National Coral Reef Monitoring Program
Climate Monitoring Brief: Flower Garden Banks National Marine Sanctuary

NOAA / Atlantic Oceanographic & Meteorological Laboratory (AOML) Coral Program

University of Miami/Cooperative Institute of Marine and Atmospheric Studies (CIMAS)

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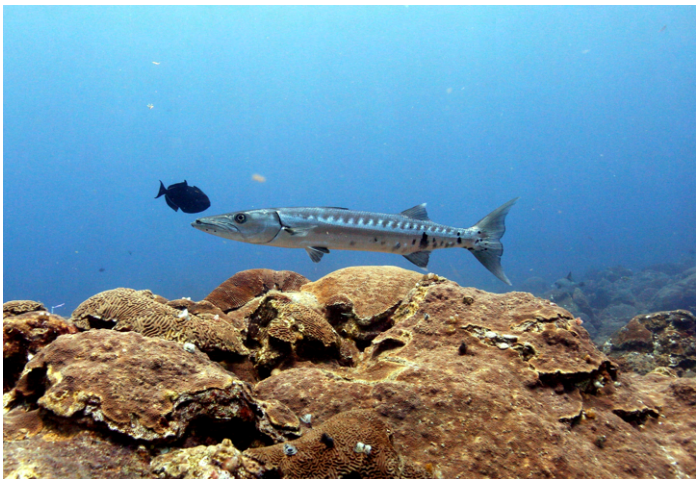

Coral reef at East Buoy 3 in the Flower Garden Banks

Mission

The AOML Coral Program tracks the status and trends of coral reef ecosystems of the U.S. Atlantic and Caribbean as part of the National Coral Reef Monitoring Program (NCRMP). This summary brief provides an overview of the most recent climate monitoring efforts at Flower Garden Banks National Marine Sanctuary (FGBNMS).

Expedition summary

- The AOML Coral Program conducted NCRMP climate monitoring operations at FGBNMS from October 3rd to October 8th, 2022
- A total of eight different sites were visited by 10 team members and local sanctuary collaborators completing a total of 98 dives.

Data collection summary

Subsurface temperature

Subsurface temperature recorders (STRs) were recovered and redeployed at east and west bank transects, including four instruments ranging in depth from 20m to 35m (Fig. 1). In total, more than four million temperature observations were collected from seven different instruments (Table 1).

Table 1: *Number of temperature observations collected by transect and depth. Sites marked with NA were not successfully recovered.*

Transect	21m	25m	30m	35m	Total
East Bank	772,166	772,334	772,301	772,097	3,088,898
West Bank	NA	399,148	446,378	529,033	1,374,559

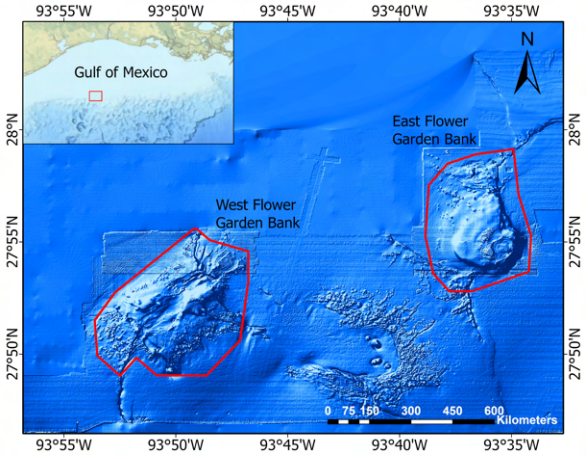

Figure 1: *Study sites and depths in Flower Gardens*

NCRMP Climate fixed sentinel site monitoring

At East Buoy 3, 20m site, located on the East Bank, short term instruments (72h) were deployed to monitor daily fluctuations in:

- **Current**: 286 observations
- **pH**: 285 observations
- **Light**: 288 observations
- **Carbonate chemistry**: 21 samples collected

Habitat persistence

Changes in bioerosion and accretion were monitored

- **Carbonate budget surveys**: Benthic cover, sponge, urchin, and parrotfish surveys completed at 6 transects
- **Bioerosion**: 14 Bioerosion Monitoring Units (BMUs) collected, 15 redeployed
- **Calcification**: 5 Calcification Accretions Units (CAUs) collected, 5 redeployed
- **Benthic cover**: 6 landscape mosaics

Subsurface temperature

The temperatures that marine organisms experience are a function of local oceanographic conditions and vary with depth. To monitor subsurface temperature, two cross-shelf transects were established at each bank within the sanctuary. Each transect consists of STRs at four depths (20, 25, 30, 35m; Fig. 2). Three years of temperature measurements were retrieved and processed from the eight sites.

Temperature was measured using SeaBird Electronics Subsurface Temperature Recorders (STR)s that collected data at 5-minute intervals. The STRs from West Bank were not collected during the last field monitoring trip in 2019, so we have included the entire temperature data collection from East Bank in Fig. 2 aid with comparison.

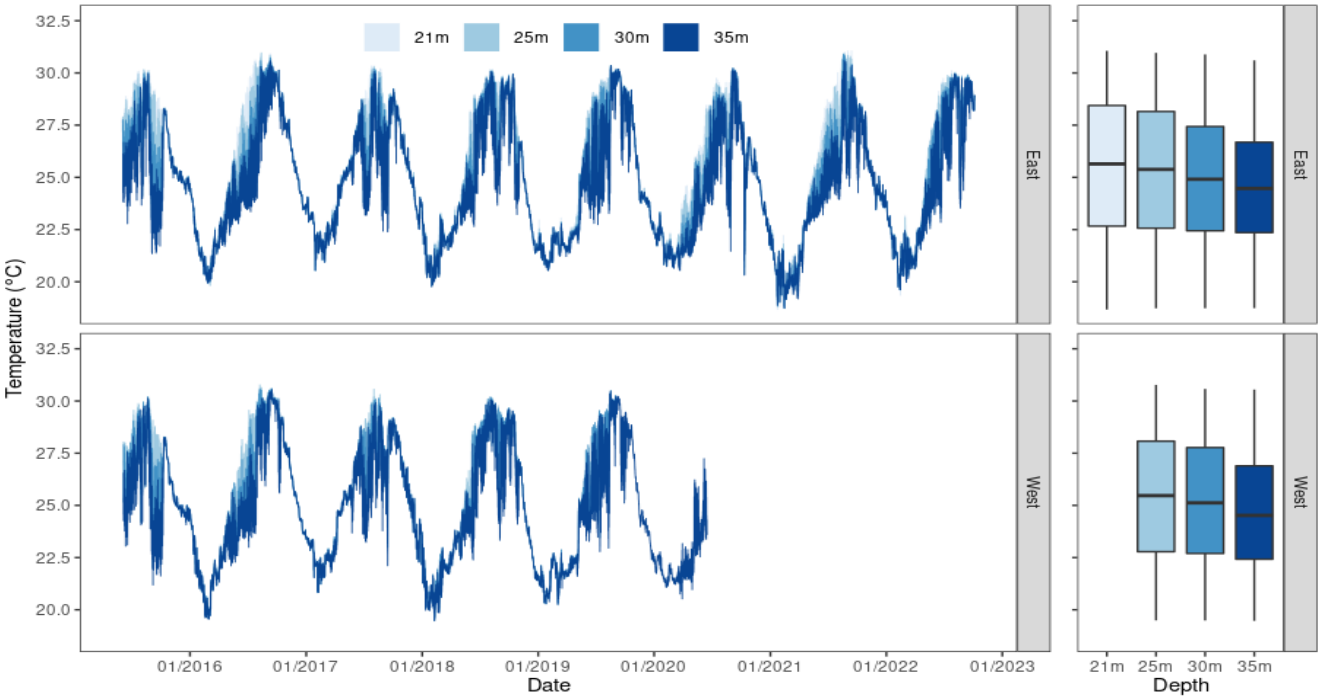

Figure 2: *Temperature conditions at two transects in FGBNMS (East Bank, West Bank) representing a depth gradient (20m, 25m, 30m and 35m). Data were collected from September 2015 to October 2022. However, the STR from West Bank - 20m was not recovered.*

Temperature values were lower at the deeper stations (30 and 35m) at both East and West Banks. A particular cold winter was recorded in 2021, when monthly mean temperatures were below 20.6°C at all depths.

September of 2016 was the hottest month recorded at both banks, with mean temperatures higher than 30.76°C at the 21, 25 and 30m stations, and higher than 29.77°C at the 35m stations (Fig. 2).

Diurnal suite deployment

Seawater carbonate chemistry can fluctuate diurnally, due to biological forcing processes such as photosynthesis and respiration, as well as calcification and dissolution. To characterize this, discrete water samples (Fig. 3) were collected at three-hour intervals (n=15) using Subsurface Automatic Samplers (SAS, www.coral.noaa.gov/accrete/sas).

These samples will be analyzed for Total Alkalinity (TA), Dissolved Inorganic Carbon (DIC), and Spectrophotometric pH (SpecpH), which will be used to calculate pCO2 and aragonite saturation state ($\Omega_{Aragonite}$). A suite of instruments was deployed for a 72-hour period at the East Bank 20m site. A SeaFET was used to log pH, an EcoPAR measured Photosynthetically Active Radiation (PAR), and a Lowell Tiltmeter measured current speed and direction. Each collected measurements at 15-minute intervals (Fig. 4).

Figure 3: *Scientists transfer discrete water samples collected from Subsurface Automated Samplers to Borosilicate glass bottles to transfer back to the lab for carbonate chemistry analysis.*

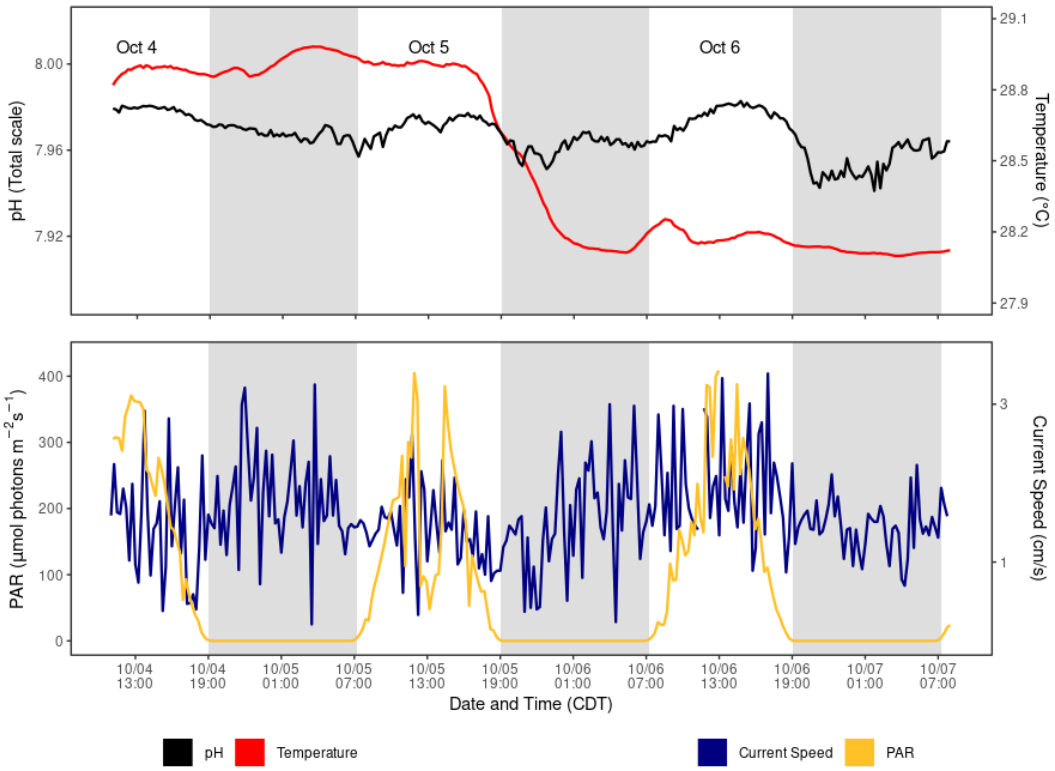

Figure 4: *Data from East Buoy 3 diurnal suite monitoring from October 4th to Oct 7th. Top panel: pH and temperature from SeaFET. Bottom panel: Photosynthetically Available Radiation (PAR) and current speed from EcoPAR and Tiltmeter. Shading denotes nighttime throughout sequence of the plot. Instruments measured parameters every 15 minutes.*

Habitat persistence

Carbonate budget assessments use transect-based surveys to quantify the abundance of carbonate producers (e.g., corals and crustose coralline algae), and carbonate bioeroders, (e.g., parrotfish and sea urchins). Abundances are multiplied by taxon-specific rates of carbonate alteration to determine if a reef is in a state of net accretion (habitat growth) or net loss (habitat loss) in Fig. 5. At East Buoy 3, six transects were surveyed in 2015, 2019 and 2022 to obtain carbonate budgets. While collecting this year's data, divers noticed abundant signs of high bioerosion activity by parrot fish. Entire colonies were scraped away around the vicinity of East Buoy 3 and in other sites too. The increase in bioerosion rates in our records was due to the sighting of very large individuals across the transects which caused a 4-fold increase in rates of parrotfish bioerosion from 2019 to 2022. This, in addition to reduced coral cover and increased macro bioerosion, resulted in a decrease in net community calcification of more than 4kg m^{-2} yr^{-1}.

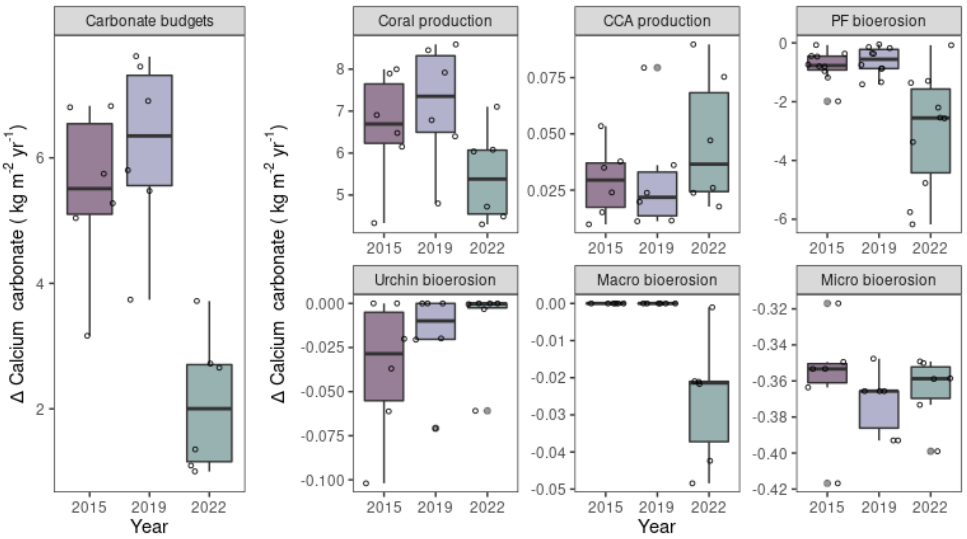

Figure 5: *Total changes in net carbonate production and separated by the functional groups contributing to either calcification or bioerosion. The horizontal line in the "Net carbonate production panel" denotes accretionary stasis, the point where the budget flips from habitat growth to loss. PF represents parrotfish.*

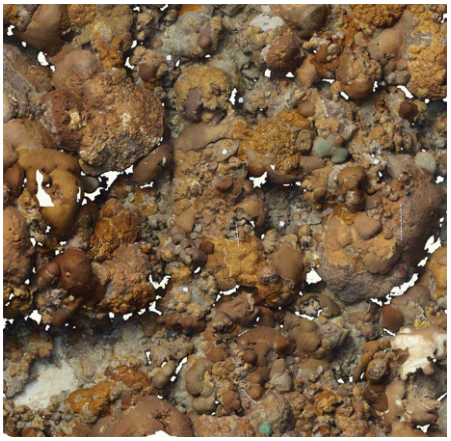

Figure 6: *Landscape Mosaic collected from transect 6*

Calcification Accretion Units (CAUs) and **Bioerosion Monitoring Units (BMUs)** were used to investigate the balance between calcification and erosion. CAUs and BMUs were collected and redeployed for the next sampling cycle. CAUs are processed by the NCRMP Pacific Climate group and the data will be available within a year. BMUs will be dried and cleaned using a hydrogen peroxide solution. These samples will be weighed and scanned using a CT scanner and then compared to their pre-scans to quantify bioerosion. Data will be available in a year. Please reference previous datasets for more information. Finally, **landscape mosaics** are used to quantify the benthic community, and to monitor changes in coral cover over time. Thousands of underwater images are digitally stitched together to create a high-resolution digital archive of the reef at the time of collection.

Rapid response to coral lesions

During an earlier monitoring cruise in August, coral lesions were noticed on a variety of coral species. Since this could be a sign of a coral disease outbreak, additional time on this cruise was spent sampling the lesions. Coral samples were collected for histology (n= 99), and 'omics (n=100) analyses. Additionally, 13 live colonies were recovered to complete land-based monitoring of lesion progression.

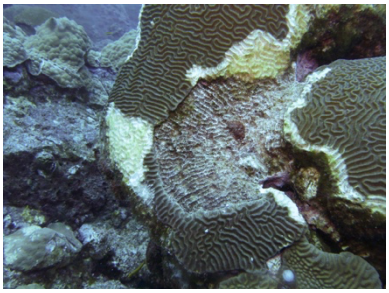

Figure 7: *Colonies showing lesions at the FGB.*

About the monitoring program

AOML's climate monitoring is a key part of the National Coral Reef Monitoring Program of NOAA's Coral Reef Conservation Program (CRCP), providing integrated, consistent, and comparable data across U.S. Managed coral reef ecosystems. NCRMP efforts aim to:

- Document the status of reef species of ecological and economic importance
- Track and assess changes in reef communities in response to environmental stressors or human activities
- Deliver high–quality data, data products, and tools to the coral reef conservation community

Points of contact

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For more information

Coral Reef Conservation Program: http://coralreef.noaa.gov
NCRMP climate monitoring: https://www.coris.noaa.gov/monitoring/climate.html
NOAA Atlantic Oceanographic and Meteorological Laboratory: http://www.aoml.noaa.gov/
FGBNMS Reef Status Report 2020
National Coral Reef Status Report 2020

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Our Team

Flower Garden Banks 2022 Field team

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