



2019 Q4 REPORT

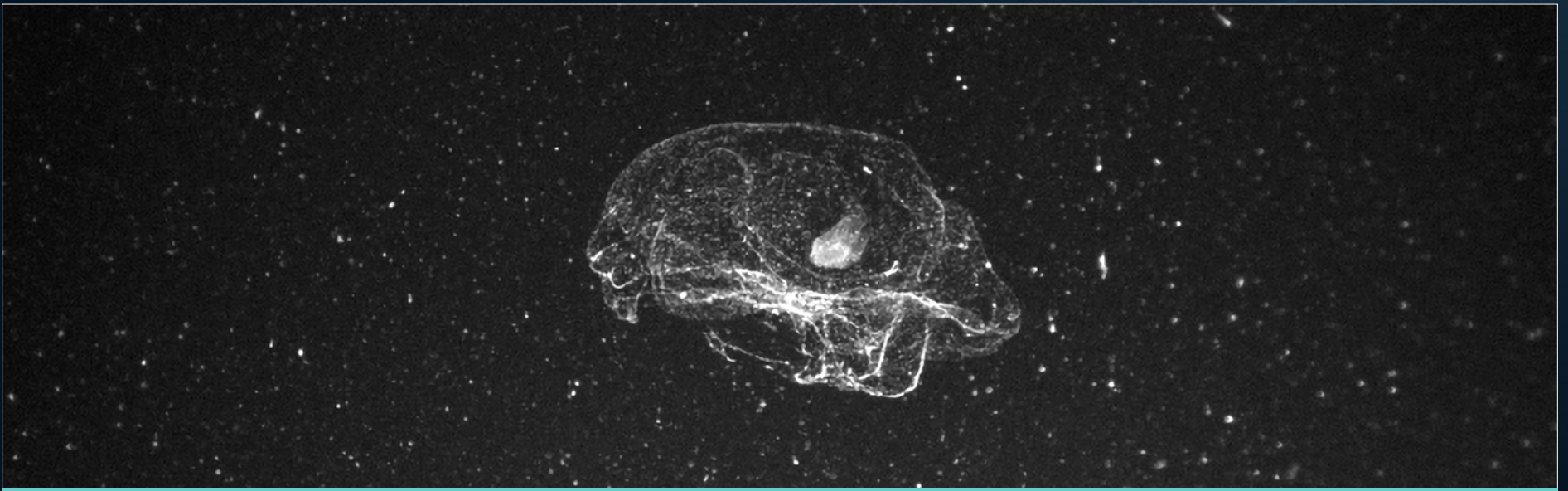
An Audacious Project

LONG-DISTANCE RACES REQUIRE A MIX OF CAREFUL PACING AND AUDACIOUS BURSTS OF SPEED, and we've seen both over the past quarter. *Mesobot* made great strides in October when it traveled to the West Coast for a critical test of its tracking system while the entire science team continued its meticulous work to analyze samples, process data, and prepare for three expeditions on the calendar in 2020. And we closed out this quarter by completing a milestone in our policy efforts—a report highlighting the economic value of the twilight zone using the idea of ecosystem services as a guiding principle.

Spotlight on Biodiversity

IN OUR QUARTERLY REPORTING, WE WILL BEGIN TO TURN OUR ATTENTION ON EACH OF THE SCIENCE THEMES IN TURN in order to more fully explain their importance and our rationale for making each a critical focal point in describing and understanding the twilight zone.

The first of these is biodiversity. Far more than cataloging weird and wonderful species—both new and known—that we encounter on our trips into the depths, the study of biodiversity in all its forms is one of the many ways in which we take stock of what is unique and important about this vital part of our planet.



2019 Q4 Highlights

In addition to continued, careful analysis of fish, gut contents, and eDNA samples, as well as acoustic and image data from 2019 expeditions, the OTZ team made strategic advances across our core scientific, technological, and engagement objectives.

- ▶ Ecosystem Services Report completed and released in time for the UN Decade of Ocean Science for Sustainable Development regional planning workshop in Halifax, Nova Scotia, January 7-10, 2020.
- ▶ Mesobot tracking test proved the system's ability to lock onto and follow mesopelagic animals for extended periods.
- ▶ With the new hire of research data scientist Ivan Lima, we have started to rapidly prototype applications for the Open Data Platform.
- ▶ Four new papers submitted or under revision paint a growing picture of the ecological and economic importance of the twilight zone.
- ▶ Tags placed on apex predators—two porbeagle sharks and four broadbill swordfish—are gathering data about the animals' interactions with the twilight zone.
- ▶ Completed semester-long market research and audience insight project with the Yale School of Management.



Spotlight on Biodiversity

Biodiversity is defined by the variation of life at all levels, from individual genes within a species to the number of different habitats available to organisms.

One of the scientific goals of WHOI's Ocean Twilight Zone project is to assess and measure the biodiversity of the mesopelagic as broadly as possible. We set this objective because life in the ocean, and on our planet as a whole, depends on biodiversity to ensure the health of the systems that make Earth livable and that provide us with a range of environmental, economic, and cultural benefits.

New technology gives us the ability to take a much fuller look at biodiversity in this relatively unexplored and undisturbed part of the ocean. By collecting and analyzing pieces of genetic material floating in the water (environmental DNA or eDNA), we now have the ability to evaluate the genetic diversity of organisms in the twilight zone. We also have newly developed, sensor-laden platforms such as Deep-See that give us an increasingly nuanced view of the structure of the mesopelagic and that enable us to identify distinct habitats within this seemingly featureless volume.

By combining these new approaches with traditional methods to identify individual species we collect, we now have a powerful toolkit to achieve our scientific goals. Even more important, we are making the broadest measures and gaining new insights into biodiversity in the twilight zone in order to better understand the health of this critical ecosystem, and of the ocean on which we all depend.



Another view of biodiversity. Photo by Erik Olsen, ©Woods Hole Oceanographic Institution

Mystery Solved

DNA BARCODING—IDENTIFYING ORGANISMS FROM SHORT, STANDARDIZED SEGMENTS OF GENETIC MATERIAL—HELPED SOLVE A MYSTERY FROM THE 2018 CRUISE ABOARD THE *HENRY B. BIGELOW*. An odd piece of tissue from a gelatinous animal brought to the surface by MOCNESS turned out, after analysis by Annette Govindarajan's team, to be a rare and poorly understood jelly, *Deepstaria*. There are two known species of *Deepstaria*—*D. enigmatica* and *D. reticulum*—with, until now, a total of only 10 published observations anywhere in the world.

These enigmatic deep-sea creatures resemble large, billowing plastic bags with a characteristic network of canals running through their tissue. WHOI biologist t Larry Madin co-discovered *D. reticulum* off Bermuda in 1988, and our finding is the northernmost record of *Deepstaria* in the Atlantic. "This discovery shows the power of DNA barcoding to not just identify a species and add to our knowledge of biodiversity of the twilight zone, but to expand on its natural history and tell us more about features like range," said Govindarajan.

Deepstaria reticulum 1,855 meters below the surface of Monterey Bay. ©2002 MBARI

New Report: Putting a value on the twilight zone

The twilight zone plays an important role in carbon sequestration and marine food webs, supporting the natural function of many planetary processes. But its value doesn't end with a measure of its ecological importance.

Ecosystem services—the many direct and indirect contributions that nature makes to human well-being, survival, and quality of life—provide a way to quantify the value of these ecosystem-based benefits and to more concretely define what we mean by “sustainable use.”

To highlight the economic value of the twilight zone, the OTZ team recently completed a report focusing on the ecosystem services provided by the mesopelagic and

released it in time to be part of a regional planning meeting for the Decade of Ocean Science for Sustainable Development in Halifax, Nova Scotia. With this information, we hope to inspire leaders and policy-makers to think more carefully about how human activity may affect the benefits we receive from the twilight zone, particularly as we strive for the sustainable, long-term use of marine resources for a growing population.

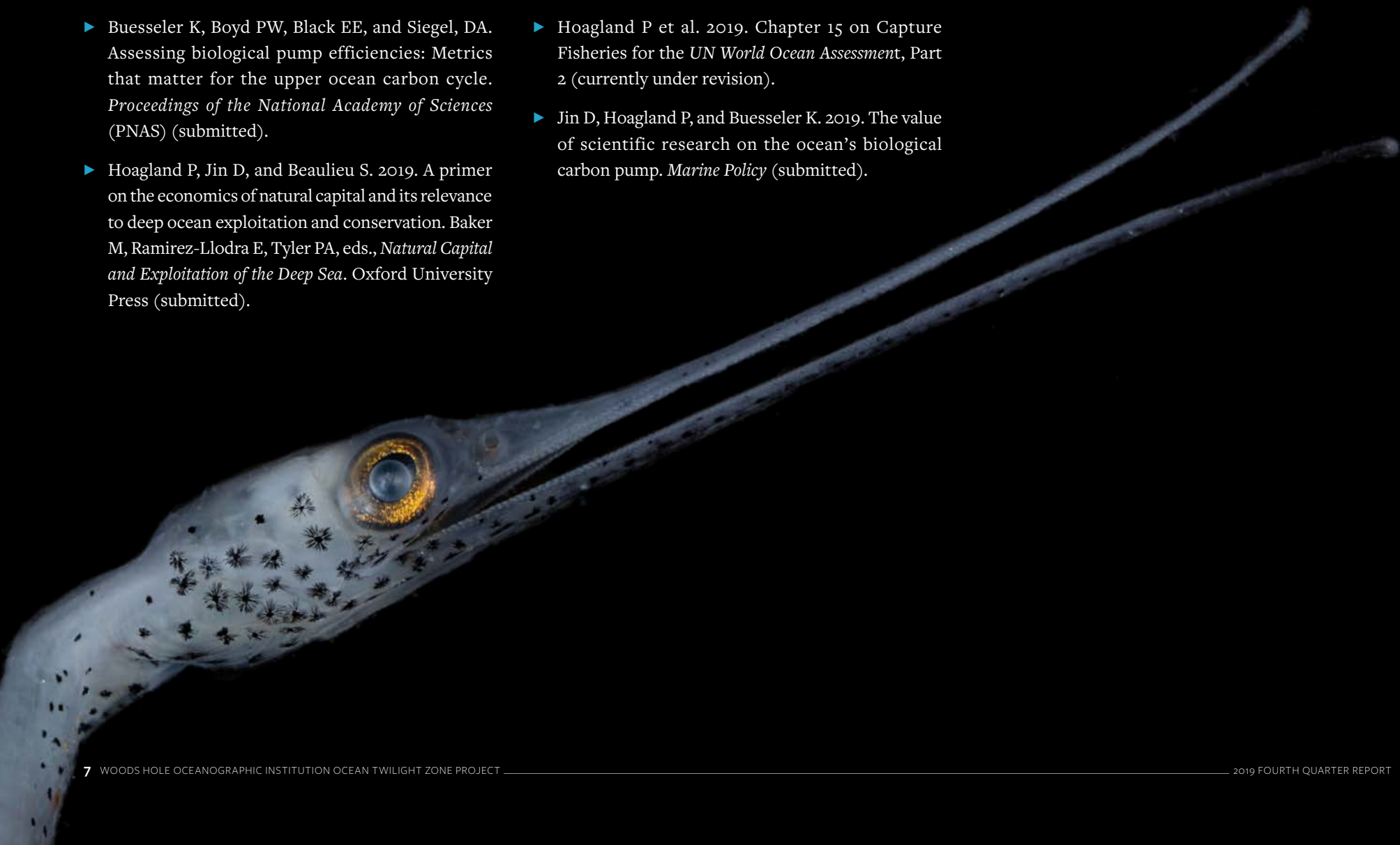


KEY TAKEAWAYS

- ▶ Biological processes in the twilight zone are responsible for sequestering 2 to 6 billion metric tons of carbon annually, with an estimated value of \$300 to \$900 billion annually.
- ▶ Without this service, atmospheric carbon dioxide levels could be as much as 200 ppm higher than they are today.
- ▶ The value of such a loss in sequestration service could amount to between \$170 billion and \$3 trillion in mitigation costs and \$23 to \$401 billion in adaptation costs by the end of the century.
- ▶ Reducing uncertainty in estimates of the amount of carbon sequestered in the ocean could have an economic value on the order of hundreds of billions of dollars.
- ▶ Twilight zone organisms support fisheries worldwide and are a potential source of protein to supply aquaculture operations.
- ▶ Greater understanding of the twilight zone provides nonmaterial benefits to society in the form of research activity, knowledge creation, and aesthetic value.

Academic Publications

- ▶ Buesseler K, Boyd PW, Black EE, and Siegel, DA. Assessing biological pump efficiencies: Metrics that matter for the upper ocean carbon cycle. *Proceedings of the National Academy of Sciences* (PNAS) (submitted).
- ▶ Hoagland P, Jin D, and Beaulieu S. 2019. A primer on the economics of natural capital and its relevance to deep ocean exploitation and conservation. Baker M, Ramirez-Llodra E, Tyler PA, eds., *Natural Capital and Exploitation of the Deep Sea*. Oxford University Press (submitted).
- ▶ Hoagland P et al. 2019. Chapter 15 on Capture Fisheries for the *UN World Ocean Assessment*, Part 2 (currently under revision).
- ▶ Jin D, Hoagland P, and Buesseler K. 2019. The value of scientific research on the ocean's biological carbon pump. *Marine Policy* (submitted).



Web, Earned Media, and Social Media

ALL DATA REPORTED FOR THE 12 MONTHS ENDING 12/31/2019

WEB

42 STORIES **24,500** TOTAL ENGAGEMENTS

EARNED MEDIA

115 STORIES WORLDWIDE **262,165,837** POTENTIAL REACH

TOP MEDIA 2019



120 million REACH

QUARTZ

TOP MEDIA Q4



5 million REACH

PHYS.ORG

SOCIAL MEDIA **315** TOTAL POSTS **3,4500,000** TOTAL IMPRESSIONS **227,398** TOTAL ENGAGEMENTS

127 POSTS

1.9 MILLION IMPRESSIONS

58,091 ENGAGEMENTS



126 TWEETS

1.4 MILLION IMPRESSIONS

14,772 ENGAGEMENTS



50 POSTS

111,346 ENGAGEMENTS



12 POSTS

43,189 IMPRESSIONS

1,895 ENGAGEMENTS



#12DAYSOFTWILIGHTZONE

A holiday-themed series of 12 posts across WHOI social channels leading up to Christmas Eve provided a lighthearted, engaging look at life in the twilight zone through the photos and videos of the OTZ team.

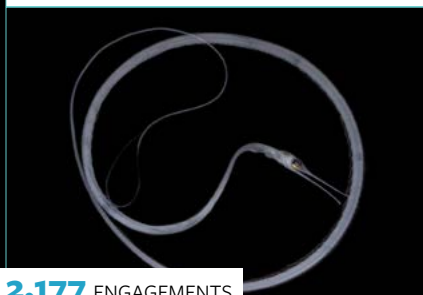
289,301 IMPRESSIONS

26,874 ENGAGEMENTS

TOP FACEBOOK POST

Woods Hole Oceanographic Institution (WHOI)
December 22, 2019 at 9:01 AM · 🌐

It could be easy to mistake this snipe eel for a simple piece of tinsel. But in fact it's another example of how remarkable life in the #OceanTwilightZone is. Snipe eels can grow up to 5 feet long and have nearly 750 vertebrae—the most of any animal on Earth. Photo by Paul Caiger #12DaysOfTwilightZone



2,177 ENGAGEMENTS

TOP TWEET

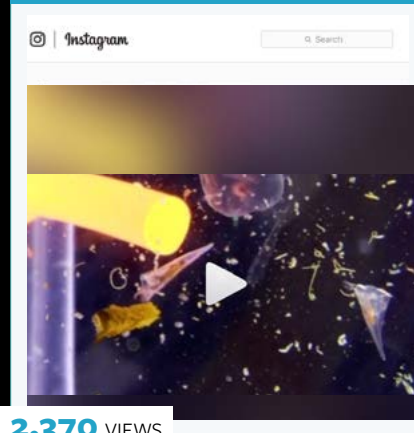
WHOI
Following

Looking for the gift no one has? How about an organic fiber optic lamp from the #OceanTwilightZone? When this Halicreas jelly was discovered in 1886, the scientists were hoping to shed "some light on the bathymetrical distribution of life."
#12DaysOfTwilightZone 📸 Larry Madin



141 REACTIONS

TOP INSTAGRAM POST



2,370 VIEWS

Making a Visual Impact



Photo by Erik Olsen, ©Woods Hole Oceanographic Institution

PAUL CAIGER is a fish biologist, underwater photographer, and postdoctoral investigator at WHOI. A New Zealand native, Caiger grew up SCUBA diving off the coast of the North Island and later pursued his PhD in marine biology at the University of Auckland.

He and his friends became intrigued by the great migration that occurs every day between the surface and the twilight zone and they began diving in the open ocean at night to see what bioluminescent animals from the depths they might encounter. Caiger soon turned his photographic talent into a central element of his professional career and many fans of the OTZ project have been enthralled by his detailed images of these nightly migrators and their stunningly diverse and photogenic adaptations to life at the edge of sunlight.

Through his lens, he has given that mysterious part of the ocean a face, or rather many faces, and helped drive home the fact that we share this planet with a stunningly diverse array of life.

[*Read more about Paul's work here.*](#)

Photo by Paul Caiger, ©Woods Hole Oceanographic Institution

The Ocean Twilight Zone Project is embarking on a journey to explore and understand one of our planet's hidden frontiers—the ocean twilight zone. Our project will combine 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.

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