# OCEAN TWILIGHT ZONE

WOODS HOLE OCEANOGRAPHIC INSTITUTION

## 2022 Q1 REPORT

# Introduction

**DESPITE BEING THOUSANDS OF FEET BELOW THE OCEAN'S SURFACE, THE TWILIGHT ZONE HAS A MASSIVE IMPACT ON GLOBAL CLIMATE.** Each year, the twilight zone shuttles up to 6 billion metric tons of carbon from shallow waters into the deep ocean–an amount roughly equivalent to twice the annual emissions of every car and truck on the planet.

Animals living in the twilight zone play a critical role in this process. Every night, trillions of organisms travel up to the ocean's surface to feed, then return to the deep before dawn with carbon-rich food inside them. In doing so, those animals transfer carbon out of the upper ocean and into deeper waters, where it can remain hidden away for hundreds to thousands of years.

Exactly how much carbon moves as a result of this process isn't yet clear, but a better understanding of the species of fish that are migrating–and what they're eating along the way–will help bring us closer to that goal. Our team is now piecing together the variety of ways that migration affects the twilight zone's food web, its role in transporting carbon, and its impact on the ecosystem's overall biodiversity. By digging deeply into these processes, OTZ scientists are starting to piece together a better picture of the ways that carbon moves through the twilight zone, and by extension, the ways it impacts global climate.

**BELOW: Artist rendering of the vertical migration. Natalie Renier © WHOI COVER: Atolla jellyfish specimen recovered during the 2021 EXPORTS expedition. Marley Parker © WHOI**

# 1st Quarter at a glance

**SIMON THORROLD'S LAB OBTAINED A SECOND BATCH OF DATA FROM A PROTOTYPE ROAM TAG** affixed to an autonomous ocean glider, letting researchers determine the range and effectiveness of the tags and test their future role as part of WHOI's new Ocean Twilight Zone Observation Network.

**JOEL LLOPIZ AND ANN BUCKLIN HAVE NEARLY FINISHED A MANUSCRIPT DESCRIBING THEIR WORK ON FISH GUT CONTENTS.** The pair analyzed those samples both visually (Llopiz) and via DNA barcoding (Bucklin), providing complementary data on twilight zone animals' feeding habits.

**THE BUESSLER, SOSIK, AND LLOPIZ LABS HAVE CONTINUED ANALYZING DATA FROM THE 2021 EXPORTS CRUISE,** providing early results on marine snow rates, primary production of phytoplankton, and animal respiration in the northeastern Atlantic. These findings will help provide a deeper understanding of how carbon moves through the twilight zone as a whole.

**THE OTZ TEAM SUCCESSFULLY RETRIEVED A BIO-ACOUSTIC MOORING** giving a first of its kind, seven-month time-series of daily vertical migration. The acoustic time-series data showed a significant increase in biomass as an eddy transited by the mooring location.

**OUR NEWLY-RELEASED REPORT, "THE OCEAN TWILIGHT ZONE'S ROLE IN CLIMATE CHANGE",** earned coverage from *PBS News Hour*, *Inside Climate News*, and *Eco Magazine*. The report was also shared widely with policymakers at the French One Ocean Summit and UN Environment Assembly in Nairobi this year.

The R/V *Sarmiento de Gamboa* (bottom), the *RSS James Cook* (middle), and the *RSS Discovery* (top) rendezvous in the northeastern Atlantic during the 2021 EXPORTS expedition. Marley Parker © WHOI

# It takes guts

**FOR ANN BUCKLIN AND JOEL LLOPIZ, FISH GUTS ARE LIKE GOLD.** Together, the two researchers are employing a few different methods to figure out the stomach contents of twilight zone fish, determining what they're eating when they migrate to the ocean's surface waters each night.

After catching midwater fish using a net, Llopiz's team dissects the animals' stomachs and takes a careful visual tally of the prey inside. At the same time, Bucklin analyzes the collective DNA of the sample, creating a list of the individual species that are present—including species that can't otherwise be identified visually, like chewed-up gelatinous animals.

The pair's complementary work, which is slated to be published in the late spring, is revealing both the twilight zone's complex food web and its role in moving carbon through the world's oceans. By understanding what each animal eats and how fast that food passes through its digestive system, this work is helping to determine how carbon contained in prey moves through the twilight zone.

RIGHT: An OTZ team member examines the stomach contents of a freshly-caught fangtooth. Helena McMonagle © WHOI

# Breathe easy

**FIGURING OUT HOW MUCH CARBON MOVES THROUGH THE OCEAN TWILIGHT ZONE IS A MAJOR CHALLENGE.** It involves not only recording the biomass—the total amount of life by weight—but how that life interacts, and even how it "breathes" in the water. Like humans breathing in air, fish and zooplankton take oxygen from the water into their bodies and release carbon dioxide back into the ocean. OTZ scientists Helena McMonagle and Joel Llopiz are measuring animals' respiration rates, creating data that can be used in a comprehensive model of carbon flow in the midwater.

While aboard the 2021 EXPORTs cruise in the northeastern Atlantic, McMonagle placed individual live fish caught via net tows into a sealed chamber of seawater. She then measured how oxygen levels in the chamber dipped over time, letting her calculate how much $CO_2$ the animal could add to its environment through respiration. This research offers another piece in the puzzle of how carbon changes at various points in the twilight zone.

"Respiration rate is just one of maybe 40 values in a model of how carbon moves through the twilight zone," she says. "Ultimately, you want to be able to calculate how much carbon each organism is transporting below a certain depth each day—so it's important to figure out whether respiration has any major impact on that process."

INSET: Helena McMonagle prepares fish samples from the twilight zone for study. Kathryn Baltes © WHOI. BACKGROUND: By measuring the respiration rates of lanternfish, McMonagle is creating valuable data about how carbon moves through the twilight zone. Paul Caiger © WHOI.

# Spotlight on *Joel Llopiz*

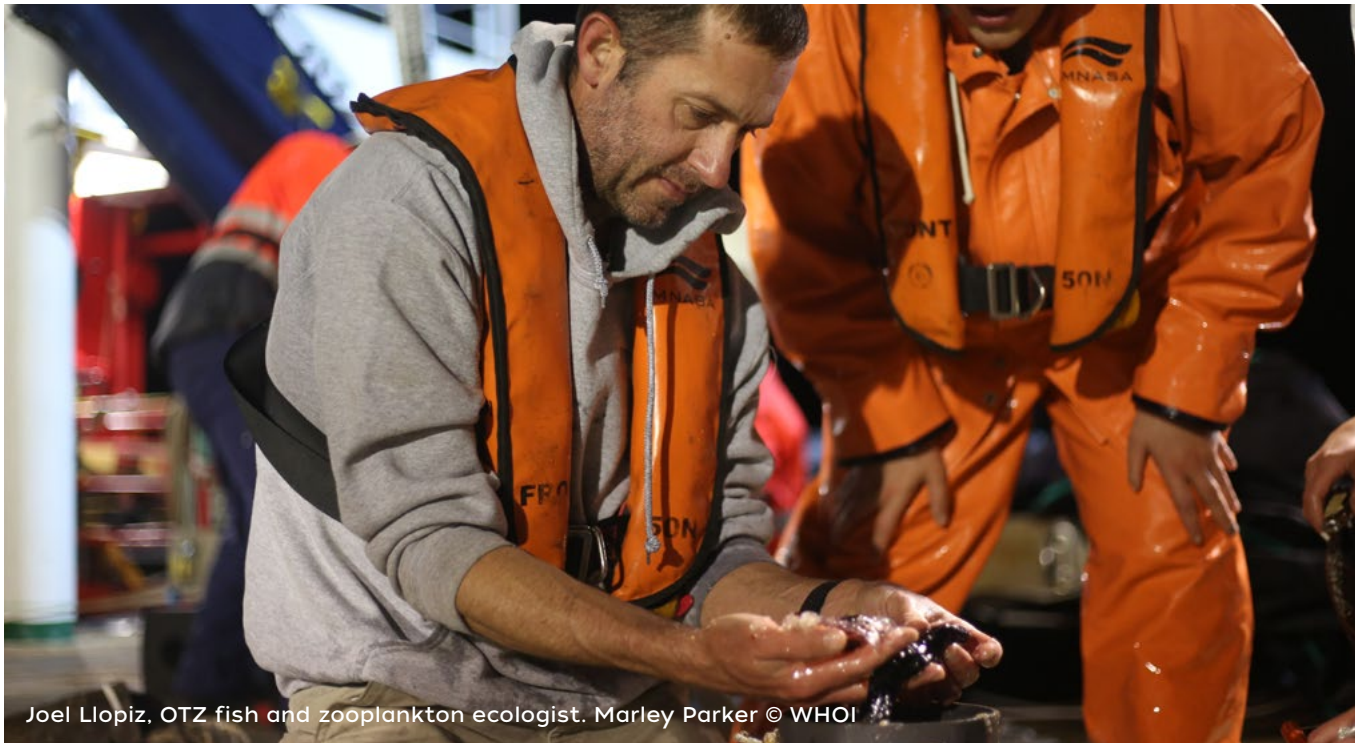
*The OTZ fish and zooplankton ecologist exploring the twilight zone to answer long-standing questions about its inner workings.*

**THE TWILIGHT ZONE IS HOME TO MORE FISH THAN ANY OTHER PART OF THE OCEAN.** Upper estimates of twilight zone fish biomass are roughly 10 billion metric tons, or about 50 times the amount of wild caught and farm-raised fish harvested each year, yet scientists still don't understand the exact ways those animals live, interact and feed on each other.

Joel Llopiz is exploring the twilight zone to answer long-standing questions about its inner workings. Llopiz, a marine ecologist with the OTZ project, studies fish living in the twilight zone. In order to chip away at understanding this important ecosystem, he says, it's essential to figure out which species are there and how they live their lives. It's a tall order.

"There are a lot of biological and ecological questions that people have answered for coastal species, but we don't know the answers to those same questions for twilight zone fish," Llopiz says. "Even basic stuff hasn't yet been studied: What age do they mature? How many eggs are released by the females? How connected are different regions of the ocean in terms of the movement of the fish in the ocean due to surface currents or swimming? We just don't know."

To find out, Llopiz and his lab are collecting twilight zone fish at sea using net tows, and are dissecting those individuals to learn more about them. By looking at the fishes' gonads, stomach contents, and otoliths (ear stones that can be used to age the fish) his team is gaining valuable insight on the life histories of twilight zone fish and is ultimately helping reveal the role these fish play in moving carbon through the deep ocean and how a sustainable fishery could potentially be developed.



Joel Llopiz, OTZ fish and zooplankton ecologist. Marley Parker © WHOI

"The Twilight Zone has a huge impact on global climate. The upper ocean takes in carbon from the atmosphere, and that carbon can slowly move down through the twilight zone to the bottom. We think it does that more efficiently or more quickly because of the fish and other organisms living there," he says. "In order to understand that process, we'll need to learn more about the organisms themselves."

# 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.

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