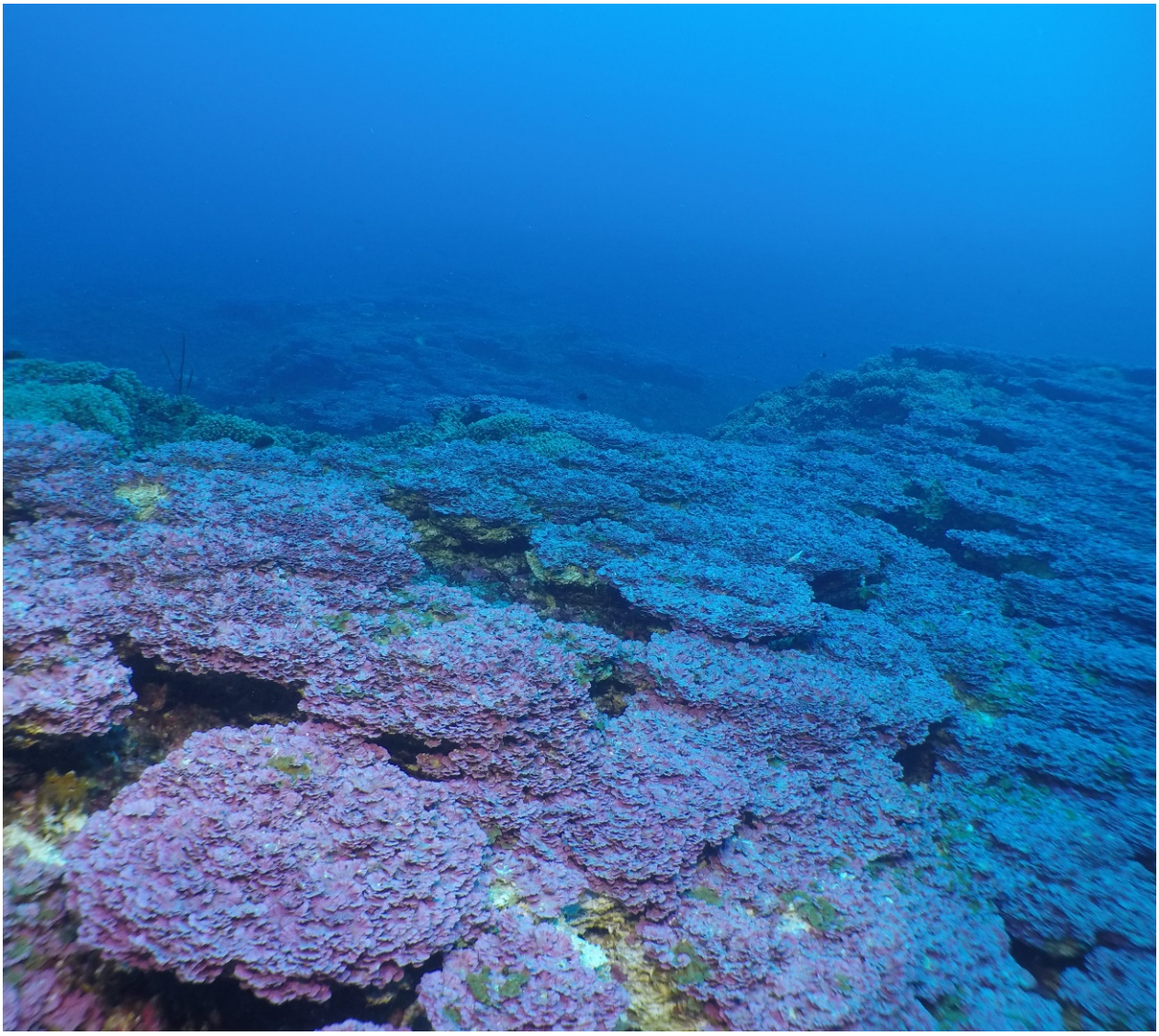
Office of National Marine Sanctuaries
National Oceanic and Atmospheric Administration

FLOWER GARDEN BANKS NATIONAL MARINE SANCTUARY

Flower Garden Banks National Marine Sanctuary 2019 Research and Monitoring Report



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The purpose of this document is to report the activities of the Flower Garden Banks National Marine Sanctuary Research Team during Fiscal Year 2019.

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Cover Photo:
A dense crustose coralline algae reef discovered and explored at East Flower Garden Bank during the FGBNMS/Global Foundation for Ocean Exploration Telepresence Expedition in August, 2019. Photo: GFOE/NOAA

Disclaimer

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Report Availability

Electronic copies of this report may be downloaded from the Flower Garden Banks NMS website at https://flowergarden.noaa.gov

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FY 2019 HIGHLIGHTS

Overview

The research team at Flower Garden Banks National Marine Sanctuary (FGBNMS) was involved in 17 research cruises and expeditions during the 2019 field season (Oct. 1, 2018 – Sept. 30, 2019). The sanctuary research vessel, R/V *Manta*, was utilized by the research team for a period of 46 days to conduct the operations. A pool of 23 sanctuary personnel and volunteers, and seven reciprocity divers, conducted 560 scuba dives. Twenty percent of the dives were conducted by reciprocity divers. Activities included biological surveys and sample collection, equipment installation and maintenance, telepresence, mosaic development, manta ray tagging, image collection, sea turtle releases, and dive safety training. Nine sanctuary permits were processed, and an additional thirteen were/are ongoing.

Figure 1. This multidisciplinary research team worked together to conduct a manta ray tagging expedition. A satellite tag was successfully attached to a manta ray by the team, and unmanned aerial systems were tested for manta surveys. L-R (back) - Josh Stewart (Manta Trust), Todd Jacobs (NOAA Unmanned Aircraft System Program), G.P. Schmahl (FGBNMS), John Carlson (NOAA/SEFSC), Nick Farmer (NOAA/SERO), Emma Hickerson (FGBNMS), David McBee (FGBNMS Volunteer Diver), Nick Garrett (Planck UAS technician), Captain Justin Blake (R/V MANTA), Diego Gil Agudelo (FGBNMS Volunteer Diver/TAMUG), L-R (front) – Dylan Stewart (R/V MANTA), Jason Marquis (Planck UAS technician), Josh Harvey (R/V MANTA). Photo: NOAA

Development of Reef Mosaic Imagery East Flower Garden Bank Study Site

Scientists and divers from Flower Garden Banks National Marine Sanctuary (FGBNMS), the NOAA Dive Center, and the University of Miami (UM) Physics Department, partnered to capture high-resolution underwater landscape photomosaic images (Figure 2) of the long-term monitoring study site at East Flower Garden Bank (EFGB) on June 27-28, 2019. In the field, divers swam above the reef capturing areal reef images of the 100 x 100 meter monitoring site. Scientists from UM processed the images to create a highly accurate reef mosaic. Unfavorable weather conditions did not allow operations at West Flower Garden Bank (WFGB), so the work at that second bank will be rescheduled for a future date. The mosaics (Figure 3) provide a snapshot in time of currently healthy FGBNMS long-term monitoring (LTM) study sites, allowing researchers to detect potential changes within the sites (e.g. hurricanes, coral mortality and impacts from bleaching). The images will also serve as education/outreach tools so the public can interact with the research site and visualize a reef area of high percent coral cover. The mosaic can be explored at: web2.physics.miami.edu/~agleason/mosaic_results/fgb2019/index.html

This project was completed in partnership with University of Miami.

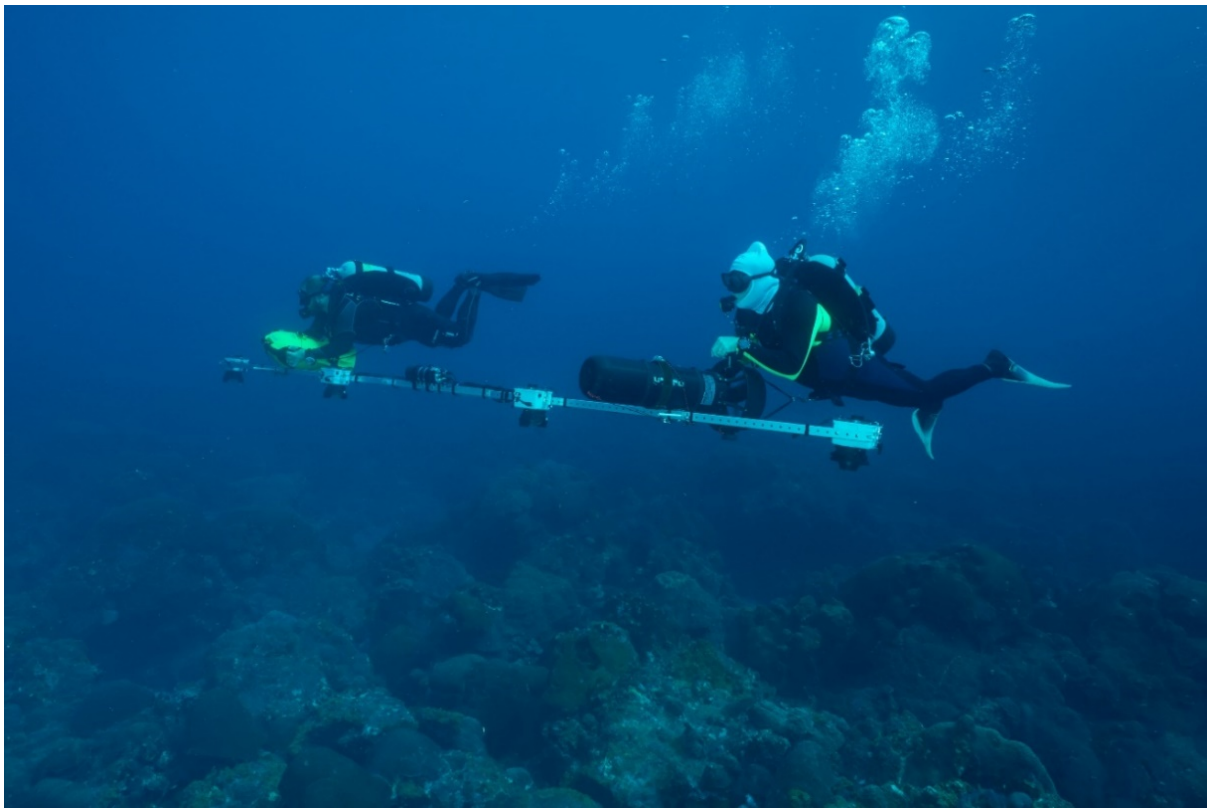

Figure 2. Divers use underwater propulsion vehicles attached to a camera array to capture downward facing images of the reef at East Flower Garden Bank. Photo: G.P. Schmahl/NOAA

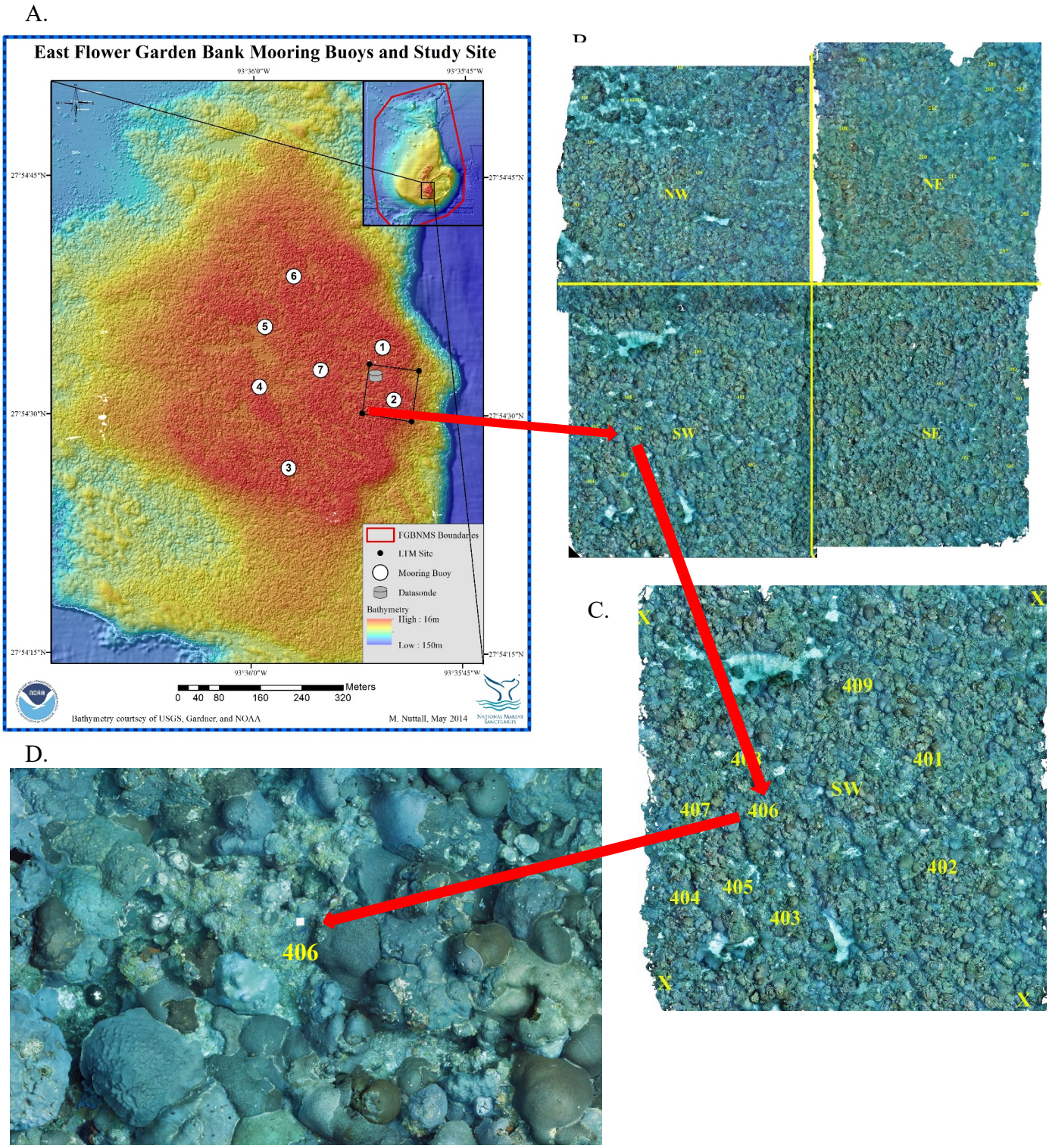

Figure 3. East Flower Garden Bank photo mosaic schematic. A. Map of East Flower Garden Bank (EFGB) coral cap showing location of buoys, and study site; B. Compilation of four quadrants of the photomosaic of the EFGB study site; C. Photomosaic of just the southwest (SW) quadrant of the EFGB study site, showing location of repetitive photostations; D. Repetitive photostation 406 in the SW quadrant of the EFGB study site. Image: UM/NOAA

Global Foundation for Ocean Exploration – Telepresence Cruises

Flower Garden Banks National Marine Sanctuary partnered with Global Foundation for Ocean Exploration (GFOE) to conduct three telepresence cruises. This is the first time FGBNMS has conducted telepresence on board the R/V *Manta*. Funded by the Office of National Marine Sanctuaries, the primary goal of the mission was to use GFOE's remotely operated vehicle (ROV) *Yogi* and portable VSAT to demonstrate the ability to perform live-broadcast ROV telepresence missions from a coastal class research vessel, and to collect a variety of imagery, including 4K video and GoPro still images, as well as some biological samples. Three research partners conducted separate cruises with different focus subjects. The dives were streamed live over the internet to the world, and to specific events and locations. The public were able to submit questions to the researchers and technicians through the GFOE website. Several Facebook Live sessions were conducted, and several point to point live interactions were also scheduled with partners, including Moody Gardens, in Galveston, Texas, and the Tennessee Aquarium in Knoxville, Tennessee.

Cruise 1 – Dr. Josh Voss – Florida Atlantic University (FAU)/Harbor Branch Oceanographic Institute (HBOI)

Coral Reef Biodiversity and Connectivity

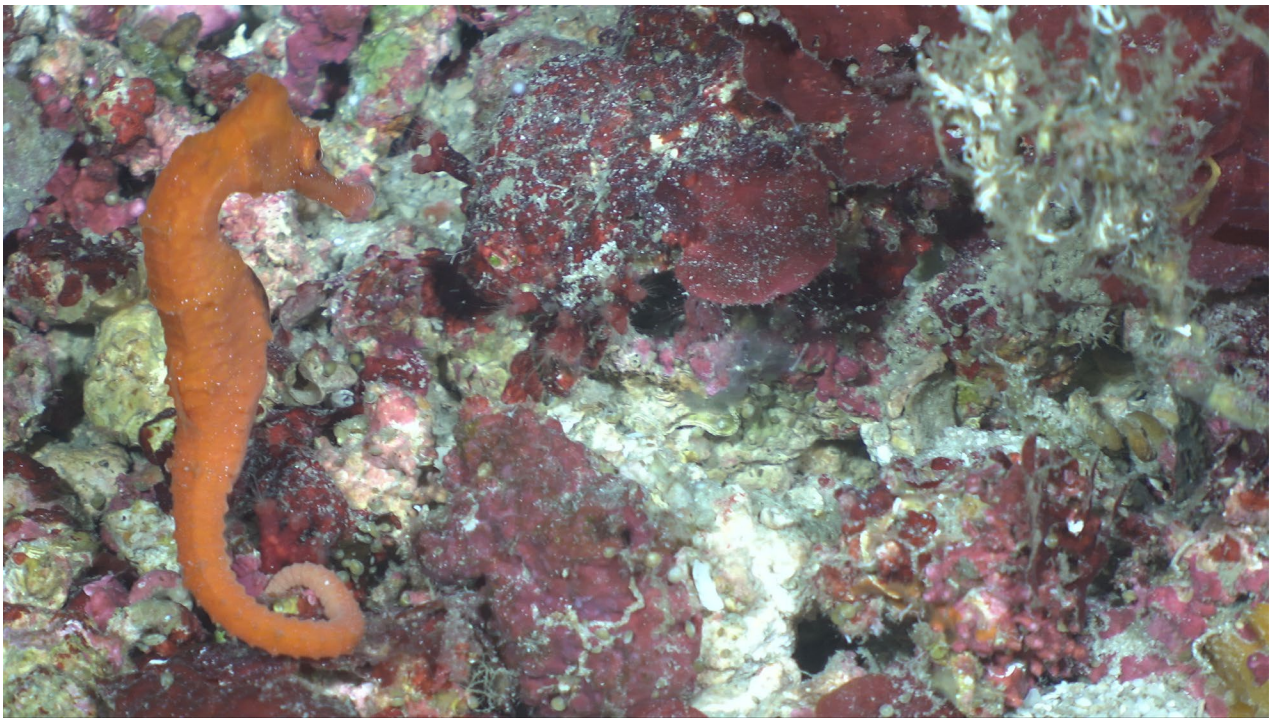

Figure 4. A longsnout seahorse was encountered at McGrail Bank during the first GFOE cruise. This is the first seahorse the FGBNMS team has seen during ROV dives. Photo: GFOE/NOAA

Objectives:

1. Conduct quantitative benthic and fish transects, including sampling of unknown or poorly-described sponge species for taxonomic verification.
2. Compare transect data collected during this project to data collected in 2010-2015 to assess potential changes in benthic and/or fisheries resources.
3. Quantify and characterize coral and sponge diseases and bleaching in FGBNMS.
4. Assess horizontal and vertical genetic connectivity among subpopulations of *Montastraea cavernosa* corals and *Xestospongia muta* sponges in the northwestern Gulf of Mexico (NWGOM), using high throughput sequencing analyses.
5. Conduct targeted scientific operations and education programs through Harbor Branch's Exploration Command Center during the cruises.

Cruise Accomplishments:

A team from Florida Atlantic University's Harbor Branch Oceanographic Institute, led by Dr. Joshua Voss, joined FGBNMS Superintendent G.P. Schmahl and partners from GFOE aboard the R/V *Manta* for a week of ROV exploration in the NWGOM. Throughout the first cruise the team explored and characterized mesophotic coral ecosystems on Alderdice Bank, McGrail Bank, Sonnier Bank and Geyer Bank, all under consideration for sanctuary expansion. The team streamed live ROV dives each day, and conducted live interactions with the Marine and Oceanographic Academy (MOA) at HBOI, as well as Moody Gardens Aquarium in Galveston, Texas. In addition to these technology demonstrations, HBOI researchers collected video transects for comparison to previous surveys on these banks conducted by FAU Harbor Branch through the Cooperative Institute for Ocean Exploration, Research, and Technology. Finally, the team tested the sampling abilities of ROV *Yogi*, collecting samples of sponges, hard corals, and black coral for use in genetic connectivity analyses throughout the NWGOM and tropical western Atlantic.

Cruise-Related Presentations & Public Outreach:

- Exploring by the Seat of Your Pants presentation: Exploring Coral Reef Biodiversity and Connectivity in Flower Garden Banks National Marine Sanctuary

Cruise 2 – Dr. Sarah Davies – Boston

University Coral Spawning

Objectives:

1. Collect 8 fragments of *Orbicella faveolata* corals from mesophotic depths at the East Flower Garden Bank (EFGB). Maintain the samples in a flow-through system on the top deck of the R/V *Manta*.
2. Document the timing and synchrony of annual broadcast spawning behavior of reef-building corals (*O. faveolata, O. franksi, Pseudodiploria strigosa, Montastraea cavernosa* and *Stephanocoenia intersepta*) inhabiting mesophotic depths at the FGBNMS.
3. Quantify the rate of gamete bundle ascent from mesophotic depths to shallower depths to determine the probability of gamete exchange across reef depths. Utilize ROV footage and basic video analysis tools to estimate the rate of gamete bundle ascent. Combined with the data on spawning time and depth, model the probability of gamete exchange across depths in surface waters at the FGBNMS. (Figure 6)

Figure 5. ROV *Yogi* uses the manipulator to collect coral samples East Flower Garden Bank. Photo: GFOE/NOAA

Cruise accomplishments:

Eight fragments of *O. faveolata* were successfully collected (Figure 5) from mesophotic depths (45-55m) using the ROV manipulator (a collection permit was issued by FGBNMS to conduct this activity). All colonies were collected during a day dive and were safely brought back to the surface. These colonies were maintained in a flow-through system on the deck of the R/V *Manta* throughout the duration of the trip. Upon arrival to shore, colonies were transported to Moody Gardens for overnight maintenance and then they were flown to Boston University where they were placed into the Davies Lab's Marine Invertebrate Research Facility. Colonies looked fairly unhealthy upon arrival, however after careful husbandry, these colonies are now all fully symbiotic and show evidence of tissue building. The Davies Lab is planning to conduct thermal performance experiments on these colonies to compare their performance to the shallow water colonies that are already maintained in the lab.

Cruise-Related Presentations & Public Outreach:

- Two cruise blogs: Monitoring coral spawning beyond recreational dive limits on the Flower Garden Banks (The Research Coordinated Network for Evolution in Changing Seas) and https://reefbites.wordpress.com/2018/06/19/mesophotic-corals-looking-to-the-deep-for-a-shallow-reef-safety-net/ (International Coral Reef Institute Reefbites blog)

- Exploring by the Seat of Your Pants presentation: Exploring Coral Spawning in Flower Garden Banks National Marine Sanctuary

Figure 6. A male *Montastraea cavernosa* spawning, in mesophotic depths, during a *Yogi* dive at East Flower Garden Bank. Photo: GFOE/NOAA

Cruise 3 – Dr. Mercer Brugler – City University New York

Black Corals

Objectives:

1. Using the ROV, collect any new species of black coral that are encountered in reefs and banks of the NWGOM.
2. Select one black coral to conduct whole genome and transcriptome sequencing, as there are currently no published black coral genomes or transcriptomes.
3. Swab one representative of each black coral species (or multiple individuals if they are found at significantly different depths) to understand their microbiome.
4. Collect sponges as directed, including several potentially undescribed species of sponges.

Figure 7. A potentially new genus and species of black coral was sampled during Leg 3. Photo: GFOE/NOAA

Cruise accomplishments:

Sampling between 60-148 meters depth, the team collected 37 black coral colonies across four of the FGBNMS proposed expansion sites (Parker, Alderdice, Elvers, and Geyer Banks). Based on morphology (which can be misleading as black corals are known to exhibit convergent evolution), the team believes it collected 17 *Elatopathes abietina*, 7 *Antipathes furcata,* 3 *A. atlantica, 3 Tanacetipathes sp.,* 3 *Acanthopathes thyoides,* 1 *Acanthopathes cf thyoides*, and 1 *Stylopathes*

cf litocrada colonies. Also collected were two juvenile black corals that were too small to be accurately identified.

There are currently no published black coral genomes or transcriptomes. Prior to selecting a specific species of black coral for whole genome and transcriptome sequencing, the team will be verifying the morphology-based identifications using molecular barcoding techniques. Once all of the identifications are confirmed, we will revisit the DNA extractions to determine which extraction yielded the highest molecular weight DNA. The Brugler lab will then proceed with RNA extraction using RNA later-preserved tissue from the same specimen.

The team collected a minimum of three different individual colonies for the following black corals: *Elatopathes abietina*, *A. furcata*, *A. atlantica*, *Tanacetipathes* sp., and *Acanthopathes thyoides*. Dr. Brugler is currently recruiting additional undergraduates to help complete the geome and transcriptome sequencing and has a meeting scheduled with Sarah Soden, a representative from the research company Genewiz to discuss pricing related to their Amplicon-EZ service.

Cruise Highlights:

Cruise 3 included two underrepresented minority students from New York City College of Technology, which is part of the City University of New York. The students were Eliza Gonzalez, an undergraduate from Puerto Rico, and Craig Dawes, a postbac from Jamaica. All post-cruise molecular analyses are being conducted by underrepresented minorities in Dr. Brugler's deep-sea molecular lab at the American Museum of Natural History (AMNH).

One *Acanthopathes cf thyoides* colony was collected that presented a unique colony morphology and thus might be an undescribed species (molecular barcoding ongoing).

The most exciting find was a single black coral colony (Figure 7) that was preliminarily identified (based on morphology) as *Stylopathes cf litocrada*. This genus has not been previously reported from FGBNMS, but *Stylopathes litocrada* is known from the northern Gulf of Mexico (Green Canyon, which is off the Louisiana coast; bathymetric range: 91-380m). Preliminary DNA sequencing revealed that its genetic signature is significantly different from *S. litocrada* and thus could represent a new genus and species.

The team also came across a very unusual anthozoan (Figure 8) while exploring Alderdice Bank (at 87 meters depth). The animal could not be identified *in situ*, but once it was collected using the slurp gun, the anthozoan uncontracted and revealed itself to be a berried sea anemone, which is known to harbor highly toxic stinging cells (nematocysts). The sample was tentatively identified as *Alicia cf mirabilis*, but this particular species is only known from the eastern Atlantic Ocean, the Mediterranean, and the Red Sea. Thus, it most likely represents an undescribed species. Given the excitement surrounding the berried sea anemone both on social media and at the AMNH, Dr. Estefania Rodriguez (Curator of Marine Invertebrates at AMNH) is

seeking funding to sequence the complete genome and transcriptome of this animal in hopes of identifying novel venom genes.

Figure 8. Berried sea anemone, sampled during the third GFOE cruise, at Geyer Bank. Photo: GFOE/NOAA

During the last dive of the cruise, at Geyer Bank, the team came across several large starfish (Phylum Echinodermata) that were actively spawning through small holes in their legs (Figure 9). The starfish were using their arms to raise their central disc high off of the substrate; the only anatomical structure that was touching the substrate was the tips of their arms. While small brittle stars have been filmed spawning in FGBNMS, to our knowledge, this behavior has not been previously documented in these larger starfish. Additionally, the brittle stars spawn through small openings along the sides of their central disks, not along their arms.

Several potential new species of sponge, as well as starfish that had seven arms, as opposed to the typical five arms, were collected. All samples were sent to Shirley Pomponi and Cristina Diaz at Harbor Branch Oceanographic Institute at Florida Atlantic University for processing. A number of marbled grouper, a “species of concern” in the FGBNMS region, were also encountered during the third cruise.

Figure 9. *Linckia* seastars spawning at Geyer Bank. Photo: GFOE/NOAA

Cruise-Related Presentations & Public Outreach

- School of Oceans & Atmosphere Colloquium presentation at Stony Brook University (SUNY).
- SciChat: Exploring the Deep Sea presentation at the American Museum of Natural History's Hall of the Universe. (Audience included ~150 middle school students and their caregivers.)
- Fall 2019 Bi-Annual Undergraduate Research Mixer presentation at NYC College of Technology's (CUNY).
- Mysteries of the Ocean presentation at Felicity House (a free social community space just for women with autism).
- Biology Colloquium presentation at Queens College (CUNY).

- Exploring by the Seat of Your Pants presentation: Exploring for Black Corals in Flower Garden Banks National Marine Sanctuary
- Twitter Post: A photo of *Stylopathes cf litocrada* was viewed 1,670 times.
- Twitter Posts: Contracted berried anemone was viewed 1,254 times and Relaxed/extended berried anemone was viewed 2,809 times.
- LSAMP (New York City Louis Stokes Alliance for Minority Participation) Research Mentor Workshop; *Undergraduate Student Perspectives* presentation at NYC College of Technology (CUNY) by student Eliza Gonzalez about her GFOE cruise experience.

Figure 10. This was only the second time FGBNMS documented a rare Maori basslet,(*Lipogramma schrieri*) in the NWGOM (Elvers Bank, 153m/502ft). The first sighting was reported in the 2018 research report, from Geyer Bank, at 141m/462ft. Photo: GFOE/NOAA

Cruise-Related Publicity

- CUNY TV show featuring undergraduates Eliza Gonzalez and Craig Dawes, and highlighting their experience of the third GFOE cruise.

- CUNY Matters article featuring Eliza Gonzalez and Craig Dawes: City Tech Prof and His Students Share the Down-low on Corals in the Gulf of Mexico. (Figure 11)

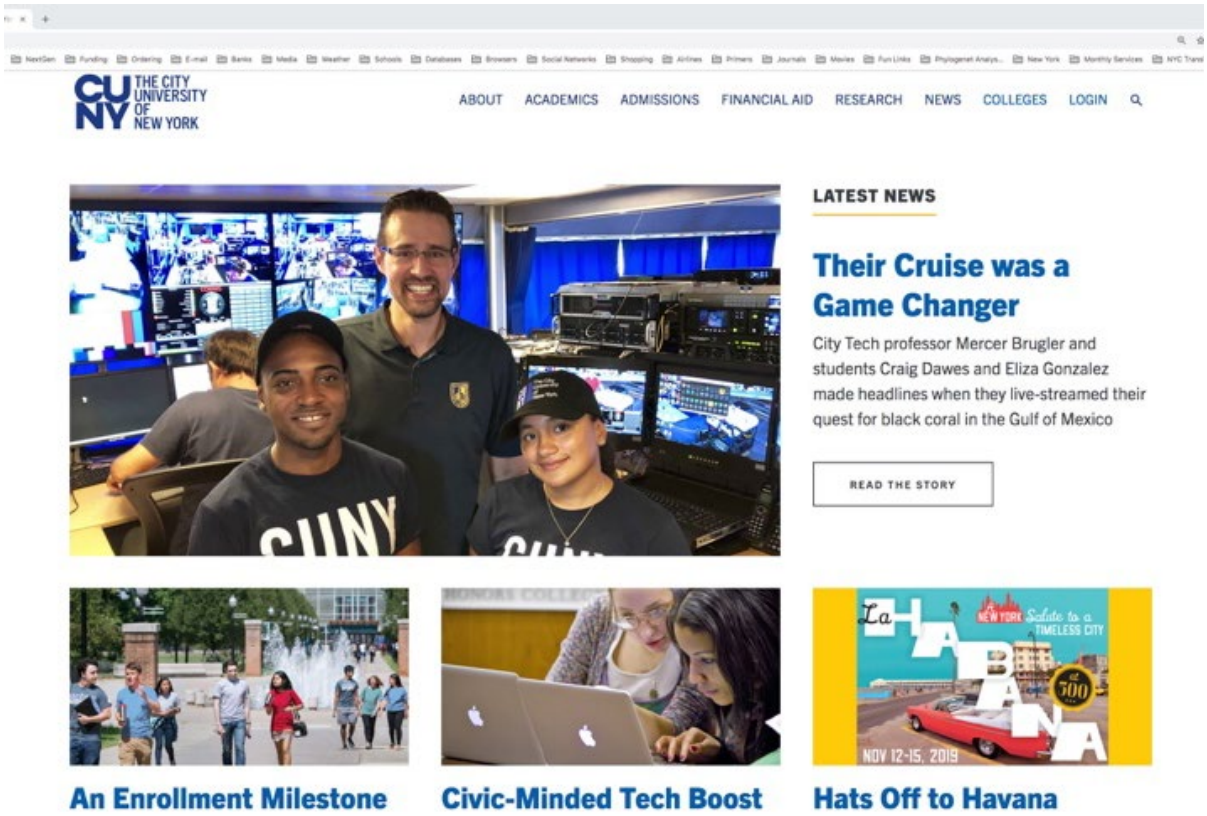

Figure 11. A City University of New York Matters article with Eliza Gonzalez and Craig Dawes was featured on the CUNY website home page. Image: CUNY

Installation of Ocean Acidification Buoy

FGBNMS and Texas A&M University (TAMU) installed an oceanographic buoy dedicated to measuring conditions related to ocean acidification at East Flower Garden Bank, with the information served online by TAMU. The 500 pound surface buoy array is outfitted with solar arrays for power, underwater sensors for collecting sea surface information, and above water sensors for meteorological data, and satellite communications. The seafloor package includes sensors measuring temperature, salinity, depth, turbidity, colored dissolved organic matter (CDOM), chlorophyll, dissolved oxygen (DO2), pH, photosynthetic active radiation (PAR), and partial pressure of carbon dioxide (PCO2), as well as an acoustic modem to deliver the data to the surface (Figure 12). The buoy was lowered into the water off the edge of R/V *Manta* before lowering the 2000 pound stacked railroad wheel anchor into place in a targeted sand flat. A team on the rigid hulled inflatable boat supported the operation by tending the buoy as the anchor was put in place. Divers fine-tuned the location of the anchor package, and also installed the seafloor sensor array. This was an extremely complicated operation, supported by a tremendous team effort and high level of professionalism and expertise on the part of the R/V *Manta* crew and FGBNMS dive team, as well as the TAMU oceanographers and technicians. This project is a partnership with TAMU Department of Oceanography, and Geochemical and Environmental Research Group (GERG), funded by Bureau of Ocean Energy Management (BOEM) and Shell.

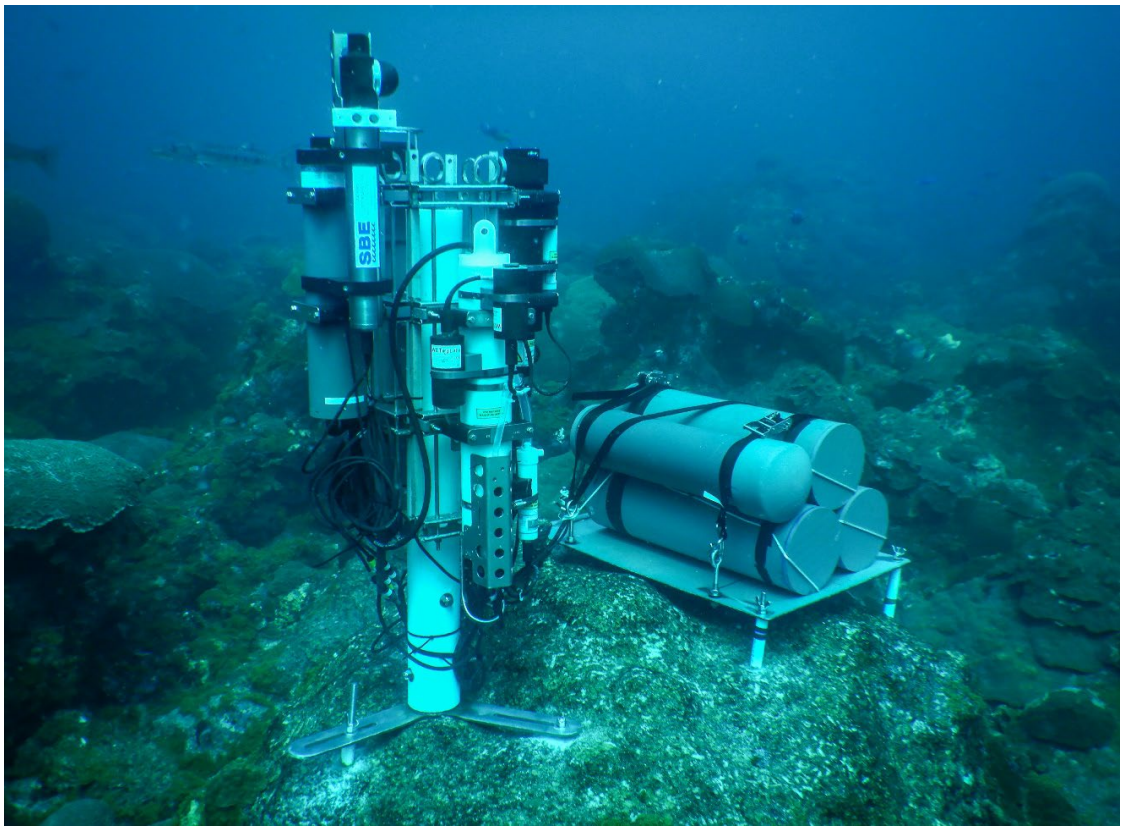

Figure 12. The seafloor ocean acidification instrument and battery package were attached to the reef at East Flower Garden Bank. Photo: G.P. Schmahl/NOAA

East and West Flower Garden Banks Long-Term Monitoring

The East and West Flower Garden Bank (EFGB, WFGB) long-term monitoring project, in partnership with BOEM, collected its 30th year of data in the long-term monitoring study sites in 2019 (IA M19PG00001). All methods for random benthic and fish surveys, as well as repetitive photostations, were completed. In 2019, mean coral cover was 52% within the EFGB study site and 56% within the WFGB study site. Divers observed three juvenile manta rays and one sub-adult loggerhead sea turtle in the long-term monitoring study site at EFGB, as well as a large black grouper and marbled grouper at the EFGB deep repetitive photostations (130 ft/39.6 m). Three juvenile mantas were also observed in fish surveys within the WFGB study site. In addition, divers noted the persistence of the exotic regal demoiselle (*Neopomacentrus cyanomos*) on the coral caps as well as invasive lionfish (*Pterois volitans*), although lionfish densities in 2019 were much lower than observed in past years.

Stetson Bank Long-Term Monitoring

The Stetson Bank long-term monitoring project collected its 27th consecutive year of data in 2019 and marked the 5th year of the Bureau of Safety and Environmental Enforcement (BSEE) interagency agreement (IA E14PG00052). All survey methods for fish and benthic community assessment were completed in 2019, including random and repetitive surveys (Figure 13). Divers noted the persistence of the exotic regal demoiselle on the bank crest. In addition, divers observed unusually high sightings of sandbar sharks (*Carcharhinus plumbeus*), in groups of up to five individuals.

Figure 13. A diver repairs and reinstalls a repetitive photostation during Stetson Bank long-term monitoring activities. Photo: G.P. Schmahl/NOAA

Post-Removal surveys – HI-A-389-A

FGBNMS staff divers and volunteer scientists performed three cruises in 2019 to collect "post-removal" data for the HI-A-389-A monitoring project, a partnership with BOEM (IA E14PG00057). The top of the gas production platform was severed and removed at a depth of 67ft/20.5 m in July 2018. In July 2019, an abbreviated trip resulted in the completion of random transect photography, using scuba. Those photographs were used to evaluate the benthic cover of the platform to a depth of 130ft/39.6 m. An ROV survey trip in September 2019 was utilized to capture photographs and video from the shallowest remaining portion of the structure to the seafloor. Nearly the entire structure was surveyed to a depth of 410ft/125m. In October 2019, the post-partial-removal bio-acoustic surveys were performed by NOAA's National Centers for Coastal Ocean Science (NCCOS) to estimate fish populations and biomass on the structure and the immediate surrounding area. FGBNMS and scientific divers completed the remaining tasks (roving fish surveys, belt transects, and repetitive photography) during this effort. Posters depicting the common benthic community and fish were developed (Figure 14).

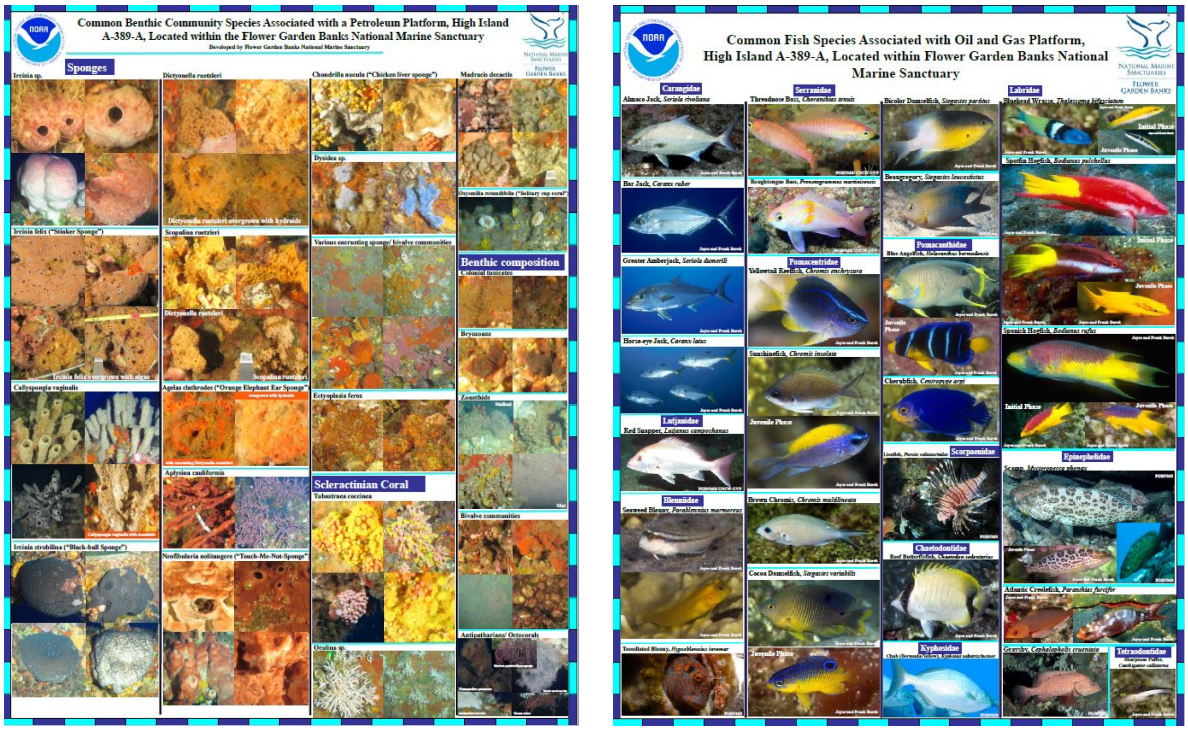

Figure 14. Two posters show common benthic and fish species found on HI-A-389-A. Image: FGBNMS

Annual Lionfish Invitational Cruises

Trained volunteer divers and research partners from across the country, as well as internationally, conducted fish surveys and removed 359 lionfish using permitted pole spears during two lionfish invitational events on board the M/V *Fling* from June 10-13, 2019 and August 26-29, 2019 (Figure 15). The activity was conducted under a FGBNMS permit, as spear guns are not allowed in sanctuary waters under sanctuary regulations. Sanctuary researchers and research partners examined the lionfish for age, growth and stomach contents to determine how many native fish species lionfish are eating. Despite skilled divers, low numbers of lionfish were observed and removed. In addition to the sanctuary, Coast Watch Alliance, Ripley's Aquarium of Canada, Georgia Aquarium, Florida Fish and Wildlife Commission, Oregon State University, and Fling Charters supported the event.

Lionfish density within the buoyed removal zones increased from 2015 to 2018, and then decreased in 2019. Lionfish density ranged from 23-89 lionfish per hectare at WFGB and 34-49 lionfish ha^{-1} at EFGB in 2015. In August 2018, lionfish density ranged from 88-164 lionfish ha^{-1} at WFGB and 89-154 lionfish ha^{-1} at EFGB. Although lionfish density increased, shifting dive times during the August 2018 trip to earlier in the morning and later in the evening during crepuscular feeding times allowed divers to target more lionfish. In August 2019, lionfish density decreased, ranging from 1-14 lionfish ha^{-1} at WFGB and 2-29 lionfish ha^{-1} at EFGB. It is hypothesized that lionfish populations throughout the Gulf and Caribbean region have been reduced due to an emerging ulcerative skin disease, which was present in lionfish removed at FGBNMS, potentially explaining the lower removal rates in 2019. The reduced lionfish numbers at FGBNMS follow boom-bust dynamic invasive species trends observed in Florida and Caribbean region lionfish populations.

Figure 15. A group photo of the 2019 August Lionfish Invitational cruise participants on board the M/V *Fling*. Photo: NOAA

Cruises and Expeditions

All of the following cruises were conducted on board the R/V *Manta,* except as noted:

October 11-12, 2018, BOEM/FGBNMS NRT Mapping – S. TX Banks, Small and Big Dunn Bar
October 13-15, 2018, BOEM/FGBNMS NRT Mapping – Claypile, Coffee Lump, Davis Bank
February 5-6, 2019, Water Quality I
February 28, 2019, Water Quality II
May 16, 2019, Water Quality – shortened due to weather
May 31, 2019, Mooring Buoy installation – shortened due to weather
June 3-4, 2019, NCRMP Ocean Acidification – shortened due to weather June
10-13, 2019, Lionfish Invitational Cruise I (M/V *Fling*)
June 11-18, 2019, Stetson Bank LTM
June 18-19, 2019, HI-A-389-A post-removal scuba – shortened due to
weather June 27-28, 2019 East FGB Mosaic – shortened due to weather
July 18-20, 2019, Installation of TAMU Ocean Acidification Buoy – EFGB#3
July 23-26, 2019, EFGB LTM
July 30 – August 2, 2019, West FGB LTM and Water Quality
August 6-8, 2019, Manta ray tagging (NMFS SERO)
August 14-18, 2019, GFOE Telepresence I (Voss) – shortened due to weather
August 21-25, 2019, GFOE Telepresence II (Davies) – shortened due to weather
August 26-29, 2019, Lionfish Invitational II (M/V *Fling*)
August 28-September 1, 2019, GFOE Telepresence III (Brugler)
September 10-14, 2019, ROV – HI-A-389-A and Stetson Bank
October 9-11, 2019, HI-A-389-A fish/repetitive stations/acoustic survey

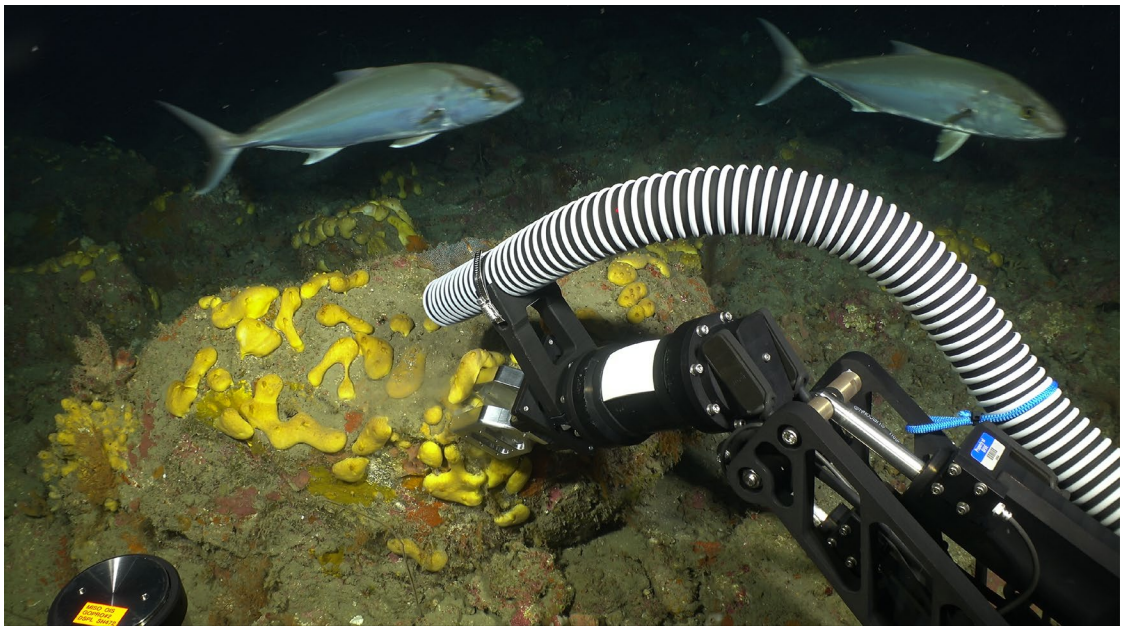

Figure 16. Two amberjacks monitor ROV sponge collection during a GFOE cruise. Photo: GFOE/NOAA

Additional R/V MANTA Cruises

The R/V *Manta* was also chartered by other user groups during the 2019 research season:

June 30, 2019 Gulick - UTIG – a training cruise for students learning about oceanography sampling techniques - shortened due to alternator fire

September 17-19, 2019 ROV – Fredericq/UL-LA/UNCW-UVP – studies focused on seaweed and algae of the NWGOM - conducted during Tropical Storm Imelda

September 24-27, 2019 ROV – Herrera/Lehigh/UNCW-UVP – Connectivity of Coral Ecosystems in the NWGOM - shortened due to loss of CTD (Figure 17)

Figure 17. Cruise participants gather on the back deck of R/V *Manta* at the start of the Herrera/Lehigh University MesoBot cruise. Photo: Herrera/Lehigh

Science Interpretation

1. Interviews for media – magazines, newspapers, radio
2. Contributions to digital slide catalog/library
3. Contributions to video library, including annotations
4. Development of PowerPoint presentations for various events
5. Facebook posts
6. Web-based research reports and blogs
7. Response to "Into the Sea" mail
8. Delivery of reusable FGBNMS grocery bags to Galveston Fire Department
9. Review and support of Earth is Blue videos
10. Coordination of the proposed FGBNMS boundary expansion video interviews
11. Review of Climate Change 4-pager
12. Participation in Marine Careers Day – Beneath The Sea
13. Coordination with Fling Charters for implementation of dive gear decontamination protocols

Additional Science Activities

1. Continued coordination of the Interagency Agreement between BOEM and FGBNMS for collection of high resolution imagery of reefs and banks in the NWGOM with NOAA Office of Coast Survey.
2. Processing of NOAA's Deep Sea Coral Research and Technology Program (DSCRTP) data
3. Mooring buoy maintenance
4. Support for sanctuary boundary expansion activities
5. Deployment of sound traps
6. Deployment of tilt/current meters
7. Permitting
8. Scheduling of R/V *Manta* cruises
9. Coordination of scuba operations and training (field training and diver propelled vehicle)
10. Coordination of shipboard research equipment and activities
11. GIS support
12. Science presence at SAC meetings
13. Participation in NOAA Coral Collaboration calls
14. Participation in NOAA Deep Sea Coral calls

Conferences, Meetings, Presentations, Training, Etc.

1. Ocean Acidification Presentation, October 17, 2018 (Johnston).
2. Coral microfragmentation workshop, December 17-19, 2019. Mote Marine Lab, Florida (Hickerson, Nuttall).
3. Gulf of Mexico Reef Symposium participation (Hickerson, Johnston, Embesi).
4. Research Coordinator's Meeting, November 5-8, 2019. Mote Marine Lab, Florida (Hickerson).
5. NCRMP FGBNMS Status Report (Johnston, Hickerson).
6. EFGB Mortality webinar for Gulf of Mexico Forum (Johnston, Blakeway).
7. Diving for Science presentation for TAMUG Scientific Diving Class (Nuttall).
8. FGBNMS Dive Operations presentation for Texas DSO Meeting (Nuttall).
9. July 10, 2019, TAMU, GERG, OA Buoy discussions. College Station, Texas.
10. Review of common mesophotic taxa of FGBNMS, SEDCI Webinar (Blakeway).
11. Characterization of deep sea corals and fishes in the Northern Gulf of Mexico, NOAA Gulf of Mexico Thesispalooza 3.0 (Blakeway).
12. Transplanting resident corals at Flower Garden Banks, an adaptive restoration effort in a challenging environment, NOAA Gulf of Mexico Thesispalooza 3.0 (Blakeway).
13. Monitoring and Research at FGBNMS , Houston Conchology Society (Blakeway).
14. Presentation to TAMUG Fisheries Management class on LTM and Lionfish (Johnston).
15. LTM and Lionfish topics for NOAA Gulf of Mexico Thesispalooza 3.0 (Johnston).
16. NOAA ERDAPP Satellite data course (Johnston).

Figure 18. A red lipped batfish rests on its walking fins at Alderdice Bank. Photo: GFOE/NOAA

Figure 19. A tangle of basket star arms was photographed on the basalt pinnacles at Alderdice Bank. Photo: GFOE/NOAA

Permitted Activities with Partners

1. National Coral Reef Management Program (Manzello), Ocean Acidification.
2. Coast Watch Alliance, two Lionfish Invitationals on board the M/V *Fling,* permit for participants to remove lionfish.
3. M/V *Fling,* removal of lionfish.
4. Harbor Branch Oceanographic Institute (Voss), Connectivity of Coral Ecosystems in the NWGOM.
5. Boston University (Davies), Understanding symbiosis of reef-building corals and collection of coral tissue.
6. University of Louisiana, Lafayette (Fredericq), Unsuspected eukaryotic life inhabits rhodolith forming coralline algae (Hapalidiales, Rhodophyta), a remarkable marine benthic microhabitat – collection of algal nodules.
7. LeHigh University (Herrera), Population connectivity of deepwater corals and collection of two species of octocorals.
8. LeHigh University (Herrera), eDNA.
9. LeHigh University (Herrera), Connectivity in the NWGOM, CYCLE.
10. NOAA Fisheries – Pascagoula (Rademacher), SEAMAP Fish Survey, Southeast Area Monitoring and Assessment Program. Deployment of baited camera array and plankton sampling.
11. Texas A&M University, Corpus Christi (Hu), Ocean Acidifcation.
12. Action for Mantas (Stewart), Population Structure and Habitat Use of Oceanic Manta Rays in the GOM and Greater Caribbean Basin.
13. Rice University (Shore), Investigating the impacts of hypoxia, wastewater contamination, and reduced salinity on coral reef ecosystems of the FGBNMS.

Research and Science Partnerships

- American Museum of Natural History
- Bureau of Ocean Energy Management
- Bureau of Safety and Environmental Enforcement
- Coast Watch Alliance
- Cooperative Institute of Ocean Exploration, Research and Technology
- City University of New York
- Florida Atlantic University
- Florida Fish and Wildlife Commission
- Geochemical and Environmental Research Group
- Georgia Aquarium
- Global Foundation for Ocean Exploration
- Harbor Branch Oceanographic Institute
- Lehigh University
- Moody Gardens Aquarium
- National Centers for Coastal Ocean Science
- National Coastal Data Development Center
- National Marine Fisheries Service Southeast Region – Office of Protected Resources
- NOAA Coral Reef Conservation Program
- NOAA Deep Sea Coral Research and Technology Program
- NOAA Office of Oceanic and Atmospheric Research
- NOAA Hydrographic Survey
- NOAA Ship Pisces
- Oregon State University
- Planck Aerosystems
- Reef Environmental Education Foundation
- Ripley's Aquarium of Canada
- Scripps Institution of Oceanography
- Smithsonian Institution
- Texas A&M University
- Texas A&M University Galveston
- Texas A&M University - Corpus Christi
- Texas General Land Office
- University of Delaware
- University of Louisiana – Lafayette
- University of North Carolina – Wilmington
- University of Southern Mississippi, Hydrographic Science Research Center
- University of Texas Rio Grande Valley
- United States Geological Survey

Publications

Dee, S.G., Torres, M.A., Martindale, R.C., Weiss, A., and DeLong, K.S. 2019. The Future of Reef Ecosystems in the Gulf of Mexico: Insights From Coupled Climate Model Simulations and Ancient Hot-House Reefs. Frontiers in Marine Science. https://doi.org/10.3389/fmars.2019.00691.

Easton, Erin E. and Hicks, D. 2019. Complete mitochondrial genome of *Callogorgia* cf. *gracilis* (Octocorallia: Calcaxonia: Primnoidae). Mitochondrial DNA Part B, 4:1, 361-362, DOI: 10.1080/23802359.2018.1511012.

Fredericq, S, Krayesky-Self, S., Sauvage, T., Richards, J., Kittle, R., Arakaki, N., Hickerson, E., and Schmidt, W.E. 2019. The critical importance of rhodoliths in the life cycle completion of both macro- and microalgae, and as holobionts for the establishment and maintenance of marine biodiversity. Frontiers in Marine Science. https://doi.org/10.3389/fmars.2018.00502

Johnston, M.A., Nuttall, M.F., Eckert, R.J., Blakeway, R.D., Sterne, T.K., Hickerson, E.L., Schmahl, G.P., Lee, M.T., MacMillan, J, Embesi, J.A. 2019. Localized coral reef mortality event at East Flower Garden Bank, Gulf of Mexico. Bulletin of Marine Science. 95 (0):000-000.2019 https://doi.org/10.5343/bms.2018.0057

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Kealoha, Andrea K., Doyle, S.M., Shamerger, K.E.F., Sylvan, J.B., Hetland, R.D., and DiMarco, S.F. 2019. Localized hypoxia may have caused coral reef mortality at the Flower Garden Banks. Coral Reefs. https://doi.ord/10.1007/s00338-019-01883-9

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Nuttall, M.F., T.K. Sterne, R.J. Eckert, X. Hu, J. Sinclair, E.L. Hickerson, J.A. Embesi, M.J. Johnston, G.P. Schmahl. 2019. Stetson Bank Long Term Monitoring: 2016 Annual Report. Marine Sanctuaries Conservation Series ONMS 19 02. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Flower Garden Banks National Marine Sanctuary, Galveston, TX. 78 pp.

Nuttall, M.F., R.D. Blakeway, J. MacMillan, T.K. Sterne, X. Hu, J.A. Embesi, E.L. Hickerson, M.A. Johnston, G.P. Schmahl, J. Sinclair. 2019. Stetson Bank Long-Term Monitoring: 2017 Annual Report. National Marine Sanctuaries Conservation Series ONMS-19-03. U.S.

Department of Commerce, National Oceanic and Atmospheric Administration, Flower Garden Banks National Marine Sanctuary, Galveston, TX. 94pp.

Nuttall, M.F., R.D. Blakeway, J. MacMillan, K O'Connell, X. Hu, J.A. Embesi, E.L. Hickerson, M.A. Johnston, G.P. Schmahl, J. Sinclair. 2019. Stetson Bank Long-Term Monitoring: 2018 Annual Report. National Marine Sanctuaries Conservation Series ONMS-19-05. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Flower Garden Banks National Marine Sanctuary, Galveston, TX. 43pp.

Venera-Ponton, D. E., Schmidt, W.E., and Fredericq, S. Population Structure of the Red Macroalga *Botryocladia occidentalis* (Borgesen) Kylin (Rhodymeniaceae, Rhodymeniales) in the Gulf of Mexico Before the Deepwater Horizon Oil Spill. 2019. Front. Mar. Sci., _____

Wright, R.M., Correa, A.M.S., Quigley, L.A., Santiago-Vazquez, L.Z., Shamberger, K.E.F., and Davies, S.W. 2019. Gene Expression of Endangered Coral (*Orbicella* spp.) in FGBNMS after Hurricane Harvey. Frontiers in Marine Science, https://doi.org/10.3389/fmars.2019.00672

Figure 20. A posse of marbled grouper were spotted at Geyer Bank. Photo: GFOE/NOAA

2019 RESEARCH STAFFING

1. Raven Blakeway, CPC, Research Specialist
2. John Embesi, CPC, Research Specialist, HI-A-389-A Project Manager
3. Emma Hickerson, Research Coordinator
4. Michelle Johnston, Research Biologist, FGBLTM Project Manager
5. Jimmy MacMillan, Research Specialist, Water Quality Project Manager
6. Marissa Nuttall, CPC, Research Specialist, Stetson Bank Project Manager
7. Kelly O'Connell, CPC, Research Specialist
8. G.P. Schmahl, Sanctuary Superintendent

R/V *Manta* core crew provided through a contract with CPC:

1. Justin Blake
2. Karole Breuer
3. Tomeka Wattel
4. Deck position filled by various people

FGBNMS NOAA Divers:

1. Raven Blakeway
2. Fernando Calderón Gutiérrez (volunteer)
3. Jacque Cresswell (volunteer)
4. Kelly Drinnen
5. John Embesi
6. Diego Gil-Agudelo (volunteer)
7. Carsten Grupstra (volunteer)
8. Joshua Harvey (volunteer)
9. Emma Hickerson
10. Lauren Howe-Kerr (volunteer)
11. Michelle Johnston
12. Sarah Linden (volunteer)
13. Jimmy MacMillan
14. David McBee (volunteer)
15. Marissa Nuttall (Unit Diving Supervisor)
16. Kelly O'Connell
17. G.P. Schmahl
18. Amanda Shore (volunteer)
19. Adrienne Simoes-Correa (volunteer)
20. Jenny Vander Pluym (volunteer)
21. Joshua Stewart (volunteer)

Glossary of Acronyms

AMNH – American Museum of Natural History
BOEM – Bureau of Ocean Energy Management
BSEE – Bureau of Safety and Environmental Enforcement
CTD – conductivity/temperature/depth instrument package
CUNY – City University New York
DNA – deoxyribonucleic acid
DSCRTP – Deep Sea Coral Research and Technology Program
EFGB – East Flower Garden Bank
FAU – Florida Atlantic University
FGBNMS – Flower Garden Banks National Marine Sanctuary
FY – Fiscal Year
GERG – Geochemical and Environmental Research Group
GFOE – Global Foundation for Ocean Exploration
HBOI – Harbor Branch Oceanographic Institute
HI-A-389-A – High Island A-389-A Platform
IA – interagency agreement
LTM – Long-Term Monitoring
LSAMP – Louis Stokes Alliance for Minority Participation
MOA – Marine and Oceanographic Academy
NCCOS – National Centers for Coastal Ocean Science
NCRMP – National Coral Reef Monitoring Program
NOAA – National Oceanic and Atmospheric Administration
NRT – Navigation and Response Team
NWGOM – Northwestern Gulf of Mexico
NYCCT – New York City College of Technology
OA – Ocean Acidification
ONMS – Office of National Marine Sanctuaries
RHIB – rigid-hulled inflatable boat
RNA – ribonucleic acid
ROV – Remotely Operated Vehicle
R/V – research vessel
SERO – Southeast Regional Office
SUNY – Stony Brook University
SW – southwest
TAMU – Texas A&M University
TAMUG – Texas A&M University at Galveston
UAS – unmanned aircraft system
UNCW – University of North Carolina – Wilmington
UTIG – University of Texas Institute of Geophysics
UM – University of Miami
UVP – Undersea Vehicle Program
VSAT – very small aperture terminal
WFGB – West Flower Garden Bank

NATIONAL MARINE SANCTUARIES

AMERICA'S UNDERWATER TREASURES