THE Ocean TWILIGHT ZONE

EXPLORING EARTH'S HIDDEN FRONTIER

JANUARY 2019

Before the holidays, you heard from Mark and Heidi about the first year of the Ocean Twilight Zone (OTZ) project: **it truly has been an exciting whirlwind of activity.**

We completed two expeditions—one in the Atlantic Ocean, one in the Pacific—involving several dozen scientists, engineers, and students from Woods Hole Oceanographic Institution and several universities and federal agencies. These expeditions brought back more than 22 terabytes of data that our team has been analyzing, and a host of striking images of twilight zone creatures that were featured in the *New York Times* and in the 2019 WHOI calendar. If you did not receive the calendar in the mail from Heidi, or if you would like more copies, please let us know.

Here are highlights of the OTZ team's accomplishments and activities in the last quarter:

Peter Wiebe stands next to a MOCNESS, which stands for a Multiple Opening/Closing Net and Environmental Sensing System. The MOCNESS net carries anywhere from six to twenty nets, plus electronic sensors for measuring temperature, depth, and salinity. The nets can be opened and closed independently to sample a specific depth of water in the twilight zone, allowing scientists control over where and when they take their samples.

CARBON AND CLIMATE

The Buesseler Lab is analyzing samples from the August 2018 EXPORTS cruise out of Seattle to understand the role of the twilight zone in regulating Earth's climate.

MARINE POLICY

Marine policy experts Porter Hoagland and Di Jin are developing a comprehensive overview of the economic value of the ecosystem services provided by the ocean twilight zone.

As part of that analysis, Hoagland and Jin have been working with marine chemist Ken Buesseler to determine the economic value of reducing the uncertainty in our estimates of the amount of carbon that moves through the twilight zone and is trapped in the deep ocean. Such estimates are critical to making well-informed policy decisions about how to respond to climate change.

LIFE IN THE OCEAN TWILIGHT ZONE

The Llopiz Lab has dissected more than 200 fish, squid, and other animals from the August 2018 *Bigelow* cruise off the U.S. East Coast. In addition to completing their own analyses, biologist Joel Llopiz's group acts as a central hub for processing and disseminating biological samples to other members of the OTZ team, including labs run by biologists Simon Thorrold and Annette Govindarajan.

- The Llopiz Lab is analyzing the stomach contents of each animal to identify what it has eaten and to develop a more detailed picture of the twilight zone food web. They will also determine the age, growth rates, and reproductive activity of collected individuals.
- Govindarajan and her team are performing DNA "barcode" analyses on samples of muscle tissue to confirm species identification and build a public database of the genetic signatures of twilight zone species.

Helena McMonagle, a research assistant in the Llopiz Lab, has dissected more than 200 twilight zone organisms collected on net tows during the 2018 *Bigelow* summer cruise.

- The Thorrold Lab is using chemical (isotopic) signatures to determine where each animal fits in the food web and to potentially reveal how changes in species abundance could impact the entire ecosystem.

TECHNOLOGY

Dana Yoerger and his team are putting the finishing touches on a full-size model of the *Mesobot* (see technology highlights) in order to design and refine the vehicle's internal components and structure.

- The WHOI shop is completing construction the main housing and internal components of the *Mesobot.*
- Construction and assembly of the vehicle is scheduled to begin in two weeks.

OUTREACH AND ENGAGEMENT

Members of the OTZ team have participated in educational and outreach activities both in person and online, and their research has been featured in high-profile media outlets.

- Preparation for a possible presence at the TED 2019 Conference.
- Acoustic engineer Andone Lavery and her lead *Deep-See* engineer, Kaitlyn Tradd, taught more than 30 teachers about new marine technology and how they could bring it into their classrooms.
- Biologist Joel Llopiz and his team strengthened an established relationship with public schools in Falmouth, Mass., by inviting administrators into their lab and creating opportunities for high school students to work in the lab.
- Members of the OTZ team interacted with students via the online initiative known as "Skype a Scientist.".
- *The New York Times* featured the OTZ project in an in-depth article and photo spread, which was published both online and in print.

PROJECT MANAGEMENT

WHOI established a new Program Office to manage this complex and highly integrated project and hired Phil Renaud, USN(ret) as Program Manager and Kathryn Baltes as the Project Manager.

NEW YORK TIMES | JANUARY 1ST, 2019


Observatory

Inside the Ocean's Twilight Zone

WHOI mechanical engineer Kaitlyn Tradd directs deck operations on the 2018 *Bigelow* cruise during a recovery of Deep-See. Tradd helped to develop and build the new 2,500-pound, instrument-laden vehicle, which is designed to be towed behind a ship using a special electro-optical cable that can transmit data back to scientists on board in real time. The unique combination of sonar, imaging, and sampling technologies on the Deep-See provide researchers with a powerful tool for studying the diversity and abundance of life in the ocean twilight zone.

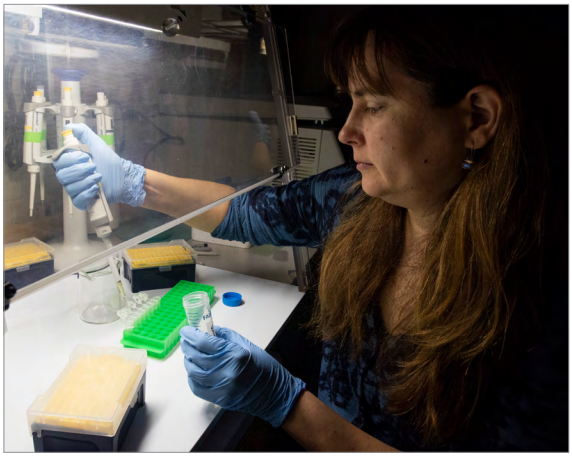
A Look Ahead: What's coming in 2019

As mentioned in the year-end update, we are developing detailed work plans for the next 18 months that will align with several themes, each of which is tied to strategies for public engagement.

- The OTZ team will lead a new expedition focused on discovery and technology acceleration, including the deployment of the *Mesobo*t, a new, specially developed autonomous robot that hovers under water and stealthily tracks elusive twilight zone animals while also measuring ocean phenomena, such as the movement of carbon-rich particles known as "marine snow."
- The team will also advance development of emerging technologies such as low-cost samplers, sensors, and camera systems that will put many "eyes" in the deep ocean.
- We aim to leverage an underwater Internet of Things (IoT) network to connect these new technologies and make their data available in real time—a unique and highly valuable opportunity made possible by OTZ funding.

SCIENCE FEATURE: eDNA

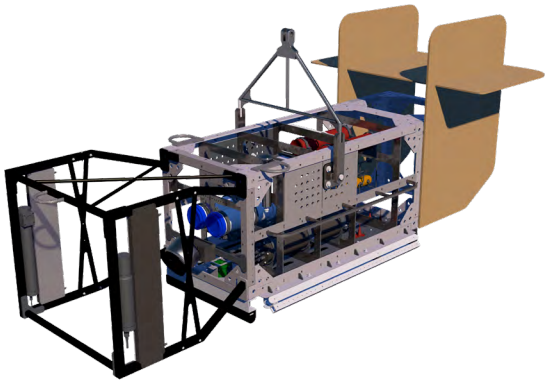
Imagine if we could identify animals in the ocean twilight zone without needing to see them, just by analyzing the genetic information that they leave behind in the water. Biologist Annette Govindarajan is doing just that, using what's known as environmental DNA (eDNA). Govindarajan is analyzing eDNA from water samples collected this past summer to identify DNA "barcodes:" signature sequences of genetic information. By comparing these barcodes to the barcodes in a database of known species, Govindarajan can determine what twilight zone animal the DNA belongs to. The technique works well if the animal's DNA has been sequenced before, and its barcode is already in the database. However, most twilight zone species are not in the database, so part of the OTZ project's mission is to take the genetic "fingerprints" of as many species as possible. Expanding the database to include more twilight zone animals will allow scientists at WHOI and elsewhere to take full advantage of these new eDNA techniques.



WHOI Biologist Annette Govindarajan works to extract eDNA from water samples taken on the 2018 Bigelow summer cruise. Govindarajan is working closely with engineers at WHOI to develop an even better sampling technique that will allow her to collect eDNA samples directly on an underwater vehicle.

TECHNOLOGY FEATURE: DEEP-SEE

The *Deep-See* is a new, sensor-filled platform for observing life in the ocean twilight zone and assessing how many and what kinds of animals are there. Weighing about 2,500 pounds and extending 16 feet in length, the Deep-See carries a multitude of camera systems, sonars, and sensors for measuring oxygen, currents, and other seawater properties, as well as a sampling device to collect water for later genetic analysis. On its first foray into the ocean twilight zone last August, the *Deep-See* already challenged scientists' previous understanding of the sheer quantity of life in the ocean twilight zone.



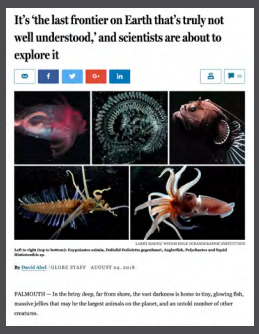
TECHNOLOGY FEATURE: MESOBOT

Like its much larger cousin the *Deep-See*, the *Mesobot* will explore the deep, dim waters of the ocean twilight zone. But unlike *Deep-See*, which was designed to help researchers quantify and identify life in the ocean twilight zone, the stealthy *Mesobot* will be able to follow individual animals, revealing subtle secrets about their behavior. The *Mesobot* looks something like a 4-foot-tall, bright-yellow bar of soap, turned on one long edge. It weighs only about 350 pounds—small and light for a sea-going robot—and has enough battery power for missions lasting up to two days. What will really set the *Mesobot* apart from other autonomous vehicles and samplers in WHOI's fleet, says lead engineer Dana Yoerger, is its ability to follow elusive ocean twilight zone species for hours or even days—and capture detailed images of their behavior. The vehicle will have two camera systems: a pair of stereo cameras for locating target animals so the *Mesobot* can follow them, and an additional camera to record what they do, in 4K video or 12 megapixel stills.

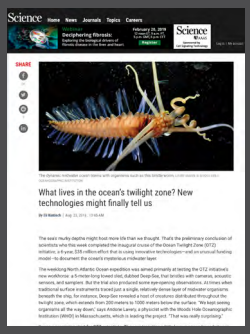
Ocean Twilight Zone 2018 MEDIA HIGHLIGHTS

MEDIA REACH

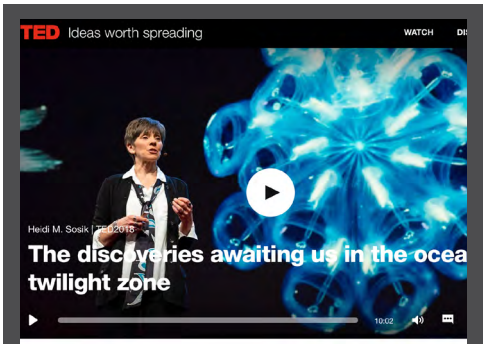
NEW YORK TIMES
2 Million



THE BOSTON GLOBE
3 Million

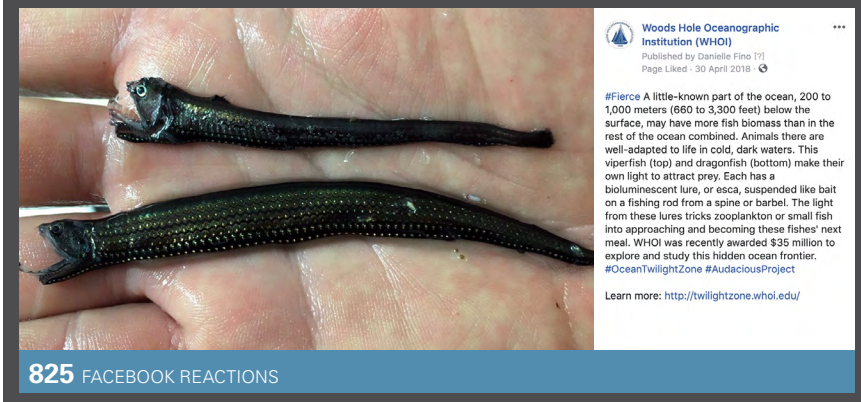


SCIENCE MAGAZINE
4 Million



1,125,921 VIEWS

TOP POSTS

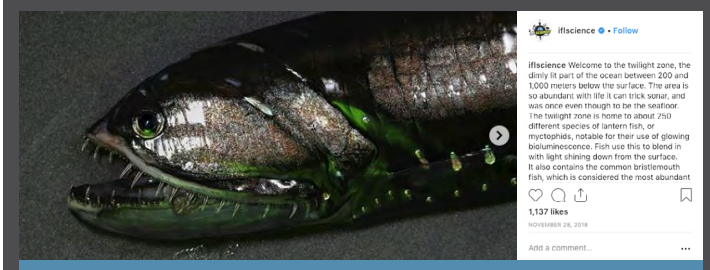


825 FACEBOOK REACTIONS

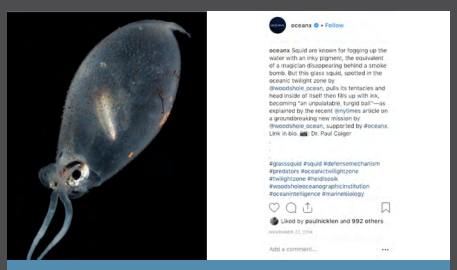
12 RETWEETS **42** LIKES

1,594 INSTAGRAM LIKES

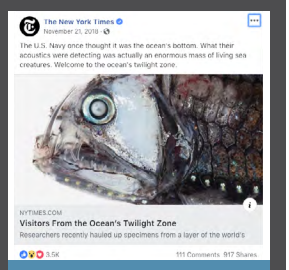
12 RETWEETS **49** LIKES



3,500+ FACEBOOK REACTIONS, **917** SHARES



1,137 INSTAGRAM LIKES



993 INSTAGRAM LIKES