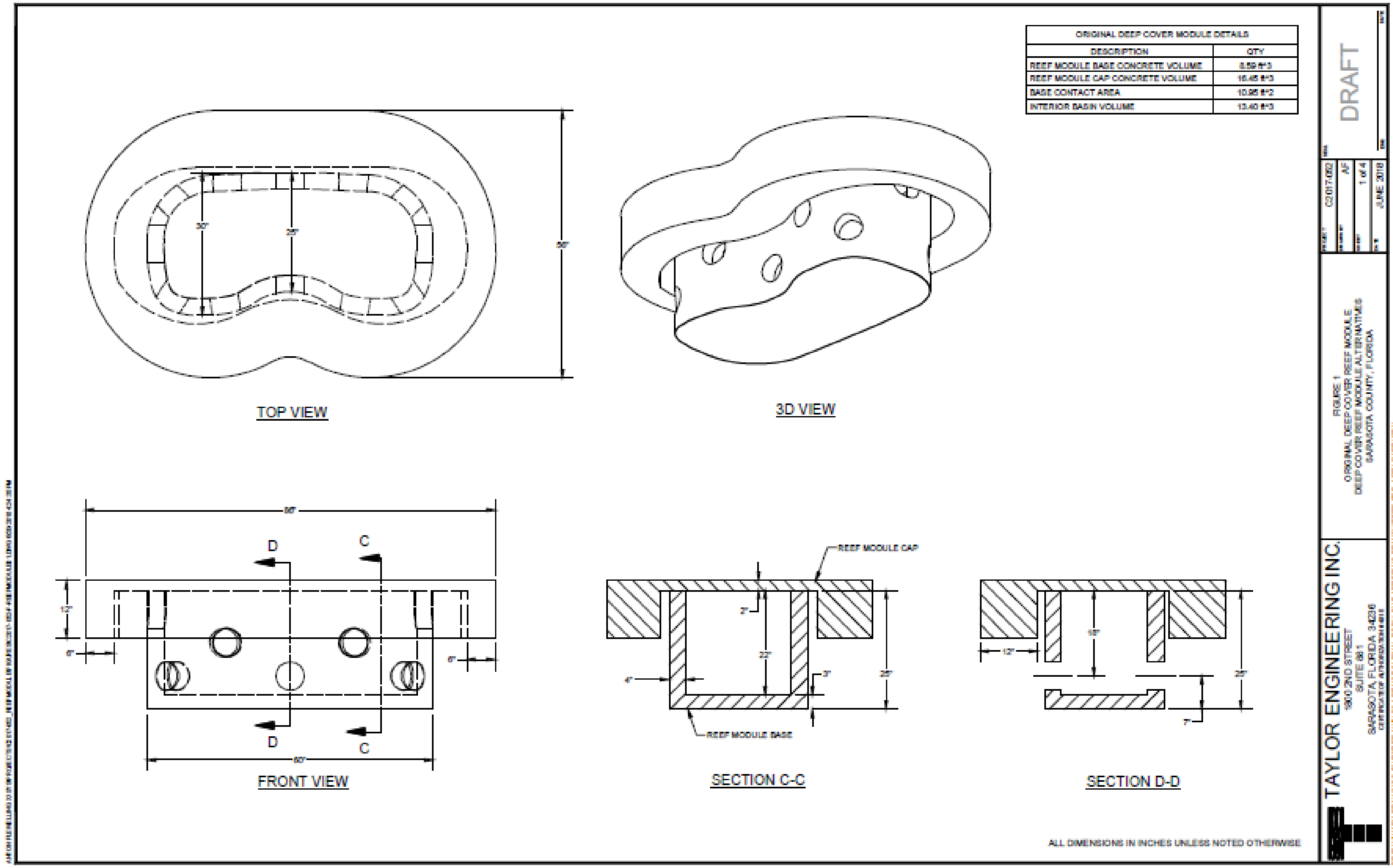


Figure 9. Walker's Reef - BRUVS2 site.

Appendix C

Deep Cover Reef Module (Version 2)



ORIGINAL DEEP COVER MODULE DETAILS	
DESCRIPTION	QTY
REEF MODULE BASE CONCRETE VOLUME	8.59 ft^3
REEF MODULE CAP CONCRETE VOLUME	16.45 ft^3
BASE CONTACT AREA	10.95 ft^2
INTERIOR BASIN VOLUME	13.40 ft^3