The Challenges of ROV Operations at Sea

Expedition: 2019 Southeastern U.S. Deep-Sea Exploration

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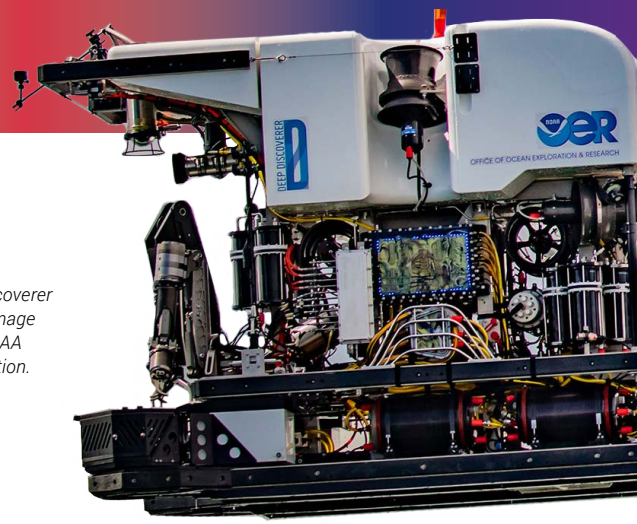


ROV *Deep Discoverer* mid-launch. *Image courtesy of NOAA Ocean Exploration.*

Whenever the mission team aboard NOAA Ship *Okeanos Explorer* plans to explore the deep sea, we know there will be challenges. No matter how much we anticipate and plan for them, it is always disappointing when we are unable to deploy the remotely operated vehicles (ROVs), *Deep Discoverer* and *Seirios*, and share the wonders of the deep with scientists and other dedicated followers who join us live online. The 2019 Southeastern U.S. Deep-Sea Exploration expedition has certainly had its fair share of challenges and lost dive days. Here is a little insight into the factors that guide our dive/no dive decisions.

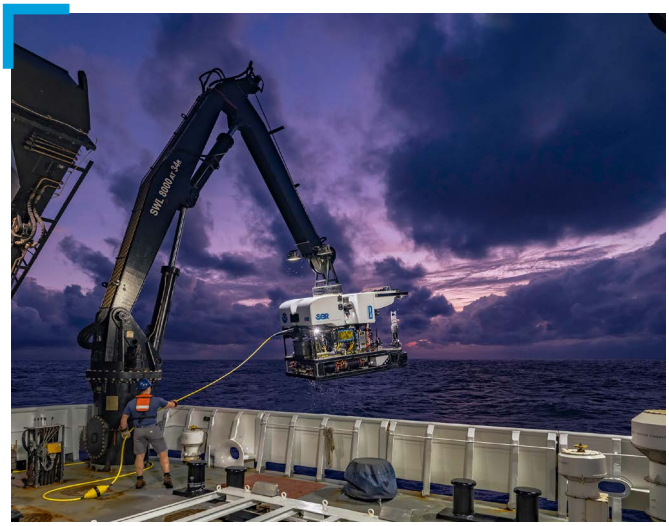
The Dangers

Potentially dangerous situations are inherent during all stages of ROV operations. During launch and recovery, deck crew and ROV engineers are on the back deck of the ship assisting with operations. In rough weather (i.e., wind over ~25 knots or 29 miles per hour and waves over ~6 feet), the ship's movvements could become so extreme that the deck crew could lose their footing on deck, or the ROVs could swing unsafely while being lifted by the crane. It is part of the dive supervisor's job to minimize the operational risks for personnel and equipment on deck, so if conditions are too rough to safely deploy the ROVs, the ROV dives will be aborted, and mission personnel will instead turn their focus to seafloor mapping.

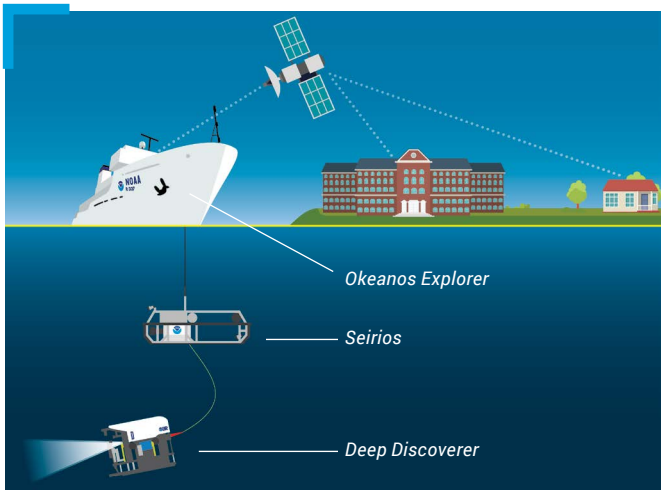
The dangers of operations are not limited to launch and recovery. While the ROVs are descending or ascending in the water column, the cable that attaches the ROVs to the ship could become entangled in the ship's propellers or rudders or if the ship is not moving properly through the water. When the ROVs are on the seafloor, operators must be careful that the currents do not push the vehicles into geological features. The dive supervisor helps manage ship speed and movements, and assesses overall conditions to prioritize safety for personnel, the ROVs, and the ship.

The Decision-Making

There is no precise formula that we can use to decide whether or not it is safe to dive. When preparing for a deepwater ROV dive, the navigator, dive supervisor, and ship operators study the three major forces acting on the ship. These major forces are the wind, the seas (i.e., the waves), and the currents. At most dive locations around the world, the wind and seas are the predominant forces.



The team of engineers recovers remotely operated vehicle *Deep Discoverer. Image courtesy of NOAA Ocean Exploration, 2019 Southeastern U.S. Deep-Sea Exploration.*



Seirios is tethered between the ship and *Deep Discoverer*. This tandem configuration allows *Seirios* to absorb the heave of the ship while keeping *D2* stable as it explores the ocean floor. *Image courtesy of NOAA Ocean Exploration.*

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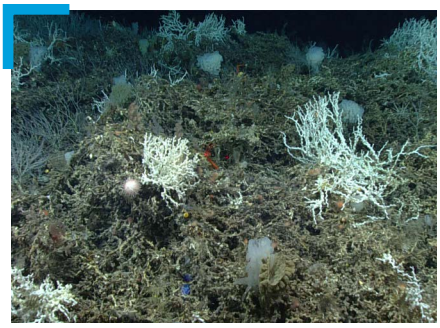
If these two forces are minimal, the dive supervisor and commanding officer usually give the "green light" for a dive. This is often not the case in the waters of the Atlantic off the Southeastern U.S. because of the Gulf Stream, which is a strong ocean current that extends along the eastern coast of the United States and Canada, bringing warm water from the Gulf of Mexico into the Atlantic Ocean.

For almost all the ROV dives during the 2019 Southeastern U.S. Deep-sea Exploration, the Gulf Stream was the predominant force on the ship. Surface currents such as the Gulf Stream affect the ship's ability to hold position during a dive and affect how the vehicles travel in the water behind the ship during launch and recovery. Since the Gulf Stream is such a large, consistent, and high-magnitude force, there are also subsurface currents that affect the ROVs during their descent, ascent, and throughout the dive while on bottom.

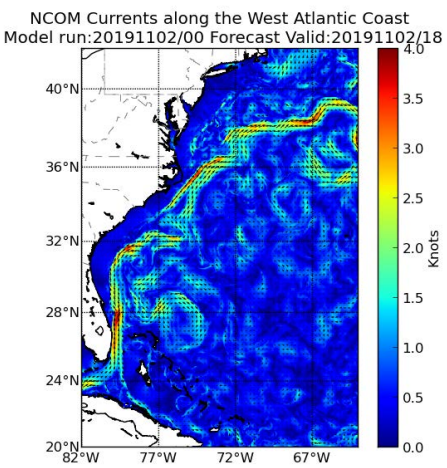
The ROV team on *Okeanos Explorer* uses an Acoustic Doppler Current Profiler (ADCP) to estimate surface and subsurface currents. The figures below show readings from the ADCP taken at a dive site that was deemed unsafe for dive operations on the day we were there. The figure on the left displays the surface current direction and magnitude, and the figure on the right displays the subsurface current profile throughout the water column. Although the 2.2 knots (2.5 miles per hour) of surface current are much higher than seen at a typical dive site, this alone did not lead to the decision to cancel the dive. With a bottom depth of about 500 meters (1,640 feet), the subsurface current profile a current close to the bottom of about 0.5 meters/second (~1 knot, or 1.7 miles per hour This situation is not safe for the ROVs, and so we made the difficult decision to cancel the dive.



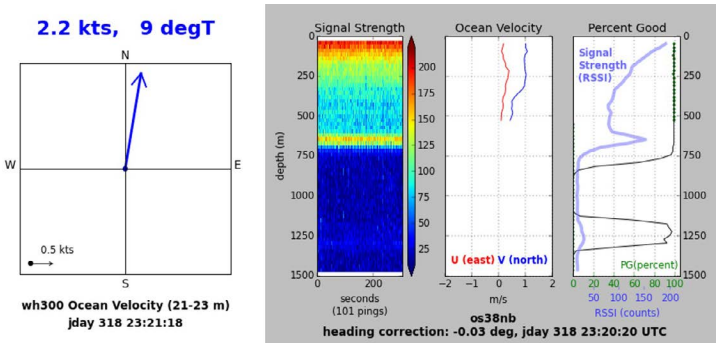
Marine life, such as Lophelia coral and glass sponges, was found to be both abundant and diverse on the Central Blake Plateau, an area through which the Gulf Stream passes. *Image courtesy of NOAA Ocean Exploration, 2019 Southeastern U.S. Deep-sea Exploration.*

Why It's Worth It

The Gulf Stream is not all bad though! It is a big reason why these dive sites are so valuable to the scientific community (and so interesting for those who follow the dives online). The warm Gulf Stream currents bring nutrients and helps sustain life like that found among the deep, dense, and diverse coral communities that we have documented throughout this expedition. With some of the imagery, samples, and data that have been collected at these dive sites, it is easy to see why diving near the Gulf Stream can be worth its challenges.



The Gulf Stream direction and magnitude is modeled by the U.S. Navy Coastal Ocean Model (NCOM), which is a high-resolution model that offers ocean current data at a 2 nautical mile (2.3 mile) resolution every 24 hours. The navigator, dive supervisor, and ship operators use this model output to roughly estimate expected currents at each planned dive site. *Image courtesy of NOAA Ocean Prediction Center.*



The conditions on November 14, 2019, were unfavorable for diving. The readings on that day from the Acoustic Doppler Current Profiler (ADCP) show the surface current direction and magnitude (left) and the subsurface current profile throughout the water column (right). *Image courtesy of the NOAA Office of Marine and Aviation Operations.*

THINK ABOUT IT...

Q: Create a checklist or decision tree for the team to use when determining whether they can launch the ROV today.

Expedition: https://oceanexplorer.noaa.gov/okeanos/explorations/ex1907/welcome.html
Deep Discoverer (image): https://oceanexplorer.noaa.gov/okeanos/explorations/ex1811/dailyupdates/oct30/media/oct30-2-hires.jpg
Explorer Profile: https://oceanexplorer.noaa.gov/okeanos/explorations/ex1907/background/explorers/explorers.html#ritter
Deep Discoverer recovery (photo): https://oceanexplorer.noaa.gov/okeanos/explorations/ex1907/dailyupdates/nov2/media/rov-recovery-hires.jpg
Ships and *Seirios* (illustration): https://oceanexplorer.noaa.gov/okeanos/explorations/ex1905/background/plan/media/telepresence-hires.jpg
Marine Life (photo): https://oceanexplorer.noaa.gov/okeanos/explorations/ex1907/logs/nov18/media/coral-hires.jpg
ADCP instrument (webpage): https://oceanexplorer.noaa.gov/technology/acoust-doppler/acoust-doppler.html
Navy Coastal Ocean Model (photo): https://oceanexplorer.noaa.gov/okeanos/explorations/ex1907/logs/nov18/media/gulf-stream-hires.jpg
ADCP readings (photo): https://oceanexplorer.noaa.gov/okeanos/explorations/ex1907/logs/nov18/media/combinedadcp-hires.jpg

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