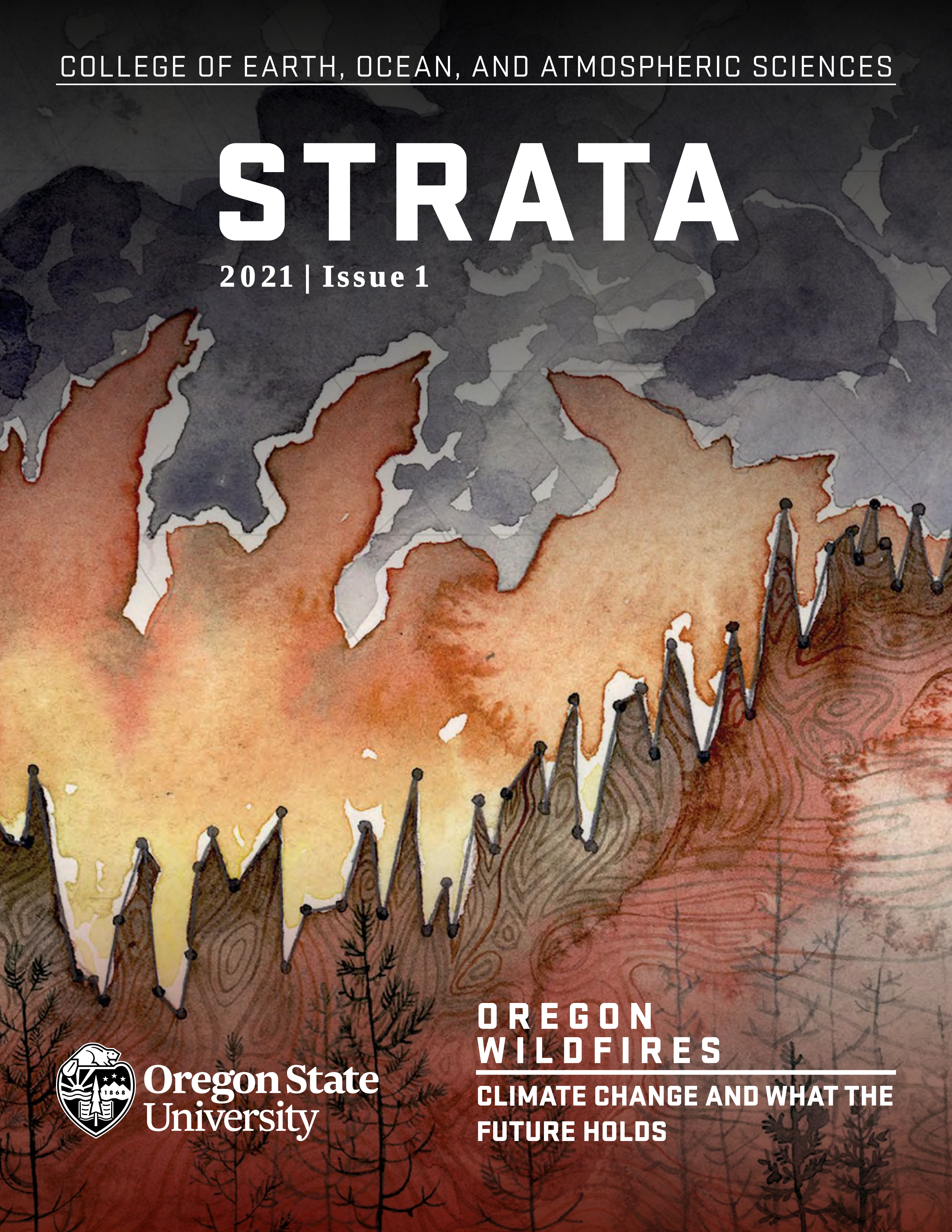
COLLEGE OF EARTH, OCEAN, AND ATMOSPHERIC SCIENCES

# STRATA

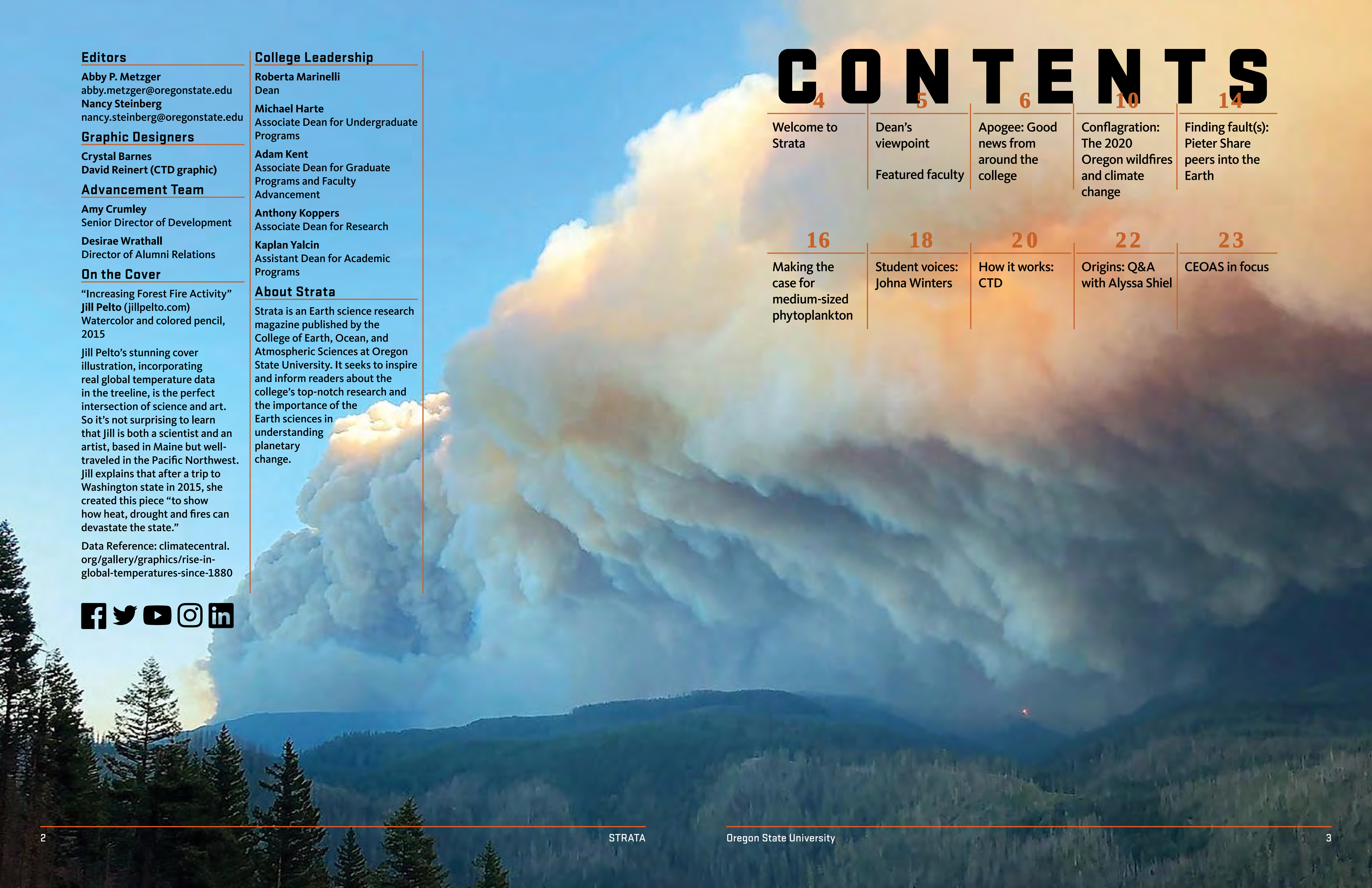
2021 | Issue 1



## OREGON WILDFIRES

### CLIMATE CHANGE AND WHAT THE FUTURE HOLDS

Oregon State University

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## On the Cover

"Increasing Forest Fire Activity"
**Jill Pelto** (jillpelto.com)
Watercolor and colored pencil, 2015

Jill Pelto's stunning cover illustration, incorporating real global temperature data in the treeline, is the perfect intersection of science and art. So it's not surprising to learn that Jill is both a scientist and an artist, based in Maine but well-traveled in the Pacific Northwest. Jill explains that after a trip to Washington state in 2015, she created this piece "to show how heat, drought and fires can devastate the state."

Data Reference: climatecentral.org/gallery/graphics/rise-in-global-temperatures-since-1880


## College Leadership

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## About Strata

Strata is an Earth science research magazine published by the College of Earth, Ocean, and Atmospheric Sciences at Oregon State University. It seeks to inspire and inform readers about the college's top-notch research and the importance of the Earth sciences in understanding planetary change.

# CONTENTS

# Welcome to Strata!

We are excited to present the debut of this new research magazine, a publication of the College of Earth, Ocean, and Atmospheric Sciences at Oregon State University, dedicated to the college's cutting-edge research around the globe and close to home.

The idea for Strata was hatched during the stay-at-home COVID days, when our isolation made us crave the collaboration we love as science communicators. Because the work of CEOAS is so diverse, choosing a title was difficult. We considered and rejected dozens of titles, but "Strata" kept floating to the top of our lists. All CEOAS scientists peer at and peel back layers, whether in a sediment core, an oceanic water column or the structure of social-environmental systems. We hope to do justice in these pages to the college's nuanced, innovative science.

Our inaugural issue focuses on "the other disaster" of 2020: The devastating wildfire season in Oregon and beyond. So much was lost last summer and fall, and along with the ash and heartache, we were left with questions. Is climate change to blame for these fires? Is this the new normal? Not surprisingly, the answers to these questions involve, yes, layers.

With the 2021 wildfire season upon us, we explore this topic with some of our faculty members who specialize in climate change and its ecosystem effects. We dive in on p. 10.

Elsewhere in the issue, we hope you enjoy reading about Pieter Share's work examining faults in the Earth (p. 14) and Laurie Juranek's new attention on the overlooked middle child of the phytoplankton family (p. 16). We also love to give our students a chance to tell their own stories, and we kick off that tradition with Johna Winters' tale of merging multiple sciences in her master's project (p. 18).

We'd love to hear what you think of Strata! Feel free to drop us a note at our email addresses listed within the table of contents.

Abby P. Metzger
Co-editor

Nancy Steinberg
Co-editor



# DEAN'S VIEWPOINT

## A POLITICAL MOMENT FOR THE ENVIRONMENT

Roberta Marinelli, Dean

For decades, scientists have been reporting that our world is warming, leading to myriad phenomena that alter ecosystem processes, services and communities in unprecedented and irrevocable ways.

Yet, broad scientific consensus on the causes and consequences of climate change, backed by substantial and compelling data, has not compelled action: Climate change has proven to be an intractable *political* and social issue. Thankfully, the nation is now witnessing a strong show of political will on behalf of the environment.

Two new pieces of proposed U.S. legislation are making a bold bet on the future of our scientific progress: the Endless Frontiers Act in the Senate and the National Science Foundation for the Future in the House. Both seek to create a new directorate at the National Science Foundation that will stimulate technological innovation and accelerate the translation of research into societal impact. This effort will move us closer to net-zero emissions and a 'greener' world.

Also in the Senate is a new bill called the Blue Globe Act, which aims to incite innovation around the blue economy, including growing and diversifying the workforce that supports it. This is a long-overdue effort to secure a healthy ocean that underpins our national and economic security, as well as our public health.

On the global scale, the ocean is receiving well-deserved attention with the U.N. Decade of Ocean Science (see p. 9 for more info). The Ocean Decade promises to mend the patchwork of policies that have hampered coordinated efforts to ensure healthy marine ecosystems.

With years of data behind our understanding of climate change, it's time to heed the scientific consensus and develop a strategy for reducing emissions and enhancing environmental security. The nation, and the world, are moving closer to these goals. S

# FEATURED FACULTY

Erica Fleishman learned first-hand the meaning of "trial by fire" when she became the director of the Oregon Climate Change Research Institute in the summer of 2020. Her career has taken her across the western part of the U.S., studying ecological responses to environmental change and the management of natural resources. She is particularly interested in applications of remote sensing to environmental sciences.

Larry O'Neill is Oregon's state climatologist and a key member of the OCCRI team. His research interests include air-sea interactions and ocean mixed layer dynamics. Larry enjoys Oregon's outdoors, where he finds it hard to turn off his climatology brain and frequently worries about how dry things have been.

Julia Jones is an Oregon State Distinguished Professor and head of the CEOAS geography program. She has studied nearly every aspect of forest ecology and water dynamics in the H.J. Andrews Experimental Forest. Despite the massive ecosystem changes she has observed over the course of her career, she finds hope in engaging with ecosystems and trying to understand them.

Pieter Share, associate professor of geology and geophysics, joined the CEOAS faculty in August of 2020. Pieter wants to save your life by studying what makes faults tick, particularly the massive fault zone on the West Coast of the U.S. When he is not studying the Earth, he can be found reading, watching movies, hiking or ballroom/Latin dancing!

Laurie Juranek is an associate professor in CEOAS where she joined the faculty in 2011. An ocean biogeochemist, Laurie loves big oceanographic data sets and collaborations with other scientists. Her expertise is in the use of dissolved gases, nutrients, inorganic carbon and associated isotope tracers to understand biogeochemical processes in the ocean.

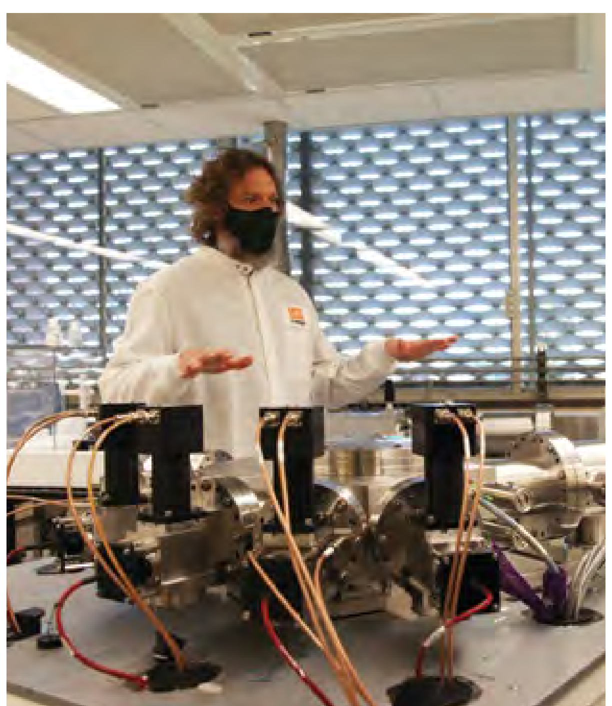
# APOGEE

## CEOAS AT THE TOP OF ITS GAME

Photos by David Reinert

## AFTER THE FIRE

### BURT HALL REBUILD GETS CEOAS SCIENCE BACK ON TRACK



Aside from a spiral of smoke that rose briefly from the rooftop, the November 2018 lab fire that broke out in the Keck Collaboratory for Plasma Spectrometry within Burt Hall was almost invisible to onlookers. There was very little external evidence, and fire trucks worked adroitly to extinguish the flames. But looks can be deceiving. Inside, fire, water and smoke damaged several other analytical facilities and displaced dozens of faculty and staff.

While no one was hurt, the fire waylaid research activities and disrupted degree progression for some students. The Keck Lab was completely gutted. For a world-renowned Earth science enterprise with advanced analytical capability, the ordeal was a major setback.

More than two years later, after a tangle of building permits and insurance claims, the damaged wing of Burt Hall reopened, right in the middle of the pandemic. Despite the complications of conducting renovations during the COVID-19 crisis, impacted researchers, students and staff are slowly resuming normal activities. Labs are coming back online. Students are getting their hands on analytical instruments and processing samples, whether rocks, forams or oyster shells. And hallway conversations about proposal opportunities are happening again, albeit with pandemic precautions as their guide.

In an article that appeared in the spring issue of the Oregon Stater magazine, Roberta Marinelli, dean of the College of Earth, Ocean, and Atmospheric Sciences, noted that the upheaval required the college to think deeply about its strategic research mission and respond accordingly.

“Because of what happened, we had an opportunity to reconstruct [the building] in a way that advanced our scientific mission,” Marinelli says. “It was the silver lining.”



## FIN WHALE SONGS

### REVEALING SEISMIC SECRETS IN THE OCEAN’S CRUST

Scientists wanting to peer into the oceanic crust to learn more about earthquakes originating there have a new imaging tool at their disposal: fin whale songs. A recent study demonstrated that these vocalizations contain signals that are reflected and refracted within the crust, including the sediment and the solid rock layers beneath. These signals, recorded on seismometers on the ocean bottom, can be used to determine the thickness of the layers as well as other information relevant to earthquake research, says John Nabelek, a professor in Oregon State University’s College of Earth, Ocean, and Atmospheric Sciences.

“People in the past have used whale calls to track whales and study [their] behavior,” Nabelek says. “What we discovered is that whale calls may serve as a complement to traditional passive seismic research methods.”

Nabelek and the study’s lead author, then-graduate student Vaclav M. Kuna, were studying earthquakes with a network of 54 ocean-bottom seismometers placed along the Blanco transform fault, which at its closest is about 100 miles off Cape Blanco on the Oregon Coast.

Using a series of whale songs that were recorded by three seismometers, the researchers were able to pinpoint the whale’s location and use the vibrations from the songs to create images of the Earth’s crust layers.

Researchers use information from these layers to learn more about the physics of earthquakes in the region, including how sediment behaves and the relationship between its thickness and sound wave velocity.

“This approach expands the use of data that is already being collected,” Nabelek says. “It shows these animal vocalizations are useful not just for understanding the animals, but also understanding their environment.”

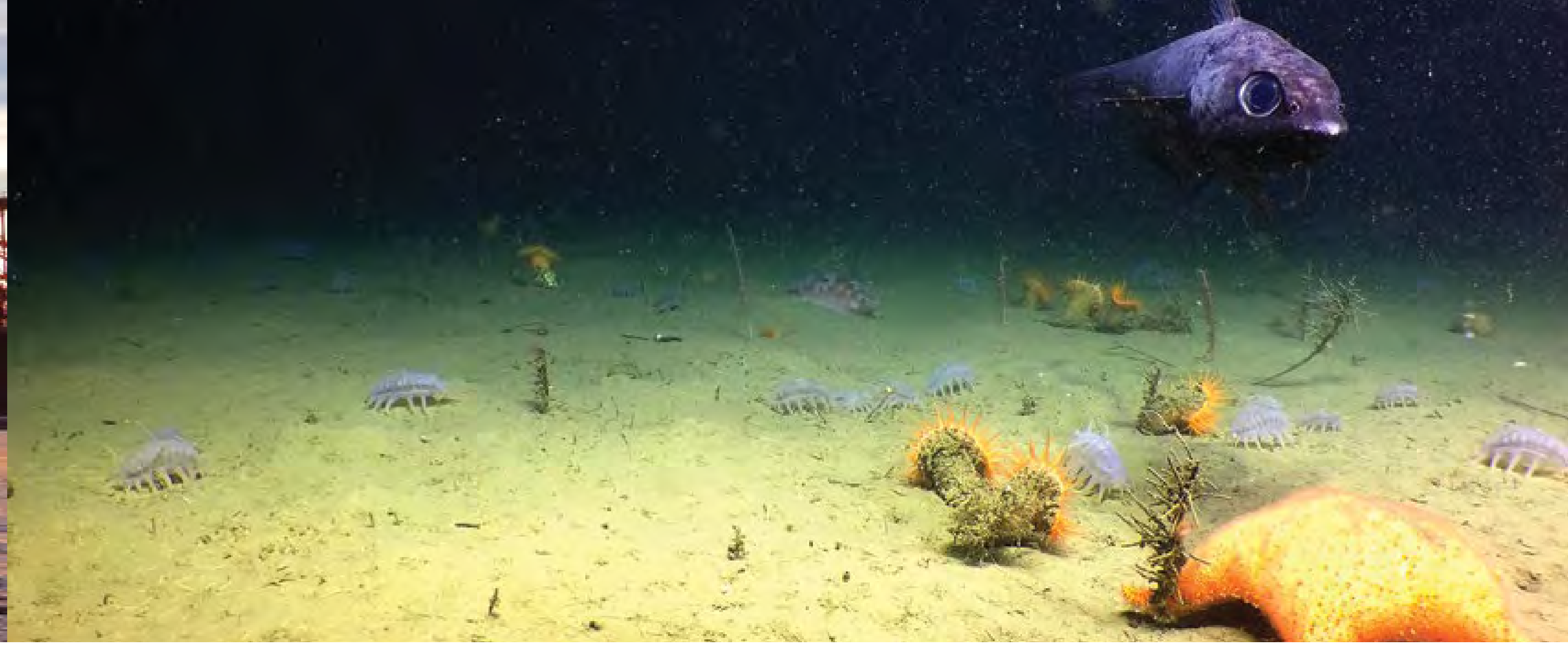


Photo by Dan Hellin

# WAVE ENERGY

## TESTING SITE MOVES FORWARD

The power of Oregon's ocean waves is undeniable, and engineers have been working for decades to find an effective way to harness that energy for our electrical grid. That effort just received a huge boost, achieving two critical milestones in the development of a grid-connected site for testing wave energy devices.

The site is one of two off the central Oregon Coast being developed by an initiative at Oregon State University called PacWave. The northern test site, a mile off Yaquina Head near Newport, is for testing the durability and performance of experimental wave energy devices. This site, operational since 2012, is not connected to our electrical grid. PacWave South will be a pre-permitted, grid-connected site seven miles off Waldport, Oregon.

After more than eight years of environmental and engineering studies, the federal Bureau of Ocean Energy Management awarded the university a lease to operate PacWave South in federal waters, and shortly thereafter the Federal Energy Regulatory Commission awarded the university a license to build and operate the site.

Construction of PacWave South began in June 2021 with underground installation of the conduits that will house subsea cables, connecting the ocean test site to a shore-based facility. Site preparation for the shore-based utility connection and monitoring facility, which operates similar to a power substation, is also underway. There, wave-generated power will be conditioned, a process to ready the power so it can be added to the local grid.

As soon as 2023, companies with wave energy devices in development will be able to deploy them into the waters of the south test site, connect them into the electrical grid, and determine how the devices perform with respect to producing power and handling the harsh conditions of the northeast Pacific Ocean. Environmental impacts will also be assessed.

"We know there is still work to do to make this project a reality," says Burke Hales, chief scientist for PacWave and a CEOAS professor. "But this is a huge moment for this project and for the industry as a whole."

Learn more about this effort at pacwaveenergy.org.

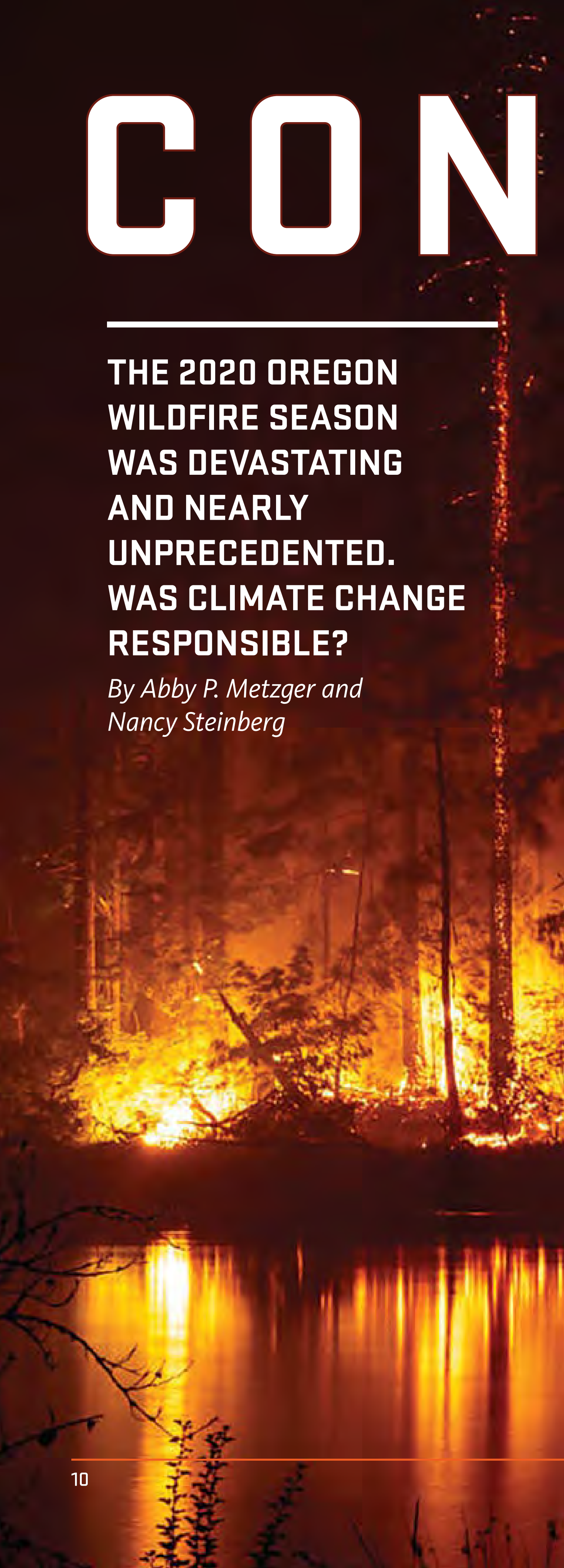
# DEEP(-SEA) THOUGHTS

## U.N. DECADE OF OCEAN SCIENCE

A threat to ocean health is a threat to all life on Earth, including the human variety. In order to bring international attention to the health of the world's oceans and its connections to sustainability, the United Nations has declared 2021-2030 to be the U.N. Decade of Ocean Science for Sustainable Development. Throughout the decade, the U.N. will support and encourage actions underlying the program's mission of finding "transformative ocean science solutions for sustainable development, connecting people and our ocean."

The U.N.'s planning includes a focus on the dearth of data from the deep sea, despite the importance of this realm as a habitat and the potential for ecosystem disturbance there by ever-increasing resource extraction activities. Andrew Thurber, an associate professor in the College of Earth, Ocean, and Atmospheric Sciences, is part of a large, multi-institutional and international team that has issued a document guiding deep-sea research for the Ocean Decade. This plan spells out priorities for research, outlines methods for turning data into knowledge and includes a specific call for more inclusivity in the deep-sea science workforce.

"The oceans connect the world independent of the international borders drawn on maps," Thurber says. "So the framework that we propose espouses a scientific approach of global collaboration to advance our understanding of the deep sea as part of the ocean and Earth system. As we face novel and expanding ocean uses, including in the deep sea, we need to work as a global community to inform management of our current and future oceans."



# CONFLAGRATION

## THE 2020 OREGON WILDFIRE SEASON WAS DEVASTATING AND NEARLY UNPRECEDENTED. WAS CLIMATE CHANGE RESPONSIBLE?

*By Abby P. Metzger and Nancy Steinberg*

Erica Fleishman propped herself up in the bucket seat of the small airplane so she could see the Oregon landscape below. One of the plane's windows was open to allow a filmmaker to take footage, making communication with the other two passengers and pilot impossible. Brand new to the Pacific Northwest, Fleishman had never seen most of the places below from the ground, but even so, she knew they were changed beyond recognition. From decades of work elsewhere in the West, she knew that wildfires will do that. Smoke still lingered in the air.

It was October 2020, and the worst wildfire season to hit the state of Oregon in decades was, thankfully, winding down. Fleishman had joined the faculty at Oregon State University a few months earlier as the new director of the Oregon Climate Change Research Institute. Today she had been invited to fly over some of the burned areas.

"The forested places that burned were intellectually really interesting in terms of the patchiness," Fleishman says. "But then, you look down and see strange, light-colored squares and realize, 'oh my gosh, those are concrete pads where homes used to be,' and that was terribly sobering."

All tolled, more than a million acres burned in Oregon, the second-highest in one season in recorded history. Eleven Oregonians lost their lives, and thousands of structures, including many homes, were destroyed. Fires burned from eastern Oregon to the McKenzie River Valley to coastal Lincoln County — marking the landscape and our memories for years to come.

Even before the flames were doused and the damage was fully surveyed, questions swirled like smoke. Why was this fire season so bad? Was it poor forest management? Was it climate change? Is this the new normal?

As Fleishman explained again and again to media outlets and seminar audiences last fall, a confounding tangle of variables was at work. Some were decades-long trends, while others felt almost like bizarre one-off events. A closer look at some of the drivers of the 2020 fires, as well as of those in the past, reveals more about climate change's effects on Oregon wildfires and might tell us something about what the future has in store.

## THE PAST

As you have likely heard, fires are a natural part of western ecosystems, even a necessary ecological process. Oregon landscapes have always been affected by fire, but wildfire patterns, frequency and severity have changed in the 150 years since Europeans arrived in the West.

Before European settlement, most forest fires were ignited by lightning strikes. "There is very little evidence that [indigenous people] had any effect on the fire regimes of the forest," says Julia Jones, Distinguished Professor of geography in the College of Earth, Ocean, and Atmospheric Sciences at Oregon State. "Although the Native peoples did migrate seasonally from the [Willamette] Valley up into the mountains, they occupied specific parts of the landscape, particularly wide, low elevation valleys, and flat broad ridges, such as the upper ridges of the H.J. Andrews Experimental Forest." In other words, they had no need to set fire to dense forests — that's not where they spent their time.

European settlers, traveling west, brought new ignition sources with them, in the form of campfires. "In the 1850s or so, Europeans began to arrive across the Cascades on the Santiam Wagon Trail, and some of their campfires escaped and blew westward into the forest," Jones says. "So, we had a new ignition source in forested landscapes."

Today, ignition sources are more diverse: Lightning strikes and campfires continue to cause fires, but sparks from cars driving by dry roadway vegetation, discarded cigarettes, and, importantly, downed power lines add to the list.

In the early 1900s, as fires became more common near human settlements, suppression became more common as well, Jones says. Suppression had a significant downside: It allowed fuels for fires to build up in some ecosystems. "When a fire eventually came along," Jones points out, "it was likely more difficult to control and burned at a much higher severity."

So, ignition and suppression have changed over time and may have contributed to the disastrous fire season of 2020. But Jones also notes that summers have been getting warmer and drier in Oregon, which brings us to the question of the impact of long-term climate trends and their role in the 2020 fire season.

## THE PRESENT (2020)

Scientists are clear: It is likely that some long-term climate-related factors contributed significantly to the 2020 wildfire season, particularly the September conflagrations. As Larry O'Neill, associate professor and Oregon's state climatologist, puts it, climate change "set the table" for more acute and unusual factors to make a terrible impact.

### Aridity: It's not just for deserts

Aridity is a measure of dryness that incorporates a range of variables, including precipitation, temperature, humidity and even winds. Trends in all of these parameters have led to increasing aridity.

For example, O'Neill explains, "Gradually increasing temperatures have increased evaporation, sucking needed moisture out of the plants and soil."

Fleishman adds, "Dry vegetation burns more easily than vegetation that has more moisture. Fuel moisture level is a key variable in controlling how fires spread." A 40-year decline in summer precipitation has reduced humidity as well. During the Labor Day 2020 fires, humidity was extraordinarily low in many areas of Oregon, 10-12% in Salem, for example.

Precipitation deserves an especially close look. In western Oregon, we think of ourselves as living in a damp environment. But climate change seems to have caused critical shifts in precipitation patterns. When water falls as snow in the winter, the mountains store that snow and then slowly release it as snowmelt into our watersheds throughout spring and summer. As temperature has increased, we are receiving less snow and more rain in winter, which reduces streamflow and therefore water availability in the warmer months.

> **“ Going forward, we have to act as if this will now be a regular occurrence. ”**
> ***-Larry O’Neill***

### You’ve heard of flash floods ...

In addition to these long-term trends in aridity, climate reared its head in distinct ways in 2020, again setting the stage for the fire season. For one thing, Oregon experienced what is called a “flash drought” in August and September. O’Neill says: “Around middle to late August and early September, we had one of the warmest periods on record in a lot of Oregon, creating a flash drought. This is basically where you have a heat wave that can last a couple of weeks, and it rapidly evaporates off any remaining moisture. In this case, climate change exacerbated typical summertime drying, and was a contributing factor in creating the flash drought.” The eight-week period from mid-July to September 10 was the third warmest and third driest period in the Cascade Range in the past 42 years, according to a report co-authored by O’Neill for the Climate CIRCulator blog. The flash drought contributed to extremely dry soils and vegetation by early September.

### Easterly winds (Those winds though)

Oregonians who experienced the 2020 wildfires will likely remember the winds at the tail end of summer. Warm, dry air careened eastward at speeds typical of severe winter storms.

“It was definitely in the 99.9% of fastest winds for that date,” O’Neill says.

Those winds can be partially explained by a meteorological pattern called an Omega block. As the name suggests, the pattern resembles the Greek letter Omega, with the round part representing a high-pressure ridge that hung off our coast, and the “feet” representing a low-pressure system. This blocking pattern contributed to strong, dry, easterly winds that stretched from the Canadian border into northern California. These winds whipped up fires already underway and ignited new ones by toppling power lines.

By themselves, the winds were indeed unusual, but scientists are starting to look at the interacting effects of two or more variables — called a compound extreme. Independently, the easterly winds and dryness were highly unusual but not unprecedented. Yet the extent to which these two things coincided had never before been recorded. It was the perfect punch.

### All together now

Many things aligned during the 2020 wildfires. Decades of management practices that favored fire suppression. New human sources of ignitions. A warmer and drier landscape with more burnable fuels. Seasonal conditions and strange weather patterns — not to mention more people living in harm’s way.

Looking back, scientists can safely say that long-term changes and extreme weather played a part in the 2020 wildfires. If climate change and the slow drying of the West set the dinner table, the 2020 conditions served the main course. The twinning forces ignited powerful wildfires that jumped rivers and roads, razing towns and closing recreational areas.

OCCRI Director Erica Fleishman offers a pointed summary. “If the vegetation is dry, and there’s a spark with extremely high winds, a fire is going to go. It’s pretty much just get the heck out of the way and hope for the best. Nothing is going to stop it.”

## THE FUTURE

As forests and debris smoldered, those who still had homes emerged from days of staying inside to avoid hazardous air and wondered what world they had just stepped into. Oregonians rubbed their burning eyes, started to sweep up the ash and asked the all-important question: Can we expect more of the same?

The short-term answer is that 2021 is shaping up to be a high-risk fire season. As early as April, much of western Oregon was under a red flag warning for critical fire weather conditions. A streak of rainless, warm and windy days felt eerily like summer.

“[The fire] warning was months earlier than normal,” Larry O’Neill says.

Thankfully, aside from the southern Oregon Cascades, 2021 saw normal mountain snowpack, partially refilling our precious water bank account. But northwest Oregon received only a little more rain this year compared to last. According to preliminary statistics, Oregon recorded its second driest spring since 1895. This means much drier soil and fuel.



“Since spring was historically dry, 2021 has the potential to be another tough and long fire season in much of Oregon, particularly in central and southern Oregon,” O’Neill says. “Compounding this situation in these regions is that they’re into the second consecutive year of severe-to-extreme drought.” In recognition of these conditions, as of July parts of Oregon were placed in an above-normal fire category by the National Interagency Fire Center.

As for those easterly winds, some scientists have proposed a much-debated hypothesis that they could become more frequent with climate change. But Fleishman says the data do not support this: “By and large, there is no good evidence right now that those types of wind events are going to become more frequent.”

The long-range view is also sobering. According to the Fifth Oregon Climate Assessment, area burned and fire frequency are projected to increase substantially over the next 50 to 100 years, first on the drier side east of the Cascade Range, and eventually in the western Cascade Range. Fires may also become more severe, depending on fire management practices and how vegetation and weather vary with climate change.

As a result, the dialog is shifting from how to prevent forest fires, like in the heyday of Smokey Bear, to how to live in a world with increased fire risk.

“Going forward, we have to act as if this will now be a regular occurrence,” O’Neill says.

## THE UPSHOT

In October of 2020, CEOAS geographer Julia Jones visited a burned area in the McKenzie River watershed. Her visit nearly coincided with Erica Fleishman’s flight to survey the sobering destruction from above. But up close and on the ground, Jones saw something different. Already, trees were making leaves. Cones were alive. It was a stunning reminder of nature’s resiliency, which can be hard to remember in the afterglow of all that burned.

Jones also looks to the power of societal resilience, noting that abrupt changes in human behavior have occurred throughout the history of the Pacific Northwest. For example, the logging that occurred after the early 1900s was once considered essential for fire suppression. Then, in the 1990s, the pendulum swung the other way, and logging in the old growth forests declined sharply.

“It seems that abrupt shifts are more likely in human societies than they are in ecosystems,” Jones says. “So, the question really is, how will human behavior change in response to this one summer? What will be different?”

Going forward, maybe this is the question we should be asking ourselves — not whether this could happen again, but what will we change?

> **“ The question really is, how will human behavior change in response to this one summer? What will be different? ”**
> ***- Julia Jones***

If we can navigate between longing and loss, between defeat and actually doing something — maybe everything.

# FINDING FAULT(S)

## PIETER SHARE PEERS INTO THE EARTH

*By Nancy Steinberg*

It is no exaggeration to say that characterization of faults — cracks in the Earth's crust caused by tectonic plate movements — can save lives. Because most large earthquakes originate at major faults, like California's infamous San Andreas Fault, the more we know about these massive cracks, the closer we get to a complete understanding of earthquake dynamics.

Pieter Share, assistant professor of geophysics in the College of Earth, Ocean, and Atmospheric Sciences at Oregon State, has studied fault zones in South Africa and California, from the surface of the Earth to the depths of industrial mines. In his quest to understand how faults work, Share has used a wide range of tools to peer beneath the Earth's surface.

He started as a master's student by using electromagnetic techniques to search for past tectonic activity in some of his native South Africa's oldest rocks, deep in the passages of platinum and gold mines. How can measuring electromagnetic signals help reveal historical earthquakes?

"Most rocks don't conduct electricity very well. But some do. As soon as you start adding any type of conductive component, like a metallic compound or mineral-rich fluids, that rock becomes more conductive," Share says.

That conductivity data can provide information about the types of rocks underfoot, sometimes deep underfoot, and even tell scientists whether there is or has been tectonic activity at a site.

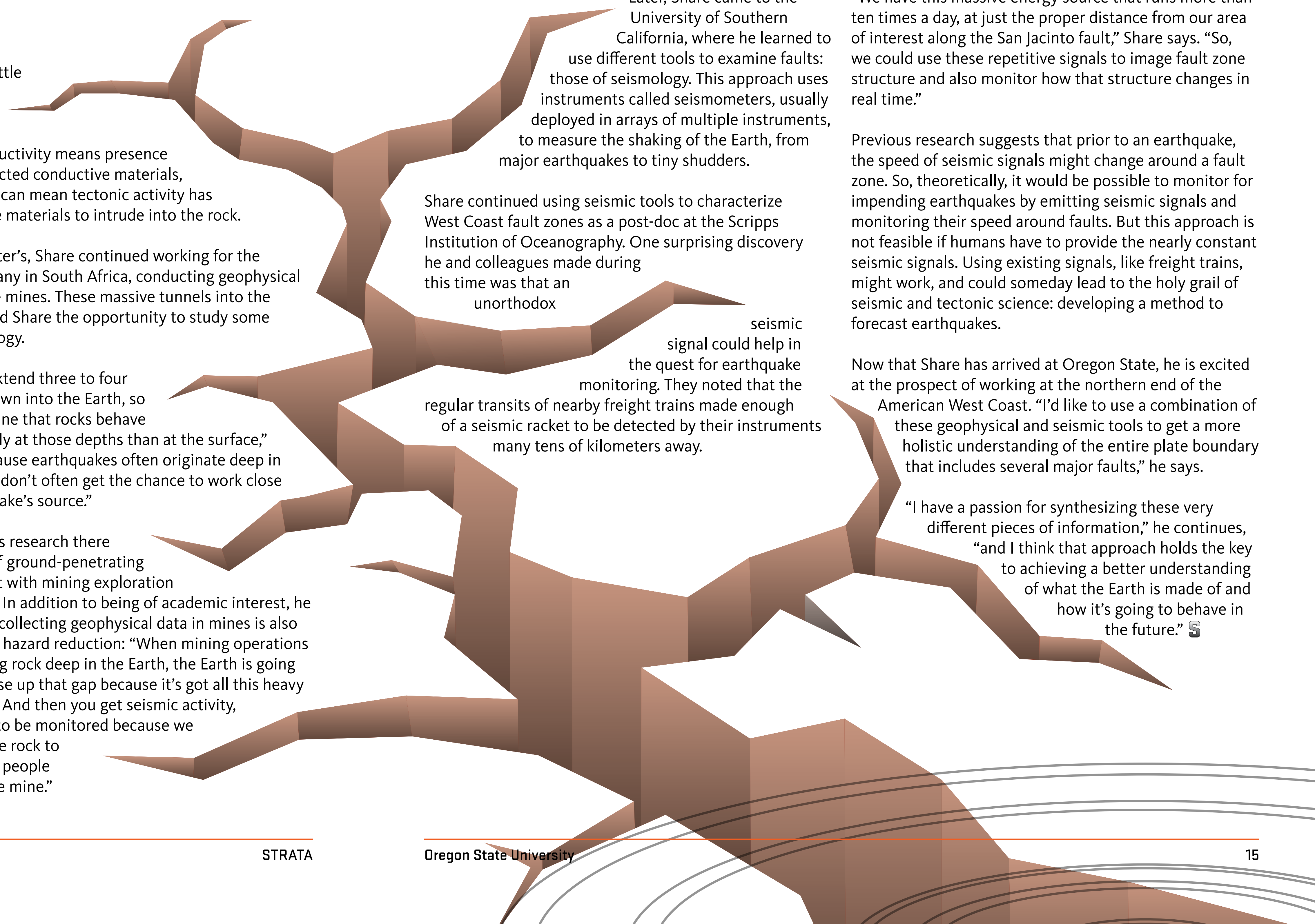
Share explains: "A fault zone is a region where earthquakes have damaged and broken up the rock. Once the rock is broken, there's the opportunity for conductive fluids to percolate through the crust from deep down and fill all those little cracks and fractures in the rock."

So, high conductivity means presence of interconnected conductive materials, which in turn can mean tectonic activity has allowed those materials to intrude into the rock.

After his master's, Share continued working for the mining company in South Africa, conducting geophysical surveys in the mines. These massive tunnels into the ground offered Share the opportunity to study some amazing geology.

"The mines extend three to four kilometers down into the Earth, so you can imagine that rocks behave very differently at those depths than at the surface," he says. "Because earthquakes often originate deep in the Earth, we don't often get the chance to work close to an earthquake's source."

Part of Share's research there used a type of ground-penetrating radar to assist with mining exploration and planning. In addition to being of academic interest, he explains that collecting geophysical data in mines is also important for hazard reduction: "When mining operations start removing rock deep in the Earth, the Earth is going to try and close up that gap because it's got all this heavy rock above it. And then you get seismic activity, which needs to be monitored because we don't want the rock to collapse onto people working in the mine."



Later, Share came to the University of Southern California, where he learned to use different tools to examine faults: those of seismology. This approach uses instruments called seismometers, usually deployed in arrays of multiple instruments, to measure the shaking of the Earth, from major earthquakes to tiny shudders.

Share continued using seismic tools to characterize West Coast fault zones as a post-doc at the Scripps Institution of Oceanography. One surprising discovery he and colleagues made during this time was that an unorthodox seismic signal could help in the quest for earthquake monitoring. They noted that the regular transits of nearby freight trains made enough of a seismic racket to be detected by their instruments many tens of kilometers away.

"We have this massive energy source that runs more than ten times a day, at just the proper distance from our area of interest along the San Jacinto fault," Share says. "So, we could use these repetitive signals to image fault zone structure and also monitor how that structure changes in real time."

Previous research suggests that prior to an earthquake, the speed of seismic signals might change around a fault zone. So, theoretically, it would be possible to monitor for impending earthquakes by emitting seismic signals and monitoring their speed around faults. But this approach is not feasible if humans have to provide the nearly constant seismic signals. Using existing signals, like freight trains, might work, and could someday lead to the holy grail of seismic and tectonic science: developing a method to forecast earthquakes.

Now that Share has arrived at Oregon State, he is excited at the prospect of working at the northern end of the American West Coast. "I'd like to use a combination of these geophysical and seismic tools to get a more holistic understanding of the entire plate boundary that includes several major faults," he says.

"I have a passion for synthesizing these very different pieces of information," he continues, "and I think that approach holds the key to achieving a better understanding of what the Earth is made of and how it's going to behave in the future." S

# MEDIUM MATTERS:

## MAKING THE CASE FOR MIDDLE-SIZED PHYTOPLANKTON

*By Abby P. Metzger*

In a world that seems to prize the largest and adore the smallest of creatures, it's hard to admire something for its medium-ness, its quality of being in between. But, a recent study led by Oregon State oceanographer Laurie Juranek stands as a scientific ode to mid-sized organisms, in this case phytoplankton.

These unicellular oceanic plants soak up atmospheric carbon dioxide, produce oxygen and form the basis of the marine food web. The middle-sized phytoplankton in particular — called nanoplankton — may play a bigger role in ocean productivity than previously thought. But like an oft-overlooked middle child, nanoplankton have historically been unaccounted for in global carbon cycle models, limiting our ability to understand and predict future ocean health.

"These medium-sized cells are overlooked," says Juranek, an associate professor who studies how ocean ecosystems are responding to environmental change. "They are not like the small and large guys, which are typically the only ones parameterized in our models. So, our models might be missing the Goldilocks optimum and getting spatial patterns of productivity and biological carbon uptake wrong at times."

Juranek never set out to study nanoplankton. They first caught her eye as a graduate student while on a cruise in a highly productive region of the North Pacific called the transition zone chlorophyll front. First described nearly 20 years ago, the front is a dynamic ocean feature characterized by swirling blooms of phytoplankton that can be seen from space. During the cruise, Juranek and her colleagues discovered unexpected pulses of productivity. "We had just a few data points that suggested a peak of productivity," she says.

These pulses could not be explained using prevailing paradigms, which assume that the most productive ocean ecosystems are dominated by the biggest plankton (microplankton), and the least productive by the smallest (picoplankton). Juranek's measurements should have indicated a high biomass of large phytoplankton, but they didn't.

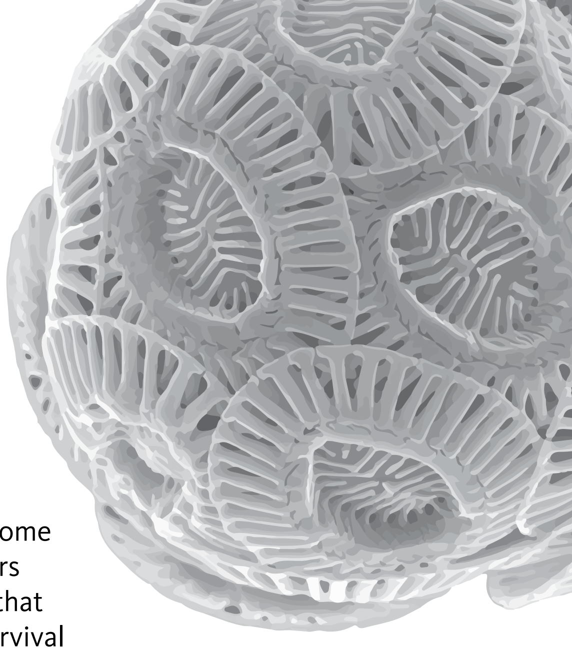
Could this big-small binary be missing the happy medium?

Juranek dug into that question during three more recent scientific cruises to the transition zone chlorophyll front, working alongside her "scientific bestie" and former Oregon State researcher, Angel White (now at the University of Hawai'i). Their intent was to gather observational data of nanoplankton and understand their unique contribution to carbon cycling.

Juranek and White used a number of high-resolution observational approaches that gave them a more precise glimpse of plankton size than is afforded by standard methods. "To determine phytoplankton size previously, we had to make loose associations between pigments that are characteristic of something bigger, like a diatom, versus something smaller," Juranek says. "But it was not precise and only hints at 'who' is actually there."

Rather than relying on pigment as a proxy for size, Juranek and White looked directly at phytoplankton using a high-resolution instrument called an imaging flow cytobot. The instrument constantly sips ocean water while aboard a research vessel and takes pictures of particles that pass in front of its camera. Using image recognition, the instrument identifies individual species, essentially amassing a database of plankton portraits. Instead of the sporadic data points Juranek collected as a graduate student, she now had thousands.

"These new imaging technologies are really advancing our understanding of who's there. And my piece of the puzzle is, how much production is happening in these systems," she says.



The types of nanoplankton that Juranek and White sampled were stunningly diverse. They included coccolithophores — armored organisms that look strikingly like a snowball — and dinoflagellates — some plant-like and others called mixotrophs that employ a hybrid survival strategy by acting like both a plant and animal.

With each cruise, Juranek noticed distinct "wiggles" in her data, suggesting a pulse of productivity. When she compared her data to White's, she found a strong correspondence.

"We found that these areas with high productivity seemed to have high biomass of medium-sized cells," Juranek says. "The patterns in the biomass and productivity matched remarkably well. We almost didn't believe it."

Buoyed by her findings, Juranek plans to go on a fourth cruise in November of 2021, this time heading south toward the equator. Her quest will be to further tease apart the contribution of mid-sized phytoplankton to ocean productivity. Understanding this relationship will be critical to evaluating how climate change may impact the carbon cycle and ocean ecosystems in the future.

### PLANKTON PORTRAITS

Juranek and colleagues use an innovative instrument that takes pictures of and then identifies individual phytoplankton cells, essentially amassing a database of plankton portraits.


# STUDENT VOICES

## STRADDLING TWO CULTURES AT SEA

*By Johna Winters*

*Editor's note: Johna Winters will finish her Master of Science in Marine Resource Management in summer of 2021. This is a shortened version of a piece she wrote for CEOAS Chronicles, a blog focused on CEOAS graduate student experiences. For more entries, see blogs.oregonstate.edu/ceoaschronicles/.*

As a marine technician, I traveled to the North Pole, the equator and the Great Lakes. I helped deploy scientific moorings off the coast of Oregon, deep-sea trawls in the sea of California, and mud grabs in the deepest part of Lake Superior. As a technician, my main job was to make sure that the scientists onboard the ship had what they needed to complete their projects, including data streams, sampling equipment and expertise to deploy that equipment safely.

But sometimes I used "people skills" as much as technical skills. Sometimes I had to grease the wheels of collaboration between scientists and crew, making an effort to communicate with each of these groups in their own language and then translating. Sometimes sampling methods didn't make a lick of sense to the crew, and sometimes scientists didn't comprehend ship operations. In communicating with both groups, I was able to make data collection more efficient and higher quality.

The longer I was a technician, the more I realized that women in leadership roles were few and far between, and it became obvious that I was treated differently because of my gender. I began to wonder: Did the unique environment of a research vessel have an influence on the cultural and historical momentum of sexism? Policies such as Title IX and Title VII had existed for decades, but how did policies designed to eliminate sexual harassment function in this unique environment?

Little did I know that in exploring answers to these questions, I would be using both my technical and people skills during my master's degree program.

In order to answer my research questions, I had to break through my past bias against the social sciences. As a younger person, I dismissed anything that in my mind was "not science." I attribute this narrow way of thinking to many influences around me, from my B.S. in chemistry to depictions of science in popular culture.

Once I moved beyond my bias, I was able to apply social science methods to better understand gender-based discrimination in oceanography. I discovered that this approach was particularly well suited to studying sexual harassment, as many people are unwilling to make a formal report about sexual harassment that they experience or witness (a trend reflected in my data). A confidential survey is an opportunity for people to write openly about their experiences without fearing retaliation. While quantitative data has its place, it cannot capture the nuances of the experience of sexual harassment.

Today I find the notion of a hierarchy of disciplines ridiculous. Different questions require different tools. The research questions for my thesis couldn't be answered with the tools that I knew from my chemistry degree or from being a technician. Instead, a combination of approaches and tools helped me to carry out my research objectives, resulting in something of value to the research vessel community. I hope my research will disrupt the patterns that keep talented women from reaching leadership roles as crew, scientists and technicians.

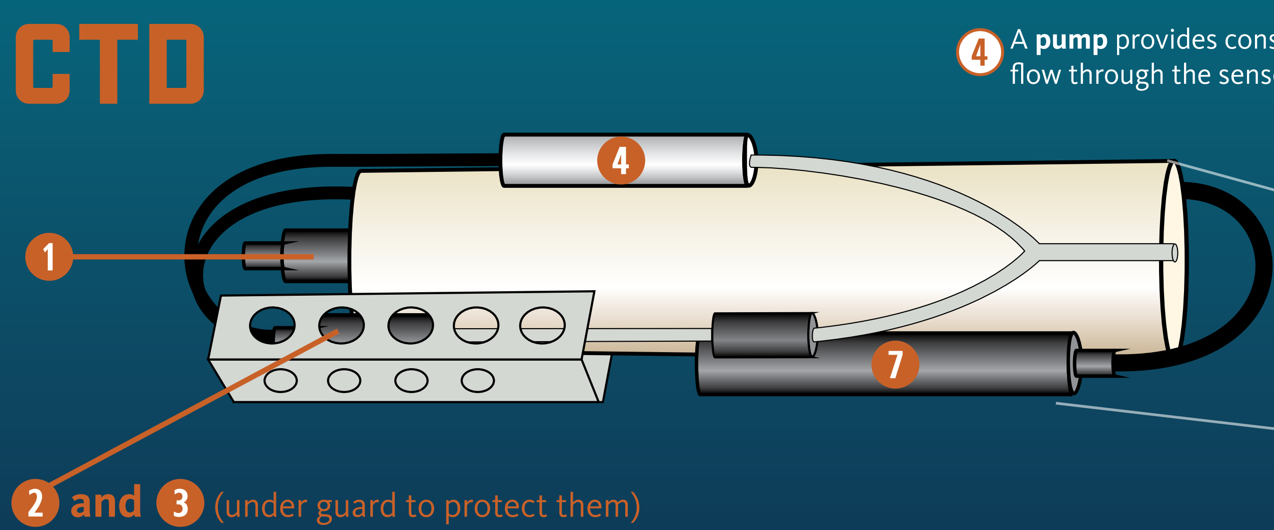
> **"Today I find the notion of a hierarchy of disciplines ridiculous. Different questions require different tools."**

# HOW IT WORKS

## CTD: THE OCEANOGRAPHER'S SWISS ARMY KNIFE

Every ocean-going scientist, whether studying waves or whales, carbon or copepods, has probably used a CTD. CTDs are the oceanographer's most basic tool, as the three types of data it collects — conductivity, temperature and depth — can reveal massive amounts of information about the ocean. In addition to those three main parameters, scientists can piggyback other types of sensors onto the CTD frame to measure pH, oxygen content, water clarity and more. All of these sensors can collect data continuously throughout the water column in order to provide a profile of what each parameter looks like from the surface to a designated depth. Even when ocean water appears uniform to the naked eye, differences in salinity, temperature and density define distinct parcels of water, called water masses. Movement of these water masses has important repercussions for transfer of heat, nutrients, oxygen and other parameters around the world's oceans.

CTDs can range in size and exact instrumentation, and can be fixed in place under the ocean or deployed from a ship, but the one sketched here is used aboard R/V *Oceanus*, Oregon State's main research vessel.



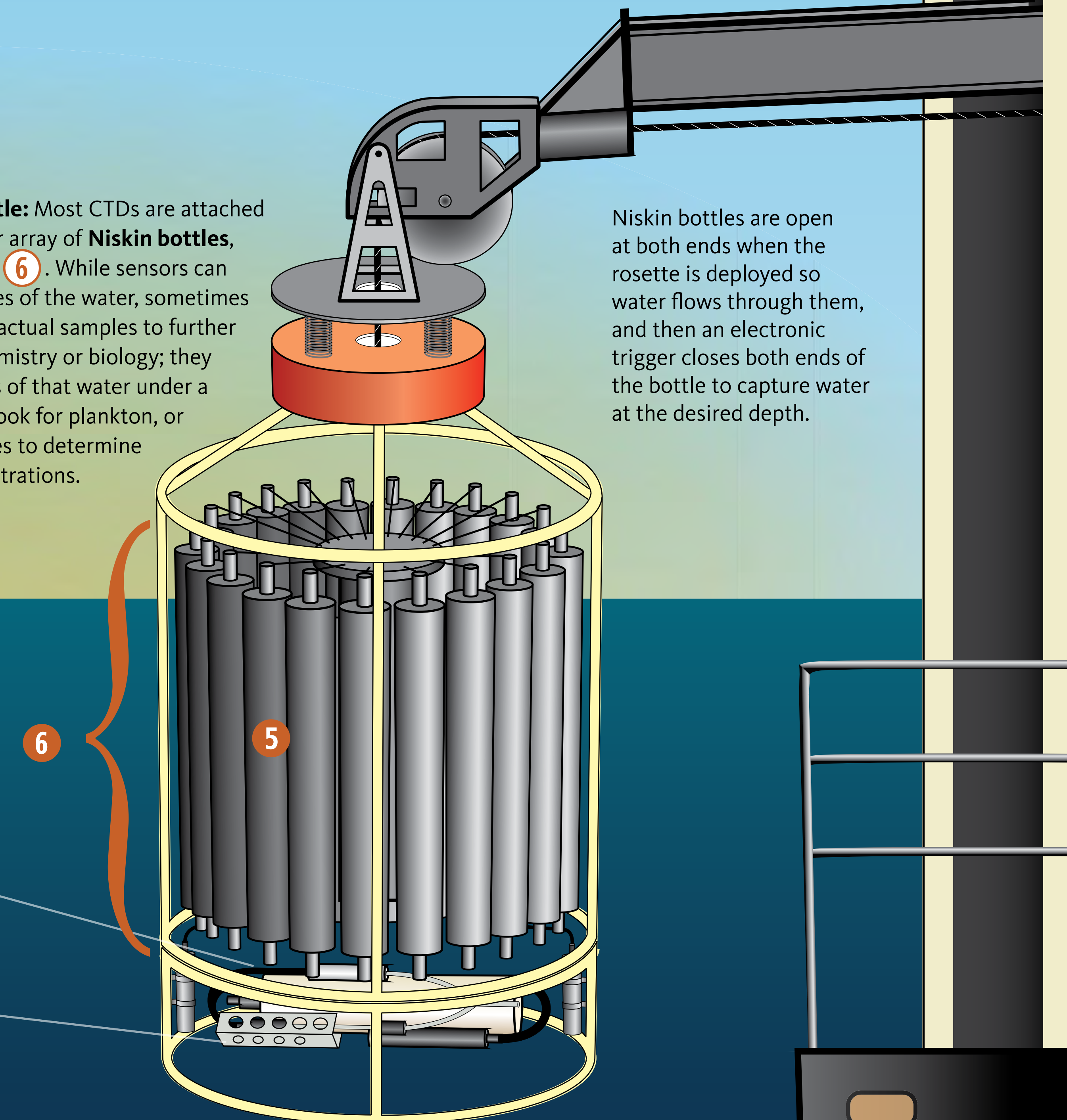

4 A **pump** provides constant flow through the sensors.

1 **Pressure sensor:** Rather than directly measuring depth, the "D" in CTD, this instrument actually measures pressure, which is correlated with depth (pressure at the surface is 0, and increases with depth). Pressure can also be combined with temperature and salinity to calculate seawater density. Seawater density controls the extent to which some things, like oxygen, can be dissolved in the water, and also, whether water masses sink or rise in the water column.

2 **Conductivity sensor:** The "C" in CTD stands for conductivity, a stand-in for salinity. Ions of sodium, chlorine and other elements dissolved in the water increase water's electrical conductivity. More ions means more conductivity and higher salinity.

3 **Temperature sensor (thermistor):** This instrument measures the temperature of the water, but not in the way that a thermometer does. A thermistor is essentially a small resistor whose resistance changes with temperature.

5 **Niskin bottle:** Most CTDs are attached to a circular array of **Niskin bottles**, called a **rosette** 6. While sensors can detect properties of the water, sometimes scientists need actual samples to further examine its chemistry or biology; they might put drops of that water under a microscope to look for plankton, or conduct analyses to determine nutrient concentrations.




Niskin bottles are open at both ends when the rosette is deployed so water flows through them, and then an electronic trigger closes both ends of the bottle to capture water at the desired depth.

7 **Dissolved oxygen sensor.** This sensor and others can be added on to the instrument package to customize the types of data collected.

Illustration: David Reinert
Scientific advisor: Miguel Goñi

Photo by Hannah O'Leary

# ORIGINS: Q&A

## ALYSSA SHIEL, ASSISTANT PROFESSOR

**Tell us about your research at CEOAS. What do you study?**
My research is focused on metal contaminants — understanding their sources, pathways, transformations and fates. Much of my research relies on the understanding and use of isotopic compositions. They serve as environmental fingerprints, providing information about sources and transformations of these metals.

**What project are you working on now that gets you excited?**
Currently, we are reconstructing histories of metal emissions and sources in the Arctic by examining ice cores. Connections between metal sources and metals found in the Arctic are investigated using physical and chemical properties of emissions, isotopic fingerprints, transport processes and models. This will allow us to tease apart natural sources versus human sources, ultimately helping us to understand the environmental impact of our heavy metal emissions. My Ph.D. student, Sophia Wensman, joined a team headed to Greenland to collect a new core that will cover the last 4,000 years.

**Let's go back to your origins. When did you know you wanted to be a scientist?**
I have always wanted to understand the natural world around me. In elementary school, I began to appreciate the impact people have on the environment. I remember reading about the devastation that followed the Exxon Valdez oil spill in 1989. I got very interested in finding local ways to make a difference. I launched a neighborhood recycling program and became a vegetarian. In college I found my way into an environmental science program and got involved in research with a local environmental nonprofit. My research focused on levels of heavy metal in home remedies and herbal medicines used along the U.S./Mexico border and southern Arizona.

**What has been the most rewarding part of your work in geochemistry? The most challenging?**
The most rewarding part of my job is working with students. I love being able to bring them in on projects early, giving them experience with the whole process — coming up with a research question, designing an experiment, carrying out the field and lab work and working through and sharing the results.

The most challenging part of my work has been overcoming setbacks. Trying something new when things don't go as planned. Following the fire in Burt Hall [see p. 6 for story], we needed to reimagine how to get research done.

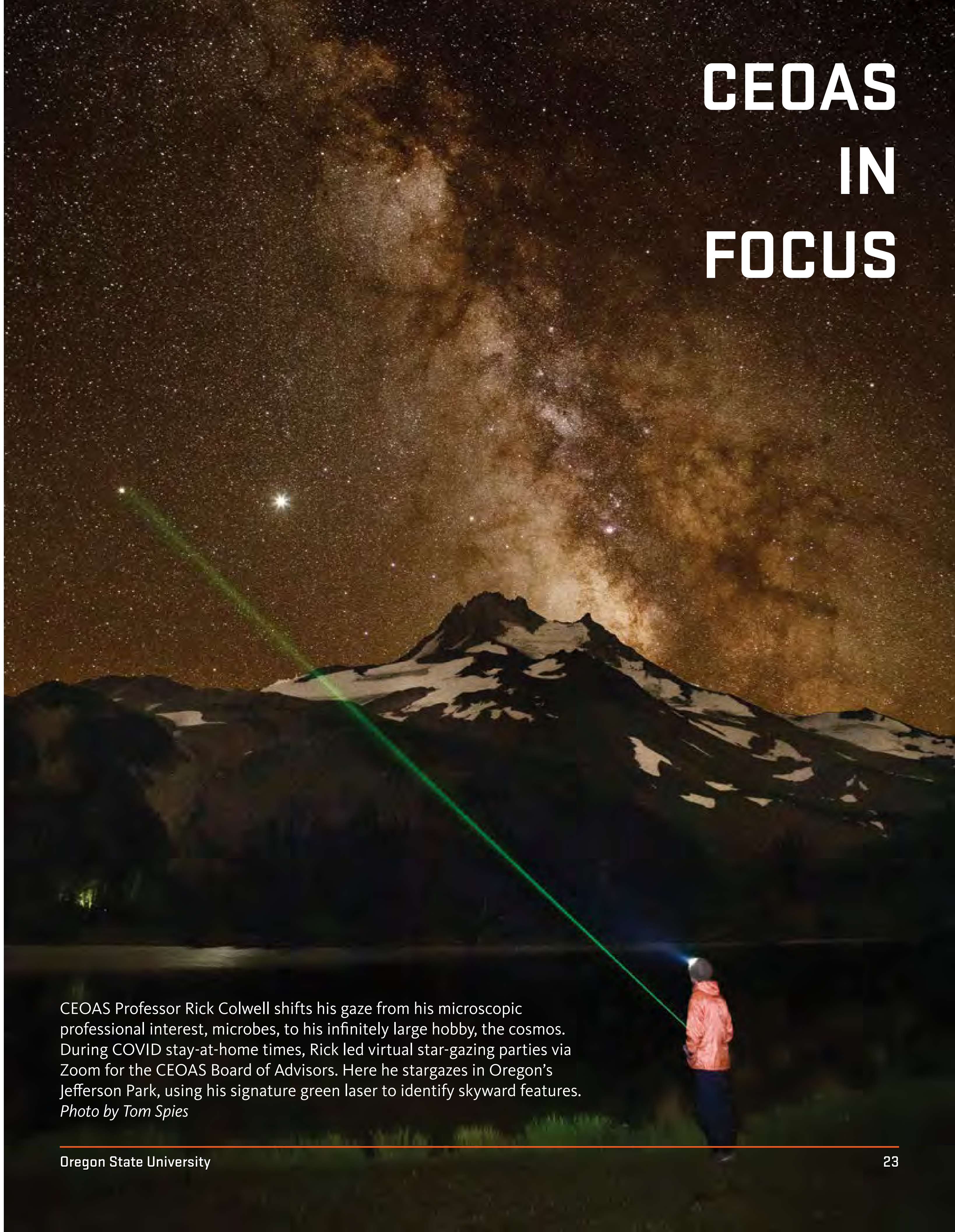
**What is the title of the last scientific paper you read? What is the last non-scientific thing you read?**
The last paper I read is "Cadmium Pollution from Zinc-Smelters up to Fourfold Higher Than Expected in Western Europe in the 1980s as Revealed by Alpine Ice."

The last book I read was "The House in the Cerulean Sea" by TJ Klune. It is a beautiful story about a caseworker who goes to a remote island to check in on an orphanage of magical children. Unexpectedly he ends up making deep connections with the children and their caregiver. Ultimately, they become a family. Really a wonderful read in current times.

**What advice would you give your former self entering the field?**
Find balance between professional and personal pursuits. Even if it is hard work, this is the key to finding happiness in both.



# CEOAS IN FOCUS



CEOAS Professor Rick Colwell shifts his gaze from his microscopic professional interest, microbes, to his infinitely large hobby, the cosmos. During COVID stay-at-home times, Rick led virtual star-gazing parties via Zoom for the CEOAS Board of Advisors. Here he stargazes in Oregon's Jefferson Park, using his signature green laser to identify skyward features. *Photo by Tom Spies*

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