AOML Keynotes
NOAA'S ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY
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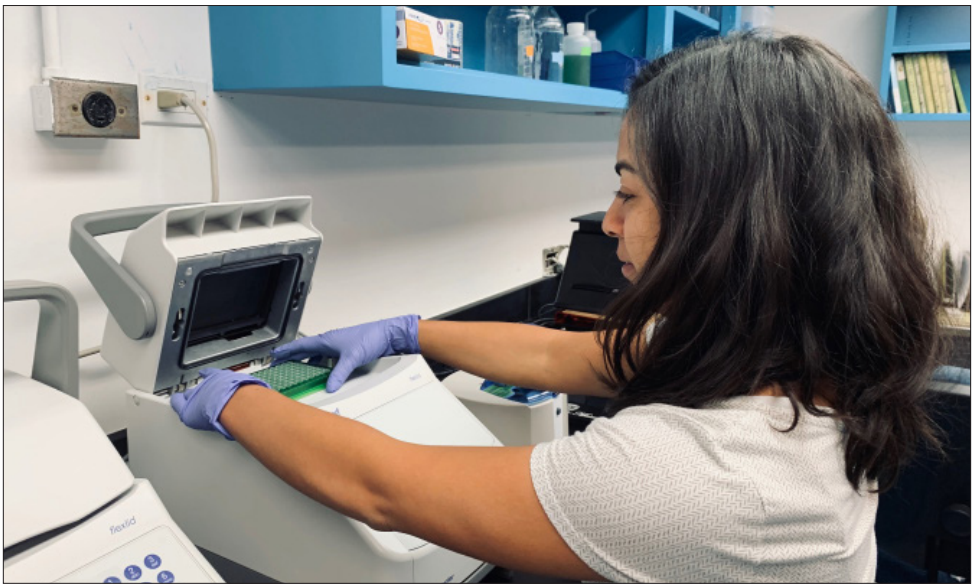
AOML is an environmental laboratory of NOAA's Office of Oceanic and Atmospheric Research located on Virginia Key in MIami, Florida

Location, Location, Location: How Habitat and Microbiomes Contribute to Coral Outplant Success

Researchers find that physical habitat characteristics at reefs can influence coral microbial communities, affecting both coral health and outplanting success



Stephanie Rosales, PhD, a University of Miami-Cooperative Institute coral scientist at AOML, processes coral tissue samples for DNA analysis collected from four reefs in southeast Florida.

A new study by coral researchers with the University of Miami's Cooperative Institute for Marine and Atmospheric Studies and AOML suggests that physical habitat characteristics at reef sites, for example, temperature, light availability, waves, and ocean currents, may have an influence on coral microbial communities that affect the overall health of coral reefs. The results of the study, published in the journal *PeerJ**, show a link between physical habitat and the coral microbiology of reefs in southeast Florida.

The Florida reef tract—extending from St. Lucie Inlet in Martin County southward to the Dry Tortugas—has been facing ongoing challenges due to ocean warming, disease, and pollution, resulting in coral bleaching and mortality. As part of the effort to reverse coral decline, scientists have been looking for methods to increase the success of their restoration efforts, including outplanting corals grown in nurseries back onto reef habitats to rebuild damaged reefs along the Florida coast.

The physical location of a reef and the unique collection of microbes associated with its corals, called the microbiome, may play a role in the successful growth of outplanted corals. The effects of sea temperature changes on corals have already been documented in previous studies. The goal of the current research was to determine whether other physical properties might have the potential to increase beneficial microbes in corals and, ultimately, improve outplant survival rates.

Researchers sampled two species of hard coral—mustard hill coral (*Porites astreoides*) and the massive starlet coral (*Siderastrea siderea*)—that are both currently impacted by a disease that has been sweeping through the Florida reef tract in recent years. The science team processed DNA from tissue samples collected from healthy coral colonies at four reef sites. They also collected data on water quality, sea temperature, currents, and depth at each reef site to determine whether correlations could be made between these physical characteristics and the microbial genetics of the corals.

The study revealed that variability of the physical habitat could affect the genomics of natural microbial communities found in corals, which impact how corals survive and thrive. The knowledge of how the physical habitat impacts corals can be used to improve ecosystem management and restoration efforts to increase coral survival.

"It's important for us to consider how conditions such as temperature, water quality, and ocean circulation impact the overall health and biology of coral colonies," said AOML-University of Miami-Cooperative Institute coral scientist and lead author Stephanie Rosales. "This study shows how physical habitat changes in temperature, currents, and turbidity can impact corals up to the microbial level, which may affect the health of coral communities and the stability of restoration efforts."

*Rosales, S.M., C. Sinigalliano, M. Gidley, P.R. Jones, and L.J. Gramer, 2019: Oceanographic habitat and the coral microbiomes of urban-impacted reefs. *PeerJ*, 7:e7552 (doi:10.7717/peerj.7552).

Study Calls for Greater Use of Satellites to Monitor Ocean Carbon

Satellites play a critical role in monitoring carbon dioxide levels in the oceans, but researchers are only just beginning to understand their full potential

The ability to predict Earth's future climate relies upon monitoring efforts to determine the fate of carbon dioxide emissions. For example, how much carbon stays in the atmosphere or becomes stored in the oceans or on land? The oceans in particular have helped to slow climate change as they absorb and then store carbon dioxide for thousands of years.

The Intergovernmental Panel on Climate Change's *Special Report on the Oceans and Cryosphere in a Changing Climate*, published in September, identified the critical role the ocean plays in regulating climate, along with the need to increase monitoring capabilities and understanding of ocean health.

The oceans, however, are vast. Covering more than 70% of the Earth's surface, it's little wonder why satellites have become such an important component in globally monitoring oceanic carbon. Although research vessels, buoys, and transport ships routinely collect carbon data, some oceans remain chronically undersampled.

A new study published in *Frontiers in Ecology and the Environment** finds that greater use of existing satellites will enable scientists to fill "critical knowledge gaps" for monitoring Earth's climate. Led by the University of Exeter, the work reports that satellites originally launched to study the wind also have the capability to observe how rain, wind, waves, foam, and temperature all combine to control the movement of heat and carbon dioxide between the ocean and the atmosphere.

Satellites launched to monitor gas emissions over the land are also able to measure carbon dioxide emissions as they disperse over the ocean. Additionally, future satellite missions offer an even greater potential for new knowledge, including the ability to study the internal circulation of the oceans, while new constellations of commercial satellites designed to monitor the weather and life on land could also aid in monitoring ocean health.

This article is adapted from a University of Exeter press release

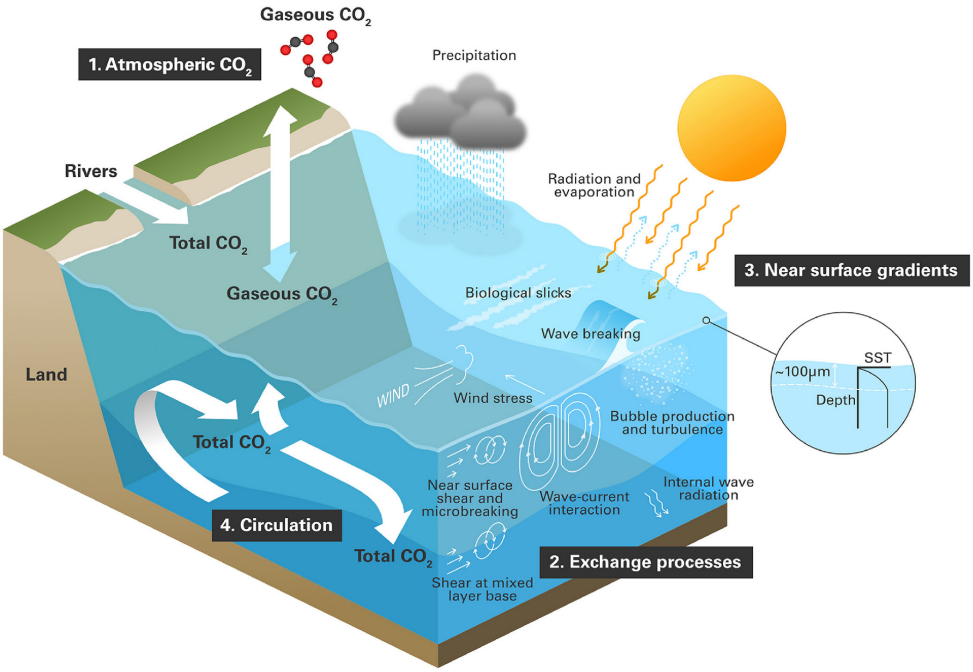


Diagram that shows the interactions, exchange, and circulation of carbon dioxide within the ocean, identifying where satellite-based Earth observations are likely to play a leading role in expanding understanding and capability: (1) atmospheric measurements at the ocean surface; (2) quantifying gas, momentum, and heat atmosphere–ocean exchange processes; (3) capturing near-surface gradients in the water; and (4) measuring internal circulation and surface transport. Image from *Frontiers in Ecology and the Environment*.

"Monitoring carbon uptake by the oceans is critical for understanding our climate and for ensuring the future health of the animals that live there," said lead author Jamie Shutler, PhD, of the Centre for Geography and Environmental Science on Exeter's Penryn Campus in Cornwall. "By monitoring the oceans we can gather the necessary information to help protect ecosystems at risk and motivate societal shifts towards cutting carbon emissions."

The research team—comprised of scientists from multiple European institutes and universities, NOAA, the Japan Aerospace Exploration Agency, and the European Space Agency—calls for a "robust network" that can routinely observe the oceans. This network would need to combine data from many different satellites with information from automated instruments on ships, autonomous vehicles, and floats that can routinely measure surface water carbon dioxide.

Recent computing advancements such as Google Earth Engine, which provides free access and computing for scientific analysis of satellite datasets, could also be used. The study suggests that an international charter that makes satellite data freely available during major disasters should be expanded to include the "long-term human-made climate disaster," enabling commercial satellite operators to easily contribute.

According to Rik Wanninkhof, PhD, a study coauthor and an oceanographer at AOML, "the work highlights the tremendous opportunities available for current and future satellite missions to observe the rapid changes occurring in the ocean carbon cycle and their impact on climate and ocean health."

Satellite-based carbon observations are needed to address knowledge gaps and inform policies that motivate societal shifts to reduce emissions. The research was supported by the International Space Science Institute in Bern, Switzerland and was initiated by Drs. Shutler at the University of Exeter and Craig Donlon of the European Space Agency.

*Shutler, J.D., R. Wanninkhof, P.D. Nightingale, D.K. Woolf, D.C.E. Bakker, A. Watson, I. Ashton, T. Holding, B. Chapron, Y. Quilfen, C. Fairall, U. Schuster, M. Nakajima, and C.J. Donlon, 2019: Satellites will address critical science priorities for quantifying ocean carbon. *Frontiers in Ecology and the Environment*, doi:10.1002/fee.2129.

AOML Flies Science Missions into Succession of Atlantic Storms

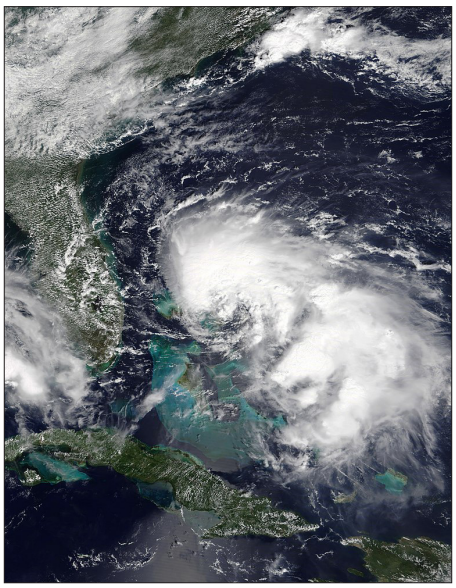
"Many of the storms we flew in 2019 were 'living on the edge,' in that they were weak, vertically sheared, but also unpredictable. In previous years, we saw these storms intensify, such as Hurricane Michael in 2018. This season, many struggled to intensify. As we continue to build a dataset of these sheared storms, we look towards improving our ability to accurately predict their future intensity change."

Jon Zawislak, PhD, Director
NOAA-Hurricane Field Program

AOML hurricane scientists Trey Alvey and Lisa Bucci prepare their workstations aboard NOAA's P-3 Hurricane Hunter aircraft as they head out to collect observations in Hurricane Humberto.

AOML's hurricane scientists conducted multiple airborne missions into several tropical systems that formed in the Atlantic in September and October. The data gathered in Humberto, Jerry, pre-Karen, Lorenzo, and Nestor improved track and intensity forecasts, aiding NOAA's efforts to prepare vulnerable communities for severe weather. The missions also supported research to better understand how tropical cyclones form, intensify, and dissipate, as well as supported efforts to validate satellite measurements of these storms.

Missions aboard NOAA's Hurricane Hunter aircraft were undertaken to gather tail Doppler radar and dropsonde observations. These data are critical for accurate forecasts, as they provide vital information about storm structure and intensity, as well as information about the atmosphere's temperature, humidity, and pressure.



Satellite image of Tropical Storm Humberto east of the Bahamas on September 14.

AOML's hurricane scientists obtain them by sampling the environment around the periphery of a storm, as well as by flying directly through the bands of towering thunderstorms that circle the eye. Here in this turbulent region reside the strongest winds and pockets of heaviest rainfall. The data are quality controlled in real-time by AOML scientists aboard the aircraft and transmitted for assimilation into NOAA's Hurricane Weather Research and Forecasting model.

Missions began aboard NOAA's P-3 Hurricane Hunter aircraft on September 13 as Humberto became the eighth named storm of the 2019 Atlantic season. Humberto intensified on its north-northeastward path, moving east of the US mainland and the Bahamas before becoming a hurricane on September 15.

Three of the Humberto missions were to gather tail Doppler radar and dropsonde observations in support of the operational requirements of NOAA's Environmental Modeling Center to improve forecast models. The fourth and final mission flown on September 16 focused on collaborative research with colleagues from NOAA's National Environmental Satellite, Data, and Information Service Ocean Winds program to measure and validate surface wind speeds obtained aboard the P-3 against satellite measurements.

Humberto intensified into a major Category-3 hurricane as it approached Bermuda, passing over the eastern portion of the island on September 18 with 125 mph winds as Jerry formed in the western Atlantic.

AOML hurricane scientists conducted two P-3 research missions into Jerry beginning on September 20 as the storm strengthened into a Category-2 hurricane. Both missions were undertaken to gather data for research studies but also supported operations by collecting, quality controlling, and transmitting tail Doppler radar and dropsonde observations off the P-3 in real-time.

NOAA's G-IV high-altitude jet also conducted four missions between September 15-21 to sample the environment in and around the periphery of Jerry, with two missions being for research purposes. One of these missions was conducted in collaboration with partners from NOAA's Joint Polar Satellite System program to validate moisture measurements from NOAA satellites against data from dropsondes deployed from the G-IV, which measure humidity as they descend toward the ocean.

The goals of the P-3 and G-IV missions were also for data collection in support of the early and mature stage science objectives of NOAA's Hurricane Field Program-Intensity Forecast Experiment. Data gathered for these objectives will help scientists better understand how storm structure changes in **(*cont. page 4*)**

(*cont. from page 3*)

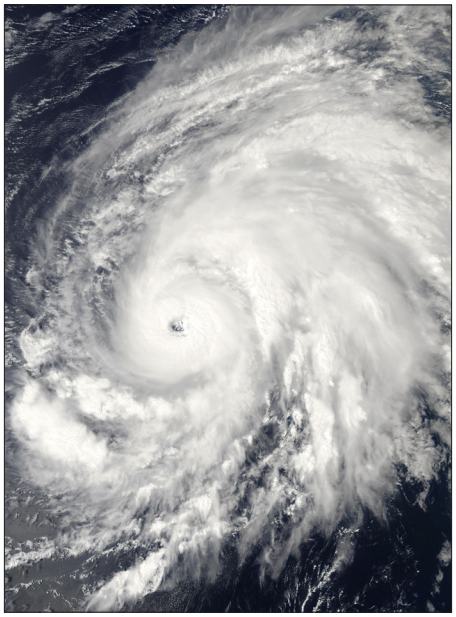
moderate to high levels of vertical wind shear, typically considered detrimental to intensification. Jerry's circulation became tilted with height due to wind shear, and AOML scientists uniquely observed changes in humidity and precipitation as its circulation structure changed.

Jerry will serve as a great comparative case for other sheared storms sampled by AOML scientists over the past few years, e.g., Hermine, Nate, and Michael. Against the odds, these storms intensified. Hurricane Jerry, however, dissipated at sea.

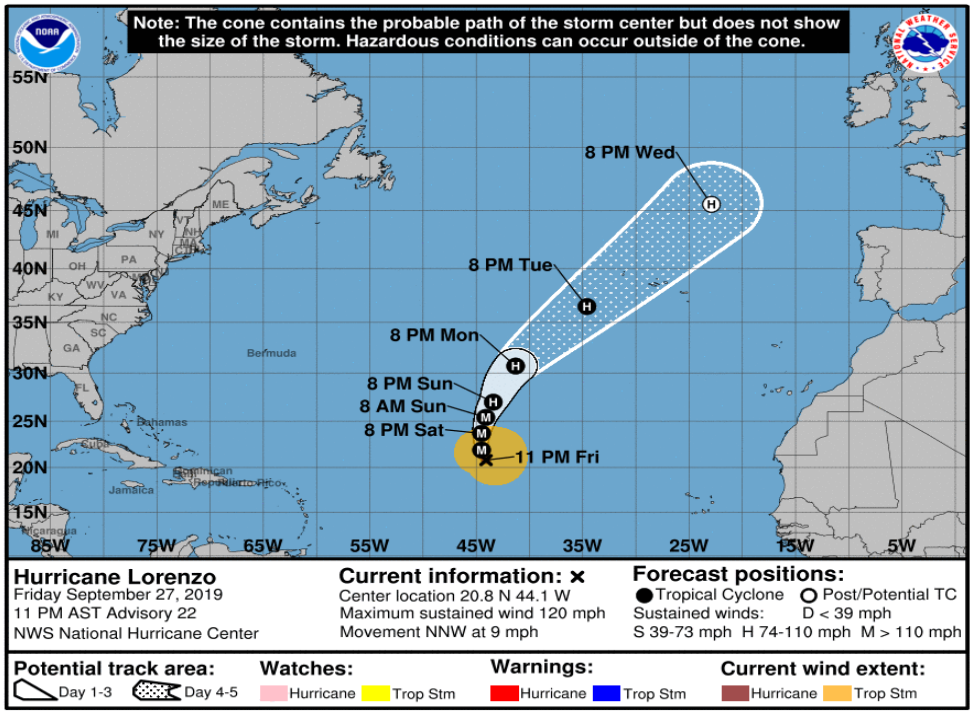
As Jerry deteriorated, Lorenzo formed in the eastern Atlantic and strengthened into a hurricane on September 25. After rapidly intensifying, Lorenzo emerged as a catastrophic storm with 160 mph winds on September 28. The powerful storm became the second Category-5 hurricane of the 2019 Atlantic season and broke records as the strongest tropical cyclone to date ever measured in the central North Atlantic.

Three P-3 research-tasked missions were flown out of Barbados to investigate Lorenzo on September 28-29. AOML scientists observed both a strengthening and weakening of Lorenzo's intensity, both of which occurred as the storm was influenced by moderate vertical wind shear. The G-IV also flew three research missions dedicated to satellite validation in support of the Joint Polar Satellite System program.

The Lorenzo missions marked the first hurricane flown by the P-3 "Miss Piggy"



Satellite image of Lorenzo in the central North Atlantic at peak intensity on September 28, 2019.

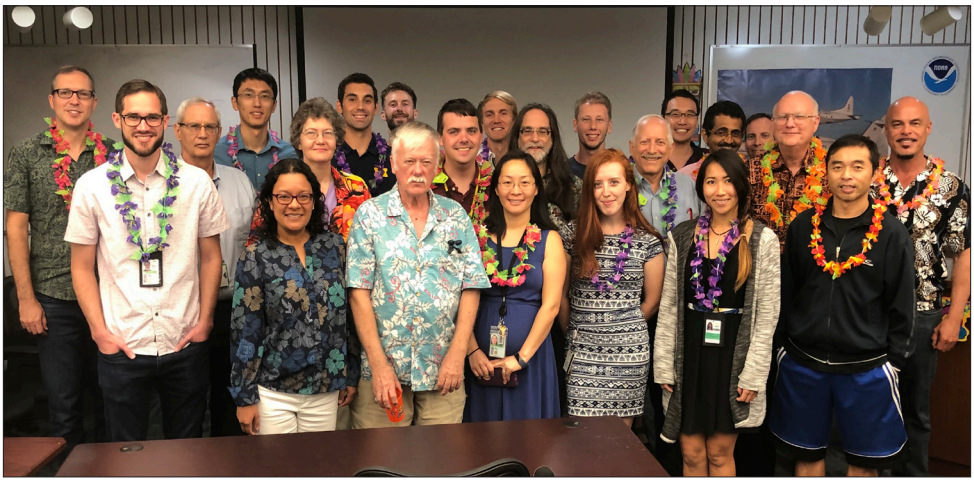


National Weather Service map of the Atlantic basin showing Hurricane Lorenzo's predicted path on September 27 based on data from an array of observing platforms, including airborne hurricane hunter missions.

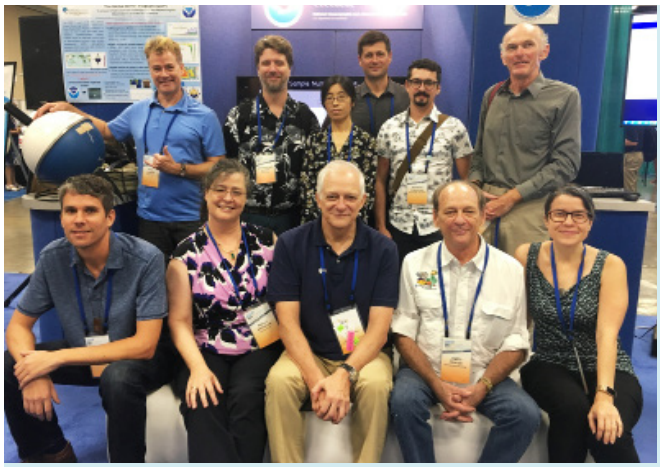
Hurricane Hunter aircraft since 2016 and included a day in which all three NOAA hurricane aircraft, both P-3s and the G-IV, flew simultaneously in and around the storm. Lorenzo weakened on its path across the Atlantic toward Europe, passing over the Azores Islands of Portugal as a Category-1 hurricane before coming ashore in County Donegal, Northern Ireland as a post-tropical cyclone.

Almost 3 weeks later on October 18, AOML's hurricane scientists flew two P-3 missions in Tropical Storm Nestor as it formed in the southern Gulf of Mexico. In addition to gathering tail Doppler radar and dropsonde observations, they also surveyed Nestor's developing low-level circulation, as well as the extensive rain and wind fields on Nestor's northern and eastern sides. Although Nestor was short-lived, the storm flooded portions of the Florida Panhandle as it moved ashore on October 19.

AOML's hurricane scientists flew multiple missions in September-October as the Atlantic entered it peak period for hurricane activity. The data gathered in Humberto, Jerry, Lorenzo, pre-Karen, and Nestor will support future research studies and were vital to accurate, up-to-date forecasts, supporting NOAA's mission of building a more weather-ready nation.



AOML's hurricane scientists and friends celebrated the last regularly scheduled tropical weather discussion of the year on October 18. While an AOML crew gathered data in Tropical Storm Nestor, those on the ground gathered for Aloha Friday. AOML hosted the daily discussions throughout hurricane season to review storm activity in the Atlantic and Pacific basins. This year's discussions were presented by scientists and students from AOML, the National Hurricane Center, and an assortment of universities and cooperative institutes.



AOML researchers at the OceanObs'19 Conference in Honolulu, Hawaii included (from left to right): Seated—Greg Foltz, Molly Baringer, Gustavo Goni, Jim Hendee, and Renellys Perez. Standing—Rick Lumpkin, Chris Meinen, Shenfu Dong, Denis Volkov, Ricardo Domingues, and Rik Wanninkhof.

Global Ocean Observing Community Meets in Hawaii

A large group of AOML researchers attended the international OceanObs'19 Conference in Honolulu, Hawaii on September 16-20, 2019. Hosted decadally, the conference brought together a diverse mix of approximately 1500 maritime stakeholders, scientists, members of indigenous tribes, and representatives from both private and public operational resource management agencies. Over the 5-day event, participants reviewed the progress made since 2009 (i.e., OceanObs'09) to improve, integrate, and expand ocean observing networks, as well as expand upon and refine the quality and types of data being gathered. They also collaborated to determine how to best address the growing demand for timely, accurate, accessible ocean information over the next decade to advance understanding of the ocean and to meet scientific, societal, and economic needs. In support for the conference, 27 AOML researchers contributed to 23 peer-reviewed white papers that were published in the journal *Frontiers in Marine Science*.

OceanObs'19 Session Highlights the Role of Women in the Ocean Sciences

During the international OceanObs'19 Conference in September, many AOML and University of Miami-Cooperative Institute scientists participated in the *Breaking Waves, Breaking Barriers* event hosted to celebrate women's instrumental role in ocean science, leadership, and mentorship. The event was open to all and brought together ocean scientists from around the globe. A panel discussion emphasized the important role women have played in shaping oceanography, with three women scientists sharing their stories of leadership and efforts to mentor younger generations. A reception followed in which event ambassadors provided the opportunity for all women to share career experiences and exchange ideas for how to build a more inclusive, robust, and forward-leaning field. Molly Baringer and Renellys Perez of AOML both served as ambassadors. More information about the event organizers and panelists can be found at https://www.eventbrite.com/e/oceanobs19-breaking-waves-breaking-barriers-registration-64667893410?

High School Students Asked to Consider STEM Careers

AOML IT specialist Alejandra Lorenzo spoke with students at G. Holmes Braddock Senior High School in September, challenging them to consider the choice of a STEM career. Alejandra emphasized the importance of obtaining Adobe, Microsoft, and networking certifications while in high school to acquire valued marketable skills. She also spoke of the benefit of seeking a summer internship to broaden and explore career options and opportunities.

Alejandra Lorenzo speaks with student about STEM professions.

AOML Goes Pink

In support of Breast Cancer Awareness Month, AOML hosted an event on October 23 for staff to learn more about the disease, one of the most prevalent forms of cancer in women. Guest speaker Dr. Elizabeth Cabrera of the Miami VA Healthcare System presented basic information about breast cancer and how to identify its signs and symptoms, emphasizing the necessity of preventative screenings and self-examination to detect lumps, masses, and other abnormalities in breast tissue. Dr. Cabrera also discussed and answered questions regarding risk factors and prevention, early detection and diagnosis, treatment options, and survival rates.

Guest speaker Dr. Elizabeth Cabrera (center) is flanked by some of AOML's pink supporters: Liz Perez, Ruth Almonte, Aly Thompson, Erica Rule, Maribeth Gidley, Evan Forde, Kristina Kiest, Renellys Perez, Howie Friedman, and Molly Baringer.

Congratulations

Dr. Natchanon Amornthammarong, aka Mana, a University of Miami Cooperative Institute scientist with AOML's Ocean Chemistry and Ecosystems Division, received a 2019 Special Appreciation Award in October from the Federal Laboratory Consortium for Technology Transfer. Mana was honored for creating "a novel low-cost, high-precision sea temperature sensor for coral reef monitoring."

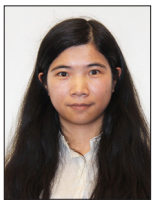
During 2019-2020, the sensor will be deployed by Reef Check Foundation and other partners at reefs in the Caribbean, Atlantic, and Indo-Pacific to determine worldwide sea temperature regimes through the Opuhala Project (https://www.coral.noaa.gov/opuhala). The expanded number of global observations from the sensors will help fine-tune satellite algorithms to better predict sea temperatures, as well as contribute to determining more accurate temperature thresholds for coral bleaching, enabling scientists to better understand the physiological dynamics of this phenomenon and other biological events.

Charline Quenée, a University of Miami Cooperative Institute research associate with AOML's Ocean Chemistry and Ecosystems Division, earned a Master's of Science degree in Marine Ecology and Society in September from the University of Miami's Rosenstiel School. Charline's thesis, *Perception of management success in the Florida Keys National Marine Sanctuary: A comparative analysis between residents and visitors*, compared how residents and visitors perceived managed success of the sanctuary based on a survey of more than 400 individuals. Results showed that while residency in the Florida Keys was an important factor in how marine resource management was perceived, industry affiliation was a stronger factor in how individuals viewed management decisions and regulations.

Welcome Aboard

Dr. Sarah Ditchek joined the staff of AOML's Hurricane Research Division in October as a University of Miami-Cooperative Institute post-doctoral scientist. Sarah will support the Quantitative Observing System Assessment Program led by Dr. Lidia Cucurull. Specifically, she will conduct data assimilation impact studies to quantify/optimize the use of new and existing atmospheric observations to improve hurricane prediction. Sarah recently earned a PhD in Atmospheric Science from the University of Albany. She previously interned with the Hurricane Research Division in 2013 as a NOAA Hollings Scholar.

Dr. Ana Maria Palacio joined the staff of AOML's Ocean Chemistry and Ecosystems Division in September as a National Research Council post-doctoral research fellow. Ana Maria will investigate the genetic basis of disease resistance in the threatened Caribbean staghorn coral, *Acropora cervicornis,* as well as assess potential trade-offs associated with disease resistance and how the environment shapes these tradeoffs. Her research is focused on improving coral restoration efforts by providing information about the advantages and risks of trait selection. Ana Maria recently earned a PhD in Marine Biology and Ecology from the University of Miami's Rosenstiel School.



Dr. Yuanyuan Xu joined the staff of AOML's Ocean Chemistry and Ecosystems Division in September as a University of Miami-Cooperative Institute post-doctoral scientist. Yuanyuan will work with the Ocean Carbon Group at AOML in exploring artificial intelligence techniques to contribute to the nascent biogeochemical Argo project. This array will be used to forecast ocean health and ecosystems in support of NOAA's mission of advancing the marine economy and fisheries. Yuanyuan recently earned a PhD in Oceanography from the School of Marine Science and Policy at the University of Delaware.

Isabelle Basden and Austin Schlenz joined the staff of AOML's Ocean Chemistry and Ecosystems Division in September as part of a year-long internship program with the Acidification, Climate, and Coral Reef Ecosystems Team. Through the coming year, Isabelle and Austin will participate in field research at reefs, help conduct experiments in the Experimental Reef Laboratory on the campus of the University of Miami's Rosenstiel School, and gain experience through ongoing coral projects at AOML. Isabel received a BS degree from Florida State University in 2018, with an honor's thesis focused on the feeding behavior of the sponge *Halichondria corrugata*. Austin received a BA degree in biology and a BS degree in animal behavior and ethology in 2017. Since 2017, he has worked on coral conservation and reef restoration in support of the Coral Restoration Foundation in Key Largo, Florida.

In Memoriam

AOML was saddened to learn of the recent death of Nina Liebig, a former budget analyst with the Admin Group. Nina passed away in Washington, Pennsylvania on June 16, 2019 at 62 years of age. She began at AOML in January 1999 after having worked more than a decade for the U.S. Army at Fort Drum in Watertown, New York. During Nina's 17 years at AOML, she was a key member of the Admin Group—monitoring budget activity and maintaining data on spending, labor costs, and budget allocations. She also ensured that AOML continually met and/or exceeded its annual fiscal year organizational budgetary benchmarks. Nina retired in 2016 after completing 29 years of federal service. She was a friend to many at AOML and will be missed. Nina is survived by an aunt and several of her siblings, as well as nieces and nephews.

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***Keynotes* is published bimonthly to highlight AOML's recent research activities and staff accomplishments.**

Keynotes editor: Gail Derr

Recent Publications *(AOML authors are denoted by bolded capital letters)*

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