INTO THE
POLAR NIGHT

ocean life abounds in a world devoid of sunlight

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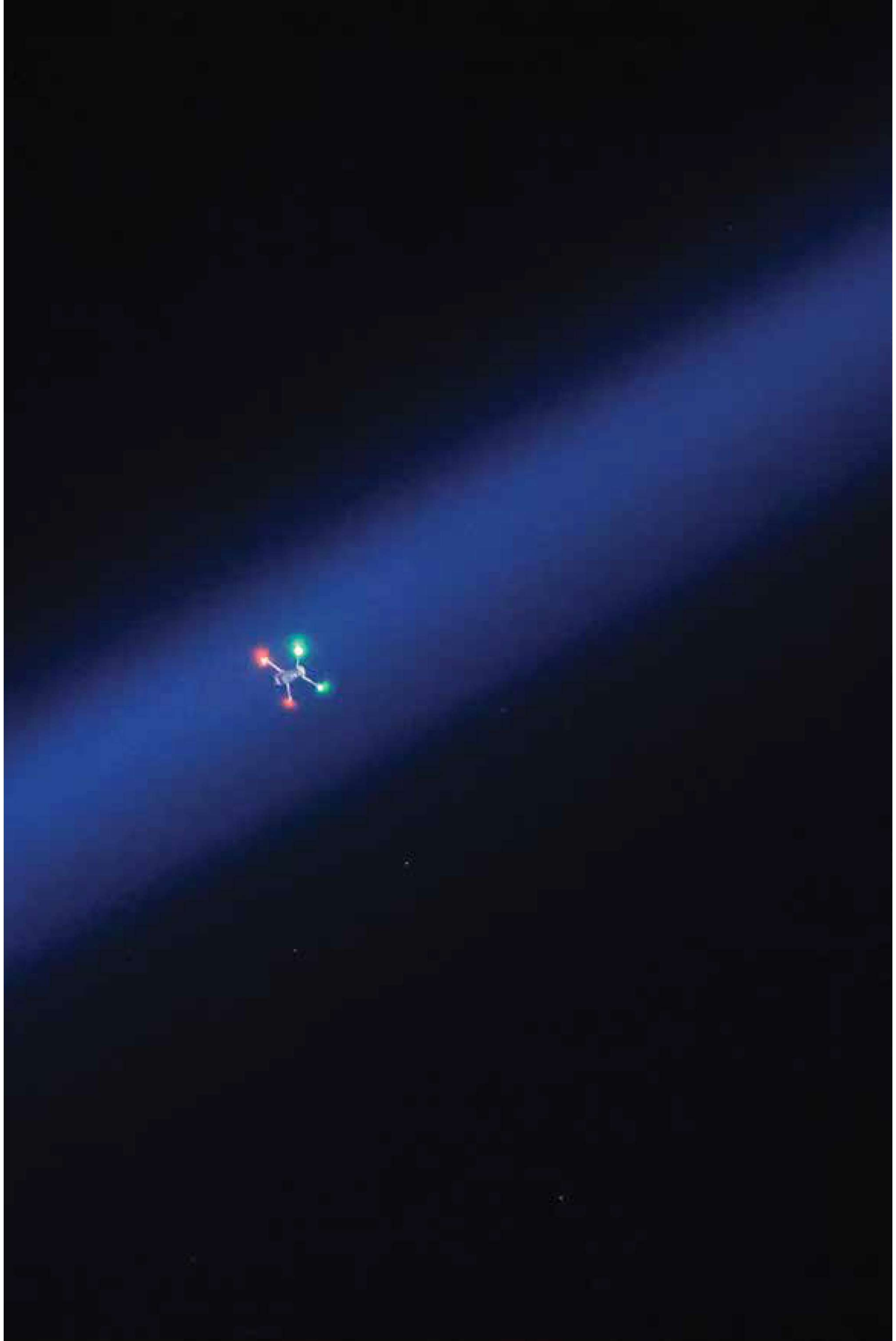

A ST. LOUIS, MISSOURI-BASED JOURNALIST AND PHOTOGRAPHER, RANDALL HYMAN HAS BEEN EMBEDDED WITH THE ARCTIC UNIVERSITY OF NORWAY'S DEEP IMPACT MISSION SINCE ITS LAUNCH IN 2020. HIS WRITINGS AND IMAGES HAVE APPEARED IN *THE ATLANTIC*, *SMITHSONIAN*, *FOREIGN AFFAIRS*, AND *NATURE*.

Somewhere in the vast Arctic darkness, an unmanned skiff named *Apherusa* is speeding toward our research vessel on a collision course. While a scientist and I launch a drone copter from our ship's icy bow, *Apherusa*'s skipper—nautical miles away—aims a GPS icon straight for our portside. It is a crucial test of the unmanned skiff's ability to collect data from the glowing waters around our research vessel.

As the drone whines above, *Apherusa*'s green navigation light suddenly materializes in the seas below. She swerves, narrowly missing our hull, only to disappear again into the night. While her sonar records zooplankton diving deep from our ship's glare, the drone copter photographs the watery halo of our ship's illumination for later analysis.

"My heart was racing," *Apherusa*'s pilot, Emily Venables, tells me that evening at the marine lab on Spitsbergen. "I was afraid I had crashed into the ship." Venables' job, and the research team's focus, was to measure how marine organisms react to human incursions of light in one of the darkest oceans on the planet at the darkest time of year.

In addition to *Apherusa,* their tools included a torpedo-shaped submersible and a variety of specially designed cameras, light meters, and sonar for exploring this frigid realm—a topsy-turvy world where deep-sea bioluminescent lantern fish bob near the surface and zooplankton maintain a circadian rhythm despite the lack of daylight.

OPENING SPREAD: THE RV *HELMER HANSSEN* SAILS THROUGH ICY WATERS DURING THE POLAR NIGHT RESEARCH CRUISE IN KONGSFJORDEN, SVALBARD ARCHIPELAGO, NORWAY. FACING PAGE: A QUADCOPTER HOVERS ABOVE THE RESEARCH SHIP.

Here, halfway between Norway and the North Pole, at a remote research station called Ny-Ålesund, scientists have discovered that darkness itself can be the basis of life, which affords tiny marine organisms a jump-start on reproduction before the returning sun kickstarts a madhouse of rebirth each spring.

They have also discovered that the very process of observing these creatures, fine-tuned as they are to darkness, alters their behavior by introducing artificial light. In a recent paper, the team showed that bright deck light scatters zooplankton and fish as deep as 200 meters, and that red lights, long considered benign, can be just as disruptive as white ones.

As sea ice vanishes, shipping routes and oil drilling rigs are expanding across the Arctic. Understanding how the region's tiniest marine organisms react to increasing light pollution is important, since oceans

generate much of the planet's oxygen—particularly during the polar spring when vast algal blooms supercharge the food chain. Svalbard, pristine and cloaked in darkness four months a year, is a perfect laboratory for gleaning such information.

UNRAVELING MARINE MYSTERIES

This was not my first trip with the team, led by marine ecologist Jørgen Berge of the University of Tromsø–The Arctic University of Norway. We had traveled together in 2016 during another of his annual winter expeditions. Scant years before that no one even bothered exploring the polar night's oceans.

For one, the region's fjords were often inaccessible, frozen solid. Rapid climate change now leaves many of those in Svalbard ice-free, even in winter. But, more importantly, organisms like algae, krill, amphipods, and copepods—the base of the food chain—were assumed to be in stasis throughout the polar night, moribund in the absence of sunlight and photosynthesis.

Then, in 2007, Berge retrieved moorings he had positioned in two Svalbard fjords the previous autumn to monitor the rebloom of life when sea ice thawed in spring. Upon reviewing the acoustic data, he noticed a mysterious daily signal of rising and falling biomass where none was thought to exist in the darkness of the polar night. Normally cued to sunlight, the discovery of plankton responding to invisible daylight rocked the world of polar marine biology.

PREVIOUS SPREAD: THE UNMANNED SURFACE VEHICLE (USV) *APHERUSA* CRUISES NEAR THE RV *HELMER HANSSEN* WITH AN ECHOSOUNDER TO MONITOR ZOOPLANKTON REACTION TO ARTIFICIAL LIGHT IN KONGSFJORDEN. FACING PAGE: SCIENTISTS AND DECK HANDS EMPTY SHRIMP COLLECTED IN TRAWL NETS ABOARD THE RESEARCH SHIP DURING A TRANSECT OF BILLEFJORDEN IN THE SVALBARD ARCHIPELAGO.

"It was like an accident, a complete surprise," Berge recalls.

Having discovered the presence of teeming life, he was in for another surprise: subsequent expeditions failed to detect the same amount of activity the moorings had shown. Several years later came another revelation, according to Berge's colleague, Maxime Geoffroy, of the Memorial University of Newfoundland in St. John's.

"What we were looking for at first was the physiology of these organisms in the pristine polar night, but we were removing the pristine part of it by coming with our big ship full of white lights," Geoffroy tells me.

This year's mission was to determine just how much human presence and bright lights impact circadian rhythms. To do so, we would be comparing marine samples collected during forays with lights out against those retrieved with deck lights glaring.

Having arrived with fish and zooplankton gleaned from three Svalbard fjords, and with a range of experiments scheduled over the coming week, the team filled darkened cold rooms in the Ny-Ålesund marine lab with trays and flasks of collected treasures.

In the week that followed, we focused on the responses of marine organisms to artificial versus natural light. Zooplankton were subjected to simulated moonlight and a bus-sized netted cage called "Azkaban" was submerged outside the marine lab, filled with two species of cod and armed with sonar for recording responses to the cyclical on-off glare of a spotlight.

One goal was to hone technology and techniques to establish acoustic profiles for individual species, minimizing the need for disruptive lights and optical confirmation.

PREVIOUS SPREAD: A COLLECTION NET IS DEPLOYED FROM THE RV *HELMER HANSSEN*. FACING PAGE: A *CTENOPHORE* GLOWS IN THE MARINE LAB AT NY-ÅLESUND—ITS LIGHT PRODUCED BY CTENES, EIGHT COMB-LIKE ROWS OF CILIA USED FOR LOCOMOTION.

"Last year we came not expecting it to work," explains Geoffroy's grad student, Muriel Dunn. "Azkaban was really more like a pilot, but it actually worked really well."

From a small hut on the icy wharf, she followed the cage's sonar signals on a laptop. As expected, the fish were migrating up and down in response to the spotlight, but for the first time distinct acoustic profiles for each species were clear. This is particularly useful information for fisheries managers since more southerly Atlantic cod are pushing northward, preying upon the Arctic's smaller, endemic polar cod.

The key to success, says Geoffroy, is the use of broadband rather than traditional sonar. "Instead of using a ping like in submarine movies, we use a chirp," he explains, demonstrating with a short birdlike whistle. "A wider range of frequencies increases vertical resolution, and we see within a few centimeters where the animals are in the water column. It's the Holy Grail of being able to identify just by using acoustics and not nets."

BEYOND THE LIMELIGHT

For scientists working aboard the ship, their mission is to "disappear." During lights-out sweeps, scientists work under ghostly red lights, deploying submersible experiments.

Beyond the darkened decks lays the vast, raw Arctic. On quiet, windless nights, sheets of emerald and lavender northern lights dance above barely visible snowy mountains.

These exquisite moments lure scientists back each year, despite frozen fingers, seasickness, and possibly worse. During lights-on operations collecting fish, *Helmer Hanssen* becomes a traditional trawler. Large nets and heavy cables drag across icy decks over massive rollers, threatening to snag careless seafarers and flip them down the stern's open trawl slide into black seas and churning propellers.

Storms were frequent during our voyage, but more than weather hindered our plans. At the start of our journey, engine trouble forced *Helmer Hanssen* back to mainland Norway and nearly canceled the entire cruise. One member was left ashore with covid. Working shoulder to shoulder in small labs and enduring Arctic chill aboard small boats, the team was threatened by rapidly spreading sore throats and coughs.

Computer bugs also plagued science instruments, including the remote-controlled submersible. Days of troubleshooting brought the system online just in time for its maiden voyage.

Running in tandem with *Apherusa,* the submersible's sonar matches its sister craft's, showing identical rise and fall of marine biomass as the pair threads their way past *Helmer Hanssen*'s lights-on, lights-off sweeps. According to Berge, it is a step toward someday using multiple autonomous vehicles to remotely record how artificial light disrupts various marine organisms.

The team also measured marine light pollution using a camera and suite of instruments armed with flashing lights and colored filters. A circular steel frame carries the array far below, measuring how far different wavelengths emanate at varying depths and what species are present.

"One way to know marine populations is to take net samples, but we're speeding up the process by putting a microscope directly in the ocean," says senior scientist Emlyn Davies, who has developed an underwater camera for identifying species based on silhouettes.

Understanding how marine populations react to the dimmest of light is equally important.

"Something allows the more Arctic species to make it through the winter," explains Maja Hatlebakk back on land as she inspects copepods illuminated by dim, eerie light in one of the dark cold rooms at the marine lab.

Several days and nights of babysitting her charges in an icy vault has worsened a nagging cough, and she describes her experiment in a whispery voice. "The southern species that come in with currents during summer, they can't make it through the winter here. We want to know why."

Last year, she and a colleague detected unusual RNA activity in *Calanus* copepods, piquing their interest. Their experiment this year simulated a shortened version of the Moon's odd cycle during the polar night—constantly above the horizon around full phase, and absent when less than half. "Our hypothesis," she says, "is that somehow some Arctic species utilize moonlight that other species can't." If Hatlebakk is right, her research will help scientists understand whether small changes in light from loss of pack ice and brightening seas could have big consequences in the Arctic.

As this year's work concludes and the land-based team begins packing up, *Helmer Hanssen*'s captain radios the marine lab to report that the on-board team has completed its final lights-out transects in another fjord. It is time to head home, but an approaching storm threatens to delay us by two days.

The next morning, a one-hour break in heavy winds allows the ship to dock, and the marine lab team scurries aboard as crates are loaded by crane. When winds suddenly worsen, we quickly push off. Sailing due south in rough seas, *Helmer Hanssen* beelines toward a faint glimmer of brightening sky on the horizon, a reminder of spring's fast approach and the teeming life already astir in the seas around us.

PREVIOUS SPREAD: THE AURORA BOREALIS DANCES ABOVE THE NY-ÅLESUND SCIENCE VILLAGE IN MID-JANUARY. FACING PAGE: RALPH STEVENSON-JONES OF SINTEF (THE FOUNDATION FOR INDUSTRIAL AND TECHNICAL RESEARCH AT THE NORWEGIAN INSTITUTE OF TECHNOLOGY) PROGRAMS AN INSTRUMENT SUITE FOR MEASURING MARINE LIGHT TRANSMISSION.