

COLLEGE OF EARTH, OCEAN, AND ATMOSPHERIC SCIENCES

RESEARCH HIGHLIGHTS 2017



Oregon State
University



A MESSAGE FROM THE DEAN

The 2017 edition of our Research Highlights features the accomplishments of our outstanding faculty and students. Their achievements reflect our intrinsic culture of scientific excellence, and a deep commitment to advancing understanding of a changing planet. This commitment is exemplified by our Regional Class Research Vessel project, the largest grant in the university's history. CEOAS is overseeing the design and construction of the newest research vessels in the U.S. fleet, which will provide valuable scientific capacity for studying our oceans.

This publication includes other exceptional research efforts that describe how past ocean temperatures may serve as a prologue to our future climate, and that examine the driving climatic forces behind toxic algal blooms and their impacts on human health and the shellfish industry. Our researchers are studying how the temperature of magma can help predict volcanic eruptions, determining the environmental drivers of krill hotspots in Antarctica, and exploring the complex linkages between the ocean, fog and coastal redwood forests. From the highest peaks to the core of the earth, from the web of rivers draining the mountains to the open ocean, and from a prehistoric past to a future yet unknown, our faculty and students are exploring today's complex problems. These pages give you a unique opportunity to follow alongside them.

Roberta Marinelli, dean

Editors

Nancy Steinberg

Abby Metzger

Graphic Designer

Crystal Barnes

Contributing Writers

Mark Floyd

Pat Kight

Abby Metzger

Nancy Steinberg

About the College

The College of Earth, Ocean, and Atmospheric Sciences (CEOAS) is an internationally recognized leader in the study of the Earth as an integrated system. With more than 100 faculty, 200 graduate students and 600 undergraduate students, the college has an annual budget of more than \$50 million. Most of the college's research support comes from the National Science Foundation, National Oceanic and Atmospheric Administration, National Aeronautics and Space Administration and other federal agencies and philanthropic organizations.

Contacts

College of Earth, Ocean, and Atmospheric Sciences

Oregon State University
104 CEOAS Admin Building
Corvallis, OR 97331-5503
541-737-3504
ceoas.oregonstate.edu

Roberta Marinelli, Dean

541-737-5195

Eric Kirby, Associate Dean for Academic Programs

541-737-5169

Philip Mote, Associate Dean for Strategic Initiatives

541-737-5694

Tuba Özkan-Haller, Associate Dean for Research and Faculty Advancement

541-737-9170

Student Services

541-737-1201

Doug Brusa, Director of Development

541-207-8686

THE FUTURE OF THE RESEARCH FLEET:

THREE REGIONAL-CLASS RESEARCH VESSELS TO BE BUILT BY OSU

Ready the champagne: It won't be long before Oregon State University will christen the first of three brand-new, state-of-the-art research vessels to serve as platforms for scientists to ask questions that take them beyond our shores and out to the open ocean.

Oregon State University has just received a grant of \$121.88 million from the National Science Foundation to spearhead the construction of the first of the three vessels for the United States Academic Research Fleet. It is the largest grant in the university's history.

The new class of research vessels will conduct research in coastal regions of the continental United States and Alaska. Additional supplemental grants may be awarded as approved by Congress. The first vessel will be operated by OSU for

research missions focusing on the U.S. West Coast. NSF will begin the competitive selection of operating institutions for the second and third vessels later this year – likely to universities or consortia for operations on the U.S. East Coast and the Gulf of Mexico.

“Oregon State University is extremely proud to lead this effort to create the next generation of regional ocean-going research vessels funded by NSF,” said OSU President Edward J. Ray. “Our exceptional marine science programs are uniquely positioned to advance knowledge of the oceans and to seek solutions to the threats facing healthy coastal communities – and more broadly, global ecological well-being – through their teaching and research.”



OSU was selected by the National Science Foundation in 2013 to lead the initial design phase for the new vessels, and to develop and execute a competitive selection for a shipyard in the United States to do the construction. Gulf Island Shipyards, LLC, in Louisiana was chosen and will conduct the detailed design verification over the next year.

This new class of modern well-equipped ships is essential to support research encompassing marine physical, chemical, biological and geologic processes in coastal waters, said Roberta Marinelli, dean of Oregon State's College of Earth, Ocean, and Atmospheric Sciences.

"Rising sea levels, ocean acidification, the onset of low-oxygen waters or 'hypoxia,' the state of our fisheries, the future of offshore energy, and the geology of continental margins are global questions," Marinelli said. "These new vessels will provide valuable scientific capacity for better understanding our changing oceans."

Clare Reimers, a professor in the College of Earth, Ocean, and Atmospheric Sciences and project co-leader, said the ships will feature state-of-the-art and sustainable technologies.

"This class of ships will enable researchers to work much more safely and efficiently at sea because of better handling and stability, more capacity for instrumentation and less noise," said Reimers. "The design also has numerous 'green' features, including an optimized hull form, waste heat recovery, LED lighting and variable speed power generation."

Keel-laying for the first of the three ships is scheduled for mid 2018. Oregon State is expected to begin operating the new vessel from Newport in the fall of 2021, after a year of testing and then official Academic-Fleet designation by the University-National Oceanographic Laboratory System (UNOLS), according to project manager Demian Bailey, also co-leader for OSU.

"There will be a full year of testing because there are many interconnected systems to try out," Bailey said. "Any new ship needs to have shakedown cruises, but we'll have to test all of the scientific instrumentation as well, from the acoustic multibeam seafloor mapping system to its seawater and meteorological data collection, processing and transfer capabilities."

Follow along the RCRV's progress and stay up to date with the nation's next generation of research vessels: blogs.oregonstate.edu/rcrv/.

Some characteristics of the new regional class research vessels (RCRVs):

- 193 feet long with a 41-foot beam
- Range of approximately 7,000 nautical miles
- Cruising speed of 11.5 knots with a maximum speed of 13 knots
- 16 berths for scientists and 13 for crew members
- Ability to stay out at sea for at least 21 days before returning to port
- High bandwidth satellite communications for streaming data and video to shore



CLIMATE CHANGE

Global change is presenting a range of challenges to populations worldwide. CEOAS scientists are examining causes and effects of climate change on a variety of space and time scales in order to understand the past, present and future climate system.



Scientists zero in on global ocean temperatures during most recent interglaciation period

As Earth's temperature warms during the current interglacial period, scientists are finding we have much to learn from the planet's previous interglacial periods.

For example, during the last major interglacial period, the ice sheets in Greenland and Antarctica were smaller than today, resulting in a global sea level that was 20 to 30 feet higher. Scientists believe ocean temperatures then were warmer than at most times in the Earth's recent history, but it's not clear how much warmer. Improved understanding of ocean temperature in the past will lead to more accurate projections of how warming affects sea level rise in the future.

A team of OSU scientists has assembled data from around the world in a comprehensive analysis of global ocean temperatures during the interglacial period of 129,000 to 116,000 years ago. The team found that global average ocean temperatures at that time were roughly half a degree (Celsius) warmer than pre-industrial times, and nearly identical to the average temperature in the modern era.

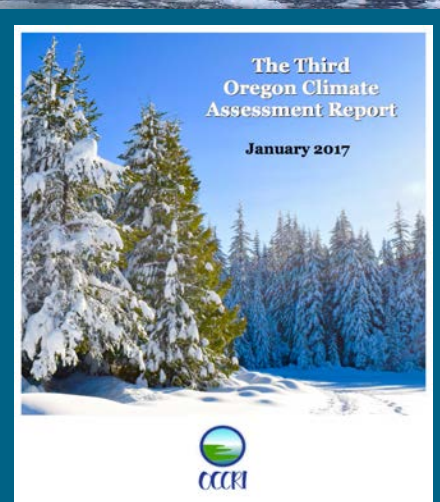
"Half a degree may not sound like very much, but in terms of average global ocean temperature, it actually is quite substantial," said lead author **Jeremy Hoffman**, who conducted the research as a doctoral student at Oregon State University.

Peter Clark, an Oregon State climate scientist and co-author on the study, said one reason for warmer temperatures and decline of the Greenland ice sheet during the last interglaciation was a shift in Earth's orbit around the sun.

"Although carbon dioxide levels then were comparable to the pre-industrial era, solar insolation in the northern hemisphere during the summer was much higher," said Clark, a distinguished professor in OSU's College of Earth, Ocean, and Atmospheric Sciences. "This more intense solar insolation contributed to the warmer temperatures."

The researchers believe the melting of the Greenland ice sheet affected ocean circulation, weakening the Atlantic Meridional Overturning Circulation, or AMOC, a system of currents that usually brings warmer water from the tropics to the north. As it weakened, sea surface temperatures rose in the southern hemisphere, also contributing to warmer global temperatures.

"It was a double whammy," Clark said. "Solar insolation warmed the northern hemisphere, a weakened AMOC warmed the south."



OREGON CLIMATE CHANGE RESEARCH INSTITUTE

OCCRI releases third Oregon Climate Assessment Report

The third Oregon Climate Assessment Report, a synthesis of peer-reviewed scientific studies of the past three years, was released in early 2017 by CEOAS's Oregon Climate Change Research Institute (OCCRI), and presented to key Oregon political leaders. Philip Mote, director of the OSU center and a co-author on the report, noted, "Overall, temperatures are still getting warmer – in Oregon, throughout the United States, and globally – and the impacts are very real. For Oregonians, it means warmer temperatures, lower snowpack and less water during the summer."

How low can you snow?

Where did all of our white stuff go? Oregon experienced depressed snowpack levels in 2014 and historically low snowpack levels in 2015. Scientists from OSU suggest that these occurrences could become much more common if average temperatures continue to increase.

The low snowpack levels were linked to warmer temperatures and not a lack of precipitation. Based on mathematical simulations of previous and predicted snowpack, the study suggests that by mid-century, years like 2015 may happen about once a decade, while snowpack levels similar to 2014 will take place every four to five years.

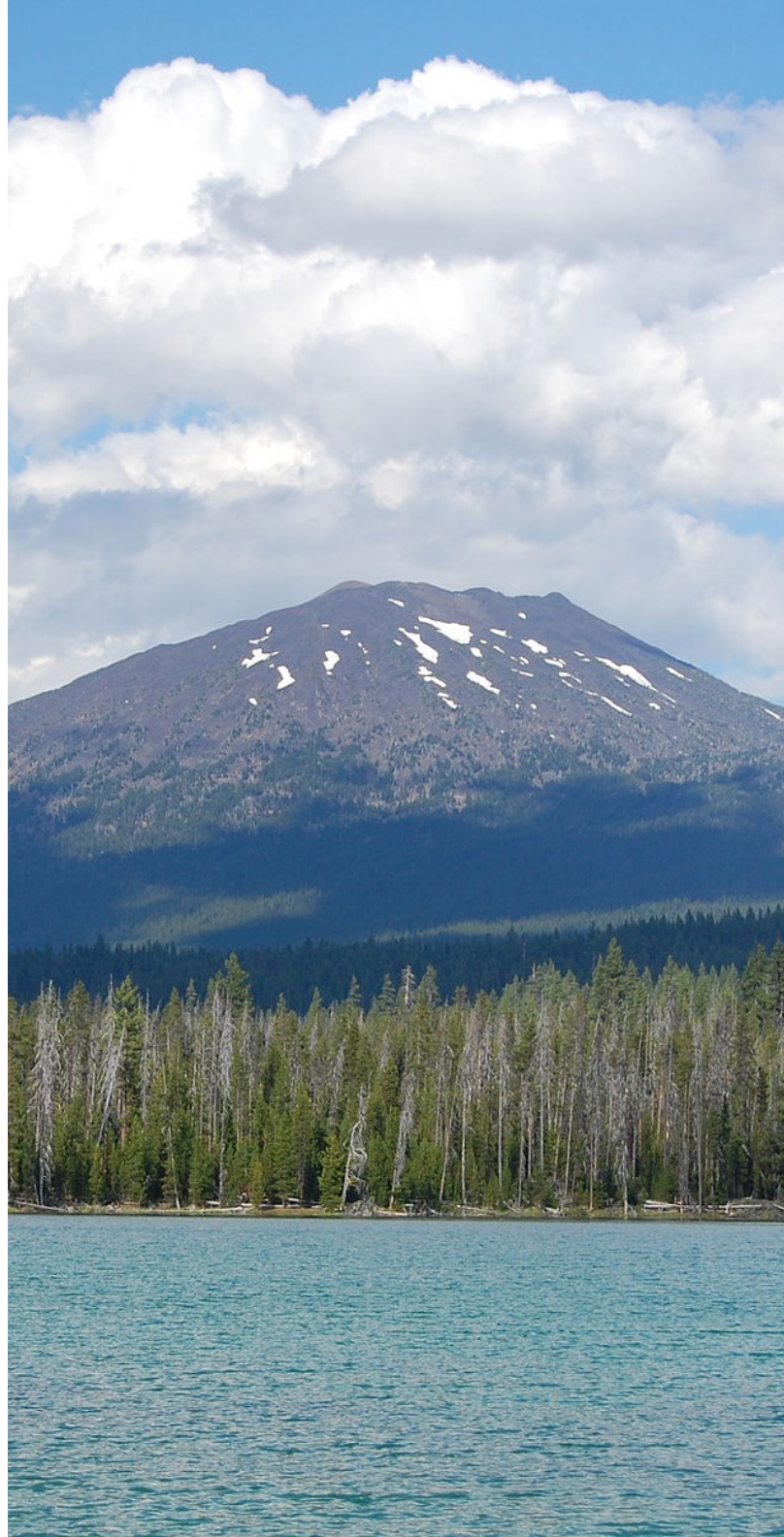
“It is a cautionary tale,” said lead author **Eric Sproles**, who conducted much of the research as a CEOAS doctoral student working with **Anne Nolin** and **Travis Roth**. “California received a lot of attention for its drought, but the economic and environmental impacts from those two low-snowpack years were profound in the Pacific Northwest.”

“We set out to learn whether they were just off years, or if they would be likely to happen more often with increased warming. Unfortunately, the data show these will become more commonplace.”

The key, Sproles said, is what happened in the Cascade Mountains at an elevation of around 4,000 feet – a level that frequently is the boundary between rain and snow. In 2014, winter precipitation in the mountain region was 96 percent of normal, and overall temperatures were 0.7 degrees (C) warmer than normal. But temperatures in the snow zone were 2.7 degrees (C) warmer than average.

That pattern was even stronger in 2015. A fair amount of precipitation still fell – 78 percent of normal – but temperatures in the snow zone were 3.3 degrees (C) warmer than average. “The low snow years took place even though precipitation wasn’t that bad. But when it falls as rain instead of snow, it loses that ability to function as a natural reservoir in the mountains,” said Sproles

“The result was a significantly reduced stream flow in the summer, water quality concerns in the Willamette Valley, an increase in wildfires, high fish mortality and a dreadful season for ski resorts,” said Sproles. “Hoodoo Ski Area was open for only a few weekends in 2013-14, and in 2015, they suspended operations in mid-January – the shortest season in their 77-year history.”



ALAN MIX

Distinguished Professor

Oregon State University named Alan Mix as a 2017 Distinguished Professor, the highest academic honor the university can bestow on a faculty member. Mix, a professor in the OSU College of Earth, Ocean, and Atmospheric Sciences, was recognized as an international leader in the field of paleoceanography – the study of past changes in the ocean and climate that helps us to understand and project impacts from future changes.

COASTAL OCEANOGRAPHY

CEOAS faculty develop and use novel tools to study the fundamental processes that take place in our estuaries, coastlines and continental shelves. This research contributes knowledge that promotes healthy coastal communities and sustainable use of natural resources.

Acid test: Correlation between domoic acid levels and climate could lead to early warning system

The diatoms of the genus *Pseudo-nitzschia* are tiny organisms that can cause big problems for fisheries, coastal communities and those that like to eat shellfish. The phytoplankton produces the neurotoxin domoic acid, which enters the marine food web and can cause symptoms in humans, including gastrointestinal disturbance, seizures, memory loss or — rarely — death.

A team of scientists, including CEOAS Associate Professor **Angelique White** and doctoral student (now graduated) **Morgaine McKibben**, has found a strong correlation between toxic levels of domoic acid in shellfish and the warm-water ocean conditions orchestrated by two powerful forces – El Niño events and the Pacific Decadal Oscillation.

Using a combination of time-series data spanning two decades, the scientists not only showed a clear link between domoic acid and these larger climatic phenomena, but also developed a new model to predict with some accuracy the timing of domoic acid risks in the Pacific Northwest.

“In the natural world there are always variations, and it’s been difficult to connect a specific event to larger forces that operate over periods of years and decades,” said White. “To do so, long observational time-series are crucial.”

With the long-term federal and state databases that the team was able to access, “we’ve finally been able to tease out short-term variability from natural climate forcing,” White said.

The new study shows that oscillations to positive, or warm-favorable conditions in natural climate cycles, can reduce the strength of the south-flowing California Current. This allows more northward movement of warmer waters and higher levels of toxic plankton, and also brings that toxic mix closer to shore where it can infiltrate shellfish.

“Part of the concern is that a large influx of the plankton that produce domoic acid can have long-term impacts,” said McKibben, the lead author on the study.

“For example, razor clams are filter-feeders that bioaccumulate this toxin in their muscles, so they take much longer to flush it out than other shellfish. The higher the toxin levels, the longer it takes for razor clams to be safe to eat again, perhaps up to a year after warm ocean conditions have subsided.”

While it might be some time before fishermen can check the domoic acid forecast along with the weather forecast before they head out to sea, this study might make such predictions a future reality.



ROB HOLMAN

Coastal Dynamics Award

Rob Holman received the Coastal Award for lifetime contributions to the field of coastal science at the 2017 Coastal Dynamics Meeting in Denmark. Holman has been a professor of oceanography at Oregon State University since 1979. He is best known as the developer of the Argus program for optical remote sensing of the nearshore ocean, an approach that has led to countless advances in the study of coastal processes by OSU and nearshore scientists around the world.



Oregon State to help lead new NSF research program in the Arctic

Ecological change can occur over very long time scales, but typical research grants last only a few years. Enter the National Science Foundation's Long-Term Ecological Research (LTER) program, which provides sustained support for research at specific sites chosen to represent major ecosystem types around the world.

Oregon State University and five other universities received a five-year, \$5.6 million NSF grant in March of 2017 to initiate a new LTER project in the Arctic that will explore how relationships between the land and water affect coastal ecosystems along the northern Alaskan coast.

The site now becomes part of a network of 27 other LTER locations.

The new site, for which CEOAS oceanographers **Yvette Spitz** and **Byron Crump** serve as principal investigators, is the Beaufort Sea Lagoons, the first marine ecosystem LTER in the Arctic Ocean. The LTER research will be based in Kaktovik, Utqiagvik (formerly Barrow), and Prudhoe Bay, Alaska. It will focus on a series of large, shallow (5-7 meters deep) lagoons that play a role in the transition of materials from land to sea.

"It is a very rich, very important ecosystem, and we don't have a good understanding of how it works," said Spitz. "There are chemicals, nutrients and other organic materials that are transported from the land to the ocean, passing through lagoons along the way."

"One of the goals of the project is to understand how the transport of these materials is affected by changing precipitation, sea ice and melting permafrost – and what effect that has on biological productivity. These changes are presently occurring and are the most rapid in the Arctic."

Research at the site will help in predicting future changes to the ecosystem that could affect Iñupiat communities, which rely on lagoon and coastal fisheries for subsistence hunting and fishing.

Crump will focus on the smallest but most abundant organisms in the ecosystem – phytoplankton, bacteria and other microbes.

"The old school of thinking was that bacteria were important in warmer ecosystems but not so much in colder regions like the Arctic," Crump said. "We're finding that this isn't true at all. Bacteria and other tiny organisms play critical roles in maintaining the food web that supports everything from krill to whales as well as important fisheries."

Crump will look at the growth rates and genomic diversity of microbes, while Spitz will develop computer models that will evaluate how microbes, plankton and other small organisms influence the ecosystem and how they will be affected by ecosystem changes.



SEDIMENT CORE COLLECTION EXPANDS

The Oregon State University repository of oceanic sediment cores will expand to one of the largest in the world, when the university assumes stewardship of a collection of sediment cores from the Southern Ocean around Antarctica. A new, NSF-funded state-of-the-art core repository will be constructed to house the expanded collection. The OSU Marine and Geology Repository will be available to scientists across the globe to study the sediment cores, which provide key evidence of Earth's past conditions.

ATMOSPHERIC DYNAMICS

Flow, turbulence, currents and mixing occur in the atmosphere just as they do in the ocean, affecting weather, short-term climate fluctuations and the hydrologic cycle. CEOAS scientists study the atmosphere using observational, theoretical and modeling approaches.

Coastal fog: The sea-tree connection

If you've ever explored the coastal redwood forests of Northern California, you know that the atmosphere among the towering giants is humid, the air pungent and loamy, smelling at once like the sea and earth.

This olfactory fusion is appropriate; scientists have discovered that redwood forests thrive on a sea-sourced fog that carries nutrient-rich coastal ocean water. Uncovering the numerous processes that make it possible for the sea to nourish the trees requires novel approaches and multiple disciplines.

Thanks to a new National Science Foundation (NSF) grant, researchers from seven institutions, including Oregon State University, have formed an interdisciplinary team to study the relationships among upwelling, fog, coastal redwood forests and climate change. The Summen Project, named after the indigenous Ohlone word for "redwood," aims to unravel the complex ocean-atmosphere-land interactions supporting one of the Earth's most productive and alluring terrestrial ecosystems and make predictions about how climate change may alter them.

Coastal fog is generated by warm, high-pressure air mixing with cold ocean water brought to the sea surface through upwelling. West Coast upwelling occurs when winds push surface waters offshore, and deeper, colder water then rises from below to take the place of the surface water. Fog drawn into the redwoods bears vital moisture, but also nitrogen, phosphorus and minerals picked up from ocean waters during upwelling.

Dissecting the dynamics of this process is challenging. "Predicting the extent of fog formation is a complex and delicate task, and one of the most difficult parameters to get right in computer simulations of the atmosphere," explains **Eric Skyllingstad**, professor of atmospheric sciences at Oregon State University and part of the Summen Project.

Upwelling occurs along our coastline beginning in spring and lasting into early fall, but there are indications that the timing and intensity of this process may be in flux because of changing land and ocean surface temperatures.

From hundreds of feet above the forest floor to beneath the ocean waves, the Summen Project will most certainly take this interdisciplinary team on an epic journey. Follow their progress and their findings at www.fogsci.com.



DAVID NOONE

New Climate Science Field Course

David Noone, a professor in the College of Earth, Ocean, and Atmospheric Sciences, led an expedition across Oregon to put climate science in the hands of students. The course enabled a dozen undergraduates to make observations, handle high-tech instruments, conduct experiments, collect climate science data and observe textbook concepts in action. Read more here: ceoas.oregonstate.edu/features/newlight/.

GEOSPATIAL SCIENCES

Geospatial sciences use mapping and geographic information systems to look for patterns, movement and change of human populations, trees, buildings, agricultural land and more. This information can reveal fundamental earth system processes and shed light on social and political issues, contributing to planning and policy implementation.

Cocaine, cut trees and cattle ranches: Central American “narco-deforestation” tracked via satellite

Central American tropical forests are beginning to disappear at an alarming rate, threatening the livelihood of indigenous peoples and endangering some of the most biologically diverse ecosystems in North America.

The culprit? Cocaine.

It is not the cultivation of the coca plant – which is processed into cocaine – that is causing this “narco-deforestation.” The problem results from people throughout the spectrum of the drug trade purchasing enormous amounts of land and clearing the timber to launder their illegal profits, researchers say.

“Starting in the early 2000s, the United States-led drug enforcement in the Caribbean and Mexico pushed drug traffickers into places that were harder to patrol, like the large, forested areas of Central America,” said **David Wrathall**, an Oregon State University geographer and co-author on the study. “A flood of illegal drug money entered these places, and these drug traffickers needed a way that they could spend it.

“It turns out that one of the best ways to launder illegal drug money is to fence off huge parcels of forest, cut down the trees, and build yourself a cattle ranch. It is a major, unrecognized driver of tropical deforestation in Central America.”

Using geospatial data, the research team identified irregular or abnormal deforestation from 2001-2014 that did not fit previously identified spatial or temporal patterns caused by more typical forms of land settlement or frontier colonization. The team then estimated the degree to which narcotics trafficking contributes to forest loss.

They estimate that cocaine trafficking may account for up to 30 percent of the total forest loss in Honduras, Guatemala and Nicaragua over the past decade. A total of 30 to 60 percent of the forest losses occurred within nationally and internationally designated protected areas, threatening conservation efforts.

Wrathall said the impact affects both people and ecosystems.

“The indigenous people who have lived sustainably in these environments are being displaced as the stewards of the land,” he said. “These are very important ecological areas with tremendous biodiversity that may be lost.”

“We are cruising through the last of our wild spaces in Central America,” Wrathall said. “Obviously, ending the illegal drug trade would be the best solution, but that isn’t going to happen. In fact, when drug enforcement efforts are successful, they often push the activity into remote areas that haven’t had issues before, such as remote biodiversity hotspots.”



SAM HOOPER

Data-Visualization Face-Off

Sam Hooper, a doctoral candidate with the Kennedy Geospatial Lab at Oregon State University, won the People’s Choice Award in the 2017 Data Stories Contest, sponsored by AAAS/Science. His “Listening to Landscapes” used animated satellite data to illustrate the dynamic nature of Earth’s surface as it gradually shifts over time.



LAURA PETERS

Jeanne X. Kasperson Award

Ph.D. student Laura Peters won the 2016 Jeanne X. Kasperson Award, a student paper competition in the Hazards, Risks, & Disasters Specialty Group of the Association of American Geographers. Her research investigates how Nepal’s ten-year civil war and the subsequent 2015 earthquake have impacted long-term peacebuilding and disaster recovery.

ELEMENTAL CYCLES

CEOAS scientists explore how elements and nutrients move in and between ecosystems in order to develop insights into the strengths, weaknesses and productivity of the planet's biogeochemical systems.

Krill hotspot fuels incredible biodiversity in Antarctic region. What fuels the krill?

There are so many Antarctic krill in the Southern Ocean that the combined mass of these tiny aquatic organisms is estimated to be more than that of the world's 7.5 billion human inhabitants.

Scientists have long known about this important type of zooplankton, but they haven't been certain why particular regions or "hotspots" in the Southern Ocean are so productive. One such hotspot exists off Anvers Island – along the western Antarctic Peninsula – where high densities of Antarctic krill episodically concentrate near the shore close to a number of Adélie penguin breeding colonies.

As it turns out, a perfect combination of tides and wind is responsible, according to a study on the krill led by CEOAS oceanographer **Kim Bernard**.

Bernard's team discovered that krill aggregations within the Palmer Deep Canyon – a region of nutrient-rich waters that produce a lot of food for the krill – are delivered close to shore by tidal currents and winds. When the winds are westerly and the tides are diurnal – one high tide and one low tide each day – the nearshore krill biomass peaks, and krill aggregations are huge.

"It's neat – we can predict exactly when humpback whales will be close to shore off Palmer Station just based on the tides," Bernard said. "When there are diurnal tides, you'll see krill from the surface to the ocean floor – they are everywhere. And when they are, the whales are there, too."

"This concentration and transport toward shore are particularly important for the penguins that breed there. The farther they have to go to forage, the less their chicks have to eat, and chick weight is a huge factor in their survival."

When the tides shift to semi-diurnal – two high and two low tides daily – currents move the krill away from shore, and their predators follow. Likewise, a shift to southerly winds keeps the krill farther from shore and more spread out. While the researchers are not sure why the two additional tides per day make such a difference, they speculate that a diurnal tide will persist longer in a given direction and lead to stronger currents when interacting with the bottom topography of the region than a semi-diurnal tide.

"Despite their abundance, there is growing concern about krill not only because of climate change, but because they are now being harvested for human food, nutritional supplements and aquaculture feed. Yet historically we've known little about what makes this particular area so productive for krill. So we set out to learn more about it."



JESSAMYN JOHNSON

Oregon Society of Conchologists Scholarship

CEOAS master's student Jessamyn Johnson was awarded the Oregon Society of Conchologists Scholarship for the 2016-2017 academic year. Working with faculty advisor George Waldbusser, she will detail the metamorphosis of Pacific oysters from larvae to juveniles to understand how ocean acidification may impact early life stages.

Magnesium within plankton provides tool for taking the temperatures of past oceans

Scientists cannot travel into the past to take the Earth's temperature, so they use proxies to discern past climates. One of the most common methods for obtaining such data is by extracting information from the remains of tiny marine organisms called foraminifera, or "forams," found in oceanic sediment cores.

Forams are sand-grain-sized organisms with shells composed of calcite. When they grow, they incorporate magnesium from seawater into their shells. As a general rule, when ocean temperatures are warmer, forams incorporate more magnesium; less when the temperatures are cooler. As a result, scientists can tell from the amount of magnesium what the temperature of the seawater was thousands, even millions of years ago. These proxies have been important tools for understanding the Earth's climate history.

However, studies of live forams reveal that shell magnesium can vary, even when seawater temperature is constant. Understanding the mechanism responsible for magnesium variability is important to ensure the accuracy of temperature reconstructions. A new study by a team of scientists led by CEOAS paleoceanographer **Jennifer Fehrenbacher** affirms that magnesium variability is linked to the day/night (light/dark) cycle in simple, single-celled forams and extends the findings to more complex multi-chambered species.

To understand how forams develop and what causes magnesium variability, the research team grew the multi-chambered species, *Neogloboquadrina dutertrei*, in a laboratory under highly controlled conditions. They used high-resolution imaging techniques to "map" the composition of these lab-grown specimens.

"We found that high-magnesium calcite is precipitated at night, and low-magnesium calcite is added to the shells during the day, similar to the growth patterns of the single-chambered species," said Fehrenbacher. "This confirms that magnesium variability is driven by the same mechanism in two species with two different ecological niches. We can now say with some level of confidence that magnesium-banding is intrinsically linked to shell formation processes as opposed to other environmental factors.

"The variability in magnesium content of the shells doesn't change the utility of forams as a proxy for temperature because the sampled populations' average Mg/Ca ratios are, indeed, linked to calcification temperature. Our results give us new insights into how these organisms build their shells and lend confidence to their utility as tools for reconstructing temperatures."



CAREN BARCELO

**PICES Best Oral
Presentation Award**

Ph.D. student Caren Barcelo won the best oral presentation award for early career scientists at the 25th Annual PICES Meeting in San Diego. Her talk examined fish assemblages – which are key indicators of overall ecosystem function – in the Northern California Current under different climate change scenarios.



WATER RESOURCES

Freshwater is one of the most precious resources on Earth. CEOAS scientists study freshwater – including natural cycles and human uses – and provide important insights to policy makers.

Adaptive governance in the Klamath

Hannah Gosnell, associate professor of geography at Oregon State, braves the intricacies of complex social-ecological systems (coupled systems of nature and people), examining human dimensions of global environmental issues and the approaches that people use to address them. One system of environmental governance she studies is so-called “adaptive governance,” an approach that fosters the emergence of collective problem-solving and innovative institutions in which rules, structures and policies change in response to new information.

Gosnell and her recent Ph.D. student, **Brian Chaffin** (now an assistant professor at University of Montana), were interested in whether and how a system of adaptive governance emerged during the Klamath Basin water wars during the critical years of 2001-2010. These years culminated in the completion of a negotiated agreement among all stakeholders for a new, more holistic way to manage the system, the Klamath Basin Restoration Agreement (KBRA).

“A big source of the conflict was that the federal government was making all the decisions,” Gosnell said. Other stakeholders – farmers, tribes, ranchers, environmentalists – came to understand that they needed to undertake problem-solving themselves, putting aside distrust and resentment and looking for common ground.

Chaffin and Gosnell looked for the hallmarks of emerging adaptive governance, and found them. Over time, governance in the Klamath became less hierarchical and included multiple overlapping centers of decision-making. Formerly marginalized groups such as the Klamath Tribes gained an important seat at the table. New approaches included more informal meetings of working groups that allowed social relationships to burgeon, implementation of small-scale collaborative restoration projects, and improved communication among stakeholders.

“A core group of key stakeholders came together and started to ask, ‘how can we share scarce water resources more effectively? Why don’t we decide rather than waiting for the next law suit and letting a judge decide?’” Gosnell said.

Common to all of Gosnell’s research is the search for solutions at the “radical center” of an issue, that sweet spot between two possibly extreme and always dearly held perspectives.

“What kind of institutions, leadership and geographic conditions need to coalesce in order for disparate groups to change the way they interact and adopt a collaborative approach to problem-solving? How people get to that place, how they leave their entrenched positions for a greater good, that’s the question I often come back to,” she explained.

While the KBRA was not authorized by Congress and expired in 2016, the Klamath story is far from over. Gosnell will continue to follow it with great interest, identifying barriers to collaborative conservation and paths to the radical center in this most complex system.



BETH RUTILA

GSA Research Grant

Water resources master’s student Beth Rutila received a research grant at the 2016 Geological Society of America conference in Denver. One of only ten recognized out of nearly 700 applicants, Rutila will work with faculty member Alyssa Shiel to examine how human inputs of metals impact the environment and water quality.

SOLID EARTH

Solid Earth science uses geological, geophysical and geochemical approaches to develop a fundamental understanding of the Earth's crust and mantle all over the globe. Field work and state-of-the-art modeling and analytical facilities are employed to understand plate tectonics, volcanic processes and more.

Documenting the aftermath of Earth's most recent supereruption

Rare but quite real, "supervolcanoes" expel more than 1,000 cubic kilometers (240 cubic miles) of ash and pumice in a catastrophic eruption. For contrast, the 1980 eruption of Mount St. Helens spewed 1 cubic kilometer of material.

These spectacular eruptions can cause massive destruction and affect climate patterns on a global scale for decades. A new CEOAS study has found that these volcanoes also may experience ongoing, albeit smaller, eruptions for tens of thousands of years after. The study focused on the Toba Caldera in Sumatra.

"The recovery from a supervolcanic eruption is a long process, as the volcano and the magmatic system try to re-establish equilibrium – like a body of water that has been disrupted by a rock being dropped into it," said **Adonara Mucek**, an Oregon State doctoral candidate and lead author on the study.

"At Toba, it appears that the eruptions continued for at least 15,000 to 20,000 years after the supereruption, and the structural adjustment continued at least until a few centuries ago – and probably is continuing today. It is the magmatic equivalent to aftershocks following an earthquake."

Toba's eruption was so massive, it is thought to have created a volcanic winter on Earth lasting years, and possibly triggering a bottleneck in human evolution.

"Supervolcanoes have lifetimes of millions of years during which there can be several supereruptions," said **Shanaka "Shan" de Silva**, a CEOAS volcanologist and co-author on the study. "Between those eruptions, they don't die. Scientists have long suspected that eruptions continue after the initial eruption, but this is the first time we've been able to put accurate ages with those eruptions."

Particularly exciting is that the study also found that lava being erupted currently from Mount Sinabung, 25 km to the north of Toba, shares age and isotopic characteristics with Toba's magmas.

"Our data suggest that the recent and ongoing eruptions of Mount Sinabung are part of the Toba system's recovery process from the supereruption," he said. "They may share the same magma system."

The discovery of the connection does not suggest that the Toba Caldera is in danger of erupting on a catastrophic scale any time soon, the researchers emphasized. "This is probably 'business as usual' for a recovering supervolcano," de Silva said.



ERIC KIRBY

A Virtual Reality Lesson in Geology

Eric Kirby, a geology professor and associate dean for academic programs at CEOAS, was featured in an NPR virtual reality tour of the Rocky Mountain National Park, where viewers could experience the grandeur of the park and learn an immersive lesson in geology. The piece was nominated for a 2017 Online Journalism Award. To view the tour, go to apps.npr.org/rockymountain-vr/.

NATURAL HAZARDS

Earthquakes, volcanoes, tsunamis, coastal storms, sea level rise and weather-related storms are all threats to human and ecological communities. CEOAS researchers seek to understand these different scenarios to help with planning, build resilience and facilitate recovery.

Analyzing magma temperatures may help get closer to forecasting volcanic eruptions

Because volcanic eruptions are a serious natural hazard, being able to forecast them is an important goal. But scientists have been unable to pinpoint the processes leading up to major eruptions – and one crucial limitation has been a lack of knowledge about the temperature history of the magma.

“To erupt onto the Earth’s surface, magma needs to heat up so it can be runny enough to be squeezed along cracks in the Earth and pushed up to the surface. At lower temperatures, the magma is too crystal-rich and viscous to move. It’s like trying to spread cold peanut butter onto a piece of bread,” explained CEOAS geologist **Adam Kent**.

So how warm does magma have to be to erupt? How can that temperature be measured?

Kent and an international team of colleagues asked these questions when studying the Taupo Volcanic Zone in New Zealand. Their research analyzed crystals of the mineral zircon – zirconium silicate – in magma from a Taupo eruption about 700 years ago to determine the magma’s history. They inferred temperature by looking at the distribution of lithium in the zircon. Lithium’s diffusion rate in the magma is controlled by temperature, so by examining the magma’s lithium distribution they can determine how much time the crystals have spent at high temperatures.

The analysis shows the magma went through a comparatively “cool” period for thousands of years before heating up. Once magma temperatures reached 750 degrees Celsius, it was a short amount of time – decades or less – before an eruption occurred.

This pattern of long-term crystal storage in near-solid magma, punctuated by rapid heating, is applicable to many other volcanoes around the world, the researchers say, and may begin to help scientists recognize when a volcano is heading toward an eruptive phase.

The finding suggests that if many volcanoes store their magma in this relatively cold state, recognizing volcanoes where warm and mobile magma is present may help researchers find volcanoes in the early throes of producing future eruptions. The technology to monitor volcanoes using seismic waves and other remote techniques is improving all the time, the researchers said.

This research could help us out right here in the Pacific Northwest: Kent said the Taupo magma system has similarities to the Cascade Range. We’ll hope for cool magma conditions for as long as possible.



BRAD PITCHER

Three-minute Thesis Competition

Recent geology graduate Brad Pitcher wowed judges and took first place in the 2017 OSU Graduate School’s Three-minute Thesis Competition. The competition gave participants only three minutes and one presentation slide to make an impression. Pitcher received \$1,000 for his animated discussion on how past volcanic eruptions can be used to predict future disasters.

Community Resilience: Helping Oregonians Prepare for the “Big One”

When you live on a seismically active coastline and the news keeps repeating dire warnings about the coming “Big One,” it’s easy to fall into denial – or despair. Associate Professor **Pat Corcoran** wants Oregonians to take a different approach: Don’t panic, face the reality of living on shaky ground, and get prepared.

“We need to find a sweet spot between fear and action,” said Corcoran, Oregon Sea Grant’s hazards outreach specialist and CEOAS faculty member. For the past decade, he has worked with Oregon’s coastal communities and state agencies on earthquake and tsunami preparedness. “What I try to do is temper the tendency of people to toggle between the poles of ‘It won’t happen here’ and ‘It will be so bad that there’s no use worrying about it.’ Both responses are a form of denial. The fact is, they do happen here. And there are lots of things we can do to prepare.”

The Pacific Northwest sits just east of the Cascadia Subduction Zone, where a deep-sea tectonic plate is slipping inexorably under the North American continent. Researchers at Oregon State University say it is inevitable that will trigger an earthquake of magnitude 8.0 to 9.0 or greater (the latter would be as strong as Japan’s 2011 Tohoku quake). OSU oceanographer **Chris Goldfinger**, one of the world’s leading experts on subduction zone earthquakes, says the geologic record and current seismic research indicate a 37 percent chance of such a quake in the next 50 years.

For coastal residents and visitors, preparedness might mean readying household and business disaster-emergency kits for home and car, practicing family earthquake drills or identifying and regularly walking the nearest tsunami evacuation route.

Corcoran’s efforts have already sparked discussion and informed others about the desirability of relocating schools and emergency services out of tsunami hazard zones, setting up neighborhood supply caches on high ground and holding regular community-wide disaster drills. Even inland cities like Portland are starting to prepare for fallen bridges and other urban destruction from a major earthquake or a tsunami-driven surge of water up the Columbia River.

Corcoran acknowledges that a magnitude 9 earthquake and tsunami – what he calls “the largest of the large” – could devastate coastal communities and destroy infrastructure throughout western Oregon and Washington.

But he adds that a more probable scenario is an earthquake closer to “the average side of large.” He suggests that people start by preparing for the “most likely next event” – and that doesn’t necessarily mean the destruction of western Oregon as we know it.

“Everything you need to do to prepare for a magnitude 8 earthquake also prepares you for a magnitude 9,” Corcoran said. “Start with the doable, and build on that.”



KATY SERAFIN

AGU Outstanding Student Paper

Ph.D. student Katy Serafin won an Outstanding Student Paper Award at the 2016 American Geophysical Union meeting for her work in nearshore oceanography. Her poster examined how individual processes combine to create coastal hazards that impact safety, recreation and livability.

NEW FACULTY



Maria Kavanaugh has been appointed as an assistant professor (senior research) in ocean ecology and biogeochemistry. Kavanaugh investigates seascape ecology and global change, bringing diverse perspectives from ecology, oceanography and modeling, to answer important

questions about the ocean's food webs. Her research interests also are geographically broad, spanning polar and temperate regions. Previously, she was a postdoctoral scholar and research associate with Woods Hole Oceanographic Institution (WHOI). She earned her Ph.D. in biological oceanography with a minor in statistics from Oregon State University in 2012.



Tuba Özkan-Haller has been appointed as the Associate Dean for Research and Faculty Advancement. She helps identify research opportunities within and across disciplinary boundaries; supports the development, acquisition and management of equipment and facilities that advance

CEOAS research; engages in long-range planning including new faculty hires; and assists with faculty advancement and mentoring. Her research uses numerical, field, laboratory and analytical approaches to predict and understand waves, circulation, and other features of the nearshore ocean. She holds a Ph.D. in civil engineering from the University of Delaware.



Eric Kirby, the R.S. Yeats Chair in Earthquake Geology and Active Tectonics, has assumed the role of Associate Dean for Academic Programs. Kirby is noted for his ability to convey complex concepts simply and effectively, his engagement of students during the delivery of lectures and his emphasis

on critical thinking and problem solving. As a named Fellow of the Geological Society of America, and as a recipient of the prestigious Alexander von Humboldt Fellowship to study abroad in Germany, he is widely recognized as a scientific leader in landscape evolution and orogeny. Kirby earned his Ph.D. from the Massachusetts Institute of Technology in geology.



Nicholas Siler has been appointed as an assistant professor of atmospheric sciences. His current research focuses on understanding regional climate variability and change, controls on the amount and distribution of mountain precipitation, changes in the hydrologic

cycle, and emergent constraints on the global cloud feedback and climate sensitivity. Previously, he was a postdoctoral scholar at the Scripps Institution of Oceanography. He earned a Ph.D. in Atmospheric Sciences at the University of Washington and has a physics degree from Harvard.



Philip Mote has been appointed as the Associate Dean for Strategic Initiatives. He oversees major college initiatives, including the CEOAS strategic planning process, identifying opportunities to make CEOAS more competitive for future research initiatives, and

maintaining connections to traditional and non-traditional funding sources. His current research interests include regional climate modeling and the influence of climate change on western U.S. snowpack. He earned a bachelor's in physics from Harvard University and a Ph.D. in atmospheric sciences from the University of Washington.



James Watson has been appointed as an assistant professor in geospatial analytics. Previously, he served as a postdoctoral researcher at the Stockholm Resilience Center, and as a visiting scholar at the Department of Ecology and Evolutionary Biology at Princeton. Watson has a wide

range of scientific interests, from coupled natural/human systems to global marine ecosystems to migration ecology. He received his Ph.D. in marine sciences from the University of California, Santa Barbara in 2011.

