



## Progress Report

**Project Title:** Accelerate Improvements in Hurricane Intensity Forecasting Through Underwater Glider Field Campaigns

**Award number:** # NA22NOS0120178

**Period of Activity:** 09/01/2023 – 02/29/2024

**Submission Date:** 3/27/2024

**Principal Investigator:** Debra Hernandez, SECOORA Executive Director

**Co-investigators:** Gerhard Kuska (MARACOOS), Travis Miles (Rutgers University), Jorge Brenner (GCOOS), Stephen Howden (GCOOS/University of Southern Mississippi), Julio Morell (CariCOOS), Patricia Chardón-Maldonado (CariCOOS), Jennifer Dorton (SECOORA), Catherine Edwards (Skidaway Institute of Oceanography, University of Georgia)

### I. PROJECT GOAL:

The overall goal of this project is to conduct targeted and sustained underwater glider deployments during the 2023 and 2024 Atlantic hurricane seasons. Glider missions collect ocean observations that optimize the representation of ocean features in ocean-atmosphere coupled models used for hurricane intensity forecasts. The glider field campaign is designed to collect data in hurricane-prone regions of the U.S. (Caribbean Sea-Tropical Atlantic Ocean, Gulf of Mexico, and the South Atlantic Bight and Mid Atlantic Bight).

Objectives from the proposal are identified in Section II Progress and Accomplishments. High-level accomplishments and any issues identified by each project team member are included for each objective. Status of each deliverable is reported as complete, on-track, or delayed. If the milestone is delayed, a justification for the delay and description of activities employed or to be employed to mitigate the delay are provided.

### II. Progress and Accomplishments

Objectives	Status
<b>Objective 1:</b> Coordinate IOOS Regional Association (RA) and OAR Atlantic Oceanographic and Meteorological Laboratory (AOML) glider sampling to measure subsurface temperature and salinity profiles during the Atlantic hurricane season.	
<p>The following accomplishments detail glider deployments during the 2023 Hurricane Season and other work that is underway by each IOOS Regional Association (RA). Accomplishments:</p> <ul style="list-style-type: none"> <li>The SECOORA glider team is comprised of members from UGA’s Skidaway Institute of</li> </ul>	On-track



Oceanography (SkIO), University of South Florida (USF), and UNC-Chapel Hill. During the 2023 hurricane season 4 missions were completed:

- Unit\_1091's inaugural mission: deployed on 8/3/23 off the coast of Georgia and recovered on 8/28/23 off the coast of North Carolina.
- Franklin was deployed on 8/3/23 off the coast of Georgia and was recovered off Georgia on 9/5/2023.
- Unit\_1091 was deployed off the GA coast on 9/5/23 and was recovered off the Georgia coast on 10/10/23.
- The USF glider Bass was deployed on 10/7/23 off the east coast of Florida and recovered off North Carolina on 11/10/23.
- The SECOORA glider team also ordered alkaline battery packs for 2024 glider deployments and repaired a leak in the G1 glider, Pelagia, in hopes that it can be used for the 2024 glider campaign.
- During the 2023 hurricane season, CariCOOS and partners at NOAA-AOML, the US Navy, and OCOVI deployed and operated 10 hurricane gliders in the Caribbean Sea and tropical Atlantic Ocean, with a total of 796 glider days at sea:
  - Five (5) gliders operated by US Navy in partnership with CARICOOS and OCOVI in the tropical Atlantic.
  - Five (5) gliders operated by NOAA-AOML in partnership with CARICOOS in the Caribbean Sea and tropical Atlantic.
- CariCOOS missions collected data during four tropical cyclones:
  - Hurricane Franklin (8/20/23 – 9/1/23)
  - Hurricane Lee (9/5/23 – 9/16/23)
  - Tropical Storm Philippe (9/23/23 - 10/6/23)
  - Hurricane Tammy (10/18/23 – 10/29/23)
- GCOOS is the glider mission planning leader for the Gulf of Mexico with collaborators from the Texas A&M Geochemical and Environmental Research Group (GERG), University of Southern Mississippi (USM), and USF.
  - GERG deployed Howdy (unit 308) on 8/16/23. The glider was successfully recovered after 60 days; however, it did not experience hurricane conditions during the deployment. The glider aborted the mission for a digifin leak and has been sent to Teledyne Webb Research for servicing.
  - USF deployed Jaialai on August 6. The glider operated off the West Florida Shelf until November 11. During this deployment the glider was positioned in the path of Hurricane Idalia, providing data to the IOOS GDAC and the GTS for model consumption. A second USF glider, deployed under complimentary funding, was on a shelf transect within the path of the hurricane. This glider was not heard from following the passing of Hurricane Idalia. After the passage of Idalia, another glider was deployed (with non-DRSA funds) in the vicinity of the lost glider, near the 50m isobath. Data from the three glider transects near the time of the passing of Idalia until two weeks later are provided in Appendix A.
  - USF ordered and received lithium long duration battery packs for its G3 gliders. They will be used during the 2024 Hurricane season.
  - USM received a shallow pump for a G3 glider as a backup pump.
- The MARACOOS glider team conducted two glider missions during this reporting period:
  - Sylvia was deployed offshore of Philadelphia, PA by VIMS on 9/11/23 and

<p>recovered off the coast of Atlantic City, NJ on 11/26/23.</p> <ul style="list-style-type: none"> <li>○ The University of Delaware glider, ud_476, was deployed offshore of NC on 8/22/23 and recovered off the coast to DE on 9/20/23. This glider crossed the shelf, went into the Gulf Stream, and then returned to the Mid-Atlantic Bight. It collected data relevant to Tropical Storm Ophelia which impacted the US East Coast 9/22/23 – 9/25/23.</li> <li>● MARACOOS received a new Slocum G3 glider in January 2024. The glider, named MARACOOS05, will be operated by Rutgers. It will be used for the 2024 Hurricane season.</li> </ul>	
<p><b>Objective 2:</b> Submit real-time ocean glider profiles to the IOOS National Glider Data Assembly Center (GDAC), where data are quality-controlled and harvested by the NWS for assimilation into the operational NOAA Real-Time Ocean Forecast System (RTOFS)</p>	
<p>Near real-time data from the above listed deployments were submitted to the IOOS GDAC.</p> <p>Additional data management accomplishments:</p> <ul style="list-style-type: none"> <li>● GCOOS co-Data Manager and GANDALF manager, Bob Carrier, has participated in planning meetings and model comparison meetings. 25 deployments were monitored on GANDALF during this progress report period, including all missions funded by this project. Two new data sources were added to the piloting tool: Free Horizon Drifters for the UGOS2 program, and a new modeling product created by Rutgers, showing velocity profiles in the Yucatan Straits. Planning is in progress to prepare for the possible loss of the HYCOM model in the next few months.</li> <li>● SECOORA glider operators are submitting delayed mode glider data to the SECOORA Research Workspace within 30 days of glider recovery. This data is then made available to the IOOS GDAC.</li> </ul>	<p>On-track</p>
<p><b>Objective 3:</b> Coordinate IOOS Regional Association (RA) and OAR Atlantic Oceanographic and Meteorological Laboratory (AOML) glider sampling strategies with the IOOS Glider Lead and the National Weather Service (NWS) National Centers for Environmental Prediction (NCEP) Environmental Modeling Center (EMC) to improve model forecast accuracy</p>	
<p>Project team representatives from each RA participate on weekly glider calls led by Kathy Bailey, IOOS Program Office. These calls are hosted on Mondays and are bi-weekly during the non-hurricane season and weekly during hurricane season. Additional collaboration efforts are listed here:</p> <ul style="list-style-type: none"> <li>● SECOORA PI Catherine Edwards coordinated with the NOAA Saildrone team for Saildrone-glider missions during the 2023 hurricane season. This included 1 Saildrone paired with SECOORA gliders for 3 missions (unit_1091, Bass, and Franklin) and a Saildrone paired with a Navy glider mission.</li> <li>● CariCOOS and partner NOAA-AOML collaborated with the Saildrone team to collect glider and co-located Saildrone observations of ocean structure (depth, salinity, and temperature) from the Caribbean and Atlantic oceanic waters. Data were available for assimilation into products and ocean models utilized for hurricane intensity forecasts, as listed:</li> </ul>	

<ul style="list-style-type: none"> <li>○ NOAA-AOML web page: <a href="https://www.aoml.noaa.gov/hurricane-glider-project/">https://www.aoml.noaa.gov/hurricane-glider-project/</a></li> <li>○ Saildrone observations coordination web page: <a href="https://www.aoml.noaa.gov/phod/goos/gliders/observations_sd.php">https://www.aoml.noaa.gov/phod/goos/gliders/observations_sd.php</a></li> <li>○ Ocean field observations and satellite-derived products continue being communicated through the CoastWatch-AOML OceanObsViewer: <a href="https://cwcgom.aoml.noaa.gov/cgom/OceanViewer/index_phod.html">https://cwcgom.aoml.noaa.gov/cgom/OceanViewer/index_phod.html</a></li> <li>○ Real-time RTOFS verification using glider data: <a href="https://www.aoml.noaa.gov/phod/goos/gliders/monitoring/RTOFS/rtofs_evaluation.php">https://www.aoml.noaa.gov/phod/goos/gliders/monitoring/RTOFS/rtofs_evaluation.php</a></li> <li>● Project team members from each RA coordinate with national efforts through participation in the Underwater Gliders User Group (UG2 - <a href="https://underwatergliders.org/">https://underwatergliders.org/</a>) community.</li> </ul>	
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<b>Additional Areas of Success and CHAOS collaboration</b>	
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<p>Project team success stories that are not specifically part of the proposal, but which contribute to the overall IOOS and project team missions, are provided below:</p> <ul style="list-style-type: none"> <li>● The new SECOORA glider (unit_1091) delivered mid-May 2023 was equipped with High-Speed data transfer capability. This capability was used between two deployments (after recovery on 8/28/23 and before redeployment on 9/5/23) to recharge the glider batteries and offload mission data without opening the glider. This resulted in a quicker turnaround time between deployments and the knowledge that there would be no leaks due to possible O-ring pinches or debris due to opening and closing of the hull sections.</li> <li>● Coverage of hurricane glider/Saildrone deployments in popular media, including interviews on live TV (Fox Weather, e.g., <a href="https://www.foxweather.com/watch/play-6a343765e00102c">https://www.foxweather.com/watch/play-6a343765e00102c</a>), recorded segments (Savannah area stations), print media, and online media (<a href="https://www.usf.edu/marine-science/news/2023/deep-diving-gliders-capture-key-ocean-data-for-hurricaneforecasting.aspx">https://www.usf.edu/marine-science/news/2023/deep-diving-gliders-capture-key-ocean-data-for-hurricaneforecasting.aspx</a>).</li> <li>● The following schools and state agencies were presented with information about the instrumentation that comprises the CARICOOS coastal ocean observing system. CARICOOS highlighted the importance of underwater glider data for improving tropical cyclone intensity forecasts, preparing for storms, and evacuating before their arrival to the following groups: <ul style="list-style-type: none"> <li>○ Students of the Escuela Montessori Alejandro Tapia y Rivera, La Parguera, Lajas, Puerto Rico</li> <li>○ Students from the Inter-American University of Puerto Rico and island public schools participating in the summer internship OCEANOS subsidized by the NASA Science Activation Program</li> <li>○ Boys and Girls Scouts of Caribe</li> <li>○ National Weather Service – San Juan Weather Forecast Office</li> </ul> </li> <li>● The GCOOS Gulf glider pilot team coordinates with other partners to contribute to their data to the IOOS GDAC – i.e., CICESE in Mexico, University of Texas in San Antonio, University of Louisiana – Lafayette, Dauphin Island SeaLab-University of Alabama, AOML – University of Miami, and AOML Saildrone Group. Although not part of this project, these are part of the collaborations developed by GCOOS Glider team.</li> <li>● On 12/11/23, the Mayor of College Station, TX, John P. Nichols, proclaimed December</li> </ul>	
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<p>11, 2023 as “10 Years of Autonomous Ocean Vehicle Operations Day” at the College Station City Council Meeting. Contact Dr. Uchenna, GCOOS, for a video and audio interviews.</p> <ul style="list-style-type: none"> <li>• The MARACOOS glider team at VIMS is working with undergraduate students on glider data research projects.</li> </ul>	
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**III. PROJECT CHALLENGES/MODIFICATIONS:**

- G1 gliders are no longer being serviced by Teledyne-Webb.
- The GCOOS University of Southern Mississippi team has experienced delays in purchasing and receiving two Hefring Ocean Scout 200m gliders. The new expected delivery date is late spring 2024 and USM is working with Hefring to schedule Ocean Scout training for glider operators. If the gliders are received in Spring 2024 then they should be available for deployment during the 2024 Hurricane season.

**IV. PUBLICATIONS:**

Edwards, C.R., A. Vincent, G. Foltz, C. Zhang. (Feb 2024). Coordinated autonomous surface vehicle and underwater glider operations in the Gulf Stream during hurricane season, Oral presentation, Ocean Sciences Meeting.

Martin, K. M., Bailey, K., Miles, T. N., Chardon-Maldonado, P., Le Hanaff, M., & Edwards, C. R. (Feb 2024). Summary of the 2023 Atlantic Hurricane Glider Operations. Ocean Sciences Meeting.

McQuarrie, Jr. F, Woodson, B., Edwards, C.R. (Feb 2024). Quantifying the Effect of Predictable Physical Process on a Shallow Coastal Reef’s Soundscape. Poster Presentation, Ocean Sciences Meeting.

Tsei, S., Howden, S. D., Miles, T. N., Zhang, J., Diercks, A. R., & Martin, K. M. (Feb 2024). Coastal Ocean Thermal Structure and Rapid Intensification of Hurricane Ida over the Western Louisiana Shelf. Ocean Sciences Meeting.

**V. BUDGET SUMMARY:**

- Were the oldest ASAP TAS BETC accounting lines invoiced first?
  - Yes.
- Give details on any delays with initiating a contract/subaward. Note any issues with the previous year funds or other issues that occurred during the reporting period. Will this result with a work stoppage or cause significant problems with the partnership?
  - SECOORA has issued all subawards related to this award and all subawards have been fully executed.
- Give a brief update on project invoicing for the reporting period. Were there any delays with invoicing or payment?
  - SECOORA is receiving invoices from all project team members for this award. Note that SECOORA receives quarterly invoices from subawardees; therefore, there is a delay between when a subawardee conducts work and when SECOORA is given an invoice for that work. SECOORA regularly monitors invoicing frequencies with subawardees.
- Provide details on any property or equipment charged directly to the award having a useful life of more than one year and an acquisition cost of \$5,000 or more per unit during the period.
  - SECOORA purchased a new Slocum G3 Glider from Teledyne Webb. The glider is used to measure temperature and salinity profiles at varying depths in support of this award. The total cost for the glider is \$246,712 and the glider has been paid for in full and



delivered in May 2023.

- Include changes in key scientific, technical or management personnel, not included in certification.
    - No changes
  - Include changes to the organizational structure such as: changes in status or partners organizations and points of contact. As a reminder, a change to the award's Principal Investigator and a change in an award's Key Person Specified in the Application requires NOAA approval through Grants Online.
    - No changes to organizational structure
  - Provide an update about travel completed during the reporting period.
    - SECOORA, the Lead PI for this award, does not have any funds for SECOORA personnel travel. Subawardees (i.e., other RA glider team members) are using travel funds to cover roundtrip travel to glider deployment/recovery locations.
  - Are there any plans to initiate a new partnership (contract or subaward) during the next reporting period?
    - No
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Figure 1: USF Gliders deployed before and after hurricane Idalia (red track line) passing through the eastern Gulf of Mexico. M131 and M132 were mid-deployment while Idalia transited the region and M133 was deployed 4 days after.

Significant changes to the overall temperature within the water column were observed (Figure 2)

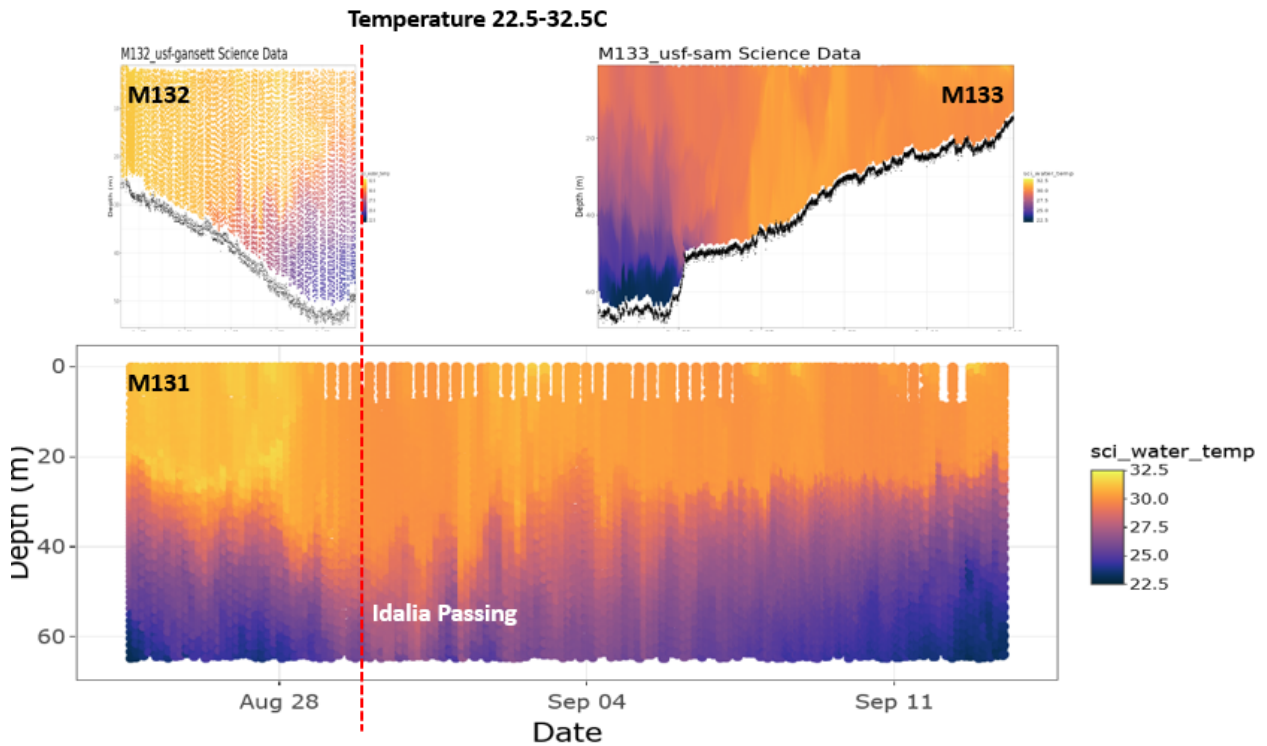


Figure 2: Temperature of the upper 60m for the two shelf gliders transiting offshore (M132) and inshore (M133), and the deep water glider (M131) during the periods before and after the passing of Hurricane Idalia (red line).