Linking coastal flooding to an unusual hypoxic event using microbial ecology

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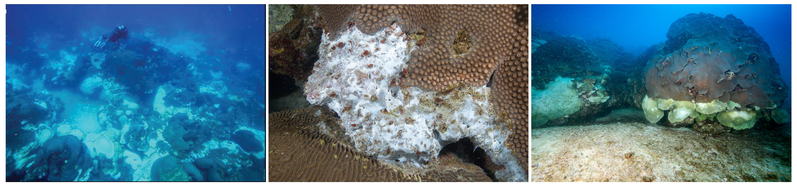
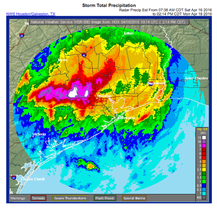
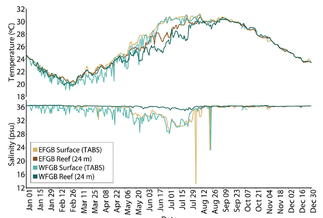
I. Mass Mortality at the Flower Gardens Banks



In July 2016, ~82% of coral colonies in a small area of the East Flower Garden Bank (EFGB) coral reef suddenly died without warning. Within the affected area, mortality was concentrated in sand flats, channels, and other reef depressions and formed visible “bathtub rings,” with tissue above the rings appearing healthy, while tissue below exhibited bleaching, sloughing, and death. Oxygen depletion was hypothesized to have been the cause.

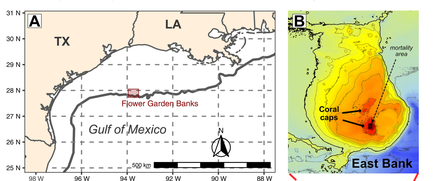




This oxygen depletion was proposed to have been caused by an unusually large plume of coastal floodwater that transited over the Flower Gardens earlier in the summer and provided favorable conditions for the local formation of hypoxic waters on top of the East Bank coral reef, similar to the mechanism by which the Gulf of Mexico "dead zone" forms during the summer.

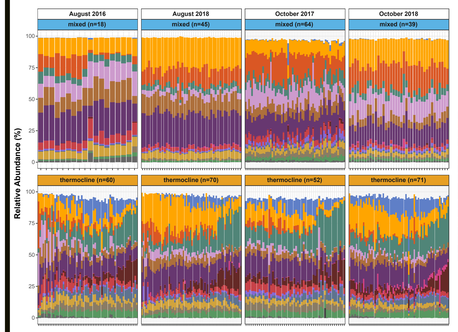
II. Project Design

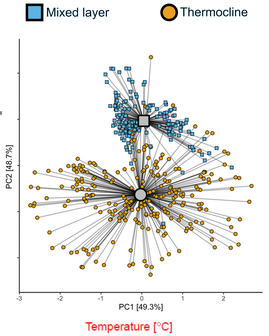
No dissolved oxygen data were available to test this hypothesis as oxygen is not continuously monitored at EFGB. Additionally, the specific mechanisms that could have lowered oxygen concentrations so far offshore remain unclear as seasonal plumes of hypoxic water typically do not extend far enough offshore to impact the Flower Garden Banks.



We thus analyzed microbial communities in water samples collected over several years at the Flower Garden Banks, including shortly after the mortality event. Microbial communities are sensitive to changes in oxygen and can be used as bioindicators of oxygen loss.

III. Microbial Community Composition

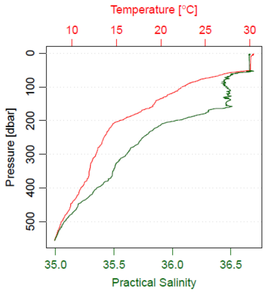




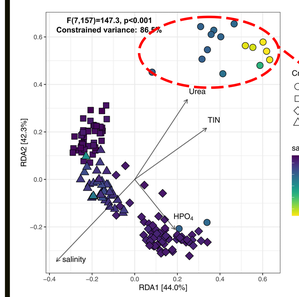
[Top-Left] Relative abundances of microbial lineages observed in seawater samples from the Flower Garden Banks. Within each plot, samples are arranged left to right by increasing depth.

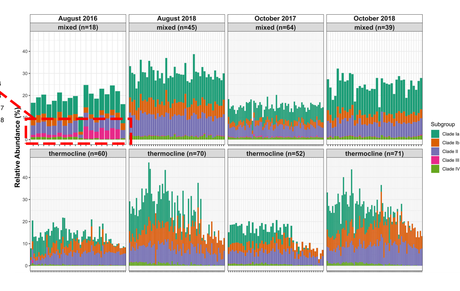
[Top-Right] Principal-component analysis (PCA) of robust Aitchison distances between samples from all four cruises shows distinct separation between those collected in the surface mixed layer (blue squares) and those from the underlying thermocline (orange circles).

[Right] Typical CTD profile observed at the Flower Garden Banks.



IV. Microbial Responses to Floodwater Plume

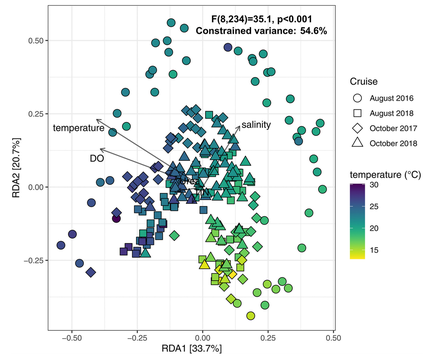


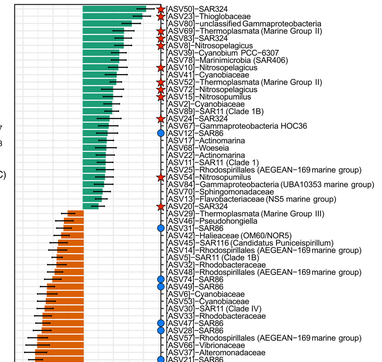


[Left] Mixed-layer microbial communities collected in August 2016 (circles), just 5 to 8 days after the localized mortality event, were notably distinct from those collected during the baseline cruises. However, these differences were also observed at West Flower Garden Bank, where no mortality event was observed.

[Right] The relative abundances of SAR11 clade III bacteria (pink), which typically inhabit brackish or freshwater, were ~18-fold higher just after the mortality event, indicating seawater microbial communities within the mixed layer had been altered by the presence of a floodwater plume.

V. Evidence of thermocline oxygen depression



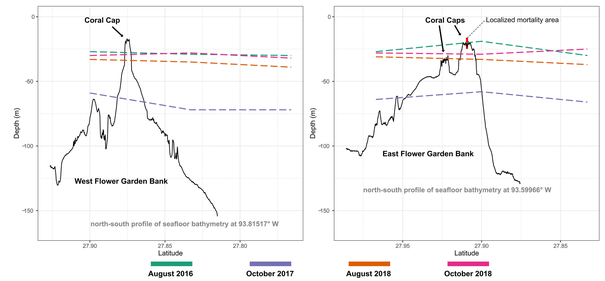


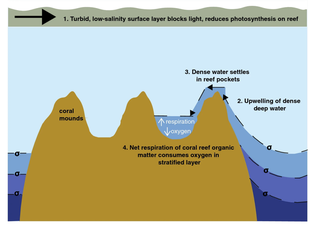
taxa with known or putative adaptation to to low oxygen =

taxa typically found in oxygen-rich waters =

[Left] Thermocline microbial communities just after the mortality event were also distinct from baseline conditions. **[Right]** These communities were enriched with species known to be active and abundant in oxygen minimum zones or that have known adaptations to oxygen limitation (red stars). Unexpectedly, these enriched species were not localized to the EFGB but were instead prevalent across the entire study area, suggesting there was a widespread depletion of dissolved oxygen concentrations in the thermocline around the time of the mortality event.

VI. Why was mortality so localized to EFGB?





[Top] Hydrographic analysis revealed the EFGB coral reef was uniquely within the underlying thermocline layer during the mortality event, where microbial data suggest oxygen had been depleted. The WFGB coral reef remained with the surface mixed layer at this time.

[Left] Higher water density, DIC, NH_4^+, and salinity, along with lower temperature and aragonite saturation near East Bank during the mortality event suggest deep water had upwelled onto the East Bank coral reef and potentially become trapped in reef depressions.