AOML Keynotes

NOAA'S ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY

October-December 2021

AOML is an environmental laboratory of NOAA's Office of Oceanic and Atmospheric Research located on Virginia Key in Miami, Florida

AOML Scientists Play Critical Role in Success of NOAA's Hurricane Field Program

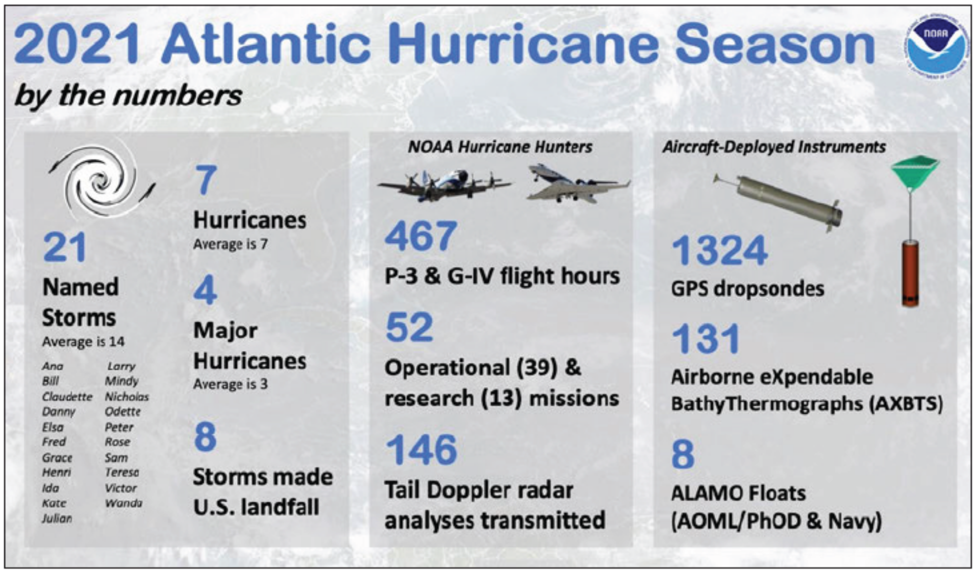
This summer hurricane scientists at AOML collected vital data, tested new instruments, collaborated with numerous partners, and used cutting-edge models to safeguard communities in the path of destructive storms. These efforts advanced the understanding of tropical cyclones and helped NOAA issue accurate, updated forecasts that protected life and property.

The active 2021 Atlantic hurricane season ended on November 30, producing 21 named tropical storms (39-73 mph winds), seven hurricanes (74 mph winds and above), and four major hurricanes (111 mph winds and above). The year will be remembered as the third-most active on record, as well as the third costliest, causing more than $80 billion in damage.

Despite ongoing challenges due to the global pandemic, scientists at AOML worked with partners at NOAA's Aircraft Operations Center to ensure Hurricane Hunter airborne missions were adequately staffed and supported by AOML's Hurricane Research Division and University of Miami-Cooperative Institute colleagues.

Their participation was critical to the success of NOAA's 2021 Hurricane Field Program, focused this year on the Advancing the Prediction of Hurricanes Experiment (APHEX) field campaign. Throughout the season they flew 52 missions in support of APHEX aboard NOAA's Hurricane Hunter aircraft, totaling 467 flight hours.

Observations gathered in Elsa, Fred, Grace, Henri, Ida, Larry, and Sam included 146 quality-controlled tail Doppler radar analyses aboard the P-3 and G-IV Hurricane Hunter aircraft and the deployment of 1,324 GPS dropsondes and 131 airborne expendable bathythermographs. The first-ever P-3 deployment of eight air-launched autonomous observer, or ALAMO, floats additionally occurred ahead of hurricanes Grace and Sam.



These real-time measurements provided invaluable information about storm intensity, atmospheric moisture, temperature, and pressure, and the temperature-salinity structure at the ocean surface to depths of 1200 meters. The data were transmitted to NOAA's National Hurricane Center and the Environmental Modeling Center, as well as assimilated into the Hurricane Weather Research and Forecasting model, for track and intensity forecasts.

A promising new instrument, an airborne Micro-pulse Doppler lidar, or MicroDop, was also tested in collaboration with NOAA's Chemical Science Laboratory. A MicroDop installed aboard a P-3 Hurricane Hunter aircraft successfully demonstrated the value of wind lidar measurements to more accurately depict the tropical cyclone environment.

In addition to NOAA's Hurricane Field Program, two separate field campaigns were conducted with partnering agencies, promoting NOAA's successful collaborations with it research associates. Data gathered during the Office of Naval Research and NASA field efforts will be used for future studies focused on a variety of research topics, including tropical cyclone rapid intensity change, the Saharan Air Layer, African easterly waves, and deep convection in the Inter-Tropical Convergence Zone.

Lastly, high-resolution, storm-following nests added to the Hurricane Analysis and Forecast System (HAFS), NOAA's next-generation modeling and data assimilation platform, enabled the movement and evolution of tropical cyclones to be tracked with ever greater detail. This milestone lays the foundation for future advances in hurricane forecasting, beyond the scope of NOAA's current state-of-the-art Hurricane Weather Research and Forecasting model.

Hurricane scientists at AOML collected key observations this summer to help vulnerable communities prepare for severe weather. Their efforts during the active 2021 Atlantic hurricane season resulted in numerous accomplishments and successful collaborations that ensured the success of NOAA's Hurricane Field Program.

GOMECC-4 Cruise Assesses Ocean Acidification Impacts in the Gulf of Mexico

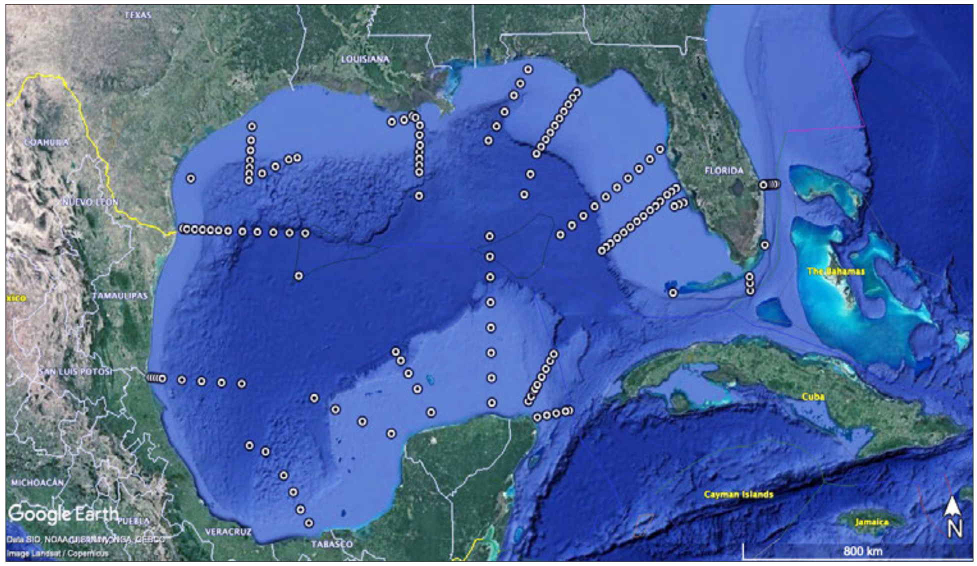
AOML scientists and partners from an assortment of universities and Cooperative Institutes successfully completed the most comprehensive ocean acidification sampling of the Gulf of Mexico to date with the conclusion of the fourth Gulf of Mexico Ecosystems and Carbon Cruise, also known as the GOMECC-4 cruise.

The research effort aboard the NOAA Ship *Ronald H. Brown* began out of Key West, Florida on September 13, 2021 with 25 scientists and graduate students aboard. It ended 39 days later on October 21 with a port stop in St. Petersburg, Florida.

The multi-institutional effort, undertaken in support of NOAA's Ocean Acidification Program, monitored ocean acidification conditions across the Gulf of Mexico to assess acidification trends and potential impacts to coastal ecosystems.

Observations from approximately 140 stations were collected to measure the extent of ocean acidification throughout the Gulf's water column, as well as key carbon, physical, and biogeochemical parameters.

Ocean acidification occurs as greater amounts of carbon dioxide (CO_2) from atmospheric emissions are absorbed by the oceans, lowering pH levels and making seawater more acidic. Although the ocean's uptake of CO_2 helps to regulate atmospheric CO_2 levels, the lower pH negatively impacts a wide range of marine organisms, impairing their ability to thrive.



Map of the Gulf of Mexico with white circles denoting the inshore and offshore locations of where data were gathered during the GOMECC-4 cruise.

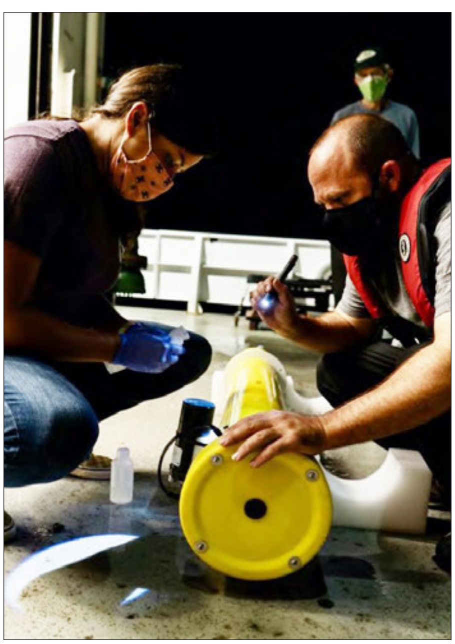
In addition to quantifying the increase of CO_2 in near surface coastal waters, the science team studied the abundance, diversity, and health of a variety of marine species. Plankton studies were conducted using net tows at select stations to capture the onshore-to-offshore variability in fish distributions and abundance, as well as larval fish age, growth, condition, diet, and evidence of microplastic ingestion.

Environmental DNA or eDNA samples were gathered from both coastal and open-ocean sites to study patterns in biodiversity and composition among populations of bacteria, plankton, and fish. The sampling was coordinated with biological, ocean acidification, and other physico-chemical measurements, allowing for statistical predictions of the relationships between ocean acidification and biodiversity.

A sediment corer was also deployed to collect samples from the ocean floor. These samples will be analyzed in relation to ocean acidification, as well as used in paleoceanographic studies.

Additionally, four biogeochemical Argo profiling floats were deployed to measure a host of biological and chemical parameters—pressure, temperature, pH, salinity, oxygen, nitrate, chlorophyll-a, and backscattering—in the upper 2000 meters of the water column. These new observations will fill vital gaps in understanding Gulf waters and deliver data to improve weather and climate predictions, as well as forecasts.

The cruise was part of AOML's ocean acidification research and was led by Leticia Barbero, PhD, a University of Miami-Cooperative Institute scientist.



AOML scientists Emily Osborne and Andy Stefanick prepare a biogeochemical Argo profiling float for deployment in the Gulf of Mexico. Photo credit: Grace Owen, University of Miami.

***Left:* A sediment corer is safely recovered after having been deployed to a depth of 3200 meters. *Right:* Emily Osborne of AOML checks the integrity of the cores after recovery of the instrument. Photo credit: Grace Owen, University of Miami.**

PIRATA Science Team Sets New CTD and Mooring Servicing Milestones

After nearly 6 weeks at sea, scientists aboard the NOAA Ship *Ronald H. Brown* docked in Praia, Cape Verde on December 19, completing the Prediction and Research Moored Array in the Tropical Atlantic (PIRATA) Northeast Extension, or PNE, cruise.

Researchers from AOML, NOAA's Pacific Marine Environmental Laboratory, the University of Miami, and the Fearless Fund began the cruise from St. Petersburg, Florida on November 12 to collect hydrography measurements, service five moorings, deploy drifting buoys and Argo profiling floats, and conduct Sargassum sampling experiments.

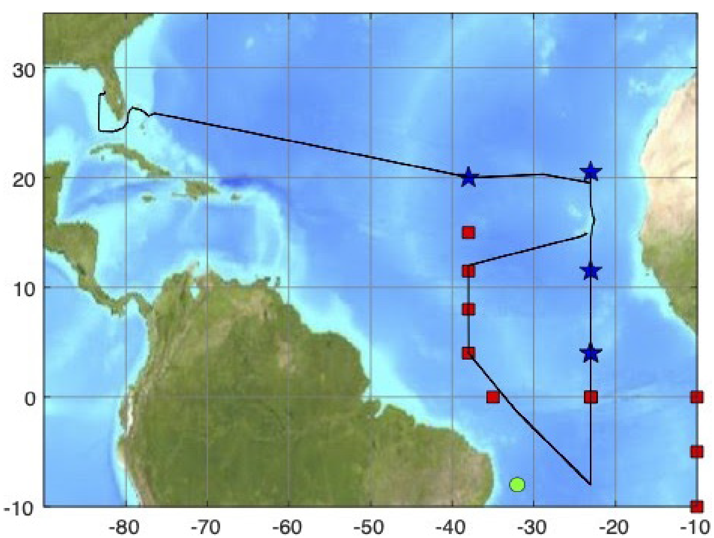
The PIRATA project is a collaborative effort between Brazil, France, and the United States to study and improve the predictability of ocean-atmosphere interactions in the tropical Atlantic. Air-sea interactions in this region have a strong impact on weather and climate variability for the countries that border the Atlantic Ocean and can be a determining factor in the prediction of extreme weather and ocean changes.

PIRATA buoys measure subsurface ocean temperature, salinity, velocity, and sea surface variables like wind direction and speed, air temperature, humidity, solar radiation, and rainfall. The PIRATA buoy array provides critical real-time data for models of the Atlantic climate system, which are used globally for ocean and weather prediction.

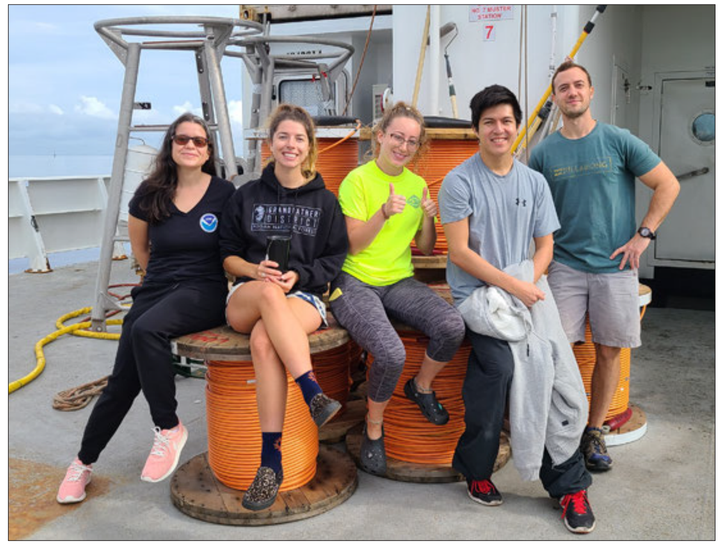
PNE is a joint project between AOML and the Pacific Marine Environmental Laboratory to expand the array of tropical moored buoys into the northern and northeastern sectors of the tropical Atlantic Ocean. The project is motivated by the need for improved prediction of weather and climate variability and is funded by NOAA's Global Ocean Monitoring and Observing program.

During the cruise, four PNE buoys were recovered, replenished with new instrumentation, and redeployed. A French PIRATA buoy was also serviced, and a Brazilian PIRATA buoy in danger of going adrift was recovered. A total of eight PIRATA mooring sites were visited, setting a new PNE milestone for the most mooring sites visited during a cruise.

While servicing the PNE buoy at 20°N, 38°W, the science team deployed 15 additional Aquadopp current meters in the upper 100 meters in support of the AOML-funded Tropical Atlantic Current Observations Study (TACOS). TACOS seeks to better understand how strong wind events, including tropical cyclones, affect ocean currents, mixing, and air-sea interactions in the region.



Track of the NOAA Ship *Ronald H. Br*own during the November-December 2021 PNE cruise. Red squares indicate the location of the PIRATA backbone moorings serviced by France and Brazil. Blue stars indicate the PNE moorings serviced by NOAA. The green circle indicates one of the Brazilian PIRATA Southwest Extension moorings.


A subset of the science team aboard the *Ronald H. Brown*: Renellys Perez (AOML, chief scientist), Grace Owen (University of Miami, graduate student volunteer), Clara Gramazio (University of Miami, graduate student Volunteer), Diego Ugaz (AOML-University of Miami Cooperative Institute, electrical engineer), and Christian Saiz (AOML-University of Miami Cooperative Institute, electrical engineer).

They also sampled the deep ocean, completing 70 CTD casts, a new PNE record. CTDs measure conductivity, temperature, and depth from the ocean's surface to 1500 meters below. These observations provide detailed snapshots of the water column, which are used to support oceanographic, meteorological, and environmental research. Fifteen surface drifting buoys and 11 Argo profiling floats were additionally deployed in areas where gaps exist in the spatial coverage of the global ocean observing system.

Lastly, Sargassum sampling experiments were conducted as part of a collaborative effort between AOML and the Fearless Fund, an organization dedicated to developing ocean solutions and supported by the U.S. Department of Energy. The collaboration targets the removal of carbon dioxide from ocean waters through the growth and harvest of seaweed biomass known as Sargassum.

Daily surveys of Sargassum filaments, patches, and mats were performed, and when a sufficient amount of Sargassum was sighted, a physical sample was obtained. A CTD cast was additionally conducted near the Sargassum and water samples collected for nutrient analysis.

The Fearless Fund experiments were undertaken to test the degradation of biomass in the deep sea as a potential means for carbon dioxide sequestration. A sample of live Sargassum deployed during the January-February 2021 PNE cruise was recovered from near the seafloor with the mooring at 2°N, 23°W. The experiment was repeated at the same location, with an additional deep sea test deployment of live Sargassum at the 4°N, 23°W mooring.

The PNE cruises ensure the buoys continue collecting data to advance the understanding of ocean-atmosphere variability in the tropical North Atlanticn. The research conducted during the cruises supports the vision of the UN Decade of Ocean Science for Sustainable Development, known as the "Ocean Decade." It also supports the AtlantOS program's vision for the implementation of an all Atlantic ocean observing system.

Research Explores Impact of Wind Shear Direction on Tropical Cyclone Intensity

A recent study in the journal *Monthly Weather Review** is the first to examine how the direction of wind shear changes how much heat and moisture are available to a tropical cyclone and how these factors influence tropical cyclone intensity change.

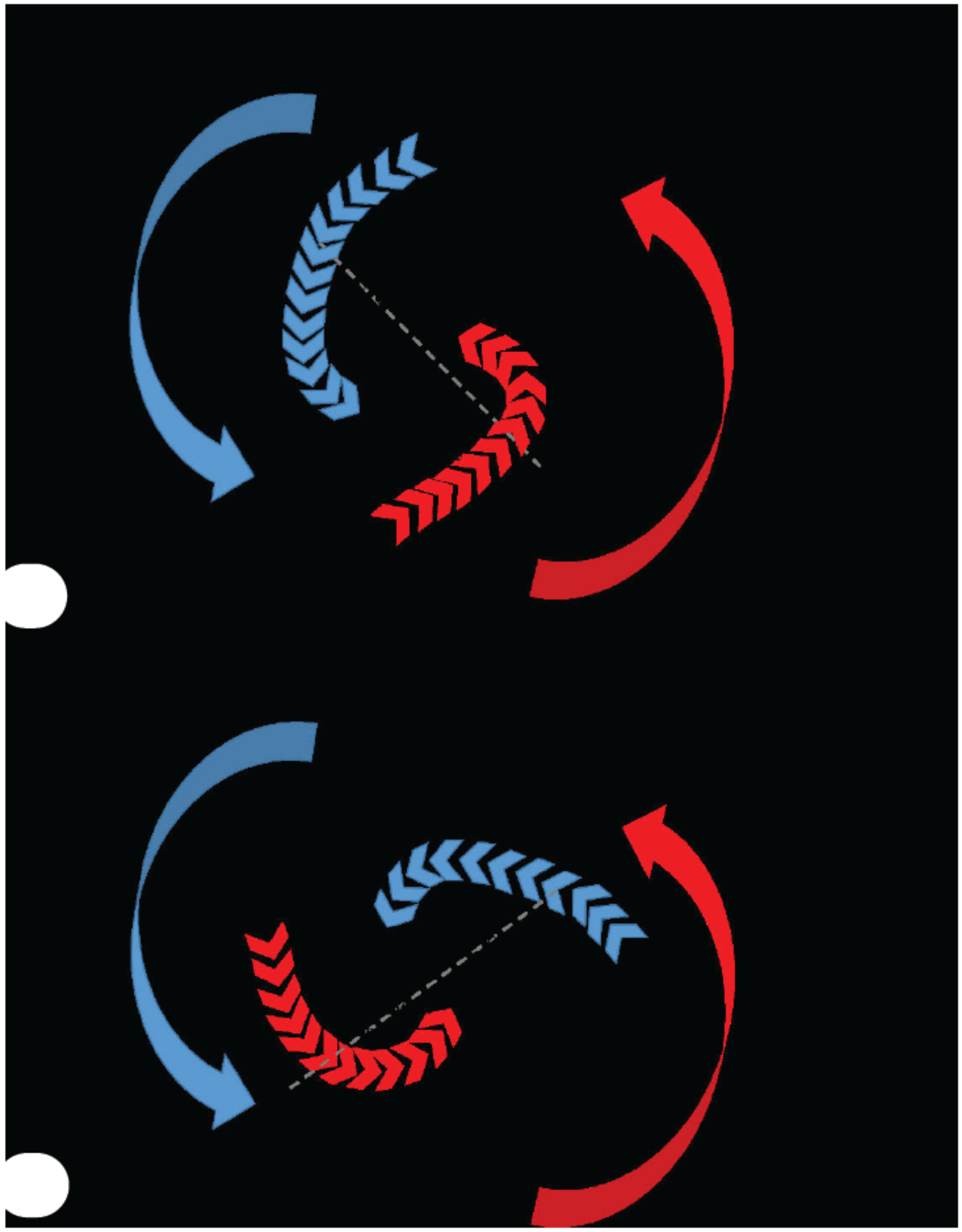
The amount of wind shear, i.e., the change of the wind with height, is one of the most commonly used predictors of tropical cyclone intensity change, with large amounts of wind shear generally being unfavorable for intensification. Regardless of the direction of the wind shear, tropical cyclones in the North Atlantic basin usually have warm, moist air from the environment near the sea surface on their east side (solid red arrows in images at right) and cool, dry air from the environment on their west side (solid blue arrows in images at right).

In addition to environmental air, when tropical cyclones are experiencing wind shear, an area of warm, moist air moves inward toward the tropical cyclone center from right-of-shear (dashed red lines in images at right) and an area of cool, dry air moves inward from downward-moving air left-of-shear (blue dashed lines in images at right). Previous studies have shown that when a tropical cyclone has temperature and humidity evenly distributed around its eyewall, known as symmetry, conditions are favorable for intensification.

When wind shear is southerly (top image at right), the downward moving cool, dry air left-of-shear is in the same location (northwest quadrant) as the cool, dry air in the environment. Additionally, the area of environmental warm, moist air coincides with the area of inward moving warm, moist air (southeast quadrant).

This overlapping cool, dry air in the northwest quadrant and overlapping warm, moist air in the southeast quadrant leads to an asymmetric distribution of temperature and moisture around the storm, which is unfavorable for intensification because the warm, moist air that tropical cyclones require to sustain their strong thunderstorms and intensify is limited.

In contrast, when the wind shear is northerly (bottom image at right), the downward moving cool, dry air left-of-shear is in the northeast quadrant in a region of warm, moist environmental air. In this scenario, the inward moving warm, moist air coincides with the region of cool, dry environmental air.



A schematic of the different environmental (solid arrows) and storm (dashed arrows) processes for tropical cyclones in the North Atlantic basin exposed to southerly wind shear (top image) and northerly wind shear (bottom image). Blue indicates cool, dry air, while red indicates warm, moist air.

Since these air masses partially cancel each other out, the temperature and moisture near the ocean surface in environments of northerly wind shear are more symmetrically distributed around the tropical cyclone, making these storms more likely to intensify. Conversely, tropical cyclones exposed to southerly wind shear environments have a more asymmetric distribution of temperature and moisture, making them less likely to intensify.

These relationships show that tropical cyclone structure and intensity are directly influenced by the surrounding environment and that knowledge of the wind environment provides tropical cyclone forecasters with another tool to predict intensity change, helping better protect both life and property.

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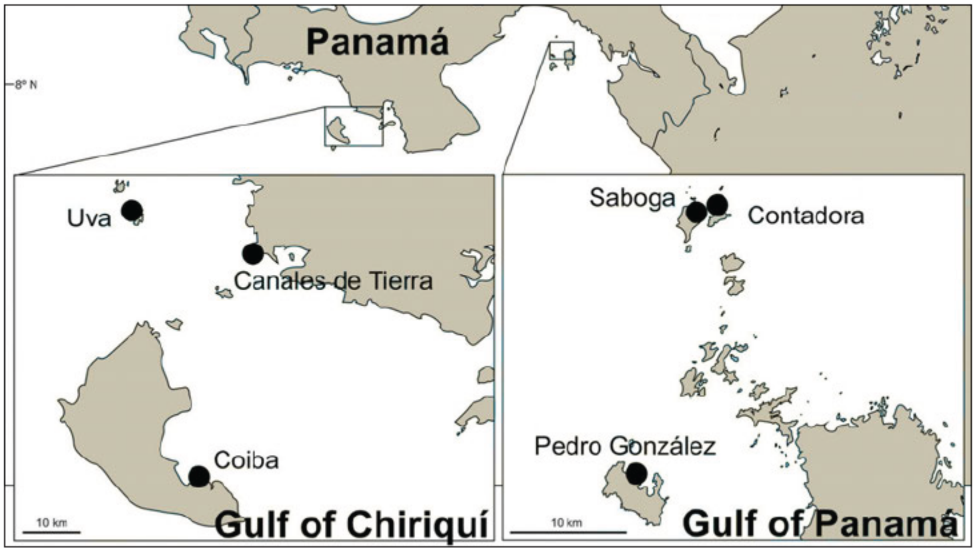
*Wadler, J.B., J.J. Cione, J.A. Zhang, E.A. Kalina, and J. Kaplan, 2022: The effects of environmental wind shear direction on tropical cyclone boundary layer thermodynamics and intensity change from multiple observational datasets. *Monthly Weather Review,* 150(1):115-134, https://doi.org/10.1175/MWR-D-21-0022.1.

Habitat Altering Processes are Uncovered for Reefs in the Eastern Pacific

"Reefs are fighting a battle on two fronts, as the changing climate decreases habitat growth while simultaneously increasing erosion. The stakes of this battle are high, with the very persistence of reefs and the ecosystem services they provide in question."

Ian Enochs, AOML research ecologist



Maps that show the location of the study sites (black circles) in the gulfs of Chiriquí and Panamá on the Pacific coast of Panamá.

Trying to predict how coral reefs will respond to warming oceans and a changing climate may be considered a daunting task. In the face of this challenge, scientists at AOML recently published a study* that characterizes the processes and organisms that lead to coral reef accretion (buildup) and bioerosion (breakdown) in the dynamic environments of the Gulf of Chiriquí and Gulf of Panamá in the eastern Pacific (see upper right image).

So how does a reef take shape and create pillars, ridges, and mountainous structures? Ocean conditions such as temperature, acidity, and available nutrients in the water play a role. But, marine organisms do as well—bioeroders graze the surface of coral skeletons as they hunt for algae (i.e., grazers), microborers dissolve microscopic tunnels, and macroborers create larger holes in the internal structure of coral.

Although grazing and erosion diminish reefs, corals, mollusks, and barnacles can form new habitat through the deposition of calcium carbonate, a process known as calcification.

Scientists studied the processes and marine organisms that contribute to the breakdown and buildup of coral reefs in the eastern Pacific through the use of bioerosion accretion replicates (BARs). The BARs, developed by scientists at AOML for the National Coral Reef Monitoring Program, are made from clean, dried, unbored *Porites* skeletons, a type of reef-building coral. They were cut into semi-circular disks and deployed at six reef sites in the gulfs of Chiriquí and Panamá for a 2-year period.

After 2 years, the BARs were collected and scanned using high-resolution computed tomography. The study revealed that external bioerosion by grazers such as parrotfish and urchins in both gulfs was the major process altering coral reef habitat, with higher rates of erosion and habitat loss observed in the Gulf of Chiriquí.

A key environmental difference between the gulfs was the greater amount of upwelling in the Gulf of Chiriquí that brought deeper, colder, nutrient-rich water to the surface (see bottom left image). Upwelling may have provided a food source for less desirable and weaker calcifying animals and macroborers, leading to less structurally stable reefs and sediment, rather than solid reef.

Keeping up with sea level rise and other stressors brought on by climate change presents a challenge for reefs struggling to grow and adapt to changes in their environment. The interaction of reef structure, habitat biodiversity, and ocean conditions can lead to a variety of ecosystem outcomes that are difficult to predict. A holistic approach to examining the impact of environmental conditions on all habitat-altering organisms is thus key for understanding reef persistence in the eastern Pacific and global ocean.

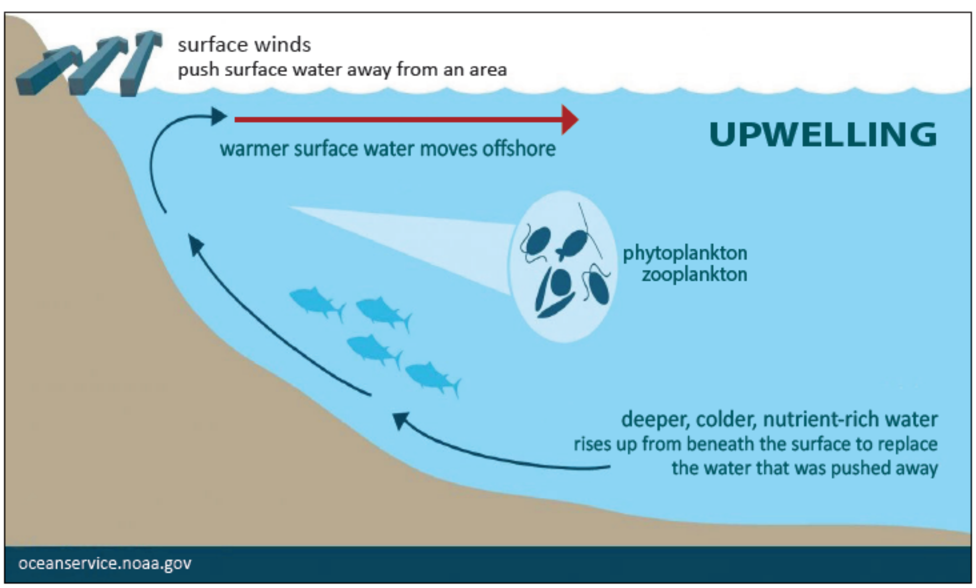
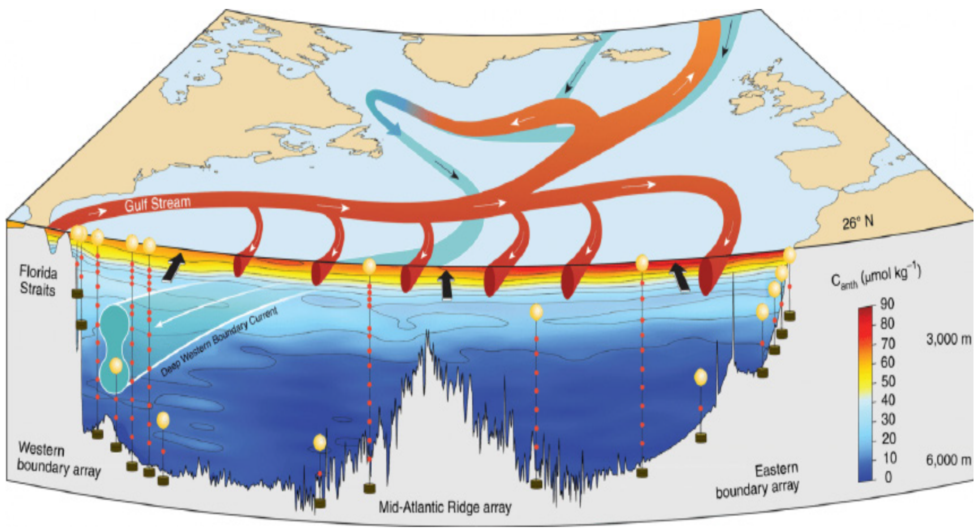


Diagram that demonstrates the process of upwelling: Surface water is displaced by colder, nutrient-rich water that "wells up" from below. The water that rises is often cooler and more acidic and may contribute to increased biological productivity due to the nutrients it brings to the surface.

*Enochs, I.C., L.T. Toth, A. Kirkland, D.P. Manzello, G. Kolodziej, J.T. Morris, D.M. Holstein, A. Schlenz, C.J. Randall, J.L. Maté, J.J. Leichter, and R.B. Aronson, 2021: Upwelling and the persistence of coral-reef frameworks in the eastern tropical Pacific. *Ecological Monographs,* 91(4):e01482, https://doi.org/10.1002/ecm.1482.

Study Explores the Relationship of Anthropogenic Carbon and Ocean Circulation

A new study represents the first instance that scientists have quantified the time variability of anthropogenic carbon transport in the ocean, which has impacts on global oceanic pH levels, the diversity and abundance of marine species, the human food supply, and multiple other factors.



A schematic of the major currents in the North Atlantic Ocean that comprise the northern limb of the AMOC. The Gulfstream is the major surface current, with along surface gyre and return flows represented by white arrows on red. Ekman transport is represented by broad black arrows, while blue, black, and white arrows on teal represent the main southward flow of colder, deeper waters. The cross section shows anthropogenic carbon concentrations along 26°N, with high values near the ocean surface indicated by the color bar scale on the right. The image is adapted with permission from Srokosz *et al.* (2015).

In a recently published study in *Nature Geoscience*,* scientists at AOML and their international partners quantified the strength and variability of anthropogenic or man-made carbon transport in the North Atlantic Ocean. The study found that the buildup of anthropogenic carbon in the North Atlantic is sensitive to the strength of the Atlantic Meridional Overturning Circulation (AMOC), as well as to the uptake of anthropogenic carbon at the ocean's surface.

Anthropogenic carbon refers to carbon dioxide (CO_2) released into the atmosphere by human activities, including the burning of fossil fuels, land use practices, industrial processes, and other sources. The ocean absorbs about a quarter of the emitted anthropogenic carbon, reducing the buildup of CO_2 in the atmosphere, a greenhouse gas, and thus reducing climate change.

The Atlantic component of the global Meridional Overturning Circulation (MOC) plays a major role in redistributing heat, salt, dissolved oxygen, nutrients, and carbon throughout the global climate system. Changes in the flow of the MOC have important societal impacts on coastal sea levels, marine heat waves, extreme weather events, and shifts in regional surface temperature and precipitation patterns. In particular, the AMOC is known to have a large influence on the weather and climate of the countries that border the North Atlantic Ocean.

The study shows a novel aspect of the MOC in how it directly impacts the movement of carbon throughout the ocean, and particularly, the amount of anthropogenic carbon transported northward. Carbon is absorbed at the ocean surface, and the upper northern limb of the MOC transports the majority of this carbon-enriched surface water northward via fast-moving, wind-driven currents. The water becomes colder and denser as travels northward and sinks to the bottom of the ocean. It then returns southward as the lower, deeper layer of the MOC.

The North Atlantic Ocean is a key region of interest to stakeholders because of the disproportionately large amount of anthropogenic carbon that accumulates due to its transport northward by the AMOC and to air-sea exchange processes.

To determine the strength and variability of anthropogenic carbon transport in the North Atlantic, the science team used hydrographic ship observations and measurements obtained between 2004 and 2012 from the RAPID mooring array stretched across the Atlantic along 26.5°N. They found that decreases in ocean circulation strength tended to decrease the northward transport of anthropogenic carbon. However, this was balanced by an increasing amount of anthropogenic carbon being absorbed by the ocean, which increased the northward transport of anthropogenic carbon.

If the strength of the MOC decreases, less carbon will enter the deep ocean. What was observed in the study, however, is that even if the strength of the MOC declines, the ocean's capture of increasing amounts of anthropogenic carbon will still significantly impact its transport into the North Atlantic Ocean in the future.

Before this study, the variability of the ocean circulation's contribution to the regional storage of anthropogenic carbon and the resilience to global change were largely uncertain. This research shows a new aspect of the impact of the AMOC on carbon cycling, in particular, the transport of anthropogenic carbon into the North Atlantic Ocean.

"The results of the study show how variable ocean circulation is and how complicated the relationship is between the MOC and carbon," said Molly Baringer, an AOML oceanographer and study coauthor. "Changes in the strength of the MOC are cancelled out by changes in the uptake of carbon in surface waters. This study is an important step to understanding these processes to better predict changes in the future."

AOML has been a long-standing leader of research on the physical transports of the AMOC and its western boundary currents. This work is an extension into the biogeochemical and biological realms, with nascent programs such as the North Atlantic Carbon Observatory (NACO) being an important step for meeting the goals of the integrated All-Atlantic Ocean Observing System (AtlantOS).

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*Brown, P.J., E.L. McDonagh, R. Sanders, A.J. Watson, R. Wanninkhof, B.A. King, D.A. Smeed, M.O. Baringer, C.S. Meinen, U. Schuster, A. Yool, and M.-J. Messias, 2021: Circulation-driven variability of Atlantic anthropogenic carbon transport, uptake, and inventory. *Nature Geoscience,* 14(8): 571-577, https://doi.org/10.1038/s41561-021-00774-5.

Rick Lumpkin Selected to Lead Physical Oceanography Research at AOML

AOML is pleased to announce the selection of oceanographer Rick Lumpkin, PhD, as the new director of the Physical Oceanography Division. Rick becomes the director after having served in an acting capacity throughout much of 2021. He succeeds Gustavo Goni, PhD, in the position, who served as the division director for the past 12 years.

Rick began at AOML with the Physical Oceanography Division in 2002 as an Assistant Scientist with the University of Miami's Cooperative Institute for Marine and Atmospheric Studies. He became a federal oceanographer in 2004 and then became the deputy director of the division in 2015. His research focuses on upper ocean dynamics, observations of submesoscale to basin-scale circulation, pathways and physics of the global thermohaline circulation, and interannual to decadal variations in ocean climate.

He received his PhD in Oceanography from the University of Hawaii in 1998 and conducted research as a postdoctoral scientist at IFREMER, the French National Institute of Ocean Science, from 1998-2000. Rick then worked as an assistant researcher at Florida State University where, in collaboration with Kevin Speer, he developed an inverse model of the global meridional overturning circulation from hydrographic data, current meter moorings, and air-sea heat and freshwater flux estimates.

As a principal investigator for NOAA's Global Drifter Program, Rick has served as the chief scientist on numerous oceanographic research cruises. He also oversees a global array of ~1300 satellite-tracked drifting buoys that measure ocean temperature, surface currents, barometric pressure, and waves and has used these data to author a number of peer-reviewed publications. He additionally serves as the lead for the US delegation to the Data Buoy Cooperation Panel and became a member of the World Meteorological Organization's Standing Committee for Measurements, Instrumentation, and Traceability in 2020.

Rick was awarded three Department of Commerce Bronze Medals in 2009 for (1) the successful research-to-operations transition of the design and monitoring of the Sea Surface Temperature Observing System, (2) exceptional service as the author of the NOAA-Smithsonian Institute publication "*Hidden Depths: Atlas of the Ocean,*" and (3) his contributions and original concepts in the design of the Smithsonian's Sant Ocean Hall.

He was additionally named a NOAA/NOAA Research Employee of the Year in 2013 for his efforts to improve the quality of drifter data by developing a new methodology that evaluates when drifters have lost their drogues and become strongly affected by winds and waves.

Congratulations and best wishes to Rick on his selection as the director of AOML's Physical Oceanography Division.

Congratulations

Sim Aberson, a meteorologist with AOML's Hurricane Research Division, was named a 2021 NOAA/Office of Oceanic and Atmospheric Research (OAR) Employee of the Year in December for his outstanding contributions to the excellence of OAR's programs and operations. Sim was recognized for his personal and professional excellence [redacted]

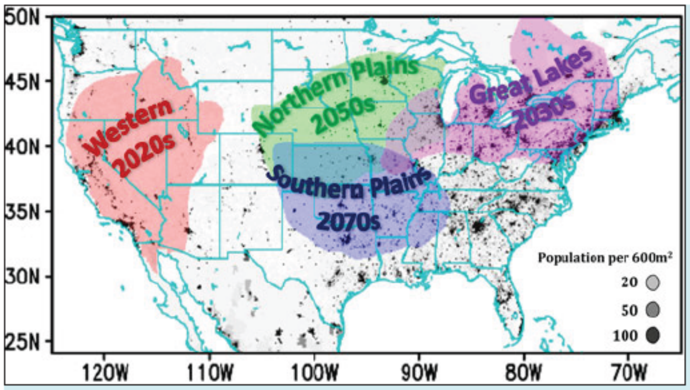
Hosmay Lopez, an oceanographer with AOML's Physical Oceanography Division, received a 2021 NOAA Administrator's Award in October. Hosmay was recognized for his research to assess the variability, predictability, and future projections of extreme heat waves affecting the continental US. His research has identified regions in the US where human-caused climate change is expected to surpass natural climate variability to become the dominant cause of heat extremes. Moving forward, climate change will drive more frequent and extreme summer heat waves in the western US by the late 2020s, the Great Lakes region by the mid 2030s, and the northern and southern Plains by the 2050s and 2070s, respectively. The Administrator's Award honors employees who have demonstrated exceptional leadership, skill, and ingenuity in their significant, unique, and original contributions that bring credit to NOAA, the Department of Commerce, and the federal government.

Sundararaman Gopalakrishnan, aka Gopal, and Robert Rogers, both meteorologists with AOML's Hurricane Research Division, completed NOAA's Leadership Competencies Development Program (LCDP) in October. The LCDP provides participants with developmental experiences and assignments to broaden their understanding of NOAA's strategic vision, mission, and goals, as well as its business practices. The competitive program focuses on individuals who have demonstrated the potential to assume leadership roles and responsibilities, providing NOAA with a source of candidates for its senior and/or executive level positions.

Gopal and Rob were members of the eleventh class of leadership trainees that were nicknamed the "transformers." They began the 18-month program in July 2019 but completed the course several months later than expected. This was due to the reorientation necessitated by NOAA's shift to a virtual work environment.

Saildrone Field Effort Named as a Top 10 Ocean Story for 2021

Smithsonian Magazine has named NOAA's Saildrone hurricane field effort as one of its Top 10 Ocean Stories for 2021. In July 2021, scientists at AOML and NOAA's Pacific Marine and Environmental Laboratory partnered with Saildrone, Inc. to deploy five extreme weather saildrones in the tropical Atlantic Ocean and Caribbean Sea. These uncrewed surface vehicles collected round-the-clock observations from both above and below the ocean surface in regions where hurricanes frequently travel. On September 29, saildrone 1045 was steered into the eye of Category-4 Hurricane Sam in the central Atlantic, battling towering waves and ferocious winds to transmit data from the surface of a major hurricane. An onboard camera additionally provided the first video footage ever recorded of the chaotic sea state encountered in this rarely-observed region of the hurricane environment. The data collected will help researchers better understand the processes that enable some tropical cyclones to rapidly strengthen, leading to better intensity forecasts.



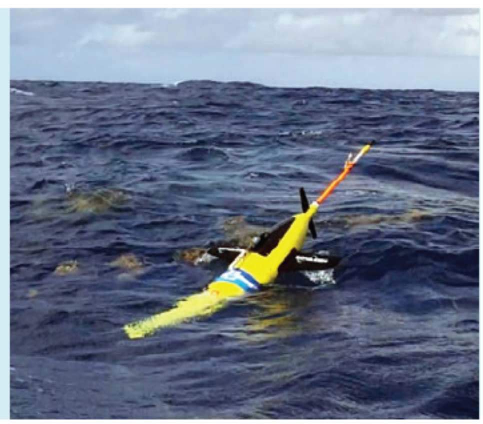
Climate change is expected to drive more frequent and extreme summer heat waves in the western US by the late 2020s, the Great Lakes region by the mid 2030s, and the northern and southern Plains by 2050s and 2070s, respectively (from Lopez *et al.*, 2018).

AOML Research Included In Nobel Prize in Physics 2021 Collection

In October, *Nature Portfolio,* a division of the international scientific publishing company Springer Nature, compiled a collection of research articles in honor of the 2021 Nobel Prize in Physics recipients—Syukuro Manabe, Klaus Hasselmann, and Giorgio Paris. The Nobel Prize in Physics 2021 Collection honors the contributions of the Nobel Prize recipients to advances in complex physical systems and the discoveries they have inspired. Included in the collection is an article entitled *"Early emergence of anthropogenically-forced heat waves in the western United States and Great Lakes"* by AOML oceanographer Hosmay Lopez *et al.* (2018) published in *Nature Climate Change* (**https://doi.org/10.1038/s41558-018-0116-y**). The article identifies regions in the United States where human-caused climate change is expected to surpass natural climate variability to become the dominant cause of heat extremes.

It's a Wrap! Hurricane Glider Missions Conclude

Scientists at AOML helped recover six hurricane gliders from the Caribbean Sea and tropical Atlantic Ocean in November, ending the 2021 glider missions in support of NOAA's Hurricane Field Program. During their time at sea, the gliders continually measured the upper ocean's properties in regions where hurricanes typically travel and intensify and where other sources of ocean profile observations are usually not available, generating more than 10,000 individual profiles of temperature and salinity. The data were transmitted to the Global Telecommunications System, the Integrated Ocean Observing System, and used in forecast models to better understand the ocean's role in the formation and intensification of tropical cyclones. This year marked AOML's eighth year of annual operations in the region, conducted with partners from the Caribbean Coastal Observing System (CARICOOS), Maritime Authority of the Dominican Republic (ANAMAR), and Cape Eleuthera Institute.



AOML Premieres Strategic Plan for FY 2022-2026

AOML premiered its new Strategic Plan for FY 2022-2026 in December 2021. The 5-year plan will serve as a blueprint for achieving the following goals and objectives:

Empower our Team — create an inclusive and cutting-edge environment that fosters discovery, exploration, and success.

Observe the Earth System — collect and evaluate oceanic, atmospheric, and marine ecosystem observations that contribute to the body of scientific knowledge of the Atlantic Ocean region to improve the ability to better assess and predict the Earth system.

Assess and Model the Earth System — understand the Earth system by creating accurate, predictive, high-fidelity models that characterize and assess change and predict future Atlantic Ocean regional and global outcomes.

Transition our Research — empower end users with research and knowledge that enables decision-making, drives outcomes for operational partners, and advances scientific knowledge.

AOML will also use its new strategic plan as a guide for making priority decisions in funding, scientific endeavors, and partnerships, as well as for identifying new opportunities. The plan can be accesssed by visiting **https://www.aoml.noaa.gov/research**.

Farewell

AOML bid farewell to two long-term federal employees during the November-December time frame. Congratulations to Joe Bishop and Mayra Pazos on the successful conclusion of their federal careers and for their dedicated service to AOML, NOAA, and the nation.

Joe Bishop, a mechanical engineer with AOML's Ocean Chemistry and Ecosystems Division, retired in December after 27 years of federal service. During his time at AOML, Joe specialized in environmental engineering and ocean acoustics. To this end, he designed, built, tested, deployed, and maintained instrument platforms to collect a broad variety of data in support of research focused on tracking the impact of suspended sediment and dredged material on coastal biota. More recently, Joe designed a real-time monitoring system deployed at Port Everglades in Fort Lauderdale, Florida to assess oceanographic conditions during a planned dredging expansion project of the port in 2022. The system is coupled with an expert system that will adaptively manage dredging activities by sending alerts to dredge operators when nearby coral reefs are likely to be negatively impacted.

Mayra Pazos, an information technology computer specialist with AOML's Physical Oceanography Division, retired in November after almost 43 years of federal service, all spent at AOML. Mayra managed the drifter Data Assembly Center (DAC) of NOAA's Global Drifter Program, collecting data in a variety of forms and formats from 26,000 satellite-tracked drifting buoys deployed globally since 1979. Mayra was responsible for processing, quality-controlling, distributing, and archiving the data for use by the international science community. These data support short-term predictions, as well as climate research and monitoring efforts. Over the years, Mayra mentored many Cooperative Institute employees who worked with her in the DAC, supported several program principal investigators at AOML, represented NOAA and the drifter program at numerous international meetings, and earned a reputation as a patient, careful, and generous NOAA advisor and colleague.

Welcome Aboard

Tyler Christian joined the staff of AOML's Ocean Chemistry and Ecosystems Division in October as a University of Miami-Cooperative Institute Research Associate I. Tyler is a new laboratory technician for the Nutrients Lab. She will work with members of the Integrated Ecosystem Assessments team at AOML—Alexandra Fine, Chris Kelble, Kelly Montenero, Emily Milton, and Ian Smith—with duties that include preparing reagents and standards, completing routine statistical tests, maintaining lab equipment, and maintaining records and sample analysis data. Tyler recently earned a BS degree in Biology with a focus on marine science from the Department of Marine Science of the University of North Carolina at Chapel Hill. While attending the University of North Carolina, she worked in multiple labs, providing animal husbandry and aquaria experiment support, as well as lab maintenance and system checks.

Rachel Cohn joined the staff of AOML's Ocean Chemistry and Ecosystems Division in October as a University of Miami-Cooperative Institute Research Associate I. Rachel is a new field technician/information technology (IT) specialist. Her time will be split between conducting field work in support of NOAA's Integrated Ecosystem Assessments project and providing IT technical support for the division. She is a recent graduate of the University of California, Los Angeles with a BS degree in Atmospheric and Oceanic Sciences. While attending UCLA, Rachel worked in the Library Cataloging and Metadata Center and completed an Arduino-based data acquisition system research project for experiments simulating oceanic lithospheric cooling and heat transfer using Python software for data analysis.

Katherine Eaton joined the staff of AOML's Ocean Chemistry and Ecosystems Division in December as a University of Miami-Cooperative Institute Research Associate II. Katie is AOML's first ever 'Omics laboratory manager. She comes to AOML from the Mote Marine Laboratory in Sarasota, Florida, where she spent the past few years coordinating a large number of coral reef-focused projects. In addition to possessing a strong marine biology background, Katie also has experience with a variety of laboratory methodologies, including microbiology and molecular biology. She will become an integral part of the AOML team as it works to enhance the lab's capacity to undertake cutting-edge molecular research in the marine realm. Katie holds a BS degree in Biology from Fitchburg State University.

Dr. Enrique Montes joined the staff of AOML's Ocean Chemistry and Ecosystems Division in October as a University of Miami-Cooperative Institute Assistant Scientist. Enrique comes to AOML from the College of Marine Science of the University of South Florida where he was a research associate with a background in biological oceanography, satellite remote sensing, and marine biodiversity. At AOML, he will perform research on natural and human-driven impacts on coastal and open ocean ecosystems and marine life by integrating in situ physical, biogeochemical, and biological measurements with space- and airborne observations. Enrique holds a PhD in Oceanography from the University of South Florida and the University of Massachusetts Dartmouth.

Oreoluwa Solanke joined the staff of AOML's Ocean Chemistry and Ecosystems Division in November as a University of Miami-Cooperative Institute Research Associate I. Ore is the new 'Omics data manager at AOML and brings with her a wealth of experience in working with marine microbial 'omics data and datasets of different types. At AOML, she will help researchers curate and standardize their 'omics data and metadata and make them publicly available following FAIR, i.e., findable, accessible, interoperable, and reusable, standards. Data management is a critical component of AOML's plans to make its 'omics data more valuable to NOAA and the international community. Ore will play a key role in this effort. She recently earned a BA degree in Earth and Environmental Sciences from Columbia University.

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

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