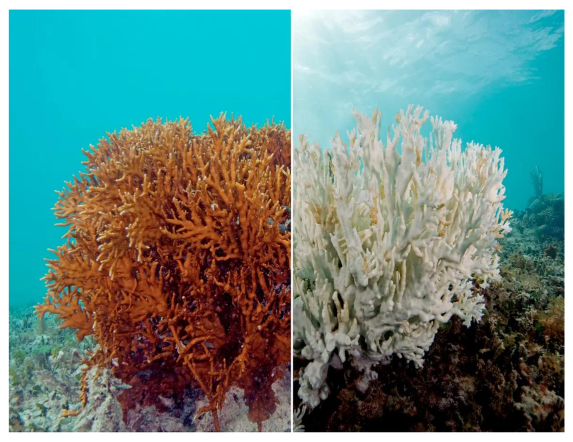
Evaluating Sea Surface Temperatures During Global Coral Bleaching Events in the Great Barrier Reef, Puerto Rico, and Mayotte

Sajiv Mahase[1], Connor Rabinowitz[1], Ricardo Peralta[2], Andrea Gomez[3], and Dr. Kyle McDonald[4]

[1]2019 High School Initiative in Remote Sensing of the Earth Systems Science & Engineering (HIRES) Scholar, [2]NOAA EPP Summer Bridge Program Scholar, [3]NOAA EPP Earth System Sciences and Remote Sensing Scholar, CUNY Graduate Center, [4]NOAA Center for Earth System Sciences and Remote Sensing Technologies and Department of Earth & Atmospheric Science, The City College of New York

Introduction

- Coral reefs make up less than 1% of the ocean floor but provide resources such as food and shelter for millions of marine species and humans (Smith 1978).
- Due to the fatal impacts of rising ocean temperatures from climate change, global coral populations have been bleaching and declining for the past 30 years (Glynn, 2012).
- Bleaching occurs when corals expel their symbiotic algae, which is their main source of energy, due to an environmental stressor such as increased temperatures. If the stress persists long enough, then it can lead to their mortality.
- There have been three global coral bleaching events to date: 1997-1999, 2009-2011, and 2014-2017.



Coral before (left) and after (right) it has experienced extensive bleaching in the 2016 mass bleaching event. Photo Credit: The Ocean Agency / XL Catlin Seaview Survey / Richard Vevers

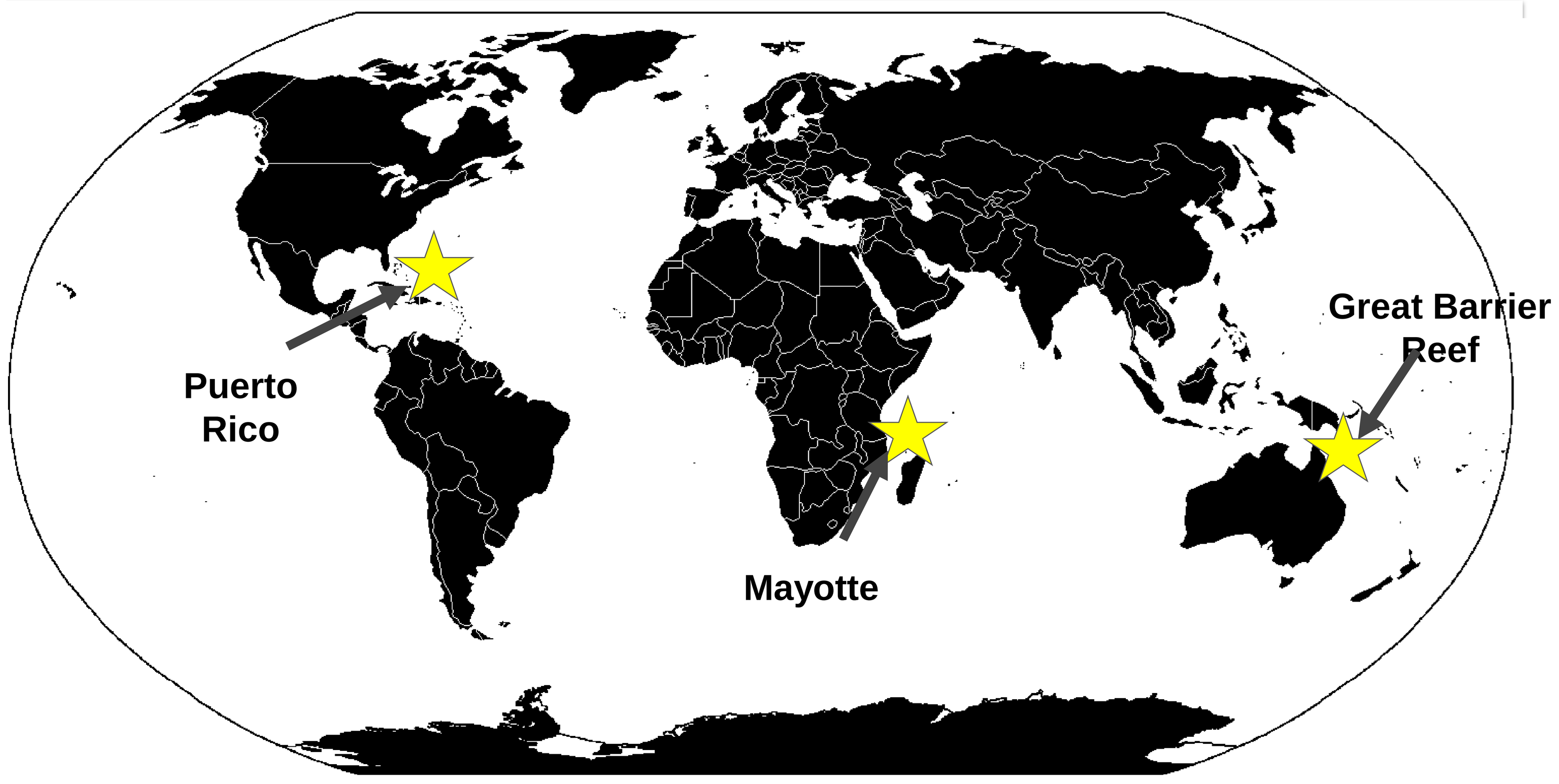
Research Questions

- Which of the three global bleaching events had the highest sea surface temperatures at each of the three studied locations: Puerto Rico, Mayotte, or the Great Barrier Reef?
- Why did these years experience such high temperatures? How did natural disasters or El Nino warming patterns impact these events?
- How does coral bleaching correlate to sea surface temperature anomalies?

Methods

- Daily, 5km sea surface temperature (SST) data was downloaded from NOAA's Coral Reef Watch (CRW) during the three global bleaching events (1997-99, 2009-11, and 2014-17) for these three locations: the Great Barrier Reef(-17.50000°, 147.00000°), Puerto Rico(17.86670°, -66.43330°), and Mayotte(-12.83330°, 45.21670°).
- CRW's current 5km SST product (version 3.1) is a combination of NOAA/National Environmental Satellite, Data, and Information Service (NESDIS) Geo-Polar Blended Night-only SST data, and the United Kingdom Met Office's Operational SST and Sea Ice Analysis (OSTIA) system.
- These locations were selected because there was significant coral bleaching observed (Hughes et al., 2017; García-Sais, Williams, & Amirrezvani, 2017; Obura, Bigot, & Benzoni, 2018).
- To analyze the SST data, the hottest and coldest years at each location were identified and compared with NOAA's CRW climatology data, which included averaged SST from 1985-2012.

Coral Reef Locations



Yellow stars indicate the location of the coral reefs that were studied.

Results

The Great Barrier Reef

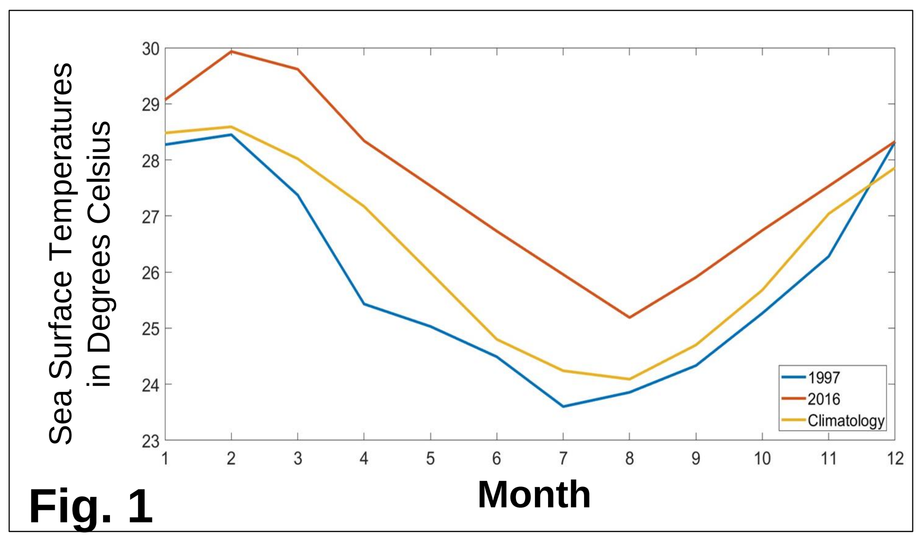


Fig. 1

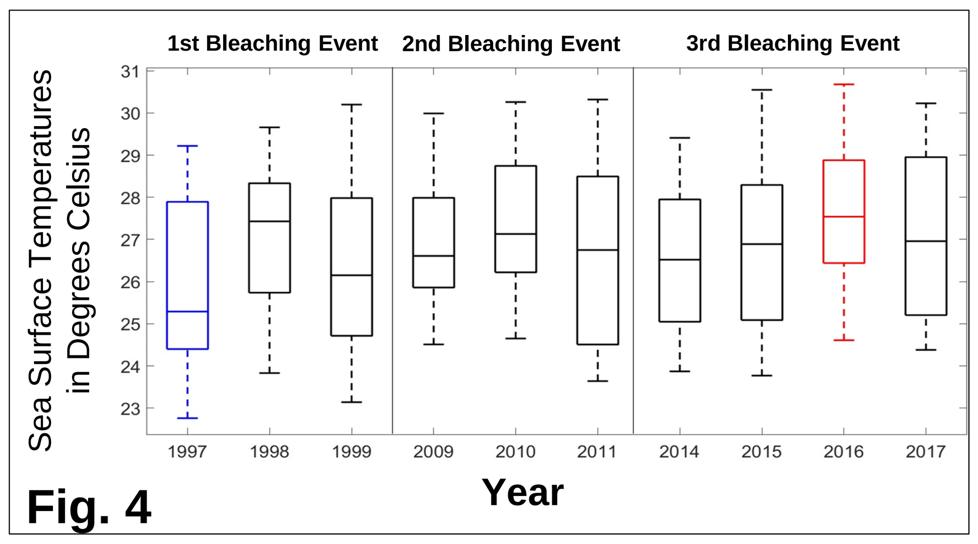


Fig. 4

Puerto Rico

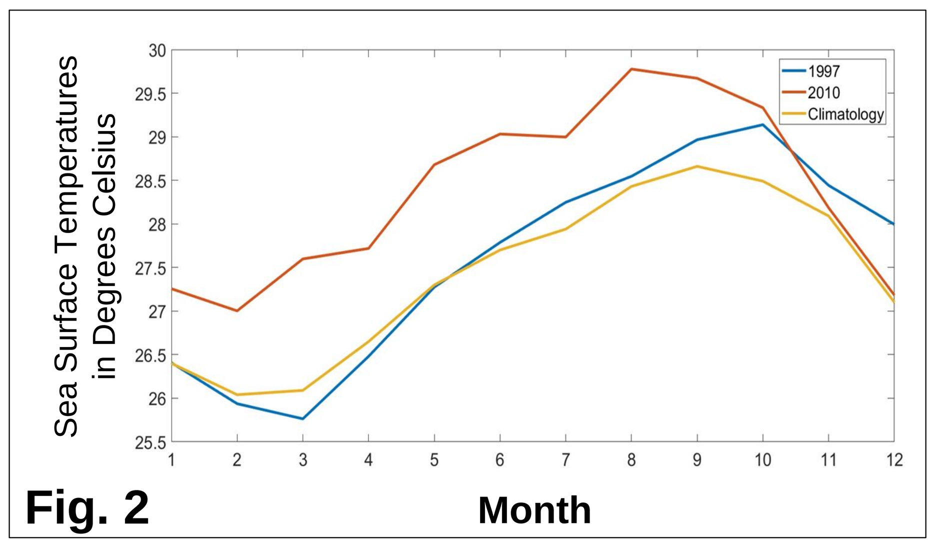


Fig. 2

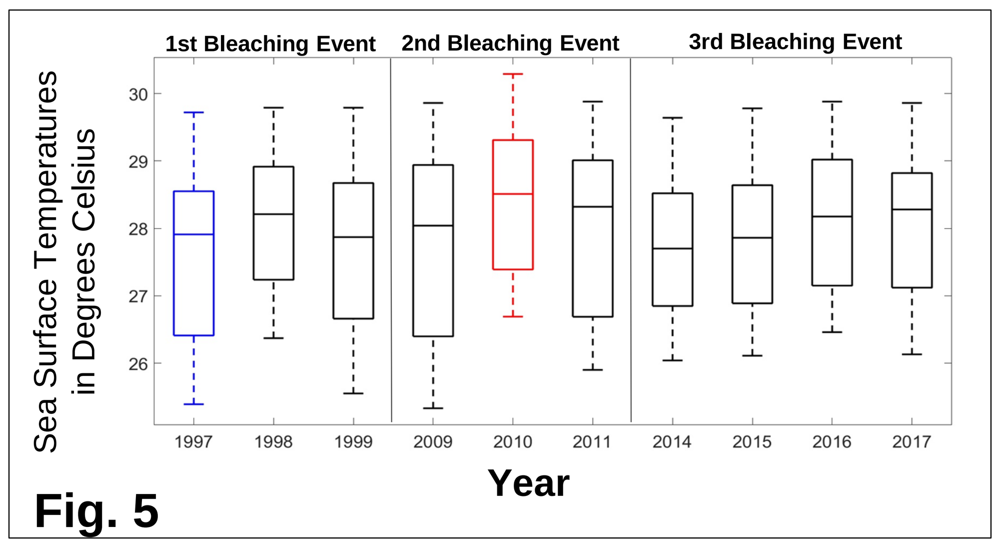


Fig. 5

Mayotte

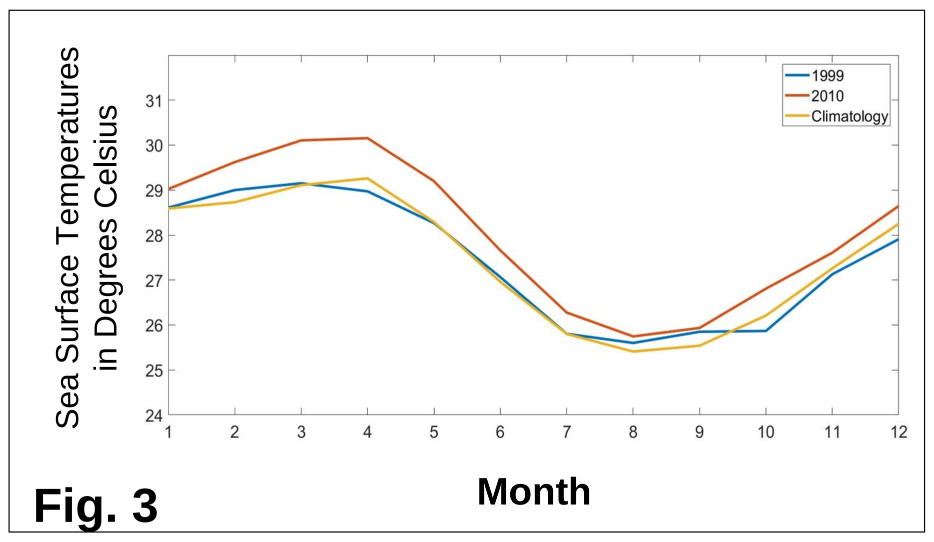


Fig. 3

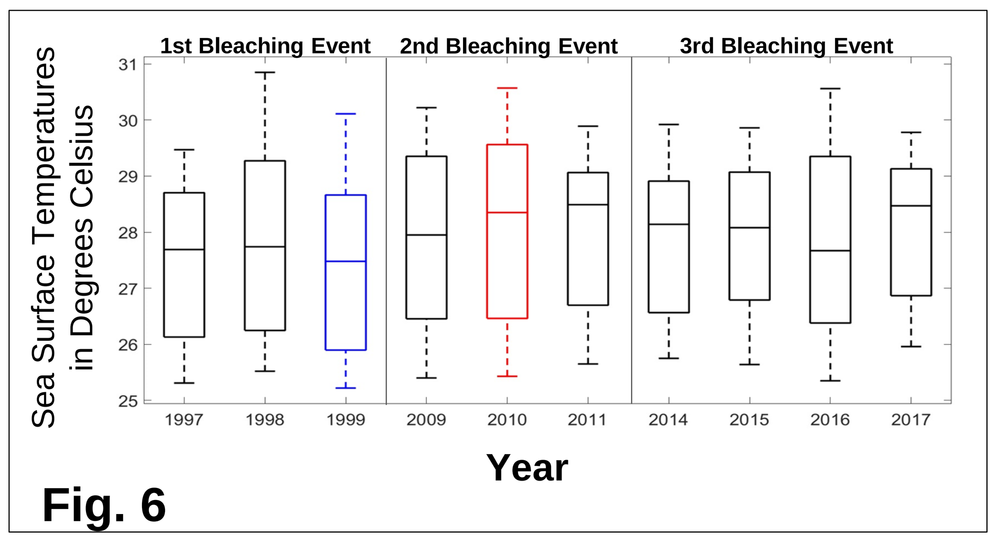


Fig. 6

Figures 1-3: Time series comparing the average monthly temperatures for the hottest and coldest years to the monthly climatology data. The red lines represent the hottest years, the blue lines represent the coldest years, and the yellow lines represent the climatology SST data.

Figures 4-6: Box plots representing the distribution of temperatures during all ten years of global coral bleaching. Each box represents a different year. For each figure, the red box represents the hottest year, and the blue box represents the coldest year.

Results (Continued)

Anomaly chart showing the hottest and coldest months out of the ten year SST data with the differences between the climatology data for each location. The anomaly was calculated by subtracting the climatology data from the corresponding month.

	Hottest		Coldest	
	Month	Difference (°C)	Month	Difference (°C)
GBR	June, 2016	1.93	April, 1997	-1.74
PR	March, 2010	1.51	March, 1997	-0.33
Mayotte	March, 2010	1.00	October, 1999	-0.34

Chart showing the hottest and coldest years with the average temperature and standard deviation for each location.

	Hottest			Coldest		
	Year	Average Temp (°C)	Standard Deviation	Year	Average Temp (°C)	Standard Deviation
GBR	2016	27.56	1.50	1997	25.88	1.76
PR	2010	28.38	1.00	1997	27.59	1.16
Mayotte	2010	28.05	1.58	1999	27.42	1.37

Discussion

- The highest SST at the Great Barrier Reef could be attributed to the most extreme El Niño warming pattern between 2014 and 2017, which caused more than 90% of the reef to undergo environmental stress (Hughes et al., 2017).
- The El Niño that occurred from 2009-2011 was moderate, yet it still had the highest SST near Mayotte and Puerto Rico, resulting in more than half of Mayotte's corals to bleach (Obura, Bigot, & Benzoni, 2018). However, the extent of the coral bleaching in Puerto Rico at this time is unknown.
- As humans continue to worsen the impacts of climate change, warmer El Niño patterns are also intensifying, and summer temperatures in absence of El Niño are becoming just as damaging (Hughes et al., 2018; Fasullo, 2018).

Literature Cited

Claar D. C., Szostek L., McDevitt-Irwin J. M., Schanze J. J., Baum J. K. (2018) Global patterns and impacts of El Niño events on coral reefs: A meta-analysis. PLoS ONE, 13(2).

Fasullo, J. T., Otto-Bliesner, B. L., & Stevenson, S. (2018). ENSO's Changing Influence on Temperature, Precipitation, and Wildfire In a Warming Climate. Geophysical Research Letters, 45(17), 9216-9225.

García-Sais, J. R., Williams, S. M., & Amirrezvani, A. (2017). Mortality, recovery, and community shifts of scleractinian corals in Puerto Rico one decade after the 2005 regional bleaching event. PeerJ. 5.

Glynn P. W. (2012) Global Warming and Widespread Coral Mortality: Evidence of First Coral Reef Extinctions. In: Hannah L. (eds) Saving a Million Species. Island Press/Center for Resource Economics, 103-119.

Hughes, T. P., Kerry, J. T., Álvarez-Noriega, M., Álvarez-Romero, J. G., Anderson, K. D., Baird, A. H., et al. (2017). Global warming and recurrent mass bleaching of corals. Nature, 543, pages 373–377.

Hughes, T. P., Anderson, K D., Connolly, S. R., Heron, S. F., Kerry, J. T., Lough, J. M., et al. (2018). Spatial and temporal patterns of mass bleaching of corals in the Anthropocene. Science, 359(6371), 80-83.

Obura, D. O., Bigot, L., & Benzoni, F. (2018). Coral responses to a repeat bleaching event in Mayotte in 2010. PeerJ, 6.

Smith, S. V. (1978.). Coral-reef area and the contributions of reefs to processes and resources of the world's oceans. Nature, 273, 225-226.

Acknowledgements

This study is partially supported and monitored by The National Oceanic and Atmospheric Administration – Cooperative Science Center for Earth System Sciences and Remote Sensing Technologies under the Cooperative Agreement Grant #: NA16SEC4810008. The author(s) would like to thank The City College of New York and NOAA Office of Education, Educational Partnership Program with Minority Serving Institutions (EPP/MSI) for support for Andrea Gomez and Ricardo Peralta. The statements contained within the poster are not the opinions of the funding agency or the U.S. government, but reflect the authors' opinions.
The authors also thank the Pinkerton Foundation and the American Museum of Natural History for funding and supporting Sajiv Mahase and Connor Rabinowitz through the High School Initiative in Remote Sensing of the Earth Systems Science & Engineering (HIRES) program.