OCEAN TWILIGHT ZONE

WOODS HOLE OCEANOGRAPHIC INSTITUTION

2021 Q3 REPORT

Introduction

OVER THE PAST QUARTER, THE OTZ TEAM HAS CONTINUED TO RAMP UP ITS ACTIVITY, LEVERAGING OPPORTUNITIES FOR SHIP TIME, PUBLIC ENGAGEMENT, AND TECHNOLOGY DEVELOPMENT.

In the field, an eight-day cruise aboard the R/V Neil *Armstrong* (5-12 July) let the team install and test new sonar moorings in the northwestern Atlantic. These moorings, which are located roughly 350 miles (563 kilometers) from the coast of Bermuda, represent the first components of the Twilight Zone Observation Network to be put into place. A second 10-day cruise on the E/V *Nautilus* provided a means to test new *Mesobot* capabilities while simultaneously introducing the lay public to the hybrid autonomous vehicle and the research it enables. While at sea, OTZ researchers participated in live-streamed video events on Facebook and Youtube, bringing the team's work to new audiences worldwide.

Back on land, the team has brought widespread public awareness to the nightly "vertical migration" that takes place within the twilight zone. This migration, and the animals that undertake it, is a key element in the ocean's biological carbon pump: a massive, planet-scale process that captures carbon dioxide from the atmosphere. Ultimately, the pump pulls carbon into the ocean's surface waters, down through the twilight zone, and into the deep ocean, where it can stay out of the atmosphere for hundreds or even thousands of years. To highlight this fact, the OTZ Team collaborated with ocean advocates to bring an unusual video installation to the United Nations' headquarters in New York. The installation, called "Vertical Migration," consisted of a 505-foot video of a siphonophore that was projected onto the facade of the United Nations' for four nights, coinciding with the 76th General Assembly and Climate Week NYC.

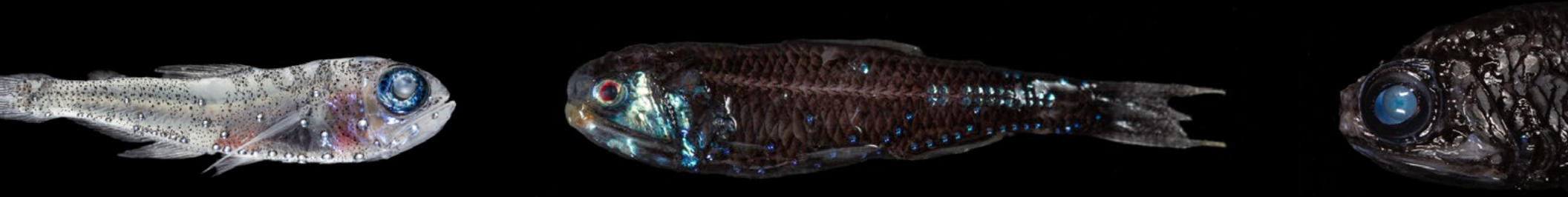
Meanwhile, OTZ researchers continued to advance scientific understanding of life in the twilight zone. Over the past few months, team members developed new ways to characterize migrating animals and gauge their impact on the marine carbon cycle: the Lavery lab created a method for identifying individual animals using multiband sonar data; the Sosik lab improved machine learning techniques for autonomously identifying zooplankton; and the Govindarajan lab made new advances in using environmental DNA (eDNA) to determine which species are present in the twilight zone at different times.

THIS PAGE: Sunset at sea on the Twilight Zone Observation Network cruise on R/V *Neil Armstrong*. Daniel Hentz © WHOI
COVER IMAGE: The art installation "Vertical Migration," a 505ft video of a siphonophore, was projected onto the U.N. Secretariat building during New York City Climate Week in September 2021. © WHOI

3rd Quarter at a glance

- Installed the first three (of five) components of the ocean twilight zone observation network in the northwestern Atlantic.
- Completed a cruise aboard the R/V *Armstrong* to deploy a bioacoustic mooring and two sound source moorings for the OTZ Observation Network.
- Completed a cruise on E/V *Nautilus* (funded by NOAA Ocean Exportation Cooperative Institute) to conduct a technology demonstration of *Mesobot* and the new eDNA multi-sampler.
- Collaborated with ocean advocates on a 505-foot-tall art installation called Vertical Migration. This dramatic projection was displayed for three nights on the side of the United Nations tower in New York.
- Published three new academic papers in prestigious journals, including a paper about a new model developed to understand eDNA diffusion throughout the twilight zone.

MIT-WHOI Joint Program graduate student Samantha Clevenger prepares a sediment trap for deployment. Instruments like these collect carbon-rich particles that drift downward in the water, which helps scientists understand how carbon moves through the twilight zone. Daniel Hentz © WHOI



Better data from eDNA

Environmental DNA (or eDNA) offers a powerful tool for understanding which animals live in the ocean's twilight zone.

Using tiny amounts of genetic material filtered from seawater—like fish scales, feces, or bits of tissue—researchers can determine the identity and relative abundance of twilight zone species without needing to see them firsthand.

A new study by OTZ researcher Eily Allen has shown that eDNA may also provide clues to where an animal is at any given time, revealing which species migrate up to the surface at night to feed, and which ones remain at depth. The study, published in the journal Scientific Reports, used a computer model to gauge whether physical processes like currents, wind, and settling of particles had any impact on the movement of eDNA. Once genetic material is shed by a host animal, it showed, the material remains within roughly 20 meters (66 feet) of where it entered the water. This means that changes in eDNA concentration can reliably be used to determine where certain species live at different times of the day, how long they spend at those depths, and the percentage of certain species that migrate from the twilight zone to the surface.

Introducing the Twilight Zone Observation Network

The OTZ team is excited to announce that the first instruments of the planned Twilight Zone Observation Network have been installed in the northwestern Atlantic ocean.

WHOI Postdoctoral Investigator Wokil Bam prepares a sediment trap for deployment within the OTZ Observation Network. This instrument is just one of the components that will help OTZ researchers understand how the twilight zone changes throughout the year. Daniel Hentz © WHOI

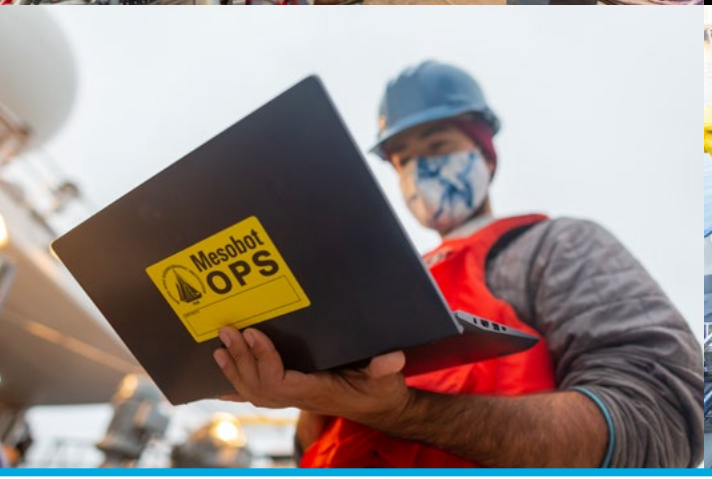
Once the network is completed, it will let scientists monitor a section of the twilight zone roughly 250,000 square kilometers (155,300 miles) in size, capturing real-time data on the zone's ecosystem over a period of months or even years. Eventually, the network will host a vast swarm of buoys, gliders, acoustic survey devices, fish-tracking tags, and optical/geochemical sensors, many of which will connect to its moored buoys remotely using acoustic signals. At the surface, Iridium satellite links will continuously send the instruments' data back to shore.

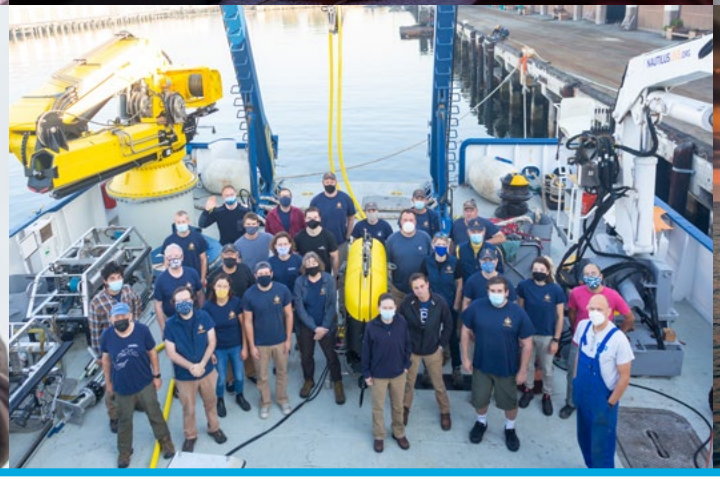
The first installed elements of the network—a set of low frequency active sonars—each transmit a continuous "beacon" of sound that will enable scientists to triangulate where fish tags and other devices are located within the zone. Those sonars are also providing valuable data to the OTZ team: using just a few days' worth of information collected on the July 2021 installation cruise, acoustical oceanographer Andone Lavery has already begun to develop new ways of characterizing what types of animals in the zone migrate to the surface each night to feed.

Future data provided by the network—which was funded by German philanthropist Dr. Otto Happel—will improve estimates of the density and distribution of fish and invertebrates in the twilight zone. It will also reveal new insights about their interactions, fuel new strategies for conservation and policy making, and help researchers better understand how the twilight zone affects carbon cycling and global climate.

Mesobot live!

In August 2021, Mesobot *joined WHOI's hybrid remotely operated vehicle* Nereid Under Ice *for an at-sea technology demonstration aboard the E/V* Nautilus.





The eight-day cruise, which was funded by NOAA's Ocean Exploration Cooperative Institute, provided a chance to show the lay public how these partially-autonomous tools are helping scientists explore new hypotheses about the ocean twilight zone.

For this cruise, the OTZ team outfitted *Mesobot* with a highly-sensitive radiometer and a high-volume environmental DNA (eDNA) sampler, two instruments that work together to study how life in the zone is governed by its daily cycles of light and dark. While at sea, OTZ scientists and engineers Dana Yoerger, Molly Curran, Allan Adams, and Annette Govindarajan also participated in a live video event that was streamed directly to Youtube and Facebook, bringing a detailed explanation of *Mesobot*—and the instruments it carries—to audiences worldwide.

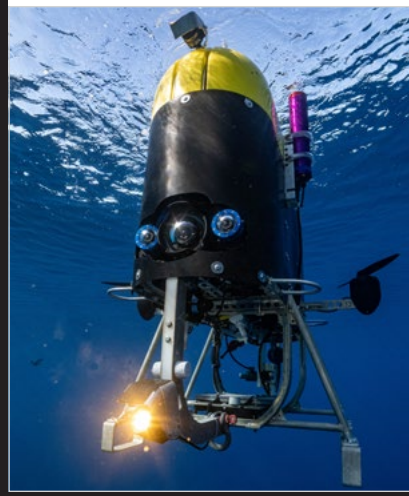
Images taken aboard the E/V Nautilus cruise in September 2021. Copyright Ocean Exploration Trust.

Engagement by the numbers

TOP ENGAGEMENT FOR THIRD QUARTER

FEATURED VIDEO

TOP MEDIA STORY: MESOBOT IN 'SCIENCE ROBOTICS'



20
DIFFERENT MEDIA PUBLICATIONS

With a potential reach of more than

50
MILLION

WIRED
A Clever Robot Spies on Creatures in the Ocean's 'Twilight Zone' *(13 million reach)*

Newsweek
Robot Dives 3,000 Feet to Film Creatures in Mid-Ocean 'Twilight Zone' *(22 million reach)*

Other outlets include **Science Magazine, PBS News, ECO News,** and more.

FEATURED EVENT

VIRTUAL EVENT ILLUMINATING THE ABYSS

September 21, 2021

PANELIST JAMES CAMERON | PANELIST RAY DALIO | PANELIST PETER DE MENOCAL | PANELIST EDITH WIDDER | HOST TATIANA SCHLOSSBERG

4,100
REGISTRATIONS

2,050
LIVE VIEWERS

The New York Times
Dancers From the Deep Sea Shine on the U.N. for Climate Week

5.5
MILLION REACH

Spotlight on *Annette Govindarajan*

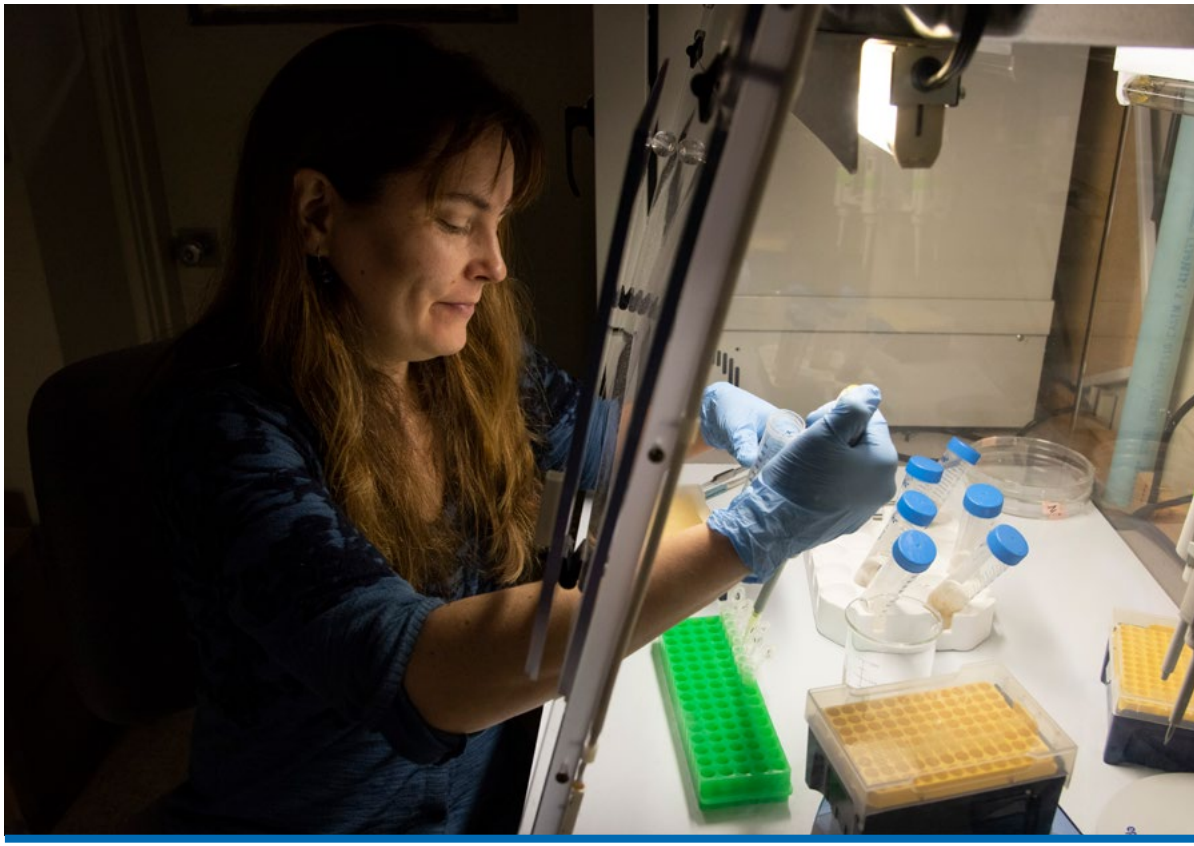
Animals in the ocean twilight zone play an important role in regulating global climate—yet studying those animals is a major challenge.

Many of them, like jellyfish and salps, have fragile bodies that break into pieces when caught in sampling nets. Others are simply too nimble to be caught by the lumbering nets, and so are rarely brought to the surface.

Annette Govindarajan is developing new methods to identify those animals, catalog their species, and study their behavior. As a biological oceanographer, she examines the biodiversity, ecology and evolution of marine animals using environmental DNA (or "eDNA"), which is made up of genetic material that animals naturally shed into seawater. By analyzing those genes, she and her lab can extract a trove of information from a few water samples—all without ever actually needing to see an animal firsthand.

"The beauty of eDNA is that you don't need to take genetic samples from specimens. Only seawater," she says. Once those samples are in the lab, she adds, they can shed light on not only which animals are in the twilight zone, but exactly where and when they travel. That information is essential for understanding the massive vertical migration that takes place from the zone each night, when trillions of animals move to the surface to feed. "By using eDNA, we hope to get a more comprehensive picture of what's down there," she says, "It's a new tool in our toolkit, and it nicely complements the other methods we're using."

twilightzone.whoi.edu/spotlight-annette-govindarajan



DNA detective–Genetic material in seawater provides WHOI biologist Annette Govindarajan with clues to investigate species in the ocean twilight zone. Tom Kleindinst © WHOI

twilightzone.whoi.edu

THE OCEAN TWILIGHT ZONE PROJECT is embarking on a journey to explore and understand one of our planet's last great frontiers—the ocean twilight zone. Our project combines exacting science, innovative technology, and broad engagement to turn knowledge into actions that improve understanding of our planet and how to live sustainably on it.

Contact:
Phil Renaud, Program Manager
prenaud@whoi.edu
508.289.2216

RIGHT: Students and postdocs prepare equipment aboard the R/V Armstrong for the OTZ Observation network. Daniel Hentz © WHOI