NOAA'S ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY

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AOML Keynotes

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

In This Issue

Wind Metrics Improve *Sargassum* Risk Assessments

Sargassum **accumulates along the shore of South Beach in Miami, a popular destination for tourists and natives alike, on June 21, 2018. Photo credit: Michael Montero/University of Miami.**

Coastal communities across the tropical Atlantic, Caribbean, and Gulf of Mexico have coped with massive blooms of *Sargassum,* a type of brown seaweed, washing ashore annually for more than a decade. Monitoring and predicting these events has been challenging due to the vast areas potentially impacted, as well as the proliferation and movement of *Sargassum* as it drifts on the ocean. To meet these challenges, scientists at AOML began producing Sargassum Inundation Risk (SIR) maps in 2019 to assess the potential risk of inundation for coastlines along the Gulf of Mexico, Florida, Bahamas, and Caribbean regions.

In a new study,* AOML scientists and their partners examined whether adding wind metrics to SIR maps better aligned *Sargassum* beaching or inundation events with citizen scientist observations of *Sargassum* accumulated along coastlines. Although physical processes near the ocean surface primarily determine where *Sargassum* moves, wind additionally plays an important role in its transport from offshore to coastal regions. Adding wind velocity (speed and direction) estimates to SIR maps could be a key factor for improving inundation assessments.

SIR maps estimate the level of beaching risk based on the quantity of offshore *Sargassum* remotely observed by satellites. The SIR algorithm uses 7-day floating algae density fields calculated from satellite imagery. The resulting weekly maps identify areas where *Sargassum* is within 50 kilometers (30 miles) of land and estimates the risk of it running ashore based on the amount of *Sargassum* located offshore. Three color-coded levels—low, medium, and high—denote the inundation potential and the likelihood of *Sargassum* reaching the coast.

cont. page 2

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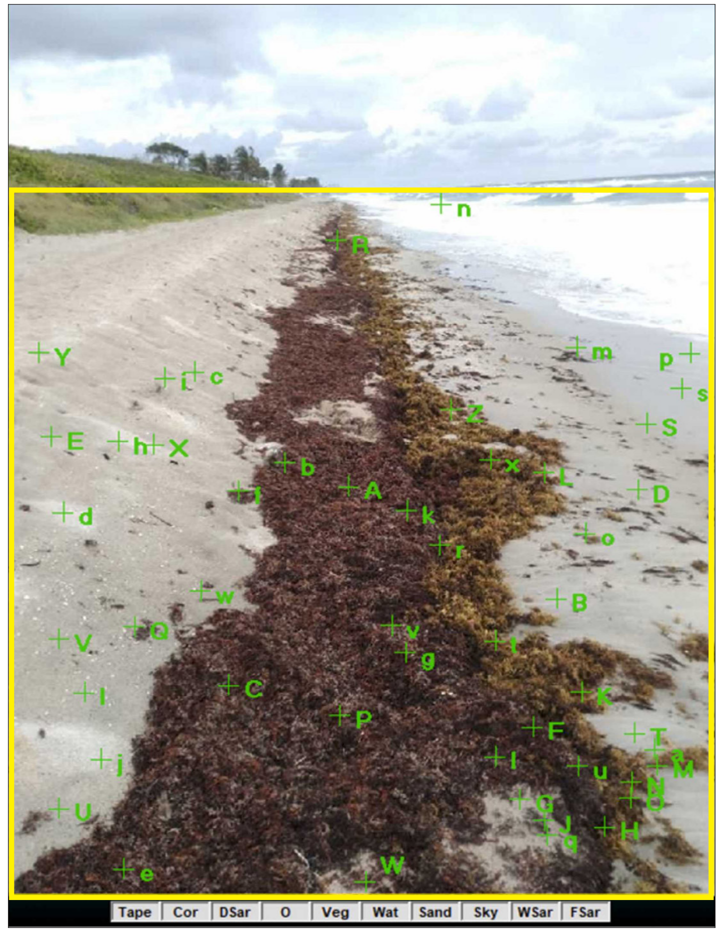
The science team quantified the percent coverage of *Sargassum* in photos and videos obtained from the Sargassum Watch project and correlated them with the corresponding floating algae density fields used in SIR assessments (see image at right). Sargassum Watch is an international citizen science project led by Florida International University that invites the public to submit time-stamped, georeferenced photos of *Sargassum* observed at beaches throughout the regions surveyed for SIR maps.

The inclusion of wind velocity measurements resulted in a dramatic improvement in the agreement between the estimated beaching risks of SIRs and actual observations of *Sargassum* piled along coastlines by citizen scientists. This finding suggests that part of the discrepancy between these two factors was due to not accounting for the wind-driven movement of *Sargassum*.

Sargassum aggregates to form large, dense mats as it drifts at sea, providing food, shade, shelter, and habitat for an abundant variety of marine species. When it accumulates close to shore, however, it can wreak havoc by smothering coral reefs and seagrass beds. *Sargassum* can also overwhelm beaches, causing a host of environmental, economic, and public health problems as it decays.

Monitoring and forecasting Sargassum beaching events are needed to improve mitigation and clean-up responses, as well as establish long-term adaptive management operations. The inclusion of wind velocity metrics in the SIR algorithm provides a promising avenue for enhancing regional risk assessments, helping coastal communities better prepare for *Sargassum* reaching their shores.

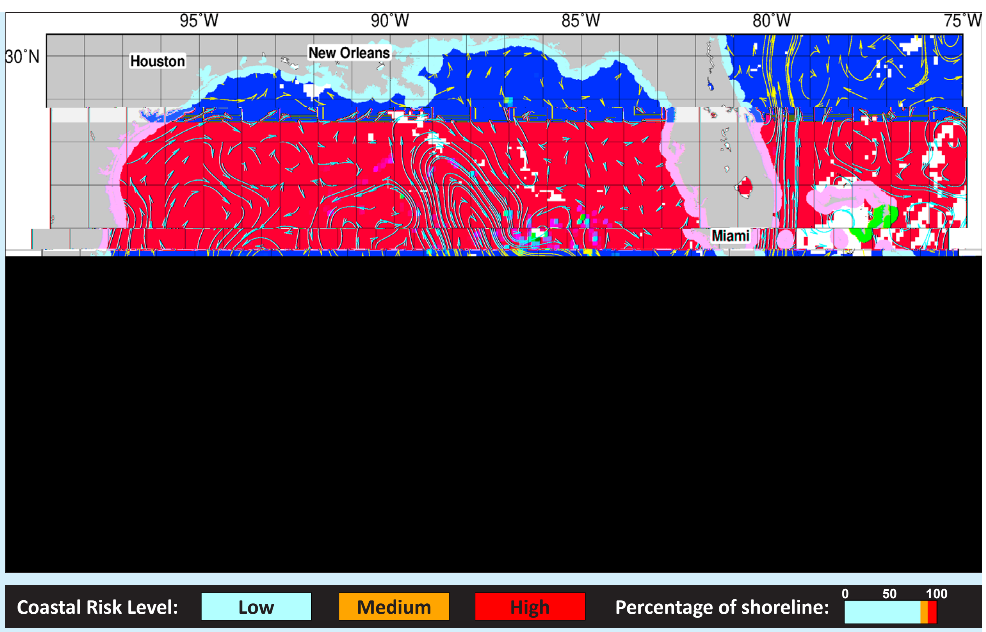
*Putman, N.F., R.T. Beyea, L.A.R. Iporac, J. Trinanes, E.G. Ackerman, M.J. Olascoaga, C.M. Appendini, J. Arriaga, L. Collado-Vides, R. Lumpkin, C. Hu, and G. Goni, 2023: Improving satellite monitoring of coastal inundations of pelagic *Sargassum* algae with wind and citizen science data. *Aquatic Botany*, 188:103672, https://doi.org/10.1016/j.aquabot.2023.103672.



Example of a Sargassum Watch photo downloaded from the Epicollect5 platform and processed using Coral Point Counter with Excel extensions software. The yellow box shows how the photo was cropped to remove the sky. Green crosses and corresponding letters indicate the locations of randomly distributed points where (at the central intersection) the location was designated as *Sargassum*, sand, sky, water, vegetation, or other. The percent coverage of *Sargassum* was determined by dividing the number of *Sargassum* points by the sum of points marking *Sargassum*, sand, water, and vegetation. This photo shows a site with 48% *Sargassum* coverage (image from Putman *et al.,* 2023).

SIR Maps Assess the Risk of *Sargassum* Inundation

Sargassum Inundation Risk maps provide an overview of the weekly risk of *Sargassum* coastal inundation for the Gulf of Mexico, tropical Atlantic, and Caribbean regions. The maps use Alternative Floating Algae Index (AFAI) fields generated by the University of South Florida as core input. The SIR algorithm analyzes AFAI values within a 50-km vicinity of each coastal pixel and computes the difference between those values and a multi-day baseline. Coastal risk levels are subsequently classified according to low (blue), medium (orange), and high (red) to assess the likelihood of *Sargassum* washing ashore based on the quantity of offshore *Sargassum* remotely observed by satellites.



A SIR map for June 20-26, 2023 shows where *Sargassum* is most likely to wash ashore along coastlines across the Gulf of Mexico, tropical Atlantic, and Caribbean regions. The maps are produced as a collaborative effort between AOML, NOAA's CoastWatch/OceanWatch program, and the University of South Florida; they can be viewed at https://cwcgom.aoml.noaa.gov/SIR/.

AOML Scientists Find Cheeca Rocks Reef Completely Bleached

The growing concerns over coral bleaching due to the ongoing marine heat wave across South Florida, the Gulf of Mexico, and greater Caribbean led scientists at AOML to recently visit Cheeca Rocks reef to observe environmental conditions.

As an inshore reef within the Florida Keys National Marine Sanctuary and a vital long-term climate monitoring site for the National Coral Reef Monitoring Program, Cheeca Rocks demonstrated persistence in the wake of the 2014 and 2015 bleaching events and is known to have some of the highest coral coverage compared to surrounding offshore reefs. What AOML scientists found there, however, was bleak.

"I've never seen anything like it," said Ian Enochs, PhD, a Research Ecologist and the lead of AOML's Coral Program. "The corals at our primary climate monitoring reef site, Cheeca Rocks, are completely bleached," he explained. "No single coral is untouched. It's shocking."

Coral bleaching occurs when the colorful algae that live in coral limestone called zooxanthellae are ejected due to environmental stress factors such as changes in temperature, light, and/or nutrient levels. With the algae expelled, corals appear white or "bleached."

It is essential to note, however, that bleaching does not alway lead to mortality. Corals are able to recover from a bleaching event as long as the physical stress, in this case sustained, above average sea surface temperatures, is reduced to a level that allows their zooxanthellae population to reestablish itself.

What is concerning about the widespread bleaching at Cheeca Rocks, however, is the timing. "I'm worried because it's so early in the season and they may continue to be stressed for some time," said Dr. Enochs. "This is more bleaching than I've seen, earlier than I've ever seen it. We still have a warm South Florida summer ahead of us, which means more stressful conditions."

A completely bleached brain coral at Cheeca Rocks reef.

AOML research ecologist Ian Enochs observes the bleached state of corals at Cheeca Rocks.

On average, August is the hottest month for South Florida. However, the mass bleaching at Cheeca Rocks reef is due to higher than average sea surface temperatures caused by the ongoing marine heat wave, which current predictions suggest could persist in the southern Gulf of Mexico and the Caribbean through October.

While sustained high temperatures could lead to significant coral mortality at Cheeca Rocks, what happens in the coming months will determine the extent of the mass bleaching event currently being observed. Coral reefs, like all natural ecosystems, are complex. In the Port of Miami, for example, research conducted by AOML and the Cooperative Institute of Marine and Atmospheric Studies has found that some "urban" corals may be more resilient to environmental stressors due to their consistent exposure to high human activity.

At AOML's Experimental Reef Lab on the campus the University of Miami's Rosenstiel School for Marine, Atmospheric, and Earth Science, scientists with AOML's Coral Program have found that repeatedly exposing coral fragments to high temperatures may enhance their resilience to extreme heat.

The widespread bleaching being observed at Cheeca Rocks is of great concern to AOML scientists who have spent more than a decade studying the site. Continued monitoring efforts in the months ahead will determine the true outcome. Ongoing monitoring efforts by AOML and its partners are critical for understanding environmental stressors and their intensity so as to enhance coral resilience and restoration.

Ultimately, it is as essential to understand the full scope of the challenge faced by these crucial ecosystems as it is to remain encouraged by the innovation and ongoing efforts of scientists to find solutions.

Meta-analysis Finds Key Bacteria Linked to Sony Coral Disease Outbreak

Using a crowdsourcing approach to gather both published and unpublished data, scientists have characterized the global bacteria patterns associated with stony coral tissue loss disease (SCTLD). Using meta-analysis, i.e., a study of data from other similar research to discover overall trends, scientists have found a key species of bacteria linked to the disease.

According to the study published in *ISME Communications*,* a journal of the International Society for Microbial Ecology, researchers with the University of Miami's Cooperative Institute for Marine and Atmospheric Studies, AOML, and other partners reviewed microbiome datasets generated by 16 field and laboratory studies to determine patterns associated with stony coral tissue loss disease.

An orange brain coral with areas of white discoloration shows lesions caused by stony coral tissue loss disease. Photo credit: NOAA-AOML.

"Research groups typically make data publicly available upon publication," said Stephanie Rosales, PhD, an AOML University of Miami-Cooperative Institute scientist at AOML and lead author of the study. "By gathering data prior, we were able to conduct the largest microbiome meta-analysis of a single coral disease, helping more rapidly improve our understanding of stony coral tissue loss disease."

Although the cause of this deadly disease is still unknown, a waterborne pathogen is considered the most likely culprit. With a 99 percent mortality rate in some coral species, stony coral tissue loss disease has significantly impacted coral populations throughout Florida and the Caribbean.

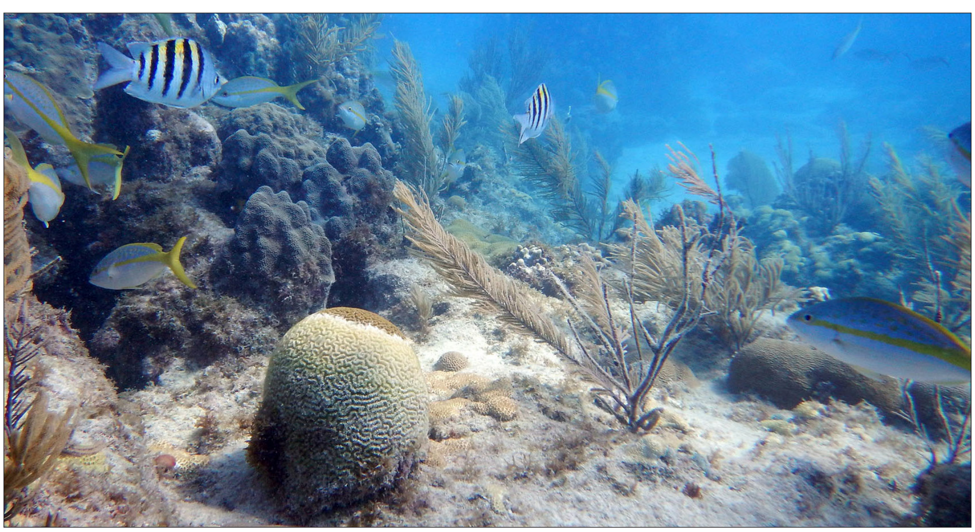
The study found that even in non-lesion areas of diseased corals, there is a disturbance of sorts that occurs within the coral microbiome. Scientists have found that this disturbance may be driven by the bacteria *Flavobacteriales*, which is highly abundant in "unaffected" coral tissue. In stony coral tissue loss disease lesions, two additional bacteria types, *Rhodobacterales* and *Peptostreptococcales-Tissierellales*, also appear to be important in structuring the microbial community and could be driving community interactions that result in the progression of lesions in corals.

To better understand not only the bacteria present in corals but also what they might be doing, researchers conducted a functional inference analysis. They found that stony coral tissue loss disease lesions were enriched by an alpha-toxin that could kill coral cells, contributing to the formation of lesions.

Corals that appear to be healthy may also suffer from the impacts of stony coral tissue loss disease. Researchers studied three types of reef disease zones: vulnerable (SCTLD never reported), epidemic (SCTLD outbreak occurring), and endemic (SCTLD regularly occurs). Reefs impacted by the disease may not only change the microbial community of diseased corals, but also the microbial community of those corals that seem to be "apparently healthy."

"Apparently healthy" corals from infected reefs had higher abundances of stony coral tissue loss disease-related bacteria compared to "apparently healthy corals" in reefs unaffected by the disease. As such, once stony coral tissue loss disease has reached a reef, corals that appear healthy may still be compromised.

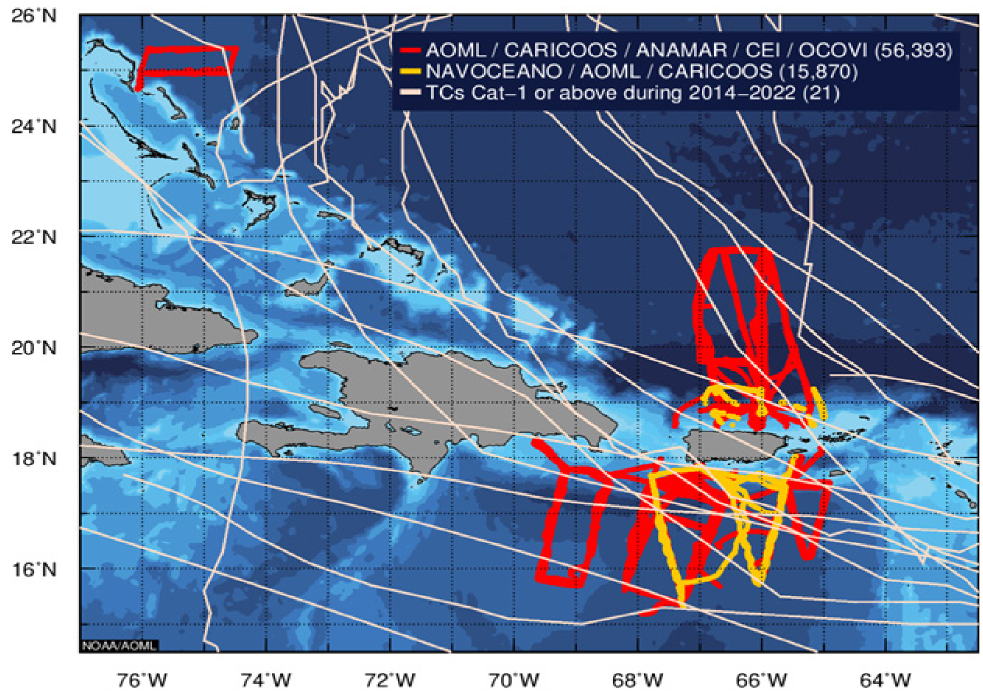
Much about stony coral tissue loss disease still remains a mystery. But, with research being conducted by multiple agencies and academic institutions, there is hope for the future of coral reefs in Florida and the Caribbean. By studying the microbial communities that impact coral reefs, scientists are one step closer to discovering the source of this deadly disease.



A diseased brain coral in Looe Key, Florida displays a large white area of recently dead skeleton in contrast with the remaining small patch of healthy tissue. Photo credit: Florida Fish and Wildlife Research Institute.

*Rosales, S.M., *et al.*, 2023: A meta-analysis of the stony coral tissue loss disease microbiome finds key bacteria in unaffected and lesion tissue in diseased colonies. *ISME Communications*, 3:19, https://doi.org/10.1038/s43705-023-00220-0.

AOML Begins Tenth Year of Hurricane Glider Operations



Map that shows the locations (red and orange tracks) of where more than 72,000 temperature, salinity, and dissolved oxygen profiles have been collected by the glider network in the Caribbean Sea and tropical North Atlantic Ocean over the past decade. Gray lines show the track of 21 tropical cyclones that have passed through the region.

This summer marks AOML's tenth consecutive year of gathering underwater glider observations during the Atlantic hurricane season. The project began in 2014 with two gliders deployed off Puerto Rico to study the ocean's role in tropical cyclone development and intensification. Since then, glider observations have become an integral part of the data gathered annually to improve tropical cyclone forecasts, as well as better understand how the ocean and atmosphere interact during the passage of tropical cyclones.

Gliders are autonomous, remotely piloted observing platforms. They monitor the thermal structure of the upper ocean along pre-programmed tracks in the Caribbean Sea and tropical North Atlantic, regions where tropical cyclones typically pass. Advancing at speeds of up to 1.2 miles per hour, i.e., 1 knot, gliders dive to depths of 900 meters several times a day to measure temperature, salinity, and dissolved oxygen. Upon returning to the surface, their data are transmitted to AOML for quality control and then added to tropical cyclone forecast models.

To date, AOML has conducted 61 glider missions, of which 12 were in partnership with the US Navy. These missions have spent more than 4,900 combined days at sea; traveled more than 68,000 kilometers, approximately one and a half times the distance around the Earth; obtained more than 72,000 profiles of temperature, salinity, and dissolved oxygen; and surveyed ocean conditions under 21 tropical cyclones (see image above right).

"Gliders have been effective in providing ocean information that was previously missing," said Gustavo Goni, PhD, a science lead for the glider project. "This information has helped us make key advances to improve our understanding of how water mass properties and ocean dynamics contribute to hurricane intensity changes."

During the 2023 Atlantic hurricane season, AOML will work with numerous partners to implement and maintain a robust network of underwater gliders. One glider will operate east of the Bahamas; another will peruse the Caribbean Sea south of the Dominican Republic; four will monitor the waters off Puerto Rico, one to the north and three to the south; and one will observe the Gulf of Mexico. AOML will also lead and/or participate in operations for three US Navy gliders off Puerto Rico and contribute to a mission led by staff from the Caribbean Coastal Ocean Observing System.

These gliders will be deployed in collaboration with the US Integrated Ocean Observing System (IOOS), Dominican Republic Maritime Authority, the Cape Eleuthera Institute, Naval Oceanographic Office, Gulf of Mexico Coastal Ocean Observing System, NOAA's National Data Buoy Center, the University of Southern Mississippi, and NOAA's Environmental Modeling Center.

Research derived from data collected by AOML gliders has advanced the understanding of the ocean's role in tropical cyclone intensity changes, leading to improved forecasts. Additionally, AOML scientists have participated in the publication of 18 peer-reviewed journal articles based on glider data.

The most relevant research results include studies of how areas of low salinity water of riverine origin, e.g., the Mississippi, Orinoco, and Amazon rivers, contribute to the intensification of tropical cyclones. Other studies have assessed the impact of glider observations in reducing intensity errors in NOAA's experimental and operational forecast models and the impact of integrating glider observations with data from other observing platforms.

More recently, AOML scientists have gathered collocated, simultaneous observations using gliders and saildrone uncrewed surface vehicles to improve estimates of heat fluxes between the ocean and atmosphere during tropical cyclone events. This summer the gliders will also collect collocated observations with NOAA drifting buoys in the Gulf of Mexico and Caribbean Sea.

AOML gliders are an integral component of NOAA's 2023 Hurricane Field Program. They are also part of the new NOAA-funded Coordinated Hurricane Atmosphere-Ocean Sampling, or CHAOS, field experiment. Glider operations at AOML are funded by US Congress appropriation funds, NOAA, and IOOS.

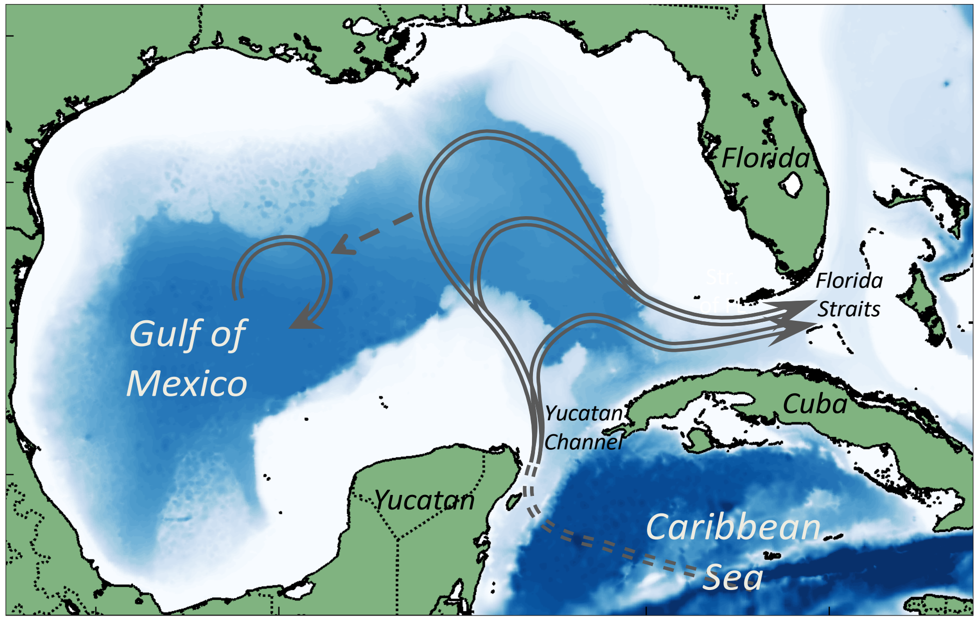
More information about AOML's 2023 hurricane glider missions and operations:

https://www.aoml.noaa.gov/hurricane-glider-project/

View the near-real time location of AOML's gliders and other instruments/satellite products:

https://cwcgom.aoml.noaa.gov/cgom/OceanViewer/index_phod.html

Eddies in the Caribbean Sea Influence the Prediction of the Loop Current



The Loop Current enters the Gulf of Mexico from the Caribbean Sea through the Yucatan Channel, exits through the Straits of Florida, and then joins the Gulf Stream.

A recent study* by scientists at AOML in collaboration with partners at the University of Miami's Rosenstiel School of Marine, Atmospheric, and Earth Science used a numerical modeling approach to investigate the impact of the eddy field in the Caribbean Sea on Loop Current predictions downstream in the Gulf of Mexico. They found that eddy activity in the Caribbean is crucial for the accurate prediction of eddy shedding by the Loop Current.

The Gulf of Mexico is a semi-enclosed basin connected to the Caribbean Sea and the North Atlantic Ocean. Its main dynamical feature is the Loop Current, which is the portion of the North Atlantic western boundary current that carries warm ocean waters from the tropics toward higher latitudes. It enters the Gulf of Mexico in the south—through the Yucatan Channel between the Yucatan Peninsula in Mexico and the western tip of Cuba—and exits to the east, through the Straits of Florida between Florida and the northern coast of Cuba. Eventually, it becomes the Gulf Stream.

The shape of the Loop Current changes with time, growing northward from a position in which it flows directly from the Yucatan Channel (between Mexico and Cuba) to the Florida Straits (between Florida and Cuba) until it forms a large loop that extends into the northern Gulf of Mexico, near the Mississippi Delta.

An eddy is an independent circular current of water that breaks off from an ocean current. When extended, the Loop Current closes its clockwise circulation to shed a large, anticyclonic, warm-core eddy called a Loop Current Eddy, which then drifts westward inside the Gulf. The shedding of a Loop Current Eddy leads to the sudden southward shift of the Loop Current to its retracted position.

Characterizing and predicting the state of the Loop Current has important implications, as it affects all ranges of ocean-related processes in the Gulf of Mexico, from larval connectivity to pollution transport to oil platform operations. The Gulf of Mexico is a large area for oil exploration. In the case of an accidental oil spill, better predictions of the Loop Current system help scientists better understand where the oil will travel.

Compared to the Gulf of Mexico interior and Yucatan Channel that have been extensively investigated, and although directly upstream of the Loop Current, the Caribbean Sea has received little attention when examining the Loop Current Eddy shedding process. In this study, scientists quantified to what extent eddy activity in the Caribbean Sea influences the Loop Current shedding process in the Gulf of Mexico and its prediction.

To do so, they conducted numerical experiments that consisted of two series of ocean forecasts, one with realistic initial conditions and one in which eddy activity in the Caribbean Sea was diminished. These experiments took place in 2015, a year when the Loop Current was very active with several Loop Current Eddy detachments, re-attachments, and separations.

In terms of sea surface height, the forecasts using realistic initial conditions had, on average, lower errors in the southeast part of the Gulf of Mexico north of the Yucatan Channel than the forecasts initialized with diminished eddy activity in the Caribbean Sea. The forecast experiments also showed that, when eddy activity in the Caribbean Sea was diminished in the initial conditions, the model sometimes failed to predict a Loop Current Eddy detachment, and the errors in the predicted date of a Loop Current Eddy detachment tended to be larger.

The results of this study show that the eddy field in the Caribbean Sea is essential for correctly predicting Loop Current Eddy shedding events and their timing, and thus cannot be ignored. To realistically predict the Loop Current's evolution, oceanographers must use data assimilative models that cover both the Gulf of Mexico and Caribbean Sea, or pay particular attention to accurate boundary conditions for limited-area Gulf of Mexico models.

"Our study stresses how ocean processes from one basin influence ocean processes in a neighboring basin," said Matthieu Le Hénaff, PhD, a University of Miami-Cooperative Institute scientist at AOML and lead author of the study. "You cannot accurately predict what will happen in the Gulf of Mexico if you ignore the processes taking place in the Caribbean Sea."

This finding is important for near-real time and operational prediction systems, especially systems that focus on forecasting the Gulf of Mexico and Loop Current evolution. Loop Current prediction is important for hurricane forecasting, larval transport, and the oil industry. Because the Loop Current is intense, it can disrupt oil operations. Its correct prediction at a range of a few weeks helps the oil industry plan accordingly to avoid disasters.

*Le Hénaff, M., V.H. Kourafalou, Y. Androulidakis, N. Ntaganou, and H.-S. Kang, 2023: Influence of the Caribbean Sea eddy field on Loop Current predictions. *Frontiers in Marine Science,* 10:1129402, https://doi.org/10.3389/fmars.2023.1129402.

Fifty-Five Days at Sea: Collecting Oceanographic Data from Brazil to Iceland

On May 9, 2023, scientists onboard the NOAA Ship *Ronald H. Brown* arrived in Reykjavik, Iceland after 55 days at sea. The team of 50 scientists and 28 crew members followed a 5,000+ mile-long track through the Atlantic from Brazil to Iceland known as the A16N, a repeat hydrography transect of the Global Ocean Ship-Based Hydrographic Investigations Program (GO-SHIP). Along the A16N transect, more than 3,000 samples were collected from the ocean surface to the seafloor at 150 stations, providing scientists with a holistic snapshot of the Atlantic Ocean basin.

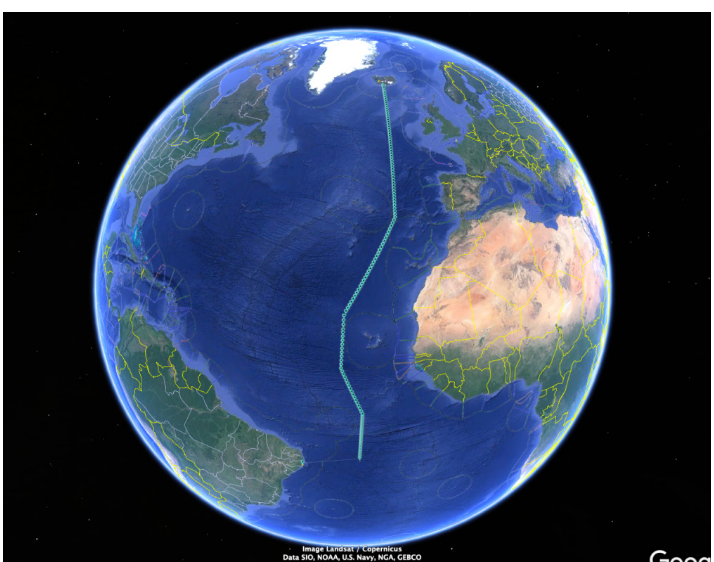
GO-SHIP is an internationally coordinated effort to decadally gather observations from transects in all major ocean basins to monitor changes in ocean heat content, ocean circulation, the carbon cycle, marine biogeochemistry, and biological parameters. This was the fourth occupation of the A16N line, with expeditions dating back to 1993. Data collected during this expedition will help researchers address critical questions regarding changes in the ocean's circulation and the uptake of human-released carbon dioxide. The data will also enable them to examine how ocean warming is impacting the movement of seawater across the entire planet and influencing climate.

The Atlantic is the only ocean basin where widespread shifts in three of the fundamental nutrients required for the growth of marine life—nitrogen, phosphorus, and iron—are observed. The availability of such fundamental nutrients uniquely shapes their diversity, distribution, and functioning, as well as biogeochemical cycles in this ocean basin.

GO-SHIP provides a platform to launch and calibrate ocean observing technologies, as well as test new research techniques. The cruises typically host a variety of crew that include university students, early-career scientists, and seasoned researchers. This tier of involvement not only provides for a diverse range of experience, knowledge, and ideas, but also a rich learning environment for students.

"I am extremely proud of everything the team did to make this expedition happen so successfully," said Leticia Barbero, PhD, the A16N Leg 2 Chief Scientist and a chemical oceanographer at AOML through the University of Miami's Cooperative Institute for Marine and Atmospheric Studies. "Our engineers and deck crew worked around the clock, paying close attention to the engine and winches; those working on the bridge were diligent; researchers were motivated; and everyone was willing to lend a helping hand. The cruise was an amazing show of teamwork and collaboration. I have so much gratitude for everyone giving their all, and I'm looking forward to a fantastic dataset!"

A conductivity-temperature-depth (CTD) instrument is recovered from the Atlantic to be brought aboard the NOAA Ship *Ronald H. Brown* after a full water column cast. Photo credit: NOAA-AOML.



Cruise track of the GO-SHIP A16N transect through the Atlantic Ocean from Suape, Brazil to Reykjavik, Iceland on the NOAA Ship *Ronald H. Brown*.

During the expedition, the *Brown* stopped at approximately 30 nautical-mile intervals to collect conductivity, temperature, depth (CTD) measurements, as well as biological samples, at pre-set coordinate points or "stations." The full-water column casts gathered 24 samples from the ocean surface to the seafloor, with the deepest measurements reaching depths of almost 3 miles. Scientists often braved intense weather conditions, sometimes working in eight to 12-foot seas, which slowed the pace of their operations. Despite these challenges, they persevered and successfully sampled all 150 stations along the transect. These observations will help researchers monitor changes occurring in the Atlantic across the entire water column over time.

During the first leg of the expedition, the ship transited through the Great Atlantic Sargassum Belt. The *Brown* sailed through this mass of vegetation for five full days, allowing scientists to collect 68 samples using hand-held nets. The samples were dried and will be sent to the Woods Hole Oceanographic Institution for analysis. With these samples, scientists hope to study the distribution of different *Sargassum* species, measuring their elemental composition to better understand their origin.

The 2023 A16N cruise was the first NOAA-led cruise to feature a full suite of biological samples taken in addition ***cont. page 8***

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to the standard GO-SHIP sampling program. Bio-GO-SHIP is a new sustained ocean observing program that incorporates biological observations into GO-SHIP. Marine organisms, specifically plankton, are essential elements of the Earth's ecosystems and climate regulation system but have not historically been measured in large-scale, repeat oceanographic monitoring efforts. The lack of a biological component in data collected from such efforts has hampered the ability of scientists to view the full picture of the ocean's biogeochemistry and food web, as well as implications for climate and food security.

The A16N Bio-GO-SHIP team used a variety of methods to measure plankton abundance and diversity. Instruments for optical backscattering, cell imagery, and flow cytometry were deployed for continuous in-line sampling to quantify plankton along the entire cruise track. Samples to measure particulate organic matter and pigments were collected from the CTD rosette, and DNA and RNA from plankton were collected by filtration and preserved for extraction and sequencing. AOML and Northern Gulf Institute scientists will process the DNA/RNA samples in the newly renovated 'Omics lab space at AOML. These sequence data will be combined with other plankton and oceanographic data to provide an integrative picture of marine plankton, as well as a baseline for understanding global ocean changes and a rich dataset for modeling ocean biology.

Large mats of *Sargassum* float on the ocean surface alongside the NOAA Ship *Ronald H. Brown* near the equator in the Atlantic Ocean. Photo credit: Ellen Park.

Scientists aboard the *Brown* encountered a northern gannet (top left), a pod of pilot whales (top right and bottom left and center), and a seagull (bottom right) spotted during the last week of the cruise. Photos credit: Michael Cappola.

The science team additionally deployed 12 robotic Argo floats, including floats capable of measuring ocean biogeochemistry in the deep ocean, and 10 drifting buoys in support of NOAA's Global Drifter Program. These autonomous floats and drifters will significantly expand the number of ocean measurements collected in the Atlantic for years to come, long after the A16N transect has been completed.

After long hours spent diligently collecting samples, scientists had the opportunity to wind down with a game of ping pong or participate in a triathlon competition in the ship's gym. The vessel was also a great platform for viewing an assortment of wildlife. Scientists were visited by flying fish, pilot whales, and dolphins, making for some exciting moments aboard the ship.

The 2023 A16N cruise marks the first NOAA GO-SHIP mission since 2018 and the last scientific voyage for the NOAA Ship *Ronald H. Brown* for the next one and a half years, as it is scheduled for dry-docking and repairs. The cruise was led by scientists at AOML and NOAA's Pacific Marine Environmental Laboratory, with support from NOAA's Global Ocean Monitoring and Observing Program. GO-SHIP is funded by both NOAA and the National Science Foundation.

US Ambassador to Iceland Visits the *Ron Brown*

Following the completion of the GO-SHIP A16N cruise and the *Ronald H. Brown's* arrival in Reykjavik, Iceland, the US Ambassador to Iceland, Carrin F. Patman, and embassy staff visited the ship. NOAA Corps officer Captain Marc Moser welcomed Ambassador Patman and her delegation aboard the *Brown* for a tour of the ship's facilities. Leg 2 Chief Scientist Leticia Barbero discussed the critical role the A16N transect has played over the past 30 years in tracking changes in heat, freshwater, carbon, oxygen, nutrients, and other crucial metrics in the Atlantic Ocean. Dr. Barbero also shared an overview of NOAA's activities in Icelandic waters, including AOML's years-long collaboration with the Icelandic cargo ship company Eimskip.

NOAA Corp officers, Ambassador Patman, Chief Scientist Leticia Barbero, and embassy staff in Reykjavik, Iceland with the NOAA Ship *Ronald H. Brown* in the background. Photo credit: Kristján Pétursson, Embassy Reykjavik's Strategic Content Coordinator.

ERDDAP Server Increases Access to Drifting Buoy Data

The Global Drifter Program at AOML has a new ERDDAP, or Environmental Research Division Data Access Program, server that is now publicly available and hosts both hourly and 6-hour quality-controlled interpolated drifter datasets (see link below). This new scientific data server uses free and open-source software created by the Environmental Research Division of NOAA's Southwest Fisheries Science Center.

ERDDAP provides a simple, consistent way to download drifter data in common file formats, resulting in easier access to data for the scientific community. It is currently used by approximately 100 organizations in more than 17 countries, and NOAA's Data Access Procedural Directive recommends ERDDAP as a data server for groups within NOAA.

The staff of the Global Drifter Program is excited to enhance its users' experience through the ERDDAP server. Distributing publicly-available data through ERDDAP provides many advantages, including compliance with NOAA's Findable, Accessible, Interoperable, and Reusable (FAIR) standards, the flexibility of offering numerous output file formats, and the minimal need to reformat data on the user's end. ERDDAP provides an additional benefit for data analysts, web application developers, and numerical modelers interested in retrieving drifter data through computer programs, rather than the ERDDAP webpage interface.

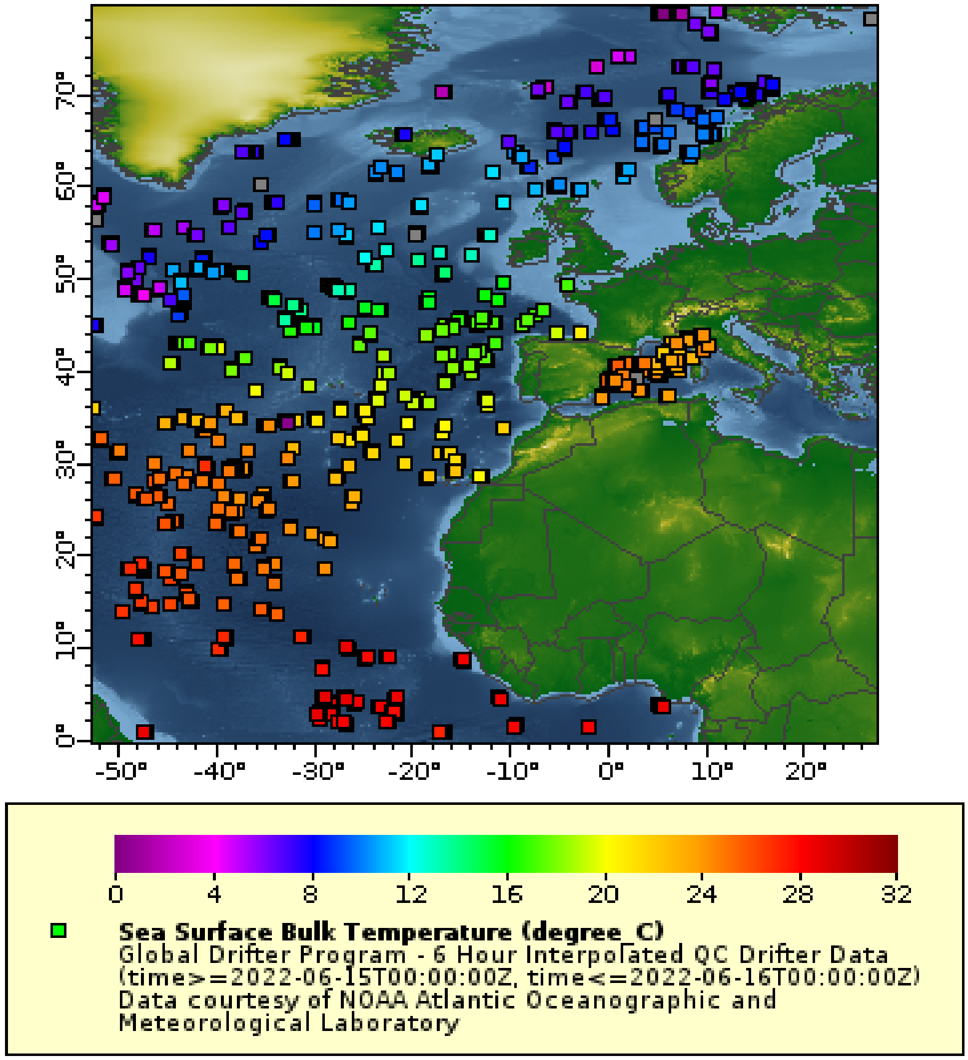
Specifically, the RESTful API feature of ERDDAP, which provides an interface for two computer systems to securely exchange information over the internet, allows users to access drifter data through coding languages such as Matlab, R, Python, Javascript, HTML, Fortran, and Bash. As a result, the ERDDAP server helps increase drifter data accessibility and data sharing for weather model improvements, the validation of satellite temperature measurements, hurricane intensity forecasts, and scientific research.

Notably, the hourly drifter dataset now includes diurnal and non-diurnal sea surface temperature estimates, in addition to drifter positions and velocities. Users can quickly retrieve these datasets in their desired file format, as well as filter their query by constraining drifter variables such as time, location, drifter identification number, and/or World Meteorological Organization number.

Additionally, simplifying the data output format and providing an option for plotting drifter trajectories further supports the Global Drifter Program's involvement in NOAA's Adopt A Drifter and Teacher at Sea programs. These educational programs enable K–12 students to use drifter data to learn about ocean climate science.

Finally, the Global Drifter Program's database spans 40+ years, covers all ocean basins, and includes contributions from more than 25 countries. The ERDDAP product provides users with access to metadata that recognizes the considerable impacts of the Global Drifter Program's global partners and the immense efforts from agencies worldwide to sustain the global coverage of drifting buoys.

The ERDDAP server was developed and implemented by Samantha Ouertani and Shaun Dolk of AOML's Global Drifter Program and Jay Harris, an IT Specialist with AOML's Physical Oceanography Division. Significant assistance was also provided by Kevin O'Brien of the Cooperative Institute for Climate, Ocean, and Ecosystem Studies at NOAA's Pacific Marine Environmental Laboratory in Seattle, Washington. The project was jointly funded by NOAA's Global Ocean Monitoring and Observing Program and AOML.



Example of a drifter data plot that shows sea surface bulk temperature (°C) in the Atlantic basin. Drifting buoys float on the ocean surface and are carried by near-surface ocean currents. They measure sea surface temperature, mixed layer currents, wind, and atmospheric pressure. The data are transmitted in real-time to the Global Telecommunications System for use in research studies and weather and climate forecasts.

Global Drifter Program: https://www.aoml.noaa.gov/global-drifter-program/

ERDDAP server: https://erddap.aoml.noaa.gov/gdp/erddap

Five Ways NOAA's Research Improves Hurricane Forecasts

Researchers at NOAA seek new techniques to advance hurricane forecasts to better protect life and property. In preparation for the 2023 hurricane season, which began June 1, scientists accelerated the use of small uncrewed aircraft technologies and the collocation of observational ocean assets, among other advancements. Here are five ways NOAA researchers aim to improve hurricane track and intensity forecasts.

1. *Developing NOAA's next-generation tropical cyclone model*

NOAA recently announced the release of the Hurricane Analysis and Forecasting System (HAFS), a new and improved tropical cyclone prediction model that will be fully operational during the 2023 hurricane season. HAFS is NOAA's next-generation hurricane model that will provide reliable forecast guidance to NOAA's National Hurricane Center on tropical cyclone track, intensity, and structure.

An important development in HAFS is the inclusion of high-resolution moving nests, a critical component to improve intensity forecasts. The model was jointly developed, tested, and evaluated by researchers at AOML and NOAA's National Centers for Environmental Prediction, in collaboration with NOAA's Geophysical Fluid Dynamics Laboratory and NOAA's Cooperative Institute for Marine and Atmospheric Studies at the University of Miami.

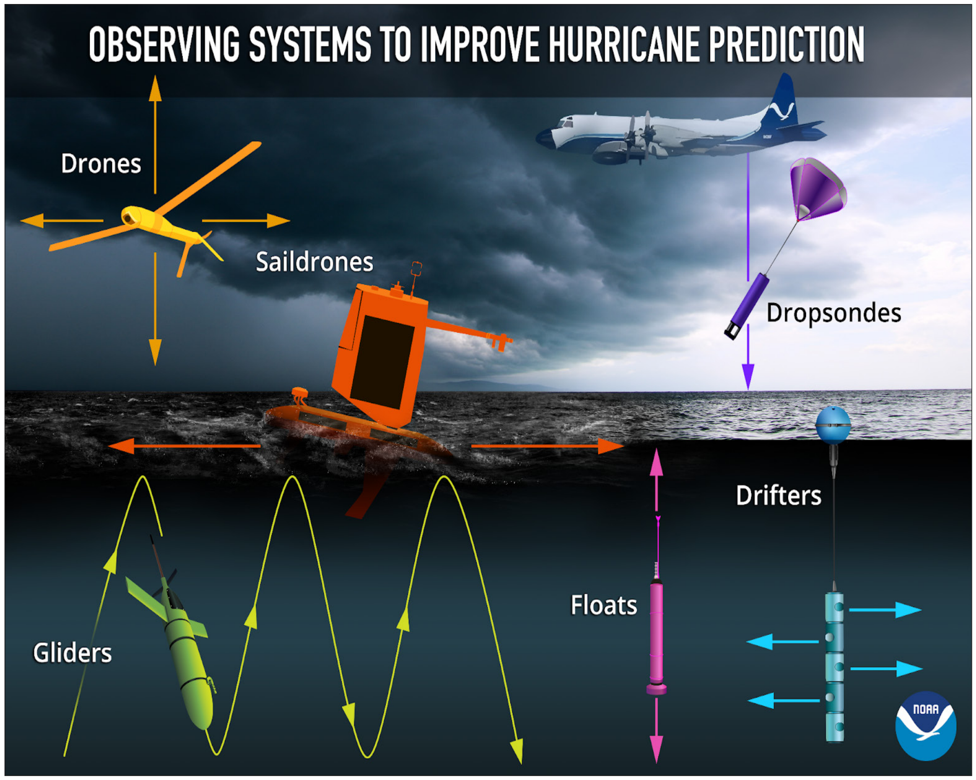
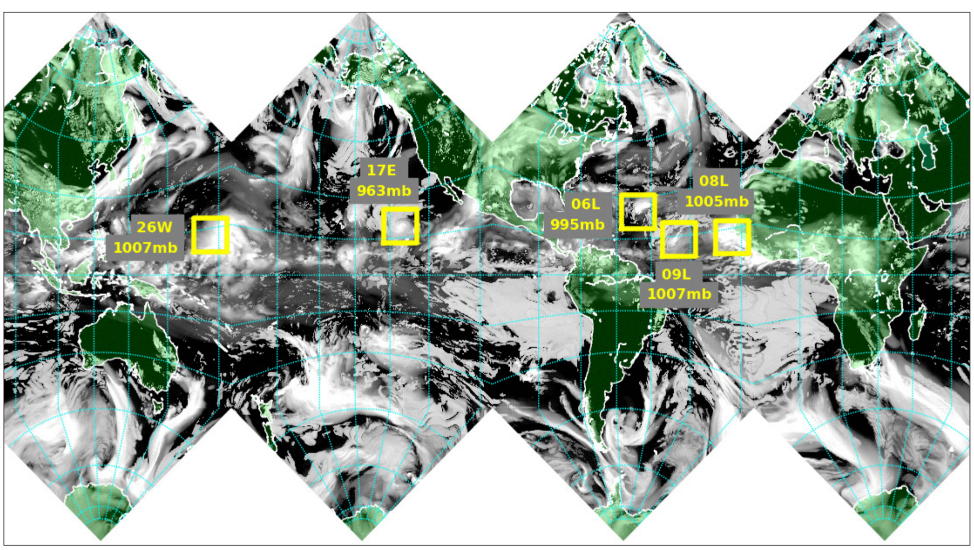


Image that shows the assortment of autonomous observing systems NOAA will use to sample the ocean and atmosphere in real-time—drones, saildrones, dropsondes, gilders, floats, and drifters—to improve track and intensity forecasts during the 2023 Alantic hurricane season. Photo credit: NOAA-PMEL.

2. *Collocating ocean observing instruments*

For the first time in 2022, NOAA deployed underwater gliders and saildrones in the same area of the Atlantic Ocean to obtain nearly collocated measurements of the upper ocean and air-sea interface. Because of the strong interaction between the ocean and atmosphere during a hurricane's passage, better representation from multiple sensors in nearly the same area of the ocean and atmosphere in weather models has led to more accurate intensity forecasts.

This season, NOAA and its partners will deploy approximately 20-30 underwater gliders, 12 uncrewed surface vehicles, a small uncrewed aircraft system, and numerous traditional expendable sensors such as GPS dropsondes, which are launched from NOAA hurricane hunter aircraft.



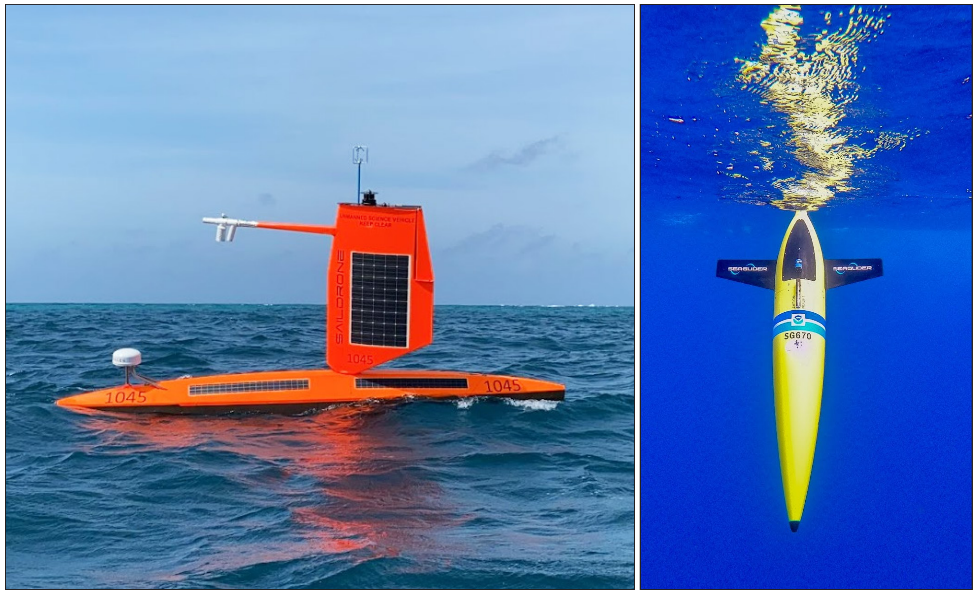
Static image that shows high-resolution moving nests (yellow boxes) that are an integral part of NOAA's new Hurricane Analysis and Forecasting System (HAFS) model. The moving nests enable researchers to track the inner core region of tropical cyclones at 1-2 km resolution, key for improving hurricane structure and intensity predictions. Photo credit: NOAA-AOML.

3. *Improving small uncrewed aircraft systems*

Researchers at NOAA have been deploying small uncrewed aircraft systems (sUAS) into tropical cyclones for almost a decade, beginning with the Coyote into Hurricane Edouard in 2014. During the 2022 hurricane season, an Area-I Altius-600 uncrewed aircraft system was deployed into the eyewall of Category-5 Hurricane Ian before its landfall in southwest Florida. In preparation for the 2023 hurricane season, Area-I and AOML made improvements to the Altius to gather even more high quality data. ***cont. page 11***

cont. from page 10

For example, a new probe has been added that will provide more accurate wind data, including the measurement of vertical winds. This will allow researchers to measure how heat from the surface of the ocean sustains a storm. These data-collection advancements are expected to improve the physics and related mathematical processes of the new HAFS forecast model, which, in turn, will improve intensity forecasts.



Left: **A saildrone surface uncrewed vehicle in the Atlantic. Saildrones are equipped with a special "hurricane wing" to withstand the extreme wind conditions encountered in tropical cyclones as they gather observations from the near-surface ocean and atmosphere in real-time (photo credit: Saildrone).** ***Right:*** **An underwater glider deployed to measure the upper ocean's properties, with a focus on temperature and salinity, to depths as great as half a mile along predetermined tracks (photo credit: Allan Jones, Cape Eleuthera Island School).**

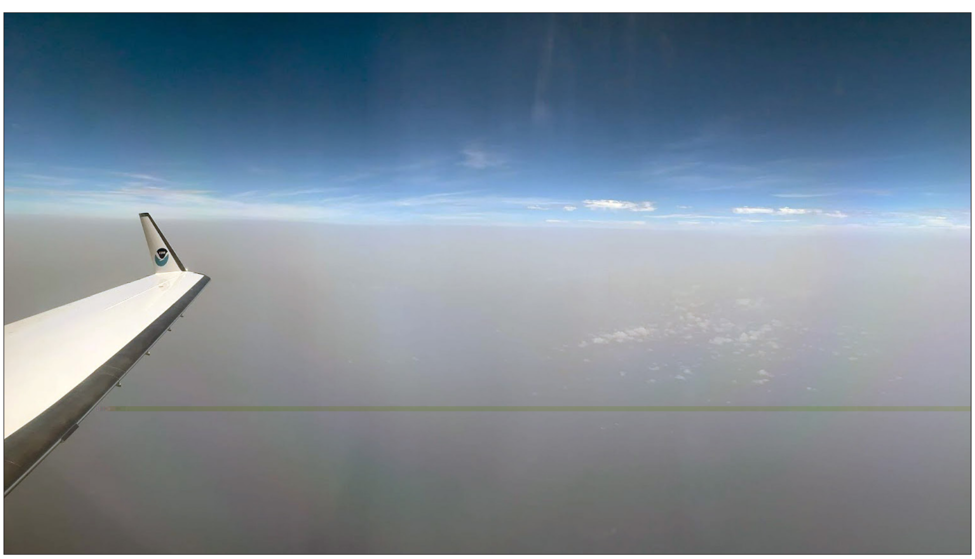
4. *Developing new instruments*

Uncrewed observing platforms such as surface drifters, Argo floats, and drones are used to measure the most turbulent region of the hurricane environment, called the boundary layer, where the air meets the ocean. Understanding this rarely-sampled area is crucial for improving forecast models and providing more advanced targeted warnings to vulnerable communities in harm's way.

To gather additional data in this hard-to-reach region, NOAA is collaborating with numerous academic partners and small businesses to improve its observational capabilities. This past spring, NOAA tested a small uncrewed aircraft system from Black Swift Technologies called the S0. The S0 is a smaller, more lightweight uncrewed aircraft system than NOAA has used in the past, with sensors that measure wind, temperature, pressure, humidity, and sea surface temperature.

NOAA also tested several complementary atmospheric profiling systems from Skyfora called StreamSondes. These small instruments are the lightest weather sondes currently available and will be deployed from NOAA's hurricane hunter aircraft. They will provide valuable profiles of wind, temperature, pressure, and humidity on their descent toward the ocean.

The tests for these systems were conducted from NOAA's Aircraft Operations Center and are a critical step in ensuring that the instruments perform their data collection tasks in a safe and effective manner during hurricane season.



NOAA's Gulfstream-IV high-altitude jet flies above a dense blanket of dust in the Cabo Verde Islands known as the Saharan air layer in September 2022. The deployment to the Cabo Verde islands marked a journey of more than 3,600 miles across the Atlantic, the farthest distance ever traveled by NOAA's hurricane hunters to improve track and intensity forecasts. Photo credit: NOAA-AOML.

5. *Flying aircraft farther east to study how storms begin*

Although the ingredients for tropical cyclone formation have been well documented for decades, it is still difficult to predict which disturbances will develop and which ones will not. Therefore, NOAA researchers are conducting a suite of experiments specifically designed to better understand how hurricanes form.

Last summer, researchers deployed to the Cabo Verde islands to explore how tropical waves that move off the coast of West Africa develop into tropical storms and hurricanes. These first-ever missions thousands of miles across the Atlantic marked the farthest distance traveled by NOAA's Hurricane Hunters to help forecast models better predict the future track and intensity of developing storms.

The region produces some of the Atlantic's longest lasting, most intense hurricanes. Storms that develop here, known as Cape Verde hurricanes, make up more than half of the named tropical systems that annually form. They also account for more than 80-85% of all major hurricanes, i.e., Category-3 and above, that strike the United States.

Members of NOAA's Hurricane Field Program will again return to the Cabo Verde islands in 2023 to observe tropical disturbances in the region and collect data to study how Saharan dust blowing off the African coast affects their development.

A Conversation with the Lead Modeler of NOAA's New Hurricane Forecast Model

Sundararaman Gopalakrishnan, PhD, is the senior meteorologist and leader of the modeling team at AOML that developed the Hurricane Analysis and Forecast System (HAFS), NOAA's newest hurricane forecast model that became fully operational in June. Gopalakrishnan leads AOML's Hurricane Modeling and Prediction Program and is also the development manager for NOAA's Hurricane Forecast Improvement Program.

What are the major ways this forecast model differs from the hurricane forecast models NOAA has used previously?

The new forecast model brings together the best of our existing hurricane forecast models and adds key research advancements to create more accurate, higher-resolution forecast information, both over land and the ocean, that can save lives and protect property. The foundational component for this model is its moving nest, which allows the model to zoom in on hurricanes across the Atlantic and Pacific basins. In the future, the model will also allow forecasters to track multiple hurricanes at once, which has been shown to improve the accuracy of track and intensity forecasts.

The moving nest is like a high-definition TV that allows us to zoom into areas of a hurricane such as the eyewall and bands of intense rain. With a resolution down to 1.2 miles or 2 kilometers in a model with a general resolution of 7 miles or 12 km, we can better predict wind speeds and precipitation amounts. The moving nest was developed at AOML in coordination with NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) FV3 modeling group.

The new model also has improved physics gleaned from high-resolution radar and flight level observations collected by AOML scientists during missions of NOAA's P-3 Hurricane Hunter aircraft in recent NOAA hurricane field campaigns. The data have enabled us to improve our understanding of the structure of hurricanes and their representation in the new model.

In the 1990s, we focused on improving the track of hurricanes. Since the early 2000s, we have also focused on improving predictions of intensity, or the strength of hurricane winds. This need was heightened by Hurricanes Katrina and Rita in 2005. The public demand continues for more accurate information about winds, rainfall, tornadic threats over land, and storm-surge, as demonstrated by hurricanes such as Michael (2018), Laura (2020), and Ian (2022).

What observations are used in the model? Are some of the newer observations from uncrewed systems?

The new model uses satellite observations, radar data, and NOAA Hurricane Hunter aircraft and US Air Force Reserve flight-level data of winds, moisture, temperature, and Global Positioning System radio occultation observations, a remote sensing technique to measure the atmosphere. The AOML team has also used invaluable turbulence measurements from Hurricane Hunter flights to improve the model's physics. There are still gaps in the model, especially in our understanding of the area where the ocean and atmosphere meet, a key area called the boundary layer, where hurricanes gain and lose strength through an exchange of heat and energy between the ocean and atmosphere. New observations from uncrewed ocean and aircraft systems will definitely help in the future to improve our understanding of this area and of our model.

How was the new model created? Who worked on this?

The model is a perfect example of teamwork. It was jointly created by AOML's Hurricane Modeling and Prediction Program and the Environmental Modeling Center (EMC) of NOAA's National Weather Service in collaboration with GFDL and NOAA's Cooperative Institute for Marine and Atmospheric Studies at the University of Miami. A major component of the physics used to represent the boundary layer relies on observations from NOAA Hurricane Hunter P-3 aircraft. The testing and evaluation was jointly done by EMC and AOML. The new Hurricane Analysis and Forecast System (HAFS) was created to aid forecasters with better tools and model products for providing guidance. Consequently, forecasters at the National Hurricane Center were involved from the developmental stages of the model all the way to its evaluation and implementation. HAFS, which is part of NOAA's Unified Forecast System, is also a great example of community-based collaboration on model development and the streamlining of the operational transition process.

What future improvements to the model are you planning that will help emergency managers and the public?

We are at the starting point of the next generation of hurricane forecast modeling. The initial operational capability is expected to replace the Hurricane Weather Research and Forecasting (HWRF) system and the Hurricanes in a Multi-scale Ocean-coupled Non-hydrostatic (HMON) model. Running the experimental version of HAFS from 2019 to 2022 in near real time, we have already seen a 10-15% improvement in track predictions compared to the best hurricane model today, HWRF. This season, these two older models will also run in parallel with HAFS as we complete the full transition.

NOAA plans to implement the basin-scale HAFS in 2025 and 2026, which is expected to improve the prediction of interactions between several tropical cyclones, as well as the prediction of how storms behave once they make landfall. This will aid forecasters at the National Hurricane Center with improved products of winds, rainfall, and inland tornado threats. NOAA's Hurricane Forecast Improvement Program is also supporting the development of the HAFS ensemble system with a focus on incorporating risk communication research to create more effective watch and warning products in the future.

To continue this work, we need to retain our motivated and talented workforce, as well as bring in new skilled researchers to ensure we have a diverse team. We also need more high performance computing power to help us accelerate the progress we are making.

NOAA Predicts Near-Normal 2023 Atlantic Hurricane Season

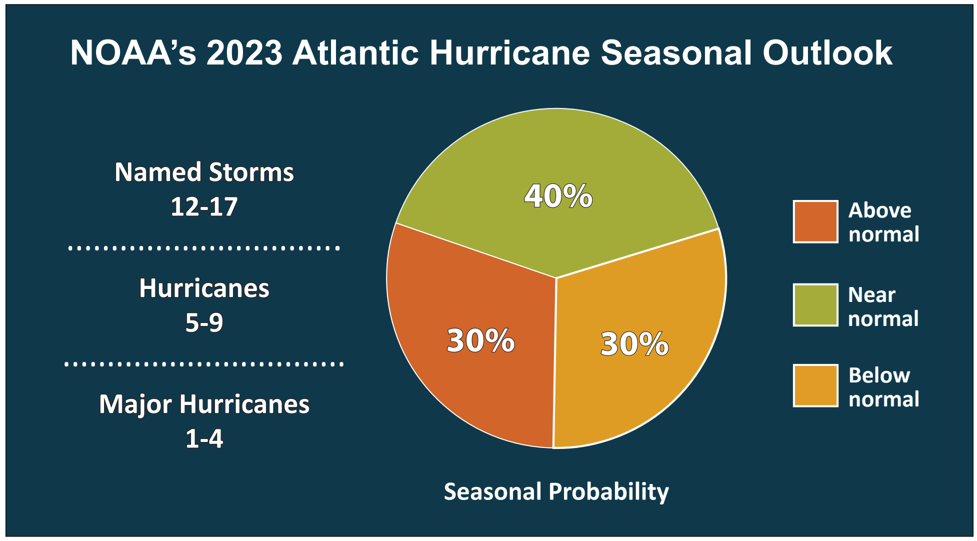
NOAA forecasters predict near-normal hurricane activity in the Atlantic during the 2023 hurricane season (June 1 to November 30). NOAA's outlook indicates a 40% chance of a near-normal season, a 30% chance of an above-normal season, and a 30% chance of a below-normal season. A range of 12 to 17 named storms (39 mph winds or higher) are expected to form. Of those, 5 to 9 could become hurricanes (74 mph winds or higher), including 1 to 4 major hurricanes (category 3, 4 or 5; 111 mph winds or higher).

The 2023 Atlantic hurricane season is forecast to be less active than in recent years due to competing factors—some that suppress storm development and some that fuel it—driving this year's overall prediction for a near-normal season.

After three hurricane seasons with La Niña present, NOAA scientists predict a high potential for El Niño to develop during the summer, which could suppress Atlantic hurricane activity. However, El Niño's potential influence on storm development could be offset by favorable conditions in the tropical Atlantic basin.

Those conditions include the potential for an above-normal west African monsoon, which produces African easterly waves that seed some of the stronger Atlantic storms, and warmer-than-average sea surface temperatures in the tropical Atlantic Ocean and Caribbean Sea that generate more energy to fuel storm development. These factors are part of the longer term variability in the Atlantic's atmospheric and oceanic conditions that have produced more active hurricane seasons since 1995.

"The data and expertise NOAA provides to emergency managers and partners to support decision-making before, during, and after a hurricane have never been more crucial," said NOAA Administrator Rick Spinrad, PhD. "This year we are operationalizing a new hurricane forecast model and extending the tropical cyclone outlook graphic from 5 to 7 days, which will provide emergency managers and communities with more time to prepare for storms."



This summer, NOAA will implement a series of upgrades and improvements to expand the capacity of its operational supercomputing system by 20%. This increase will enable NOAA to improve and run more complex forecast models, including significant model upgrades.

A new model developed by scientists with AOML's Hurricane Modeling and Prediction Program and NOAA's Environmental Modeling Center, the Hurricane Analysis and Forecast System (HAFS), became operational in June. HAFS has been shown to improve track forecasts by 10-15% over existing operational models. It will run in tandem with NOAA's current operational Hurricane Weather Research and Forecasting system and the Hurricanes in a Multi-scale Ocean-coupled Non-hydrostatic model during the 2023 season.

An upgrade to the Probabilistic Storm Surge model advances storm surge forecasting for the contiguous US and provides new surge, tide, and wave forecasts for Puerto Rico and the US Virgin Islands. Forecasters now have the ability to run the model for two storms simultaneously, providing the likelihood of various flooding scenarios to help communities prepare for all potential outcomes.

Flooding from tropical cyclone rainfall has been the single deadliest hazard over the past 10 years. To give communities more time to prepare, the Weather Prediction Center has extended the Excessive Rainfall Outlook to include an additional 2 days, providing forecasts up to 5 days in advance. The outlook shows general areas at risk for flash flooding due to excessive rainfall.

Additionally, the National Weather Service will unveil a new generation of forecast flood inundation mapping for portions of Texas, the Mid-Atlantic, and Northeast in September 2023 that will show the extent of flooding at the street level. These forecast maps will extend to the rest of the US by 2026.

NOAA will continue to improve its observing systems with new aircraft drones, more saildrones and underwater gliders, and WindBorne global sounding balloons, all of which will help advance the knowledge of hurricanes, fill critical data gaps, and improve hurricane forecast accuracy.

The modernization and upgrade of the Tropical Atmosphere Ocean buoy array will also provide additional capabilities, updated instruments, a more strategic placement of buoys, and higher-frequency observations. Data from these buoys are used to forecast El Niño and La Niña, which can influence hurricane activity.

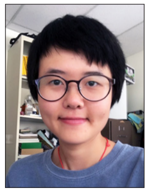
NOAA's 2023 Atlantic seasonal outlook is for overall hurricane activity; it is not a landfall forecast. The Climate Prediction Center will update its seasonal outlook in early August, just prior to the historical peak of the season.

Atlantic Storm Names for 2023

Arlene	Don	Gert	Jose	Margot	Philippe	Tammy
Bret	Emily	Harold	Katia	Nigel	Rina	Vince
Cindy	Franklin	Idalia	Lee	Ophelia	Sean	Whitney

This article is modified from a May 25, 2023 web article on https://www.noaa.gov.

Welcome Aboard



Dr. Xiaoyue Hu joined AOML's Physical Oceanography Division in May as a University of Miami-Cooperative Institute for Marine and Atmospheric Studies post-doctoral scientist. Xiaoyue comes to AOML from the South China Sea Institute of Oceanology, Chinese Academy of Sciences, with expertise in analyzing oceanic observations in the Indo-Pacific region. She will work with Drs. Shenfu Dong and Gustavo Goni on a project to analyze expendable bathythermograph data and other ocean observations to study the variability of boundary currents and their relationship to sea level and large scale ocean circulation changes. Xiaoyue holds a PhD in Physical Oceanography from the Institute of Oceanography, Chinese Academy of Sciences.

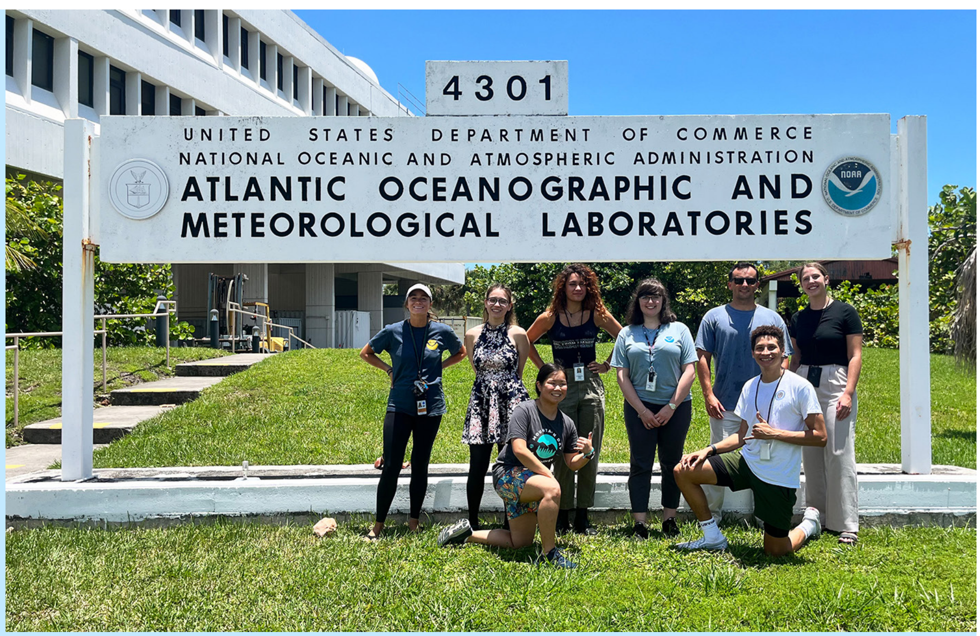
Christopher Malanuk joined AOML's Ocean Chemistry and Ecosystems Division (OCED) in June as a University of Miami-Cooperative Institute for Marine and Atmospheric Studies Communications Intern. Over the next year, Chris will work with OCED staff to promote their research and accomplishments by writing science articles for the AOML website, preparing web pages, supporting outreach events, documenting field activities, making posts for social media, and other activities as needed. Chris will also work closely with the communications team at AOML. He recently earned an MPS degree in Marine Conservation from the University of Miami's Rosenstiel School of Marine, Atmospheric, and Earth Science.

Marike Pinsonneault joined AOML's Office of the Director in May as a University of Miami-Cooperative Institute for Marine and Atmospheric Studies Communications Intern. For the next year, Marike will collaborate with AOML's Communications Team to promote the lab's research by writing science articles for the AOML website, producing photos and videos, supporting and growing the lab's social media presence, assisting with outreach activities, and more. She holds a BS degree from Dalhousie University with a double major in Marine Biology and Cinema and Media Studies. Marike is currently working towards an MPS degree in Marine Conservation, with a focus on Science Communication, at the University of Miami's Rosenstiel School of Marine, Atmospheric, and Earth Science.

Dr. Ajda Savarin joined AOML's Physical Oceanography Division in May as a National Research Council post-doctoral scientist. Ajda will collaborate jointly with colleagues at AOML and NOAA's Pacific Marine Environmental Laboratory (PMEL) on research related to the international Years of the Maritime Continent program and Saildrone hurricane observations project under the mentorship of Drs. Greg Foltz at AOML and Chidong Zhang at PMEL. She holds a PhD in Atmospheric Sciences and Meteorology from the University of Washington.

AOML Welcomes 2023 Summer Interns

AOML began welcoming its class of 2023 summer interns in May, with more than 20 motivated undergraduate and graduate students from across the nation set to complete 4- to 10-week internships with the lab's three science divisions. A few high school student volunteers also spent time at AOML over the summer to learn about NOAA and explore career choices as they assisted with tasks in support of AOML's scientific and administrative functions.



Some of AOML's 2023 summer interns take a break from a networking luncheon to gather in front of the AOML street sign that faces the Rickenbacker Causeway.

All interns were mentored by scientists and technical experts who guided their research studies on corals, hurricanes, microbes, air-sea interactions, and other topics while also helping them hone and acquire new knowledge and skills. Besides learning from a cadre of seasoned professionals eager to train the next generation of scientists, interns had the chance to become better acquainted with NOAA, its research, and the agency's mission of science, service, and environmental stewardship.

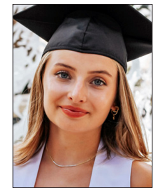
Interns also had the chance to network through peer-mentoring events and discussions with NOAA leaders, as well as learn about the numerous pathways NOAA offers students interested in pursuing careers in the marine and atmospheric sciences. In fact, many of AOML's 2023 interns were NOAA scholarship recipients through the William M. Lapenta, Ernest F. Hollings, and Educational Partnership Program-Minority Serving Institutions (EPP-MSI) programs. It is hoped that the skills and relationships developed by AOML's 2023 summer interns will have a positive impact and better prepare and position them for future career and educational opportunities.

Farewell

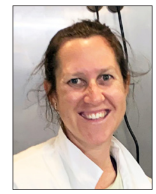
Gloria Aversano, the librarian for the NOAA Miami Regional Library at AOML, retired in May. For more than 17 years, Gloria provided valuable library services to the staff of AOML and the National Hurricane Center. She was a member of the NOAA Central Library (NCL) team in Silver Spring, Maryland who worked closely with AOML library patrons to ensure the lab's needs were met with resources purchased by the NCL or services backed up by NCL. Gloria's work positioned AOML to operate well moving forward without a physical library or a librarian onsite. Before her departure, she worked creatively to transfer most of the unused physical AOML library books to the Internet Archive where they will be digitized. This project was achieved at no cost to AOML and freed up additional physical space in the library to be used for other purposes. Gloria also transferred most AOML-authored or NOAA-authored items in the AOML library to the NCL for eventual digitization and preservation in NOAA's Institutional Repository. With Gloria's departure and with no physical library left in AOML, all future library services for AOML staff will be provided by the NCL team.

Sabine Belanger, an ISS contract employee with the Office of the Director's Admin Group, resigned in May to accept a position as the new Executive Assistant for the Assistant Administrator of NOAA's National Ocean Service. During Sabine's 3 years at AOML, she performed an assortment of duties, including serving as an administrative assistant, the AOML front-desk receptionist, and later as a budget analyst who helped the Office of the Director during the transition of its administrative team members. Sabine's professionalism and service forged much needed collaboration and aided in moving the centralization effort forward.

Dr. Kelly Goodwin, a microbiologist and valued member of AOML's Ocean Chemistry and Ecosystems Division for more than 24 years, joined NOAA Ocean Exploration in April to serve as the NOAA Research 'Omics Portfolio Manager. When Kelly founded the Environmental Microbiology Lab at AOML in 1999, her focus was on the biogeochemistry of one-carbon compounds. Her work on molecular microbiology gradually expanded to research on the development of molecular methods for applications such as protecting swimmers from sewage-polluted waters and Great Lakes drinking water from toxic algae. Kelly's current research has included the autonomous detection of environmental DNA (eDNA) for a microbes-to-mammals approach to biodiversity tracking. She will continue to represent AOML's 'omics portfolio in leadership roles such as the Chair of NOAA's Omics Working Group and the Vice-Chair of the Science and Technology Synergy Committee, both under auspices of NOAA's Science Council. In these roles, Kelly is responsible for providing agency-wide direction with regard to harmonizing the integration of bioscience and biotechnology into NOAA research and operations. The goal is to accelerate mission outcomes across a range of national priorities, including the biomolecular mapping of biodiversity to mitigate impacts arising from ecosystem threats such as climate change, pollution, disease, and invasive species.



Olivia Howson, a University of Miami-Cooperative Institute communications intern with AOML's Ocean Chemistry and Ecosystems Division (OCED), completed her year-long internship at AOML in May. During Olivia's time at the lab, she worked closely with OCED staff to highlight their research activities and accomplishments by writing news features for the AOML website, preparing web pages, creating educational materials, supporting outreach events, and a host of other duties. In addition to her work with OCED, Olivia was a valued member of the communications team at AOML. She recently graduated from the University of Miami's Rosenstiel School of Marine, Atmospheric, and Earth Science with an MPS degree in Marine Conservation.



Dr. Nastassia Patin, a University of Miami-Cooperative Institute post-doctoral scientist with AOML's Ocean Chemistry and Ecosystems Division, resigned in April to accept a Project Scientist position at the Scripps Institution of Oceanography. During her time at AOML, Nastassia worked with Dr. Kelly Goodwin at the Southwest Fisheries Science Center in La Jolla, California where she used microbiome sequence data and biological computational methods to study microbial marine communities. Nastassia also used environmental DNA metabarcoding to link microbiomes to higher tropic levels and draw connections between microbes and other important members of the California Current. As a Project Scientist with Scripps, she will work in support of the California Cooperative Oceanic Fisheries Investigations (CalCOFI) program.

Holly Stahl, a University of Miami-Cooperative Institute communications intern with AOML's Office of the Director, completed her year-long internship in May. During Holly's time at AOML, she promoted the lab's accomplishments and research activities in a variety of ways, including writing news articles for the AOML website, maintaining and growing the lab's social media platforms, creating web pages, developing AOML's new Google site, and other related duties. Holly also supported and promoted AOML's Hurricane Research Division, especially the Hurricane Field Program. She additionally was a valued member of the communications team at AOML. Holly recently graduated from the University of Miami's Rosenstiel School of Marine, Atmospheric, and Earth Science with an MPS degree in Climate and Society.

Congratulations

Dr. Katelyn Schockman, a University of Miami-Cooperative Institute post-doctoral scientist with AOML's Ocean Chemistry and Ecosystems Division, has been awarded the 2023 William M. Sackett Prize for innovative research. Katelyn was recognized for her PhD paper entitled "*A hybrid conductometric/spectrophotometric method for determining ionic strength of dilute aqueous solutions*" that was published in the August 2022 issue of *Analytica Chimica Acta*. The Sackett Prize is awarded to the most meritorious research completed within the College of Marine Science at the University of South Florida by one or more deserving students.

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

Berghoff, C.F., **D. PIERROT,** L. Epherra, R.I. Silva, V. Segura, R.M. Negri, M.C. Hozbor, M.O. Carignan, **L. BARBERO**, and V.A. Lutz, 2023: Physical-biological effects on the carbonate system during summer in the northern Argentine Continental Shelf (southwestern Atlantic). *Journal of Marine Systems*, 237:103828.

CHEN, **X.**, **A. HAZELTON**, **F.D. MARKS**, **G.J. ALAKA**, and C. Zhang, 2023: Performance of an improved TKE-based eddy-diffusivity mass-flux (EDMF) PBL scheme in 2021 hurricane forecasts from the Hurricane Analysis and Forecast System. *Weather and Forecasting*, 38(2):321-336.

Chidichimo, M.P., **R.C. PEREZ**, S. Speich, M. Kersalé, J. Sprintall, **S. DONG**, T. Lamont, O.T. Sato, T.K. Chereskin, R. Hummels, and **C. SCHMID**, 2023: Energetic overturning flows, dynamic inter-ocean exchanges, and ocean warming observed in the South Atlantic. *Communications Earth & Environment*, 4:10.

Cornwall, C.E., S. Comeau, S.D. Donner, C. Perry, J. Dunne, **R. VAN HOOIDONK**, S. Ryan, and C.A. Logan, 2023: Coral adaptive capacity insufficient to halt global transition of coral reefs into net erosion under climate change. *Global Change Biology,* 29(11):3010-3018.

CUCURULL, **L.**, and R.J. Purser, 2023: An improved one-dimensional bending angle forward operator for the assimilation of radio occultation profiles in the lower troposphere. *Monthly Weather Review*, 151(5):1093-1108.

DITCHEK, **S.D.**, **J.A. SIPPEL**, P.J. Marinescu, and **G.J. ALAKA**, **Jr.**, 2023: Improving best-track verification of tropical cyclones: A new metric to identify forecast consistency. *Weather and Forecasting,* 38(6):817-831.

Good, S., B. Mills, T. Boyer, **F. BRINGAS**, G. Castelão, R. Cowley, **G. GONI**, V. Gouretski, and C.M. Domingues, 2023: Benchmarking of automatic quality control checks for ocean temperature profiles and recommendations for optimal sets. *Frontiers in Marine Science*, 9:1075510.

Johnston, M.A., **M.S. STUDIVAN**, **I.C. ENOCHS**, A.M.S. Correa, **N. BESEMER**, R.J. Eckert, K. Edwards, R. Hannum, X. Hu, M. Nuttall, K. O'Connell, **A.M. PALACIO-CASTRO**, G.P. Schmahl, A.B. Sturm, B. Ushijima, and J.D. Voss, 2023: Coral disease outbreak at the remote Flower Garden Banks, Gulf of Mexico. *Frontiers in Marine Science*, 10:1111749.

Klepac, C.N., **K.R. EATON**, C.G. Petrik, L.N. Arick, E.R. Hall, and E.M. Muller, 2023: Symbiont composition and coral genotype determines massive coral species performance under end-of-century climate scenarios. *Frontiers in Marine Science*, 10:1026426.

LIM, **S.J.**, **L.R. THOMPSON**, and **K.D. GOODWIN**, 2023: Genetic features of the marine polychaete *Sirsoe methanicola* from metagenomic data. *Frontiers in Marine Science*, 9:1067482.

Ntaganou, N., V. Kourafalou, F.J. Beron-Vera, M.J. Olascoaga, **M. LE HENAFF**, and I. Androulidakis, 2023: Influence of Caribbean eddies on the Loop Current system evolution. *Frontiers in Marine Science*, 10:961058.

O'Malley, M., A.M. Sykulski, **R. LUMPKIN**, and A. Schuler, 2023: Probabilistic prediction of oceanographic velocities with multivariate Gaussian natural gradient boosting. *Environmental Data Science*, 2:e10.

PATIN, **N.V.**, and **K.D. GOODWIN**, 2023: Capturing marine microbiomes and environmental DNA: A field sampling guide. *Frontiers in Microbiology*, 13:1026596.

PEREZ, **R.C.**, **S. GARZOLI**, R. Hummels, and I. Ansorge, 2023: Inclusive science in the South Atlantic. *Communications Earth & Environment*, 4:11.

Stone, Z., **G.R. ALVEY III**, **J.P. DUNION**, **M.S. FISCHER**, D.J. Raymond, **R.F. ROGERS**, S. Sentic, and **J. ZAWISLAK**, 2023: Thermodynamic contribution to vortex alignment and rapid intensification of Hurricane Sally (2020). *Monthly Weather Review*, 151(4):931-951.

THOMPSON, **L.**, and P. Thielen, 2023: Decoding dissolved information: Environmental DNA sequencing at global scale to monitor a changing ocean. *Current Opinion in Biotechnology,* 81:102936.

TRINANES, **J.**, N.F. Putman, **G. GONI**, C. Hu, and M. Wang, 2023: Monitoring pelagic Sargassum inundation potential for coastal communities. *Journal of Operational Oceanography*, 16(1):48-59.

Zavadoff, B.L., K. Gao, **H. LOPEZ**, **S.-K. LEE**, **D. KIM**, and L.M. Harris, 2023: Improved MJO forecasts using the experimental global-nested GFDL SHiELD model. *Geophysical Research Letters,* 50(6):e2022GL101622.

ZHANG, **J.-Z.**, 2023: Cyanobacteria blooms induced precipitation of calcium carbonate and dissolution of silica in a subtropical lagoon, Florida Bay, USA. *Scientific Reports*, 13:4071.

Zhang, X., **S.D. DITCHEK**, K.L. Corbosiero, and W. Xu, 2023: Global and regional characteristics of radially outward propagating tropical cyclone diurnal pulses. *Journal of Geophysical Research-Atmospheres,* 128(7): e2022JD037660.

Zhu, P., **J.A. ZHANG**, and **F.D. MARKS**, 2023: On the lateral entrainment instability in the inner core region of tropical cyclones. *Geophysical Research Letters,* 50(8): e2022GL102494