OCEAN TWILIGHT ZONE

WOODS HOLE OCEANOGRAPHIC INSTITUTION

2022 Q3 REPORT

Introduction

FOR THE PAST FOUR YEARS, WHOI'S OCEAN TWILIGHT ZONE (OTZ) PROJECT HAS UNDERTAKEN AN INTERDISCIPLINARY, COMPREHENSIVE STUDY OF ONE OF OUR PLANET'S FINAL FRONTIERS: THE OCEAN TWILIGHT ZONE. This vast, dark swath of the world's oceans is rich in biodiversity and plays a critical role in global climate–yet the gaps in scientific knowledge of the zone's inner workings are still immense.

This quarter, the team officially launched into phase III of the project. The guiding theme of this final two-year phase of the OTZ project, which started July 1, 2022, is "Application, Synthesis, and Impact": in other words, applying previous data, information, knowledge, and technological development to our primary scientific goals; synthesizing the OTZ project's vast data and knowledge repositories, and exerting maximum effort toward shaping international ocean policy development and solving climate-related challenges.

To that end, researchers embarked on a multi-ship, fully integrated research cruise in August 2022. The cruise involved all the project's principal investigators and labs, all specialized technologies developed to date and an interdisciplinary approach focused on the team's central scientific question: **What is the role of diel vertical migration (DVM) on food webs and carbon sequestration, and what might be the consequences of disrupting it?**

The sheer amount of data collected on this cruise outpaces almost every other field expedition the team has conducted to date, meaning that OTZ scientists will be able to spend the remainder of the project analyzing their samples and extracting new information about the twilight zone.

On this three-vessel field effort this past August, the OTZ team deployed every tool in its arsenal, from tried and true trawl nets to the incredibly high-tech Mesobot (pictured above), often at the same time. The complementary datasets these instruments collected will provide unprecedented insight into diel vertical migration, the massive movement of organisms from the zone to the surface and back again–and how that migration can affect global climate. Photo by Taylor Crockford © Woods Hole Oceanographic Institution

3rd Quarter *at a glance*

OTZ engineer Kaitlyn Tradd (right) helps to recover TZEX while aboard the R/V *Endeavor* in August 2022. The instrument features a new rotating marine snow sampler that Tradd designed. © Woods Hole Oceanographic Insitutution

- The OTZ project was officially endorsed by the U.N. Decade of Ocean Science for Sustainable Development, giving our team a bigger platform and broader opportunities to collaborate with international colleagues. This designation will help the team more effectively unravel the twilight zone's biggest mysteries.
- OTZ researchers embarked on a two-week, multi-ship cruise in the northwest Atlantic, studying the twilight zone with dozens of different instruments and robotic vehicles.
- Simon Thorrold's lab continues to develop ROAM tag technologies, which are used to track the movement of apex predators in three dimensions through the twilight zone. He has also begun the process of adding satellite data connectivity to the tags, which will send data back to scientists remotely instead of needing to find and recover the tiny devices themselves.
- Annette Govindarajan's lab published a paper in the journal *Deep Sea Research* documenting their new in-situ eDNA studies and analysis techniques. These advances have already revealed the presence of species that scientists have yet to capture or observe in the twilight zone, providing detail on the zone's biodiversity that would otherwise be impossible to obtain.
- In a paper published in the journal *Natural Resource Modeling*, OTZ economists Di Jin and Melina Kourantidou found that it may be possible to sustainably harvest fish in the zone without harming its ability to move carbon into the deep ocean.
- Ken Buessler and OTZ policy advisor Kilaparti Ramakrishna attended the UN Ocean Conference in Lisbon, Portugal in June 2022, where Buessler presented research on the movement of carbon through the twilight zone. At the same meeting, WHOI President Peter de Menocal also announced the Ocean Vital Signs Network, an outgrowth of the OTZ project's existing observation network.

OTZ endorsed by U.N.

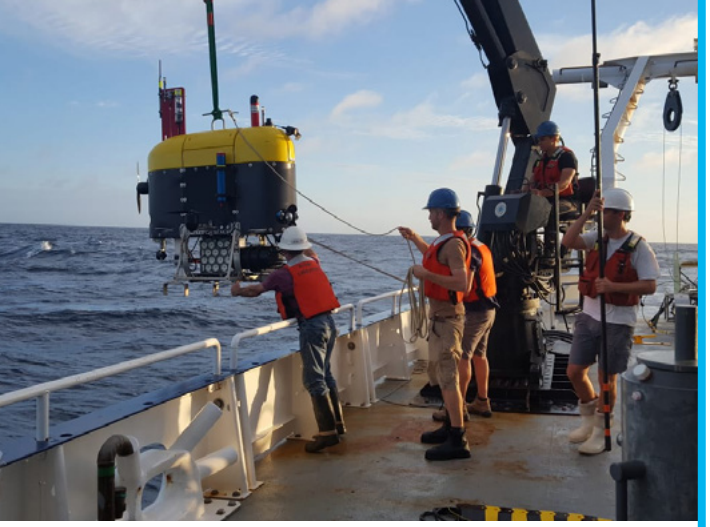
It's official: as of June 2022, the OTZ Project has been formally endorsed by the U.N. Decade of Ocean Science for Sustainable Development—a designation that will give our scientists a greater global platform and wider opportunities to collaborate, improving their ability to answer the twilight zone's biggest mysteries.

As our team gains a deeper scientific understanding of the twilight zone, we will use that information to inform government leaders and decision makers—and inspire policy that protects the zone while still harnessing its resources to address global climate change and food insecurity.

To that end, members of the OTZ team traveled to Lisbon, Portugal for the 2022 United Nations Ocean Conference, where senior scientist Ken Buesslerpresented insights on how the ocean twilight zone moves vast quantities of carbon from the atmosphere to the deep, where it can remain hidden away for hundreds to thousands of years. The conference, co-hosted by the Governments of Kenya and Portugal, is propelling innovative and much-needed science-based solutions that usher in a new chapter of global ocean action.

"WHOI's mission is to advance knowledge of the ocean and its connection to all life on Earth and to apply this knowledge to problems facing society," said WHOI President and Director Peter de Menocal. "The themes and objectives of the UN Decade of Ocean Science are tailor-made for scientists, engineers, and technicians at WHOI to advance the state of our knowledge in ways that will ensure a long-term, sustainable path for society and a thriving, healthy ocean. For the coming decade and beyond, our goal is to make the ocean more transparent and to turn what we learn into meaningful, actionable information available to all."

Marine chemist Ken Buessler presents work conducted by the OTZ team at the U.N. Oceans Conference in Lisbon, Portugal. Photo by Ken Kostel © Woods Hole Oceanographic Insitutution



Multi-ship cruise completed

Over the past quarter, OTZ scientists conducted a 'grand experiment' at sea, integrating all of the various technologies and data collection methods developed to date through this audacious project. In August 2022, the team set out on an unprecedented multi-ship field expedition, sailing on two different research ships (NOAA Ship *Henry B. Bigelow* and R/V *Endeavor*) and a commercial longline fishing vessel (F/V *Monica*). This historic research mission took place in the project's primary study area of the Northwest Atlantic Ocean within the boundaries of the newly established Ocean Twilight Zone Observation Network.

Each ship served a different yet complementary purpose on this voyage. Aboard the *Monica*, Simon Thorrold's team captured and tagged apex predators like sharks and swordfish, which dive into deep water to feed, generating data that will help the OTZ team understand both the predators' behavior in the twilight zone and their role in the zone's food webs. The activity of the tagged predators also informed sampling strategy while the cruise was underway.

The *Bigelow* characterized migrating fish and other organisms, both by capturing them in traditional nets and viewing them using acoustic signals from the *Deep-See* towed vehicle. On the *Endeavor*, scientists measured the movement of carbon through the twilight zone, collected images of gelatinous animals, gathered environmental DNA for analysis, and repeatedly deployed *Mesobot* to capture acoustic data, light data, video footage and still images. All the data collected by each vessel will be coordinated and cross-referenced with data collected from the other vessels.

While each of these different activities is exciting in its own right, the combination of all this research on one mission is truly groundbreaking. Taken together, the multiple overlapping data sets that scientists gathered on this expedition will help fill wide gaps in knowledge, providing a previously unattainable level of detail on the twilight zone as the researchers analyze the data over the next two years.

Mesobot is lowered over the side of the R/V *Endeavor*. This powerful imaging robot captures video of gelatinous animals as well as eDNA samples from the water column. Photo by Taylor Crockford,

MOCNESS awaits its first deployment. This high-tech tow net allows researchers to match what is found in nets at specific intervals with discrete properties of water at those depths. Photo by Andrea Vale.

The crew and science team of the R/V *Endeavor* team safely recover a CTD as waves crash over the gunwhales of the ship. Photo by Taylor Crockford,

Highlights from the August 2022 Expedition

13
PREDATORS TAGGED
2 blue sharks,
4 swordfish,
6 tuna, 1 marlin

80
HOURS DEEP-SEE DEPLOYED

450
KILOMETERS TRAVELED BY STINGRAY SLED
390 horizontally,
70 vertically

7
MOCNESS DEPLOYMENTS

4
TZEX DEPLOYMENTS

1
MESOBOT SHARK ENCOUNTER
During an August 2022 autonomous dive, *Mesobot* encounters a curious Mako Shark, captured here on the vehicle's black-and-white cameras.

192
eDNA SAMPLES COLLECTED

5
AUTONOMOUS MESOBOT DIVES
A new record dive: 21 hours

An OTZ team member cups four myctophids, two hatchet fish and a sawtooth eel in her hand. Myctophids, or lanternfish, sport bioluminescent lights on their underbellies, creating counterillumination that helps them blend in against the relatively sunlit surface above.

A viperfish, a common name for species in the genus Chauliodus. The viperfish's ventral sides are covered in tiny spots called photophores, which let them camouflage themselves in the murky light that penetrates the Ocean Twilight Zone. (Photos by Andrea Vale © Woods Hole Oceanographic Institution_

WHOI Postdoctoral scholar Wokil Bam stands tall next to a large bottom tethered trap on the stern of R/V *Neil Armstrong*. The trap will collect falling organic materials in the twilight zone to better understand how this layer helps the ocean sequester atmospheric carbon. (Photo by Daniel Hentz © Woods Hole Oceanographic Institution)

Following the carbon

WHEN IT COMES TO CLIMATE, THE OCEAN PLAYS A MASSIVE ROLE. Every year, it absorbs about one quarter of all human-emitted carbon dioxide (CO_2) from the atmosphere into its surface waters, where it can slowly descend into the deep and remain there for hundreds or thousands of years. This carbon-absorbing superpower helps regulate global climate and provides food for billions of marine organisms.

As CO_2 emissions in the atmosphere continue to rise, however, it will be critical to know exactly how much carbon sinks to the sea floor, how long it stays there, and how ocean acidification and warming affect that carbon storage capacity. These findings will help policymakers put a value on ocean conservation, and will help researchers make more accurate predictions about our future climate.

To meet that need, OTZ Project researchers pulled out all the stops on their August 2022 expedition. After deploying the team's entire arsenal of scientific instruments from two research vessels, they've collected more data than any previous OTZ research cruise. While it will take years to thoroughly analyze, Ken Buessler and his colleagues have already found active "carbon recycling hotspots" within the twilight zone by comparing acoustic signals, water samples, images of zooplankton, and nets full of sediment and fecal matter.

"Once you get past the upper 100 meters of the twilight zone, we see a big loss of marine snow, but around 300 meters below that, there's another active layer with more particles. The fact that it's disappearing from the upper layer means someone's eating it, which makes sense, because it's the freshest, most juicy stuff," says Buesseler, a marine chemist and member of the OTZ science team. As those animals eat, he adds, they also poop, which sends an additional wave of marine snow further down into the twilight zone at 300 meters—providing a major source of food for animals in deeper waters, he says. "Mother Nature is very efficient—you put food out and animals will come eat it and grow."

Spotlight on *Ciara Willis*

Ciara Willis, a PhD candidate in the MIT-WHOI Joint Program, studies not just biological oceanography, but policy as well—namely, how governments across the globe communicate and work together to manage shared marine spaces and fisheries. In this mini-interview conducted on NOAA Ship Bigelow, *she shared her unique perspective and experience.*

WHAT'S UNIQUE ABOUT THIS PARTICULAR CRUISE?

The OTZ team has developed all this technology to study the twilight zone, but we've never had the opportunity to use it all in one place and time. The data we'll get from each device or vehicle kind of complements the others, so we should end up with a massive amount of information about what happens in the zone during diel vertical migration. That's really important. It means we'll have much better understanding of what species live there, how they help move carbon into the deep ocean, how they fit into the food web—and pretty much all of the other questions we've been trying to answer for the past few years

WHAT DO YOU WANT PEOPLE TO UNDERSTAND ABOUT THE OCEAN TWILIGHT ZONE?

We are more connected to it than we realize! The twilight zone provides many important ecosystem services, such as acting as an important food source for commercially fished species like tuna and swordfish, and exporting carbon to the deep ocean.

HOW COULD YOUR WORK HELP TO PROTECT THE TWILIGHT ZONE IN THE FUTURE?

I'm very much a biologist and an ecologist, but I have a strong interest in fisheries management and policy. I try to always tie that theme into my work—whatever I do, it has to generate data that's useful for making policy decisions. In this case, we're figuring out what happens if you fish one group of species in the zone: does that impact its predators, and vice versa? That's currently one of the big dark holes in our understanding. The twilight zone is a relatively new frontier for fisheries, so it's really important that we don't just go blindly into that harvest, and that we first establish some foundational science on its ecosystem. The data we're getting from this cruise will help us do that.

WHAT DO YOU THINK IS THE MOST FULFILLING PART OF DOING SCIENCE AT SEA?

One of my favorite things about my job is getting out onto the ocean. I've been on nine cruises so far, on Canadian, American, German, and Norwegian vessels, for a total of about 20 weeks at sea. The sense of teamwork and collaboration on a research ship is always incredibly strong, and is a great reminder that you're part of a larger community of scientists trying to answer big questions about the oceans. It can make long nights of collecting and processing samples feel really satisfying. On this particular cruise, I was also able to help collect fish samples from the twilight zone for the first time, and it was really exciting for me to see those animals in person when we pulled up our nets.

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 our understanding of our planet and how to live sustainably on it.

CONTACT
Phil Renaud, Program Manager
prenaud@whoi.edu
508.289.2216
twilightzone.whoi.edu

Front: benthic shrimp. Back: copepod. Photos by Paul Caiger.